APPLIED MATERIALS®

Etch EyeD Endpoint for 200mm and 300mm Systems

User Guide

Date: June 2004 Revision: 001

Applied Materials Confidential

Confidentiality Notice
The materials and information contained herein are being provided by Applied Materials to its Customer solely for Customer's use for its internal business purposes. Applied Materials retains all right, title, interest in and copyrights to the materials and information herein. The materials and information contained herein constitute confidential information of Applied Materials and Customer shall not disclose or transfer any of these materials or information to any third party.

PUBLICATION HISTORY

Revision:	001
Date:	June 2004
Cleanroom Part No.:	0230-02830
Standard Part No.:	
CD-ROM Part No.:	0230-03249
Document Production Number	358-022-02X

PART NUMBER HISTORY

Part Number Cleanroom/Standard/ CD-ROM	**Date**	**ECO**
0230-01874/01875	November 2002	XXXXXX
300mm 0230-01644/01645	May 2002	
200mm 0230-01314/01313	August 2001	

3050 Bowers Avenue
Santa Clara, California 95054

U.S. and Foreign Patents Pending

Applied Materials, the Applied Materials logo, Centura, and Precision 5000 are registered trademarks of Applied Materials, Inc. in the U.S. and other countries; BLOk, Black Diamond, DARC, DCVD, DxZ, Giga-Fill, GPLIS, ∝Clean, Optima, Precision Liquid Injection System, Producer, Remote Clean, SACVD, and Twin Chamber

© Copyright Applied Materials, Inc., 2003, 2004
3050 Bowers Avenue
Santa Clara, California 95054

All rights reserved. No part of this book may be reproduced in any form without written permission from Applied Materials, Inc.

Trademarks

The following registered trademarks are some of the trademarks used in Applied Materials manuals.

Name	Owner
Baratron®	Registered trademark of MKS Instruments, Inc.
Cajon®	Registered trademark of Swagelok Company
Conflat®	Registered trademark of Varian Associates, Inc.
Convectron®	Registered trademark of Granville-Phillips Company
DRYVAC®	Registered trademark of Leybold Vacuum Products Inc.
FastRegen™	Trademark of the CTI Cryogenics, Inc.
Freon®	Registered trademark of E.I. DuPont de Nemours & Co., Inc.
Kalrez®	Registered trademark of E.I. DuPont de Nemours & Co., Inc.
Kovar®	Registered trademark of Westinghouse Electric Corporation
Krytox®	Registered trademark of E.I. DuPont de Nemours & Co., Inc.
Lucite®	Registered trademark of E.I. DuPont de Nemours & Co., Inc.
Procomm®	Registered trademark of DATASTORM Technologies Inc.
Pyrex®	Registered trademark of Corning Glass Works
Q-tip®	Registered trademark of Cheseborough Ponds
RUVAC®	Registered trademark of Leybold Vacuum Products Inc.
Snap-Loc®	Registered trademark of Nor-Cal Products, Inc.
Swagelok®	Registered trademark of Swagelok Company
Scotch-Brite®	Registered trademark of 3M Corporation
Teflon®	Registered trademark of E.I. DuPont de Nemours & Co., Inc.
TRIVAC®	Registered trademark of Leybold Vacuum Products Inc.
Unival®	Registered trademark of Unival Company
VCR®	Registered trademark of The Swagelok Company
VCO®	Registered trademark of The Swagelok Company
Vespel®	Registered trademark of DuPont de Nemours & Co., Inc.
Viton®	Registered trademark of E.I. DuPont de Nemours & Co., Inc.
Windows NT®	Registered trademark of Microsoft Corporation.
X-Acto®	Registered trademark of Hunt Manufacturing Co.

Table 1: Glossary

Browser	A computer application that allows a user to interface with an Internet style network device.
CCD	Charge Coupled Device - A light detector comprised of a single row or a two dimensional array of detectors called pixels. Photons of light striking a pixel are converted to electrons that are stored on the pixel during an integration time period. At the end of the integration time, the charge on each pixel is proportional to the amount of light that struck the pixel. The charge on each pixel can be electronically read and reset to zero at the start of the next integration period.
CCD Integration	The collection of light information by extracting and counting the charges of each pixel of the CCD.
Combobox	A field in a window that can accept a typed selection, or can be activated with a cursor and mouse click to extend a drop down menu of available selections.
Configuration 1)	An arrangement of equipment.
Configuration 2)	A digital file containing instructions and parameters necessary for the analysis of spectral data and endpoint detection
Data (or Spectral Data)	Can mean the digital data collected from the analysis of one or more spectra, or saved digital files of this information.
DI/O	Digital Input/Output - A simple computer communication method in which a message in the form of a digital bit or group of bits is transmitted. The timing and significance of each bit set high or low is fixed and the meaning assigned and understood by both systems in communication. The output bits of one system are the input bits to the other.
Endpoint 1.	The point at which the wafer-processing activity for a recipe step is completed and should be halted to avoid over processing and destroying wafer structures.
Endpoint 2.	A change in the spectral data indicating that the desired stopping point in the wafer-processing activity has been reached.
Equation	Can mean either the name assigned to one or more algebraic or vector operations, or the result obtained by applying those operations on a given set of data.
Ethernet	A hardware interface that serves as a communication transport mechanism for several communication protocols, including TCP/IP.
Group Box	A delineated portion of a software window with related functions and choices. Only one radio button within a group box can be selected at one time.

Table 1: Glossary

GUI	Graphical User Interface - A method of presenting Text, Graphics, Icons and other visual symbols that allows a person (user) to interact with a computer. Typically, this refers to a Microsoft Windows presentation style.
IEP	Interferometric endpoint
LCD	Liquid Crystal Display - An electronic display that uses liquid crystal technology to display text and/or graphics using dots or lines
Millisecond	One one-thousandth of a second.
MTC1000	A PC housed in the same style case as an SD1024D spectrograph, usually dedicated for use as an endpoint PC (EyeD computer).
Nm	Nanometer(s) - A unit of length measurement equal to 10e-9 meters, used in this application for defining a wavelength of light.
OES	Optical emissions spectroscopy
Process Module, or PM	Is a single element of a Process Tool that performs a specific operation during on a semiconductor wafer. The element consists of a process chamber and associated mechanics, electronics, and software.
Process Chamber, or Vacuum Chamber	An enclosure used for semiconductor wafer processing. This portion of the process module isolates the process environment (temperature variations, partial vacuum, reactant gasses) from the ambient atmosphere. (See Process Module.)
Radio Button	A small circular field adjacent to a text selection in a software window. Selecting a radio button will cause a black dot to appear in the center of the circle.
Recipe	The list of process module settings and operations required to produce the desired thin film operation(s) on a semiconductor wafer. A recipe can have many steps that are sequentially performed on a wafer as part of the semiconductor fabrication process. Typically, a Recipe is specific to the wafer-processing tool for which it was originally defined.
Region	A user-specified range of wavelengths within the overall 200-800nm spectrum
Reprocess	To feed stored data file(s) back through the spectral analysis software to test new equations, settings and endpoint detection methods.
SMA	Sub Miniature type A connector is a fiber optic cable connection that uses a ferule plug to secure the fiber in the connector receptacle and it is held in place with a threaded coupling nut.
EyeD Computer or Endpoint PC	The computer designated to perform endpoint detection task using Applied Materials EyeD software to analyze spectra received from the spectrograph. Note: This definition does not imply that the computer must be used exclusively for endpoint processing.

Table 1: Glossary

SRM	Spectra Resource Manager - A companion utility of EyeD used for communication between instances of EyeD and one or more Spectrographs
Step	A group of tool settings designed to perform a unit operation in a Recipe of a process module. For example, a Stabilization Step will turn on gas flows and stabilize the chamber pressure before the Etch Step turns on the RF to start the plasma etch (see recipe).
TCP/IP	TCP/IP is a family of protocols. A few provide low-levellow-level functions needed for many applications. These include IP (Internet Protocol), TCP (Transmission Control Protocol), and UDP. Others are protocols for doing specific tasks, e.g. transferring files between computers, sending mail, or finding out who is logged in on another computer. Initially TCP/IP was used mostly between minicomputers or mainframes
Tool Controller	An automated wafer processing system containing the mechanics, electronics, and software required to perform one or more steps in the integrated circuit fabrication process. This tool monitors and controls the process module(s).
URI	Universal Remote Interface - A companion utility to EyeD that enables bi-directional communication between EyeD and the Tool Controller.
USB	Universal Serial Bus - A Standardized High Speed Serial communications interface used for transfer of Commands and/or Data.
Vacuum Chamber	(See Process Chamber)

P Preface

The EyeD Endpoint system and software User Guide provides instruction on the configuration and operation of the system. The EyeD Endpoint system is a “smart” embedded control system, providing multi-wavelength process monitoring for OES or IEP applications. The design of the spectrograph incorporates intelligent instrument control, data acquisition and endpoint capabilities.

- **Chapter 1, Safety,** is a comprehensive safety guide for any system on which EyeD may be installed.
- **Chapter 2, Functional Description,** provides an in-depth look at hardware and software components, complete with schematics and instructions for connecting the EyeD unit to other hardware modules. Current and future configuration options of the EyeD endpoint system are presented, providing information on existing capabilities and further functions soon to be available.
- **Chapter 3, EyeD Software Operations,** This software application currently operates under the Windows environment, utilizing Ethernet communication. This section outlines the basic principles under which the EyeD system operates and provides detailed instructions for operating the EyeD software.
- **Chapter 4, EyeD 200mm Installation**, includes steps for installing the EyeD hardware on 200mm Platforms. This section provides detailed instructions for connecting the EyeD system, interconnect diagrams, and photographs of installed components.
- **Chapter 5, 200mm Software Installation and Setup,** is an explanation of how to start up and configure an EyeD system on a 200mm chamber for the first time, as well as an explanation of how to start up a previously configured system in the field for the first time.
- **Chapter 6, EyeD 300mm Installation**, includes steps for installing the EyeD hardware on 300mm Platforms. This section provides detailed instructions for connecting the EyeD system, interconnect diagrams, and photographs of installed components.
- **Chapter 7, 300mm Software Installation and Setup,** is an explanation of how to start up and configure an EyeD system on a 300mm chamber for the first time, as well as an explanation of how to start up a previously configured system in the field for the first time.
- **Chapter 8, System Management**, provides advanced computer system information about configuration and interfacing to other devices.
- **Chapter 9, Maintenance**, provides instructions for periodic maintenance, basic troubleshooting, and updating software.

- **Chapter 10, Error Tables,** explains error messages that could occur during EyeD operation.

- **Appendix A, EyeD Software Operation Tutorial,** takes the user through a logical progression of tasks designed to promote a basic understanding of the application. Phase one of this tutorial is an introduction of learning objectives and discussion of the type of hardware and software required. Tutorial lessons encompass more than 30 hands-on exercises designed to guide users through the intricacies of this system

- **Appendix B, Wavelength Listing,** provides a table of all the wavelengths by material type.
- **Appendix C, Hardware Specifications,** lists the hardware specifications and requirements.
- **Appendix D, Neural PCA Equation Worksheet,** provides a series of tables identifying all the parameters.
- **Appendix E, CCD Integration Process,** explains the operation of the CCD.

Table of Contents

Title			Page
P	**Preface**		**P-1**
1	**Safety**		**1-1**
1.1	Safety		1-1
	1.1.1	Safety References	1-1
	1.1.2	Visual Hazard Alerts	1-1
	1.1.3	Electrical Hazards	1-3
		1.1.3.1 Hazardous Voltage	1-4
		1.1.3.2 Monitor (Video Display Terminal)	1-4
	1.1.4	Radiation Hazards	1-4
		1.1.4.1 Sound	1-5
		1.1.4.2 Laser and X-ray	1-5
	1.1.5	Hazardous Waste	1-5
	1.1.6	Compliance with SEMI S2	1-5
	1.1.7	Applied Materials Emergency Contact	1-6
2	**Functional Description**		**2-1**
2.1	Hardware Introduction		2-1
2.2	External Hardware Components		2-1
2.3	Hardware Configurations		2-2
	2.3.1	Single Fiber Optic Input	2-2
	2.3.2	Multiple Fiber Optic Inputs	2-2
2.4	Hardware Specifications		2-3
2.5	Software Overview		2-3
2.6	EyeD Window Components		2-5
	2.6.1	Application Window	2-5
	2.6.2	Menu and Button Toolbars	2-5
		2.6.2.1 Menu Toolbar	2-5
		2.6.2.2 Button Toolbar	2-5
	2.6.3	System Window	2-5
	2.6.4	Output Window	2-6
	2.6.5	Real-Time Event Statistics	2-6
	2.6.6	Multiple Document Interface (MDI) Workspace	2-6
	2.6.7	Wafer Information	2-6
	2.6.8	Status Bar	2-6
2.7	Operation Modes		2-7
2.8	EyeD Operating States		2-7
	2.8.1	Review State	2-7
	2.8.2	Reprocess State	2-7
	2.8.3	Run States	2-7
	2.8.4	Monitor State	2-8
	2.8.5	Capture State	2-8
	2.8.6	Process State	2-8
2.9	Endpoint Detection Software		2-8
2.10	Threshold-Based Software		2-8
2.11	Neural Network Software		2-9
	2.11.1	Principal Components Analysis	2-9
2.12	Equation Types		2-9
	2.12.1	Spectral Equations	2-9
	2.12.2	Region Equations	2-10
	2.12.3	Trend Equations	2-10
	2.12.4	Advanced Equations	2-10

2.12.5 Logical Progression of Equation Types 2-10
2.13 Graph Types 2-11
2.13.1 Spectral Graphs 2-11
2.13.2 Trend Graphs 2-11

3 EyeD Application 3-1

3.1 EyeD Window Components 3-1
3.1.1 EyeD Operator Interfaces 3-1
3.1.2 Application Window 3-7
3.1.3 Menu and Button Toolbars 3-8
3.1.4 Menu Toolbar 3-9
3.1.5 Button Toolbar 3-10
3.1.6 System Window 3-10
3.1.7 Output Window 3-12
3.1.8 Multiple Document Interface (MDI) Workspace 3-12
3.1.9 Wafer Information 3-14
3.1.10 Status Bar 3-15
3.1.11 Real-Time Event Statistics 3-16
3.2 Spectrograph Internal Parameters 3-16
3.3 Options 3-18
3.3.1 Enable Global Event Logging 3-18
3.3.1.1 Event History Viewing 3-21
3.3.1.2 Logging User Defined Events (Specific Event Selection) 3-21
3.3.1.3 Event Plot Tool Bar Buttons 3-21
3.3.1.4 Event Plot Window 3-22
3.3.1.5 Initial Display or Reset 3-23
3.3.1.6 Event History Window Legend 3-23
3.3.1.7 Forcing Configuration Events into Separate Columns 3-24
3.3.1.8 Event Statistics Analysis 3-25
3.3.1.9 Starting Event Analysis 3-26
3.3.2 Directories 3-29
3.3.2.1 Example: Configuration for Data File Storage 3-31
3.3.2.2 Data File Types 3-33
3.3.3 Auto Delete/Archive 3-34
3.3.3.1 Auto Delete Activity Sequence 3-36
3.3.4 Remote Data Archiving 3-38
3.3.5 Automatic Data File Deletion 3-38
3.3.6 Users (Security) Option 3-39
3.4 Operation Modes 3-43
3.4.1 Local Mode 3-44
3.4.2 Remote Mode 3-44
3.5 EyeD Operating States 3-44
3.5.1 Review State 3-44
3.5.2 Reprocess State 3-45
3.5.3 Run States 3-45
3.5.4 Monitor State 3-46
3.5.5 Capture State 3-47
3.5.6 Process State 3-47
3.6 Configuration Attributes 3-47
3.6.1 Overview 3-47
3.6.2 Order of Functions in EyeD 3-49
3.6.3 Configuration Validation 3-50
3.6.4 Setup 3-51
3.6.4.1 Disable Background Subtraction 3-53
3.6.4.2 Flashlamp Control 3-54
3.6.4.3 SRM Control of Flashlamp Intensity 3-58

3.6.5 Data Sources . . . 3-61
3.6.6 Regions . . . 3-61
3.6.7 Variables . . . 3-62
3.6.8 Equations . . . 3-64
3.6.8.1 Spectral Equations . . . 3-65
3.6.8.2 Spectral Equations List . . . 3-66
3.6.8.3 Region Equations . . . 3-68
3.6.8.4 Trend Equations . . . 3-69
3.6.9 Adaptive Fringe Counter . . . 3-74
3.6.9.1 Fringe Counter With Frequency Averaging (FCFA) . . . 3-77
3.6.10 Error Correction Algorithm . . . 3-81
3.6.11 Neural PCA . . . 3-83
3.6.12 Film Thickness Measurement Capability . . . 3-96
3.6.12.1 Overview . . . 3-96
3.6.12.2 Using the Thickness Measurement Capability . . . 3-97
3.6.12.3 Reference Generation . . . 3-97
3.6.12.4 Manual Reference Generation . . . 3-97
3.6.12.5 Automated Reference Generation . . . 3-103
3.6.12.6 Comparing Auto Reference with Initial Reference After P/M . . . 3-107
3.6.12.7 Variables . . . 3-109
3.6.12.8 Define Variable in Configuration File . . . 3-109
3.6.12.9 Cautions . . . 3-110
3.6.12.10 Using the Film Thickness Measurement Resource . . . 3-110
3.6.12.11 Optical Properties Database . . . 3-111
3.6.12.12 Selecting Wavelength Range and Number of Data Analysis Points . . . 3-111
3.6.12.13 Setting up the Film Stack Model . . . 3-113
3.6.12.14 Specifying Reference to be Used . . . 3-117
3.6.12.15 Passing Thickness Result to Etch Control Algorithm . . . 3-119
3.6.13 AMAT IEP-Etch . . . 3-122
3.6.13.1 Options Page . . . 3-123
3.6.13.2 Model Page: . . . 3-124
3.6.13.3 Output page . . . 3-125
3.6.14 IIR and FIR Filtering with Trend and Region Equations . . . 3-126
3.6.15 Calculation Order . . . 3-129
3.6.16 Snapshots . . . 3-129
3.6.17 Graph Types . . . 3-133
3.6.17.1 Spectral Graphs . . . 3-133
3.6.17.2 Trend Graphs . . . 3-134
3.6.17.3 Numerical Cursor Coordinates for Graphs Window . . . 3-134
3.6.18 Using Endpoint Factors for Statistical Endpoint Backup . . . 3-136
3.6.19 Sequence Definition . . . 3-138
3.6.19.1 Delay . . . 3-139
3.6.19.2 Automatic Gain Control (AGC) . . . 3-139
3.6.19.3 AGC Parameters . . . 3-141
3.6.19.4 Setup Parameters . . . 3-142
3.6.19.5 CCD Saturation . . . 3-143
3.6.19.6 User Event . . . 3-143
3.6.19.7 Operator Notification Window . . . 3-149
3.6.19.8 Log Event . . . 3-150
3.6.19.9 Activation/Deactivation of Sequence Items . . . 3-150
3.6.19.10 Comment Fields . . . 3-151
3.6.20 Logic Expressions . . . 3-151
3.6.21 Automatic Flash Lamp Intensity Control . . . 3-161
3.6.22 Pattern Detection . . . 3-163
3.6.22.1 Threshold-Based Software . . . 3-163

3.6.22.2 Neural Network Software . . . 3-164
3.6.22.3 How Neural Net Works . . . 3-166
3.6.22.4 Preparing for Neural Net Training (Step 1) . . . 3-170
3.6.22.5 Identifying the Endpoint Pattern (Step 2) . . . 3-171
3.6.22.6 Endpoint on Multiple Wafers . . . 3-172
3.6.22.7 Adjusting For Amplitude Variation (Step 3) . . . 3-173
3.6.22.8 Adjusting the Grid Resolution (Step 4) . . . 3-174
3.6.22.9 Caution About Grid Resolutions . . . 3-174
3.6.22.10 Adjusting the Shift Assurance (Step 5) . . . 3-175
3.6.22.11 Training On Multiple Tag Files (Step 6) . . . 3-175
3.6.22.12 Other Neural Net Advanced Parameters . . . 3-176
3.6.22.13 Troubleshooting . . . 3-176
3.6.22.14 Examples of Marker Placement . . . 3-178
3.6.23 Delta-Y Detector . . . 3-180
3.6.24 Parallel Sequence . . . 3-186
3.6.24.1 Review of Sequence Attributes . . . 3-186
3.6.24.2 Parallel Sequence Example . . . 3-188
3.6.25 Overetch . . . 3-189
3.6.26 Set Variable . . . 3-190
3.6.27 Endpoint . . . 3-193
3.6.28 Stop . . . 3-193
3.6.29 Activation/Deactivation of Sequence Items . . . 3-193
3.6.30 Comment Fields . . . 3-193
3.7 Reprocess List . . . 3-193
3.8 Configuration Properties Window . . . 3-199
3.9 Application Features . . . 3-199
3.9.1 Back-to-Back Sequence Timing . . . 3-199
3.9.2 Data Analysis List . . . 3-202
3.9.3 Creating an Endpoint Report . . . 3-206
3.9.4 Transpose Data Matrices . . . 3-207
3.10 Using Event Statistics to Review Production: . . . 3-209

4 200mm Hardware Installation . . . 4-1

4.1 Introduction . . . 4-1
4.2 EyeD-OES Hardware Overview . . . 4-2
4.3 200mm EyeD-IEP Hardware Overview . . . 4-4
4.4 Power . . . 4-4
4.5 Safety . . . 4-5
4.6 EyeD Computer and Monitor Installation for 200mm DPS and eMAX . . . 4-5
4.6.1 Upgrading the Centura 1 AC Box . . . 4-6
4.6.2 EyeD-IEP 200mm Computer Installation . . . 4-9
4.6.3 200mm Ergotron Cart Installation . . . 4-10
4.7 EyeD-OES Installation of SCS Remotely from 200mm eMAX Chamber . . . 4-16
4.7.1 Install SCS Assembly . . . 4-16
4.7.1.1 Install Magnet Synchronous Detection Module Hardware . . . 4-16
4.8 Connecting Cables . . . 4-16
4.8.1 200mm Computer Assembly . . . 4-16
4.8.2 Spectrograph Assembly . . . 4-18
4.8.3 Mainframe . . . 4-19
4.8.4 Installing the RS-232/RS-485 Converter . . . 4-24
4.9 Power Up System . . . 4-32
4.10 Basic Functionality Check of Spectrograph Using Room Light . . . 4-32
4.11 Installation Complete . . . 4-36

5 200mm Software Installation and Set-Up . . . 5-1

5.1 EyeD Software Installation . . . 5-1

5.1.1 Installing EyeD Software onto the EyeD Computer 5-2
5.1.1.1 Production Mode Installation 5-9
5.1.1.2 Research Mode Installation 5-13
5.1.1.3 Installation Status. 5-19
5.1.2 Installing EyeD Software onto an AMAT K-Station (Windows NT) 5-22
5.2 Inserting Multiple Spectrograph Icons 5-23
5.3 SRM and URI 5-23
5.3.1 Spectra Resource Manager Setup 5-24
5.3.1.1 Manually setting the IP address for a Spectrograph 5-34
5.3.2 Universal Remote Interface (URI) Setup for Centura 5200 5-36
5.3.2.1 URI Setup for IDEC (for Reference Only) 5-36
5.3.2.2 URI Setup for Digital Communication 5-39
5.3.2.3 Mapping Digital Signals (for Reference Only) 5-43
5.3.2.4 URI Setup for DIO Interfacing 5-46
5.3.2.5 Mixed EyeD/Serial Communications Option 5-47
5.3.3 Mixed Interface Setup Procedure 5-48
5.3.3.1 Setup the Mainframe System Constants 5-48
5.3.3.2 Setup EyeD URI for Mixed Mode Operation 5-49
5.3.3.3 Verify Mixed Mode Settings in URI 5-50
5.3.3.4 Final DI/O Check 5-54
5.3.3.5 Validating Communication to the Centura 5-56
5.3.4 EyeD IDEC Communications Lockups 5-58
5.3.4.1 Background 5-58
5.3.4.2 Applicable Software Versions 5-58
5.3.4.3 Detailed Problem 5-59
5.3.4.4 Procedure for URI 2.38 5-60
5.3.4.5 Troubleshooting and SECS logging. 5-61
5.4 Set File Management 5-62
5.4.1 Setup and Verify Automatic File Naming 5-62
5.4.2 Setup and Verify Auto Delete and Archive Options 5-62
5.4.3 Mainframe Setup 5-62
5.5 Communication Validation 5-65
5.6 Chamber Performance Validation and Lamp Setup (EyeD-IEP Only) 5-65
5.7 Flashlamp Safety Interlock (EyeD-IEP only) 5-70
5.8 Local Area Network (LAN) Setup 5-71
5.8.1 Configuration of Network Connection Names. 5-73
5.8.2 Configuring the Spectrograph LAN Ethernet Adapter. 5-74
5.8.3 Default NIC TCP/IP Addresses. 5-76
5.9 Finding the IP Address of a Spectrograph 5-76
5.10 Installation Complete 5-77

6 300mm Hardware Installation 6-1

6.1 Introduction. 6-1
6.2 EyeD-OES Hardware Overview 6-2
6.3 EyeD-IEP Hardware Overview 6-3
6.4 Power 6-4
6.5 Safety 6-4
6.6 EyeD Installation of Ergotron Stand with Computer for 300mm DPSII and eMAX 6-5
6.7 EyeD-IEP Flashlamp and DCS Installation on 300mm DPSII Chamber 6-6
6.8 EyeD-OES Installation of SCS on 300mm eMAX Chamber. 6-10
6.9 Connecting Cables 6-14
6.9.1 Computer Assembly 6-14
6.9.2 Spectrograph Assembly 6-16
6.9.3 Mainframe. 6-17
6.10 Power Up System. 6-20
6.11 Basic Functionality Check of DCS using Room Light. 6-22

6.12 Installation Complete 6-25

7 300mm Software Installation and Set-Up 7-1

7.1 EyeD Software Installation 7-1
7.1.1 Installing EyeD Software onto the EyeD Computer 7-3
7.1.1.1 Production Mode Installation 7-8
7.1.1.2 Research Mode Installation 7-13
7.1.1.3 Setup Completion 7-20
7.1.2 Installing EyeD Software onto an AMAT K-Station 7-22
7.2 Configuring Multiple Spectrographs 7-23
7.3 SRM and URI 7-23
7.3.1 Spectra Resource Manager Setup. 7-23
7.3.1.1 Manually setting the IP address for a Spectrograph. 7-32
7.3.2 Universal Remote Interface (URI) Setup 7-34
7.3.2.1 Validating Communication to the Centura 7-36
7.4 Set File Management 7-38
7.4.1 Setup and Verify Automatic File Naming 7-38
7.4.2 Setup and Verify Auto Delete and Archive Options 7-38
7.5 Mainframe Setup 7-38
7.5.1 Verifying Software communication 7-39
7.5.2 Configuring Millennium Software to use EyeD 7-41
7.5.3 Dual-mode Operation 7-52
7.6 Communication Validation 7-54
7.7 Local Area Network (LAN) Setup 7-54
7.7.1 Configuration of Network Connection Names. 7-56
7.7.2 Configuring the Spectrograph LAN Ethernet Adapter. 7-57
7.7.3 Default NIC TCP/IP Addresses. 7-59
7.8 Chamber Performance Validation and Lamp Setup (EyeD-IEP Only) 7-59
7.9 Flashlamp Safety Interlock (EyeD-IEP only) 7-64
7.10 Finding the IP Address of a Spectrograph 7-65
7.11 Installation Complete 7-66

8 EyeD System Management 8-1

8.1 EyeD OES 8-1
8.2 EyeD IEP 8-1
8.2.1 Reducing Data File Size to Minimum 8-2
8.2.2 Reducing Data File Size Proportionately 8-3
8.2.3 Remote Data Archiving. 8-4
8.2.4 Automatic Data File Deletion 8-4
8.2.5 Defragmentation. 8-5
8.2.6 CPU Utilization.. 8-7
8.2.7 Burning CDs 8-7
8.2.8 Utilities 8-7
8.2.9 Data File Naming 8-8
8.2.10 Network security 8-8
8.2.11 Accessing the Windows 2000 Registry for SRM: 8-10
8.2.12 Modifying Registry Access Privileges 8-11
8.2.13 Modify the Current User Key 8-15
8.3 Virus Protection Recommendations 8-20
8.3.1 Determining Total EyeD and Windows Tasks on Win2000Pro OS . . . 8-21
8.3.2 Verify Windows and EyeD Tasks 8-21
8.4 Microsoft Performance Monitor for Determining CPU Utilization 8-22
8.4.1 Background. 8-22
8.4.2 Overview. 8-23
8.4.3 Procedure 8-23
8.4.4 Other. 8-27
8.5 HDD Backup/Recovery CD Generation 8-29

8.6 Efficient Algorithms . . . 8-30
8.7 Alternative Hard Drive Backup and Image Installation . . . 8-33
8.7.1 Backup Process . . . 8-34
8.7.2 Restoring Backup Files . . . 8-38
8.7.3 Creating an Emergency Start Disk . . . 8-42

9 Maintenance and Upgrades . . . 9-1

9.1 Flashlamp Bulb Replacement Procedure . . . 9-1
9.1.1 Definitions . . . 9-1
9.1.2 Requirements . . . 9-1
9.1.3 Reflectometer Removal Procedure . . . 9-1
9.1.4 MHIF Bulb Replacement Procedure . . . 9-1
9.2 Embedded Code Upgrade for the Spectrograph (SD 1024D): . . . 9-3
9.3 Spectrograph Recovery from Failed Flash Attempt . . . 9-7
9.3.1 Flash Error 1 . . . 9-7
9.3.2 DUGZ . . . 9-8
9.4 Spectrograph Changes . . . 9-14
9.4.1 Background . . . 9-14
9.4.2 Change or Swap a Spectrograph . . . 9-15
9.4.3 Changing an IP Address . . . 9-17
9.4.4 Troubleshooting . . . 9-17
9.4.4.1 Cannot Connect to Spectrograph . . . 9-17
9.4.4.2 Windows Spectrograph LAN Settings do Not Update: . . . 9-18
9.5 Software Upgrades . . . 9-21
9.5.1 Changing Software Configuration . . . 9-21
9.5.2 Installing a New Version of Software . . . 9-21
9.6 Latency . . . 9-22
9.7 Installing EyeD on Tool with Active Endpoint System . . . 9-22
9.7.1 Terminology . . . 9-22
9.7.2 Hardware Setup . . . 9-22
9.8 Configuring URI for Verbose Logging . . . 9-22
9.8.1 Enable Logging URI in URI . . . 9-23
9.8.2 Proper Launching of URI/EyeD for Verbose Logging . . . 9-23

10 Error Tables . . . 10-1

10.1 EyeD . . . 10-1
10.1.1 EyeD Errors . . . 10-1
10.1.2 Auto Delete . . . 10-4
10.1.3 Directories . . . 10-5
10.1.4 User Page . . . 10-7
10.1.5 User Page Edit . . . 10-7
10.1.6 Neural Net . . . 10-7
10.1.7 Configuration Setup Dialog . . . 10-8
10.1.8 Advanced . . . 10-9
10.1.9 Reprocess Dialog . . . 10-10
10.1.10 Reprocess List . . . 10-10
10.1.11 Spectral Graphs . . . 10-11
10.1.12 Region Equation . . . 10-11
10.1.13 Snapshot . . . 10-12
10.2 Spectra Resource Manager (SRM) Errors . . . 10-12
10.2.1 SRM . . . 10-12
10.3 Embedded Firmware Errors in the SD1024 series Detector . . . 10-15
10.3.1 Embedded Code Errors . . . 10-15

A EyeD Software Operation Tutorial . . . A-1

A.1 Hardware and Software Requirements . . . A-1
A.2 Different Mathematical Quantities . . . A-1

A.3 Order of Calculations . . . A-2
A.4 Scenario and Material Organization . . . A-2
A.5 Tutorial Exercises . . . A-3
A.5.1 Starting the EyeD Software . . . A-3
A.5.2 Configuring the EyeD Screen . . . A-4
A.5.3 Creating a New Configuration File . . . A-6
A.5.4 Preparing a Configuration to Collect and Display Spectra . . . A-7
A.5.5 Collecting and Displaying Spectra with EyeD . . . A-13
A.5.6 Starting Data Collection . . . A-15
A.5.7 Reprocessing Previously Collected Spectra . . . A-18
A.5.7.1 To Reprocess Previously Collected Data . . . A-18
A.5.7.2 Reprocess List . . . A-21
A.5.8 Becoming Familiar With Data Navigation Tools . . . A-26
A.5.8.1 To Become Familiar With the Data Navigation Tools . . . A-27
A.5.9 Examining Reprocessed Spectra . . . A-28
A.5.10 Tracking Configuration Changes . . . A-30
A.5.11 Defining Spectral Regions . . . A-31
A.5.12 Adding a Graph to the Existing Configuration . . . A-36
A.5.13 Saving and Activating Configuration File Changes for Endpoint Algorithms . . . A-39
A.5.14 Debugging Errors . . . A-39
A.5.15 Running (Testing) an Edited Configuration File . . . A-41
A.5.16 Adding Another Trend Equation . . . A-45
A.5.17 Use Snapshots to Normalize a Data Trend to an Initial Value . . . A-49
A.5.17.1 Snapshots . . . A-49
A.5.18 Configure Endpoint Sequence Based on Derivative Trend and Snapshots . . . A-50
A.5.19 Defining an Endpoint Sequence . . . A-52

B Wavelengths by Emission Species . . . B-1

B.1 Representative Emission Lines Used in Endpoint Detection of Plasma Etching . . . B-1
B.2 Common Spectral Lines in Etching Applications (by Species) . . . B-4

C Hardware Specifications . . . C-1

C.1 Recommended Application Computer Requirements . . . C-1

D Neural PCA Equation Worksheet . . . D-1

D.1 NPCA Equation Properties Definitions . . . D-4
D.2 Example NPCA Parameters . . . D-7

E CCD Integration Process . . . E-1

Index . . . 1-i

List of Tables

Title		Page
Table 1-1.	Ergonomic Requirements of SEMI S8-95A	1-6
Table 2-1.	Hardware Specification Table	2-3
Table 3-1.	Directory Path Syntax	3-30
Table 3-2.	Spectral Equations	3-66
Table 3-3.	Commands to EyeD Equation Parser for Trend Equations	3-69
Table 3-4.	Neural Net Marker Color Definitions	3-176
Table 3-5.	Common Neural Network Problems	3-178
Table 3-6.	Progress Marker Table	3-183
Table 5-1.	IP Address Last Digits	5-31
Table 5-2.	IP Address Final Digits	5-35
Table 5-3.	Association Between Centura DI/O and URI DI/O	5-42
Table 5-4.	Distribution of the 32 DI/O Channels	5-44
Table 5-5.	Events Table for Mapping	5-44
Table 5-6.	Commands Recognized by EyeD	5-45
Table 5-7.	Syscons to Change	5-49
Table 5-8.	Endpoint Communications Channel Setup	5-64
Table 7-1.	IP Address Final Digits	7-29
Table 7-2.	IP Address Final Digits	7-33
Table 9-1.	200mm Spectrograph IP Addresses	9-14
Table 9-2.	300mm Spectrograph IP Addresses	9-14
Table 9-3.	IP Address Final Digits	9-17
Table 10-1.	EyeD Errors	10-1
Table 10-2.	Auto Delete Page	10-4
Table 10-3.	Directories	10-5
Table 10-4.	User Page	10-7
Table 10-5.	User Page Edit	10-7
Table 10-6.	Neural Net	10-7
Table 10-7.	Configuration Setup Dialog	10-8
Table 10-8.	Advanced	10-9
Table 10-9.	Reprocess Dialog	10-10
Table 10-10.	Reprocess List	10-10
Table 10-11.	Spectral Graphs	10-11
Table 10-12.	Region Equations	10-11
Table 10-13.	Snapshot	10-12
Table 10-14.	Spectra Resource Manager Errors	10-12
Table 10-15.	SD1024D Firmware Error Messages	10-15
Table 1-1.	Wavelength (in nanometers)	A-33
Table B-1.	Representative Emission Lines	B-1
Table B-2.	Common Spectral Lines in Etching Applications (by Wavelength)	B-3
Table B-3.	Common Spectral Lines by Species	B-4
Table B-4.	Element Wavelengths by Wavelength	B-7
Table C-1.	Computer Requirements	C-1
Table C-2.	Detector Specifications	C-1
Table D-1.	Settings (All of these user-selected parameters are applied in real-time to modify the incoming data)	D-1
Table D-2.	Setup Calibration (These parameters are used only once during the calibration of the Neural PCA algorithm)	D-1
Table D-3.	Calibrate (These parameters are used only once during the calibration of the Neural PCA algorithm)	D-2
Table D-4.	Equation Properties Definitions	D-4
Table D-5.	Settings (All of these user-selected parameters are applied in real-time to modify the incoming data)	D-7
Table D-6.	Setup Calibration (These parameters are used only once during	

the calibration of the Neural PCA algorithm). D-7
Table D-7. Calibrate (These parameters are used only once during the calibration of the Neural PCA algorithm) D-8

List of Figures

Title		Page
Figure 1-1.	Safety Symbols and Icons	1-2
Figure 1-2.	Hazard Alert Label Format (example)	1-3
Figure 2-1.	View of EyeD Spectrograph Showing Cable Connections	2-2
Figure 2-2.	Handshake Sequence	2-4
Figure 2-3.	EyeD OES Spectrograph Basic Architecture	2-4
Figure 2-4.	Menu and Button Toolbars	2-5
Figure 2-5.	Status Bar	2-7
Figure 3-1.	Selecting the Default Mode for the Application	3-2
Figure 3-2.	Basic Interface Components	3-3
Figure 3-3.	EyeD A instance is in Primary Focus	3-4
Figure 3-4.	EyeD B Instance is in Primary Focus	3-5
Figure 3-5.	Context Menu to Switch to Advanced Interface Mode	3-6
Figure 3-6.	Switching to Basic Interface Mode From Advanced Interface Mode	3-7
Figure 3-7.	EyeD Application Window	3-8
Figure 3-8.	Menu and Button Toolbars	3-8
Figure 3-9.	Movable Toolbar Menus	3-9
Figure 3-10.	Button Toolbar Defined	3-10
Figure 3-11.	System Window a) Configuration Tab b) Data Files Tab	3-11
Figure 3-12.	Output Window	3-12
Figure 3-13.	Configuration Editor (Setup) Window	3-13
Figure 3-14.	Spectral and Trend Graph Windows	3-14
Figure 3-15.	Recipe and Wafer Information Window	3-15
Figure 3-16.	Status Bar	3-15
Figure 3-17.	Spectrograph Internal Parameters	3-17
Figure 3-18.	Selecting Options	3-19
Figure 3-19.	General Options	3-19
Figure 3-20.	Log User Defined Event	3-21
Figure 3-21.	View Event History	3-21
Figure 3-22.	Event Plot Tool Bar	3-22
Figure 3-23.	Event Plot Window	3-22
Figure 3-24.	Event Plot	3-23
Figure 3-25.	Initial Display	3-23
Figure 3-26.	Event History Window Legend	3-24
Figure 3-27.	Multiple Steps Per Column	3-24
Figure 3-28.	One Step Per Column	3-24
Figure 3-29.	Event Statistics Database Relationships	3-25
Figure 3-30.	Select Event Analysis	3-26
Figure 3-31.	Event Analysis Window	3-26
Figure 3-32.	Query Options	3-27
Figure 3-33.	Execute Query	3-28
Figure 3-34.	Move Cursor Over Symbols to Show Information	3-28
Figure 3-35.	Directories and File Naming	3-29
Figure 3-36.	Options - Directories Tab	3-31
Figure 3-37.	Recognized Data File Types	3-34
Figure 3-38.	Auto Delete/Archive Selections	3-35
Figure 3-39.	Remote Data Archive Window	3-38
Figure 3-40.	Auto Data File Delete Window	3-39
Figure 3-41.	Default Users	3-40
Figure 3-42.	User Record Properties Tabs	3-41
Figure 3-43.	User Rights Tab	3-41
Figure 3-44.	Configuration Access Drop Menu	3-42
Figure 3-45.	Data File Access Drop Menu	3-43
Figure 3-46.	Selecting Local or Remote Mode from Button Toolbar	3-43

Figure 3-47. Run State Button Toolbar . . . 3-46
Figure 3-48. Configuration Components . . . 3-48
Figure 3-49. Setup Fields . . . 3-51
Figure 3-50. Background Subtraction Default . . . 3-53
Figure 3-51. Background subtraction deselected . . . 3-54
Figure 3-52. Flashlamp Mode Selection . . . 3-55
Figure 3-53. Alternating Strobe Alert . . . 3-55
Figure 3-54. Data Sources Window . . . 3-56
Figure 3-55. Inserting an equation . . . 3-56
Figure 3-56. Spectral Equation Properties Window . . . 3-57
Figure 3-57. Equation Field . . . 3-57
Figure 3-58. Equations Window . . . 3-58
Figure 3-59. Select EyeD Instance . . . 3-58
Figure 3-60. Select Adjust Flash Lamp Intensity . . . 3-59
Figure 3-61. Adjust Flash Lamp Intensity . . . 3-59
Figure 3-62. Warning Window . . . 3-60
Figure 3-63. Default Intensity Warning . . . 3-61
Figure 3-64. Data Sources . . . 3-61
Figure 3-65. Setting up a Region . . . 3-62
Figure 3-66. Insert Variable . . . 3-63
Figure 3-67. Variable Properties Window . . . 3-63
Figure 3-68. Variables Listed . . . 3-64
Figure 3-69. Fringe Count Properties . . . 3-75
Figure 3-70. Setup Tab: Fringe Count with Frequency Averaging . . . 3-77
Figure 3-71. FCFA Data Tab . . . 3-79
Figure 3-72. Viewing FCFA Data . . . 3-80
Figure 3-73. Error Correction Algorithm Setup Tab . . . 3-81
Figure 3-74. Piece-Wise Fit Tab . . . 3-82
Figure 3-75. Select Neural PCA . . . 3-84
Figure 3-76. Browse for Calibration Data File . . . 3-85
Figure 3-77. Calibrate Tab . . . 3-86
Figure 3-78. Settings Tab . . . 3-87
Figure 3-79. Info Tab . . . 3-88
Figure 3-80. Temporal Parameters . . . 3-89
Figure 3-81. Check Boxes Enable Associated Fields . . . 3-90
Figure 3-82. Wavelength Parameters . . . 3-90
Figure 3-83. Other Parameters . . . 3-91
Figure 3-84. Graphs Window . . . 3-92
Figure 3-85. Selecting Regions . . . 3-93
Figure 3-86. Scale Adjustments . . . 3-94
Figure 3-87. Viewing PCA Graphs . . . 3-95
Figure 3-88. NPCA Equation Listed . . . 3-96
Figure 3-89. List of Equation Window . . . 3-98
Figure 3-90. Reference Properties Window . . . 3-98
Figure 3-91. Reference Properties Calibration Window . . . 3-99
Figure 3-92. Calibration Wafer Properties Window . . . 3-99
Figure 3-93. Layer Properties Window . . . 3-100
Figure 3-94. Layer Properties . . . 3-100
Figure 3-95. Calibration Wafer Properties . . . 3-101
Figure 3-96. Calibration Window . . . 3-101
Figure 3-97. Capture Window . . . 3-102
Figure 3-98. Captured Reference Spectrum . . . 3-102
Figure 3-99. Save Reference File . . . 3-103
Figure 3-100. Advanced Equation List . . . 3-103
Figure 3-101. Reference Properties Window . . . 3-104
Figure 3-102. Automation Window . . . 3-104
Figure 3-103. Reference File Name Automatically Generated . . . 3-105

Figure 3-104. Choose References 3-105
Figure 3-105. Choose Active Reference Window 3-106
Figure 3-106. Select the Starting Reference 3-107
Figure 3-107. Comparison of Reference Spectrum 3-108
Figure 3-108. Warning of Large Reflection Spectrum Variation 3-108
Figure 3-109. Setup Window. 3-109
Figure 3-110. Variables List 3-110
Figure 3-111. Variable Properties Window 3-110
Figure 3-112. Material Optical Properties File. 3-111
Figure 3-113. Advanced Equations List 3-112
Figure 3-114. Film Thickness Equation Properties 3-112
Figure 3-115. Film Stack Model 3-113
Figure 3-116. New Layer in Film Stack. 3-114
Figure 3-117. Material Selection Window 3-114
Figure 3-118. Material Palette Builder Window. 3-115
Figure 3-119. Specify Material Window 3-115
Figure 3-120. List of Available Material in the Database. 3-116
Figure 3-121. Film Stack Model 3-116
Figure 3-122. Film Stack Model 3-117
Figure 3-123. Reference Properties Window 3-118
Figure 3-124. Spectral Equation Properties Window 3-118
Figure 3-125. Reference Properties Window Automation Screen 3-119
Figure 3-126. Output of Film Thickness Equation. 3-119
Figure 3-127. Set Variable in Sequence 3-120
Figure 3-128. Set Variable Properties. 3-120
Figure 3-129. Assign Film Thickness Value to Variable 3-121
Figure 3-130. Define Variable in Etch Control Algorithm 3-121
Figure 3-131. Tend Equation Properties Window 3-122
Figure 3-132. Add an AMAT IEP-Etch equation. 3-122
Figure 3-133. AMAT IEP-Etch Properties Window 3-123
Figure 3-134. AMAT IEP-Etch Model Screen. 3-124
Figure 3-135. AMAT IEP-Etch Equation Output Screen. 3-125
Figure 3-136. Region of Interest Defined 3-127
Figure 3-137. Required Region and Trend Equations 3-127
Figure 3-138. Unmodified Trend Line and Filtered Outputs 3-128
Figure 3-139. Insert Snapshot. 3-130
Figure 3-140. Snapshot Configuration 3-130
Figure 3-141. Name Snapshot 3-131
Figure 3-142. Snapshot Source 3-131
Figure 3-143. Snapshot Selections Completed. 3-132
Figure 3-144. Completed Snapshot Command. 3-133
Figure 3-145. Spectral Graph Window 3-134
Figure 3-146. Trend Graph Window 3-134
Figure 3-147. XY Coordinates Listed 3-135
Figure 3-148. Coordinate and Scale Function 3-135
Figure 3-149. Graphs from Cascade to Tile 3-136
Figure 3-150. Endpoint Factors Window. 3-137
Figure 3-151. Trend Equation Properties Window 3-137
Figure 3-152. Parallel Sequences Properties Window 3-138
Figure 3-153. Set Delay Time in Seconds 3-139
Figure 3-154. Select AGC from Sequence 3-140
Figure 3-155. Insert AGC Algorithm in Sequence List 3-141
Figure 3-156. Automatic Gain Control Screen 3-142
Figure 3-157. Select User Event. 3-143
Figure 3-158. User Event Window 3-144
Figure 3-159. User Event Text 3-145
Figure 3-160. User Event Follows Delay. 3-145

Figure 3-161. Trend Graph . . . 3-146
Figure 3-162. Event Marked . . . 3-147
Figure 3-163. Events Marked . . . 3-148
Figure 3-164. Enable Operator Notification . . . 3-149
Figure 3-165. Windows for Notification, Warning, and Error . . . 3-150
Figure 3-166. Log Event Checkbox . . . 3-150
Figure 3-167. Activating/Deactivating Sequence Items . . . 3-151
Figure 3-168. Simple Sequence Branch Using an If Statement . . . 3-151
Figure 3-169. While Sequence Statement . . . 3-152
Figure 3-170. Nested Loops Logic Flow . . . 3-153
Figure 3-171. Example Sequence Configuration . . . 3-154
Figure 3-172. Two ways to Implement Nested IF Statements in EyeD . . . 3-154
Figure 3-173. Selecting Logic Item . . . 3-155
Figure 3-174. Enter an If expression . . . 3-156
Figure 3-175. Enter Threshold pattern . . . 3-157
Figure 3-176. Select an equation for the threshold function . . . 3-157
Figure 3-177. Else Statement . . . 3-158
Figure 3-178. Else If Statement . . . 3-159
Figure 3-179. Select Neural Net Pattern Recognition and Associated Neural Net File . . . 3-160
Figure 3-180. Sample Sequence Configuration . . . 3-161
Figure 3-181. Sequence Definition Drop-down Menu . . . 3-162
Figure 3-182. Automatic Flash Lamp Intensity Control Window . . . 3-162
Figure 3-183. Setting a Threshold function . . . 3-164
Figure 3-184. Neural Network Graph . . . 3-165
Figure 3-185. Neural Net Stages . . . 3-166
Figure 3-186. Neural Net Sequence . . . 3-167
Figure 3-187. Selecting a file for Neural Net training . . . 3-167
Figure 3-188. Setting Indicators to Train a Neural Net . . . 3-168
Figure 3-189. Progress Bars . . . 3-169
Figure 3-190. Neural Net Properties Window . . . 3-170
Figure 3-191. Edit Neural Net Tag Window . . . 3-171
Figure 3-192. Ghost Pattern . . . 3-171
Figure 3-193. Start Neural Net Marker Placement . . . 3-172
Figure 3-194. Advanced Neural Net Parameters Window . . . 3-173
Figure 3-195. Adjusting The Grid Resolution . . . 3-175
Figure 3-196. Neural Net Stages . . . 3-176
Figure 3-197. Neural Net Progress Markers . . . 3-177
Figure 3-198. Neural Net Activity Log Entries . . . 3-177
Figure 3-199. Marker Positioning . . . 3-179
Figure 3-200. Delta-Y Detector Window . . . 3-180
Figure 3-201. Delta-Y Continuous Test . . . 3-182
Figure 3-202. End of Time Interval Test . . . 3-185
Figure 3-203. Percentage of Y Value . . . 3-186
Figure 3-204. View Sequence List . . . 3-187
Figure 3-205. Insert Parallel Sequence . . . 3-187
Figure 3-206. Parallel Sequences Properties Window . . . 3-188
Figure 3-207. Parallel Sequence Example . . . 3-189
Figure 3-208. Overetch Properties Window . . . 3-190
Figure 3-209. Set Overetch Type . . . 3-190
Figure 3-210. Set Variable Sequence Item . . . 3-191
Figure 3-211. Select Variable from List . . . 3-191
Figure 3-212. Enter Equation Expression for Variable . . . 3-192
Figure 3-213. Variable Listed in Sequence . . . 3-192
Figure 3-214. Activating/Deactivating Sequence Items . . . 3-193
Figure 3-215. Insert Data File or Insert Directory . . . 3-194
Figure 3-216. Browsing Files (left) or Directories (right) . . . 3-195
Figure 3-217. Listed Files for Reprocessing . . . 3-195

Figure 3-218. Select Reprocess List . . . 3-196
Figure 3-219. List reprocessed . . . 3-197
Figure 3-220. Reprocess File Properties Window . . . 3-197
Figure 3-221. Configuration History Properties . . . 3-199
Figure 3-222. Response Time Adjustment Definition Chart . . . 3-201
Figure 3-223. Select Data Analysis . . . 3-202
Figure 3-224. Selecting File Browser . . . 3-202
Figure 3-225. Files Selected . . . 3-203
Figure 3-226. Fiber Input A Viewed for All Files . . . 3-203
Figure 3-227. Data Source Equation Options . . . 3-204
Figure 3-228. Use Zoom feature to enlarge spectral region . . . 3-204
Figure 3-229. Six Nanometers of Spectra Showing 11 Files . . . 3-204
Figure 3-230. Local Run_3 Highlighted . . . 3-205
Figure 3-231. Local Run_5 Highlighted . . . 3-205
Figure 3-232. Local Run_7 Highlighted . . . 3-205
Figure 3-233. Endpoint Report Dialog . . . 3-206
Figure 3-234. Specify Location to Save Endpoint Report . . . 3-207
Figure 3-235. Data Source Equation Options . . . 3-207
Figure 3-236. Select only desired spectra . . . 3-208
Figure 3-237. Select Export . . . 3-208
Figure 3-238. Name File and Select Transpose Spectra Vertically . . . 3-209
Figure 3-239. Opening Event Analysis . . . 3-209
Figure 3-240. Select Database to Test . . . 3-210
Figure 3-241. . . . 3-210
Figure 4-1. EyeD-IEP 200mm DPS Chamber Assembly with DCS and Flashlamp . . . 4-2
Figure 4-2. 200mm EyeD-OES Software/Hardware Communication Overview . . . 4-3
Figure 4-3. Computer and Ethernet Hub Attached to Mainframe - New Systems Use Ethernet Switch Instead of Hub (See Figure 4-19) . . . 4-3
Figure 4-4. 200mm EyeD-IEP Software/Hardware Communication Overview . . . 4-4
Figure 4-5. AC Box Showing Location F3 . . . 4-6
Figure 4-6. Spade Lugs F3-1 and F3-2 . . . 4-7
Figure 4-7. F3 Front Fuse Panel . . . 4-7
Figure 4-8. L-Clamp on Support Shelf . . . 4-9
Figure 4-9. 200mm Mainframe Side View Showing Computer Shelf . . . 4-9
Figure 4-10. Computer and Ethernet Hub - New Systems Include Ethernet Switch as Shown in Figure 4-19 . . . 4-10
Figure 4-11. 200mm Ergotron Cart with Mounted Monitor and Keyboard . . . 4-11
Figure 4-12. Location of DCS Shelf on 200mm DPS, DPS+ Chamber . . . 4-12
Figure 4-13. Front View of DCS Shelf on 200mm DPS, DPS+ Chamber . . . 4-12
Figure 4-14. Side View of DCS Shelf (Mounting Bracket) with Arm . . . 4-13
Figure 4-15. Installed EyeD-IEP Detector and Lamp on 200mm DPS Chamber . . . 4-14
Figure 4-16. Power Strip Attached to the Bottom of the Chamber AC Box . . . 4-14
Figure 4-17. 200mm IEP Fiber Optic Cable Support Conduit on System . . . 4-15
Figure 4-18. 200mm Control Computer Connections . . . 4-17
Figure 4-19. 200mm Ethernet Switch . . . 4-18
Figure 4-20. Cable Connections to Spectrograph . . . 4-19
Figure 4-21. Port VP6/Com1 in the System Controller for 200mm Systems . . . 4-20
Figure 4-22. EyeD-IEP AMAT IDEC/SECS Interconnect Diagram . . . 4-21
Figure 4-23. EyeD-IEP Mixed Serial / DI/O Interconnect Diagram . . . 4-22
Figure 4-24. EyeD-IEP Optional DI/O Interconnect Diagram . . . 4-23
Figure 4-25. EyeD-OES Interconnect Diagram . . . 4-23
Figure 4-26. RS485 Converter Equipment, Kit P/N 0240-42328 . . . 4-24
Figure 4-27. System Side Converter . . . 4-24
Figure 4-28. EyeD Computer Side Converter . . . 4-25
Figure 4-29. 75-Foot Communication Cable Between Converters . . . 4-25
Figure 4-30. RS485 Connections From Mainframe to RS485 Converter . . . 4-26
Figure 4-31. RS232/RS485 System Side Cable . . . 4-27

Figure 4-32. 4-27
Figure 4-33. RS232/RS485 EyeD Side Cable 4-28
Figure 4-34. Connecting Converter to System Serial Board 4-28
Figure 4-35. Connect to SBC Port 6 (VP6) 4-29
Figure 4-36. Attach Power Wires 4-29
Figure 4-37. Detail of Power Wire Connections 4-30
Figure 4-38. Install EyeD Connections 4-31
Figure 4-39. Set Converter Jumpers 4-31
Figure 4-40. Spectrograph Correctly Powered Up 4-32
Figure 4-41. EyeD-IEP Fiber Optic Cable Diagram (arrows show direction of light propagation) 4-33
Figure 4-42. Fiber Optic Cable Installed on DCS (Rear Bezel) 4-34
Figure 4-43. genericROOM_LIGHT Equations Menu of the Configuration Editor 4-35
Figure 4-44. OES and IEP Time Average Trend Equation Properties of the 577nm Spectral Line 4-35
Figure 4-45. Response to Motion Graph for OES Cable 4-36
Figure 5-1. Saving Power Scheme 5-2
Figure 5-2. RS-232 IDEC Hardware and Software Configuration 5-3
Figure 5-3. RS-485 IDEC Hardware and Software Configuration 5-3
Figure 5-4. DI/O Hardware and Software Configuration 5-4
Figure 5-5. EyeD Install Wizard 5-5
Figure 5-6. InstallShield Wizard: First Working Screen 5-5
Figure 5-7. Install Fundamentals 5-6
Figure 5-8. Remove, Repair, or Override Existing EyeD Installation 5-7
Figure 5-9. Select Mode: Research or Production 5-8
Figure 5-10. Select Mode: Research or Production 5-8
Figure 5-11. Select Number of EyeD Instances 5-9
Figure 5-12. Select Communication Interface 5-10
Figure 5-13. Even Statistics Selection Screen 5-11
Figure 5-14. Option Confirmation Screen 5-12
Figure 5-15. Select Research Mode for R&D 5-13
Figure 5-16. Location Selection Screen 5-14
Figure 5-17. Security Override Screen 5-15
Figure 5-18. Select Number of EyeD Instances 5-16
Figure 5-19. Communication Interface Selection Screen 5-16
Figure 5-20. Event Statistics Selection Screen 5-17
Figure 5-21. Option Confirmation Window 5-18
Figure 5-22. EyeD Software Installation Status 5-19
Figure 5-23. Overwrite Activity Log Options: Yes or No 5-19
Figure 5-24. Overwrite Auto Delete Options: Yes or No 5-20
Figure 5-25. Overwrite Data File Template Options: Yes or No 5-20
Figure 5-26. URI Verification Window 5-20
Figure 5-27. Reboot the Computer to Complete the Installation 5-21
Figure 5-28. EyeD Directory 5-22
Figure 5-29. Changing the EyeD Instance Target to the EyeD.bat File 5-23
Figure 5-30. SRM Setup Diagram 5-25
Figure 5-31. SRM Configuration Overview 5-26
Figure 5-32. Flowchart for Configuring SRM - New Software 5-27
Figure 5-33. Flowchart for Configuring SRM - Old Software 5-28
Figure 5-34. Spectra Resource Manager Window 5-29
Figure 5-35. Insert Application Pop Up Within SRM 5-29
Figure 5-36. Application Setup Window showing a detected Spectrograph 5-30
Figure 5-37. Dialog to change IP Address 5-31
Figure 5-38. Changing the Spectrograph IP Address 5-31
Figure 5-39. SRM Main Window with Application EyeD-A Listed 5-32
Figure 5-40. SRM Application Setup for EyeD-IEP 5-33
Figure 5-41. SRM Application Setup for EyeD-OES 5-33

Figure 5-42. Message Indicating SRM Has Yet to Detect Spectrograph 5-34
Figure 5-43. TCP/IP Device Settings Dialog 5-35
Figure 5-44. Application Setup Window 5-37
Figure 5-45. Parameter Settings for SECS Communication 5-38
Figure 5-46. Com Port Settings for SECS and RS232 Communication 5-39
Figure 5-47. URI Main Window 5-40
Figure 5-48. Application Setup Window for Digital Communication 5-40
Figure 5-49. DI/O Hardware Configuration Window 5-41
Figure 5-50. URI Diagnostics Window 5-42
Figure 5-51. Map Digital Signals Window 5-43
Figure 5-52. Map Digital Input Signal Dialogue Box 5-45
Figure 5-53. Properties for 'Start' Command 5-46
Figure 5-54. EyeD Tool Interface: Communication and Custom Settings 5-47
Figure 5-55. IDEC Cable Connection Diagram 5-48
Figure 5-56. Communication Interface Screen: IDEC+DI/O Mixed 5-49
Figure 5-57. Data File Template Prior Settings Question 5-50
Figure 5-58. Universal Remote Interface Window 5-50
Figure 5-59. I/O Hardware Configuration Window 5-51
Figure 5-60. Mapped Digital Signals 5-52
Figure 5-61. URI Window 5-53
Figure 5-62. SECS Parameters 5-53
Figure 5-63. Spectral Plot for D-I/O Functionality 5-55
Figure 5-64. Initial Communications Log for Chamber A 5-56
Figure 5-65. Communications Log for Active Chamber A 5-57
Figure 5-66. Communications Log Window Where There is a Serial Cable Problem 5-58
Figure 5-67. Serial Log Showing Framing Error Generated by Port Lockup 5-59
Figure 5-68. URI Version Window from Help Menu 5-60
Figure 5-69. System Constant List 5-61
Figure 5-70. URI Icon Properties 5-62
Figure 5-71. Source Fiber Branch IEP Cable Connection Detail 5-66
Figure 5-72. IEP Fiber Optic Cable Distribution 5-67
Figure 5-73. Fiber Optic Cable Routed to IEP Access Port on 200mm DPS Chamber . . . 5-68
Figure 5-74. Flash Lamp Intensity Adjustment Window 5-69
Figure 5-75. FL2002 Interlock Connectors 5-71
Figure 5-76. Network Diagram 5-72
Figure 5-77. Network Dial-up Connections 5-73
Figure 5-78. Network and Dial-up Connections 5-73
Figure 5-79. Local Area Connection Properties 5-74
Figure 5-80. Local Area Connection Properties Showing Selection 5-75
Figure 5-81. TCP/IP Properties 5-76
Figure 6-1. EyeD-OES Chamber Assembly with SCS on 300mm Enabler 6-1
Figure 6-2. EyeD-IEP Assembly with DCS and Flashlamp on 300mm DPS II 6-2
Figure 6-3. 300mm Software and Hardware Communication EyeD-OES Overview 6-3
Figure 6-4. 300mm Ergotron Computer Assembly 6-3
Figure 6-5. 300mm Software and Hardware Communication EyeD-IEP Overview 6-4
Figure 6-6. Retrofitted Tray with Lid Heater PID Control on 300mm DPS II Chamber . . . 6-6
Figure 6-7. Installed EyeD-IEP Detector and Lamp on 300mm DPSII Chamber 6-7
Figure 6-8. Retrofitted Dual Manometer Assembly on 300mm DPSII Chamber 6-8
Figure 6-9. Bracket for Fiber Optic Cable on 300mm DPS II Chamber IEP Window 6-9
Figure 6-10. IEP Mirror Assembly on 300mm DPSII Chamber 6-10
Figure 6-11. Location for Bracket Installation 6-11
Figure 6-12. Front View of Installed Detector Module on 300mm Enabler 6-12
Figure 6-13. 300mm Control Computer Connections 6-15
Figure 6-14. 300mm Ethernet Hub 6-16
Figure 6-15. Cable Connections to Spectrograph 6-16
Figure 6-16. Port 4/Com1 under the 300mm DPSII Chamber 6-17
Figure 6-17. EyeD-IEP Interconnect Diagram 6-18

Figure 6-18. IEP Interconnect Diagram Showing TCP/IP Control Interface 6-19
Figure 6-19. EyeD-OES Interconnect Diagram 6-20
Figure 6-20. Spectrograph Correctly Powered Up 6-21
Figure 6-21. EyeD-IEP Fiber Optic Cable Diagram With Arrows Noting Light Direction. . . 6-22
Figure 6-22. Fiber Optic Cable Installed on DCS Rear Bezel 6-23
Figure 6-23. Equations Menu for genericROOM_LIGHT in Configuration Editor 6-24
Figure 6-24. OES and IEP Time Average Trend Equation Properties for 577nm Spectral Line 6-24
Figure 6-25. Response to Motion Graph for OES Cable 6-25
Figure 7-1. Saving Power Scheme 7-2
Figure 7-2. EyeD 300mm Hardware and Software Configuration 7-3
Figure 7-3. EyeD Install Wizard 7-4
Figure 7-4. InstallShield Wizard Extracting Files for Installation 7-5
Figure 7-5. Install Fundamentals Window (Read before proceeding) 7-6
Figure 7-6. Remove Existing EyeD Installation Before Installing New Version. 7-7
Figure 7-7. Select Research Mode for EyeD Installation 7-8
Figure 7-8. Select Number of EyeD Instances 7-9
Figure 7-9. Select Tool Interface 7-10
Figure 7-10. Set Event Statistics Mode 7-11
Figure 7-11. Option Confirmation 7-12
Figure 7-12. Selecting Research Mode Installation 7-13
Figure 7-13. Select Installation Location 7-14
Figure 7-14. Choose Security Access Level 7-15
Figure 7-15. 300mm Verity Serial Interface Selection. 7-16
Figure 7-16. Optional 300mm Interface Selection: High Speed TCP/IP 7-17
Figure 7-17. Set Event Statistics Mode 7-18
Figure 7-18. EyeD Install Option Confirmation Window 7-19
Figure 7-19. EyeD Software Installation Status 7-20
Figure 7-20. Select Yes to Overwrite Activity Log Options 7-20
Figure 7-21. Select Yes to Overwrite Auto Delete Options 7-21
Figure 7-22. Select Yes to Overwrite Data File Template 7-21
Figure 7-23. URI Update Complete Window 7-21
Figure 7-24. Reboot the Computer to Complete the Installation 7-22
Figure 7-25. Changing the EyeD Instance Target to the EyeD.bat File 7-23
Figure 7-26. SRM Configuration Overview 7-24
Figure 7-27. Flowchart for Configuring SRM - New Software 7-25
Figure 7-28. Flowchart for Configuring SRM - Old Software. 7-26
Figure 7-29. Spectra Resource Manager Window. 7-27
Figure 7-30. Insert Application Pop Up Within SRM 7-27
Figure 7-31. Application Setup Window showing a detected Spectrograph 7-28
Figure 7-32. Dialog to change IP Address 7-29
Figure 7-33. Changing the Spectrograph IP address 7-29
Figure 7-34. SRM Main Window with Application EyeD-A Listed 7-30
Figure 7-35. SRM Application Setup for EyeD-IEP 7-31
Figure 7-36. SRM Application Setup for EyeD-OES 7-31
Figure 7-37. Message Indicating SRM Has Yet to Detect Spectrograph. 7-32
Figure 7-38. TCP/IP Device Settings Dialog 7-33
Figure 7-39. URI Window for SECS Communication 7-34
Figure 7-40. Application Setup Window 7-35
Figure 7-41. Com Port Settings for RS232 Communication 7-36
Figure 7-42. Initial Communications Log for Chamber A 7-37
Figure 7-43. Communications Log for Active Chamber A. 7-37
Figure 7-44. Communications Log Window where there is a Serial Cable Problem. 7-38
Figure 7-45. TCP/IP Connection Diagram 7-39
Figure 7-46. Mainframe Details Screen with Eyed Not Connected. 7-40
Figure 7-47. EyeD Activity Window Showing Communication Established 7-40
Figure 7-48. Mainframe Details Screen with EyeD Connected. 7-41

Figure 7-49. Misc. Menu . . . 7-42
Figure 7-50. Setting Up the Sensor for New Algorithm . . . 7-43
Figure 7-51. Sensor 1 is Automatically Added . . . 7-44
Figure 7-52. Selecting the Sensor Number . . . 7-45
Figure 7-53. Sensors 1 and 4 are configured . . . 7-46
Figure 7-54. Creating a New Algorithm . . . 7-47
Figure 7-55. Naming the Algorithm . . . 7-48
Figure 7-56. Selecting the Detection Type . . . 7-49
Figure 7-57. Selecting EyeD to Call Endpoint . . . 7-50
Figure 7-58. Setting the Combination Function . . . 7-51
Figure 7-59. Choosing Sensors to Monitor Endpoint . . . 7-52
Figure 7-60. Example of Mainframe GUI Showing Eyed and Monochromator Data . . . 7-53
Figure 7-61. Network Diagram . . . 7-55
Figure 7-62. Network Dial-up Connections . . . 7-56
Figure 7-63. Network and Dial-up Connections . . . 7-56
Figure 7-64. Local Area Connection Properties . . . 7-57
Figure 7-65. Local Area Connection Properties Showing Selection . . . 7-58
Figure 7-66. TCP/IP Properties . . . 7-59
Figure 7-67. Source Fiber Branch IEP Cable Connection Detail . . . 7-60
Figure 7-68. IEP Fiber Optic Cable Distribution . . . 7-61
Figure 7-69. Fiber Optic Cable Routed to IEP Access Port on 300mm DPS Chamber . . . 7-62
Figure 7-70. Flash Lamp Intensity Adjustment Window . . . 7-63
Figure 7-71. SP2000 Interlock Connectors . . . 7-65
Figure 8-1. Setup Window — Spectral Data Entry . . . 8-2
Figure 8-2. Setup Window With Limiting Spectral Range . . . 8-3
Figure 8-3. Remote Data Archive Window . . . 8-4
Figure 8-4. Auto Data File Delete Window . . . 8-5
Figure 8-5. Disk Defragmentation Analysis . . . 8-6
Figure 8-6. Defragmentation Analysis . . . 8-7
Figure 8-7. Run Command . . . 8-10
Figure 8-8. Registry Editor . . . 8-10
Figure 8-9. Registry Editor Showing Software Level and Verity . . . 8-11
Figure 8-10. Permissions for Verity . . . 8-12
Figure 8-11. Access Control Settings . . . 8-13
Figure 8-12. Select User or Group . . . 8-13
Figure 8-13. Permission Entry . . . 8-14
Figure 8-14. Permission Entry Showing Allowed . . . 8-15
Figure 8-15. Registry Editor . . . 8-16
Figure 8-16. Permissions for Verity . . . 8-17
Figure 8-17. Access Control Settings for Verity . . . 8-18
Figure 8-18. Select User or Group . . . 8-18
Figure 8-19. Permission Entry for Verity . . . 8-19
Figure 8-20. Permission Entry for Verity . . . 8-20
Figure 8-21. Task Manager Screen . . . 8-21
Figure 8-22. Windows Task Manager with 19 Tasks . . . 8-22
Figure 8-23. CPU Tracker Setup . . . 8-23
Figure 8-24. Administrative Tools Window . . . 8-24
Figure 8-25. Performance Window . . . 8-24
Figure 8-26. Performance Window Showing 75%CPUTrigger . . . 8-25
Figure 8-27. Select Counter Logs . . . 8-25
Figure 8-28. Select Process in Monitor Properties Window . . . 8-26
Figure 8-29. Select Counters Window . . . 8-26
Figure 8-30. Performance Window with Green Trigger . . . 8-27
Figure 8-31. Application Log Event Viewer . . . 8-27
Figure 8-32. Event Properties Window . . . 8-28
Figure 8-33. System Task Utilization . . . 8-29
Figure 8-34. Recovery CD Reminder Window . . . 8-30

Figure 8-35. Command Prompt Window . . . 8-31
Figure 8-36. Performance Monitor Window . . . 8-31
Figure 8-37. Adding a Counter . . . 8-32
Figure 8-38. Monitoring Processor Time and CPU Usage . . . 8-33
Figure 8-39. Select the Backup tab from the Backup Utility window . . . 8-34
Figure 8-40. Mark Hard Drive and System State Files for Backup . . . 8-35
Figure 8-41. Specify Location of Backup File . . . 8-36
Figure 8-42. Review Backup Information . . . 8-36
Figure 8-43. System is Preparing to Backup . . . 8-37
Figure 8-44. Backup Progress . . . 8-37
Figure 8-45. Backup Location is Out of Storage Space . . . 8-37
Figure 8-46. Backup Process Complete. . . . 8-38
Figure 8-47. Restore Backup Files to Original Location . . . 8-39
Figure 8-48. Files in Original Location Are Overwritten by Backup Files . . . 8-39
Figure 8-49. Restore Confirmation . . . 8-39
Figure 8-50. Default Advanced Restore Options. . . . 8-40
Figure 8-51. Figure 13. Enter Backup File Name . . . 8-40
Figure 8-52. Restore Progress . . . 8-41
Figure 8-53. Figure 15. Restore Complete Report . . . 8-41
Figure 8-54. Restart Computer to Complete System File Restore . . . 8-42
Figure 8-55. Create an Emergency Repair Disk . . . 8-42
Figure 8-56. Emergency Diskette Dialog with Backup Registry Option . . . 8-43
Figure 8-57. Creating Repair Diskette. . . . 8-43
Figure 8-58. Successful Completion of Emergency Repair Diskette . . . 8-43
Figure 9-1. Rear of Flashlamp . . . 9-2
Figure 9-2. Exposed Flashlamp Bulb . . . 9-3
Figure 9-3. Flash Loader Software Saved in C Directory . . . 9-4
Figure 9-4. Flash Loader Installation Wizard . . . 9-4
Figure 9-5. Communication Options Window . . . 9-5
Figure 9-6. FLDFlash - Flashform1 Window . . . 9-6
Figure 9-7. Opening Code File Primary.hex for Output to Spectrograph . . . 9-6
Figure 9-8. Output Window . . . 9-7
Figure 9-9. Use USB for Spectrograph Communication . . . 9-10
Figure 9-10. SRM Showing USB Connection to Spectrograph . . . 9-10
Figure 9-11. Communication Options Window . . . 9-11
Figure 9-12. FLDFlash - FlashForm 1 . . . 9-12
Figure 9-13. Outputs . . . 9-13
Figure 9-14. Changing Spectrograph IP Address . . . 9-13
Figure 9-15. Spectra Resource Manager Window . . . 9-15
Figure 9-16. Blank SRM . . . 9-16
Figure 9-17. Application Setup Window . . . 9-16
Figure 9-18. Enter Device TCP/IP Address . . . 9-17
Figure 9-19. Connection Error Message . . . 9-18
Figure 9-20. . . . 9-19
Figure 9-21. Dial-up Connection Showing LAN Enabled . . . 9-20
Figure 9-22. Dial-up Connection Showing LAN Disabled . . . 9-20
Figure 9-23. Transferring Active References to a New Software Version. . . . 9-21
Figure 9-24. URI Properties Window . . . 9-23
Figure 9-25. Enable Log File Saving . . . 9-23
Figure A-1. EyeD Main Window . . . A-4
Figure A-2. View Pull-down Menu . . . A-4
Figure A-3. Toolbar Customizing Window . . . A-5
Figure A-4. EyeD Applications Window . . . A-5
Figure A-5. New Configuration Window . . . A-6
Figure A-6. Saving Files With User Identification . . . A-7
Figure A-7. Configure to Collect and Display Spectra . . . A-8
Figure A-8. Data Source Selection . . . A-10

Figure A-9. Select Region in Configuration Editor . . . A-10
Figure A-10. Select Equations . . . A-11
Figure A-11. Set Snapshot and End of Snapshots . . . A-11
Figure A-12. Graph Selection Window . . . A-11
Figure A-13. Spectral Graph Properties Window . . . A-12
Figure A-14. Sequence List Window . . . A-13
Figure A-15. Set Current Configuration File . . . A-14
Figure A-16. Selected Configuration File . . . A-14
Figure A-17. Capture Data Window . . . A-16
Figure A-18. Configuration Window . . . A-19
Figure A-19. Data File Window . . . A-20
Figure A-20. Insert Data File or Insert Directory . . . A-22
Figure A-21. Browsing Files (left) or Directories (right) . . . A-23
Figure A-22. Listed Files for Reprocessing . . . A-24
Figure A-23. Select Reprocess List . . . A-24
Figure A-24. List Reprocessed and Endpoint Found for all Files . . . A-25
Figure A-25. Reprocess File Properties Window . . . A-26
Figure A-26. Synchronize Configuration Message . . . A-27
Figure A-27. Spectral Toolbar . . . A-27
Figure A-28. Data File Wavelength Graph . . . A-30
Figure A-29. Spectral Region Definition . . . A-32
Figure A-30. Select Regional Peak . . . A-33
Figure A-31. Region Properties Window . . . A-34
Figure A-32. Spectral Graph Properties Window . . . A-35
Figure A-33. Spectral Graph of Three Regions . . . A-36
Figure A-34. Spectral Graph Properties Window . . . A-37
Figure A-35. Completed Spectral Graph Properties Window . . . A-38
Figure A-36. Graph Edit Window . . . A-39
Figure A-37. Region Properties Window . . . A-40
Figure A-38. Output Window Activity Log Validation Message . . . A-40
Figure A-39. Validation Error Icon . . . A-41
Figure A-40. Original Configuration . . . A-42
Figure A-41. Revised Configuration . . . A-44
Figure A-42. Configuration Window . . . A-45
Figure A-43. Trend Equation Properties . . . A-46
Figure A-44. Completed Trend Equation Properties Window . . . A-46
Figure A-45. Resulting Equations Window . . . A-47
Figure A-46. Trend Graph Properties . . . A-48
Figure A-47. Maximized Trend Monitor Graph . . . A-49
Figure A-48. Trend Equation Properties Window . . . A-50
Figure A-49. Trend Graph Properties . . . A-51
Figure A-50. Time Average and Derivative Trends . . . A-52
Figure A-51. Insert Items Menu . . . A-53
Figure A-52. Time Delay Properties . . . A-53
Figure A-53. Mark Event Parameter Window . . . A-54
Figure A-54. Pattern Detect / Threshold . . . A-55
Figure A-55. Threshold Parameters . . . A-55
Figure A-56. Building Endpoint Equation . . . A-56
Figure A-57. Endpoint Graph . . . A-57
Figure B-1. Spectra of Common Species . . . B-1
Figure D-1. Transient Periods . . . D-5
Figure E-1. Read-Out Row is Empty of Charge Following the Last Read Out . . . E-1
Figure E-2. Rows of charges are shifted down leaving first row empty . . . E-2
Figure E-3. Charges Accumulate on First Row as a New Read Out Occurs and the Read-Out Row is Emptied of Charge . . . E-2
Figure E-4. Charges Continue to Accumulate on all Rows as They are Shifted Down . . . E-3

THIS PAGE INTENTIONALLY LEFT BLANK.

1 Safety

1.1 Safety

This section covers safety information pertaining to the EyeD system. Depending on the system in use, some or all of the information given in this section will be applicable.

Only well-trained personnel should service and maintain the system. This training must include electrical and radiation safety, ergonomics and familiarization with hazards specific to this system. The consequences of unskilled, improper, or careless maintenance of this system can be serious.

Any safety instructions preceding any operating or maintenance tasks must be followed.

The computer and monitor are listed by a Nationally Recognized Testing Laboratory and are affixed with CE marking.

The EyeD system contains the following potential hazards:

- electrical shock
- ultraviolet light

1.1.1 Safety References

Consult the following documents for information on the safe operation and service of the DPS II chamber and the Centura Mainframe.

- *Applied Materials Corporate Safety and Health Policies and Procedures: Hazardous Energy Control Program* (Lockout/Tagout) Standard No. 23.2
- *OSHA 29 CFR 1910.147*
- *OSHA 29 CFR 1910.331-335*
- *Centura Safety Manual* (generic for Centura platform) (Standard 0230-09352; Cleanroom 0230-09353)
- *Silicon Etch HART 200mm Centura Safety Addendum* (Standard 0230-01156; Cleanroom 0230-01155)
- *Metal/Silicon Etch 300mm DPS II Chamber Safety Manual* (Standard: 0230-01053; Cleanroom: 0230-01052)
- *Etch Centura AP Safety Manual* (Standard 0230-01528/Cleanroom 0230-01529)
- *Centura 300mm Safety Manual* (Standard: 0230-36267/Cleanroom 0230-36268)

1.1.2 Visual Hazard Alerts

Before working on the EyeD system, refer to the appropriate section of this manual. Read and understand the warnings and cautions found in that section before performing any maintenance.

Figure 1-1 for Safety Symbols (Icons) identifies the potentially hazardous situations and/or consequences of not avoiding the hazard that may be inherent with the EyeD system. The

symbols are used in hazard alerts throughout the manual. They also appear on the equipment where exposure to a hazard is possible. For an example of a hazard alert label, see Figure 1-2.

The hazard alerts provided in the manual and hazard alert labels use the signal words Danger, Warning, or Caution. These signal words are defined as follows:

Danger: Indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.

Warning: Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.

Caution: Indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury.

International Symbol	Intended Meaning	Alternate Symbol
	**Hazardous Voltage** Potential lethal electrical voltages and currents are present in the system which could cause shock, burn, or death.	
	**Eye Protection Required** Intense light may exists at the process chamber view port. Intense light can cause eye damage or blindness.	
	**Lockout/Tagout Required** Servicing or maintenance in certain portions of the EyeD may expose personnel to hazards. Lockout/Tagout must be followed to ensure that the hazards are properly isolated before performing the task.	**No Alternate Pictogram**
	**Heavy Object** A heavy part and/or awkward location could result in muscle strain or permanent back injury.	

Figure 1-1. Safety Symbols and Icons

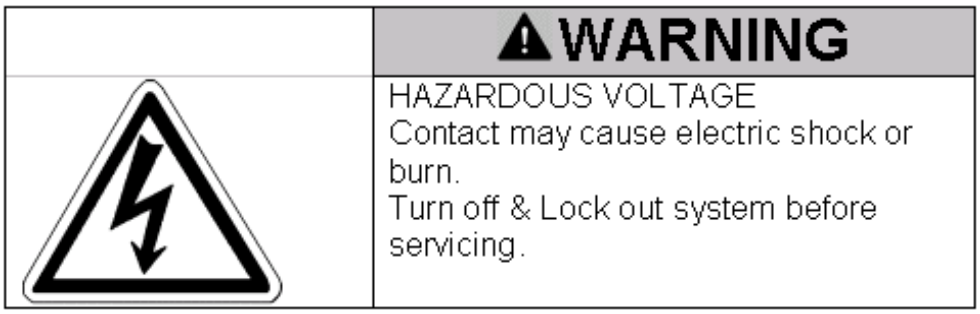


Figure 1-2. Hazard Alert Label Format (example)

The hazard alert label contains a pictogram of the hazard, the signal word (Danger, Warning, or Caution) and the text message containing:

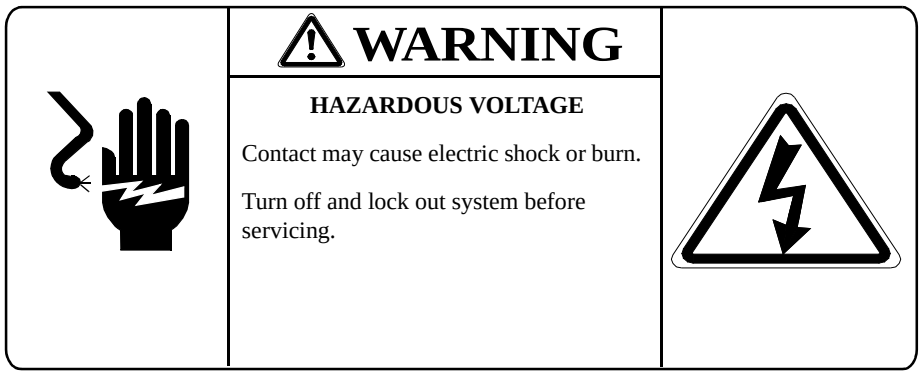
- Identification of the hazard
- Consequence if the instructions to avoid the hazard are not followed.
- Instructions on how to avoid the hazard

The pictorial message helps ensure that non-English speaking persons and those with limited reading skills are alerted to the hazard.

1.1.3 Electrical Hazards

The EyeD system is designed to protect operators and maintenance personnel from exposure to dangerous electrical circuits. Design features for electrical safety include, but are not limited to, the following:

- Electrical enclosures can only be opened with the use of a tool.
- The PC and Monitor are listed by recognized product safety testing laboratories
- The Spectrometer is low voltage low power and is enclosed within a metal enclosure



The EyeD system does not contain any serviceable parts within the computer, monitor or the spectrometer enclosure. Do not remove the covers of the computer, monitor (video display terminal) or the spectrometer.

Servicing of the EyeD system must be done only by trained and qualified service personnel familiar with the hazards of high voltage.

Maintenance personnel must be trained in electrical maintenance procedures as specified in NFPA-70E, National Fire Protection Association's standard for Electrical Safety Requirements for Employee Workplace, Part II, Safety Related Work Practices.

1.1.3.1 Hazardous Voltage

Hazardous voltage (120 Vac mains) is present in the computer and monitor. Do not remove the covers of the computer and monitor.

1.1.3.2 Monitor (Video Display Terminal)

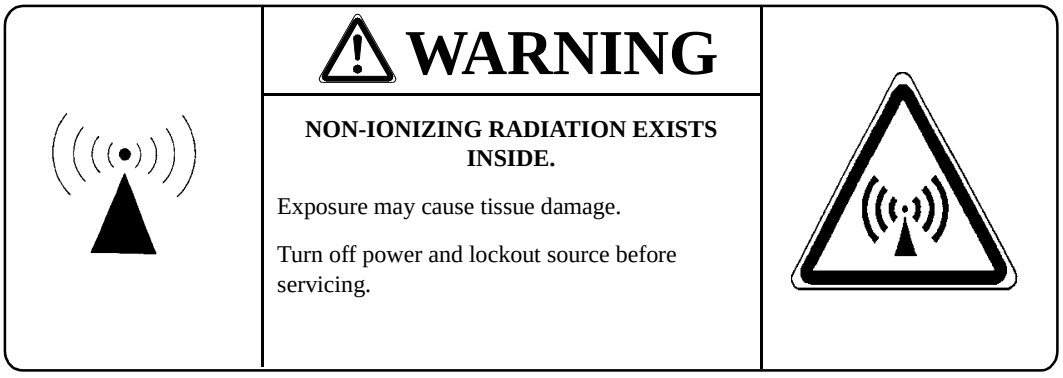
High voltage (kV) is present within the monitor (video display terminal) around the cathode ray tube assembly. Voltage may remain in the monitor circuits after power is disconnected. Do not remove the covers of the monitor.

1.1.4 Radiation Hazards

The EyeD system is provided with a fiber optics cable that is intended to be attached to the process chamber viewport. The process chamber viewport can potentially be a source of intense light, ultraviolet and/or infrared radiation, which may result in eye damage when stared at directly.

Design features for safeguarding intense light include, but are not limited to:

* View port attachment for the fiber optics cable



Radiation hazards may be present at the process chamber viewport in the form of:

- Visible intense light
- Ultraviolet radiation
- Infrared radiation

Visible intense light may exist at the chamber viewport during operation. Exposure to intense visible light may be harmful to your eyes. Misuse of controls and adjustments, or performing tasks other than those specified in this manual can result in exposure and may cause blindness.

Ultraviolet (UV) radiation is produced by the plasma generated within certain process chambers and may exist at the chamber viewport during operation if the fiber optic viewport attachment is removed. Fiber optic cables can conduct UV radiation.

Infrared radiation (IR) may exist at the chamber viewport during operation. This radiation is very intense when power is applied to the lamps and even short duration exposures can result in temporary injury to the cornea, iris, retina, and lens of the eye. Repeated exposure can, over time, result in cataracts.

To minimize eye injury or blindness,

- Do not operate process chamber when the fiber optics viewport or the fiber optics cable is removed.
- Do not remove the fiber optics cable from the fiber optics viewport attachment or the spectrometer enclosure.
- Do not stare into process chamber viewport.
- Always wear proper eye protection against potential UV, IR and visible intense light.

1.1.4.1 Sound

Sound radiation associated with the EyeD system meets OSHA requirements.

1.1.4.2 Laser and X-ray

There is no laser or X-ray radiation associated with the EyeD system.

1.1.5 Hazardous Waste

Normal operation and maintenance of the EyeD system should not create any hazardous wastes that require special handling and disposal.

In terms of end-of-life disposal of the EyeD system, the EyeD system may contain products (e.g., lithium battery within the personal computer, phosphorus coating within cathode ray tube (CRT), tin lead solder on printed wiring boards, etc.) which may be subject to regulatory waste control.

Contact your local regulatory authority to ensure proper disposal of potentially regulated waste material.

1.1.6 Compliance with SEMI S2

To ensure that the EyeD is compliant with the Electrical and Emergency Shutdown requirements of SEMI S2-0200, the computer and monitor for the EyeD should be connected to a convenience receptacle of the semiconductor processing equipment such that the power to the computer and monitor is disconnected when the EMO is activated or when the main disconnect of the semiconductor processing equipment is turned off.

To ensure that the EyeD system is properly installed and operated in accordance with the Ergonomic requirements of SEMI S8-95A, be sure the following conditions are met:

Table 1-1. Ergonomic Requirements of SEMI S8-95A

Indicator	Acceptance Criteria	
Height of VDT for standing station.	Maximum 147.3 cm (58.0 in.)	
Measured from floor to center of monitor screen.	Minimum 132.1 cm (52.0 in.)	
Height of VDT for sitting station.	Maximum 119.4 cm (47.0 in.)	
Measured from floor to center of monitor screen.	Minimum 94 cm (37.0 in.)	
Height of keyboard/trackball/mouse) for standing station.	**Fixed Height**	**Adjustable Height**
Measured from floor to home row of keyboard, top of ball or mouse.	101.6 cm (40 in.)	91.4 to 111.8 cm (36 to 44 in.)
Height of keyboard for sitting station.	**Fixed Height**	**Adjustable Height**
Measured from floor to home row of keyboard, top of ball or mouse.	76.2 cm (3o in.)	58.4 to 83.8 cm (23 to 33 in.)

Use proper lifting techniques when lifting or carrying the monitor. Avoid lifting or carrying the monitor away from your body as this would significantly lower the Recommended Weight Limit of a single person lift. There is no maintenance book for the computer assembly. However, if rebuilding or upgrading is required, the task will be performed in place and no heavy lifting is required.

1.1.7 Applied Materials Emergency Contact

In the event of an emergency, equipment failure, or safety concerns, please contact Applied Materials Global Product Safety, 1-408/563-7810. A Product Safety Event Report form may also be faxed to this same number.

2 Functional Description

2.1 Hardware Introduction

There are two versions of the EyeD Endpoint system, both utilizing charge-coupled device (CCD) scientific-grade spectrographs, integrating sophisticated embedded processors and software designed to provide precision endpoint capabilities. Both use intelligent instrument control and data acquisition. The two versions are OES and IEP. The OES version of this product monitors a single signal. The IEP version of this product is capable of monitoring two signals simultaneously.

Some of the principal features of EyeD include:

- High speed data transfer and communication flexibility
- Robust optical endpoint determination for plasma-based processes through threshold-based software, proprietary Neural Net and Principal Components Analysis (see note below)
- Resolution of 1.7 nm throughout the 200-800 nm spectral range
- Excellent low-light performance and low noise provided by TE-cooled, back-thinned CCD array (EyeD IEP only)
- Highly configurable software application

The EyeD optical system uses a 1024-element, scientific-grade, charge-coupled device (CCD) specifically designed for multi-channel spectroscopy. The advantages of the EyeD Smart Detector include its excellent ultraviolet (UV) response (down to 200 nm), stability against degradation under UV exposure, high sensitivity, wide dynamic range, and superior output linearity.

The compact optical platform takes full advantage of this high-performance sensor, providing 1.7 nm spectral resolution with sharp imaging over the entire CCD array without the use of folding mirrors. The unique design incorporates an optical element that frees the system of all Seidel aberrations without aperture restriction. This high fidelity slit image in the detector plane enables simultaneous intensity measurements of six or more fiber optic inputs. Through real-time, spline-fit computations, the EyeD provides read-out data in 0.5 nm increments from 200-800 nm.

OES applications include a single channel spectrograph (SCS), while IEP applications include a dual channel spectrograph (DCS).

2.2 External Hardware Components

The EyeD external components include:

1. I/O port through a 15-pin Ethernet connector
2. Liquid crystal information display
3. On/Off power switch with a direct current (DC) power entry module

4. Fiber optic cable coupler
5. Locking hardware for the fiber optic cable connection
6. Dual cooling fans move air in the rear bezel and out the front bezel

Figure 2-1 shows an outline drawing of the EyeD.

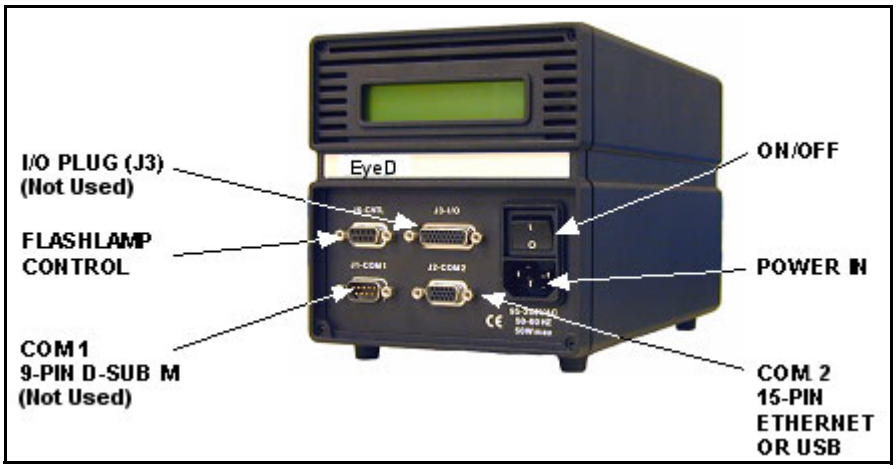


Figure 2-1. View of EyeD Spectrograph Showing Cable Connections

2.3 Hardware Configurations

The EyeD system software is highly configurable, with integration choices, including EyeD-OES or EyeD-IEP spectrographs, being contingent upon customer needs. See Table 2-1 for hardware specifications.

2.3.1 Single Fiber Optic Input

The Single Fiber Optic Input configuration for the OES application utilizes the EyeD software, operating from a separate application computer or embedded within a 2 GHz system controller. OES collects optical spectra from a single source, the side window through a fiber optic cable.

2.3.2 Multiple Fiber Optic Inputs

The Multiple Fiber Optic Input configuration for the IEP application enables EyeD to simultaneously collect optical spectra from two sources, the IEP (top) and OES (side) windows through fiber optic cables. The IEP application utilizes the EyeD software, operating from a separate application computer or embedded within a 2 GHz system controller.

2.4 Hardware Specifications

Table 2-1. Hardware Specification Table

Model Number	EyeD IEP-DCS	EyeD OES-SCS
Type	"Smart" Spectrograph	"Smart" Spectrograph
Performance/Optics		
Range	200 - 800 nm	200 - 800 nm
Resolution	1.7 nm	1.7 nm
CCD	1024 x 128 Array, TE Cooled Back-thinned (for enhanced UV sensitivity)	1024 x 1 Phosphor Enhanced
Mechanical		
Slit Width [inches (mm)]	25 microns	
Dimensions	9.25 (235.0) x 5.4 (137.2) x 6.05 (153.5) [See Outline Drawing for details]	
Software		
Endpoint Algorithms	Endpoint Algorithms Algebraic, trigonometric, Boolean logic functions Threshold-based, FFT Thickness Measurement, PCA, NPCA Neural Network Pattern Recognition	
Applications Software	EyeD	
Applications Software Platform Single-Fiber Input Two-Fiber Input	Tool: WIN 2000 PRO Reprocessing: Windows NT 4.0, WIN 2000, WIN XP (OffLine)	
Communications to Applications Single-Fiber Input Two-Fiber Input	Ethernet	

2.5 Software Overview

EyeD and its companion utilities Spectra Resource Manager (SRM) and Universal Remote Interface (URI), comprise a suite of software applications that perform communication, data collection, data processing, and reprocessing of file data sources. SRM receives spectral data from one or more spectrographs for transmission to EyeD, while URI provides a communication interface between EyeD and the process tool. EyeD provides data analysis, algorithm development, and step sequence execution for endpoint detection.

EyeD, URI, and SRM operate under Windows 2000 on production tools. SRM uses either USB or Ethernet to interface with the Spectrograph, while URI can communicate via RS232 serial, Digital I/O, mixed RS232 and Digital I/O or Ethernet depending upon the process module / process tool.

The user can perform setup and administrative tasks, script execution, step configuration, and, most importantly, send the start and stop events to control the spectrograph. In remote

mode, the detector produces a ready signal upon power up and waits for a start command from the process chamber before applying selected calculations to the spectral data stream. This simple handshake is illustrated below.

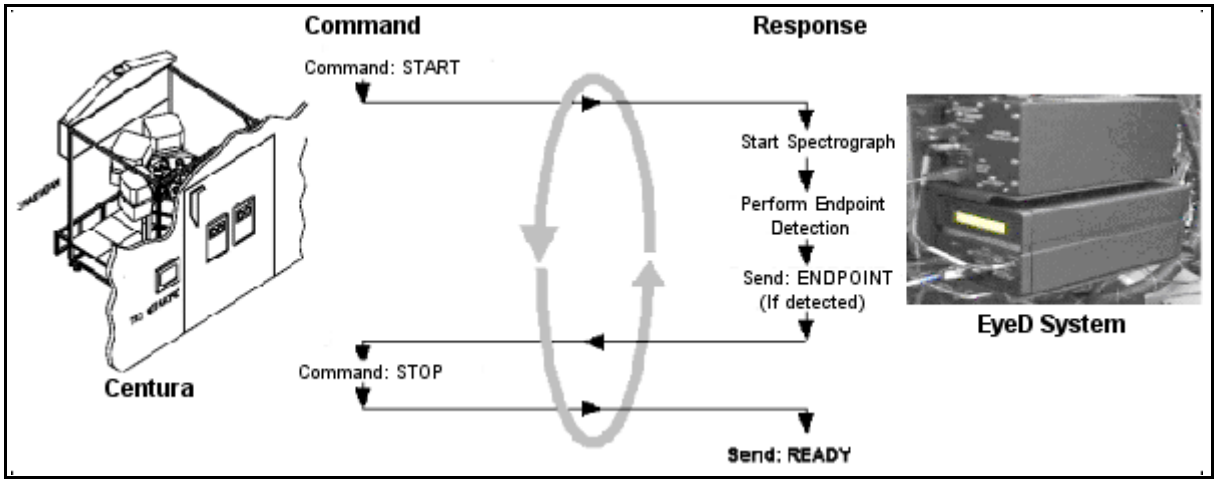


Figure 2-2. Handshake Sequence

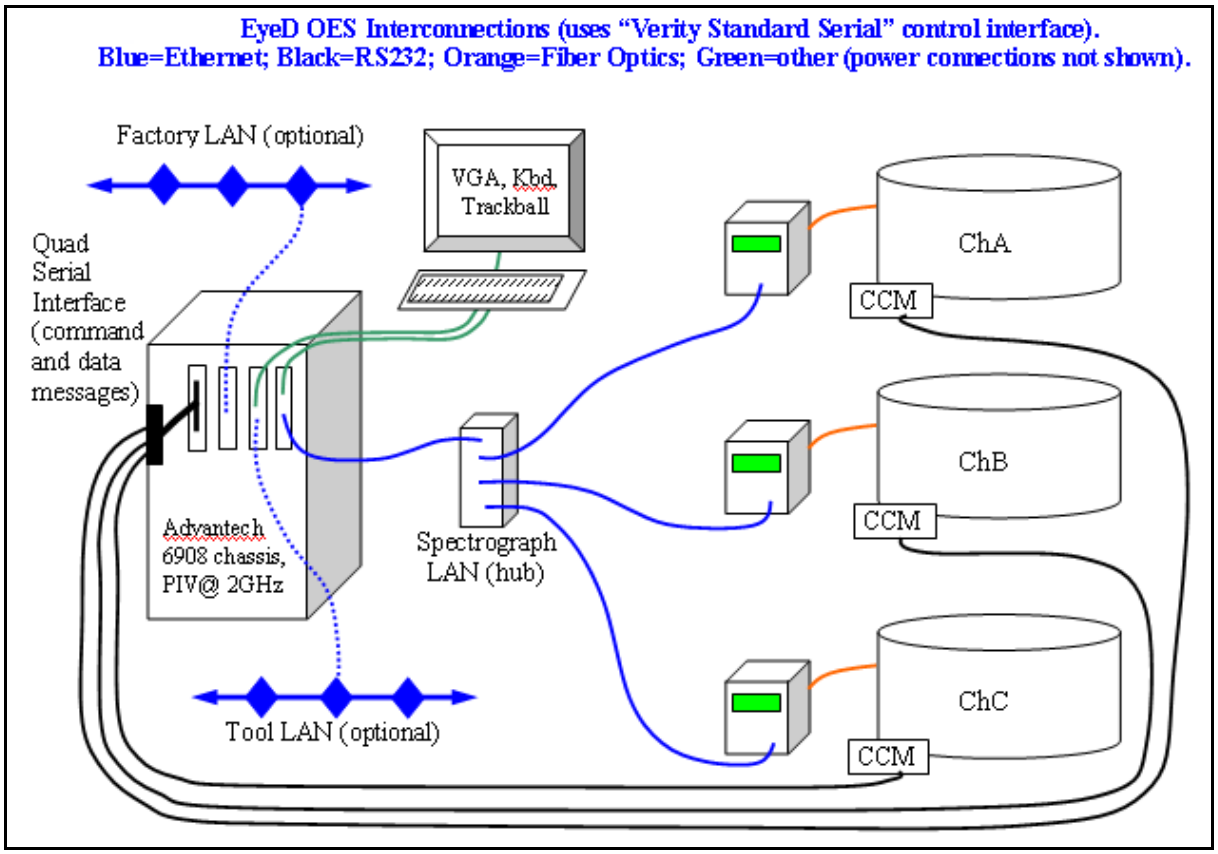


Figure 2-3. EyeD OES Spectrograph Basic Architecture

Figure 2-3 shows the software and hardware setup for an EyeD system connected to process chambers.

2.6 EyeD Window Components

EyeD window components provide a graphical user interface (GUI) for viewing spectral data and system configuration. An Application Window serves as the user interface for control of the software and hardware, providing command options in either Local or Remote mode.

2.6.1 Application Window

The Application Window is the initial window the user sees when launching EyeD. Core components to the Application Window include the Menu tool bar, Button toolbars, System window, Multiple Document Interface (MDI) workspace, the Output window, and the Status tool bar.

2.6.2 Menu and Button Toolbars

The default menu and button toolbars open with the most commonly used features. These can be customized and new toolbars can be created, or existing toolbars can be consolidated into one.

These docking toolbars are referred to as System Context menus. System Context menus are available for most windows in Configuration and Data menus.

Toolbars can be docked by either: 1) left-clicking on the toolbar background and dragging it to a new location, or 2) right-clicking on the toolbar and selecting Allow Docking, Hide, or Float In Main Window (Figure 4-22) from the pop-up menu.

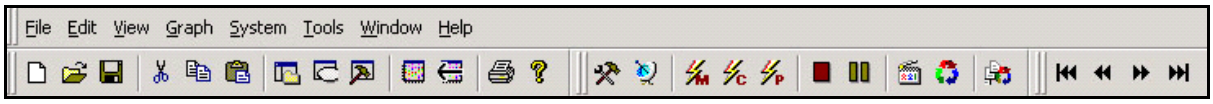


Figure 2-4. Menu and Button Toolbars

The button toolbars can be shown or hidden using the View or Tools menu options. A check mark (✔) appears beside the active toolbar(s).

2.6.2.1 Menu Toolbar

The Menu toolbar allows the selection of various menu options for EyeD. These menu options also are accessible from the button bars or drop-down list boxes contained in other areas of the software.

2.6.2.2 Button Toolbar

When selecting Toolbars from the View menu, the user can select to show or hide any of the four toolbars. The Spectral Buttons toolbar provides, in a “live” environment setting, the ability to move from the beginning (Start) to the end (End) of the spectral data or back (Previous) and forward (Next) to view the trend as it appears.

2.6.3 System Window

The System Window is a docking window that includes two sub-windows: Configuration Files and Data Files. It is possible to reposition, hide, or display the System Window anywhere on the computer screen.

2.6.4 Output Window

The Output Window is a docking window, like the System window, and contains two sub-windows: Activity Log and Output.

The Activity Log window displays each activity, such as processing or system changes, occurring in the system. Optionally, this log can be saved to a text file for later review. This file contains all log entries for the entire run time of EyeD and clears itself when a process starts so that it displays only the most current and relevant information.

The Output window displays multiple errors or warning messages such as sequence validation. This information cannot be saved and appears only for informational purposes regarding the previous run.

2.6.5 Real-Time Event Statistics

The user has the ability to track and log User Defined and Endpoint Events during processing of a Sequence. The Events are stored in a relational database that can be interrogated off-line using Microsoft Access. This database is stored in a Directory under the EyeD Instance Root (EX: *C:\EyeD\EyeD-B Events*). In addition, the user has the option to display a Graphical plot of events as they are logged. The following figures and descriptions provide details of this feature.

2.6.6 Multiple Document Interface (MDI) Workspace

The Multiple Document Interface (MDI) Workspace is the main window space remaining after all the toolbars and docking windows have been positioned on the computer screen. This workspace displays one of three window types: the Configuration Editor, the Spectral Graph or the Trend Graph.

2.6.7 Wafer Information

The Wafer Information window includes job-specific data that was sent by the mainframe as the process run executed.

2.6.8 Status Bar

The Status Bar is found at the bottom edge of the EyeD main window. This bar is a quick reference for information regarding the current activity of EyeD. It displays any informational strings, toolbar descriptions, menu selection details, the current operating mode (Local or Remote), State status (Run or Review), and the date/time stamp of the spectra being displayed in the graph.

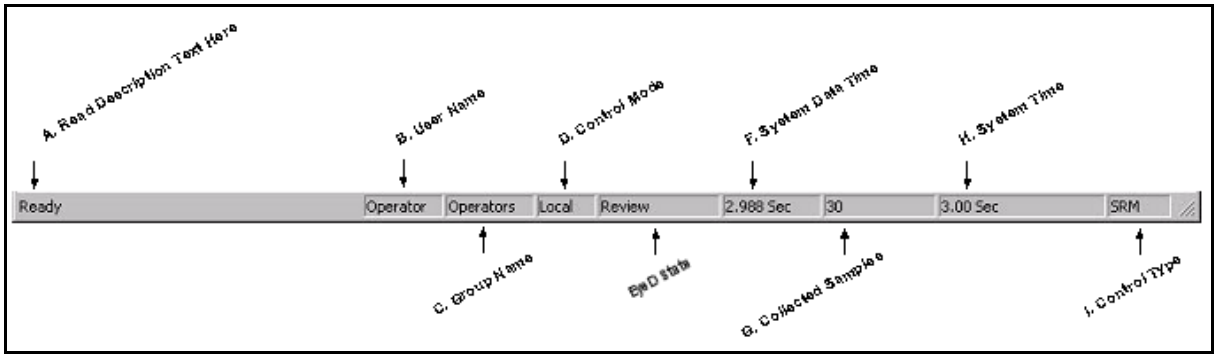


Figure 2-5. Status Bar

2.7 Operation Modes

The operation modes available in the EyeD software application include Local and Remote. Each operation mode dictates how the system runs and what triggers the process to start. Local mode allows the user to manually create and edit EyeD configurations for use in any one of three Run states (Monitor, Capture, and Process) or two Review states (Review and Reprocess). Remote mode is for fully automated operation in a production environment (see note).

2.8 EyeD Operating States

The EyeD software operates in one of several user-selected states: Review, Reprocess, Monitor, Capture, and Process. The Review and Reprocess states operate on stored data, while the Monitor, Capture, and Process states operate in real-time during data collection. The current state displays on the Status Bar to the right of the Local or Remote operation mode identifier.

2.8.1 Review State

Review is the idle state that EyeD enters into after initial start-up. All other states return to the Review state once execution stops, and all data animation returns to this state. In Review state, the system can perform advanced data interrogation, including editing equations and configurations, altering the visibility of objects in the MDI graph windows or adding data sources.

2.8.2 Reprocess State

Reprocess allows the current configuration to be tested with data from a previous run. This state is only available when reviewing a data file. By choosing to reprocess the file from the Review state, the data in the file loads with the current configuration designated in Review state, NOT the configuration stored with the data. The Reprocess state then processes equations and endpoint sequences, if available, using data saved in the file instead of live spectrograph data.

2.8.3 Run States

The Monitor, Capture, and Process states receive spectral data from the EyeD system and deal with the data in real-time. For this reason, these states are collectively referred to as Run states.

These states (Monitor, Capture, Process) appear on the Status Bar to indicate the Run method. Review appears on the Status bar when the EyeD application is not running. A copy of the current configuration is loaded when the run starts. Saving the configuration will modify the configuration file, but will not affect a run in progress, as the configuration file is only read at the start of a run.

2.8.4 Monitor State

Monitor state allows the viewing of spectral information without saving the data. This is the simplest spectrograph run state and can be used to verify that the EyeD system is working properly once shipment of the device has been received. A Monitor state can be used to first view spectra from the EyeD system prior to manually capturing or processing the data. The current configuration displays real-time spectrograph readings in the Monitor state.

At anytime EyeD is running in Monitor state, the user can:

- Pause
- Stop
- Start the Capture state
- Start the Process state

2.8.5 Capture State

Capture state records the spectra from the EyeD system to a data file and executes any equations defined in the current configuration. This state uses the current configuration to display desired spectral and trend graphs when the run begins. EyeD automatically creates a file name based on the current date, assigns a unique run number and saves the configuration settings in the data file as they were at the end of the run.

2.8.6 Process State

This state allows the system to process the endpoint sequence while the run is taking place. This state is the only one that uses the endpoint sequence configuration to refer to equations during real-time data acquisition. The Process state loads the current configuration and automatically creates a data file when the run begins. In this state, the system continues to process spectral data until the run is stopped or the maximum runtime for the sequence expires.

2.9 Endpoint Detection Software

Endpoint detection software is directly related to the Sequence portion of the configuration file. EyeD includes a powerful suite of endpoint algorithms such as Neural Network pattern recognition, Principal Components Analysis and threshold-based software. In addition, it is possible to combine these approaches for maximum robustness.

2.10 Threshold-Based Software

Threshold-based endpoint recognition software relies upon the output rising above or below a preset threshold for a predetermined period of time. The output being traced is not raw optical data, but is the output of user-selectable wavelength(s) that can be mathematically

refined to produce endpoint signature. This software permits simple mathematical functions such as addition, subtraction, multiplication, division and derivatives, as well as more sophisticated formulas. Neural Network software is typically used for more demanding applications.

2.11 Neural Network Software

The Neural Network algorithm greatly improves the sensitivity and robustness of all endpoint schemes as pattern recognition is sometimes more dependable than processing the same data through a threshold-based endpoint determination process. Input to the Neural Network is a single stream of data, which is typically the result of various mathematical formulas. The algorithm can be applied in real-time to any single parameter that varies over time.

An additional benefit of the EyeD Neural Network is that it can be applied by those without extensive mathematical knowledge of algorithmic function. The users will simply add the Neural Network algorithm to the training set to improve endpoint robustness.

2.11.1 Principal Components Analysis

Principal Components Analysis (PCA) is a powerful technique that finds the component features and concentrations of characteristics from multiple-wavelength spectral data. This approach allows correction for oscillations in a process caused by rotating plasma, power supplies, pressure control loops, etc. The Neural Net or threshold-based software also can be used to analyze PCA output.

2.12 Equation Types

Optical spectra produced by the EyeD system during one integration period can be thought of as a vector (or a matrix with dimensions 1xn). A vector is defined as having both direction and magnitude. In this spectroscopy application, the term direction can be replaced with wavelength, while magnitude can be replaced with intensity. A spectral vector from the EyeD system shows the intensity at each half-nanometer wavelength from 200nm to 800nm (1,201 separate wavelengths = the value of n). Therefore, one spectrum from the EyeD system is a spectral vector with dimensions 1x1201. Looking at any element nx in the vector, the most recent light intensity at wavelength nx can be found. Looking across all the n elements in this vector, the intensity reported for every wavelength during the most recent integration time period can be charted.

2.12.1 Spectral Equations

A common task might include reviewing the entire spectrum. For example, comparing the spectrum just collected to a reference spectrum collected earlier from a known good run. Another example occurs in reflectometry while looking through plasma. In this case, subtraction of the spectrum with the light source turned off from the spectrum with the light source turned on is done. This removes the spectral contribution of the plasma. EyeD provides Spectral Equations to perform algebraic operations on each element in the vector (pixel or wavelength) one at a time. For example, the most current spectrum (row vector) can be subtracted from a second spectrum one wavelength at a time. Note that a Spectral Equation operates in real-time on a spectrum (a row vector) and produces a vector that looks like a new spectrum. The new spectrum can be given a unique name for additional real-time operations, such as plotting the spectrum, or applying equations.

2.12.2 Region Equations

Another common task is to identify wavelength regions of the spectra that are of interest. Since the EyeD system has a resolution of 1.7nm, even very narrow atomic spectral emission lines will have an apparent width in the spectrum reported by the EyeD system. Pixels on which the spectral line is imaged would be summed (or averaged) in the CCD plane to monitor the intensity of such a spectral line. A unique name must be assigned to each spectral region for later reference. There is no practical limit to the number of regions that can be identified in the spectrum. The Region Equation operates on each named region, and pixels can be averaged or added to calculate the value assigned to the region.

A typical example would be to isolate a peak at 400nm. The average peak intensity from 399-401nm could be determined and subtracted from it the average intensity of adjacent peaks (397-399nm and 401-403nm). In this manner, the background oscillation could be eliminated. This process is known as background correction.

2.12.3 Trend Equations

The Region Equation operates on a portion of the spectral vector and produces a scalar value. That scalar value can be used in real-time calculations and plots to show trends in the scalar value over time. EyeD uses Trend Equations to make those scalar calculations. A complete algebraic function menu is available to operate on the created scalar values. This produces appropriate values to track over time for detecting endpoint and other phenomena.

An example would be to identify one Spectral Region that increases at endpoint and a second Spectral Region that decreases at endpoint. Define the Trend Equation, ENDPOINT, to equal the division of the increasing scalar by the decreasing scalar. The scalar value, ENDPOINT, effectively amplifies the spectral change that can be seen at either of the spectral regions at endpoint.

2.12.4 Advanced Equations

Advanced equations encompass a wide range of equations, such as Interferometer Equations, or PCA. Interferometer Equations are specialized Region Equations that perform reflectometer measurements in real-time during an etch process. Like Region Equations, the Interferometer Equation returns a scalar value. Interferometer equations contain least squares fit routines for producing the best fit of a model-generated spectrum to a measured spectrum. The single scalar output is a thickness measurement of the item of interest on the wafer as it is being produced in the plasma reactor.

2.12.5 Logical Progression of Equation Types

Equation types follow a logical progression of Spectral, Region, Advanced Equations, and Trend. EyeD processes the equations in this order. No matter how the equations are ordered in the Equations window, EyeD will process all the Spectral equations first, the Region equations second, the Advanced Equations third, and finish with the Trend equations. Any Spectral or Trend equation can reference another Spectral or Trend equation. A Region equation can reference any Spectral equation or raw data source that precedes it in the list.

2.13 Graph Types

Graph types allow spectral or trend data to be viewed in two separate graph windows. EyeD provides Spectral and Trend graph types. In setting up a configuration file, the only limitation to how many graph windows to define or use for displaying spectral data is system performance (system speed).

2.13.1 Spectral Graphs

Spectral Graphs display dynamic real-time two-dimensional plots of:

- Data sources (the original spectral vectors produced by the EyeD and data file sources);
- Spectral Equations (the new spectral vectors that result from a spectral equation operation on a vector);
- Spectral Regions (defined by the user).

The horizontal axis plots the wavelength, while the vertical axis plots the intensity. The plot is updated at the end of the interval (Data Interval) specified for the EyeD system in the Setup section of the current configuration. The spectra plotted are real-time spectral vectors or vectors calculated in real-time from the spectrum.

2.13.2 Trend Graphs

Trend Graphs are dynamic plots of scalar values calculated in real time. As stated previously in this section, scalar values result from Region Equations and Trend Equations. The vertical axis for the Trend Graphs plots the scalar value. The horizontal axis plots the time, thus showing the trend of scalar values developing over time. The EyeD software plots any scalar value from a Region Equation, Trend Equation, or Advanced Equation. A conditional event in the configuration can be defined and, when the event conditions are met, the Trend Graph will record the event using a non-movable labeled marker.

THIS PAGE INTENTIONALY LEFT BLANK

3 EyeD Application

3.1 EyeD Window Components

EyeD window components provide a graphical user interface (GUI) for viewing spectral data and system configuration. To become familiar with this software application, the user needs to understand the individual elements contained in each window component in relation to various operation modes and states.

The Application Window serves as the user interface for control of the software and hardware, providing command options in either Local or Remote mode. When in remote mode, this system automatically responds to Centura requests to process spectral data in real time. Local mode offers the ability to review and reprocess stored files of spectral data.

Appendix A provides, by alphabetical order, a descriptive explanation of each dialog box, pop-up menu, button, edit box, and window in EyeD.

NOTE

Configuration and algorithm are used interchangeably.

3.1.1 EyeD Operator Interfaces

EyeD Operator Interfaces

The EyeD application provides one of two user interfaces, depending on whether it will be operated in a production or research environment. The Basic interface is a UI with most of the EyeD components hidden or disabled completely and is designed for use in production, once algorithms have been developed and finalized. The Advanced interface allows access to all EyeD components. This interface is discussed in the rest of the manual, and is where configurations are developed and tested.

EyeD may be configured to start up in either the Basic or Advanced interface mode by default. This must be done during installation of the software: for instructions refer to the chapters on software installation (5 and 7).

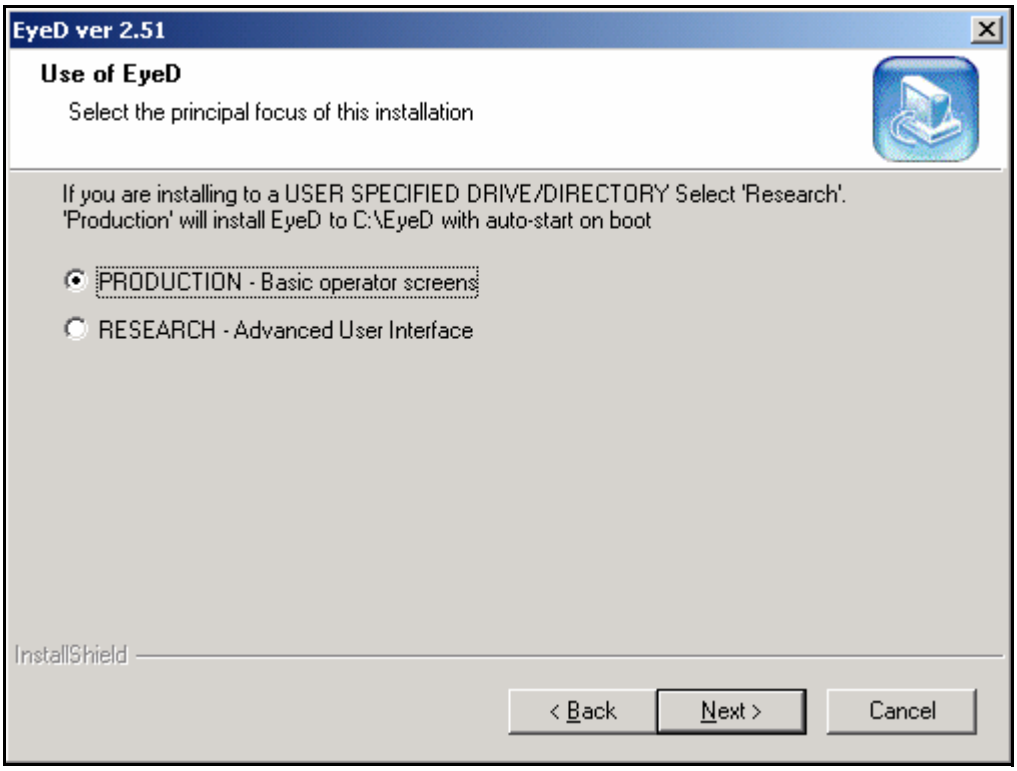


Figure 3-1. Selecting the Default Mode for the Application.

When Basic option is selected, EyeD places a shortcut to the EyeDManager.exe file in the Windows startup menu so that it launches automatically. EyeDManager.exe can also be launched manually from the C:/EyeD folder. EyeDManager.exe brings launches up to four instances (see note below) of EyeD along with URI, and SRM and a control tool bar with seven buttons.

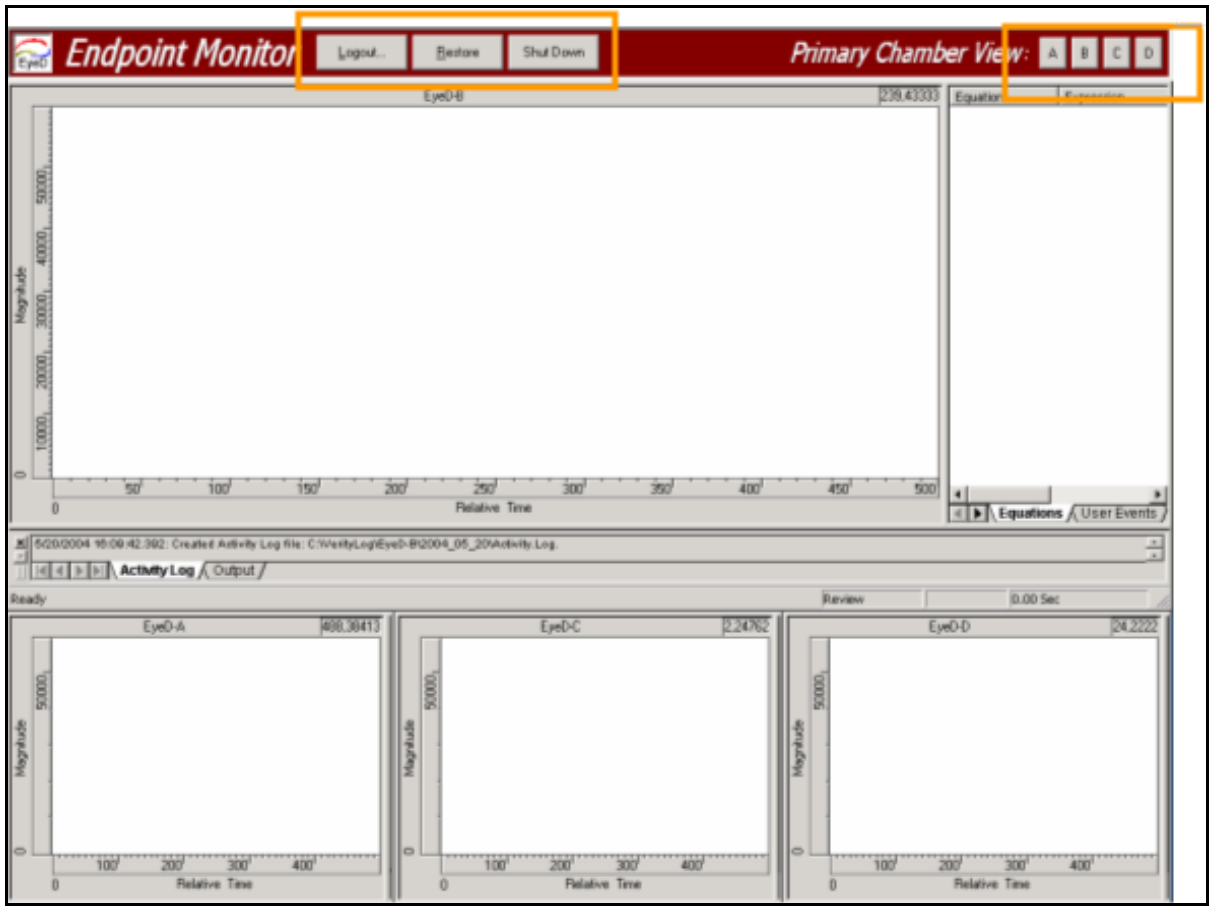


Figure 3-2. Basic Interface Components

The first three control access to the system:

- **Login -** allows the user to login to perform restricted access actions.
- **Restore -** does a logout and restores any EyeD instances back to basic interface mode if the full EyeD interface has been opened.
- **Shutdown -** will attempt to close all applications and close the EyeD manager if the user has the privileges to do so.

The remaining four buttons are used to give primary focus to any one of the instances. This instance will occupy the majority of the screen allowing its trends to be displayed in greater detail. The remaining three instances will be displayed as smaller windows along the bottom of the screen.

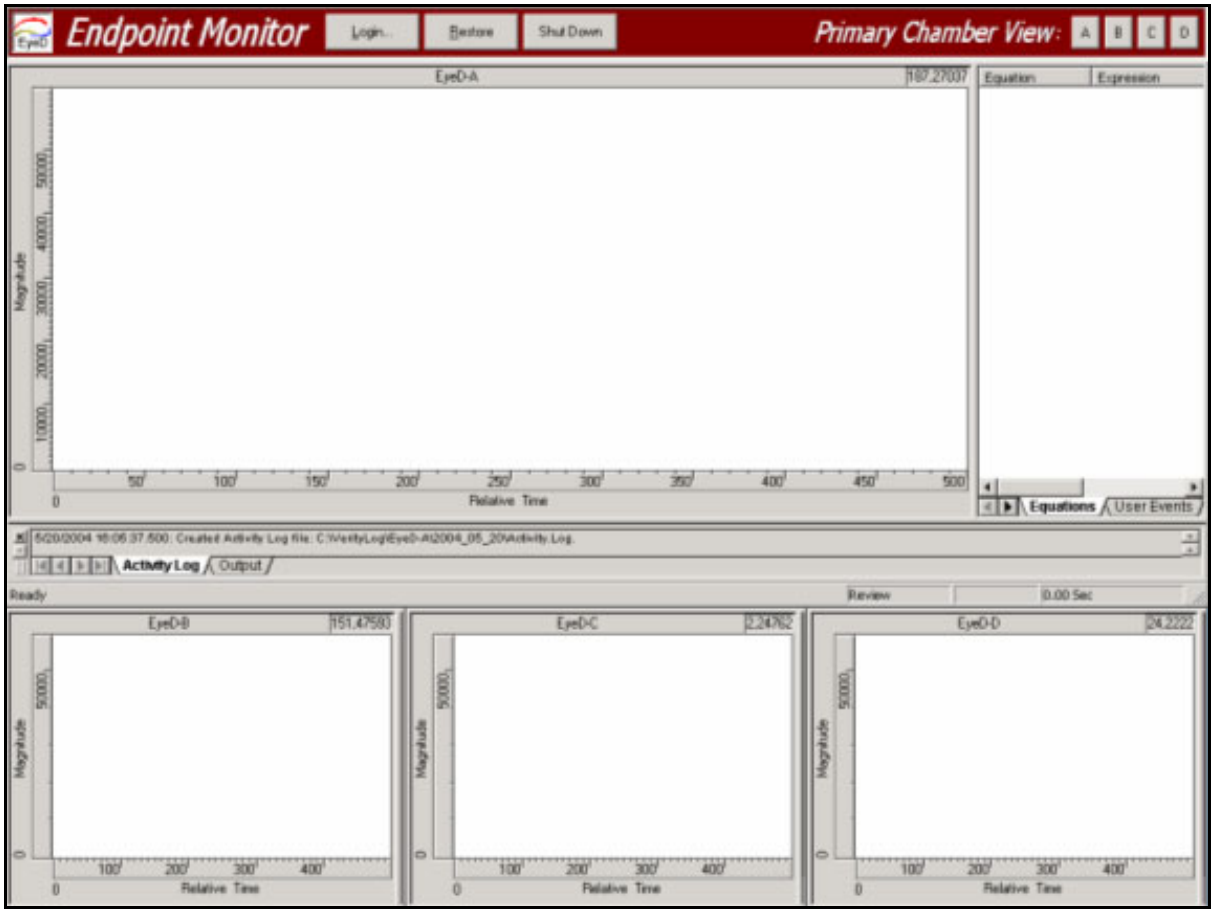


Figure 3-3. EyeD A instance is in Primary Focus

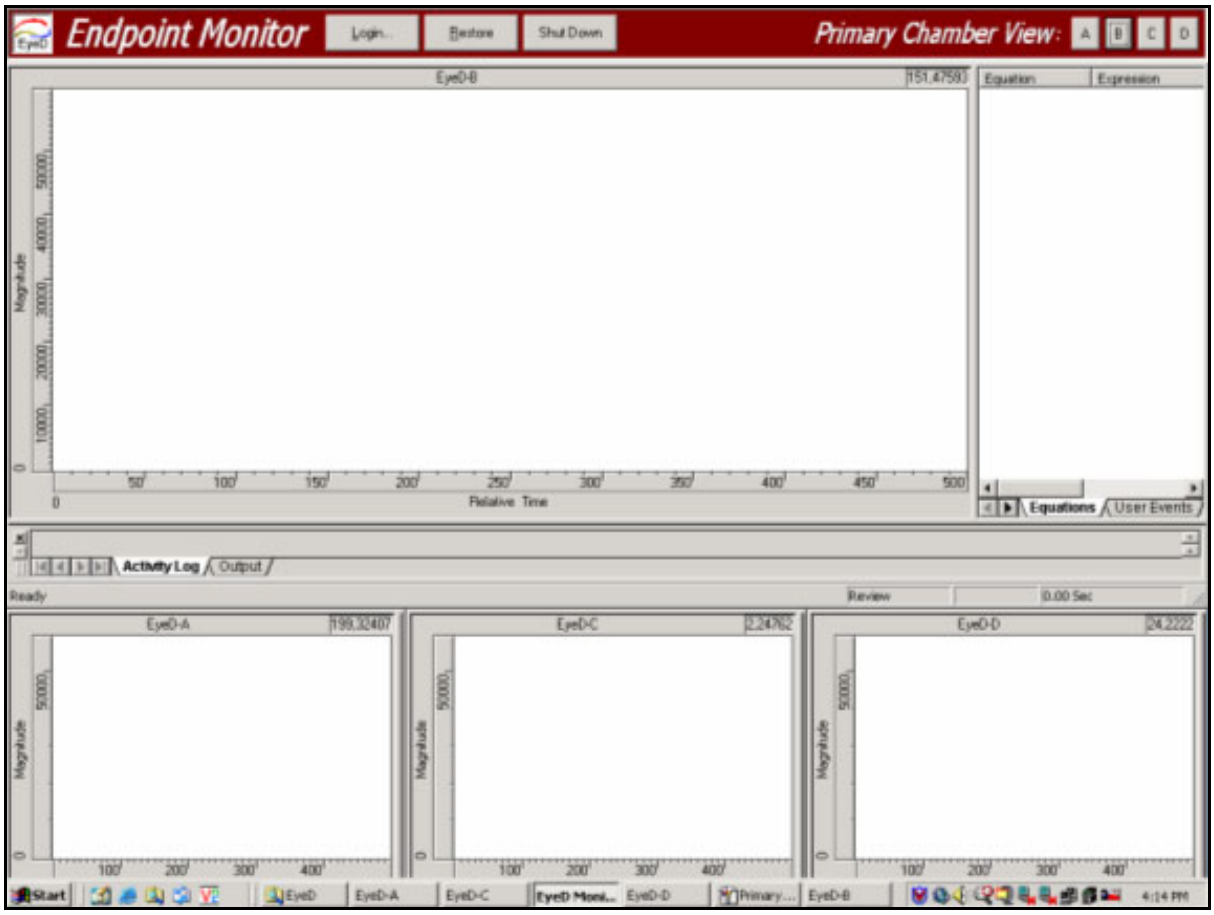


Figure 3-4. EyeD B Instance is in Primary Focus.

For each spectrograph, process trends are displayed. If multiple trend graphs exist in an EyeD configuration, the first one is the one displayed. Multiple trends can be displayed but they must all be selected for display on the first trend graph.

From the basic interface mode, it is possible to switch back to Advanced interface mode, so along as the user has the privileges to do so - ie login may be required. If the user right-clicks in the graph area of the desired instance, a simple menu allows the selection of "Advanced Interface" which will close the basic application and start EyeD.exe to bring up the Advanced interface for that instance only.

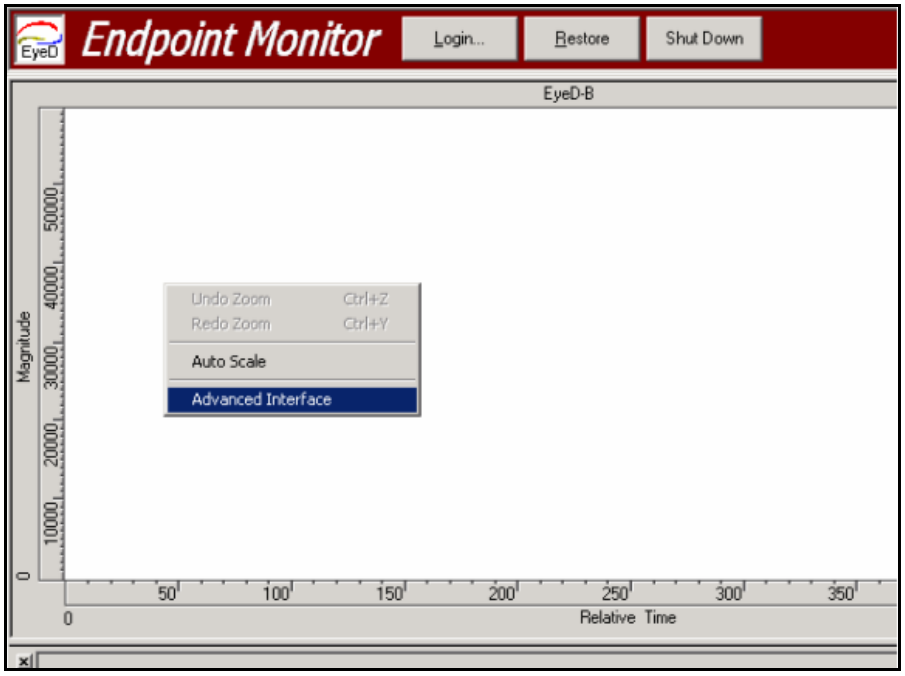


Figure 3-5. Context Menu to Switch to Advanced Interface Mode

It is also possible when in Advanced Interface mode to switch to basic mode. The command is located in the System menu. Note that this will switch only the active instance to basic mode. It will also not bring up the EyeDManager tool bar.

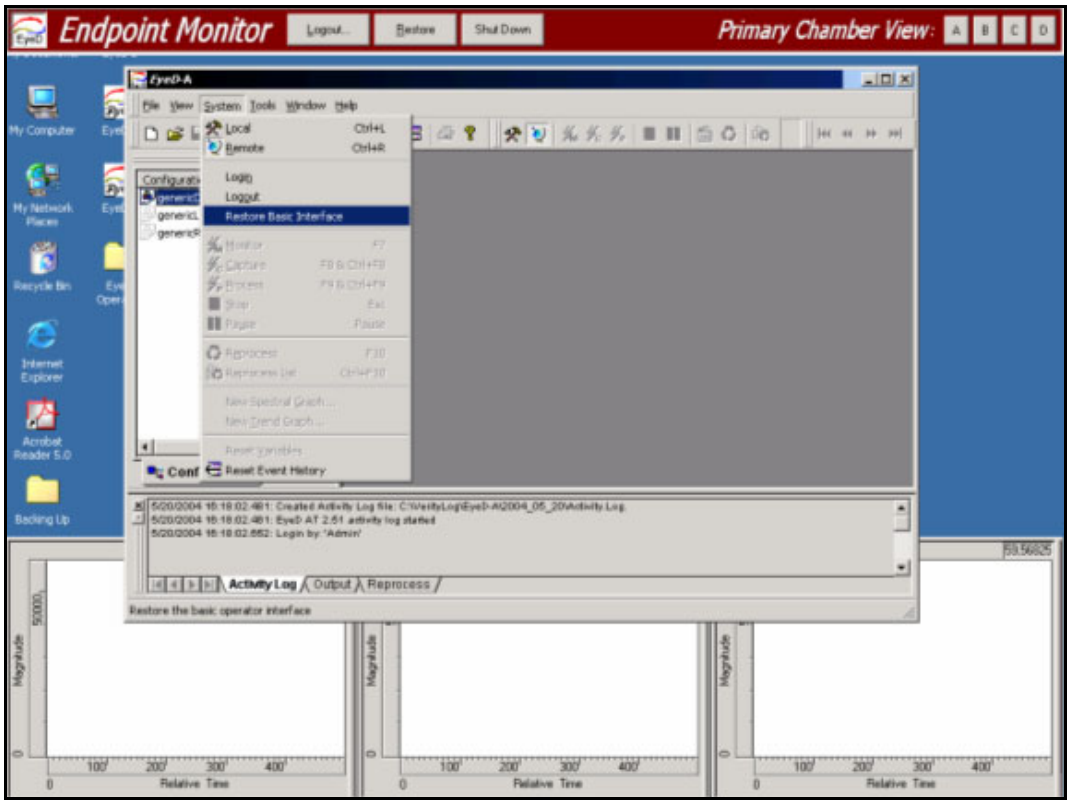


Figure 3-6. Switching to Basic Interface Mode From Advanced Interface Mode

NOTE

The Basic Interface mode will not function properly if EyeD cannot find spectrographs to connect to. Complete the Hardware installation of spectrographs and the configuration of SRM before running in Basic Interface mode.

3.1.2 Application Window

The Application Window is the initial window the user sees when launching EyeD, when Advanced Interface is installed as the default mode. See Figure 3-7. Core components to the Application Window include the Menu toolbar, Button toolbars, System window, Multiple Document Interface (MDI) workspace, the Output window, and the Status toolbar. The user has the option of displaying or hiding all windows, except the MDI workspace.

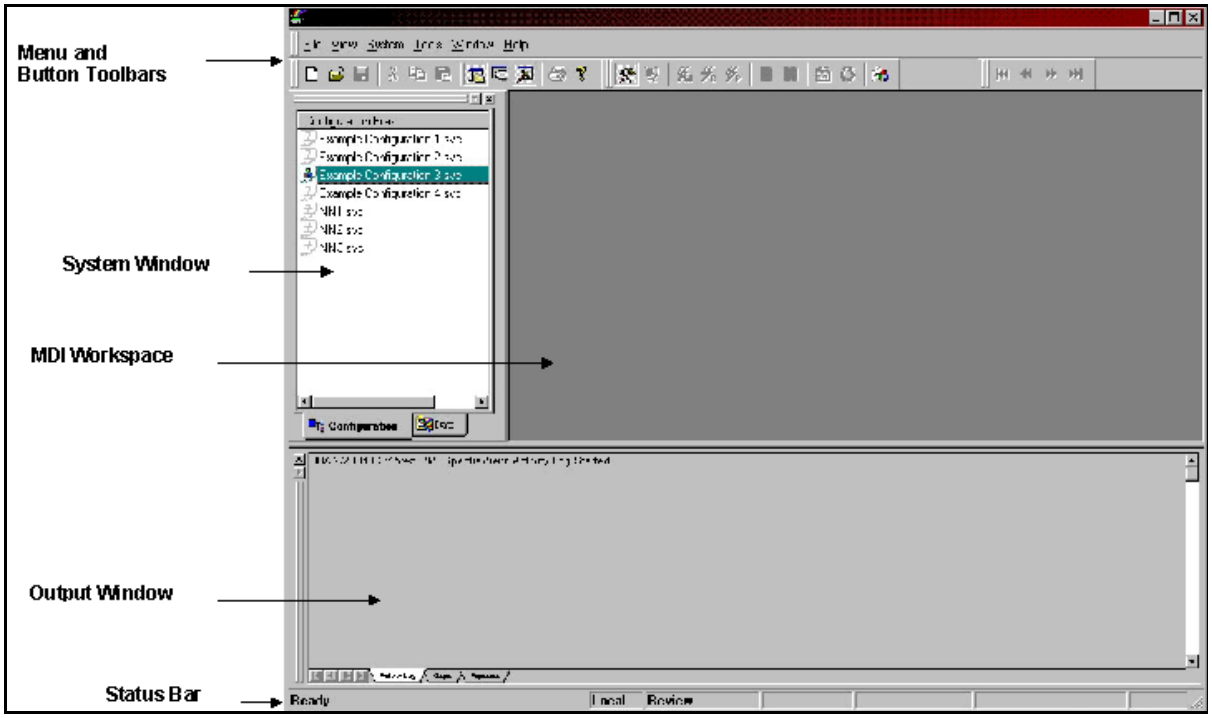


Figure 3-7. EyeD Application Window

3.1.3 Menu and Button Toolbars

The default menu and button toolbars (Figure 4-19) open with the most commonly used features. See Figure 3-8. These can be customized and new toolbars can be created, or existing toolbars can be consolidated into one.

Toolbars can be docked by either: 1) left-clicking on the toolbar background and dragging it to a new location, or 2) right-clicking on the toolbar and selecting Allow Docking, Hide, or Float In Main Window (Figure 4-22) from the pop-up menu.

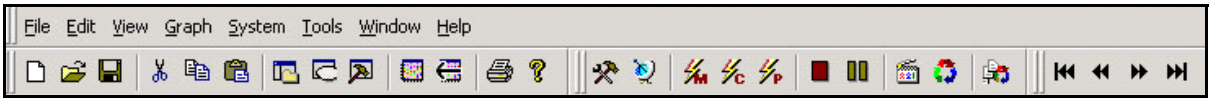


Figure 3-8. Menu and Button Toolbars

The button toolbars are movable, and can be docked in different places, or can be shown or hidden using the View or Tools menu options. A check mark (✓) appears beside the active toolbars. See Figure 3-9.



(a.) Configuration Context **(b.) Data Context**

Figure 3-9. Movable Toolbar Menus

These docking toolbars are referred to as System Context menus. System Context menus are available for all windows in EyeD except the MDI workspace.

a. This system context menu is for configuration files in the system window.

b. This system context menu is for data files in the system window

3.1.4 Menu Toolbar

The Menu toolbar, Figure 3-8, allows the selection of various menu options for EyeD. These menu options also are accessible from the button bars or drop-down list boxes contained in other areas of the software. A brief overview of each Menu toolbar item includes:

- **File:** a new configuration or data file can be created, existing configurations or data files can be opened and closed, standard printer functions (select, preview, and send) can be performed, a list of the most recently opened files can be found and the application exited.
- **Edit**[1]**:** standard Windows editing functions of Undo, Redo, Cut, Copy, and Paste can be performed.
- **View:** show or hide the standard toolbars and menu commands or place windows within the software in a workbook-like mode similar to an Excel spreadsheet.
- **Graph**[1]**:** beginning (Start), ending (End), next (Next), or previous (Previous) graph positions can be viewed.
- **Config**[1]**:** insert, delete and validate configuration parameters or view configuration properties [Note: This menu option only appears when viewing Configuration (*.svc) files].
- **System:** enter Local or Remote modes; enter Monitor, Capture, or Process states; or stop or pause the process currently running. The security system Login and Logout features can be accessed through this item. In addition, the resetting of Variable values and Event statistics can be accomplished here as well.

1.This selection may not be visible and available when EyeD is first started. Edit becomes available, as does Config, when a configuration file is opened in the system MDI window. Graph becomes available when a data file is opened.

- **Tools:** select a specific communication link, show and hide toolbars and menu commands (the same functions exists in the View menu option), customize the look and feel of toolbar gripper controls, or view or modify the system properties.
- **Window:** existing windows can be cascaded or tiled, or minimized window icons can be arranged.
- **Help:** information about the current software version and release is listed.

3.1.5 Button Toolbar

Figure 3-10 shows the Button toolbar with each button identified by operation and shows the grouping of each button palette for its respective toolbar option. When selecting Toolbars from the View menu, the user can select to show or hide any of these four toolbars.

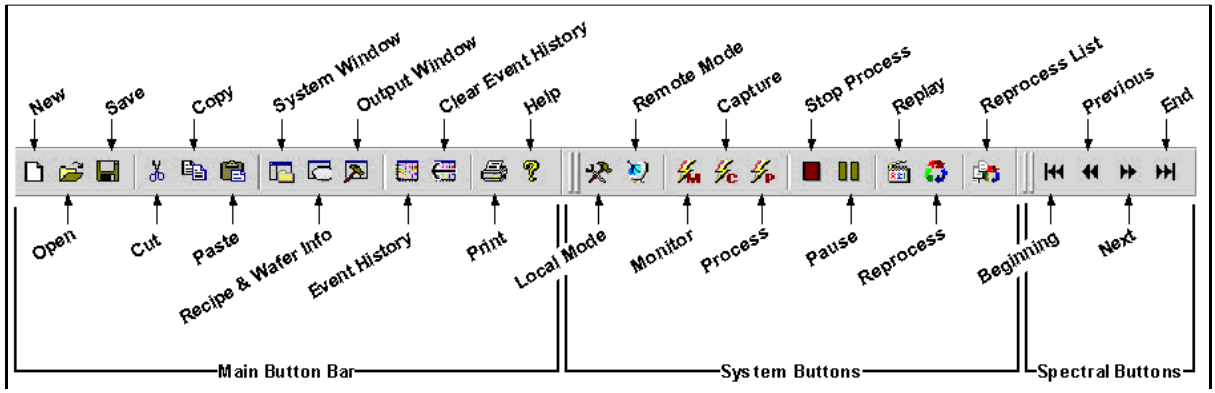
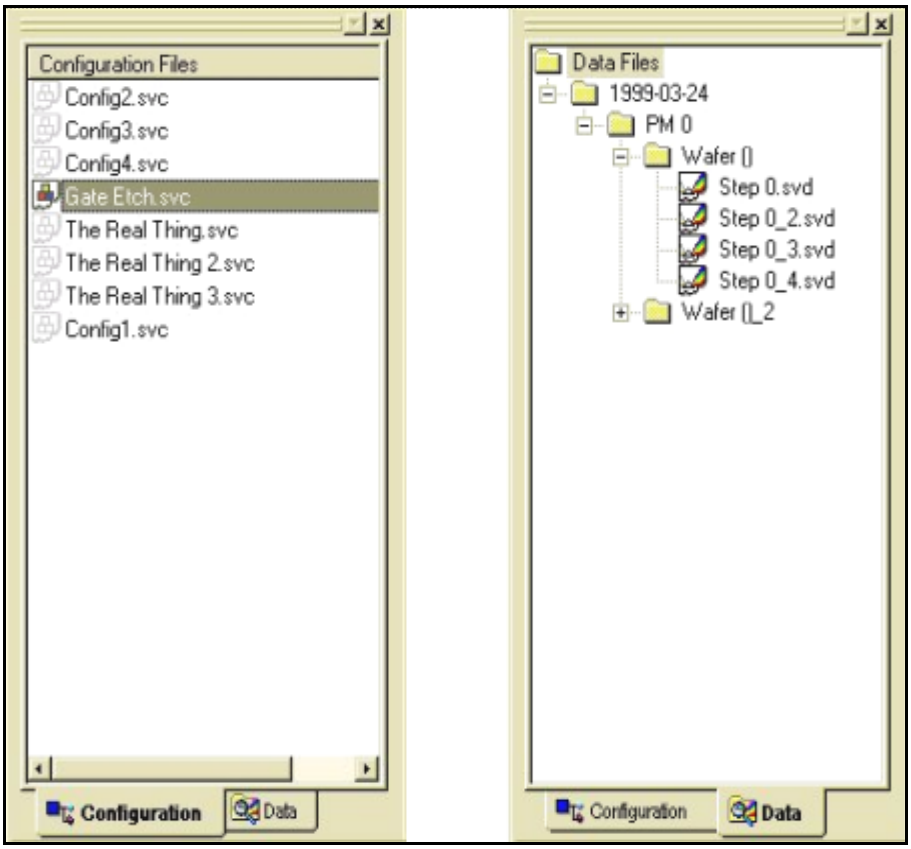


Figure 3-10. Button Toolbar Defined

The Spectral Buttons toolbar provides, in a live environment setting, the ability to move from the beginning (Start) to the end (End) of the spectral data or back (Previous) and forward (Next) to view the trend as it appears.

3.1.6 System Window

The System Window is a docking window that includes two sub-windows: Configuration Files (Figure 3-11a) and Data Files (Figure 3-11b). It is possible to reposition, hide, or display the System Window anywhere on the computer screen. If desired, the Configuration tab and the Data (files) tab can be set to float freely as unattached toolbars. This is done by right clicking to bring up the options for each.



a **b**

Figure 3-11. System Window a) Configuration Tab b) Data Files Tab

The Configuration Files tab lists all available Configuration files, which are designated by the *.svd file extension. The Data Files sub-window uses a selection tree operation similar to that used in the Windows Explorer application. Data files are designated by the *.svd extension.

The Configuration Files folder is a sub-window that lists all algorithms (configurations) available. Only those files stored in the directory that is set as the root directory for configuration files will be available. See Figure 3-11a. Refer to the Tutorial section for an explanation of each configuration type. (Contrast this to the data files folder.) The selected configuration can be designated as the current configuration for manual operation in Local mode. After highlighting the desired configuration, right click and select Set as Current. The current configuration appears in bold print with a colored icon.

The Data Files folder, displayed in Figure 3-11b, is a multi-level selection tree that can be tailored to capture pertinent information automatically, regarding spectral data in the file. Detailed instructions on defining the file structure of a specific application can be found in section 3.2.2. The information appearing in this folder is actually created during Capture and Process states. When the system creates a file, it is automatically highlighted, and any data file can be opened for review or reprocessing by double clicking on the file in the multi-level selection tree.

3.1.7 Output Window

The Output Window is a docking window, like the System window, and contains three sub-windows: Activity Log, Output and Reprocess Windows. See Figure 3-12.



Figure 3-12. Output Window

The Activity Log tab displays each activity, such as processing or system changes, occurring in the system. Optionally, this log can be saved to a text file for later review. This file contains all log entries for the entire run time of EyeD and clears itself when a process starts so that it displays only the most current and relevant information.

The Output tab displays multiple errors or warning messages such as sequence Validation messages. This information cannot be saved and appears only for informational purposes regarding the previous run.

The Reprocess tab displays the results of using the Reprocess List function to reprocess a list of stored data files. The same configuration is used on several data files one after another in batch mode, and the results of processing - typically, whether or not an endpoint condition has been satisfied - are listed in the reprocess window. See Section 3.7.

3.1.8 Multiple Document Interface (MDI) Workspace

The Multiple Document Interface (MDI) Workspace is the window space in the application GUI. See Figure 3-7. This workspace displays one of three window types: the Configuration Editor, the Spectral Graph or the Trend Graph.

The Configuration Editor window appears when the user is editing a configuration. See Figure 3-13. This window appears in a splitter window (a window with two side-by-side frames, similar to Microsoft Outlook). The left frame shows the configuration setup icons: Setup, Data Sources, Regions, Equations, Graphs, and Sequence. The right frame displays a window determined by clicking on one of the icons located on the left under the Configuration area of the Configuration Editor window. See Section 3.6, Configuration Attributes for more details.

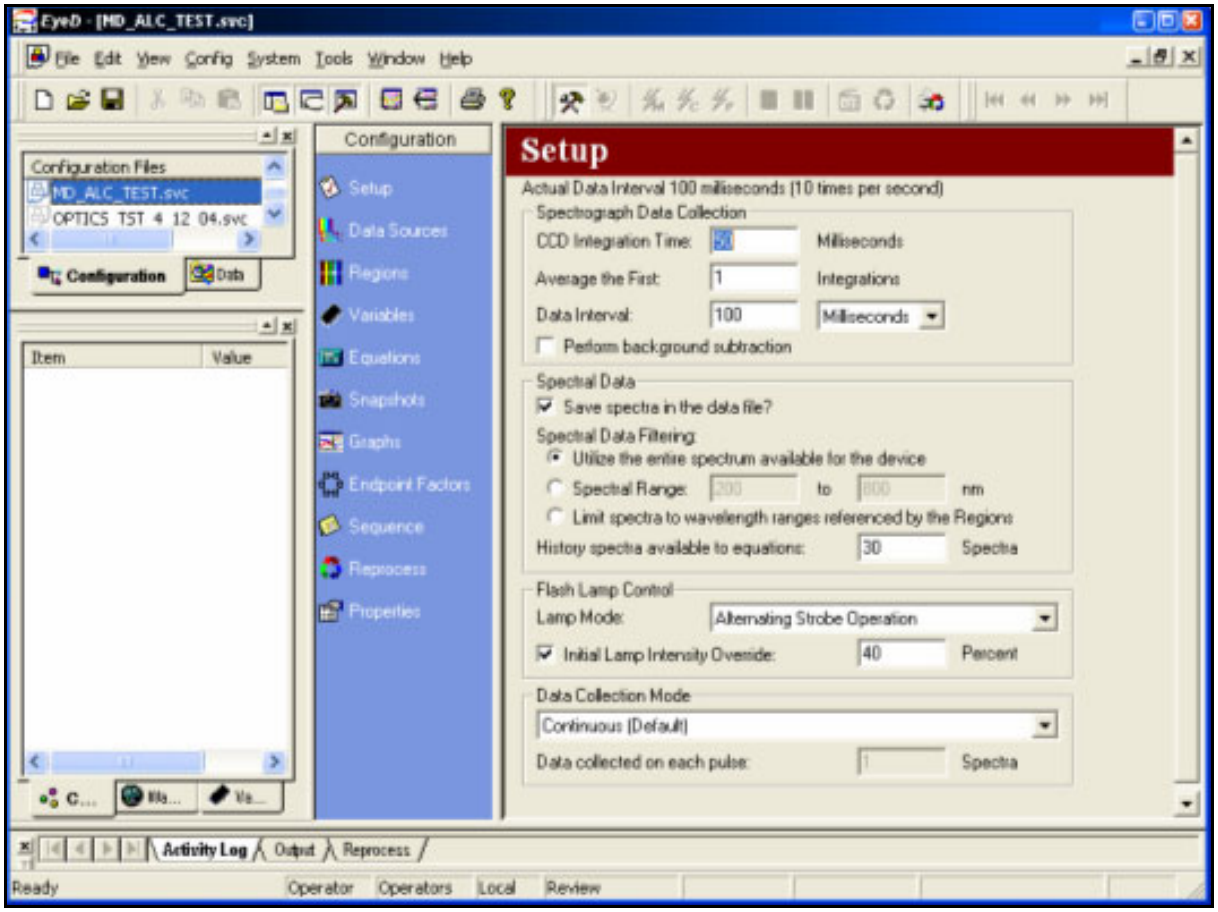


Figure 3-13. Configuration Editor (Setup) Window

Figure 3-14 shows the remaining two MDI windows, Spectral and Trend Graphs that appear when a configuration is executed. The current configuration specifies the display of spectral and trend graphs in real-time. See Section 3.6.17, Graph Types, for more detail.

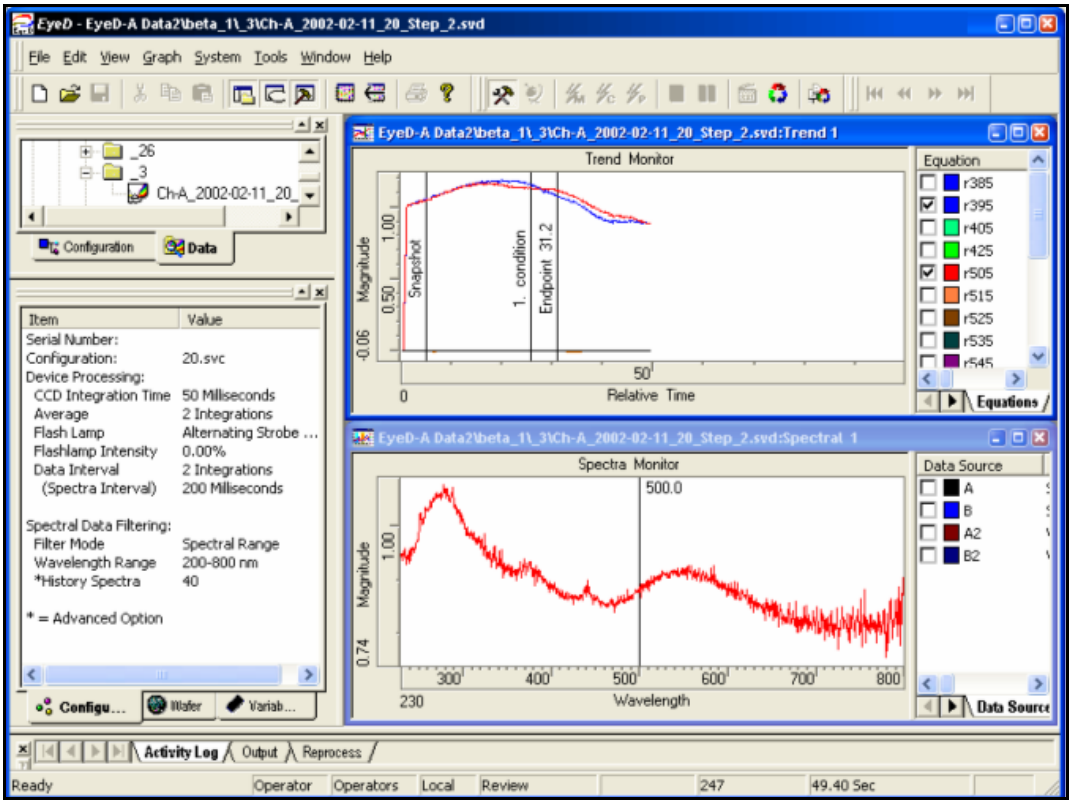


Figure 3-14. Spectral and Trend Graph Windows

3.1.9 Wafer Information

The Recipe and Wafer Information window is activated by selection from the View pull down menu on the Menu toolbar, or the associated tool bar button. The Configuration tab in this window is activated by default. This window (Figure 3-15) includes parameters from the Configuration being used for this process. The Wafer tab includes wafer lot information as well as updated information sent by the process tool during the actual run. The Variables tab shows all variables available to the Configuration.

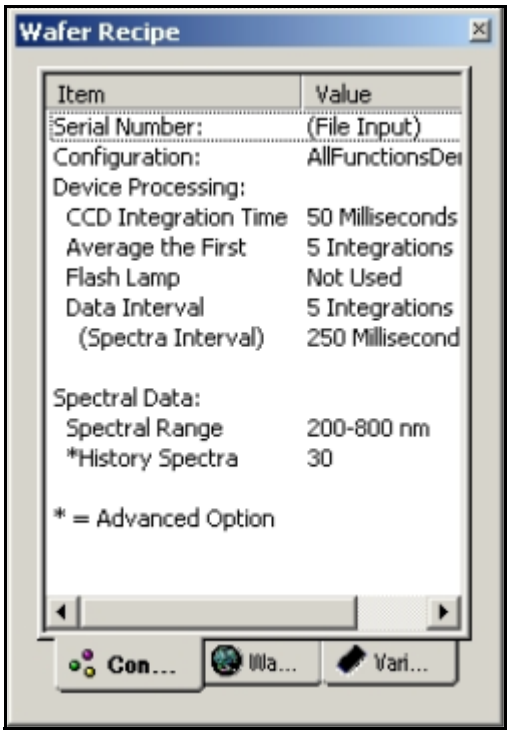


Figure 3-15. Recipe and Wafer Information Window

3.1.10 Status Bar

The Status Bar is found at the bottom edge of the EyeD main window. This bar is a quick reference for information regarding the current activity of EyeD. It displays any informational strings, toolbar descriptions, menu selection details, the current operating mode (Local or Remote), State status (Run or Review), and the date/time stamp of the spectra being displayed in the graph.

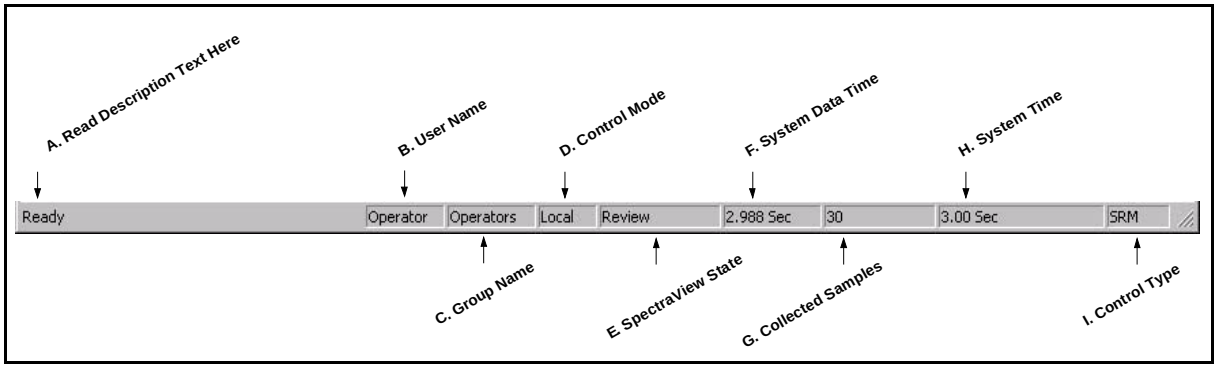


Figure 3-16. Status Bar

A. Read Description Text Here - By moving the cursor over active toolbar icons, explanatory text can be viewed in this field. The default state of this field is ready.

B. User Name - The User name currently logged into EyeD is listed here. The default is shown in Figure 4-27.

C. Group Name - The Group name for the user currently logged into EyeD is listed here. The default is shown.

D. Control Mode - This field indicates whether EyeD is in Local Mode or Remote Mode.

E. EyeD State - This field indicates the current activity of EyeD.

F. System Data Time - EyeD reads this time stamp from the spectrograph and indicates the instant the spectrograph began collecting data.

G. Collected Samples - This shows the number of the last spectral sample received since the beginning of the run.

H. System Time - This time is a product of the System Data Time and the Collected Samples number.

I. Control Type - This indicates the source of the spectral data being processed.

NOTE

In Figure 3-17, the process times listed at fields F and H differ slightly. This is due to the lag time required for the spectrograph to receive the start signal, verify its configuration, create a data file, etc., and begin sampling. Normally, this is the only difference in these two times. EyeD uses the time shown in field H, which includes a response-time adjustment factor to compensate for the difference in H and F times. See Section 3.9.1.

3.1.11 Real-Time Event Statistics

The user has the ability to track and log User Defined and Endpoint Events during processing of a Sequence. The Events are stored in a relational database that can be interrogated offline using Microsoft Access. This database is stored in a Directory under the EyeD Instance Root (EX: *C:\EyeD\EyeD-B Events*). In addition, the user has the option to display a Graphical plot of events as they are logged.

3.2 Spectrograph Internal Parameters

The Device Parameters dialog, accessible from the Tools menu, displays information about spectrograph devices connected to the EyeD computer. The fields in the Device Parameters are read from the spectrograph as follows:

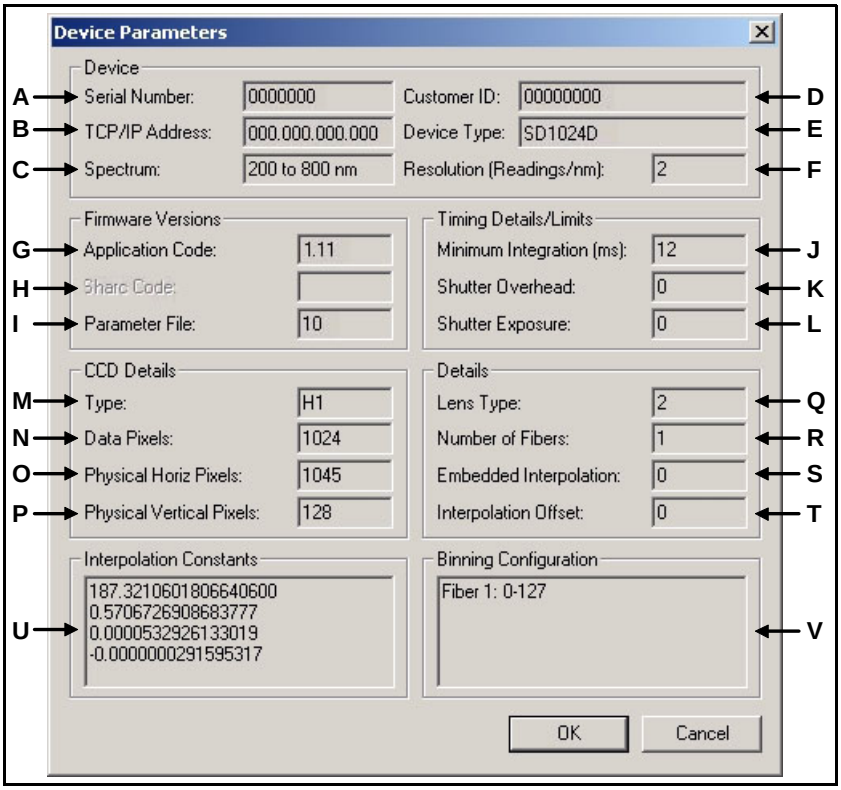


Figure 3-17. Spectrograph Internal Parameters

A. **Serial Number -** the serial number of the spectrograph

B. **TCP/IP Address -** current spectrograph address

C. **Spectrum -** the limits of the spectrum being collected

D. **Customer ID -** a unique customer identification number

E. **Device Type -** model of the attached device

F. **Resolution -** the direct optical resolution of the spectrograph

G. **Application Code -** version of the embedded code flashed to the spectrograph

H. **Sharc Code -** devices that are equipped with Sharc hardware will have a version listed for embedded code

I. **Parameter File -** listings in the Device Parameters window vary between version numbers, and this field lists the version ID of the parameter file structure

J. **Minimum Integrations -** CCD minimum integration time in milliseconds

K. **Shutter Overhead -** minimum cycle time for customer-special shutter

L. **Shutter Exposure -** exposure time for customer-special shutter.

M. **Type -** the type of CCD used in the imaging hardware of the spectrograph

H1 = High density 128 x 1024 pixels

S1 = Medium density 1 x 1024 pixels

N. **Data Pixels -** number of horizontal pixels available on the CCD

O. **Physical Horiz Pixels -** total number of horizontal pixels on the CCD

P. **Physical Vertical Pixels -** total number of vertical pixels

Q. **Lens Type -** can be filtered or non-filtered

R. **Number of Fibers -** the number of fiber optic inputs to the spectrograph

S. **Embedded Interpolation -** constant term of the third-order polynomial.

T. **Interpolation Offset -** is the value to be added to each pixel ID in order to use it as the independent variable in interpolation.

U. **Interpolation Constants -** Pixels are interpolated to wavelengths based on these constants.

V. **Binning Configuration -** Lists discrete areas of the CCD surface that are mapped as fiber channels for spectral sampling. When this same window (Device Parameters) is viewed in EyeD as opposed to SRM, these channels are listed as Data Source Mapping, with a channel number assigned for each (See Page 21 Mapping CCD Spectral Channels).

3.3 Options

The EyeD Options window has four subcomponents (tabs) and each tab contains various global settings for EyeD operation. These settings include user levels and security, automatic deletion and archiving of data files, setting directory roots for automated file creation, and general settings for logging event and activity data.

3.3.1 Enable Global Event Logging

Event logging is enabled from the *Tools —> Options Dialog —> General Options* Tag. See Figure 3-18.

In addition to settings for the automatic collection and reporting of Event Statistics, General options also includes a single setting for the Reprocess List function and the option to save Activity Log Files. See Figure 3-19.

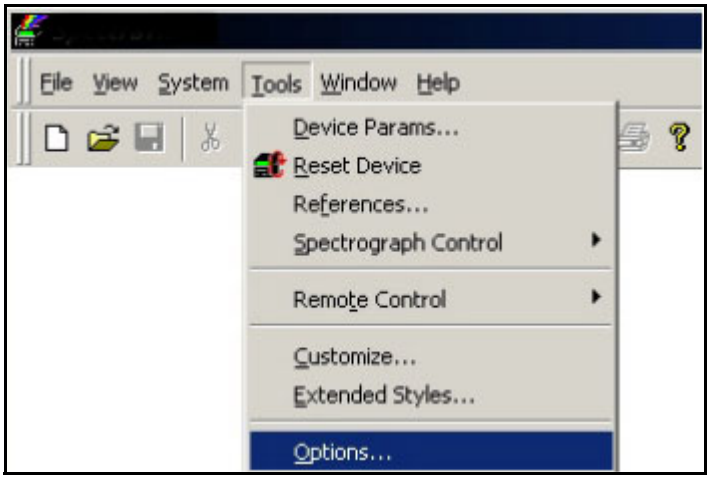


Figure 3-18. Selecting Options

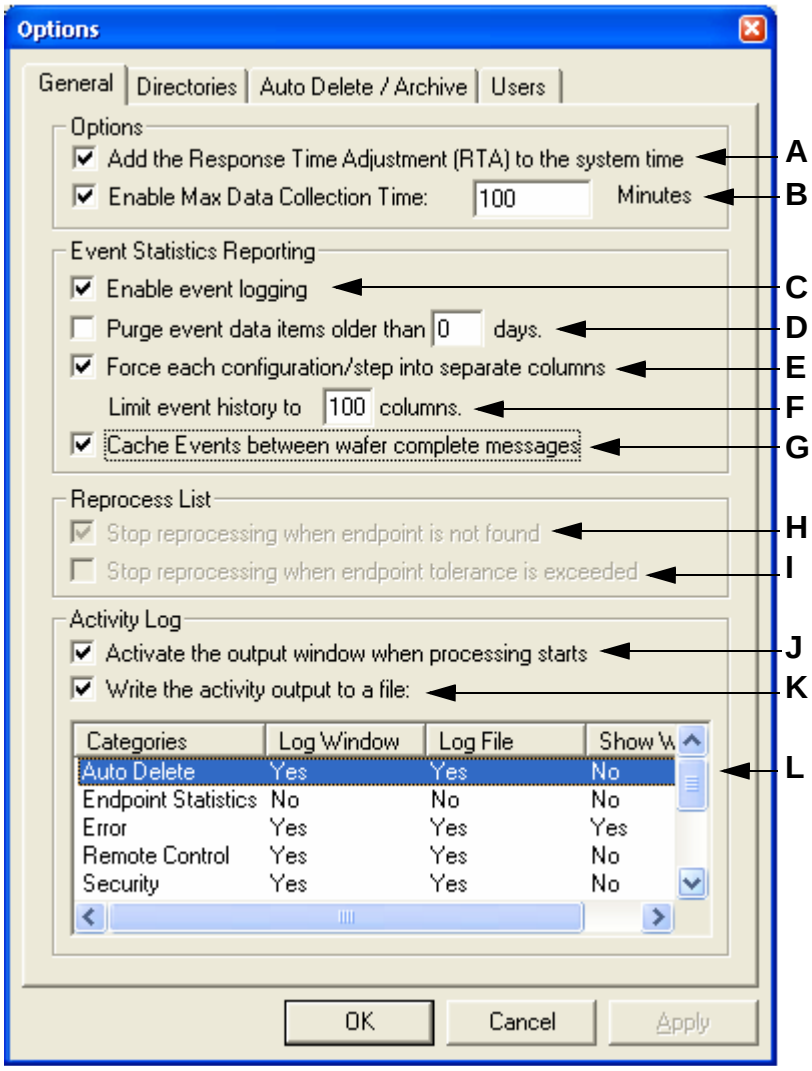


Figure 3-19. General Options

Fields in the General Options tab and corresponding functions are as follows:

A. **Add Response Time Adjustment (RTA) to the system time** -

B. **Enable Max Data Collection Time** (in minutes) -

C. **Enable event logging -** this stores any user events marked for logging as well as all endpoint events and error events that occur over multiple process runs. These can be viewed through the Event History Window under Toolbars (see Figure 3-21). This information can be viewed and manipulated with Microsoft Access™ software. This database is stored in a Directory under the EyeD Instance Root (Example: C:\EyeD\EyeD2 Events).

D. **Purge event data items older than -** this field sets a maximum number of days that event log information is retained in the event log. If checked then the entry field will indicate how old the data must be before it is deleted. Data purging only takes place during tool startup.

E. **Force each configuration / step into separate columns -** Checking this field forces data from each process run to be listed in a separate column in the Event History window (See Figure 3-27 and Figure 3-28). By default the event history window attempts to group configuration/steps and it does this placing each step in to a single column until a step is repeated. For example configurations 1,2 and 3 are used in a series of steps. If this option is left unchecked then the event history window will show datum points for all three configurations, so that if the order is #1 then #2 and finally #3 these will be overlapped. Then if #1 is run again then that will start a new column and the process of overlapping events will continue.

F. **Limit History to _#_ Columns -** limits the number of columns that will be plotted in the Event History window. The actual number of steps displayed will depend on the state of the previous checkbox and potentially the number of steps in a process.

G. **Cache Events between wafer complete messages -** Selection improves (reduces) runtime latencies when process has B to B steps.

H. **Stop reprocessing when endpoint is not found -** Checking this box will cause the Reprocess List function to halt when the application fails to find endpoint on one of the spectral data files in the list (See section Section 3.6, Reprocess List).

I. **Stop reprocessing when endpoint tolerance is exceeded -** Reprocessing list option for use with endpoint statistics.

J. **Activate the output window when processing starts -** This field activates the Output window, which by default comprises the lower part of the main EyeD workplace window. The Output window contains the Activity Log tab, the Output tab and the Reprocess tab.

K. **Write the activity output to a file -** Checking this box causes the application to store Activity Log information in a log file for later viewing.

L. This area shows the summary of Logging / Database selections.

3.3.1.1 Event History Viewing

To view a chronological representation of specific events compiled during a number of process runs open the Event History Window by accessing the View Drop list. The Event History Window does not display itself by default. The associated Button on the tool bar can also be used to show or hide the Event Plot window. See Figure 3-21.

3.3.1.2 Logging User Defined Events (Specific Event Selection)

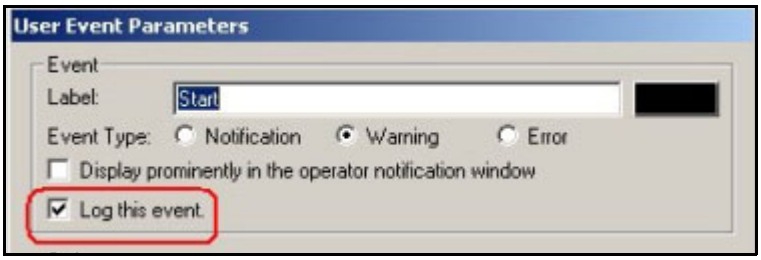


Figure 3-20. Log User Defined Event

As shown in Figure 3-20 there is a check box in the User Event dialog for specifying whether or not to log an event. This box MUST be checked for the associated event to be logged. (For more information on the User Event dialog, refer to Section 3.6.19.6, User Event.

NOTE

The Endpoint Event is a special case that has no dialog and is logged automatically (given that Event Logging is active- defined above).

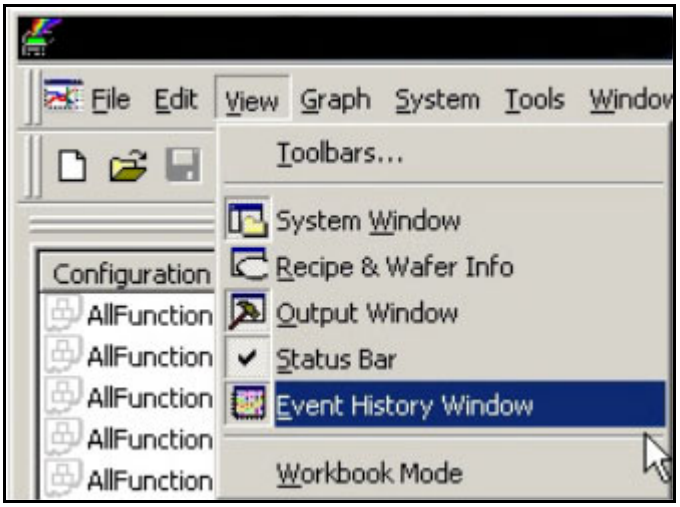


Figure 3-21. View Event History

3.3.1.3 Event Plot Tool Bar Buttons

The encircled buttons in Figure 3-22 will toggle the display of the event history window. The right button will reset the event history data. While all the data will be logged in the

EventStatistics.MDB database any points previously displayed will be lost from the history window.

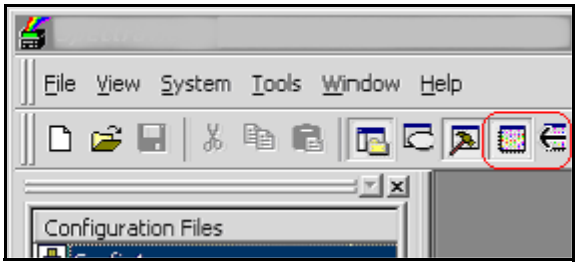


Figure 3-22. Event Plot Tool Bar

3.3.1.4 Event Plot Window

Figure 3-23 is a screen shot of a docked event history window. Solid circles indicate an endpoint event and squares indicates a user event. The column of numbers to the left is the number of seconds elapsed since the sequence or step was started. Each configuration will be displayed in its own color that will vary depending on the number of configurations and the color used for the last set of detection runs. The Event Statistics legend (Figure 3-26) details other symbols that may be displayed in the plot.

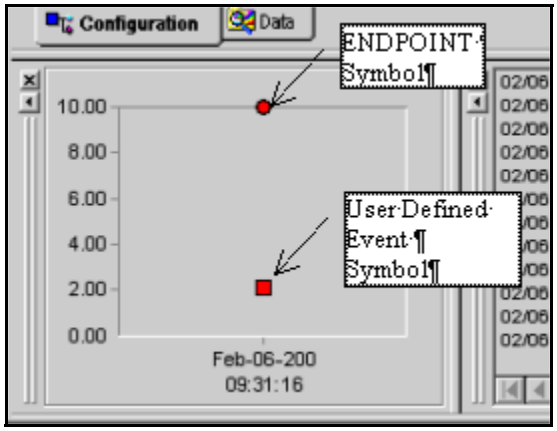


Figure 3-23. Event Plot Window

The 'tool tip' (yellow fly-over), Figure 3-24, text shows the name of the sequence, event label and configuration file name, as well as the elapsed time of the event.

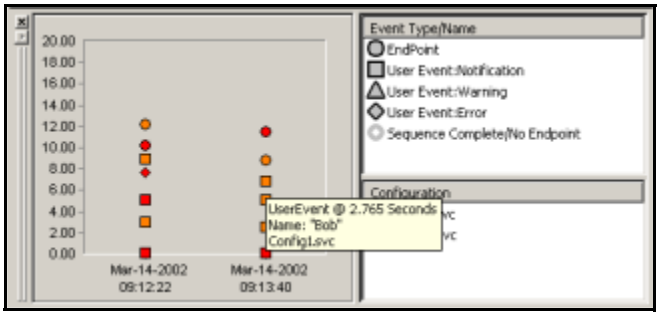


Figure 3-24. Event Plot

After each processing step (sequence completion), the graph will resize the y-axis to best fit the displayed points so that the maximum value displayed is a integer to a single digit of precision that will still show all points. This means that if the highest value point in terms of time is 3.8 seconds then the max value of the y axis will be 4. If the greatest time offset is 11.4 then the y axis will show 20. Finally, if the highest time value is 154.4 seconds then the y axis will show up to 200.

The Window can be resized by repositioning or dragging the splitter bars.

3.3.1.5 Initial Display or Reset

If the event history window is reset or on first display with no data to show it will look like Figure 3-25.

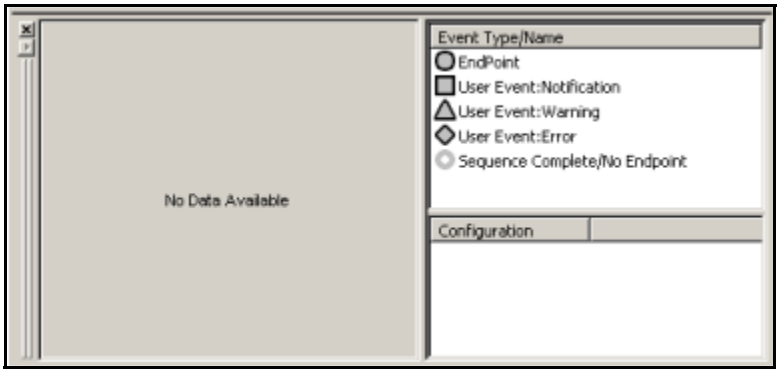


Figure 3-25. Initial Display

3.3.1.6 Event History Window Legend

The top part of the legend identifies the shapes used in the event history plot used to display different event types. The bottom portion will be populated with configuration names as they are processed by the tool and displayed by the event history window. This part of the legend will be blanked every time the tool is started or the event history window is reset.

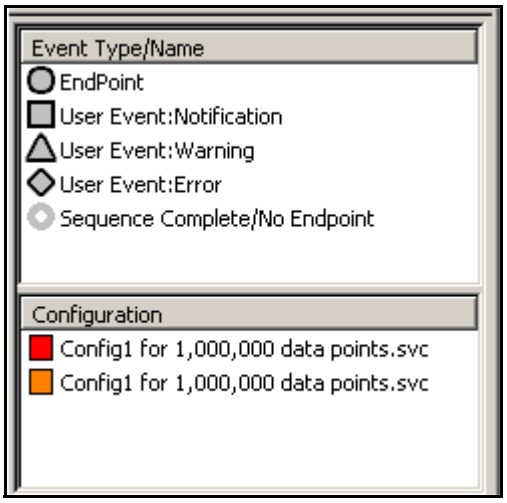


Figure 3-26. Event History Window Legend

3.3.1.7 Forcing Configuration Events into Separate Columns

Refer to Figure 3-19. If the checkbox at field C is unchecked, the events for multiple process steps will appear in the same column, but in a different color. This is useful for comparing multi-step processes on individual wafers over the entire production cycle. It is possible, however, for one event symbol to completely block another event symbol if their respective events occurred at the exact same time from the start of the step.

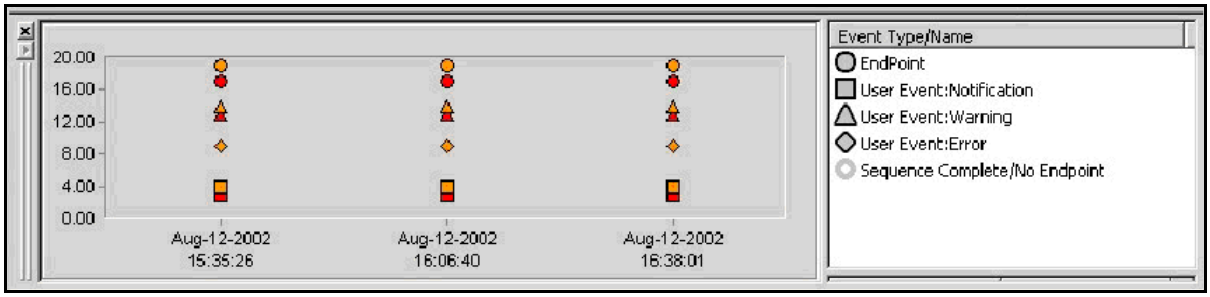


Figure 3-27. Multiple Steps Per Column

If the checkbox at field C in Figure 3-19 is checked, event markers from each step will be graphed in a different column and each column will be represented in a different color.

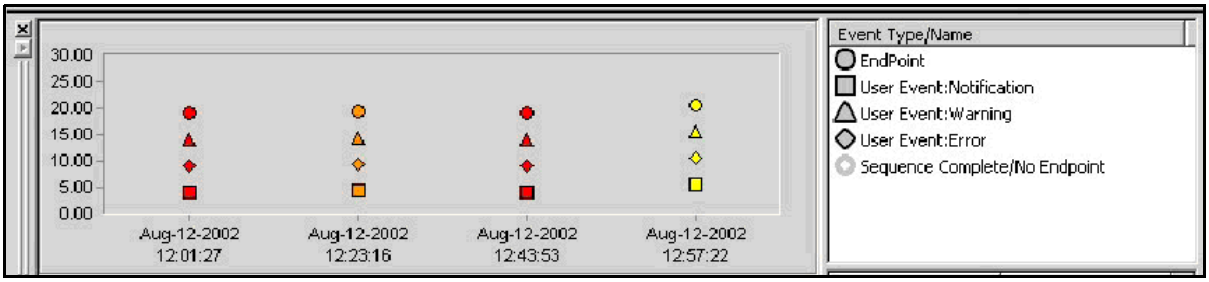


Figure 3-28. One Step Per Column

3.3.1.8 Event Statistics Analysis

The Event Statistics data collection function includes an analysis interface for reviewing database entries. This viewer can be used in the process environment during significant idle time.

> **⚠ CAUTION**
>
> Review should not be attempted during an active process step.

Each box in Figure 3-29 represents a Microsoft Access™ database table that is created by EyeD. The log entries for each table are shown. The bold line in each of the boxes indicates a unique number that is the main item in each table. This unique number can be sent to other log tables, which is represented by the directional lines in the figure. Although all of the tables shown are created by EyeD, some might be empty, depending on the settings made in EyeD.

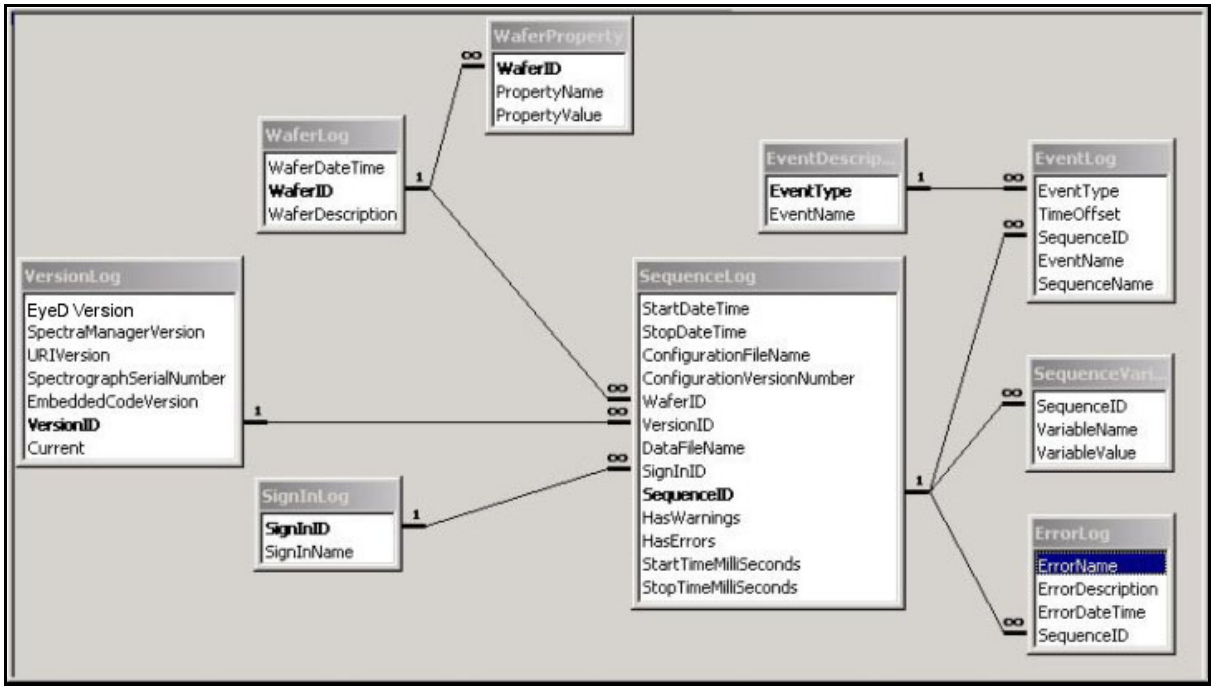


Figure 3-29. Event Statistics Database Relationships

Generally, the tables are updated in the order shown in Figure 3-29 (from left to right). While the variables are updated on a Sequence-by-sequence basis, the value at the time that the sequence is completed is the value that will be stored.

3.3.1.9 Starting Event Analysis

To gain access to the Analysis window first select File New from the Main Menu or select the New document icon on the tool bar. The selection dialog shown should appear: Select Event Analysis and select OK.

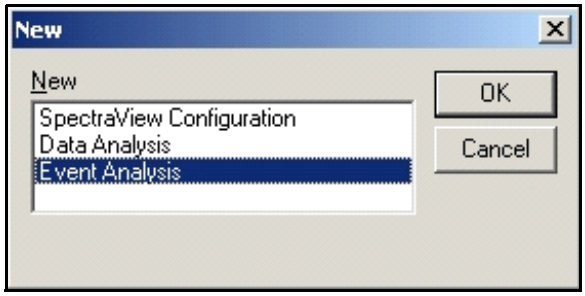


Figure 3-30. Select Event Analysis

This will bring up the Event Analysis window.

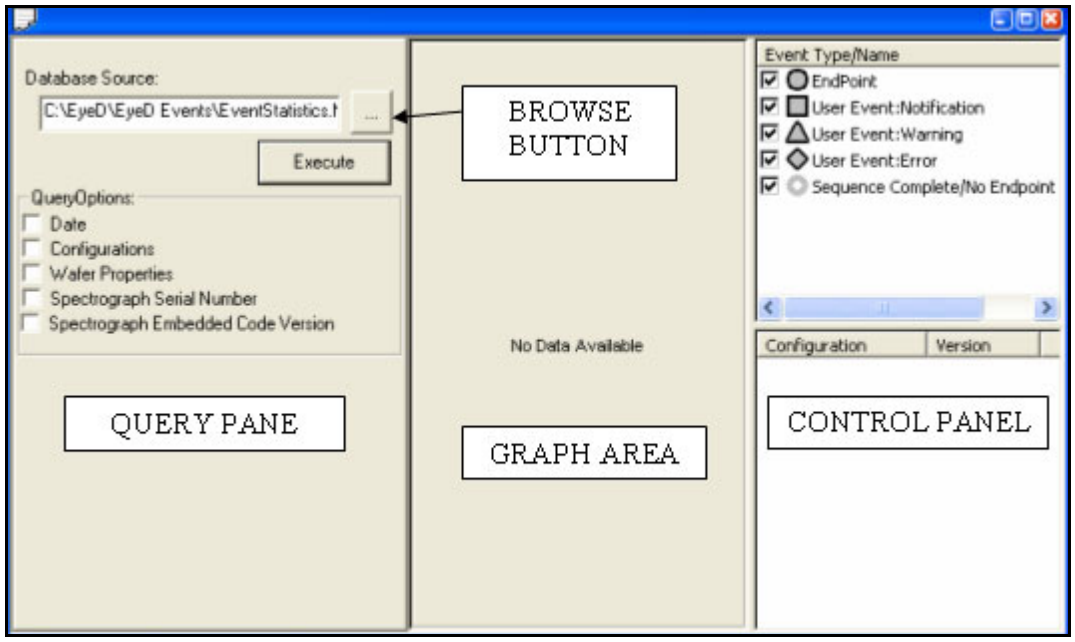


Figure 3-31. Event Analysis Window

The default settings for analysis initially cause the Database Source to be the default location for the associated EyeD Instance (Typically C:\EyeD\EyeD1 Events). To select a different database for query, press the browse button and find the desired EventStatistics.MDB file for the query.

By selecting the Execute button. The default query reads the entire contents of the database, and displays all events and all endpoints found. While the database is being read, the new graph will be blank. This process could take some time, depending on the size of the database being queried.

To customize the analysis query, use the checkboxes listed in the Query Options part of the window.

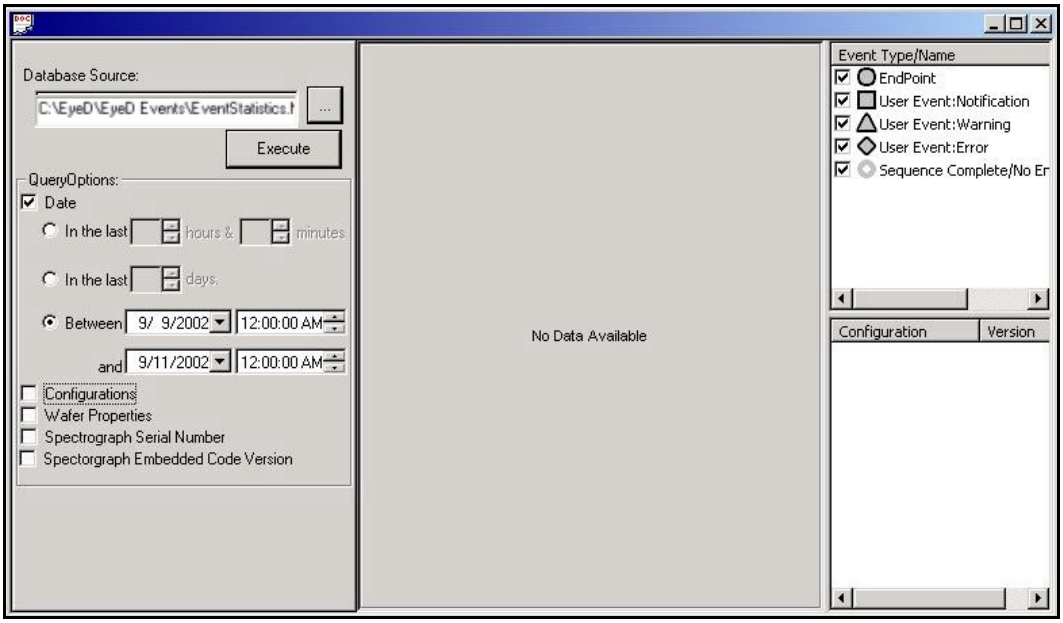


Figure 3-32. Query Options

Selecting any of the available check boxes will cause that option to be expanded for value entry or selection. In the Date example in Figure 3-32, the date range will always default to the start and end dates available in the selected source. The range also can be set based on elapsed days or elapsed time.

Selecting Execute will begin the search for events matching the query criteria. The settings for a query can be saved for future use by selecting File Save As, and specifying an.svs file type.

Once the query is executed, the Control Pane now shows configuration files found and associates a color with each. In the window above, symbol legend is explained. Associated check boxes can hide or reveal events from various files or of various types. In Figure 3-34, there is no center column or User Events. This was accomplished by unchecking the associated check boxes.

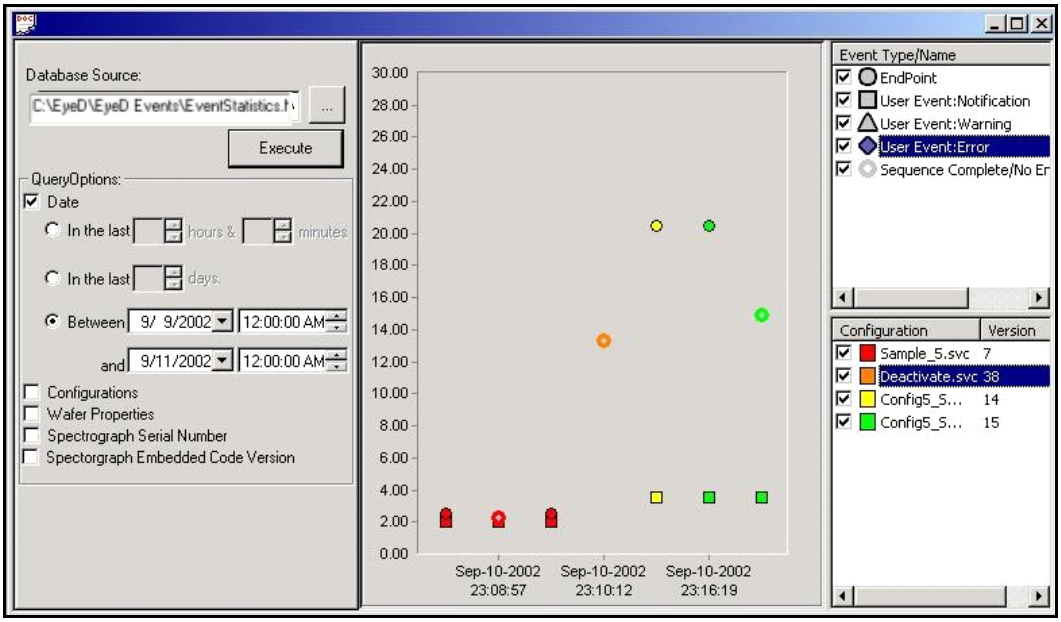


Figure 3-33. Execute Query

These check boxes allow the graph content to be customized without re-executing the query.

Placing the mouse pointer over an event symbol will produce a pop-up message providing specific details about that event. Double-clicking on a point will load and display its associated (.svd) data file, as long as that file remains in the directory location stored in the database.

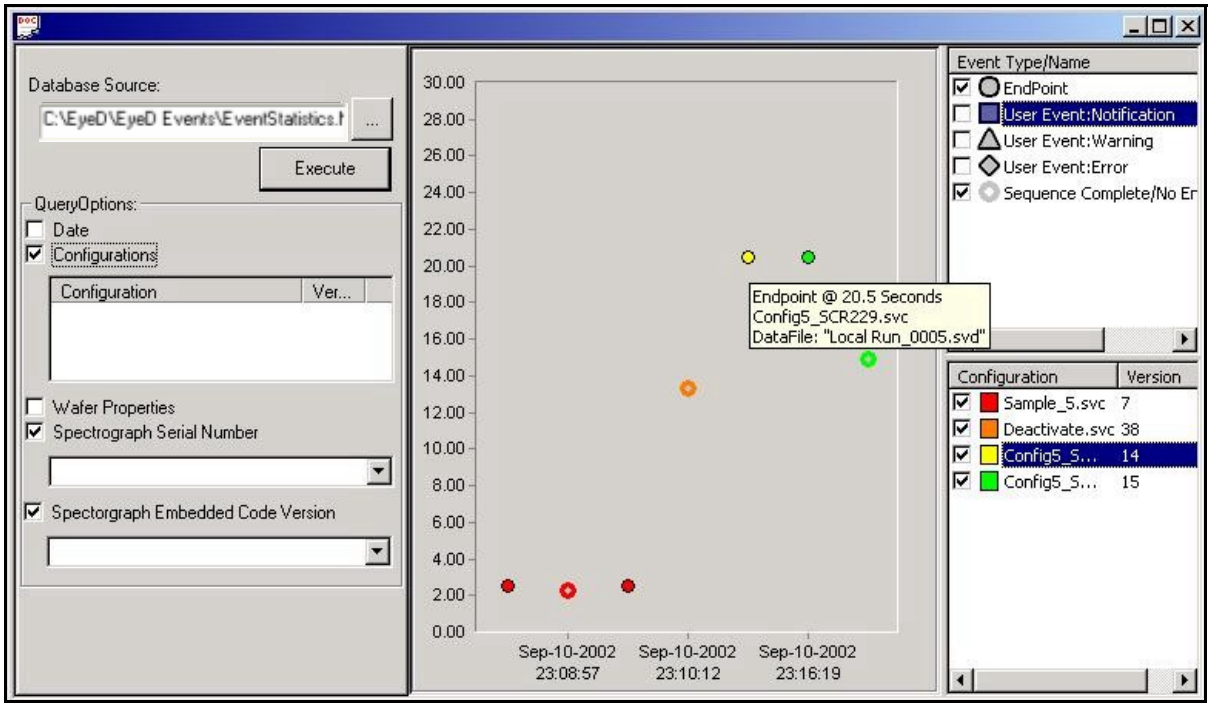


Figure 3-34. Move Cursor Over Symbols to Show Information

3.3.2 Directories

The Directories tab under the Options window contains all of the automatic storage pathways and naming conventions for files created within EyeD. Select Tools' Options to bring up this window. Figure 3-35 shows where this information is located and edited.

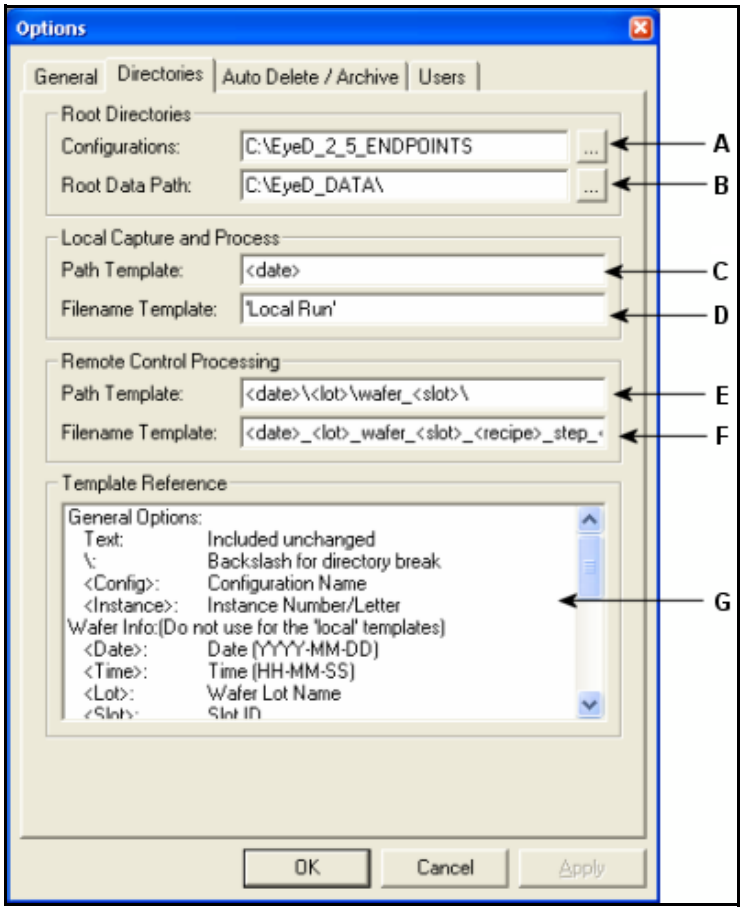


Figure 3-35. Directories and File Naming

A. This entry specifies the path to the folder where EyeD will store configuration files (*.svc). The directory specified must have been created prior to entering the path in this field. Only configurations stored in this directory will be displayed in the system window, and only those configurations listed in the system window can be selected for processing.

   Note: Unlike data files (B), configuration files cannot be managed using subdirectories.

B. The path to the data files (*.svd) folder is entered in this field. These directories must be created in the proper location before the path can be listed in this field. Files can be stored in the specified folder, or in one or more levels of subdirectories. Find the Configuration/Data tabs in the EyeD window and select the Data tab to view files and subdirectories. The window will show all subdirectories and files at the root specified by the B path.

C. This entry specifies a dedicated name and/or path extension from the end of the data root (B). EyeD will automatically use this path extension for storing data collected in Local mode. Using the substitution template symbols (see G), more than one level of subdirectories can be created to better organize saved data files. If this field is left blank, all data files created in local mode will be stored at one level at the data root specified by B.

D. The name format for data files when EyeD is operated in local mode is specified here. This field cannot be left blank. By using the first four substitution template symbols (see G), date and instance number can be incorporated in the file name.

E. For storing data files created in Remote mode, the path extension from the end of the data root is specified here. More than one level of subdirectories can be created to better organize saved data files. Using the substitution template symbols (see G), specific information regarding a wafer lot can be captured in this data path.

F. In this field, specify the filename format for data files created and stored during remote mode operation. Using the substitution template symbols (see G), specific details regarding a wafer lot and other information can be captured in this data filename.

G. This space is a legend for substitution template symbols and syntax for creating path and filename templates within EyeD. When the path or filename is created, the assigned information will be substituted for these entries and will be used to define the format of paths and filenames.

Table 3-1. Directory Path Syntax

Template Entries	Syntax
Text	Wafer
Directory break	\
Configuration Name	<Config>
Instance Letter	<Instance>
Date	<Date>
Wafer Lot Name	<Lot>
Slot ID	<Slot>
Cassette ID	<Cassette>
Wafer ID	<Wafer>
Recipe Name	<Recipe>
Step Number	<Step>
Workflow	<Workflow> (FUTURE)
Tool ID	<Tool> (FUTURE)

Table 3-1. Directory Path Syntax	
Template Entries	**Syntax**
Custom 1	<Cust1>
Custom 2	<Cust2>
Custom 3	<Cust3>
Custom 4	<Cust4>
Custom 5	<Cust5>

Note that the wafer information, which can be embedded in the path and filenames templates for remote control processing, must be provided to EyeD by the process module. Wafer information is transferred via RS232, or Ethernet communication link between the process module and EyeD. Upon receiving a start signal from the mainframe, EyeD creates the path and file names from the most recent wafer information.

3.3.2.1 Example: Configuration for Data File Storage

EyeD is configurable in terms of selection of data file structures and file naming. Access to the file naming and file structure area is through EyeD ==>Tools ==>Options. Go to the Directories tab. You will see this setup window:

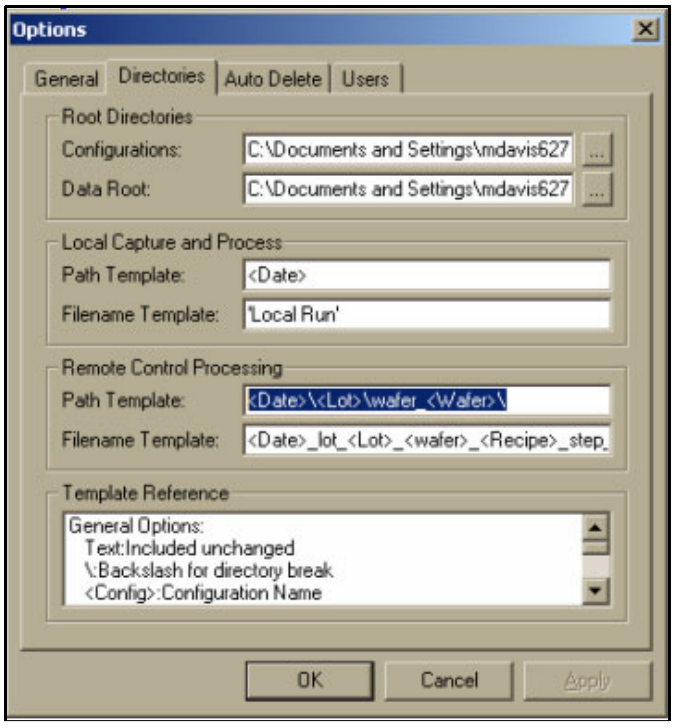


Figure 3-36. Options - Directories Tab

In the Template Reference, there are a number of arguments that can be selected to set up file path and file naming in a nearly unlimited number of ways. These arguments are

differently supported on 200 and 300mm platforms until mainframe SW version 2.0. This table summarizes the differences:

Version support	200mm	300mm
From local info:		
<Config>	yes	yes
<Instance>	yes	yes
<Date>	yes	yes
<Time>	yes	yes
From wafer information transmitted at the beginning of the endpointed step:		
<Lot>	yes	yes
<Slot>	yes	yes (mainframe SW 2.0)
<Cassette>	yes (A or B)	yes (mainframe SW 2.0)
<Wafer>	yes (if OCR equipped)	yes (example is PodA13)
<Recipe>	yes	yes
<Step>	yes	yes (mainframe SW 2.0)
<Tool>	no	no
<Workflow>	no	no

Example 1)
path structure 200mm
<Date>\<Lot>\Slot_<Slot>
data file structure 200mm
<Date>_lot_<Lot>_Slot<Slot>_<Recipe>_step<Step>

Result

2003-10-03
Q00345REW
Slot_23
2003-10-03_lot_Q00345REW_Slot23_PGE02033_step2.svd
2003-10-03_lot_Q00345REW_ Slot23_PGE02033_step4.svd
2003-10-03_lot_Q00345REW_ Slot23_PGE02033_step6.svd

Example 2)
path structure 300mm
<Date>\<Lot>\wafer_<Wafer>
data file structure 300mm
<Date>_lot_<Lot>_<wafer>_<Recipe>_step_

Result
2003-10-03
Q00345REW

Wafer_PodA23

2003-10-03_lot_Q00345REW_PodA23_PGE02033_step_.svd
2003-10-03_lot_Q00345REW_ PodA23_PGE02033_step_0001.svd
2003-10-03_lot_Q00345REW_ PodA23_PGE02033_step_0002.svd

When running in Local mode, the control (Ctrl) key can be held down as processing or capturing starts (before execution begins). This will bring up a filename and path window specifically for the file about to be created. This allows a review of the file destination and the ability to provide a unique name prior to creation of the file, rather than waiting until the run is completed and renaming the newest file.

For Remote collection, the majority of directory/file fields depend on indications that the wafer has changed. Switching back and forth between Local and Remote while capturing data files in both modes, will automatically reset the directory and file naming each time. The directory will be re-created because EyeD recognizes a change and determines that there must be a different wafer being processed. Since the directory already exists, EyeD will create the same directory but make it unique by adding a sequential numeric suffix.

Other triggers for indicating a new directory should be created are:

- 100 auto numbered files exist in the current directory
- The date changes (i.e. midnight is reached)
- Wafer Info is re-sent or changes
- *New Wafer* command is received
- Reset, Present, or Wafer Complete commands are received

While the felxibility of EyeD allows the user to redefine the path structure and data file naming setup to most any convenient form, creating *flat* data file paths should be avoided. In other words, the number of files or filders stored in the same directory should be limited. When the number of data file entries in the active data folder approaches 1,200, CPU start delay problems can occur. This is due to an inherent delay within the Windows operating system as the resources searches over a thousand entries for a valid and unique name for the file it is trying to open.

It is a good rule-of-thumb to avoid start delay issues is to keep the maximum number of items in any data folder to less than 100.

3.3.2.2 Data File Types

EyeD saves information from process runs into EyeD data files with the suffix.svd. Included in EyeD data files are:

- A configuration section containing details of the configuration (.svc) file used to process the data;
- Details about the spectrograph used to collect the data,
- A results section that includes trend outputs,

- Raw spectral data in arrays of two-byte integers.

Settings in the Configuration will establish whether all or part of the 200nm to 800nm spectrum is stored in the data file.

In addition to EyeD data files EyeD can import other types of data files.

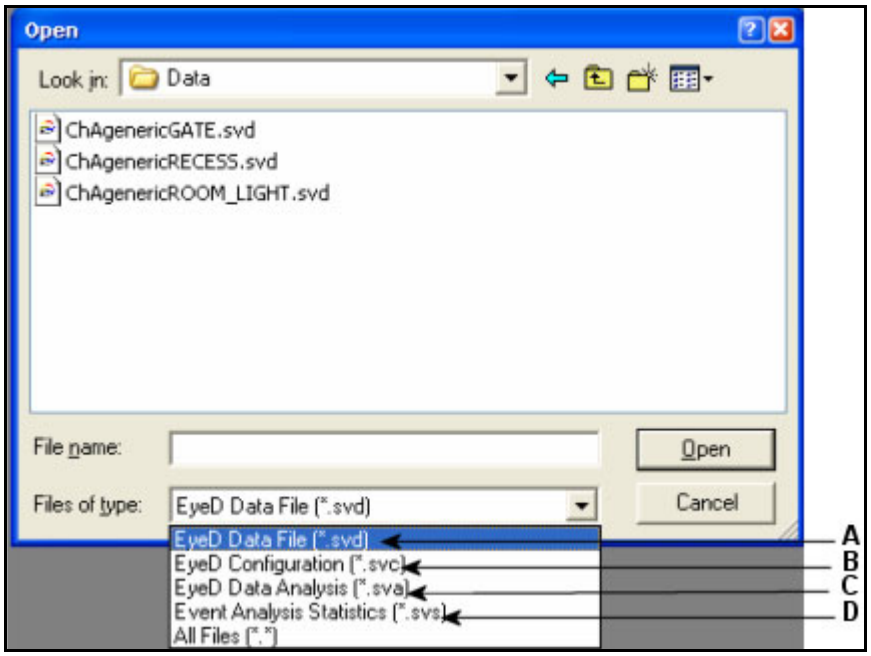


Figure 3-37. Recognized Data File Types

Figure 3-37 shows recognized data file types. These include:

A. EyeD data files: These files also contain the configuration under which the data file was taken.

B. EyeD Configurations: also known as algorithms.

C. EyeD Data Analysis: a file which compares the results of many runs in an overlay mode.

D. Event Analysis Statistics: a file which allows endpoint times, user defined event times and variable values to easily be studied across many runs.

3.3.3 Auto Delete/Archive

Auto Delete/Archive is a tool for managing and maintaining drive space while retaining information from data files produced during recent process runs. Auto Delete/Archive operates in the background and is paused during any kind of processing. As a result, this function runs when EyeD is not performing other tasks, which is typically between process runs. This utility can be tailored to utilize extra disk space for archiving data, or to manage the most useful data files in a system with limited drive space. To access this utility, select *Tools ==> Options*.

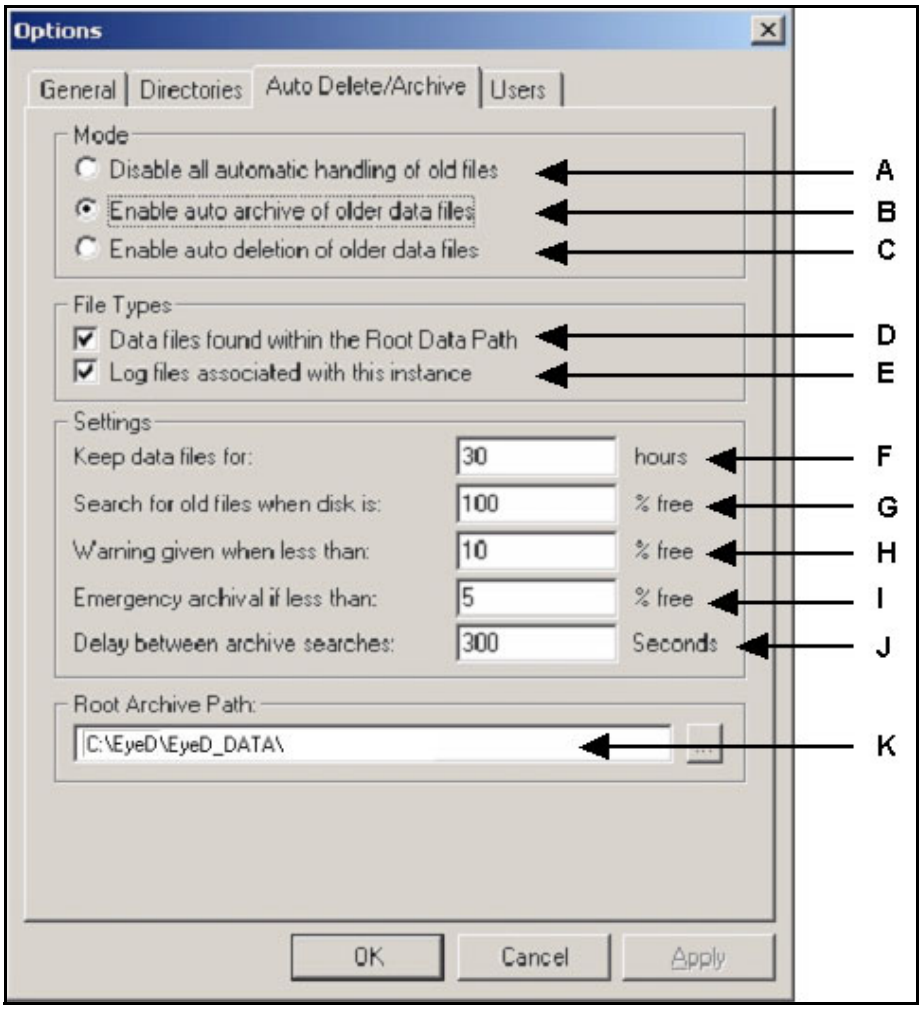


Figure 3-38. Auto Delete/Archive Selections

A. By default, this radio button is selected and disables all automatic archive and file deletion. Select option B or C to remove this selection and activate the functions.

B. Selecting this radio button will cause older data files to be archived (moved) to the root directory specified by field K.

C. Selecting this radio button will cause older data files to be deleted and the root archive location at K will be grayed out.

D. The File Types area includes selections to specify the type of files to be archived. Checking this box will include data files in the archive/delete search.

E. This selection will include associated log files along with the archiving or deleting of data files. When archive is chosen, and this box is checked, log files will be archived to the same Root directory specified in the Root Archive Path (See item K).

F. Keep data files for - In this field, type the number of hours (for archive) or days (for delete) for files to be kept on the drive. If a large amount of data from past

runs is desired as a potential information resource, extend this time. If drive space is low and no history is to be stored on this machine, shorten the time.

NOTE

The Auto Delete/Archive utility only searches for files along the data directory root (and any subdirectories) specified in the Directories tab. Any EyeD data files intended for permanent or long-term storage should be manually copied to another folder outside the specified path.

G. Search for old files when disk is - In the next box down, the utility can be configured to assess drive space requirements before deleting files. The default value is 100 percent of disk space, meaning the utility will always search for files to be deleted. If, for example, 50 is typed in this box, the utility will only begin searching for files to delete when the drive reaches half capacity. At this time, a search is made for any file marked for deletion by the other parameters of the utility.

H. Warning given when less than - The following parameter causes a warning to appear in the activity log indicating that, although all files have been deleted according to the established parameters, free space remains below this percentage. When this occurs, the error forces EyeD to activate the Output window (in the lowest part of the main EyeD window by default). Warning text will appear here.

I. Emergency archival if less than - By entering a percentage for minimum drive space, the emergency deletion selection begins deleting the oldest files to stave off a system failure due to drive-space depletion. Emergency deletion will remove the oldest files automatically until free space exceeds the percentage typed in this box.

NOTE

The Emergency Archive/Emergency Delete function is based on a minimum percent of drive space and is done without consulting the above parameters, meaning that data files can be lost without meeting the other configuration settings.

J. Delay between archive searches - The final configuration box sets the interval, in number of seconds, between searches made for files marked for Deletion or Archival in this tab. If this number is reduced, the frequency of file deletion searches will increase.

K. In this field, the path to the desired root directory for data archive must be listed if Archival is selected.

3.3.3.1 Auto Delete Activity Sequence

The Auto Delete subroutine follows the following pseudo code steps:

```
// Perform Auto Delete Each time a User Specified number of Seconds expires
// Note that the amount of time Auto delete takes is dependant upon the
// Number of data files created between searches

WHEN User specified "Search Time" expires DO
{
     // Define "On event" handler that will preempt Auto Delete activity
     ON OS event activation of a higher priority data processing task DO
     {
         Complete current single file delete (if already in progress)
         Abort Auto Delete
     } // end ON

   // Perform the following Auto Delete tests and actions in sequence defined:
     IF (Disk Free Space < UserSetEmergencyLevelPcnt) THEN
     {
        Starting at the User define "Root" data dir
                and recursing the directory tree…
     Delete data files beginning with the oldest SVD files only until Disk Free
        Space > EmergencyLevel
     } //end IF
     IF (Disk Free Space < UserSetWarningLevelPcnt) THEN
     {
        Place Warning Message In the Log
        Display Warning message box
     } //end IF
     IF (Disk Free Space < UserSpecifiedSearchPcnt) THEN
     {
        Starting at the User define "Root" data dir
                and recursing the directory tree…
        Search for Files Older than the User Specified number of Days
        Delete Files as they are found
     } //end IF
} end WHEN
```

3.3.4 Remote Data Archiving

Designate a network server for data archiving, and set the EyeD application (fully functional in EyeD 2.51 and later) such that the controller HDD retains data files for a short period of time, for instance one hour, before it archives to the server. As soon as the file is copied to the remote drive, the local file is deleted.

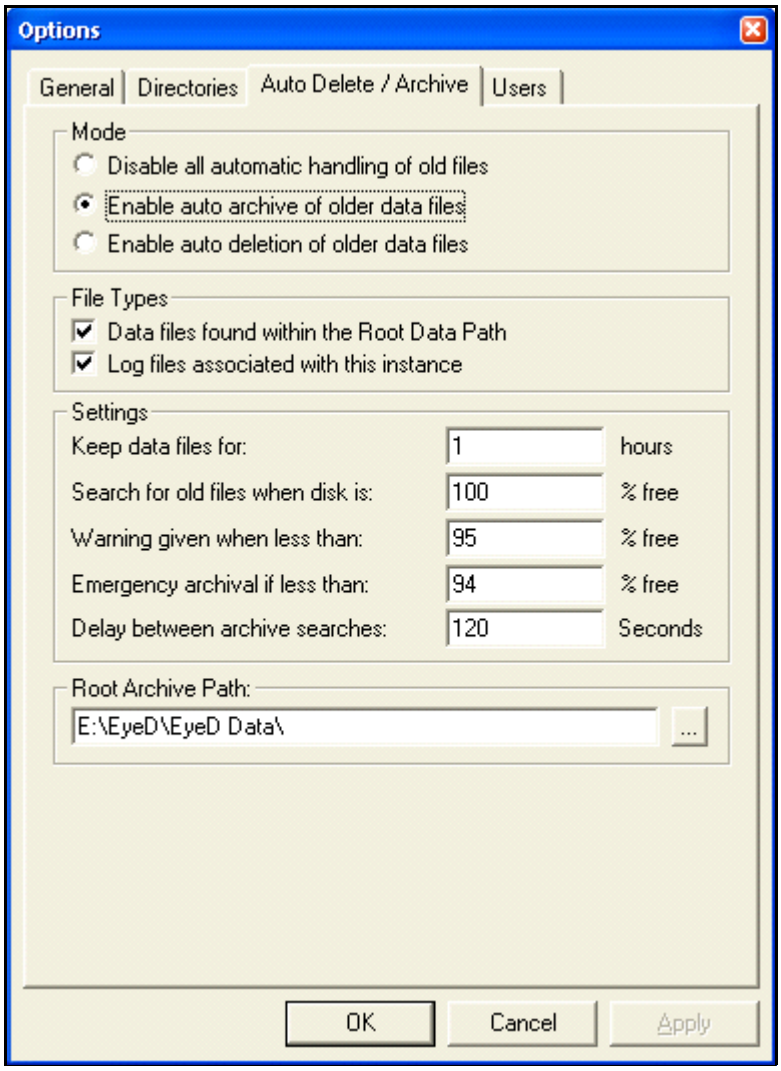


Figure 3-39. Remote Data Archive Window

Figure 3-39 is an example of archiving which maintains the maximum free space on the HDD. Archived data files will appear on the archive server 1-2 hours after processing.

3.3.5 Automatic Data File Deletion

Setting up the auto delete function of EyeD is very similar to that of the auto archiving function.

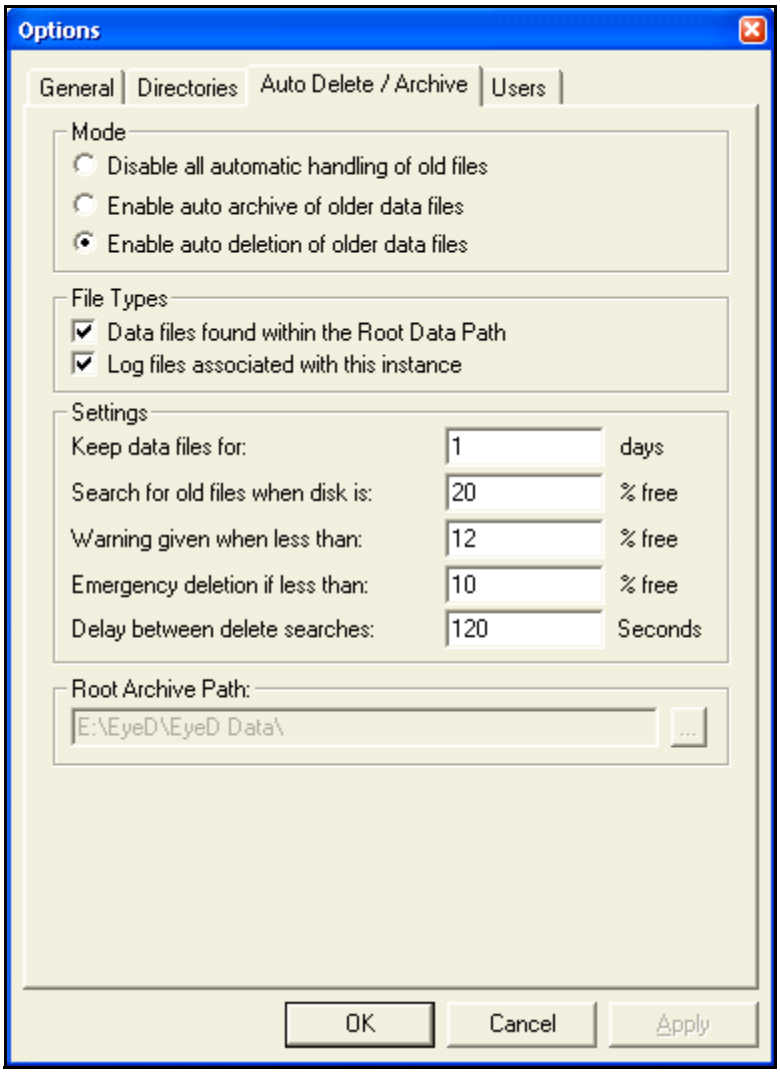


Figure 3-40. Auto Data File Delete Window

Figure 3-40 is an example of Auto Deletion setting which maintains the HDD with ~10% free space; the production history saved on the HDD depends upon selections made for data file size. This setup will maintain a large production history on the local HDD, but still maintains safe free space on the HDD.

3.3.6 Users (Security) Option

Authorized access can be configured to support individual user IDs as well as user groups. The Users tab in the Options window contains a list of two types of User Groups. By default, there is a single user named Admin, and this individual user is part of the Administrators group. Password security for user levels is determined during the EyeD install. If password security was disabled during the install, then no password will be required to access the Options tab and components.

The default password for the Admin user is: 752762. This is the number sequence resulting from dialing the word ***PLASMA*** on a telephone keypad.

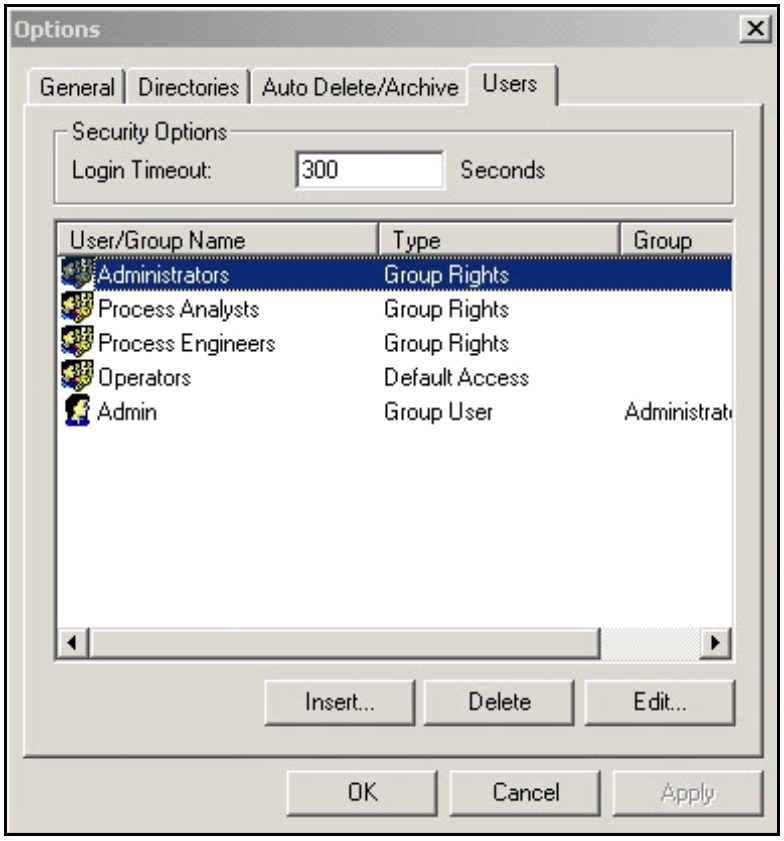


Figure 3-41. Default Users

New users or groups can be added using the Insert button at the bottom of the window. The Edit button allows existing groups to be renamed and rights changed. There must be at least one user with administration rights, so if Admin is not desired as a user name, it can be renamed or deleted once another user has been inserted with administrative rights.

When a new user is added, or an existing one is edited, the Properties dialog is displayed to allow specification of the access list entry. The new entry requires a record type specification, either as User, Group, or Custom.

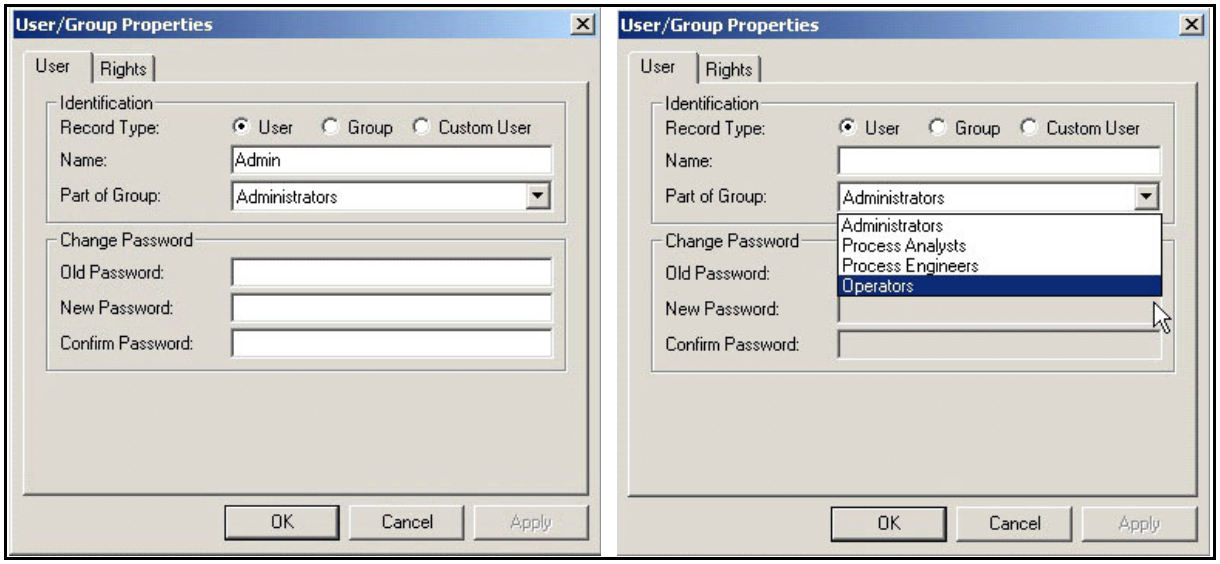


Figure 3-42. User Record Properties Tabs

A name is required and a group designation is required if the Record Type entry is User (See the Part of Group drop menu in Figure 3-42). A password may need to be entered.

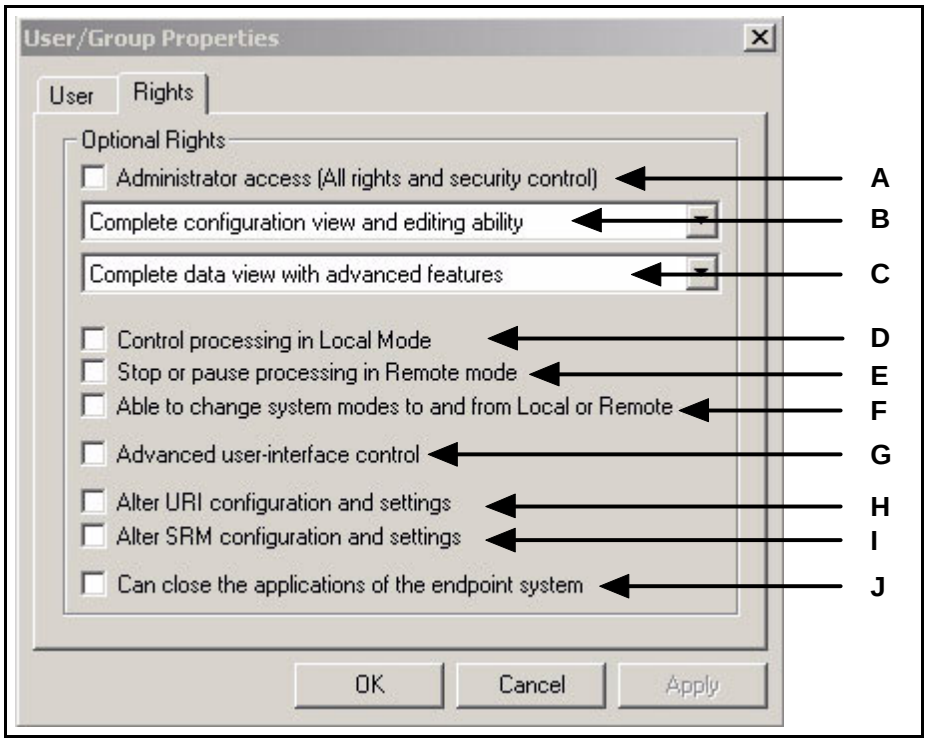


Figure 3-43. User Rights Tab

Selecting the Rights tab allows the setting of access privileges for a group or a custom user type.

The following selections can be made from options available under the Rights tab:

A. If checked, all options are enabled. In addition, administration functions such as setting user rights are enabled. Administration rights should be given only to the people who are responsible for the tool. Advanced users can be given all capability except administration rights, providing full access with the exception of the Tools' Options dialog box.

B. Configuration file access level for this user/group is set here.

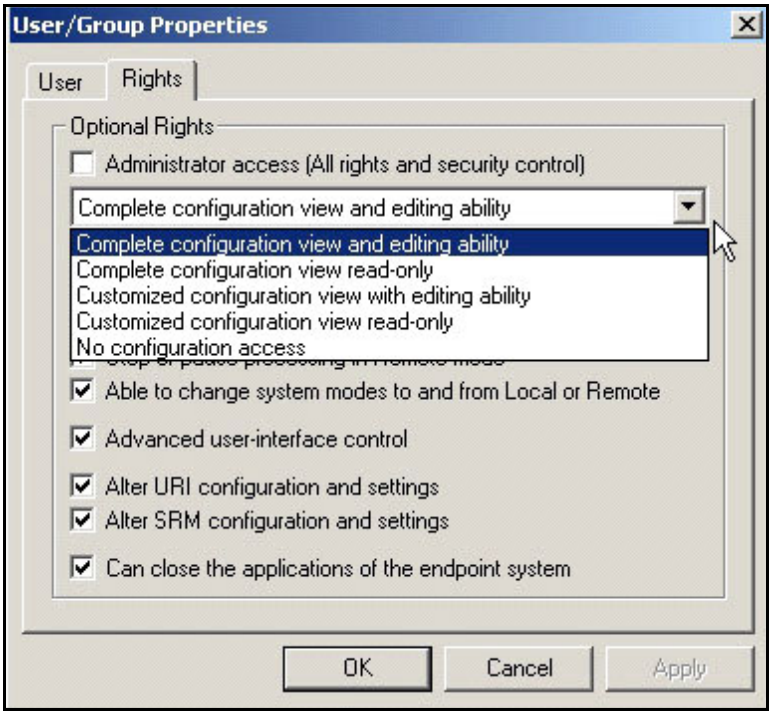


Figure 3-44. Configuration Access Drop Menu

C. Rights for access to data files are set here.

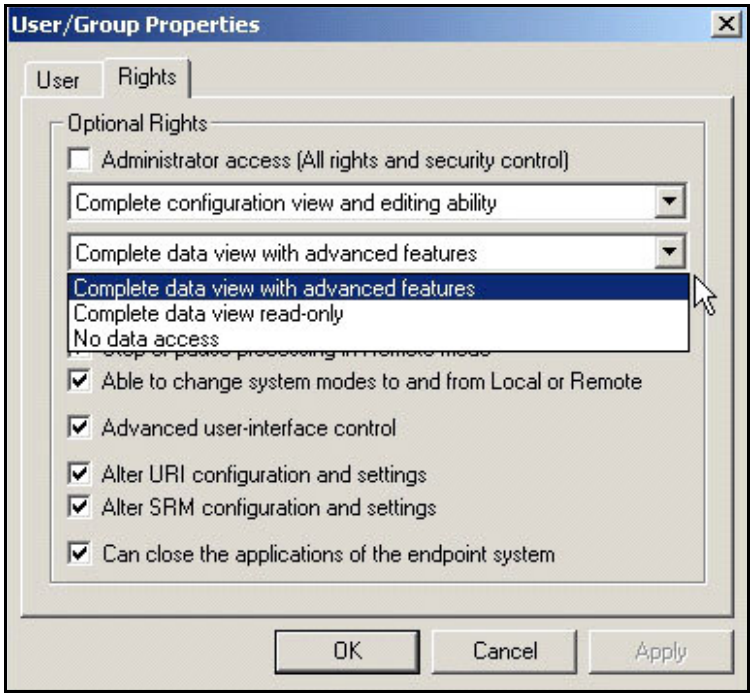


Figure 3-45. Data File Access Drop Menu

D. If checked, this setting allows the user/group to manually operate the system in local mode.

E. If checked, this setting allows the user/group to stop or pause processing when in remote mode.

F. If checked, this setting allows switching between Local and Remote modes.

G. If checked, this setting allows the user/group to hide or show docking windows or change the toolbars.

H. If checked, this setting allows URI settings to be altered.

I. If checked, this setting allows SRM settings to be altered.

J. If checked, this setting allows the user to close any part of the system.

3.4 Operation Modes

The operation modes available in the EyeD software application include Local and Remote. Each operation mode dictates how the system runs and what triggers the process to start. Local mode allows the user to manually create and edit EyeD configurations for use in any one of three Run states (Monitor, Capture, and Process) or two Review states (Review and Reprocess). Remote mode is for fully automated operation in a production environment



Figure 3-46. Selecting Local or Remote Mode from Button Toolbar

Figure 3-46 shows the representative button bar icons for switching between Local (the hammer and wrench icon) and Remote (the satellite dish icon) modes. These modes also are accessible by selecting Local or Remote from the System menu. The word Local or Remote appears in the middle of the Status Bar at the bottom of the EyeD window, indicating the active operation mode.

3.4.1 Local Mode

Local mode is the initial start-up mode of the EyeD software. The user, with password permission, has complete manual control of the system to:

1. Collect and see spectral data in real-time
2. Review previously collected data
3. Create and store configurations, the unique sets of instructions for EyeD to collect, process, display, analyze, and store spectral data
4. Switch to Remote mode for fully automated operation
5. Run the system using the current configuration in one of the Run states, Monitor, Capture, and Process

Local mode is commonly used for developing endpoint detection routines that later will be used in production runs in Remote Mode. In Local Mode the configuration selected as Current will be the only configuration executed.

3.4.2 Remote Mode

Remote mode is for endpoint detection in a production environment. Start (including configuration selection) and stop are triggered by messages received by EyeD from the tool. This communication can take place through a variety of Eye-D supported interfaces. Endpoint and other events are signaled back to the process tool through the same means of communication by the application computer.

3.5 EyeD Operating States

The EyeD software operates in one of several user-selected states: Review, Reprocess, Monitor, Capture, and Process. The Review and Reprocess states operate on stored data, while the Monitor, Capture, and Process states operate in real-time during data collection.

The current state displays on the Status Bar to the right of the Local or Remote operation mode identifier.

3.5.1 Review State

Review is the idle state that EyeD enters into after initial start-up. All other states return to the Review state once execution stops, and all data animation returns to this state. In Review state, the system can perform advanced data interrogation, including editing equations and configurations, altering the visibility of objects in the MDI graph windows, or adding data sources.

The configuration of memory varies depending on how the Review state is entered. After start-up and before running in another state, an existing stored configuration must be selected or a new one created. When any other state stops running, EyeD maintains this configuration as the current configuration upon return to Review state.

Opening a data file in Review state loads the original configuration, which was stored with the data file header at the time the data was collected. The original configuration is used for inspection of the selected data file, which appears in the Review state as if it had just been completed. The last spectra from the data sources appear in the MDI Spectral Graph window, while the complete trends and event markers appear in the MDI Trend Graph window.

3.5.2 Reprocess State

Reprocess allows the current configuration to be tested with data from a previous run. This state is only available when reviewing a data file. By choosing to reprocess the file from the Review state, the data in the file loads with the current configuration designated in Review state, NOT the configuration stored with the data. The Reprocess state then processes equations and endpoint sequences, if available, using data saved in the file instead of live spectrograph data.

3.5.3 Run States

The Monitor, Capture, and Process states receive spectral data from the EyeD system and deal with the data in real-time. For this reason, these states are collectively referred to as Run states.

- The Monitor state graphically displays real-time spectra in Spectral Graphs and trends in Trend Graphs without saving the data.
- The Capture state does everything that the Monitor state does, and saves the spectral data and the corresponding EyeD configuration to a file.
- The Process state performs the same functions as the Capture state, but also analyzes the data to search for endpoint in real-time. This search is conducted using a sequence defined within the EyeD configuration. If no endpoint exists, this state performs the same function as the Capture state. See section 3.5.11, sequence definition.

These states (Monitor, Capture, Process) appear on the Status Bar to indicate the Run method. Review appears on the Status bar when the EyeD application is not running. A copy of the current configuration is loaded when the run starts. Saving the configuration will modify the configuration file, but will not affect a run in progress, as the configuration file is only read at the start of a run.

Figure 3-47 shows the Run State Button Toolbar representations (the lightning bolt followed by an alphabetic designator) for the Monitor (M), Capture (C), and Process (P) Run states. The user can also select System from the Menu toolbar followed by the state itself.



Figure 3-47. Run State Button Toolbar

The run states of Monitor, Capture and Process are discussed throughout the remainder of this section.

3.5.4 Monitor State



Monitor state allows the viewing of spectral information without saving the data. This is the simplest spectrograph run state and can be used to verify that the EyeD system is working properly once shipment of the device has been received. A Monitor state can be used to first view spectra from the EyeD system prior to manually capturing or processing the data.

The current configuration displays real-time spectrograph readings in the Monitor state.

At anytime while EyeD is running in Monitor state, the user can:

- Pause
- Stop
- Start the Capture state
- Start the Process state

Switching states will reset graphs, reload the current configuration, and may create the data file. Data file creation depends upon the use of Capture or Process states.

The Pause button is a toggle between pause and continue. The first click on the pause button suspends EyeD data monitoring and graph generation. A second click on the Pause button resumes data monitoring and writing to the existing graphs. If any other button is clicked, EyeD will first execute a Stop and then execute the action associated with that button.

Pressing the Stop button interrupts the state being executed and returns EyeD to the Review state. The graphs retain data displayed prior to the stop. Restarting any Run state causes the current configuration from the Review state to be reread. Setting up this new configuration automatically clears the graphs.

Once the execution is stopped, available options will be limited as no data file was created to recalculate or view scans. If capturing or processing is requested, the graphs are reset, the system creates a data file and the parameters of the new state are asserted.

Clicking the Capture icon when in the Monitor state causes EyeD to begin saving spectral data coming from the EyeD.

Clicking the Process icon when in Monitor state also begins saving data coming from the EyeD. Equations are always calculated in the current configuration and will be applied to EyeD data in real-time. The same configuration continues to define graphs.

3.5.5 Capture State



The Capture state performs the same processing functions as Monitor (Equation execution; Graph Display & Update) and records spectra (and/or trends) to a data file. These activities are performed in accordance with the settings of the selected current Configuration. EyeD automatically creates a data file name based on the root data path and Local Mode file name template defined in Tool-->Options-->Directories. A unique run number may be assigned in the case of file name duplication. When the collection is stopped, the data file is closed following a save of the configuration settings.

The user can stop data capture or change to the Monitor state at any time during the Capture state. If execution is stopped, the graph windows in the Run state will enter into the Review state. Clicking the Monitor icon while in the Capture state resets graphs and continues data capture and display, but it does not save data. The data file that was previously created will be considered the current data file, and this can be reopened at a later time.

3.5.6 Process State



.This state allows the system to process the endpoint sequence while the run is taking place. This state is the only one that uses the endpoint sequence configuration to refer to equations during real-time data acquisition. The Process state loads the current configuration and automatically creates a data file when the run begins. In this state, the system continues to process spectral data until the run is stopped or the maximum runtime for the sequence expires.

3.6 Configuration Attributes

3.6.1 Overview

The entire set of instructions for collecting spectral data and analyzing it in real-time is contained in the Configuration. In EyeD, this file of parameters is the core component of a process step.

The Configuration file that has been set as current in EyeD is used to process when the application is under manual control (Local Mode), or the required Configuration is loaded at the time data collection is begun automatically (Remote Mode). Similarly, a selected Configuration can be used to Reprocess a stored data file to see the same results that would have been produced had that Configuration been used at the time the data was collected. This is useful for improving the performance of an endpoint algorithm by making incremental changes to a configuration and observing the results while reprocessing an historical data file.

The Configuration handles all three of the tasks involved with optical endpoint detection:

1. Control of the spectrograph for the collection of spectra and sending those spectra to EyeD.

2. Perform calculations and tests based on the most recent spectrum (and previously collected spectra) for the purpose of generating a trend chart that correlates to the progress of the process and displays a recognizable endpoint transition when the process is complete. These calculations start when the average spectrum arrives

from the spectrograph, and all of these real-time calculations must be complete before the next spectrum arrives.

3. Perform various tests on one or more trend charts calculated in real-time to search for the endpoint transition and sending the endpoint signal to the process module to stop the process when that transition is found.

The information contained in the Configuration is organized and stored under nine topic headings. The topic headings are displayed in the Configuration column on the left of the configuration window as seen in Figure 3-48.

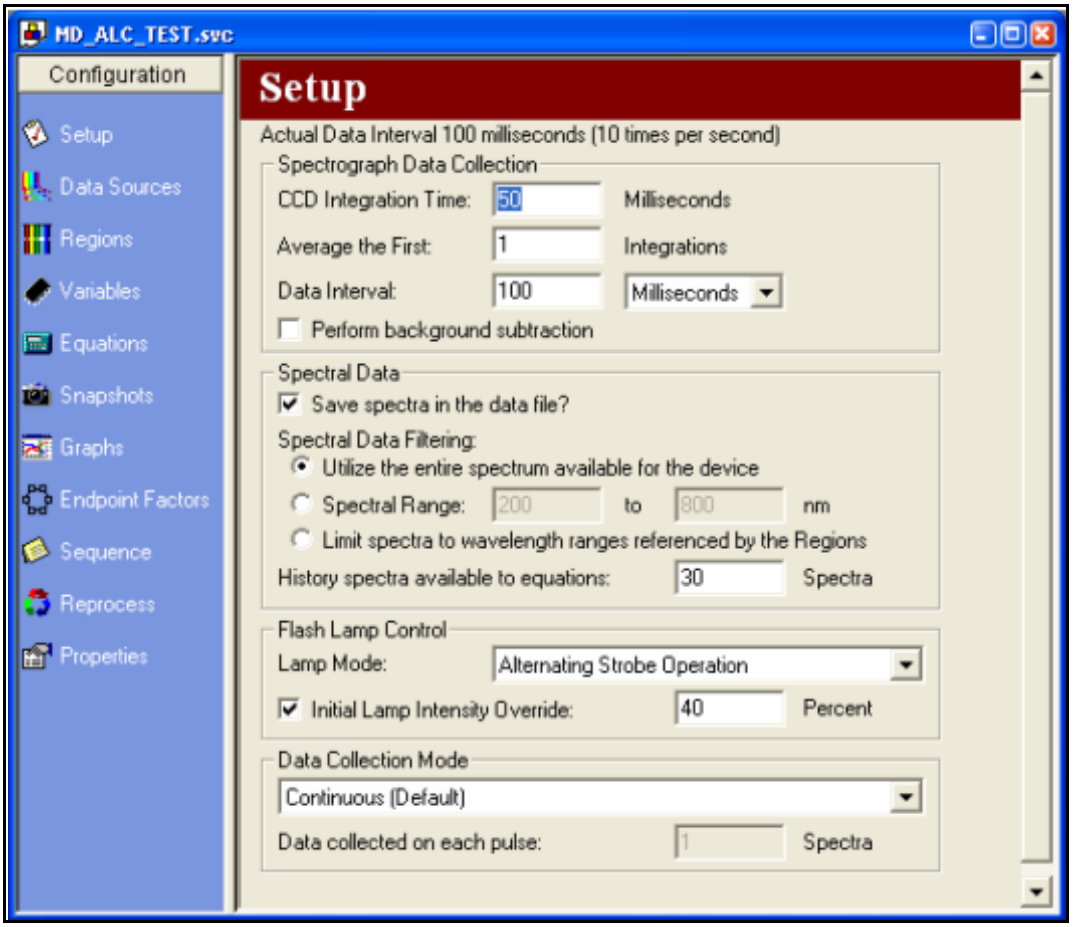


Figure 3-48. Configuration Components

The top-to-bottom order of the topics displayed in the list corresponds to the order in which the instructions are executed by EyeD in real-time.

1. **Setup -** contains all of the instructions and settings for real-time operation of the spectrograph (and flashlamp when used) and handling the data sent to EyeD. The set of instructions in the Setup are executed once at the beginning of a data collection run or at the reprocessing of a data file. See Section 3.6.4, Setup.

2. **Data Sources -** define of all of the sources of spectra-both real-time spectra from one or more spectrograph channels, or historical spectral data files. See Section 3.6.5, Data Sources.

3. **Regions -** define specific parts of the spectrum over which the pixel intensity count will be converted from spectra (a vector) to a single value (a scalar) such as the average intensity, or maximum intensity in the region (See 4.5.5 Regions).

4. **Variables -** are defined in the configuration for use in both Equations and the Sequence. A variable enables the use of Equations (evaluated in real-time), based on tests results that are performed in the Sequence (See 4.5.6 Variables).

5. **Equations -** are listed in the order in which EyeD will evaluate them after receiving each new spectrum (See 4.6 Equations). Equations can operate on

   a. one or more spectra to produce another spectrum (Spectral Equation)

   b. a defined spectral Region to convert the intensities in the region to a single value, such as the average intensity (Region Equation)

   c. one of more scalar values to produce a single scalar value (Trend Equation)

   d. an Advanced equation combine many computational steps to achieve objectives. For example: one of the advanced equations, Neural PCA, selects in one step, those wavelengths that change most at endpoint and combines those wavelengths to produce an endpoint trace. Without this advanced equation, it would require a great number of standard equations to generate the same endpoint trace.

6. **Snapshots -** will capture one spectrum from the stream of real-time spectra at the specified time. The Snapshot spectrum can be used in real-time calculations (See 4.7 Snapshots).

7. **Graphs -** enable the display in real-time of any spectra (Spectral Graph) and calculated scalar values (Trend Graph). Each graph defined in the configuration is updated after all of the Equations have been calculated following the receipt of each spectrum in real-time (See 4.8 Graph Types).

8. **Endpoint Factors** - Enable a configuration to access event database for creating *backup* endpoint functions based on statistics.

9. **Sequence -** is a list of tests that are performed one after the other (in sequence) on the calculated results following the completion of all real-time calculations (#5 through #7 above). Any number (from zero to all) of the tests in the sequence can be satisfied following the completion of the real-time equations on the latest spectrum received. A primary function of the sequence is to recognize the endpoint transition in a specified trend graph and declare endpoint to stop the process module (See 4.9 Sequence Definition).

10. **Reprocess -** specifies the path to one or more data files or directory of data files to be reprocessed. (See 4.10 Reprocess List).

11. **Properties** - displays history information relating to the configuration file (.svc) being used (See 4.11 Configuration Properties Window).

3.6.2 Order of Functions in EyeD

EyeD performs activities in the order the icons appear on the EyeD Configuration Window. Setup, Data Sources, Regions, and Variables are defined only once at the beginning of a

EyeD run. Equations, Snapshots, Graphs, and Sequence activities are performed each time a new spectrum arrives at EyeD.

Setup parameters are sent to the spectrograph one time when EyeD receives a start command, which is received when the Monitor, Capture, or Process icons are selected while in Local mode. In Remote Mode operation (the usual production environment), the start command is received from the process module.

After Setup parameters are sent, Data Sources are defined - then Regions are defined - and then Variables are defined.

The above activities are performed only once at the start of each EyeD run. Below are activities that are performed immediately after each new spectrum arrives at the EyeD PC.

1. When a new spectrum arrives, Equations are executed first, and are executed in the order listed in the Equations window. After an equation is executed, the starting value for that equation is replaced with the newly calculated value. It should be remembered that old equation values are being replaced with newly calculated values as EyeD works down the list of equations.

2. Snapshots are taken after completion of all the Equations, if the specified time for the snapshot has been reached. The spectrum stored in a Snapshot will change only once at the specified time in the EyeD run.

3. Graphs are updated next, using the current values of Spectra, Regions, Variables, Equations and Snapshots.

4. Sequence execution is the last activity performed on each new spectrum as it arrives. EyeD performs these tests and commands one time for each spectrum - in the order they appear in the Sequence Window. If the sequence test is successful, execution progresses down to the next line in the Sequence and performs that test. This continues until a sequence line item fails. EyeD will hold at that line item and begin execution there again when the next spectrum is received and the above Equations, Snapshots, and Graphs are completed for that new spectrum.

5. Therefore, when a new spectrum arrives, EyeD repeats the above process, starting with Equations and ending with the Sequence. When EyeD progresses to a line item in the sequence that includes a Stop command, the run ends and EyeD returns to an idle state.

If EyeD reaches an impasse or runs out of instructions at the end of the sequence list, the application will default to the idle state, in which it is waiting for the next spectrum to arrive.

3.6.3 Configuration Validation

EyeD has a built-in validation mechanism that checks each configuration (*.svc) file for errors. When Validation is selected, this mechanism checks the open (selected) configuration for self-consistency and other errors. If a fatal error is found, an error message will appear and the specifics of the Error listed in the Output window. Non-fatal errors are listed as Warnings. A configuration that contains Warnings but no Errors can still be used. However, EyeD will not operate if the applied configuration contains one or more Errors.

Validation is automatically performed each time a configuration is saved and, in addition, can be performed manually by selecting this function from the Edit menu. Although an error containing configuration can be saved, it cannot be used until the errors are corrected. When no errors are found, Validation will display the text: Validation - 0 errors, 0 warnings found. This text is found in the Output window.

3.6.4 Setup

The Setup screen provides a list of parameters, which the spectrograph will apply while processing the raw spectra. These are fundamental settings that affect the way spectral data is collected with the spectrograph and fed into the EyeD instance for analysis.

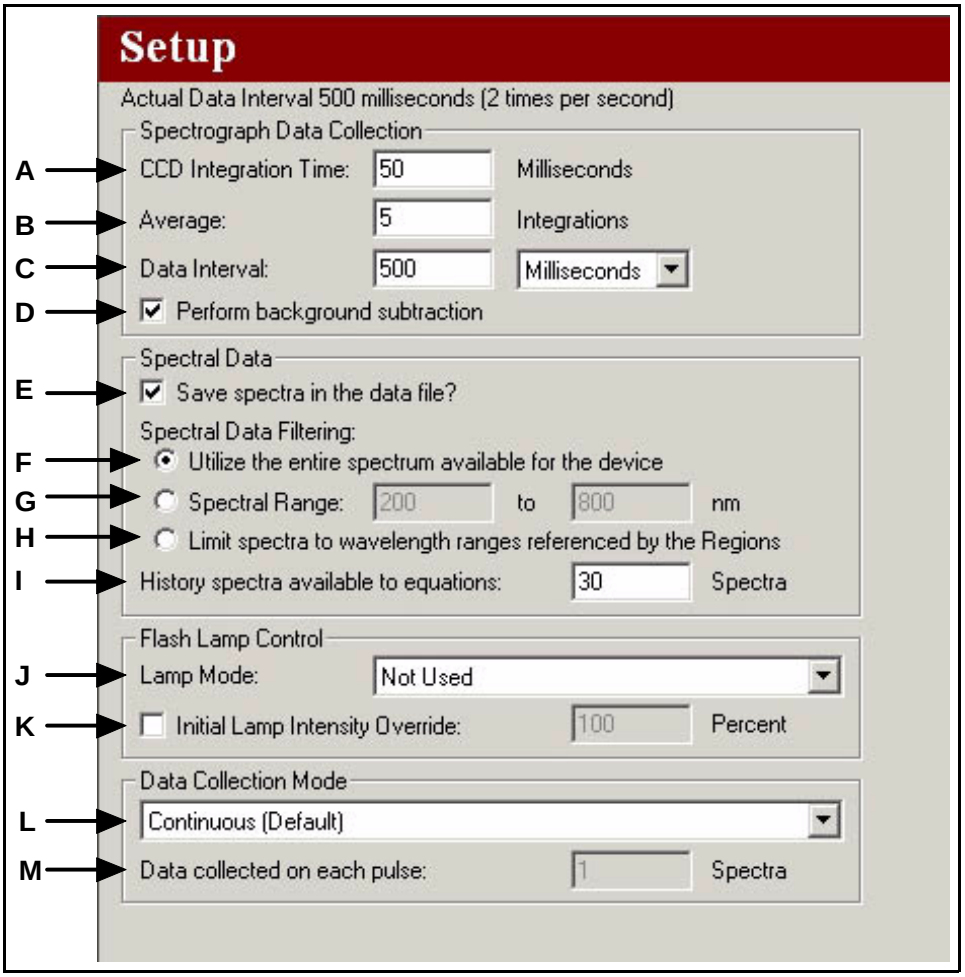


Figure 3-49. Setup Fields

A. This field sets the length of time, in milliseconds, that the CCD will integrate the electrical charge produced when light strikes the pixels. The longer the integration time, the more charge will accumulate on the CCD. See Chapter E, CCD Integration Process. Each integration produces one full spectrum.

B. This sets a number of integrations (spectra) to be averaged by the spectrograph to produce one spectrum. The first spectra in the series of spectra collected during the Data Interval are averaged.

C. The Data Interval specifies the period of time the average spectrum will be sent to EyeD. The time can be defined as a number of integrations or milliseconds.

- Integrations - this number specified must be greater than or equal to the value of B.
- Milliseconds - for Continuous Strobe or Not Used flash modes, this number must be greater than or equal to the value of (A x B). It is recommended that the interval time be an integer multiple of the integration time (A).

For Alternating Strobe flash mode, this number of milliseconds must be greater than or equal to (2 x A) x B. It is recommended that the interval time be an integer multiple of twice the integration time (2A).

NOTE

AGC requires millisecond setting for interval timing.

D. Background Subtraction should always be checked for OES algorithms so that CCD background noise will be subtracted from the spectra. IEP algorithms should not use background subtraction.

E. By removing the check from this box, data files will not retain full spectra. This will produce a much smaller data file that retains trend data from the run.

F. Selecting this button automatically accepts a full spectrum from 200nm to 800nm for inclusion in the data files from the run.

G. In these fields, the upper and lower limits of the spectrum that will be collected and sent to EyeD are defined. The shortest wavelength in the spectrum is entered on the left. A wavelength of 200 nanometers is the low limit of the system. The setting on the right is the upper limit of the spectrum, and 800nm is the longest wavelength that can be collected with this system.

H. This selection will allow storage of spectra for only those regions defined in the Regions list of each configuration. See Section 3.6.6, Regions. The data file produced during process will be reduced in size because data from the excluded wavelengths will be discarded. However, neither will this data be available for later reprocessing of data files for analysis. When the data files are viewed, wavelengths outside of the stored regions will appear with zero (0) intensity.

I. This sets the number of spectra to be stored in system RAM memory for use in real-time calculations during the run.

J. This drop menu provides settings for Flashlamp use. See Section 3.6.21, Automatic Flash Lamp Intensity Control.

K. This setting will override the lamp intensity setting that has been stored in the SD1024 spectrograph for the FL2002 flashlamp, allowing EyeD to set a percentage for the initial intensity.

L. This setting allows a continual collection of data, or pulsed collections for rotational or alternately flashed collections. (FUTURE)

M. Sets the number of spectra to be collected in a pulsed collection. (FUTURE)

3.6.4.1 Disable Background Subtraction

Background subtraction is ideal for equalizing single-source signals, but can cause interpretation problems with the virtual input of synchronous flashlamp operations. By default, EyeD enables background subtraction when an endpoint configuration is not using alternately flashed spectra.

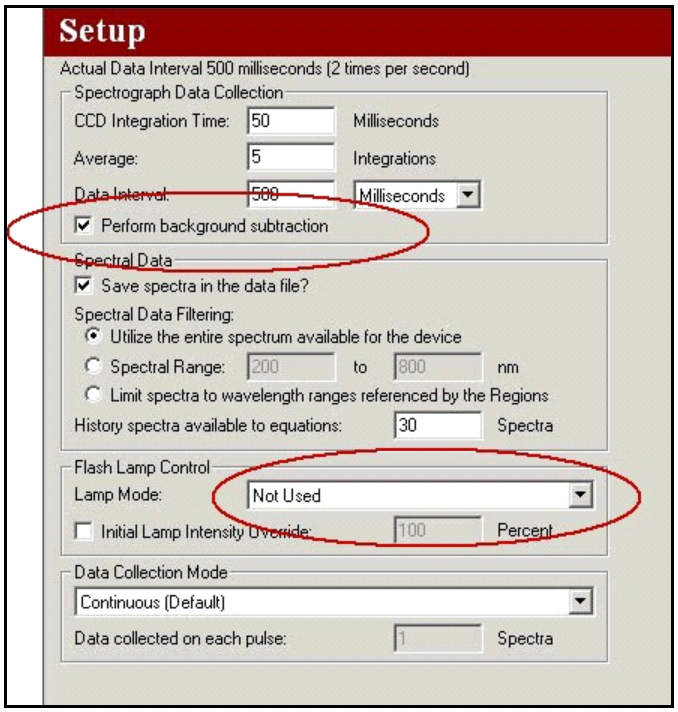


Figure 3-50. Background Subtraction Default

When Flashlamp Mode is selected, the background-subtraction function is automatically turned off.

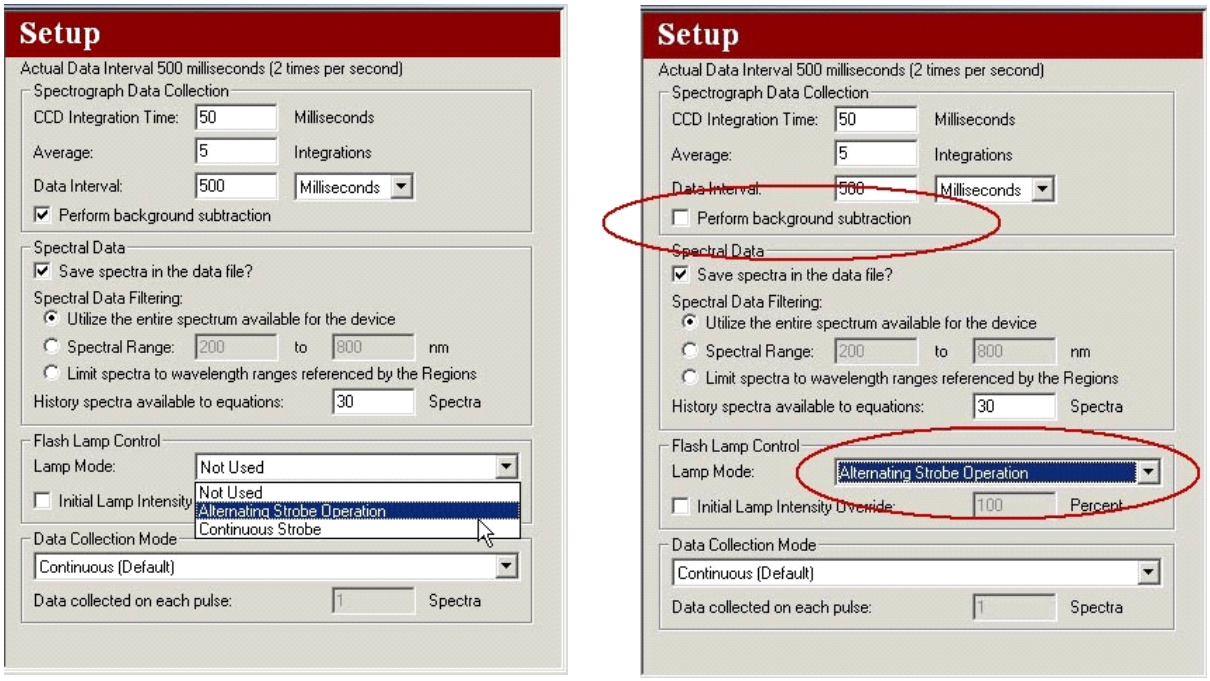


Figure 3-51. Background subtraction deselected

In OES only configurations, background subtraction is used to better compare the most dynamic portions of the spectral graph.

3.6.4.2 Flashlamp Control

In most flashlamp configurations, the spectrograph directly controls the flashlamp through a 9-Pin D-sub connection labeled J6, while EyeD supplies instructions to the spectrograph via selections made in the configuration file.

To configure the system for flashlamp operation, complete the following steps:

1. Open the EyeD application and select a configuration file to be used for this process. Select Setup from the Configuration menu.
2. From the setup window, move to the Flash Lamp Mode combobox and select a method for flashlamp operation.

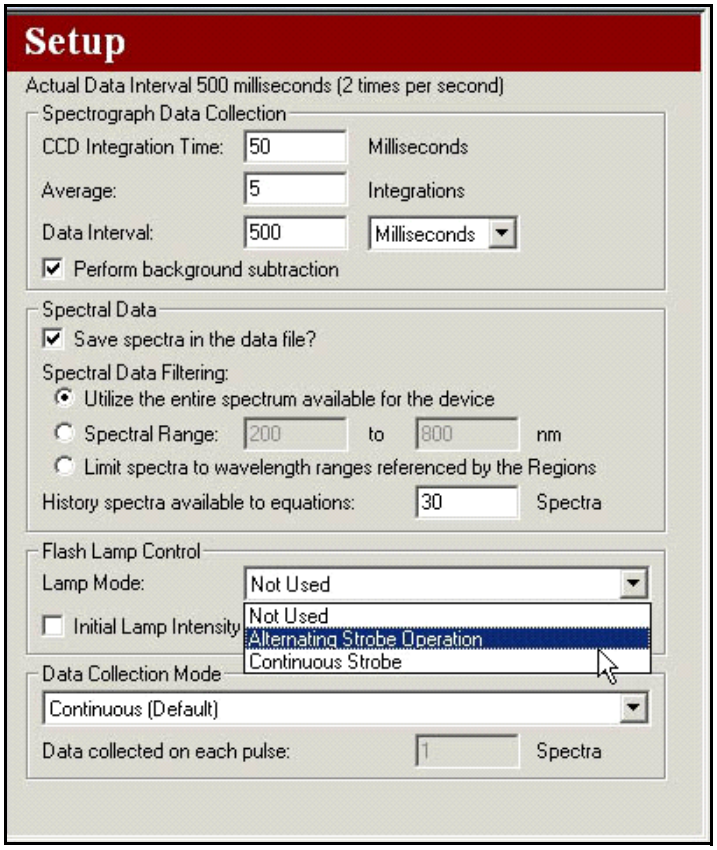


Figure 3-52. Flashlamp Mode Selection

3. Selecting Continuous Strobe operation configures the flashlamp to fire with every averaged integration. Alternating Strobe Operation creates two different data streams, one with the flashlamp on and another with the flashlamp off. The second sampling, without the flashlamp's contribution, is read by the EyeD application as a virtual fiber optic channel.

4. Selecting alternating strobe operation will bring up a warning window, alerting the user that a virtual data source will be added to the configuration. Select Yes in this window.

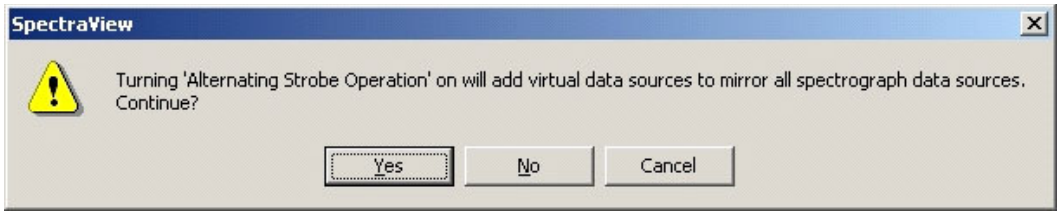


Figure 3-53. Alternating Strobe Alert

By selecting the Data Sources icon from the Configuration window, data sources will include source A, comprised of samples taken with the flashlamp on. Source A2 is displayed as a virtual fiber, although this data source is simply data gathered

without the flashlamp, coming in on the same fiber as A-source data, but in alternate samplings.

NOTE

If the Data Interval is set in milliseconds instead of integrations, the single-source time limit should be doubled to accommodate alternating strobe sampling.

5. Select Data Sources from the left to view the virtual input.

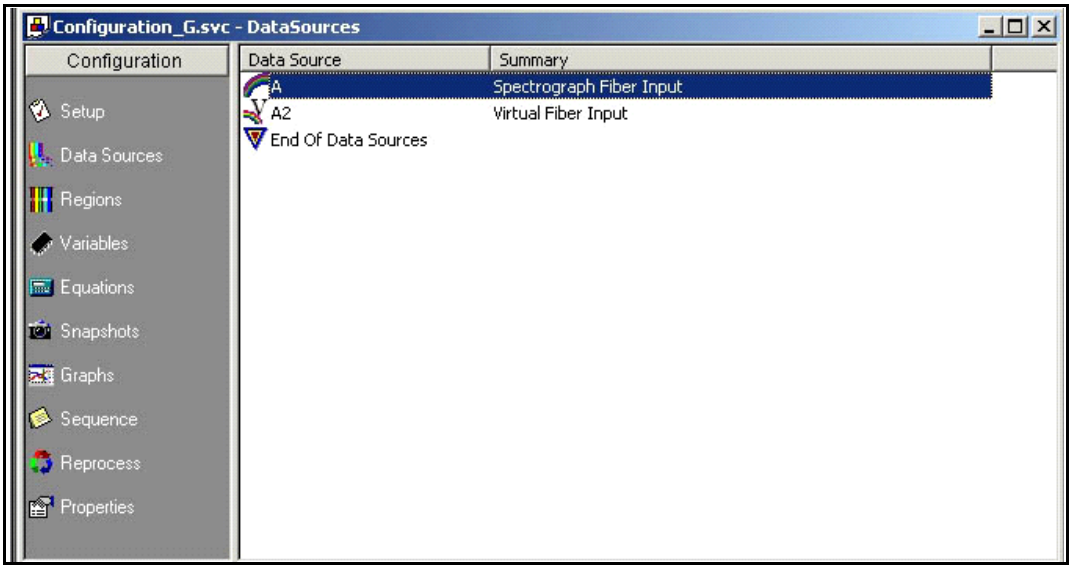


Figure 3-54. Data Sources Window

6. To manipulate data using these sources, an equation of some type is required. Select the Equations icon and right click in the white space of the equations window.

7. The Insert Equation window will pop up. Select the type of equation to be entered. Example: for background subtraction, select Insert Equation and Spectral Equation.

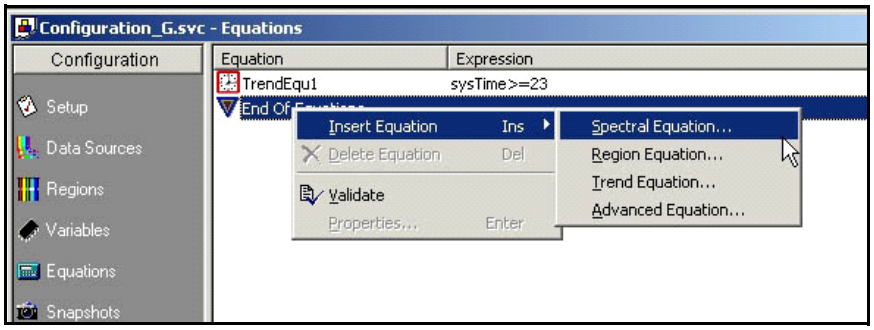


Figure 3-55. Inserting an equation

8. The Spectral Equation Properties window will appear. Type a name for this new equation in the first field.

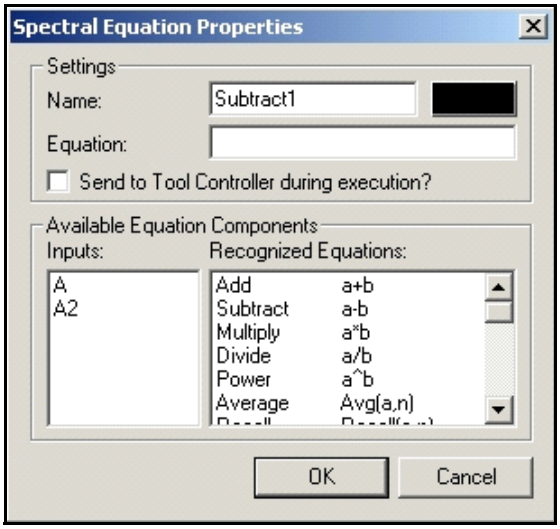


Figure 3-56. Spectral Equation Properties Window

9. To direct the spectrograph to perform background subtraction, leaving only flashlamp-induced spectra, the data stream from the unflashed spectra should be subtracted from the flashed samplings. This is done by typing **A-A2** in the equation field.

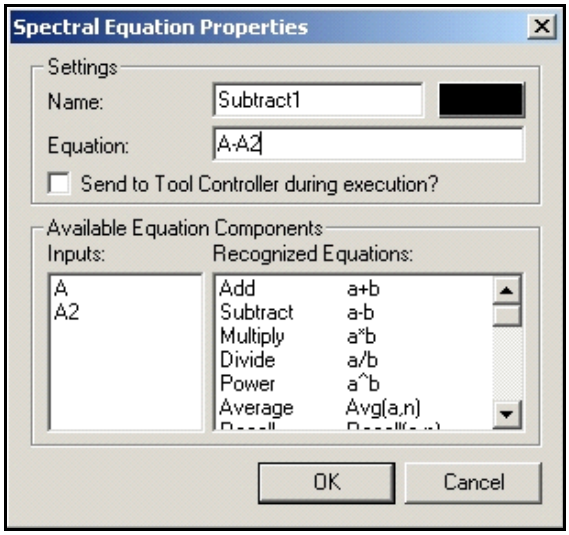


Figure 3-57. Equation Field

10. Select **OK**.

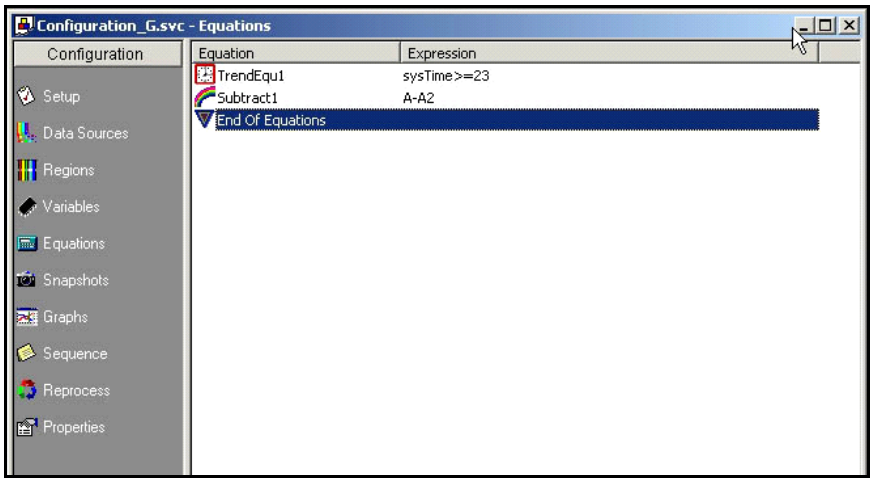


Figure 3-58. Equations Window

The new equation now is listed as part of the configuration file.

3.6.4.3 SRM Control of Flashlamp Intensity

SRM can be used to control flashlamp intensity when used in conjunction with a flashlamp system comprised of a spectrograph and FL2002 flashlamp combination. Embedded code allows SRM to serve as an interface to monitor and adjust this intensity during processing.

Use the following steps to engage this function.

1. Make sure the Spectrograph and FL2002 flash lamp are on and connected to the Endpoint Computer.
2. Start SRM (Start Programs Endpoint Detection Spectra Manager). If you have not already done so, add an entry for the EyeD instance that will be communicating with the spectrograph/flashlamp system (see Section 5.3.1, Spectra Resource Manager Setup or Section 7.3.1, Spectra Resource Manager Setup.).

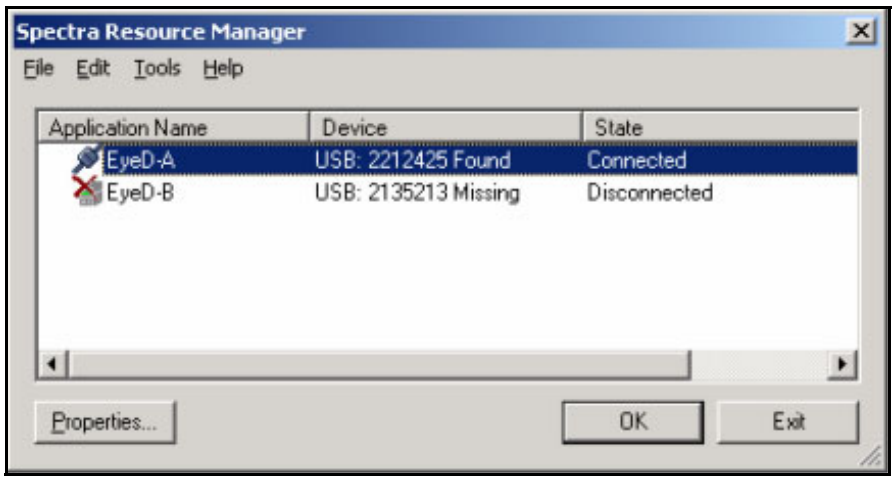


Figure 3-59. Select EyeD Instance

Flash intensity is read and changed only for the spectrograph\flashlamp system that is associated with selected Instance of EyeD. Using the wrong instance of EyeD could cause intensity settings to be made on the wrong hardware system in multiple unit configurations.

Flash intensity control is independent of the method used for communication, so both Ethernet and USB are supported.

3. Select Flash Intensity Control from the Tools menu (Tools Device Administration Adjust Flash Lamp Intensity).

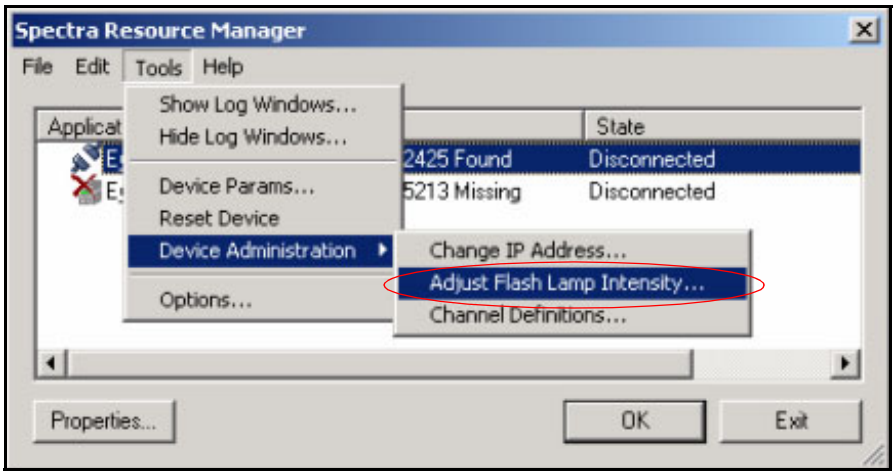


Figure 3-60. Select Adjust Flash Lamp Intensity

This should bring up the flashlamp adjustment window.

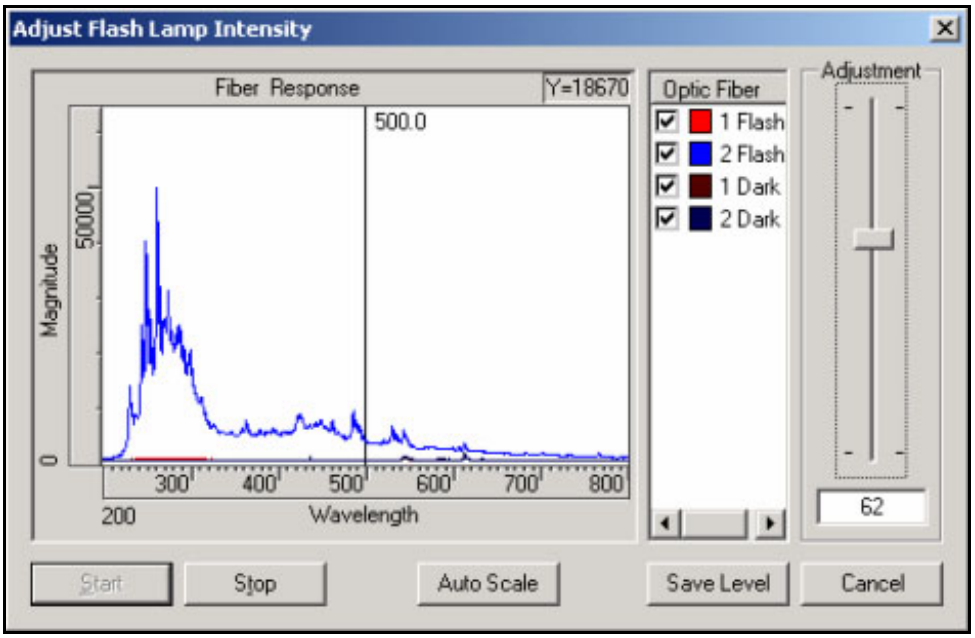


Figure 3-61. Adjust Flash Lamp Intensity

From this window, data collection can be started and stopped to find the best adjustment for the flashlamp intensity, which is set at the far right side of the window. In the Adjustment field on the far right side of the window, position the cursor over the box in the center of the vertical slide bar, depress the left mouse button and move the mouse up or down to set intensity. If the flashlamp is off or is not connected, the options shown in Figure 2-75 will be grayed out and unavailable.

There are no options to change Integration settings or Data Interval, which must be done in EyeD. The Integration time is fixed at 125ms, the Interval is 250ms, and the strobe activity is continuous. All Spectral data sources available are displayed and may be turned on or off with the checkboxes found under Optic Fiber listings.

Spectra are shown in terms of Channel Numbers, just as reported by the Spectrograph. There is no alphabetic number-to-letter mapping performed.

4. The Auto Scaling is off by default, since intensity level is usually related to saturation. Adjusting the scale automatically can mask wavelength saturation. However, based on multiple channels, it may be necessary to compare signal levels, thus the need for scaling.

5. Selecting Start will bring up a warning window. Select Yes in this window to continue.

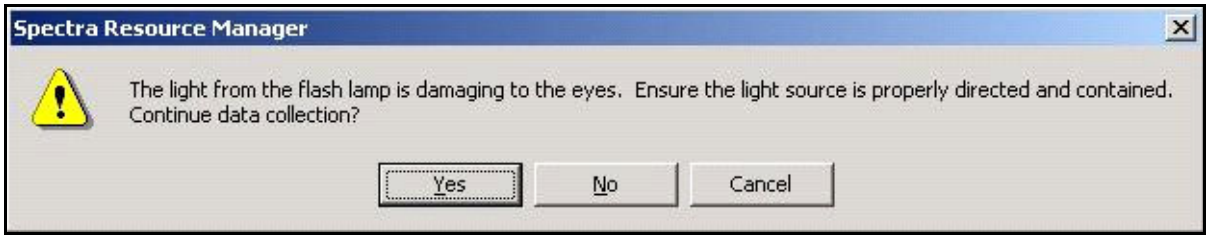


Figure 3-62. Warning Window

6. The slider at the far right of the adjustment window should now be moved up or down to set the intensity in single percent increments.

7. Once the desired level has been achieved, use the Save Level button to save changes.

Settings below 35 percent cannot be saved due to hardware manufacturer's limitations and recommendations for performance. An attempt to do so will bring up a separate warning window (see below).



Figure 3-63. Default Intensity Warning

8. Once the new settings are saved, they are permanently stored in the spectrograph embedded code. Since this is stored in the spectrograph, the spectrograph and flashlamp are no longer interchangeable. If the FL2002 or spectrograph is replaced, this adjustment step needs to be performed again.

3.6.5 Data Sources

The Data Sources window lists all fiber optic inputs to spectrographs connected to the EyeD system. In addition, virtual input sources can be established for certain pulsed data and flashlamp operations.

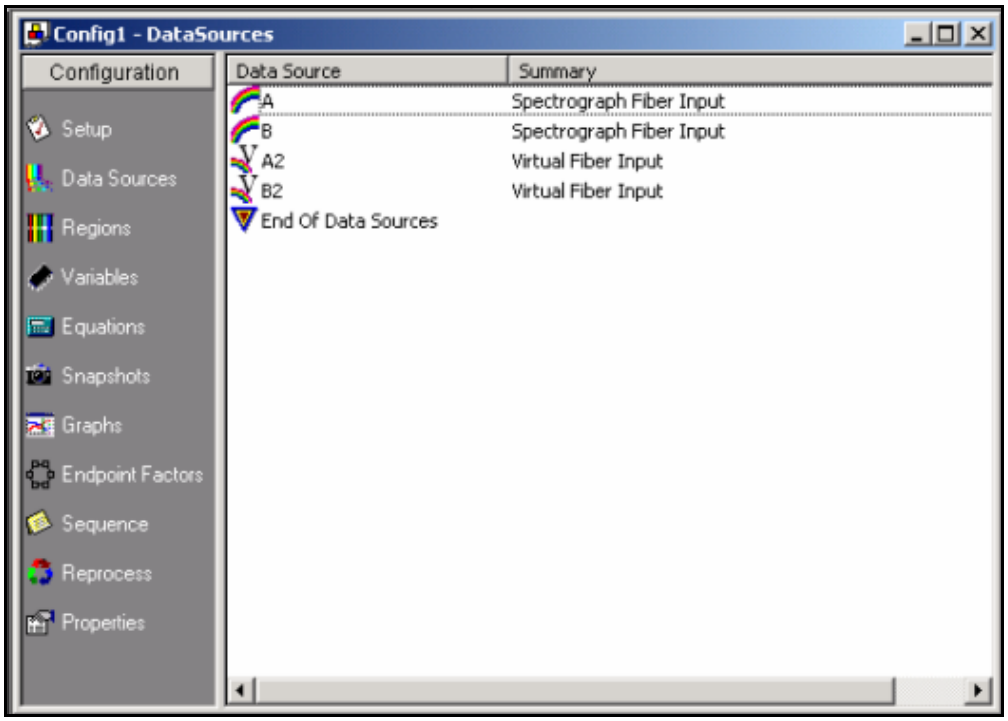


Figure 3-64. Data Sources

3.6.6 Regions

The Regions tool is a method for identifying wavelength regions of the spectra that are of interest. Since the SD1024D-2-s and SD1024DL have an optical resolution of 1.7nm, even very narrow atomic spectral emission lines will have an apparent width in the spectrum reported by the detector. Pixels on which the spectral line is imaged would be summed (or averaged) in the CCD plane to monitor the intensity of such a spectral line. A unique name

must be assigned to each spectral region for later reference. There is no practical limit to the number of regions that can be identified in the spectrum.

A typical example would be to isolate a peak at 400nm. The average peak intensity from 399-401nm could be determined and subtracted from it the average intensity of adjacent peaks (397-399nm and 401-403nm). In this manner, the background oscillation could be eliminated.

Regions are defined as a center point and bandwidth. See Figure 3-65.

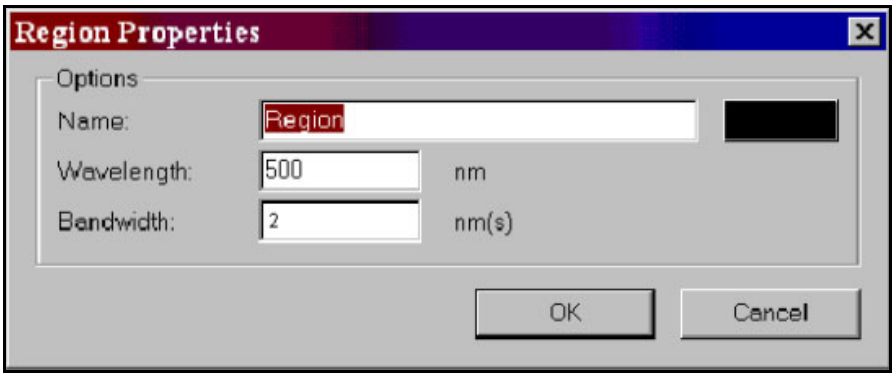


Figure 3-65. Setting up a Region

3.6.7 Variables

A variable provides a means to take test results or changes detected in the sequence and communicate these to equations that are recalculated by EyeD between receiving each spectrum. A variable can be used to change an equation outcome based on conditions detected during the sequence. It can also be used to pass information between configurations of different process steps.

The Variable selection, allows a value or an equation scalar to be derived during the process sequence and be applied to calculations involved in subsequent processing. To accomplish this, a Variable with a unique name must be defined in the Configuration. This is done by selecting the Variables choice from the Configuration list at the left. This should show a list of all variables that have been established for the current Configuration file.

There are five preset variables in a new configuration. These include:

- **SysSpectr**a - the number of spectra received (one per data interval) by EyeD since the start signal was received. This count begins at integer 1.
- **SysIndex** - the number of data intervals since the start signal is received. This count begins at zero (0).
- **SysTime** - is a product of the System Data Time and the Collected Samples number, which is the number of the last spectral sample received since the beginning of the run.
- **SysDataTime** - EyeD reads this time stamp from the spectrograph and indicates the instant the spectrograph began collecting data.

- **SysCpuUsage** - During processing, this is the average CPU usage from the last one (1) second. During reprocessing, this is the percentage of the time required to perform the data analysis on a spectrum, relative to the data interval used in collecting the spectrum. This can indicate a problem in overtaxing the system during a reprocessing run.

The following steps are one example for setting up the Variable function:

1. Right click on the End of Variables icon at the bottom of the list and select Insert Variable to begin creating a Variable with a unique name.

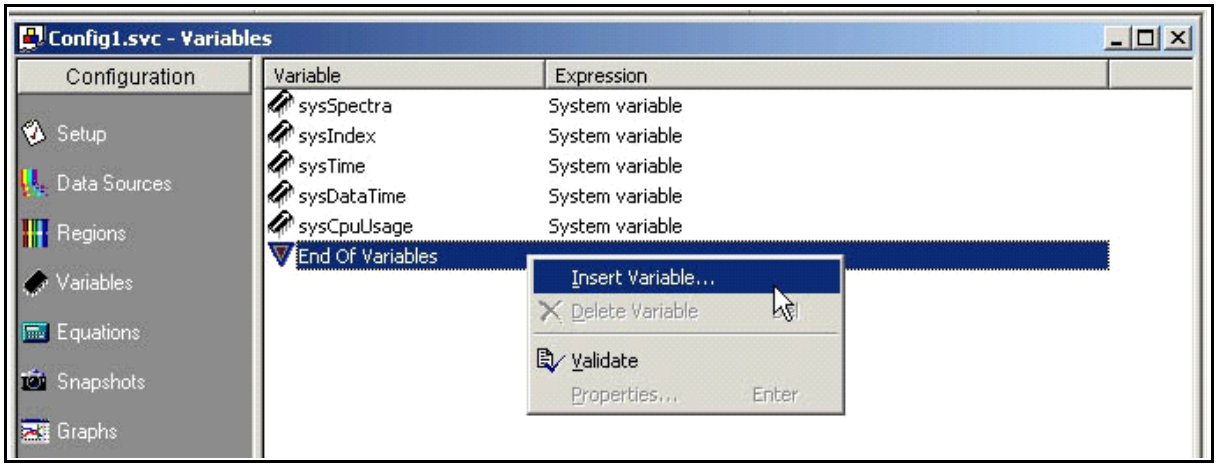


Figure 3-66. Insert Variable

2. The Variable Properties window appears. Enter a unique name for this Variable. A common naming convention is Var1, Var2, etc.

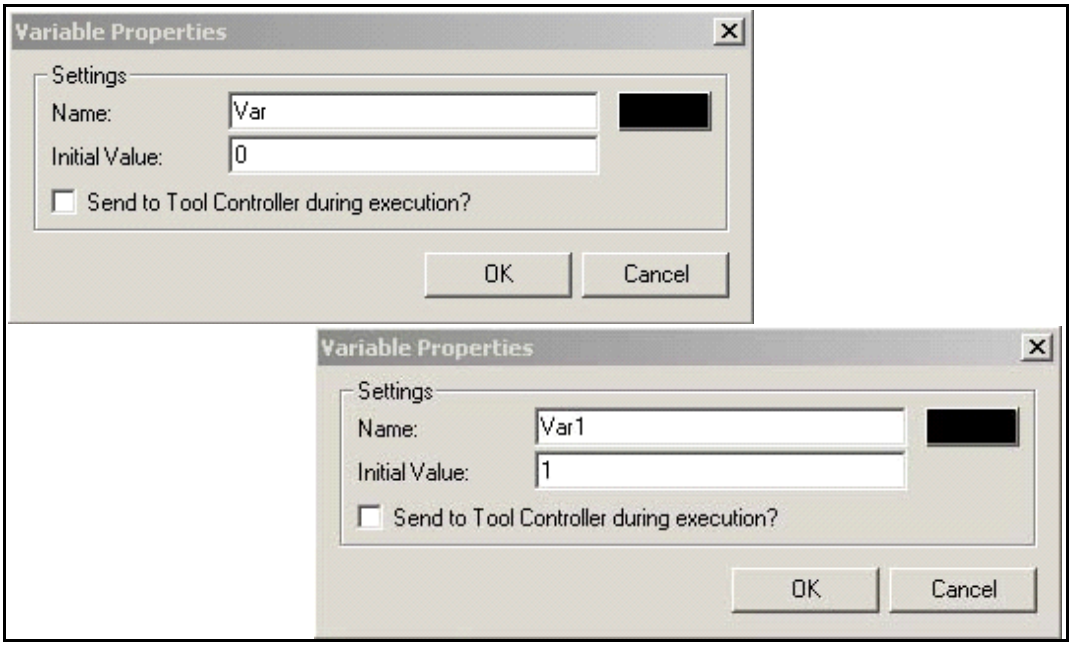


Figure 3-67. Variable Properties Window

3. The default initial value is 0. Enter another number if this variable is to be used for division, or if a number that more closely approximates subsequent process results is required.

4. A checkbox provided allows the Variable value to be sent to the mainframe during execution. (300mm only)

5. Select **OK** to show the uniquely named variable in the list.

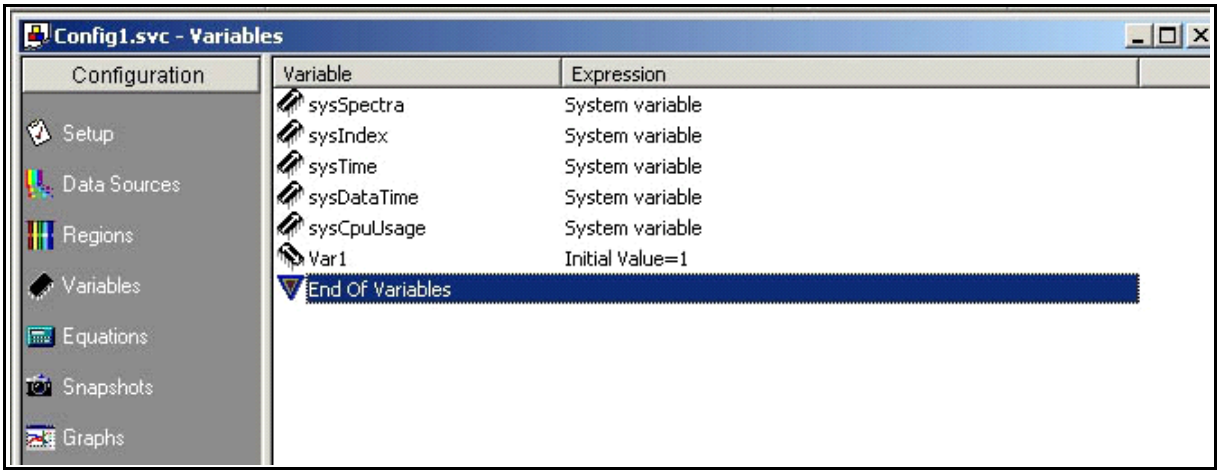


Figure 3-68. Variables Listed

6. The value of the Variable can be changed with the Set Variable command in the Sequence (See 4.9.8 Set Variable).

3.6.8 Equations

NOTE

EyeD executes equations in the order they are specified in the equation list section of the associated configuration. If an input to this equation is a trend, and it is defined after this equation, the value used from that trend will be the previous one it calculated. The first time the trend is asked for data, the last value it has will be the default value since it has not had a chance to calculate anything yet. The default value is usually 0 and that can produce unexpected results or even errors in this equation. Care should be taken to set the default value of trend equations sensibly and to ensure that trend equations are calculated in the correct order.

A spectral vector (or array) from the SD1024 detector is a numerical intensity for each 1/2-nanometer wavelength from 200nm to 800nm. Therefore, spectral data provided by the detector will always have a row of 1,201 numerical intensities listed for each of the 1/2-nanometer increments in the 200-800nm range. Any scalar (single numerical reading) in the vector shows the light intensity reading for the wavelength at the corresponding point along the spectral range. Looking across all the scalars in this vector, the intensity reported for every wavelength during the most recent CCD integration can be determined.

NOTE

The SD1024 spectrograph provides spectral data for every 1/2-nanometer. The SD2048, however, provides a readout for every 1/4-nanometer in the range, creating 2,401 individual numerical intensities in a spectral vector.

EyeD can collect and store the spectrum (each of the optical vectors) received from the spectrograph in chronological order. This data file is a table (or matrix) with each column representing a wavelength. The 1,201 columns represent the series of wavelengths 200.0, 200.5, 201.0 ... 799.0, 799.5, 800.0nm. Each row in the matrix records the spectral intensity of each wavelength collected during one integration of the CCD. Looking down any column of the matrix, the change in intensity at that wavelength can be seen over time.

To deal with these spectra produced several times a second, EyeD equations process each spectrum as it is received from the detector. Four types of equations exist in the EyeD software: Spectral Equations, Region Equations, Trend Equations and Advanced Equations. This section discusses each equation type in the order that EyeD applies them to spectral data.

It is important to understand that, when requested, EyeD stores both the equations and the raw spectral vectors in the order they were collected. The real-time performance of a run can be recreated by recalculating Spectral, Region, Trend, and Advanced Equations. A matrix of the original spectra produced by the spectrograph is compiled in this process.

3.6.8.1 Spectral Equations

The term value or a and b in this table can indicate either a scalar or a spectrum (vector). At least one of the values used in a spectral equation must be a spectrum. When both values are spectra, both spectra must be the same size. A spectral equation always returns another spectrum the same size as the starting spectrum.

When the arguments a and b of a spectral equation are both spectra, the spectral equation operation is applied to the intensity values one wavelength at a time. The result is placed in the same wavelength in the new spectrum.

For example, if

$$a = (a_1, a_2, \ldots a_{1201})$$

$$b = (b_1, b_2, \ldots, b_{1201})$$

then

$$a + b = (a_1 + b_1, a_2 + b_2, \ldots, a_{1201} + b_{1201})$$

When one of the arguments of a spectral equation is a scalar, the spectral equation operation is performed by applying that scalar to the intensity values of the spectrum one wavelength at a time. Each result is placed in the same wavelength in the new spectrum.

For example, if

$$a = (a_1, a_2, \ldots, a_{1201})$$

b = scalar value

then

$$a + b = (a_1 + b, a_2 + b, \ldots, a_{1201} + b)$$

When only one value appears in a spectral equation, the value must be a spectrum.

For example, if

$$a = (a_1, a_2, \ldots, a_{1201})$$

then

$$Abs(a) = (|a_1|, |a_2|, \ldots, |a_{1201}|)$$

3.6.8.2 Spectral Equations List

Table 3-2. Spectral Equations

Function	Definition	Written As
Add	Sum two values.	a+b
Subtract	Subtract second value from the first.	a-b
Multiply	Multiply two values.	a*b
Divide	Divide second value into the first.	a/b
Power	Value a raised to the power of b.	a^b
Average This equation cannot use a previously defined spectral equation, but the formula of that spectral equation can be reentered as part of this equation.	Sums the current (ak) and previous n-1 values (ak-1,… ak-n+1) of a and divides by n regardless of the actual number available. A ramping effect is evident until n number of data points is available to the function. If n<k then $\bar{a} = \frac{1}{n}\sum_{i=k}^{1} a_i$ If n>k then $\bar{a} = \frac{1}{n}\sum_{i=k}^{k-n+1} a_i$	Avg(a,n)

Table 3-2. Spectral Equations

Function	Definition	Written As
Recall* This equation cannot use a previously defined spectral equation, but the formula of that spectral equation can be reentered as part of this equation.	The Recall(a,n) spectral equation returns the spectrum a fixed number (n) of samples ago. Recall(a,0) will return the current spectrum. Recall(a,1) will recall the previous spectrum. The value of a can be a complex expression. For example, Recall(Avg(a,5)+b/c,2) is acceptable where at least one of the variables a, b, and c must be a spectrum. The Recall(a,n) spectral equation operates similar to the Recall2(a,n) trend equation. At the start of the run, the first spectra is returned. Once n+2 spectra have been collected, the function will return the spectra that is the nth spectrum prior to the current spectra. This is intended to return a representative spectra during the startup period.	Recall(a,n)
StdDeviation This equation cannot use a previously defined spectral equation, but the formula of that spectral equation can be reentered as part of this equation.	StdDeviation provides the value of the standard deviation found in the latest n samples of the spectrum a. A ramping effect is evident until n number of data points is available to the function. $\left(\frac{1}{n-1}\sum_{i=k}^{k-n+1}(a_i-\bar{a})^2\right)^{\frac{1}{2}}$ where $\bar{x}=\frac{1}{n}\sum_{i=1}^{n}x_i$ If n<k then $\bar{a}=\frac{1}{n}\sum_{i=k}^{1}a_i$ If n>k then $\bar{a}=\frac{1}{n}\sum_{i=k}^{k-n+1}a_i$	StdDev(a,n)
Shift	Takes all data points that comprise a spectral graph (a) and shifts them n units to the right (greater). A negative n will shift left (lower). Units are dependent upon the resolution of the spectrograph being used. Common is ½ nm per unit, but high-resolution instruments move ¼ nm per unit.	Shift(a,n)
Max	The resulting value is the largest value for either a or b. During execution, at any given time, this function may return a or b.	Max(a,b)

Table 3-2. Spectral Equations

Function	Definition	Written As
Min	The resulting value is the smallest value for either a or b. At any time during execution, this function may return a or b.	Min(a,b)
Modulo	Returns the remainder of the division of b into a. if b divides evenly into a then 0 is returned. If not, then the remainder is the resulting value. The resulting vector will contain the remainders from dividing b into a, one element at a time.	Mod(a,b)
Abs Val	If a is 0 or higher, then the result is a. If a is negative, then the result is made positive.	Abs(a)
Floor	Floor rounds the value for a to the nearest integer less than a. If a is 133.33333333 then Floor(a) is 133.	Floor(a)
Ceiling	Ceil rounds the value for a up to the nearest integer above a. If a is 133.33333333 then Ceil(a) is 134.	Ceil(a)
EXP	Performs the exponent function on the value for a.	Exp(a)
LOG10	Performs the log10 function to the value for a.	Log10(a)
LOG	Performs the log function to the value for a.	Log(a)
Sqrt	Results in the square root of the value for a.	Sqrt(a)
TAN	Performs the trigonometry function tangent to the value a.	Tan(a)
ATAN	Performs the trigonometry function arctangent to the value a.	Atan(a)
ASIN	Performs the trigonometry function arcsine to the value a.	Asin(a)
ACOS	Performs the trigonometry function arccosine to the value a.	Acos(a)
COS	Applies the cosine function to value a.	Cos(a)
SIN	Performs the trigonometry function sine to the value a.	Sin(a)

**Spectral equations that use historical spectra (Recall, and Avg2) have a special requirement on the Setup screen of the configuration. To manage computer memory efficiently, only the spectra actually used for real-time calculations are maintained in memory, and older spectra are stored to disk. It is important that the Setup screen specifies a number of history spectra equal to or greater than the number required by the spectral equations in use. Specifying too few history spectra will cause the Recall, and Avg2 functions to return incorrect results. A good rule of thumb is to set the number of history spectra at the same time one of these functions is added to the configuration. For example, if Setup History Spectra = 5 and Spectral Equation Avg2(A,15) is used, the moving average will be performed using only the five spectra available in history instead of the 15 spectra requested.*

3.6.8.3 Region Equations

The Region Equation operates on each named region (See Section 3.6.6, Regions), and the numerical values for these wavelengths can be averaged, added, or the minimum, maximum, etc. calculated to provide a single value to assign to the region. Sum, average, minimum and maximum are the only operations available for Region equations. These simple operations reduce the spectral data to a single trend line for use in other calculations. In this way, Region

Equations are the building blocks of Trend Equations. The result of a Region equation is always a scalar.

3.6.8.4 Trend Equations

Table 3-3. Commands to EyeD Equation Parser for Trend Equations

Function	Definition	Written As
Basic Operators (Follow algebraic precedence and return a scalar result)		
Add	Sum two values.	a+b
Subtract	Subtract second value from the first.	a-b
Multiply	Multiply two values.	a*b
Divide	Divide second value into the first.	a/b
Power	Value a raised to the power of b.	a^b
Basic Functions	(Return Result)	
Average	Simple moving average Sums the current (a_k) and previous n-1 values (a_{k-1},… a_{k-n+1}) of a and divides by n regardless of the actual number available. A ramping effect is evident until n number of data points is available to the function. If n<k then $$\bar{a} = \frac{1}{n}\sum_{i=k}^{1} a_i$$ If n>k then $$\bar{a} = \frac{1}{n}\sum_{i=k}^{k-n+1} a_i$$	Avg(a,n)

Table 3-3. Commands to EyeD Equation Parser for Trend Equations

Function	Definition	Written As
Average 2	Special Moving Average Sums the current (ak) and previous n-1 values (ak-1,… ak-n+1) of a and divides by n or the actual number of historical a values available, whichever is smaller. The ramping effect evident in Avg(a,n) does not apply to this function. If n<k then $$\bar{a} = \frac{1}{k}\sum_{i=k}^{1} a_i$$ If n>=k then $$\bar{a} = \frac{1}{n}\sum_{i=k}^{k-n+1} a_i$$ NOTE: Noise suppression from averaging increases as the number k approaches n, so early graph points can exhibit more noise distortion.	Avg2(a,n)
Recall	The Recall(a,n) function returns the value of a, a fixed number (n) of samples ago. Recall(a,0) will return the current value of a. Recall(a,1) will recall the previous value of a. The value of a can be a complex expression. For example, Recall(Avg(a,5)+b/c,2) is acceptable because the entire history since the start of the run of the calculated variables a, b, and c are stored in memory. The Recall function will return zero until the required number of historical samples are available. For example, Recall(a,5) will return zero as the first five samples are received and the value of a is calculated. As the sixth sample is received, the value of a is calculated and the Recall(a,5) function will return the a value calculated from the first sample (five samples ago).	Recall(a,n)
Recall 2	Works like Recall but will return the first data point ever evaluated for a until n+2 points exist. Recall(a,5) returns the very first value for a until there are seven data points. The second value is returned at that time. Recall2 functions exactly like Recall after the number of available historical values is greater than n+1.	Recall2(a,n)

Table 3-3. Commands to EyeD Equation Parser for Trend Equations

Function	Definition	Written As
IIR_Filter	The Infinite Impulse Response filter will smooth a trend equation by adding a portion of the last smoothed data signal (Sk-1) to the complimentary fraction of the current data point (ak). Sk = p * Sk-1 + (1-p) *ak where p = $\frac{\%}{100}$ As the value of % increases, more weight is given to the last smoothed signal value and less weight applied to the current data point. The result is more smoothing of the signal and greater delay or phase shift of the smoothed signal relative to the input data. The valid range for the % value is 0.0 to 99.999. The IIR smoothing function sometimes can cause an oscillation in the trend line, requiring adjustment of the IIR Filter criteria.	IIR(a, p)
Scale as Percent	ScalePct will normalize a trend equation using the average value of the trend equation between two points in time. The trend equation a is averaged from time t1 through t2. Starting at t2, the values of the trend equation a will be divided by the average and multiplied by the value of target. Acceptable values are 0<target=100. This can be helpful in instances of progressive window clouding.	ScalePct(a,t1,t2,target)
StdDeviation	StdDeviation provides the value of the standard deviation found in the latest n samples of the equation a.	StdDev(a,n)
Max	The value returned is the largest of the values for either a or b.	Max(a,b)
Min	The resulting value is the smaller value of either a or b. At any time during execution, this function may return a or b, whichever is the smaller value.	Min(a,b)
Modulo	Returns the remainder of the division of b into a. If b divides evenly into a then zero is returned. If not, then the remainder is the resulting value. Example: Mod(100,25) is zero. Mod(100,24) is 4.	Mod(a,b)
Delta	From the current value of a, this function subtracts the value of a from n values ago.	Delta(a,n)
Abs Val	If a is = 0, then the result is a. If a is negative, then the result is made positive.	Abs(a)
Floor	All values are real or floating-point numbers in the system. Floor rounds the value for a to the nearest integer less than a. If a is 133.33333333 then Floor(a) is 133.	Floor(a)
Ceiling	All values are real or floating-point numbers in the system. Ceil rounds the value for a up to the nearest integer above a. If a is 133. 33333333 then Ceil(a) is 134.	Ceil(a)
EXP	Performs the exponent function on the value for a.	Exp(a)

Table 3-3. Commands to EyeD Equation Parser for Trend Equations

Function	Definition	Written As
LOG10	Performs the log10 function to the value for a.	Log10(a)
LOG	Performs the log function to the value for a.	Log(a)
Sqrt	Results in the square root of the value a.	Sqrt(a)
SIN	Performs the trigonometry function sine to the value a.	Sin(a)
COS†	Applies the cosine trigonometry function to value a.	Cos(a)
TAN†	Performs the trigonometry function tangent to the value a.	Tan(a)
ASIN†	Performs the trigonometry function arcsine to the value a.	Asin(a)
ACOS†	Performs the trigonometry function arccosine to the value a.	Acos(a)
ATAN†	Performs the trigonometry function arctangent to the value a.	Atan(a)
†All trig functions assume the angle is in units of radians (2p radians = 2x3. 1416 radians = 360 degrees)		
Comparison Operators‡ (Return 1 or 0)		
‡These are helpful for true-false expressions in if, then, and while expressions.		
Greater Than	Returns true (1. 0) if a is greater than b, otherwise returns false (0.0).	a>b
Greater Than or Equal	Returns true (1.0) if a is greater than or equal to b, otherwise returns false (0.0).	a>=b
Less Than	Returns true (1.0) if a is less than b, otherwise returns false (0.0).	a<b
Less Than or Equal	Returns true (1.0) if a is less than or equal to b, otherwise returns false (0.0).	a<=b
Equals	Returns true (1.0) if a equals b, otherwise returns false (0.0). Either "==" or "equals" can be used.	A==b, a equals b
Not Equal	Returns true (1.0) if a is not equal to b, otherwise returns false (0.0). Either "!=" or "not" can be used.	A!=b, a not b
Comparison Functions (Return 1 or 0)		
Is Above?	Returns true (1.0) only if a is greater than t, otherwise, returns false (0.0).	IsAbove(a,t)
Is Below?	Returns true (1.0) only if a is less than t, otherwise, returns false (0.0).	IsBelow(a,t)
Is Near?	Returns true (1.0) only if a is within plus-or-minus r from t (with the range t ± r), otherwise, returns false (0.0).	IsNear(a,t,r)
Conditional Operators: (Return 1 or 0)		
And	Returns a true (1.0) only if both conditions, c1 and c2, are true. Otherwise, it returns false(0.0).	c_1&&c_2,c_1 and c_2

Table 3-3. Commands to EyeD Equation Parser for Trend Equations

Function	Definition	Written As
Or	Returns a true (1.0) if either condition is true. Otherwise, it returns a false(0.0).	c_1 || c_2, c_1 or c_2
Conditional Functions: (Return real numbers)		
Condition: a if c is true, else b	Returns a if the conditional expression c is true. Otherwise, b is returned. Note: In all conditional functions, only the value 0.0 will generate a false response. The conditional operator c is true whenever c is not equal to zero (sometimes written c!=0). For example, the conditional operator c is true if the value is (1.0), or (-0.8), or (0.3), or (-1.0). Only (0.0) is false.	Cond(c,b,a)
CondAvg only where c (a conditional expression) is true (?0)	Conditional Moving Average Performs the Avg function when trend equation c is true. If c is false (=0), then the current value for a is not included as one of the n (number of) data points in the moving average. The initial ramping affect can take longer to stabilize, because the conditional operator may cause some data to be ignored.	CondAvg(c,a,n)
CondAvg2 only where c (a conditional expression) is true (?0)	Conditional Moving Average 2 Like CondAvg but does not have a ramping affect because it functions in the same manner as Avg2.	CondAvg2(c,a,n)
CondAvg3 only where c (a conditional expression) is true (?0)	Conditional Moving Mean Performs a mean average function for trend a over the last n data points when the conditional expression c is true. If c is false (=0), then the current value for a is not included in the sum of data points in the moving average. The divisor for this calculation is the actual number of true data points included in the sum. If there are no true data points of a, the result is zero (0). As more false (0) data points are calculated, the signal grows more noisy and will eventually fall to zero if all data points of a are false. To avoid this, create a condition that will normally succeed, filtering out only unusual or undesirable artifact in the signal.	CondAvg3(c,a,n)

⚠ CAUTION

Caution: In conditional average equations, do not use a variable or a constant for c. Using anything other than a conditional expression, or a trend equation, for c can cause EyeD to graph erroneous results without sending an error message. This is because conditional operators have a history that can be used to complete the n number of samples.

Example 1 (using a conditional trend equation)

Trend1: "RegionEqu1 - RegionEqu2"

Trend2: "Trend1 > 0"

Trend3: CondAvg2(Trend2, Trend1, 10)

Example 2 (using an embedded conditional expression)

Trend1: "RegionEqu1 - RegionEqu2"

Trend2: CondAvg2(Trend1 > 0, Trend1, 10)

3.6.9 Adaptive Fringe Counter

The Fringe Counter is a method for evaluating the real-time evolution of an etch or deposit process by watching features change over time. To accomplish this, spectral data from a past run must be evaluated and manipulated to produce a trend with a simple sine-wave pattern that is indicative of fringe evolution (the converging and diverging of light waves) over time, which is caused by the changing thickness of the film.

Past versions of the Verity Fringe Counter algorithm relied on static constants for the time based parameters of: Ignore Time, Start Time, and Window Times, plus Min/Max oscillation periods. To provide additional flexibility and precision, the interface and algorithm will also support the use of an equation/variable result as the value of the associated time period.

Before continuing, it is important to state the restrictions and concerns that should be considered before changing from a constant value to a dynamic value:

- The Algorithm may be running, and Ignore Time may increase beyond current System Time. If this happens, the Input Data history will revert to zero length, and the algorithm will return zero until System Time once more exceeds Ignore Time.
- The Algorithm may be running, and Start Time may increase beyond current System Time. If this happens, the algorithm will return zero until System Time once more exceeds Start Time.
- The Window Time may increase faster than the system time. If this happens, and [(System Time) - (Ignore Time)] is positive, early data points that had been dropped will be added back to the Input Data history.

- EyeD executes equations in the order they are specified in the equation list section of the associated configuration. If an input to this equation is a trend, and that trend is defined after this equation, the value used will be the previous one it calculated. The first time the trend is asked for data, the last value it has will be the default value since it has not had a chance to calculate anything yet. The default value is usually 0 and that can produce unexpected results or even errors in this equation. Care should be taken to set an appropriate default value to trend equations, and to ensure that trend equations are calculated in the correct order.

The following figure indicated parameters available in the Fringe Counter setup window.

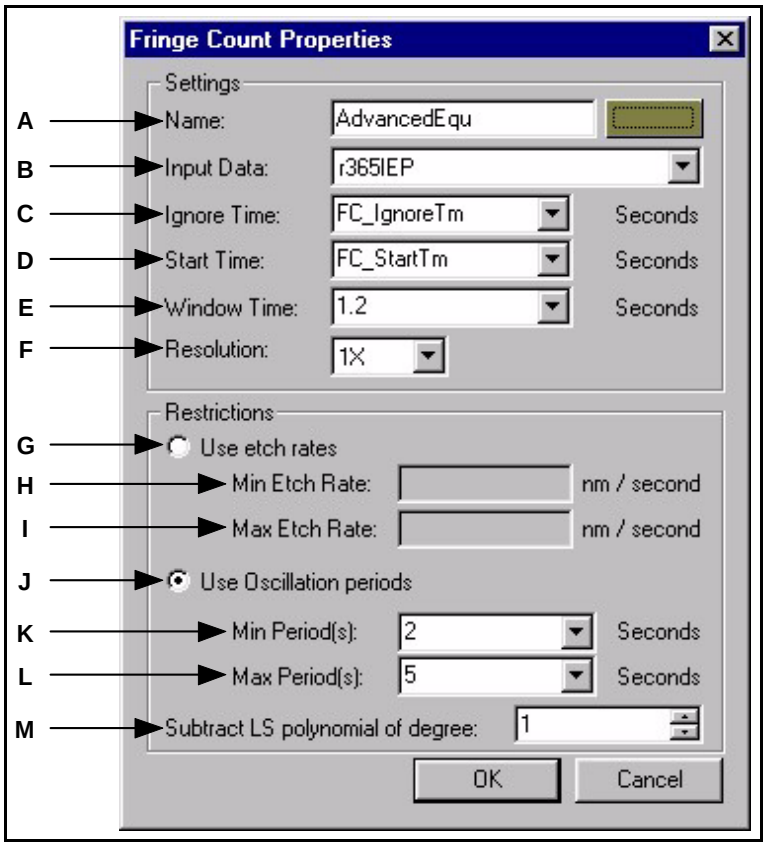


Figure 3-69. Fringe Count Properties

A. **Name:** Enter a unique name for the Fringe Count equation being created.

B. **Input Data:** This is the name of the region equation or trend equation that will be source of input data into this equation. As noted above, the input should have reasonably clean fringes.

C. **Ignore Time:** Is the time in seconds until the onset of fringes occurs. The equation value will be zero (0) during this entire period. The result of the selected equation, variable, or typed constant, must be a number >= 0.

D. **Start Time:** Is the time in seconds during which history data is stored, but no output data is calculated. This many seconds after the ignore time must elapse before output data is calculated and displayed. This value should be set so that at

least 1½ fringes of the input data are available before the output data for this equation is calculated. The equation value will be zero until this time has elapsed. The result of the selected equation, variable, or typed constant, Must be a number >0.

E. **Window Time:** Is the time in seconds (as determined by the specified constant, or result of the previously calculated equation, or variable) of the entire data sequence for which fringes will be counted. This value is relative to the ignore time and MUST be greater than the start time. If this window time plus the ignore time is = the current time, all of the values from this time to the ignore time will be used. If (window time + ignore time) is less than the current time, only the data gathered during the window time will be used, or sliding window time. Since this occurs one point at a time, the fringe count will be divided by the total number of points in this window to measure the contribution of a single data point. This value will be added to the last fringe count, and that value will be appended to the output values.

F. **Resolution:** This is a proprietary value that controls detail s of the spectral analysis. Normally it should be set to the lowest value that will yield accurate results. IMPORTANT - If faster computation is needed, a lower value should be used.

G. **Use etch rates:** This flag allows access to the Min Etch Rate and Max Etch Rate. The etch rate input allows the user to choose a range of values in the frequency domain. These values will be searched for the maximum, and that max is used to find the period. In order to convert etch rate to frequency, the center wavelength of the input data must be known. Therefore, only region equations can be used as input data if this option is chosen. If the Min Etch Rate and the Max Etch Rate are equal, the entire frequency domain will be searched. Since we do not provide the Frequency domain plot, the etch rate can be very difficult to use.

H. **Min Etch Rate:** The minimum rate at which the material is being etched, expressed as nanometers / second. This value is ignored if the Use etch rates radio button is unchecked.

I. **Max Etch Rate:** The maximum rate at which the material is being etched, expressed as nanometers / second. This value is ignored if the Use etch rates radio button is unchecked.

J. **Use oscillation periods:** This flag allows access to the Min Periods and Max Periods. The period input allows the user to choose a range of values in the frequency domain. These values will be searched for the maximum, and that max is used to find the period.

K. **Min Period(s):** This is the minimum period (1/frequency) in seconds. This value is ignored if the Use Oscillation periods radio button is unchecked.

L. **Max Period(s):** This is the maximum period (1/frequency) in seconds. This value is ignored if the Use Oscillation periods radio button is unchecked.

M. **Subtract LS polynomial of degree:** This integer value is limited to -1, 0 or +1. If the value is -1, the original input data will be used unaltered, if it is 0 the input

data will be mean-centered, if greater than 0 a least-squares polynomial of this degree will be fit to the input data, and the value of the polynomial at each of the input data points will be subtracted.

3.6.9.1 Fringe Counter With Frequency Averaging (FCFA)

Any combo-box input can be either a single numeric value, or a choice of Trend or Region equations or Variables selected from the drop-down. Any input chosen from a drop-down combo-box cannot be verified for correct numeric values until runtime. Invalid runtime data will result in a log error message and an equation value of zero or NAN, but will not stop EyeD from continuing to run.

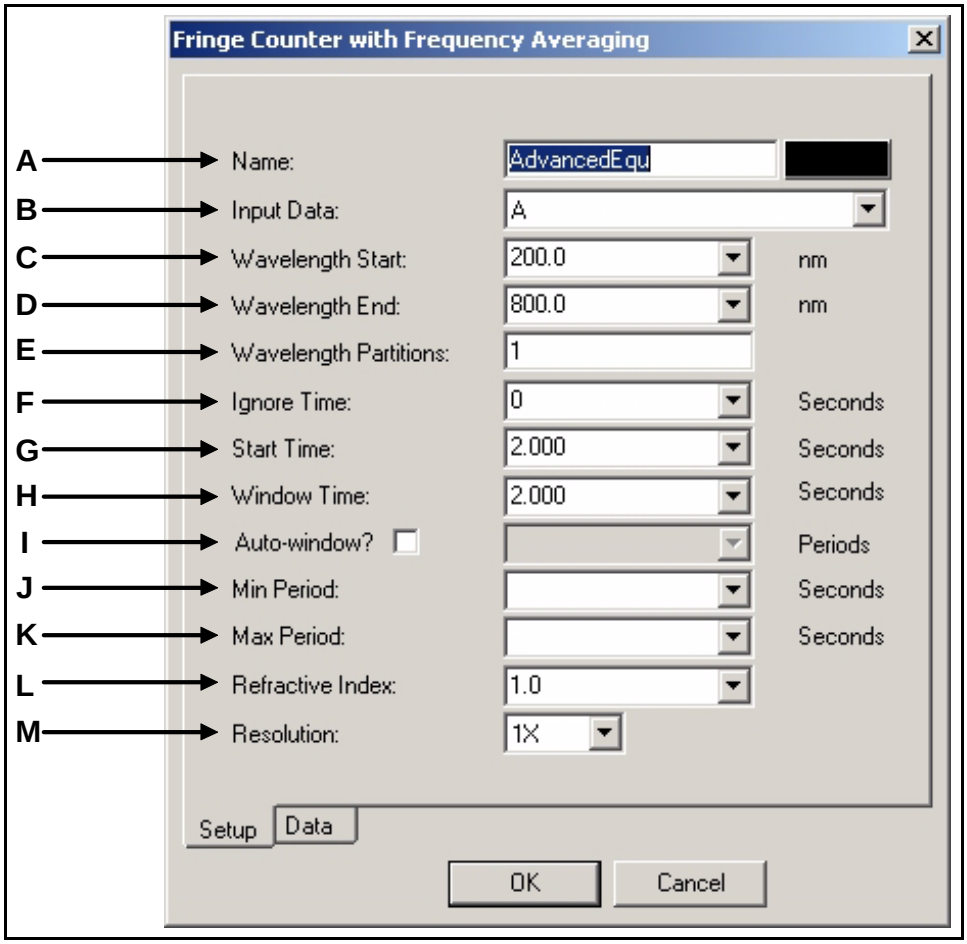


Figure 3-70. Setup Tab: Fringe Count with Frequency Averaging

A. **Name:** Enter a unique name for the Fringe Count equation being created.

B. **Input Data:** Use this drop-down list to choose the spectral data or equation that will be the input to this equation.

C. **Wavelength Start:** This field sets a starting wavelength in nanometers for the Input Data source. This wavelength must be within the ranges established in the configuration file (.svc), or equations can be selected with the drop-down feature of the combo-box.

D. **Wavelength End:** This field sets an ending wavelength in nanometers for the Input Data source. This wavelength must be within the ranges established in the configuration file (.svc), or equations can be selected with the drop-down feature of the combo-box.

E. **Wavelength Partitions:** This field sets the number of equally divided partitions between the start and end wavelengths. Positive integer values will average the wavelengths each partition; a zero value will create a partition for each wavelength in the interval; a negative integer value will use the center wavelength of each partition with no averaging of the other wavelengths in the partition.

F. **Ignore Time:** The time in seconds that the input data will be ignored. This is usually set to remove transients, or noise, until the onset of useful fringes occurs. The equation value will be zero (0) during this time. The result of the selected equation, variable, or typed constant, must be a number >= 0.

G. **Start Time:** The time in seconds that data is stored, but no output data is calculated. The start time interval begins when the ignore time interval ends. At the end of the start time interval, output data is calculated and displayed. Typically, this value is set so that at least 1½ fringes of all wavelengths of the input data are in the start time interval. The equation value will be zero until this time has elapsed. The value for start time must be a number greater than or equal to zero.

H. **Window Time:** The time interval, in seconds, of the data sequence during which fringes will be counted. If the window time is greater than the difference between the current time and the ignore time, a temporary window time will be set to the difference between the ignore time and the current time. This must be a number greater than or equal to zero or one of the drop-down selections from the combo-box.

I. **Auto-Window?:** This check box allows the program to control the Window Time. When the fringe counter receives a new data point, it calculates the period of the fringes in the current window. The text box gives the number of calculated periods in the window for the next data point. The Window Time value is only used to obtain the first fringe. This must be a number greater than or equal to zero, or a selection can be made from the drop-down feature of the combo-box.

J. **Min Period(s):** This is the minimum period in seconds and corresponds to the maximum frequency for finding the maximum peak in the power spectral density. This must be a number greater than or equal to zero or a drop-down selection. This value can also be set from the PSD Data screen. If this number is zero, it will be set to the data interval time.

K. **Max Period(s):** This is the maximum period in seconds and corresponds to the minimum frequency considered for finding the maximum peak in the power spectral density. This must be a number greater than or equal to the min period or a drop-down selection from the combo-box. This value can also be set from the PSD Data screen. If both the min and max periods are set equal to each other, the entire frequency range is used to find the maximum peak.

L. **Refractive Index:** The refractive index of the material in the film that is being measured. It is used to compute the depth. This value may be obtained from materials tables. A value chosen at the midpoint of the wavelengths is preferred.

M. **Resolution:** The size of the FFT used; 1X=4096, 2X=8192, 4X=16384, etc. Normally it should be set to the lowest value that will yield accurate results. If faster computation is needed, a lower value should be used. Note that no new peaks can be generated with this number; however, the actual peak value can be better resolved using larger values. This is a drop-down (combobox) list.

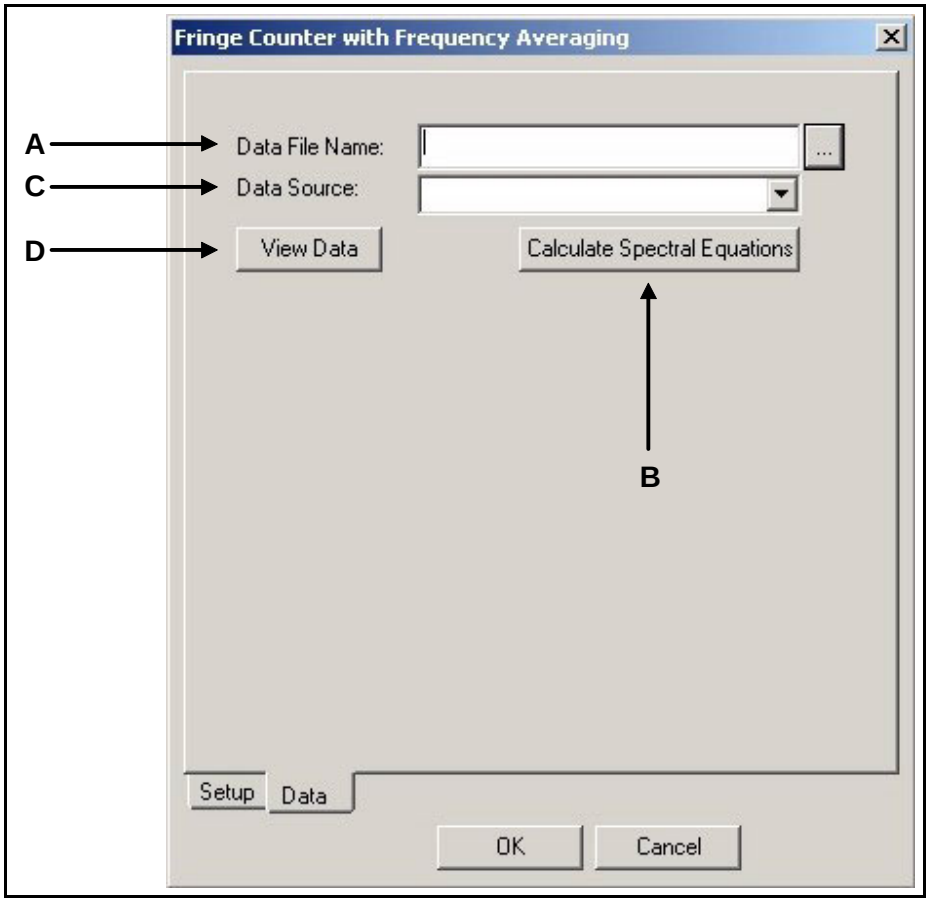


Figure 3-71. FCFA Data Tab

This screen checks the current settings without exiting and reprocessing. The data file must have the same data interval as the current configuration (.svc) being used. Usually the data file is the current data file. The following are in the order that they should be set.

A. Data File Name: This is the name of the data file.

B. Calculate Spectral Equations: This will calculate the spectral equations in the data file and put their names in the Data Source drop-down list.

C. Data Source: This is the spectral data from the file.

D. View Data: This will apply the current settings of the Fringe Counter with Frequency Averaging to the spectral data chosen in Data File Name and Data Source. It will then be displayed in graphical format (See Figure 4-59).

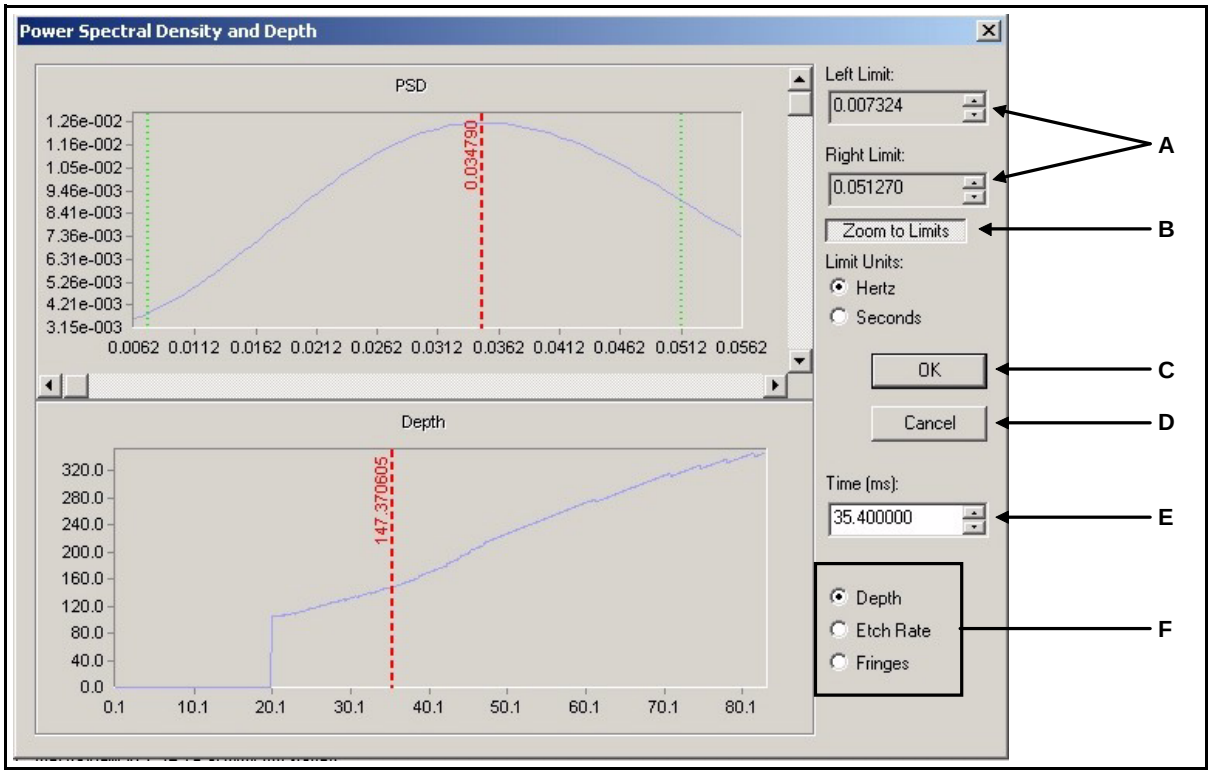


Figure 3-72. Viewing FCFA Data

Select the View Data button on the Data tab to bring up the Power Spectral Density and Depth window.

A. **Left and Right Limits:** correspond to the Min Period and Max Period boxes. These limits can be viewed in seconds (as they appear in the Setup screen) by choosing the Seconds radio button. This will only change the text; the graphical scale on the upper graph will remain in Hertz. The green dotted lines in the graph space correspond to these limits and the red dotted line in the graph represents the frequency chosen to produce the value of the Depth seen at this point in time in the bottom graph. The text associated with the red dotted line gives the Frequency (x) value.

B. **Zoom to Limits:** This button will automatically zoom to the left and right limits entered at fields A. This option will remain on until it is toggled off by selecting it again.

C. **OK:** The left and right limits are saved to the Setup Screen, and control returns to the Data screen.

D. **Cancel:** Return to the Data screen - discard any changes.

E. **Time (ms):** This edit box will place the red dotted line in the Depth window to that value and change the PSD in the top graph to this point in time.

F. **Depth, Etch Rate, and Fringes:** These radio buttons set the values plotted the lower window.

3.6.10 Error Correction Algorithm

The Film Thickness and model-based fit algorithms return a measurement at every time increment. When these algorithms are functioning correctly within the system, data points form a continuous smooth progression of returned measurements (e.g. trench depth).

Occasionally, however, there may be intervals during which convergence of the algorithm is poor. If the algorithm fails to converge, it still returns a result, but the result is essentially meaningless. The presence of even a single occurrence of non-convergence may cause a premature endpoint if a threshold condition is used in the sequence. Accurate endpointing, however, does not require that a valid measurement be received at every single time step - provided that the errors were not too frequent, and that the erroneous measurements can be reliably identified.

The Error Correction Algorithm provides a smooth trend approximating the values of the input trend. The output trend is a linear, or piece-wise-linear, approximation of the input trend - with the exception that points significantly divergent from the main trend line are ignored. The error scale parameter (see D below) defines how far off the main trend line these ignored points will be. Any point outside the distance specified in the error scale will have little influence on the computed value of the corrected result. Outliers will be ignored whether they are the most recent points or earlier points.

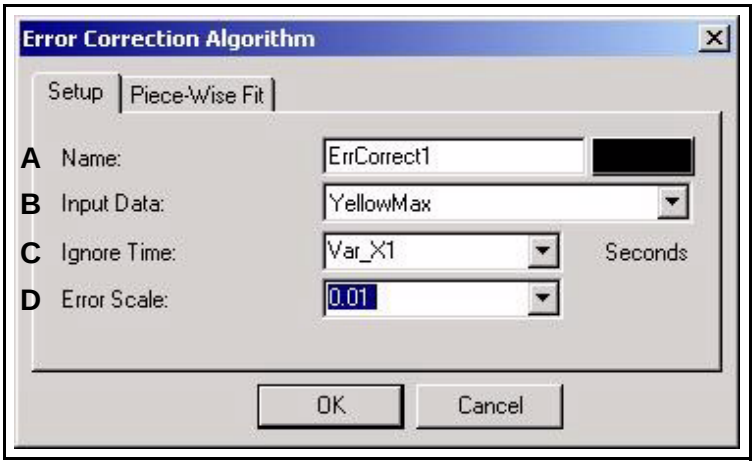


Figure 3-73. Error Correction Algorithm Setup Tab

A. **Name:** The name of this equation. This must be filled in, and the name should be unique.

B. **Input Data:** The name of the Trend that will be the input to this algorithm. Chosen from a drop-down list.

C. **Ignore Time:** The number of seconds (since Start of the Step) that Input Data should not be considered in calculating the result. This entry can either be a typed

constant, Trend / Region equation, or Variable Name. Equations and Variables can be typed or selected from the drop-down list.

D. **Error Scale:** A small value here exaggerates the presence and detection of a trend deviation. Care needs to be taken in selecting this value to ensure that only real, and significant errors are detected. This entry can either be a typed constant, Trend / Region equation, or Variable Name. Equations and Variables can be typed or selected from the drop-down list.

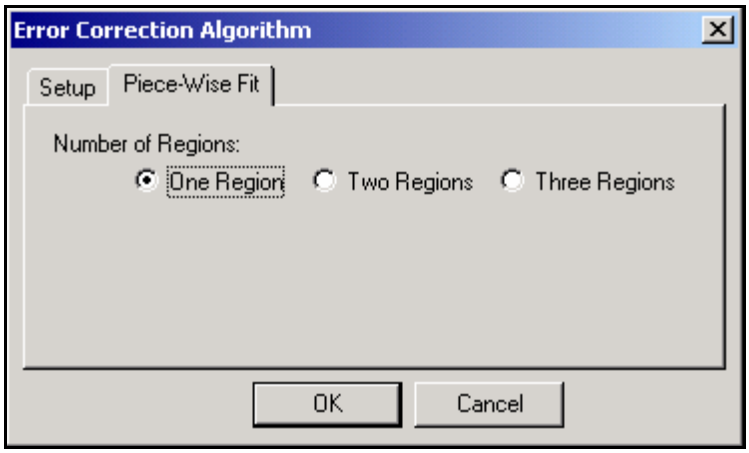


Figure 3-74. Piece-Wise Fit Tab

These selections define the model type, and must be specified for the error-corrected trend. The default is 1 Region or Linear). At a given time, there are N measurements Si at times ti (i= 1...N).

Selecting One Region results in a linear, or one-piece fit:

$$S^M(t) = a + b(ti),\ i = 1...N$$

Selecting Two Regions results in:

$$S^M(t) = a_1 + b_1\ (ti),\ i = 1...N_1$$

$$S^M(t) = a_2 + b_2(ti),\ i = N_1 \ldots N_2$$

Selecting Three Regions results in:

$$S^M(t) = a_1 + b_1\ (ti),\ i = 1...N_1$$

$$S^M(t) = a_2 + b_2(ti),\ i = N_1...N_2$$

$$S^M(t) = a_3 + b_3(ti),\ i = N_2...N_3$$

NOTE

The main risks inherent in this algorithm are convergence to the wrong (local) minimum, and excessive execution time. It is possible that the multiple-region linear version will prove impractically slow. This determination should be made in testing.

3.6.11 Neural PCA

Neural PCA (Principle Components Analysis) is an advanced equation option in EyeD. This is a powerful technique for finding the component features and concentrations of characteristics from multiple-wavelength spectral data. This approach allows correction for oscillations in a process caused by rotating plasma, power supplies, pressure control loops, etc. This section discusses the setup and capabilities of the Neural PCA algorithm available in the EyeD software application.

The Neural PCA equation is designed to create a trend chart for detecting endpoint by processing large quantities of spectral data generated by the spectrograph during a process run. The NPCA algorithm is an empirical technique for identifying those wavelengths that change intensity at endpoint. After the wavelengths are selected, NPCA offers three proprietary methods for effectively combining those changes in wavelength intensities to generate a trend chart for endpoint detection in real time.

NPCA is designed for the engineer or technician familiar with the process requiring an endpoint. The first step in setting up an NPCA is the collection of spectra during a process run that generates a strong endpoint signal. For an etch process, use a test wafer that has the same film and stop layer to be etched in the actual production process. All films must be smooth on a smooth wafer surface. The calibration wafer should have no photoresist coating. Spectral data collected during this run will be used to calibrate the NPCA. Using the same etch chemistry and process module settings, this one run will be sufficient to calibrate the NPCA for low-percent-open-area etches of the same film and stop layer.

To access NPCA, select a configuration in EyeD and go to Equations in the Configuration window. Bring up the Advanced Equations window and select Neural PCA.

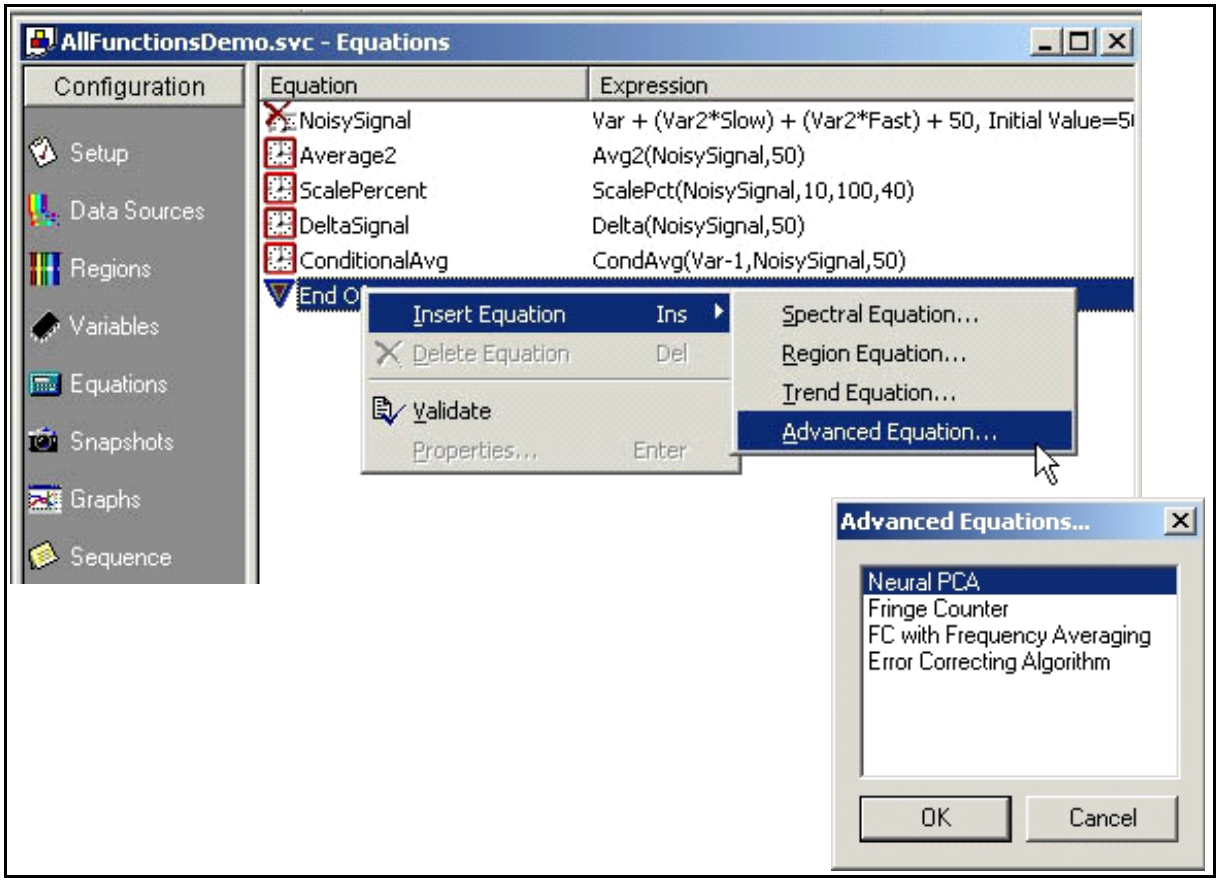


Figure 3-75. Select Neural PCA

There are two tabs under the Neural PCA setup window. In this window, the Calibrate tab should be the first displayed. If no calibration file is yet associated with the NPCA, a data-file-selection window will appear in the Calibrate tab window. Use the browse button (Figure 3-76 left) to open a window to browse for a calibration data file (Figure 3-76 right).

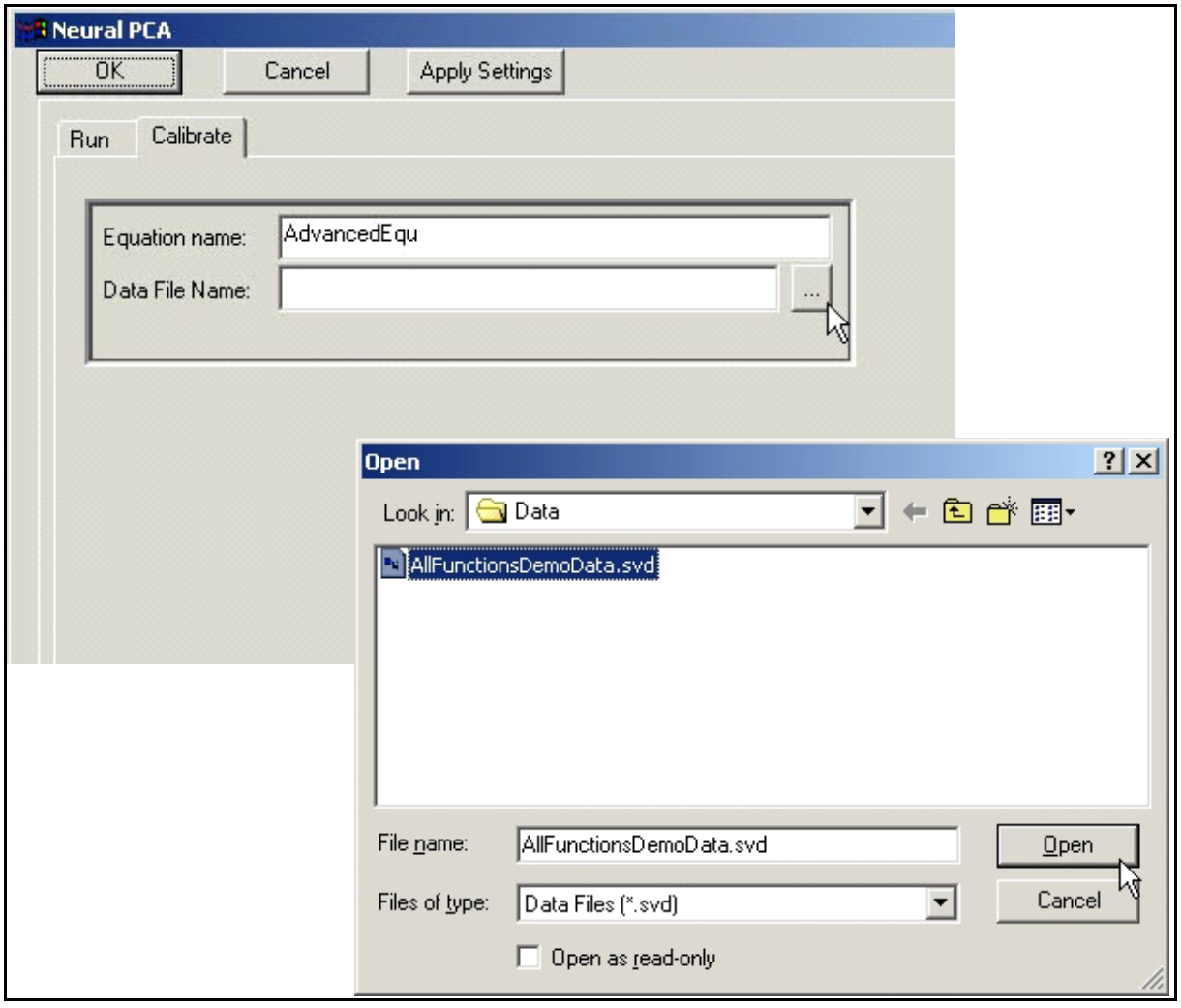


Figure 3-76. Browse for Calibration Data File

When a calibration data file has been selected, the Calibrate tab window will appear. Select the Calculate Spectra Eq. button near the center of the window (see Figure 3-77). This operation recalculates the results of any spectral equations that were generated while this data file was collected. In this way, those spectral equations are made available to the calibration process.

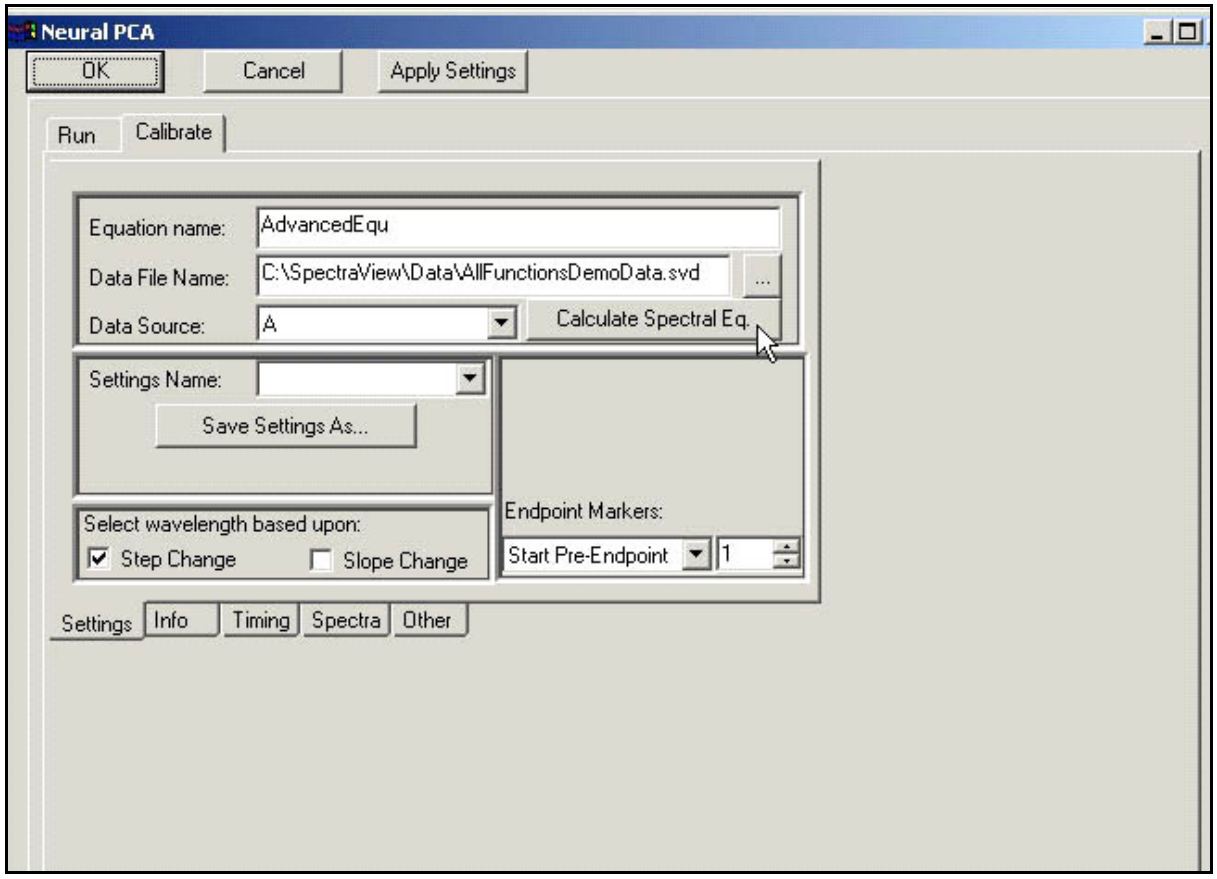


Figure 3-77. Calibrate Tab

The values in the Setup tab of the current Configuration (see Figure 3-79) should match those of the data file selected to calibrate NPCA.

The Neural PCA window has three tabs. By default, the Calibrate tab is displayed first so that the calibration data file can be specified. Instructions for preprocessing that file are entered in this tab as well. The Test tab is then selected to calibrate the NPCA algorithm. Finally, the Run tab is used to begin the NPCA process. It is the Calibrate tab, however, where most of the setup choices are made. These selections are further divided according to File Information, Temporal Parameters, Wavelength Parameters and Other Parameters.

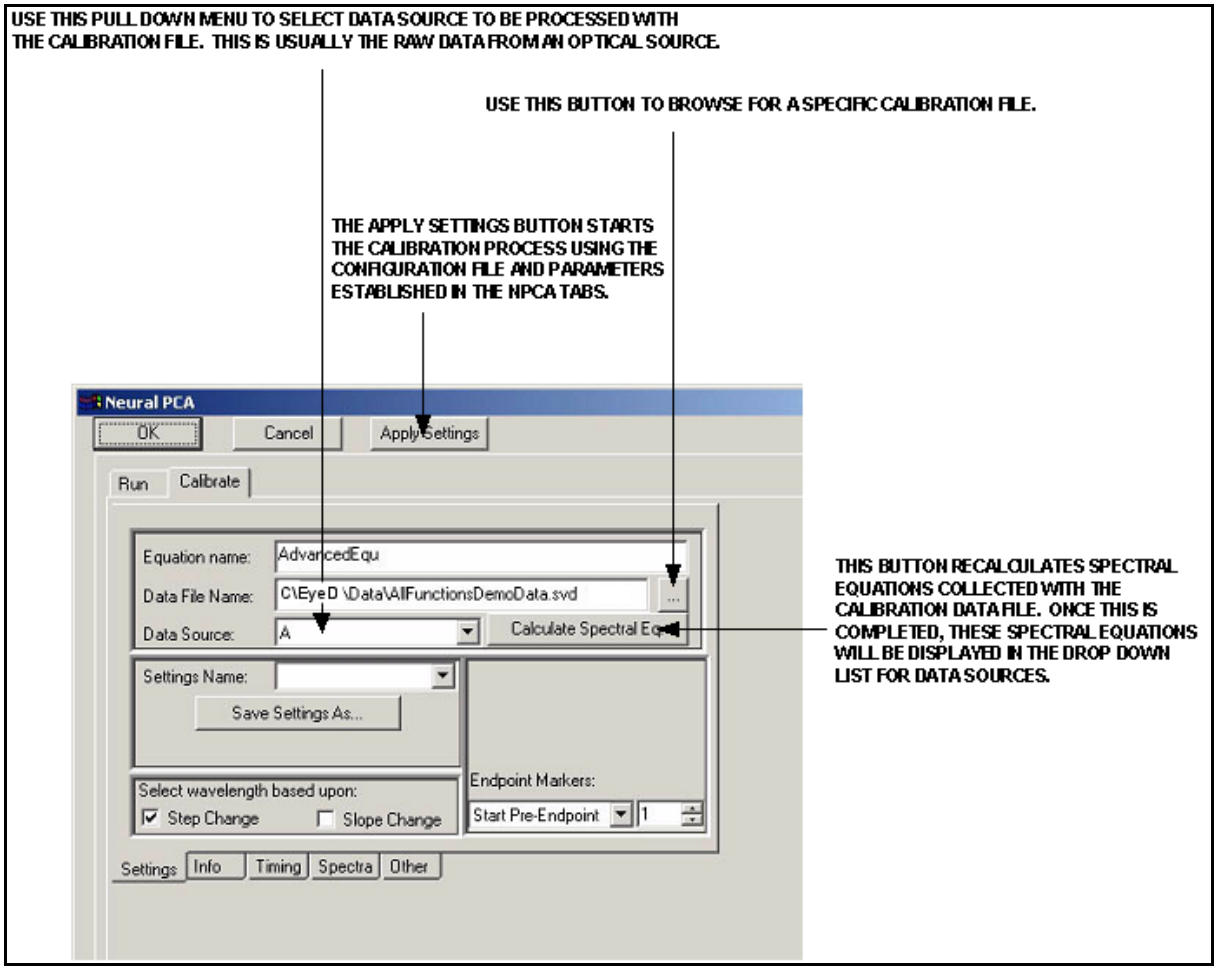


Figure 3-78. Settings Tab

Eight parameters from the selected calibration data file are displayed when the Info tab is selected (Figure 3-79). These include:

- Data Collection Mode: This describes how the data was collected, either Continuous or Pulsed.
- Total Samples: The total number of spectra in the data file.
- Samples/period: The number of spectral samples per period.
- Total Periods: Total samples divided by the samples/period.
- Min Period (sec): Minimum time between the start of one period to the start of the next period.
- Max Period (sec): Maximum time between the start of one period to the start of the next period.
- Period Error (sec): One standard deviation of all the period times.
- Period Error (%): The period error divided by the average period time.

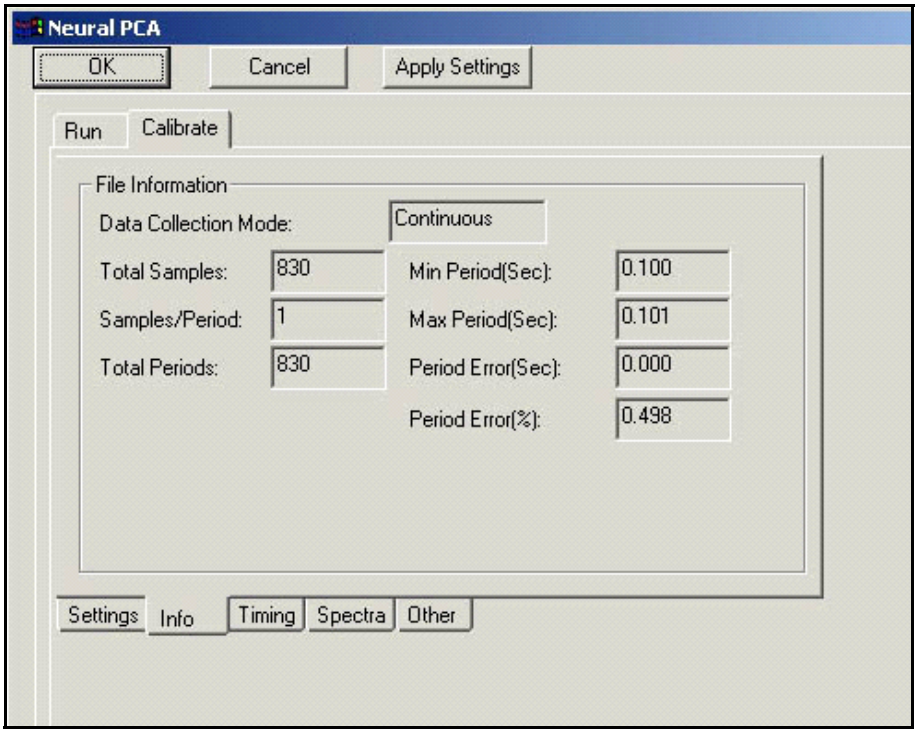


Figure 3-79. Info Tab

NOTE

Period parameters are different means to measure the reproducibility of the period of oscillating processes, such as magnet rotation.

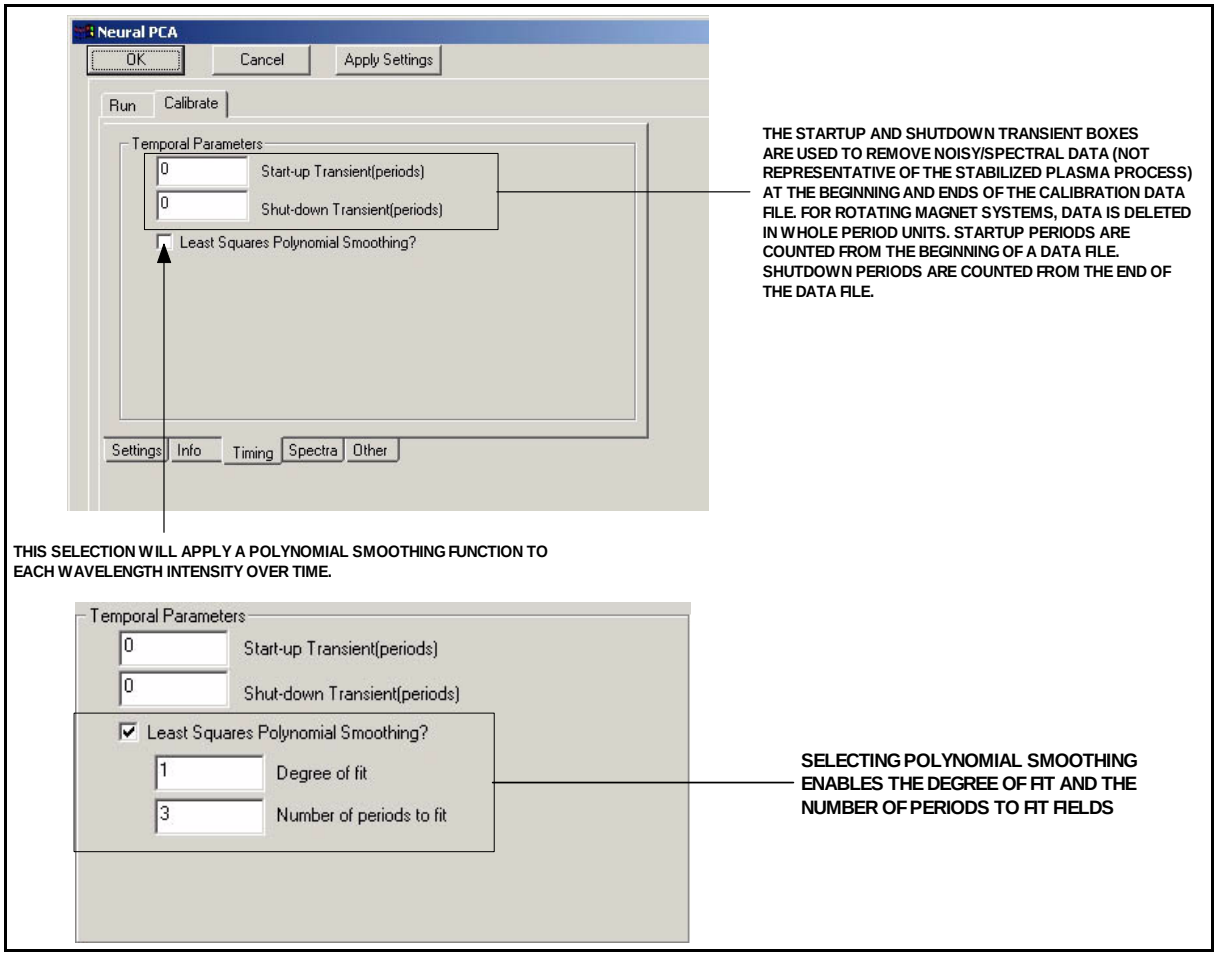


Figure 3-80. Temporal Parameters

There are five settings accessible with the Temporal Parameters tab. These include:

- Startup Transient (periods): Number of periods (collected spectra) at the start that should be ignored. This plus the Shutdown Transient field must be less than the total number of periods.
- Shutdown Transient (periods): Number of periods at the end that should be ignored. This plus the previous field (Startup Transient) must be less than the total number of periods.
- Least squares polynomial smoothing? If the data should be smoothed in time, check this box; otherwise no temporal smoothing is performed. Smoothing uses a Savagest-Golay technique. The next two options are only available for edit if this box is checked. This option only applies to the Setup/Calibrate File step; it is ignored at run time.
- Degree of Fit: Degree of the polynomial to use for least squares fitting.
- Number of Samples to fit: Number of periods to fit. This will actually fit all samples in the period individually over this many periods in order to smooth. This number must be greater than the previous field.

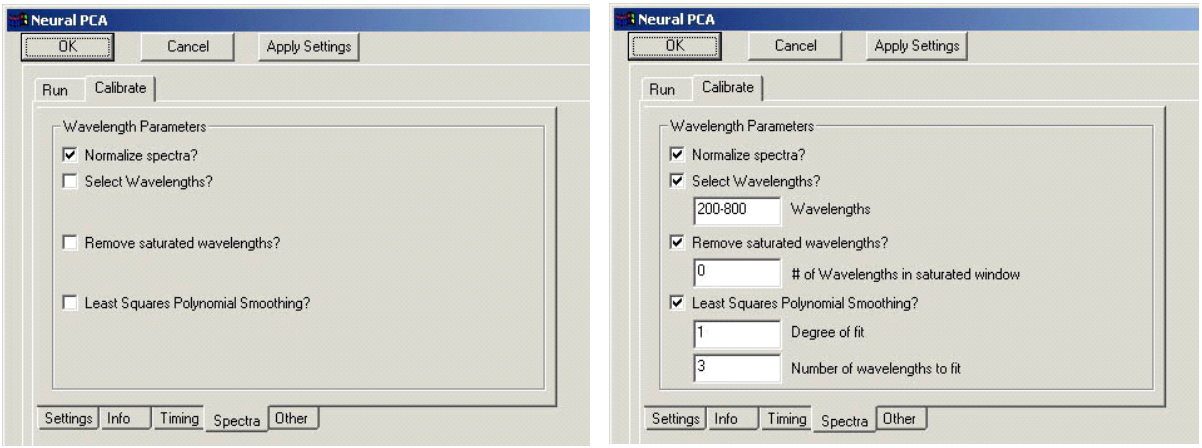


Figure 3-81. Check Boxes Enable Associated Fields

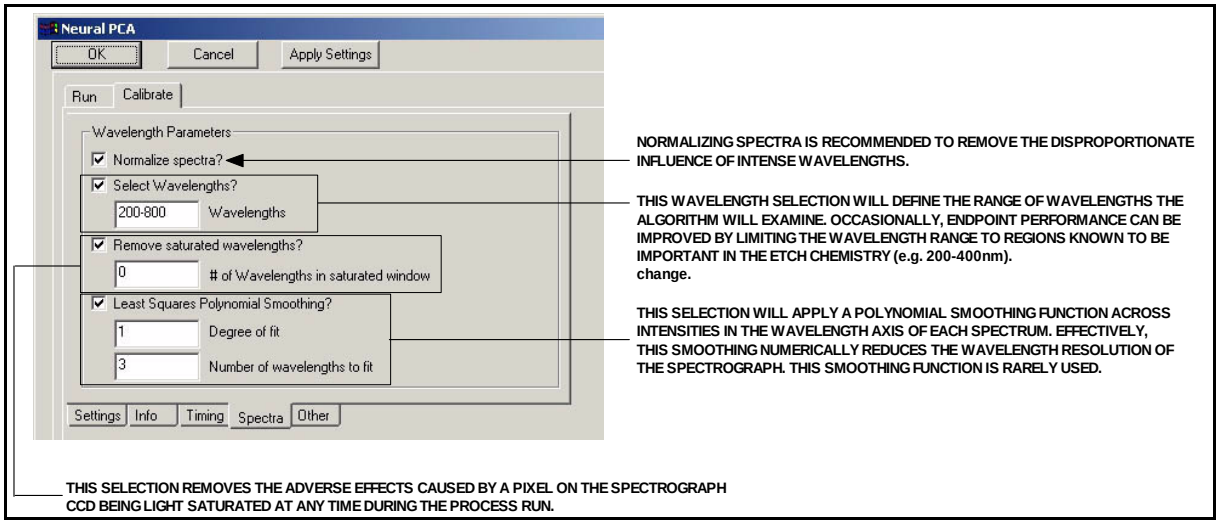


Figure 3-82. Wavelength Parameters

There are eight settings accessible through the Wavelength Parameters group box. These include:

- **Normalize spectra:** This will normalize the intensity variance at endpoint. This technique allows wavelengths to be selected based on the percent intensity change at endpoint - instead of absolute intensity change.
- **Select Wavelengths:** If selected, only wavelengths chosen in the next option are used, the rest are ignored. If this check box is not selected, all wavelengths are used regardless of what is specified in the accompanying field. The next option can only be edited if this box is selected.
- **Wavelengths:** Particular wavelengths in the sample, that are indicative of process events, can be selected here. Wavelengths are given in nanometers, and have a minimum and maximum value defined by the current configuration's spectral range. Wavelengths can be separated by commas or spaces for individual selection, or with a dash if an inclusive range is desired. (example: 395,398 400-405 selects

395, 398, 400, 401, 402, 403, 404, 405 and ignores all other wavelengths). These wavelengths will be validated when this field is exited and at start time to ensure that only legal values for the current configuration are chosen.

- **Remove saturated wavelengths?** This will currently check for values equal to 0. These are assumed to be super-saturated pixels. The wavelengths corresponding to these values will be removed from all samples. The next option can only be edited if this box is selected.
- **# of wavelengths in saturated window:** This number of wavelengths on each side of a saturated value will be removed from all samples, in addition to the saturated pixel itself.
- **Least squares polynomial smoothing?** If the data should be smoothed over wavelengths using a Savitsky-Golay technique, check this box; otherwise no wavelength smoothing is performed. The next two options are only available for edit if this box is checked. This option only applies to the Setup/Calibrate File step; it is ignored at run time.
- **Degree of Fit:** Degree of the polynomial to use for least squares fitting.
- **Number of Samples to fit:** Number of wavelengths to fit. The routine will fit this number of wavelengths at each wavelength for every sample in order to smooth. This number must be greater than the previous field.

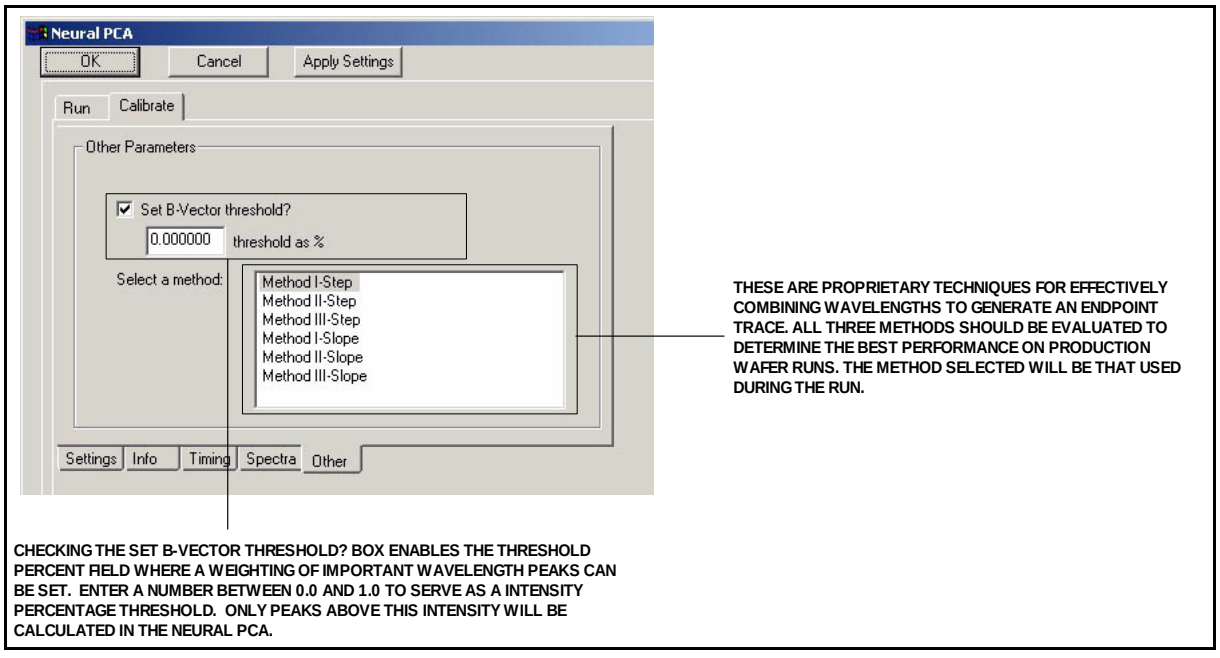


Figure 3-83. Other Parameters

Settings available through the Other Parameters tab include:

- **Set B-Vector Threshold:** This is a method for discarding wavelengths that vary little during the process run.

- **Select a Method:** The method highlighted in the list will be applied at runtime (the selected method will be indicated with a green square in the Graph Results list).

To calibrate the equation with these settings, select Apply Settings at the top of the Neural PCA window. This will complete the calibration and bring up graphs of the file.

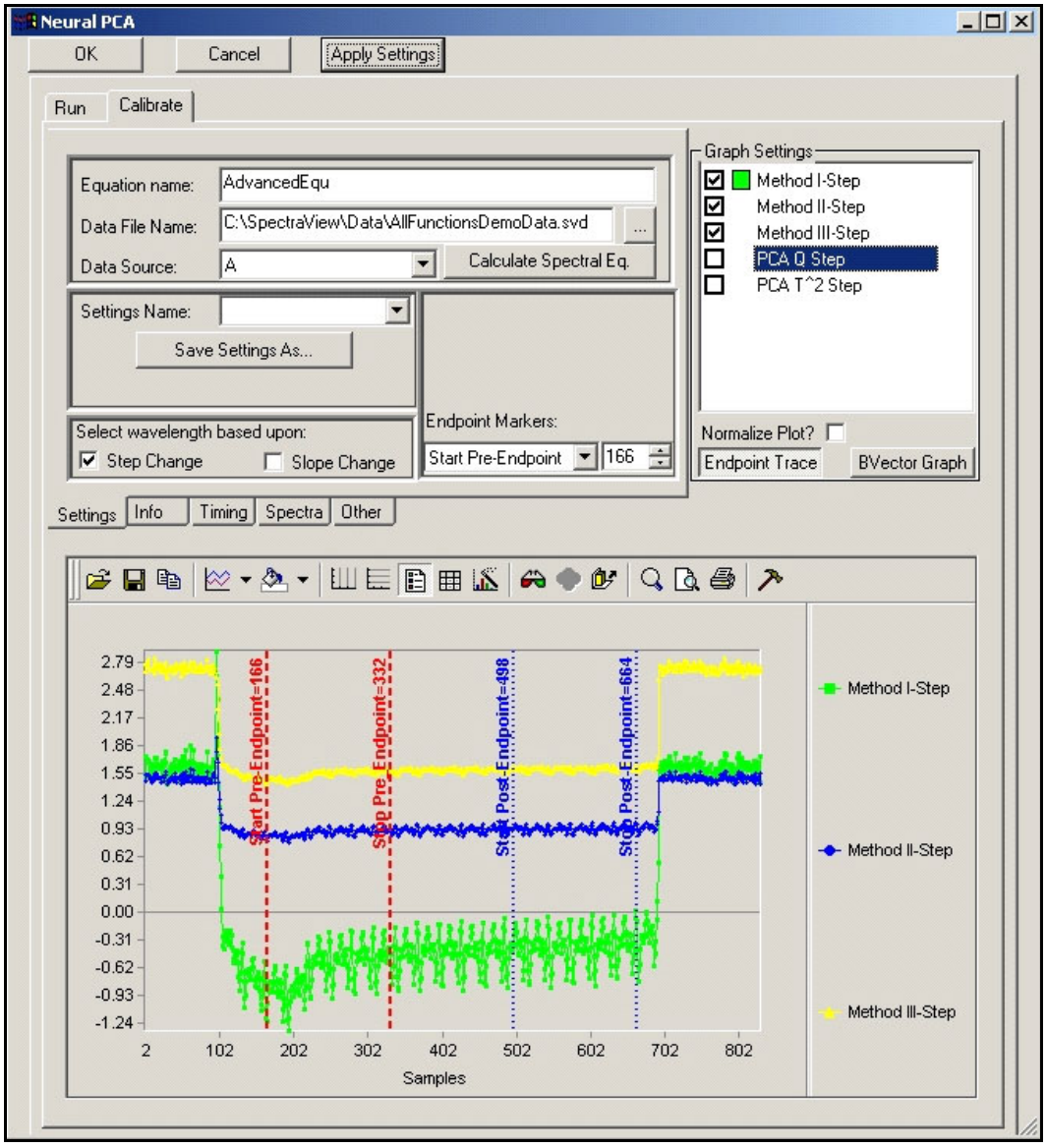


Figure 3-84. Graphs Window

The Calibrate tab records the parameters that define the point at which the endpoint transition occurs in the calibration data file; and which of three methods to use to combine selected wavelengths for generating an endpoint trace.

Calibration calculations begin when the Apply Settings button is selected. The cursor should change to indicate a wait state while these calculations are being performed. Continuous data collection mode can produce large files that can take as long as five minutes to calibrate.

Once the calculations have completed, three graphs are produced to help the user visualize the endpoint event in the calibration data (See Figure 3-85). The length of time required to complete calibration depends on the size of the data file and the speed of the computer.

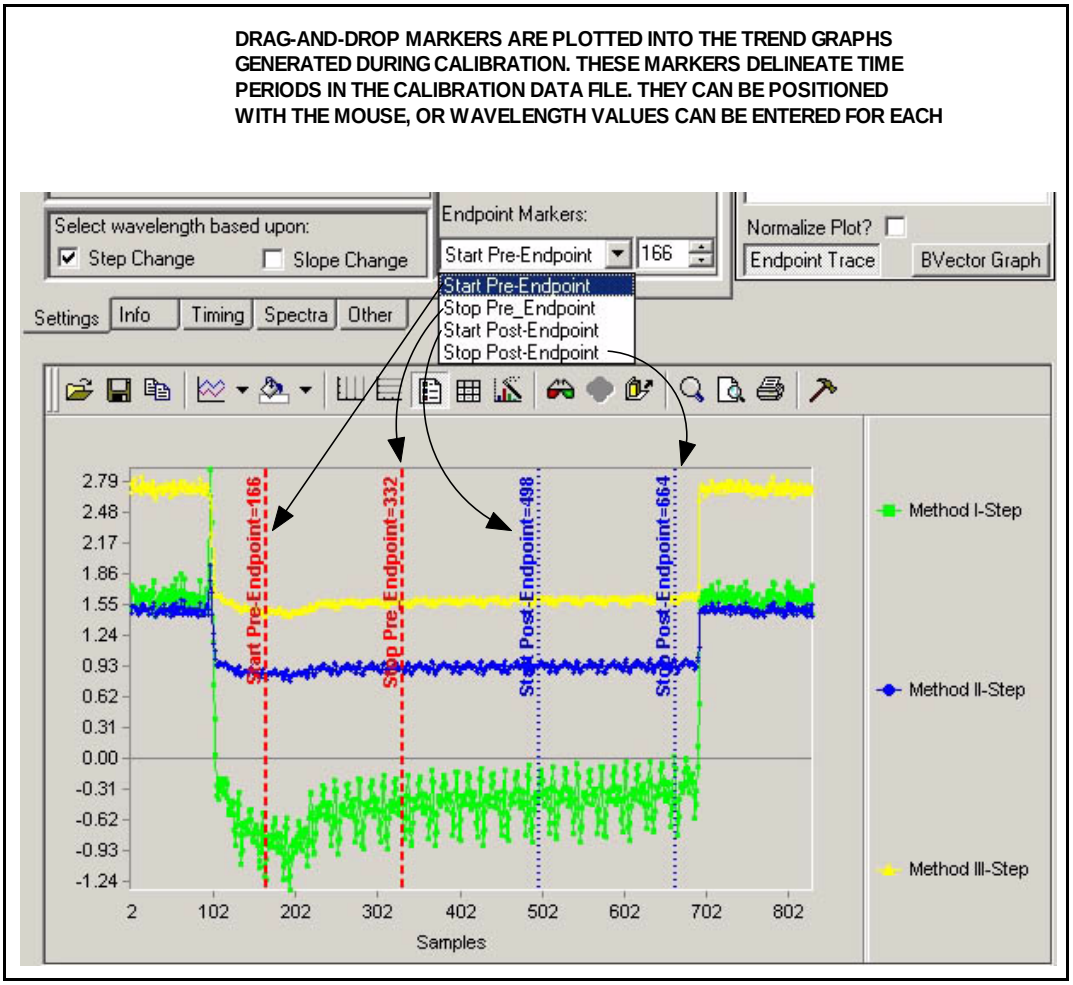


Figure 3-85. Selecting Regions

The time markers (vertical lines) are used to graphically define three periods.

- Start Pre-Endpoint through Stop Pre-Endpoint should represent the stable process before endpoint
- Stop Pre-Endpoint through Start Post-Endpoint should represent the process in its endpoint transition
- Start Post-Endpoint through Stop Post-Endpoint should represent the stable process after endpoint

For NPCA to accurately select the proper wavelengths, the time markers must accurately define the boundaries between these time regions in the calibration data file. The data file being used should include a strong endpoint transition.

Note: When the drag-and-drop method is used to position the markers graphically, the software limits the values of these markers to whole periods. Therefore, it is possible to make

a minute change in marker location on the graph and have the value not change or change markedly as it snaps to the end of the next period.

The graph is scaled to display all the data. The graph can be scaled to better display a portion of the data by right clicking in the graph window and selecting Properties (Figure 3-86, left) to bring up the Chart FX Properties window (center).

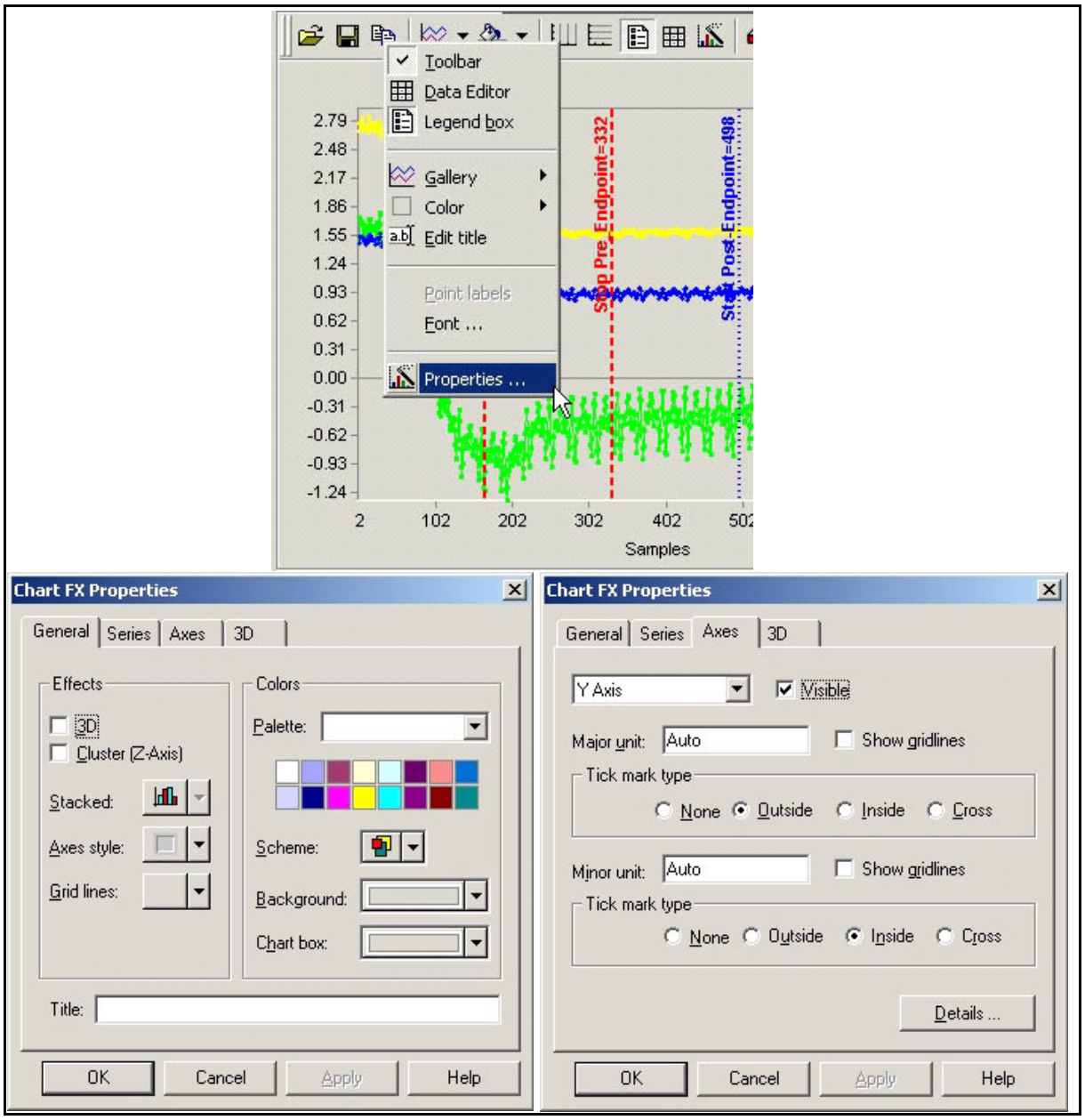


Figure 3-86. Scale Adjustments

Select the Axes tab (Figure 3-86, right) to access graph parameters for the X and Y-axes. Set the scale to best represent the desired endpoint shift.

Because the Neural PCA is an empirical method, it is not possible to provide the exact best settings to use for all endpoint detection problems. For this reason, all combinations of

settings provided in the Neural PCA Calibrate tab should be reviewed to determine the best settings. There are six (6) combinations of two (2) calibration methods and three (3) wavelength combination methods.

By default, all three methods are selected for graphing. Also available under the Graph Results drop menu are the Q and T2 plots of a one-component principle component model of the data. The PCA graphs provide other ways to visualize the data for positioning the time markers.

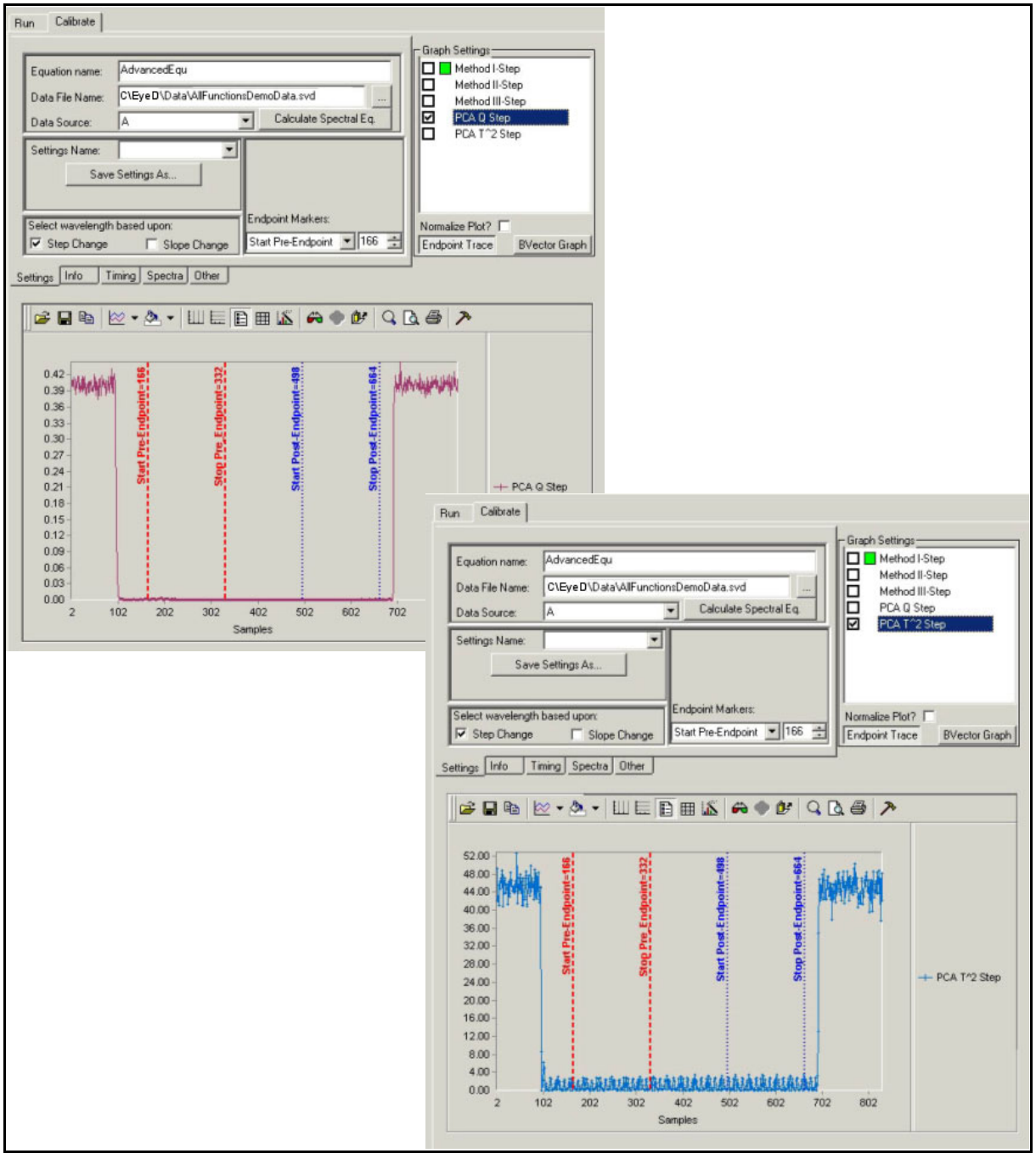


Figure 3-87. Viewing PCA Graphs

When changes are made to the NPCA settings, use the Apply Settings button at the top of the screen to recuperate the equation.

The Neural PCA is a trend equation that produces a scalar value for each spectrum received in real time. The output value can be plotted on a trend graph during real-time runs or during the reprocessing of previously collected data files.

A unique name for the Neural PCA equation can be entered in the Equation name fields in either the Run or Calibrate tabs. Both tabs also have a field for selecting the data source to be analyzed with the new Neural PCA equation.

When completed, use the OK button to save the equation, which will then be visible in the list of available equations.

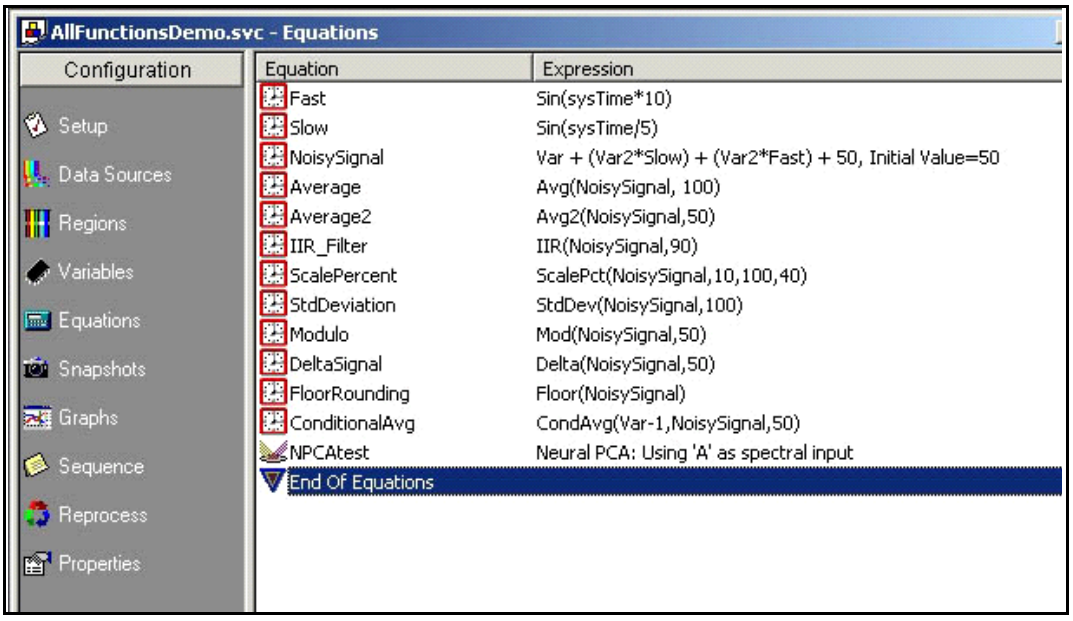


Figure 3-88. NPCA Equation Listed

3.6.12 Film Thickness Measurement Capability

3.6.12.1 Overview

EyeD contains an internal modeling and regression fitting resource that can determine the top one or two layer thicknesses on a blanket film stack (blanket means homogeneous optical properties in the plane of the wafer). This measurement capability allows for accurate determination of nitride mask thickness in, for instance, recess applications. Future versions of EyeD will contain modeling resources that will allow for accurate determinations of thickness in cases where the films are non-homogeneous, for instance, for polysilicon patterned by photoresist.

The resource matches the actual reflectance data of a production wafer to a model film stack which has the best fit to the wafer data; the model film stack thicknesses or expected ranges are entered by the user in the model setup. When layer thicknesses are known (for example pad oxide layers), these should be entered as constants. The unknown, the thickness of the layer of interest, is entered as an expected range. This range can be 0 to Xnm for the case of

a film which will etch significantly during a process run, or X to Ynm for the case where the expected range of thickness will not vary as much.

Film thickness measurement relies upon an accurate determination of reflectance vs. wavelength for each production wafer. This in turn requires that an accurate, up-to-date optical reference file exists for each chamber. A reference file is a representative data file taken of the IEP source light as reflected off of a clean (unetched) silicon wafer. This file can easily be updated automatically by the EyeD system on a periodic basis, in order to accommodate for any small changes in the optical transmission properties of the IEP optics, the top-access window, or alignments over time. The automated reference generation is carried out by executing a special algorithm while a Si wafer is in chamber. It is recommended that these reference files be updated during each periodic gas-only particle check, using Si particle qual wafers.

Film thickness measurement relies upon an accurate determination of reflectance vs. wavelength for each production wafer. This in turn requires that an accurate, up-to-date optical reference file exists for each chamber. A reference file is a representative data file taken of the IEP source light as reflected off of a clean (unetched) silicon wafer. This file can easily be updated automatically by the EyeD system on a periodic basis, in order to accommodate for any small changes in the optical transmission properties of the IEP optics, the top-access window, or alignments over time. The automated reference generation is carried out by executing a special algorithm while a Si wafer is in chamber. It is recommended that these reference files be updated during each periodic gas-only particle check, using Si particle qual wafers.

The film thickness result can be passed as a parameter from the algorithm used for measurement to the algorithm, which is used to call endpoint in a subsequent step, using the global variable feature of the EyeD code. A caution on using variables: once variables are set with a particular value, they will retain that value until the value is reset. This can lead to unexpected results if the user does not manage the variables with care.

3.6.12.2 Using the Thickness Measurement Capability

3.6.12.3 Reference Generation

The layer thickness measurement uses a fit to model method to interpret the IEP data, in which the layer thicknesses are determined by simultaneous fit of entire spectrum to reflection model calculated for films in question. The thickness measurement algorithm requires a spectral reference taken from a clean (unetched) silicon wafer. The reference spectrum can be taken either manually or automatically.

3.6.12.4 Manual Reference Generation

1. With bare Si wafer in the chamber and the cathode in process position, open any valid configuration and add the *AMAT IEP-Reference* equation from the Advanced Equation List.

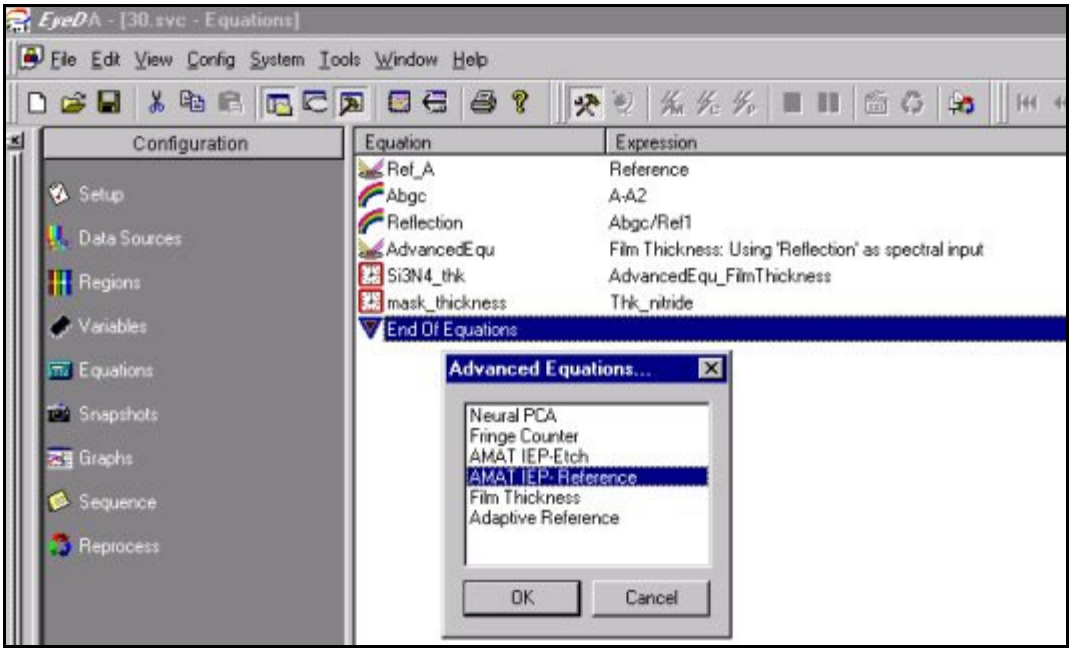


Figure 3-89. List of Equation Window

1. Select **OK**. The following window appears:

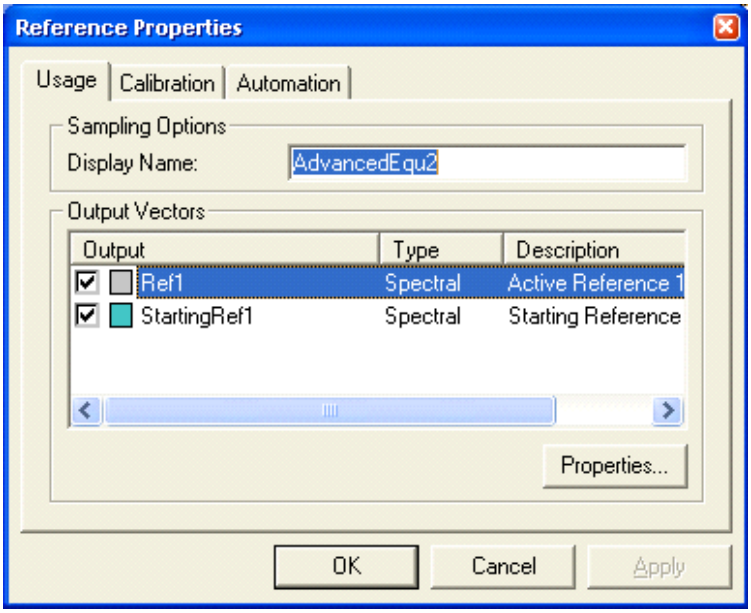


Figure 3-90. Reference Properties Window

2. Choose the **Calibration** tab, then select **Insert**.

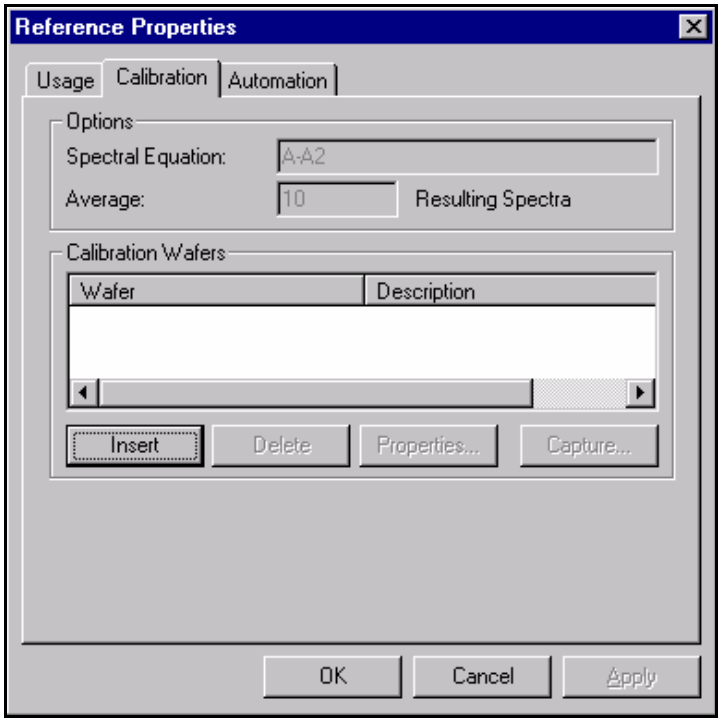


Figure 3-91. Reference Properties Calibration Window

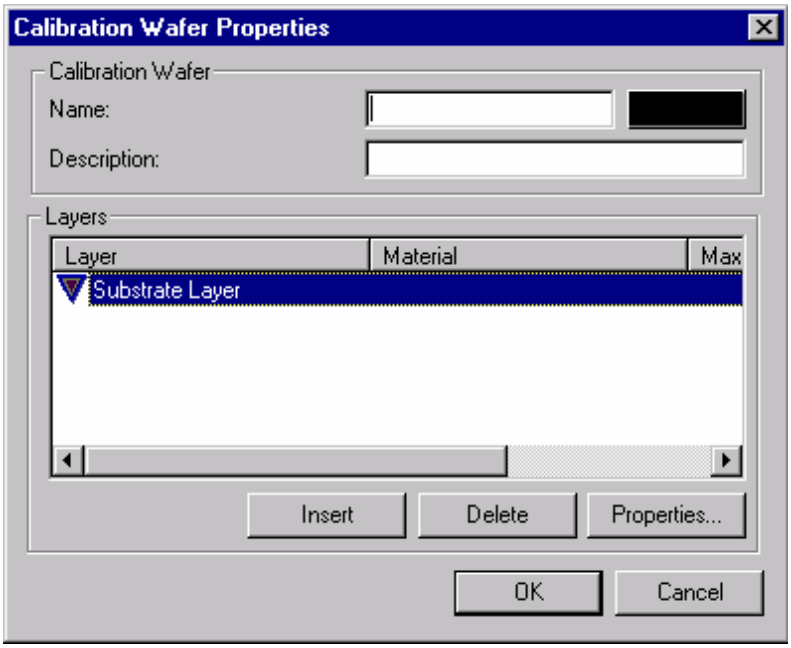


Figure 3-92. Calibration Wafer Properties Window

3. Here an optical model of the reference wafer can be entered. Since a clean bare silicon wafer is used, a single crystal silicon layer should be inserted by choosing **Insert**. The following window appears.

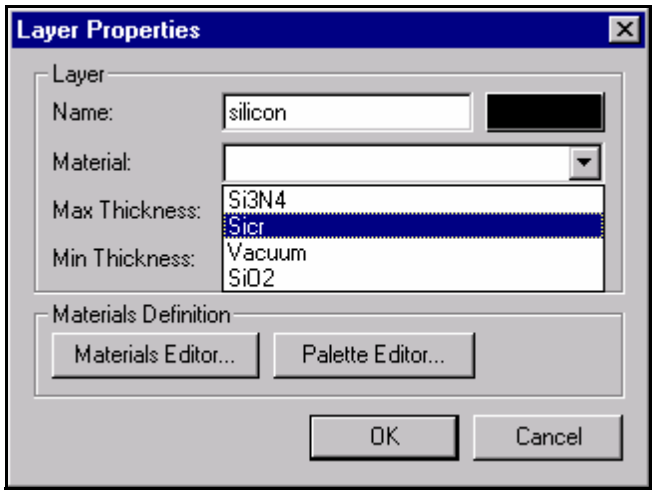


Figure 3-93. Layer Properties Window

The name of the layer can be typed in and the material property can be chosen from the pull down menu. Since a single crystal silicon layer is chosen here, the maximum and minimum layer thickness can be any positive number.

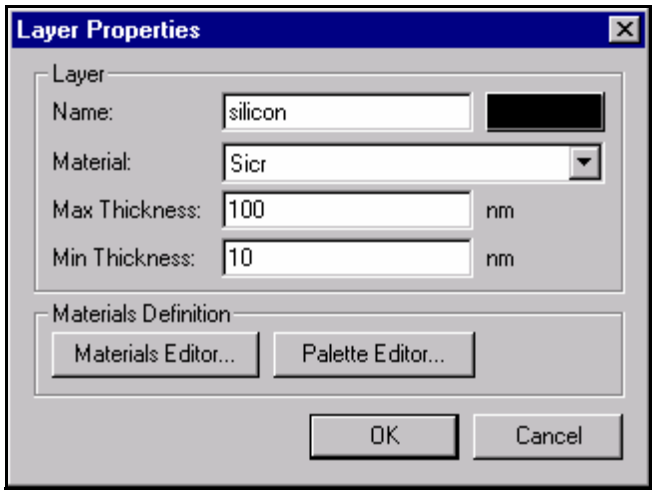


Figure 3-94. Layer Properties

4. Select **OK** after the layer properties are defined, then the *Calibration Wafer Properties* window appears.

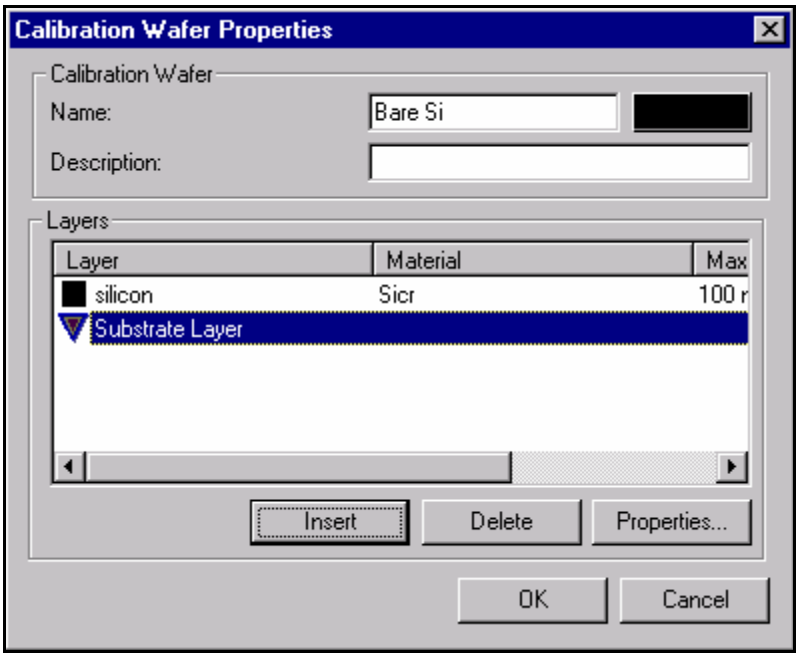


Figure 3-95. Calibration Wafer Properties

5. Select **OK**. The *Reference Properties* window opens. Select the **Capture** option.

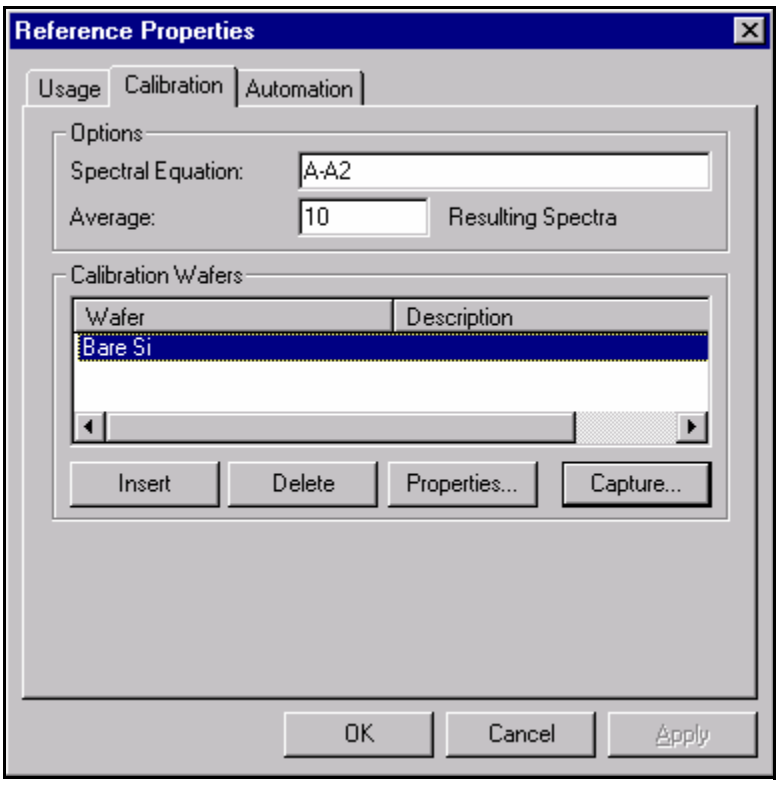


Figure 3-96. Calibration Window

6. Then set any desired options in the following window, and select **Capture**. The reference spectrum is collected.

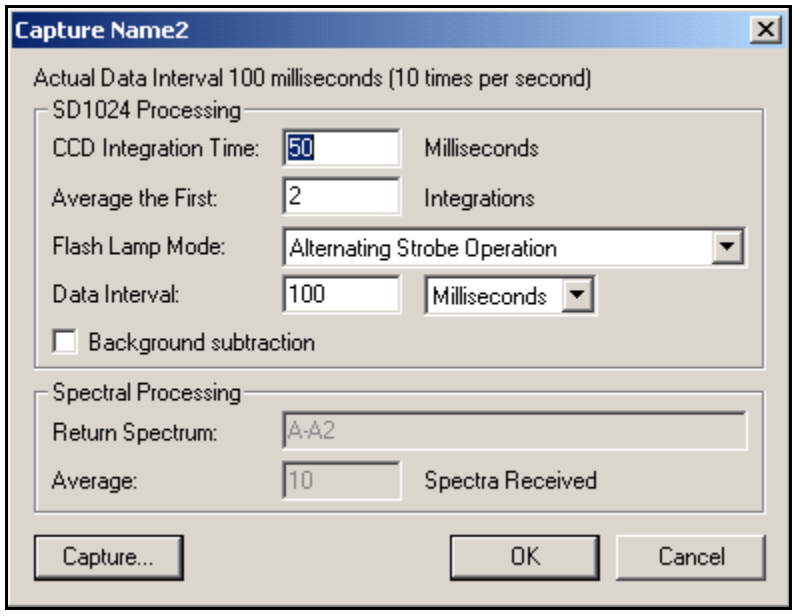


Figure 3-97. Capture Window

7. When the acquisition is finished, select **OK**.

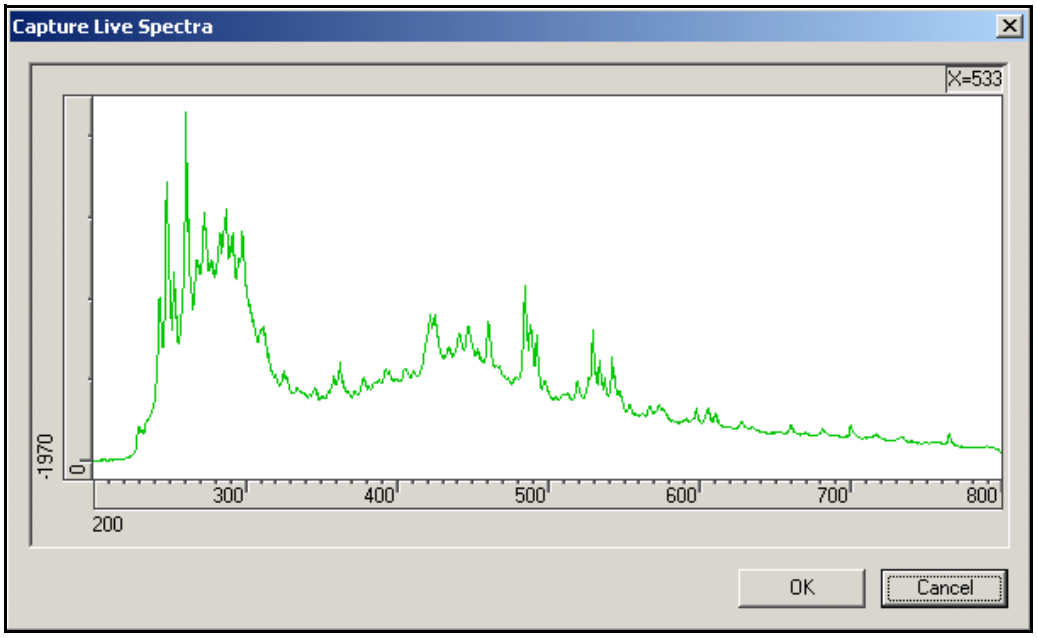


Figure 3-98. Captured Reference Spectrum

8. Assign a name for the reference file in the *Save As* window. This file then contains the reference information that applies to the tool in its present state. Note that each instance will track its own references automatically, this ensures that they remain

chamber specific: the user *DOES NOT* need to track or manage the chamber associations of .svr files.

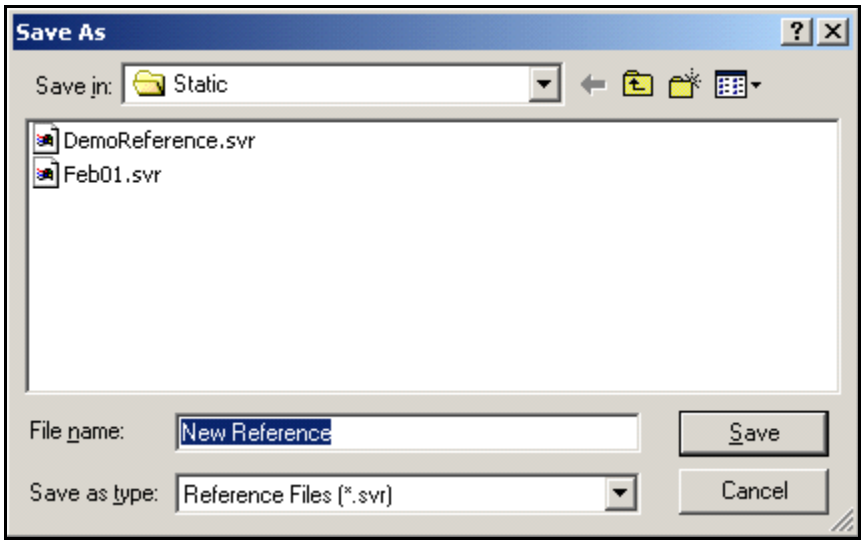


Figure 3-99. Save Reference File

3.6.12.5 Automated Reference Generation

The reference file can also be updated automatically by the EyeD program on a period basis. The algorithm 62.svc can be reserved for this usage. It can be executed while a Si wafer (such as a Si particle qual wafer) is in the chamber to update the reference file. The configuration file 62.svc can be set up as following.

1. Add equation from the Advanced Equation list.

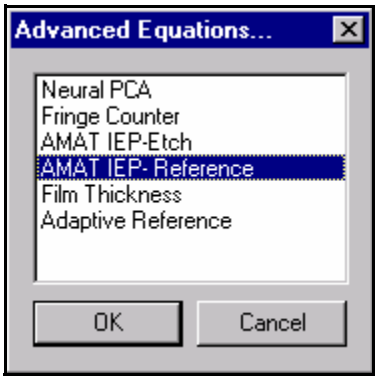


Figure 3-100. Advanced Equation List

2. Name the equation and check **Ref1** as output.

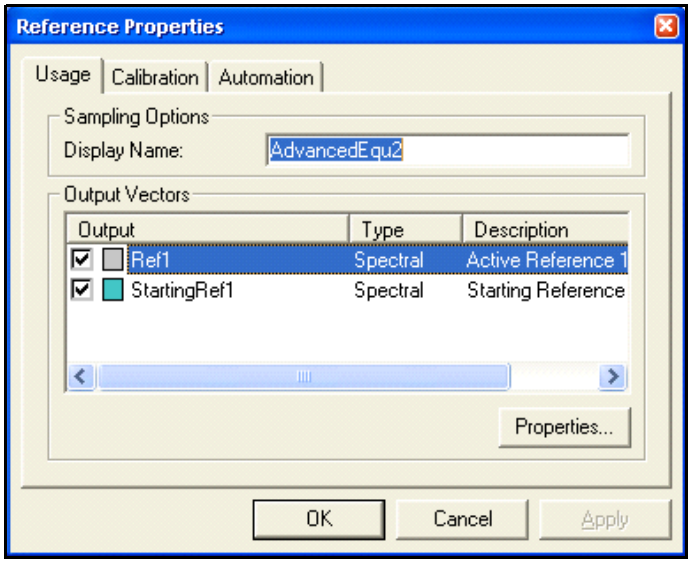


Figure 3-101. Reference Properties Window

3. Click on the **Calibration** tab to define the calibration wafer properties as outlined in Section 3.6.12.4, Manual Reference Generation.

4. Click on the **Automation** tab. The following window appears.

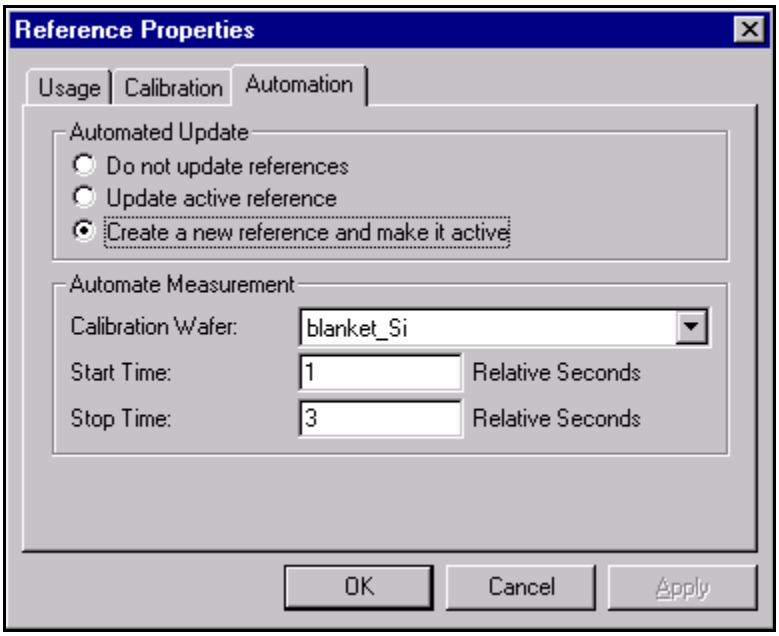


Figure 3-102. Automation Window

If **Create a new reference and make it active** is chosen, then when 62.svc is executed, a reference file with a new name will be created and made active. The name of this reference file contains the specific date and time when the reference file is generated as follows.

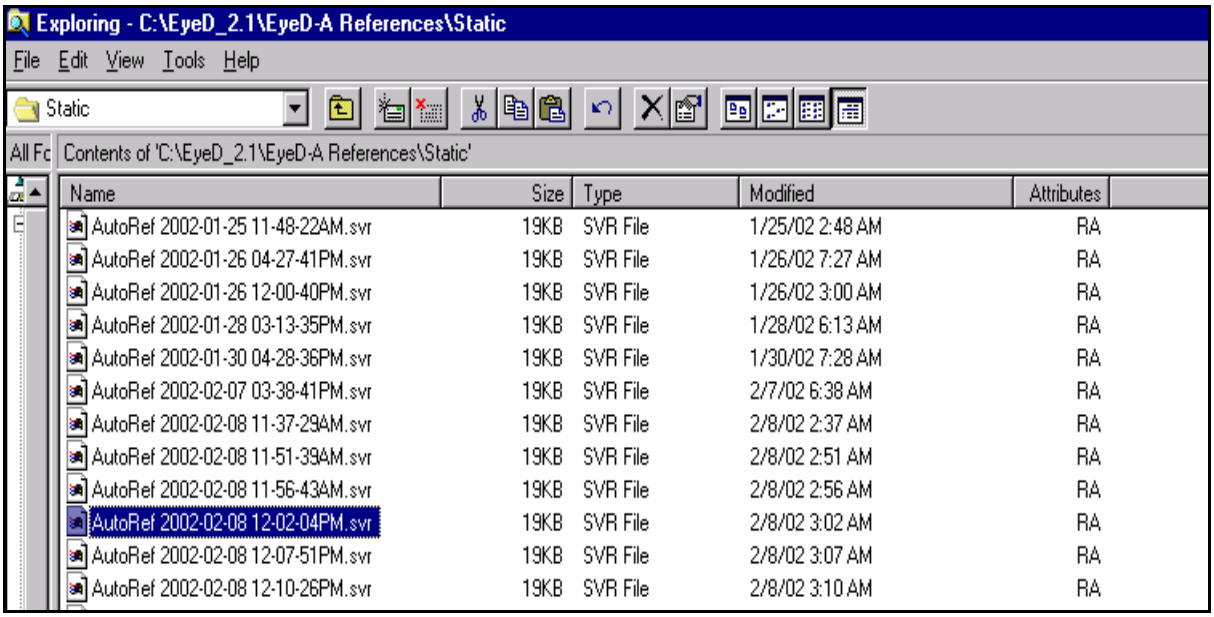


Figure 3-103. Reference File Name Automatically Generated

If **Update active reference** is selected, then when this configuration is executed the chosen active reference file is updated. The active reference file is chosen by clicking on *Tools* ==> *References* ==> *Active Reference* on the heading:

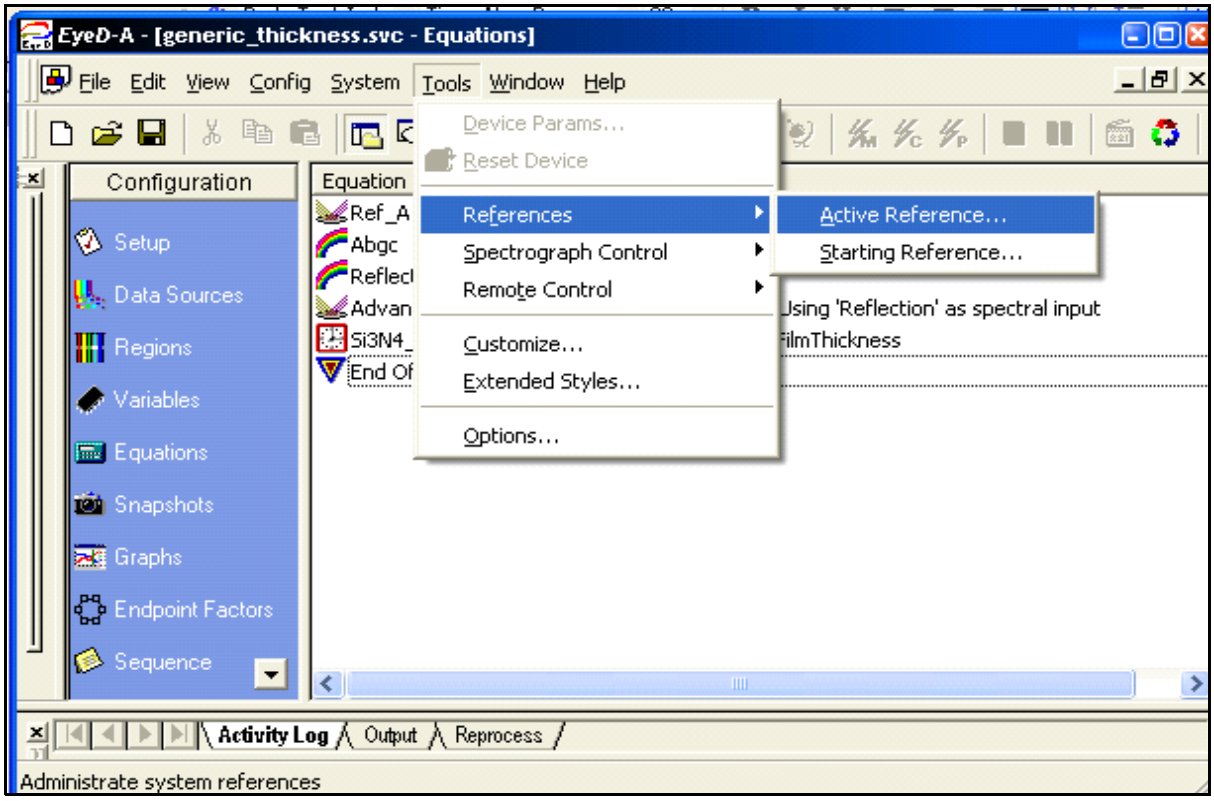


Figure 3-104. Choose References

5. Then choose the reference file and click on **Open**.

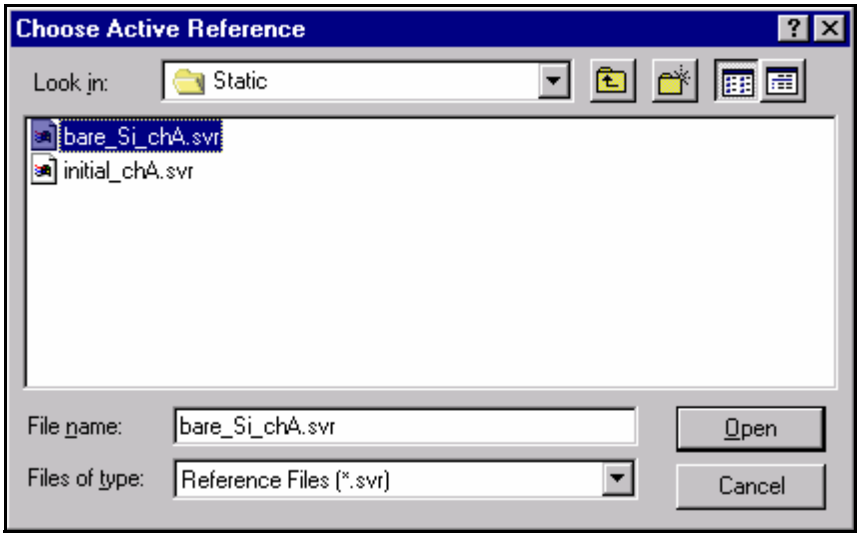


Figure 3-105. Choose Active Reference Window

3.6.12.6 Comparing Auto Reference with Initial Reference After P/M

Every time after a lamp or fiber optic cable are replaced during the preventive maintenance, a baseline reference file should be taken and saved under a specific name. This initial reference file can be taken by having an unetched silicon wafer in the chamber at process position as outlined in the previous section. This baseline spectrum can be compared with reference spectrums taken later. The lamp or fiber optic aging can be easily detected this way. This comparison can be achieved by selecting the initial reference file as the starting reference from the menu bar.

Every time a lamp or fiber optic cable are replaced during the preventive maintenance, a baseline data file should be taken and saved under a specific name. Please be aware that a baseline data file (.svd) instead of a reference file (.svr) should be taken for this purpose.

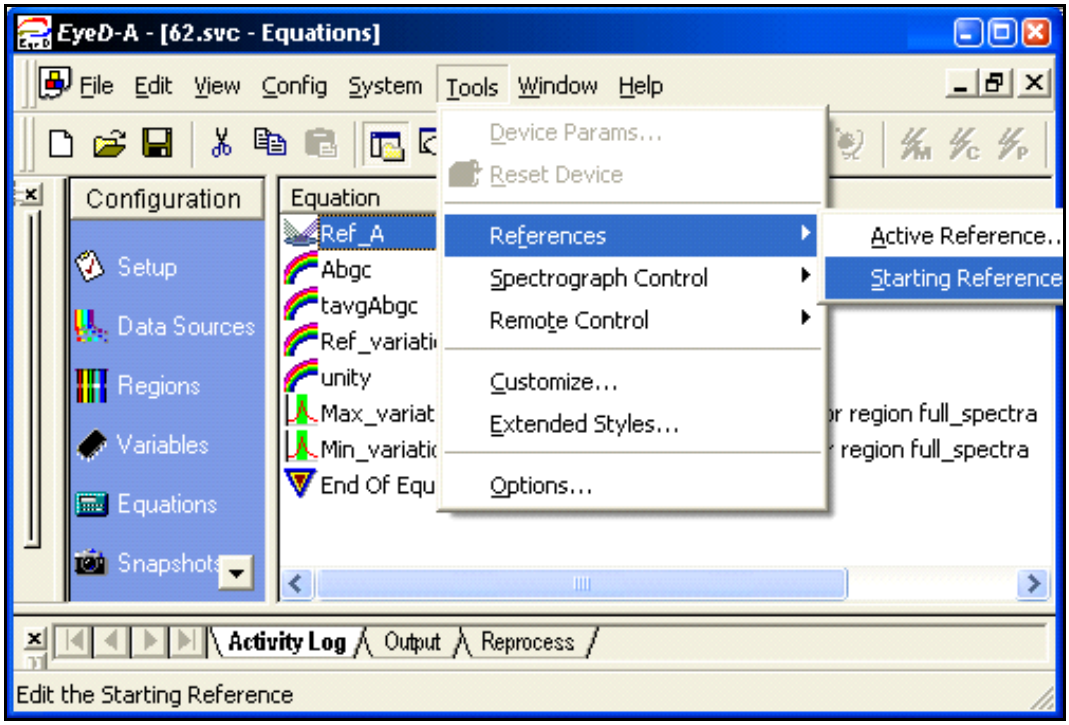


Figure 3-106. Select the Starting Reference

In the equation list, an equation that measures the variation of the current reflection spectrum compared to the initial baseline spectrum can be added. The percentage of the maximum and minimum variation can be calculated by the equation named *Max_variation* and *Min_variation* respectively in the example shown in Figure 3-107.

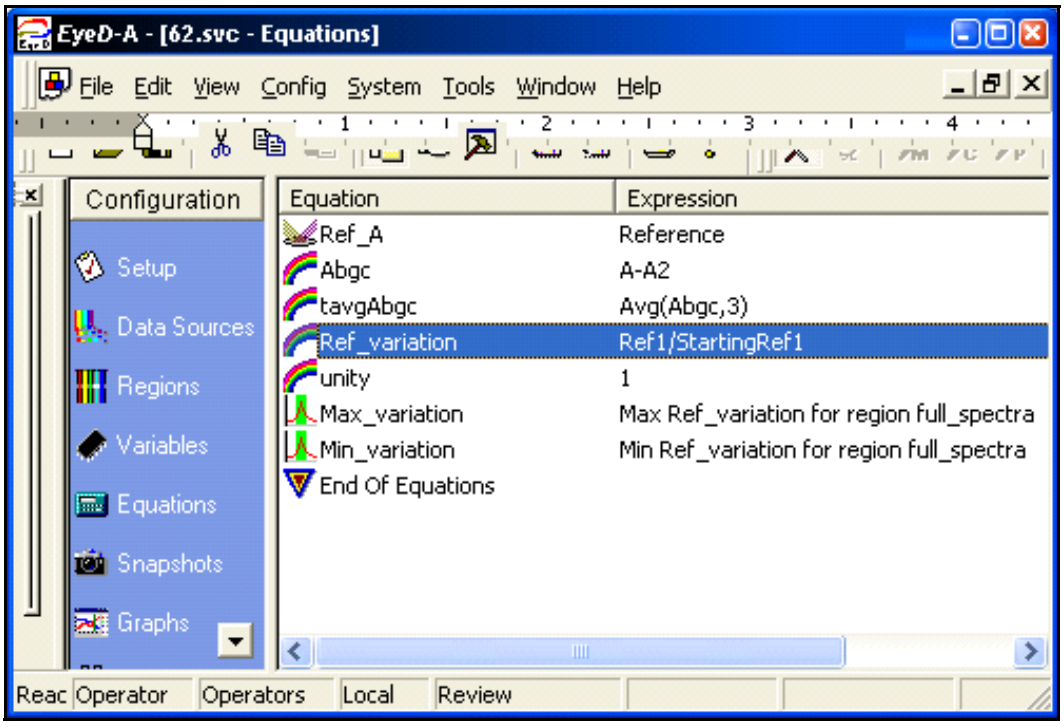


Figure 3-107. Comparison of Reference Spectrum

If the variation is over certain limit defined by the user then a warning message can be generated. This can be done by adding a user event in the sequence list. See Figure 3-108.

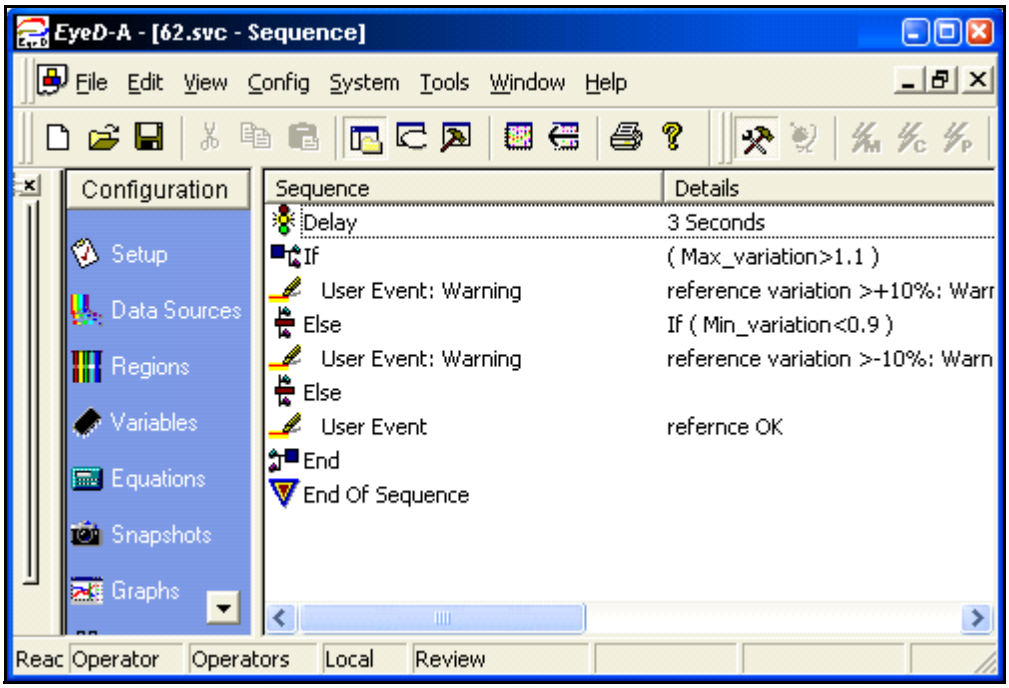


Figure 3-108. Warning of Large Reflection Spectrum Variation

In this example, a warning message will be generated if there is a 10% change in the intensity at any wavelength within the specified spectrum range compared to the initial baseline spectrum.

3.6.12.7 Variables

The EyeD program has a variable feature, which allows different algorithms to share the value of the same variable.

3.6.12.8 Define Variable in Configuration File

1. Open the configuration file in which the variable is needed. See Figure 3-109.

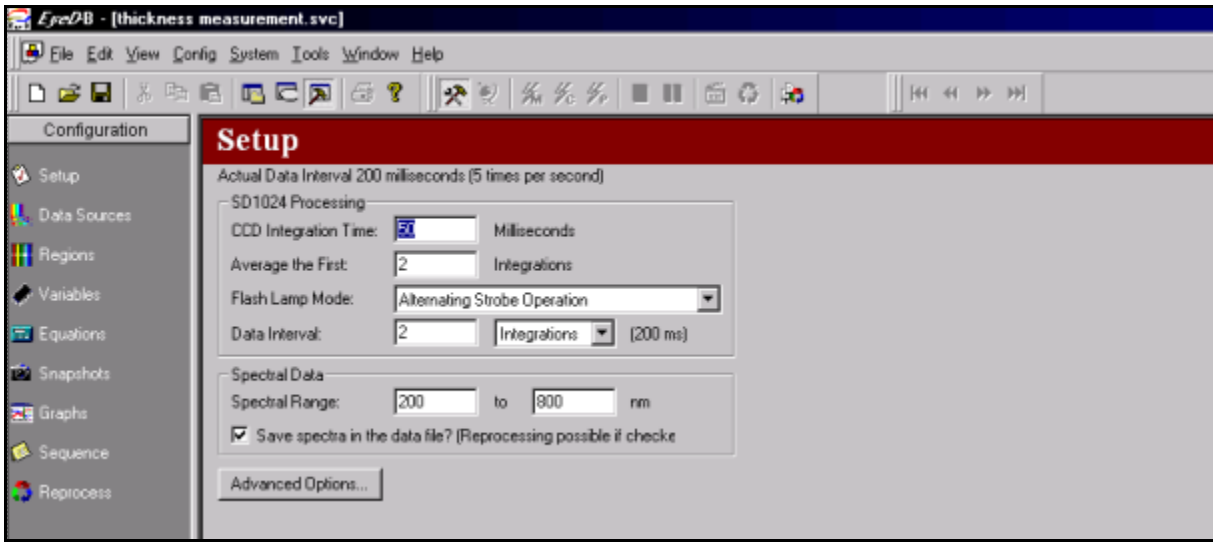


Figure 3-109. Setup Window

2. Left-click **Variables** (Figure 3-110) under the *Config* menu.

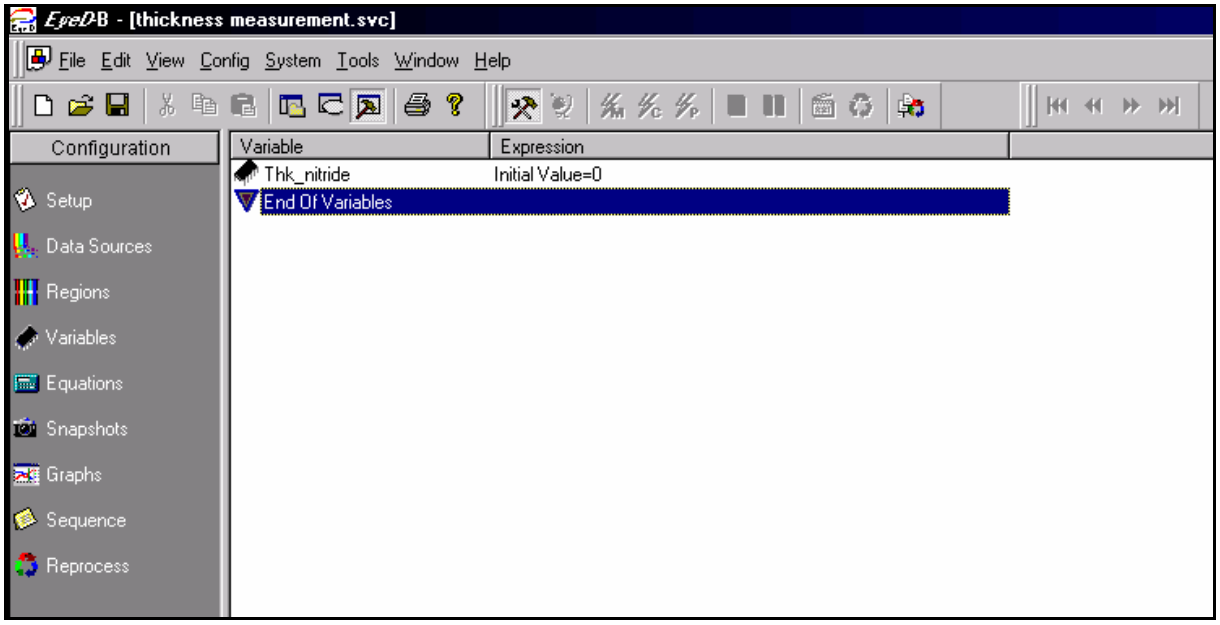


Figure 3-110. Variables List

3. Right-click **End of Variables** and select **Insert Variable**. Figure 3-111 appears.

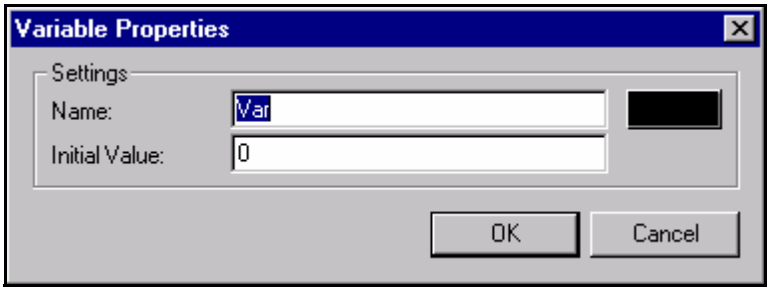


Figure 3-111. Variable Properties Window

Both the variable name and initial value must be set. The initial value will only be used during the first time this variable is called. After that, the most recent value assigned to this variable will be used and the initial value set in the configuration file will be ignored. The same variable must be defined in all the configuration files that call it.

3.6.12.9 Cautions

The value of a variable remains until a new value is assigned to that variable, or is reset at End of Wafer. Since a variable is usually used in two or more algorithms, its value can be updated during the execution of any of these algorithms. Therefore, the user must manage the variables with care and keep track of the most recent value assigned to a variable.

3.6.12.10 Using the Film Thickness Measurement Resource

This section presents a procedure to measure a film thickness during an RF-off step.

3.6.12.11 Optical Properties Database

The film stack that needs to be measured by the fit-to-model method can be made of different materials. For example, it can be nitride on oxide, poly on oxide, or other types of materials. The EyeD program offers users the ability to modify or add their own material properties to the model. The material optical properties database is under the directory *C:\EyeD\Materials\Table*. An example of the data file is shown in Figure 3-112.

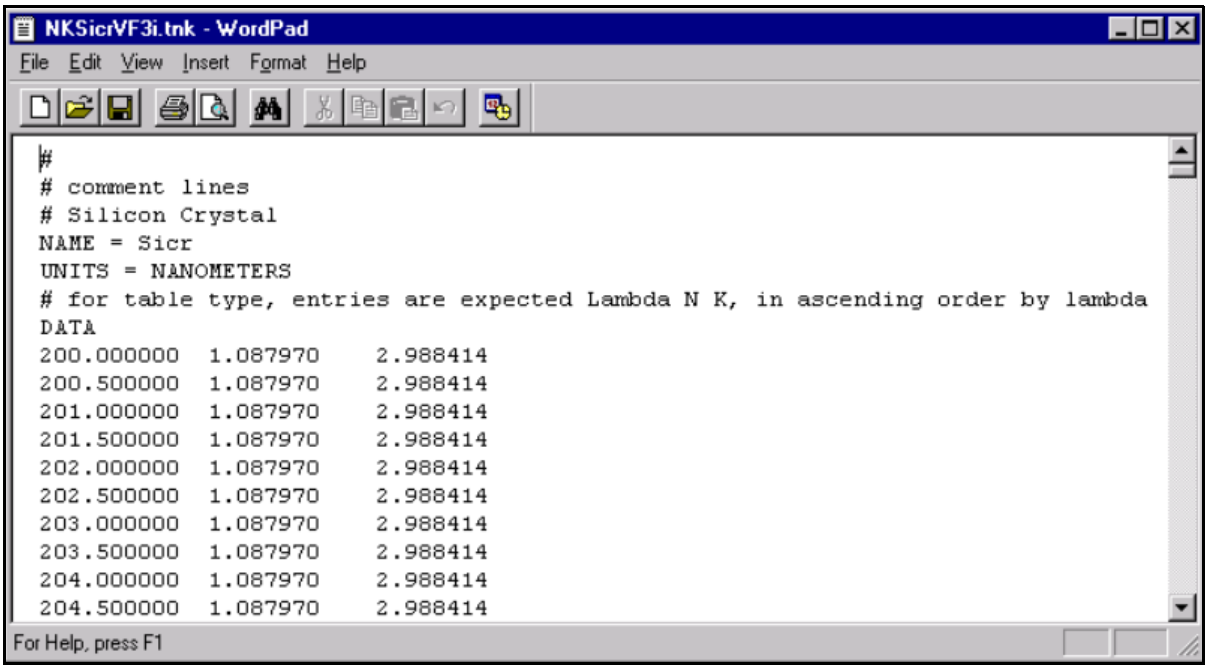


Figure 3-112. Material Optical Properties File

The name (4th line in Figure 3-112, *Sicr*) is the name EyeD will use to refer to the material in the user interface. The units are the units of wavelength in the table. Other valid choices for Units are *ANGSTROM* and *MICRON*. After the line containing the word *DATA*, there are any number of lines of the form,

wavelength n k

The data used by the algorithm will be interpolated between the values provided, so it is only necessary to ensure that the table spans the range of wavelengths to be used in the algorithm. The user can easily add their own material properties data file or modifying the existing data files according to this file format.

3.6.12.12 Selecting Wavelength Range and Number of Data Analysis Points

Using the Film Thickness Measurement feature requires that a valid IEP reference is present. This means that the equation list will already contain a Reference equation and another equation in which the incoming data is divided by the reference to yield the wafer reflectivity. The Film thickness equation must be added below these equations, as it will use the output of the second equation as its input. It is added by inserting the Advanced Equation *Film Thickness* in the usual way.

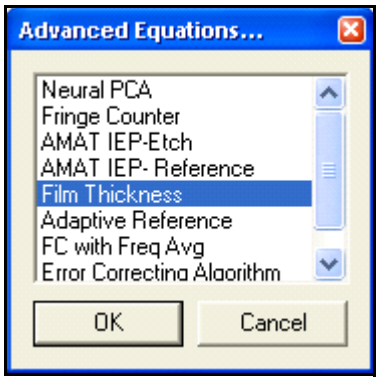


Figure 3-113. Advanced Equations List

1. Select **Film Thickness** and click on **OK**. The following dialog box appears.

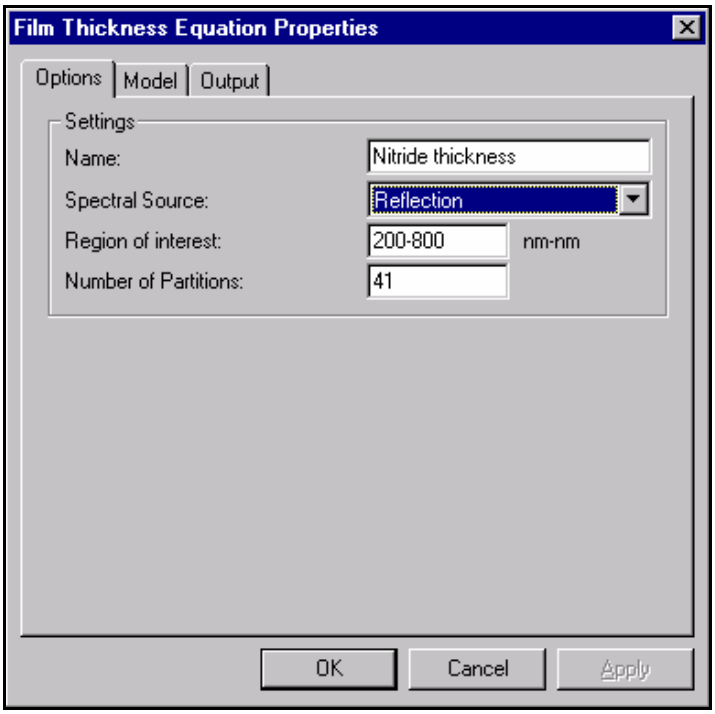


Figure 3-114. Film Thickness Equation Properties

2. Enter a name for the equation output into the first field.

   The second field, *Spectral Source*, must be the reference-normalized reflectivity.

The next two fields are best chosen after examination of the spectra captured during some wafer etch runs. The region of interest should be chosen with some care. The film thickness measurement is done by finding the value of the film thickness for which the model most nearly matches the observed pattern of reflection minima and maxima within the spectral range defined here.

Depending on the film thickness, its range of transparency, and the nature of the substrate, better results may be obtained if something less than the full range of 200 - 800 nm is chosen.

The range chosen should contain at least one minimum and one maximum for all thicknesses within the expected measurement range.

The Number of Partitions is the number of discrete points within the range at which the comparison is made. It should be large enough to faithfully capture the oscillations expected in the spectral reflectivity. Generally, thicker films call for larger numbers. As a rule of thumb, the maximum expected total film stack thickness in nm divided by 10 is a good number.

3.6.12.13 Setting up the Film Stack Model

1. Select **Model** in the *Film Thickness Equation Properties* window. The following window appears, Figure 3-115.

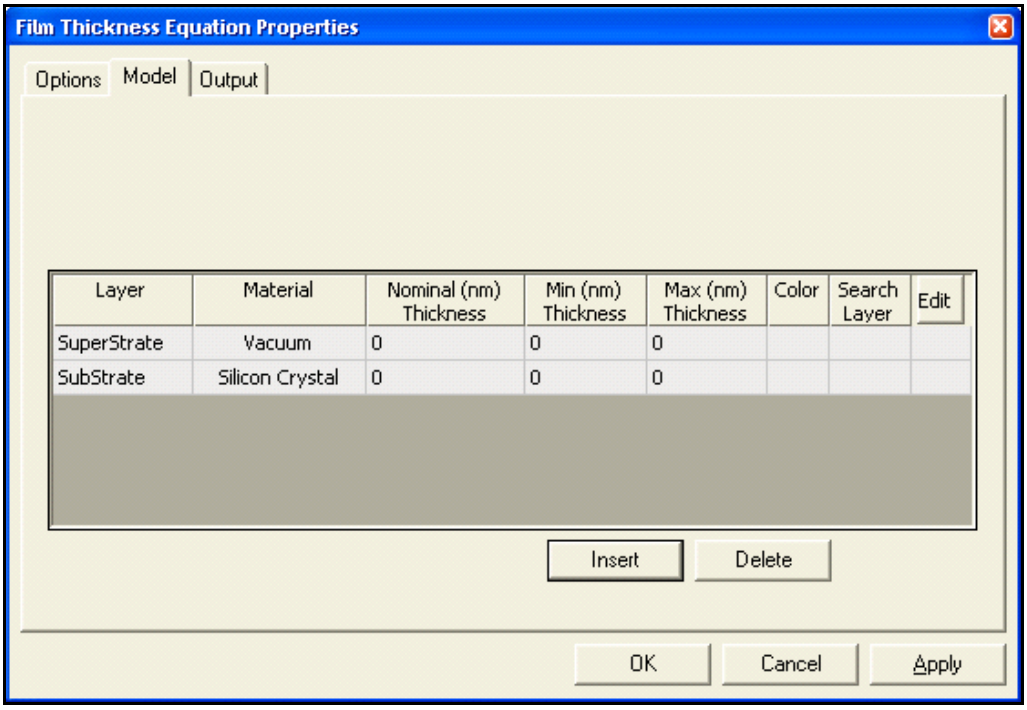


Figure 3-115. Film Stack Model

2. Click on **Insert** to add a new layer to the Film Stack.

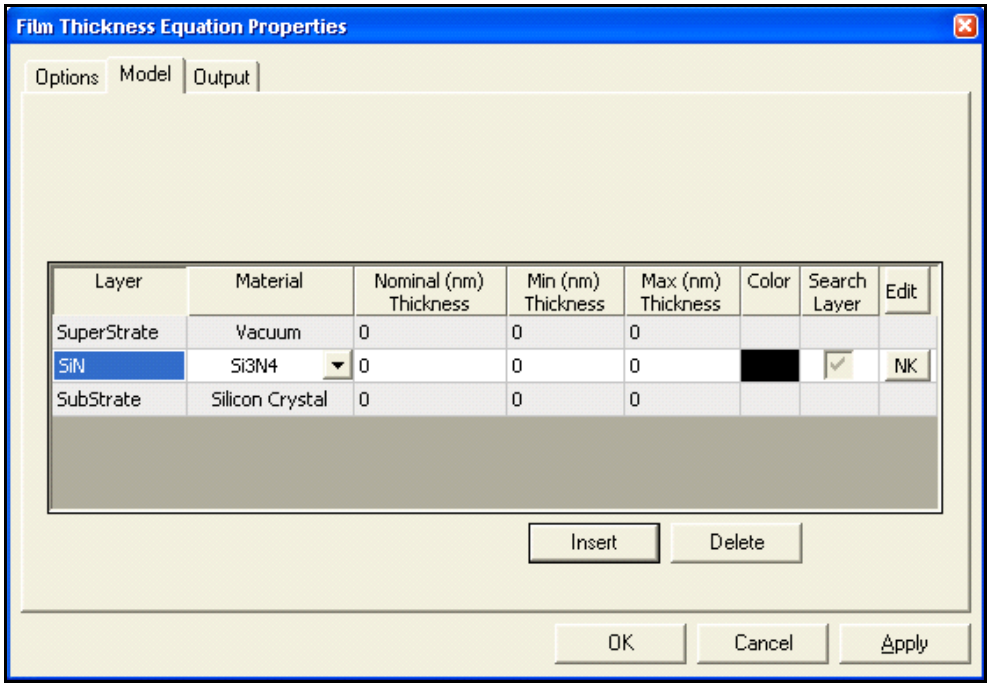


Figure 3-116. New Layer in Film Stack

3. The name, material and thickness range of the layer are all defined in this window. Choose the material from the pull down list, as shown in Figure 3-117.

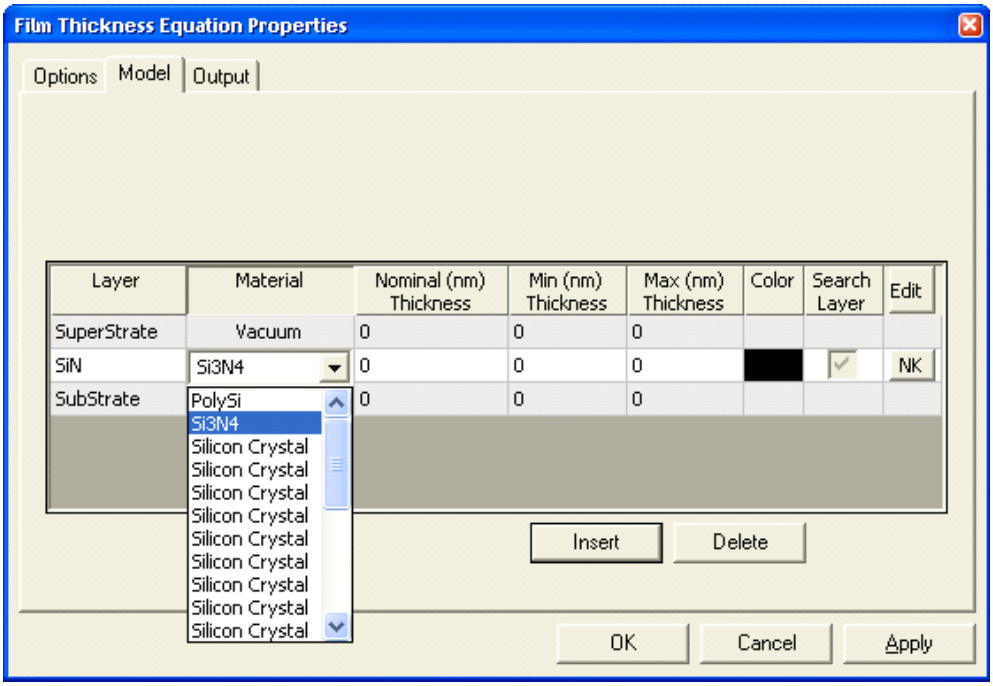


Figure 3-117. Material Selection Window

If the desired material is not found in the pull down menu, it can be added to the list. Click on the **Edit** button (it is presumed that the desired material properties

have already been added to the optical properties database discussed in Section 3.6.12.11). The following screen appears. See Figure 3-118.

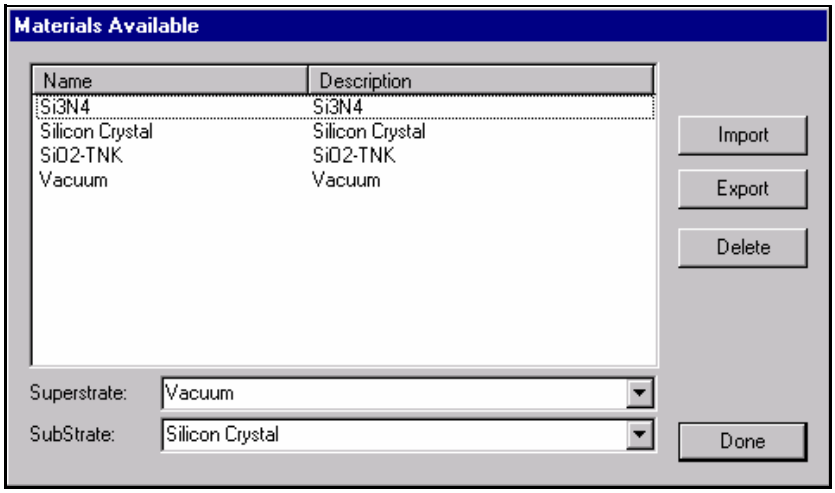


Figure 3-118. Material Palette Builder Window

4. Click on **Import** to open the available material database.

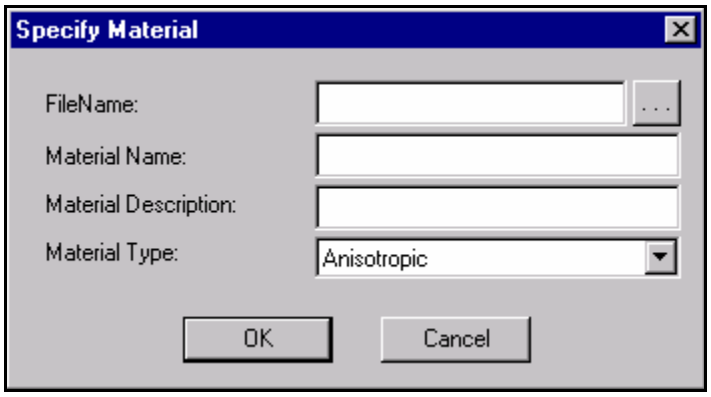


Figure 3-119. Specify Material Window

5. Click on the browse tab to display all the available material in the database.

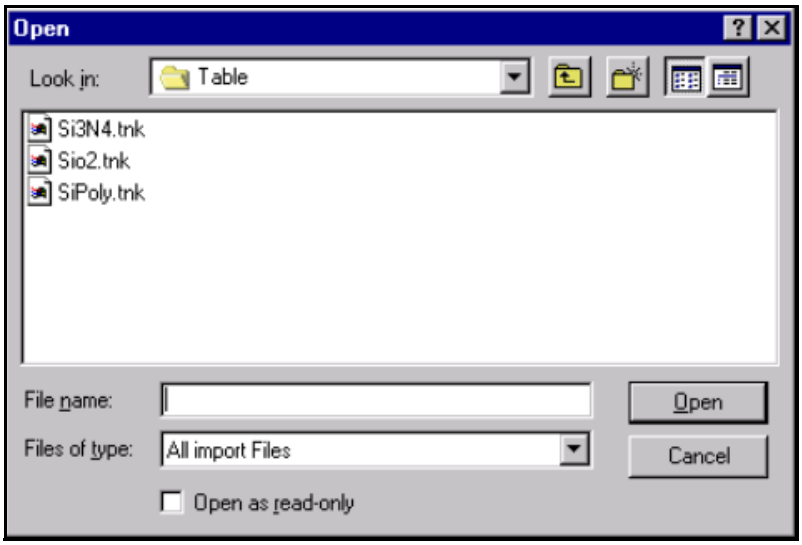


Figure 3-120. List of Available Material in the Database

6. Choose the desired material and click **Open**. The selected material is now added to the list of *Material Available*. This procedure will add the desired material to the material palette and make it available to set up the film stack model.

7. Select **OK** to exit this window.

8. Type the range of the film thickness, then select **OK** in the *Layer Properties* window. One layer in the film stack is now defined.

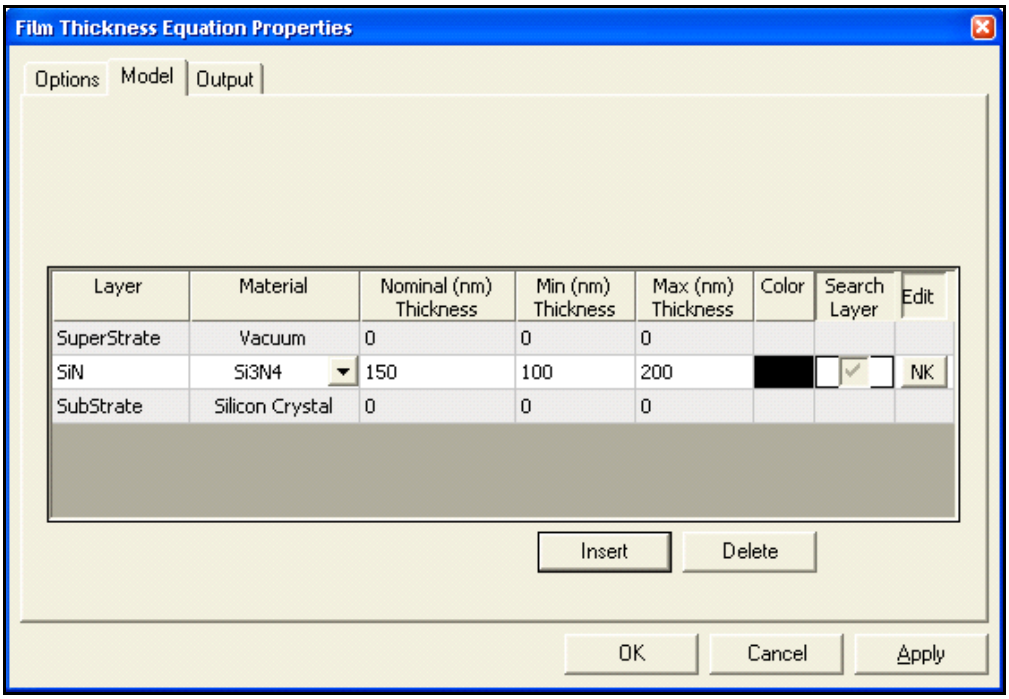


Figure 3-121. Film Stack Model

More layers can be added by repeating the above procedure. The film thickness equation can be used to measure the thickness of the top two layers. The very top layer is always a Search Layer. The second layer thickness will be measured if the Search Layer box is checked for this layer. See Figure 3-122.

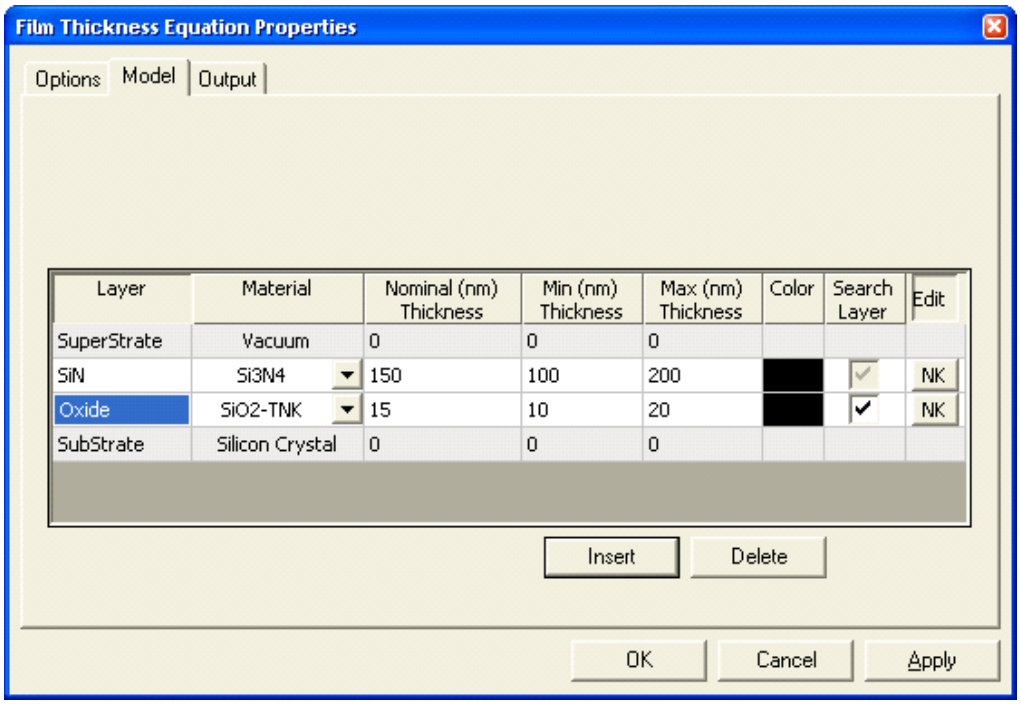


Figure 3-122. Film Stack Model

The order of the layers should be the same as that on the wafer. If the layer thickness is known (e.g. the pad oxide layer), it should be entered as a constant. Then the model will yield a more accurate result for the thickness of the other layer whose thickness is unknown.

9. Select **OK** when the film stack is defined.

3.6.12.14 Specifying Reference to be Used

Open the configuration file for thickness measurement, add the reference equation to the list of equations. Make sure the box beside output vector *Ref1* is checked (Figure 3-123). This will make the reference spectrum available for other spectral equation (Figure 3-123).

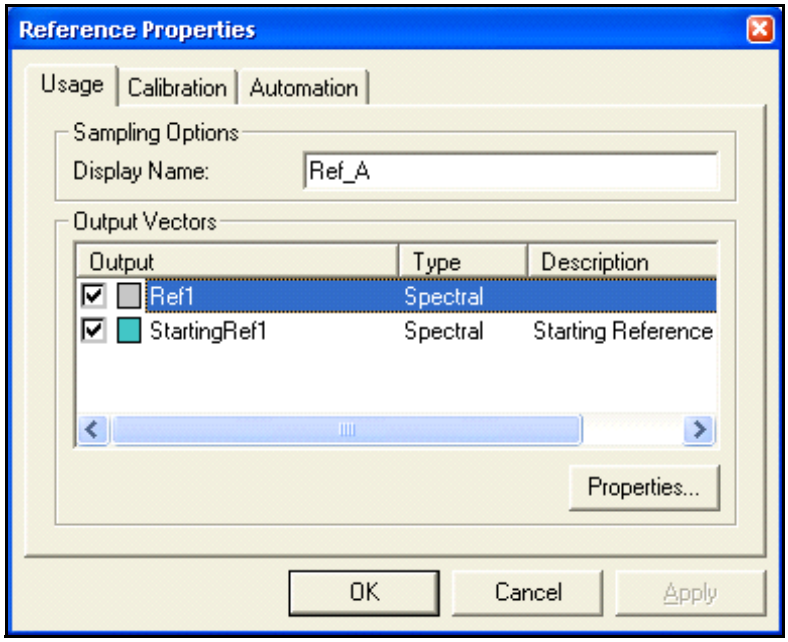


Figure 3-123. Reference Properties Window

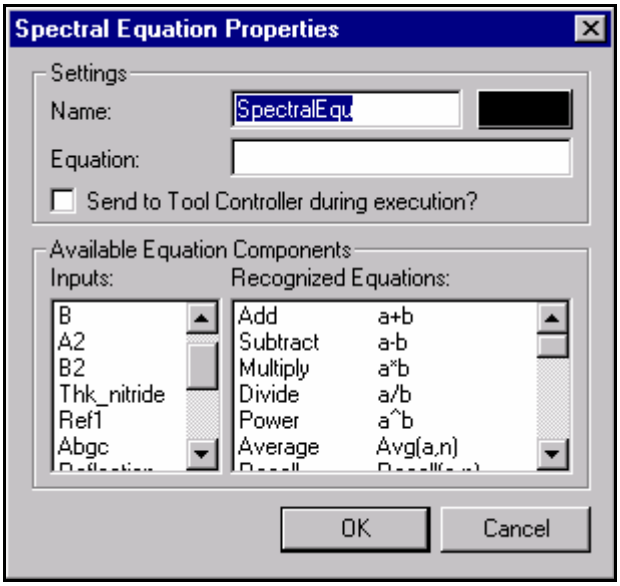


Figure 3-124. Spectral Equation Properties Window

But the spectrum contained in *Ref1* has not been defined yet. *Ref1* is similar to variables in the sense that it is not defined until you select the specific reference file as the source of the data. If the reference file is taken in manual mode, then the active reference file must be chosen according to the procedures outlined in Step 4 of Section 3.6.12.5.

Usually the most recent reference file should be chosen. After the active reference file is chosen, *Ref1* contains the bare silicon spectrum. This way, the reference can be changed without the configuration having to change. If automated reference generation is used, then the reference file taken most recently will be set as the active reference file automatically

and the above procedure is not needed.The user should also make sure the automation function of the reference equation in the film thickness algorithm is not enabled as shown in Fig. 37.

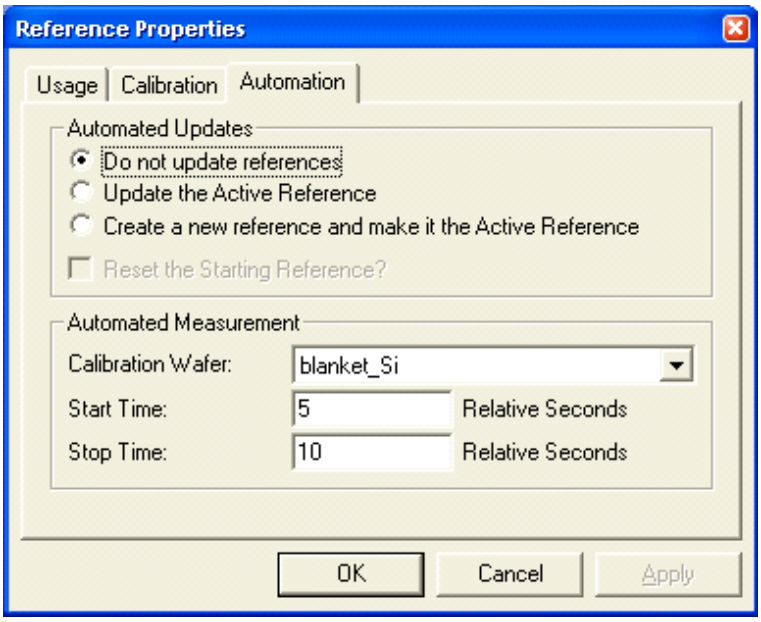


Figure 3-125. Reference Properties Window Automation Screen

3.6.12.15 Passing Thickness Result to Etch Control Algorithm

The outputs of the thickness measurement equation include the film thickness, the measured and best fit reflectance spectrum, and the calculation error.

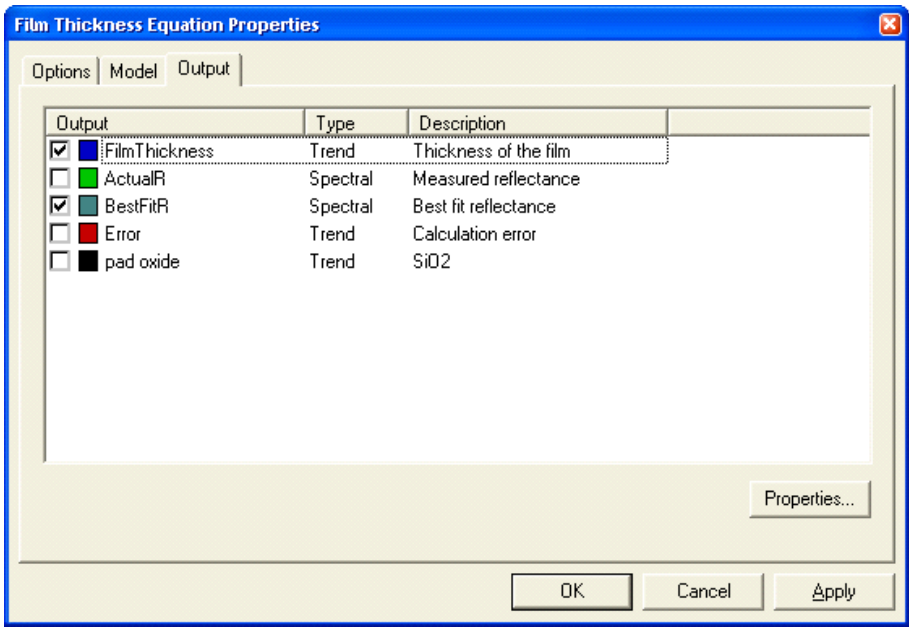


Figure 3-126. Output of Film Thickness Equation

A variable must be defined in the thickness measurement configuration according to the procedure outlined in Section 3.6.12.7. Assign the output of the Film Thickness Equation to the variable in *Sequence*.

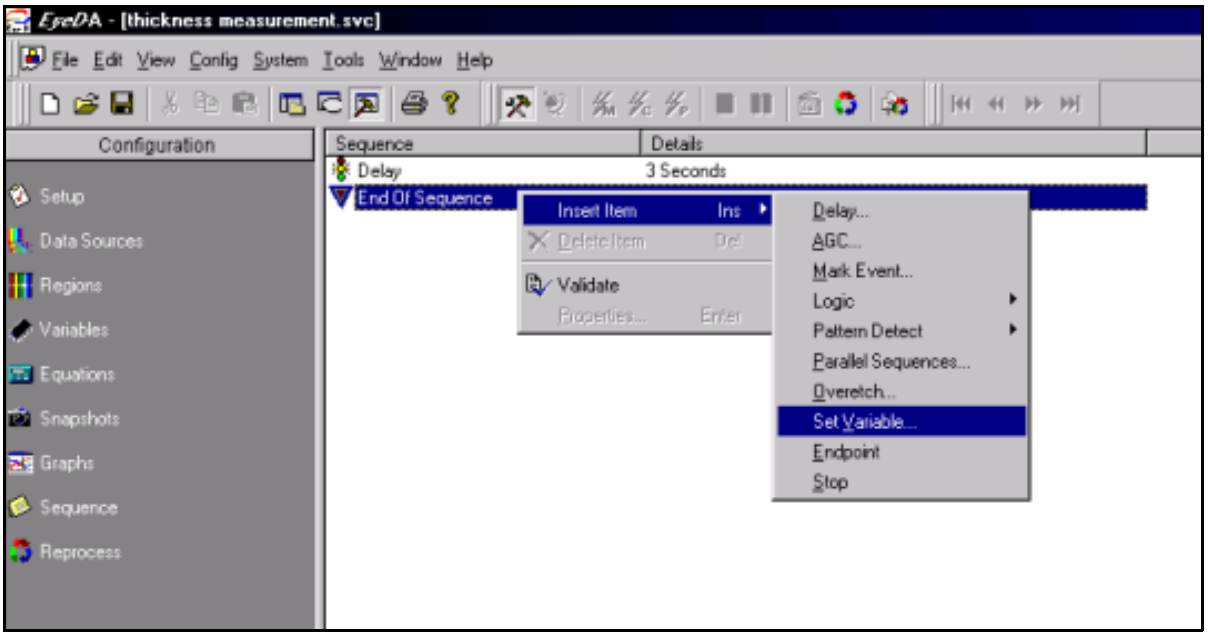


Figure 3-127. Set Variable in Sequence

1. Choose the name of the variable from the pull-down menu in the *Set Variable Properties* window.
2. Double click on *AdvancedEqu_FilmThickness* in the list of *Inputs*. Click **OK**.

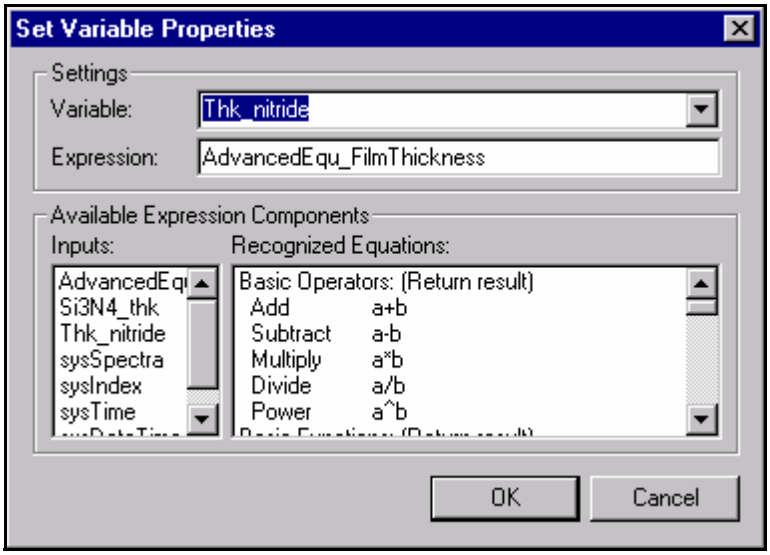


Figure 3-128. Set Variable Properties

Now the value of the film thickness has been assigned to the variable, named *Thk_nitride* in the example, as shown in Figure 3-129.

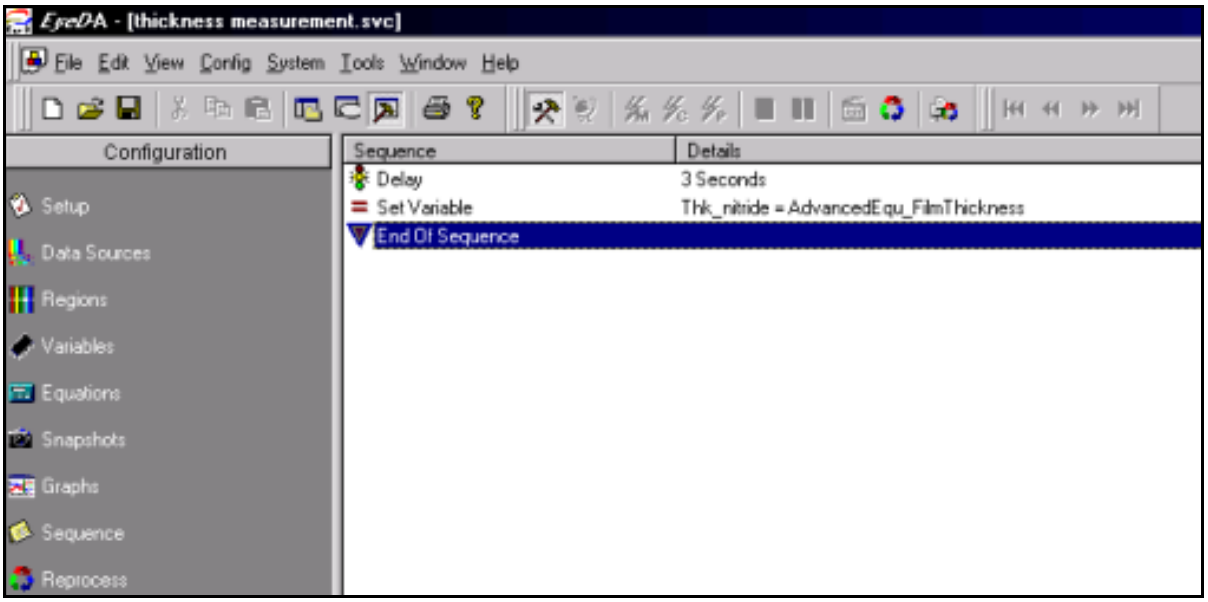


Figure 3-129. Assign Film Thickness Value to Variable

3. Open the etch control algorithm. Define the same variable as the one in the thickness measurement configuration. The name of the variable is *Thk_nitride* in this example.

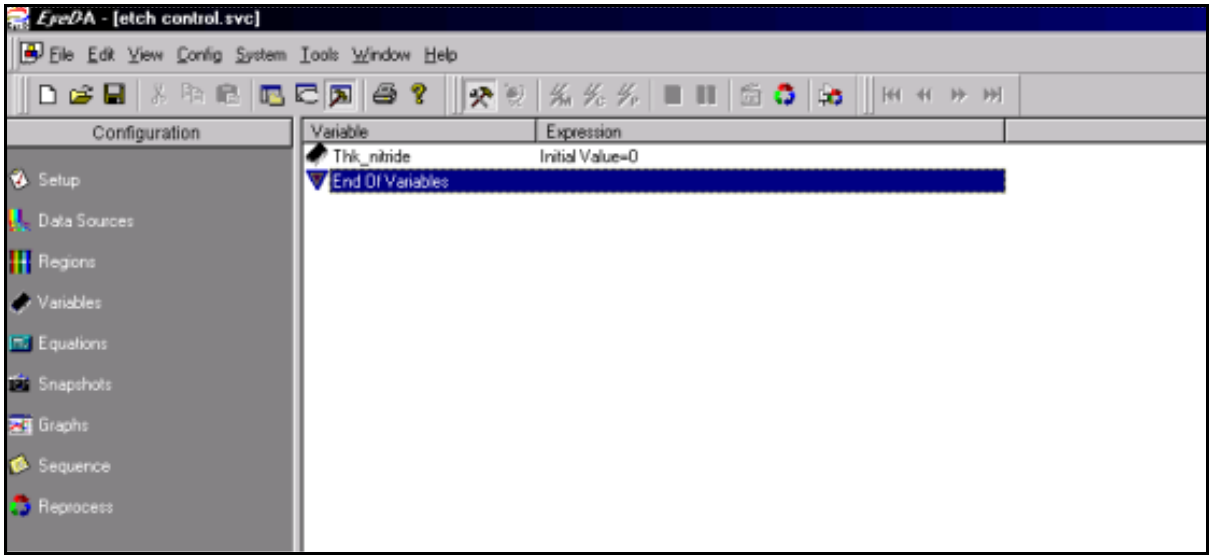


Figure 3-130. Define Variable in Etch Control Algorithm

Now the value of the variable is passed to the etch control algorithm and available as inputs in trend equations.

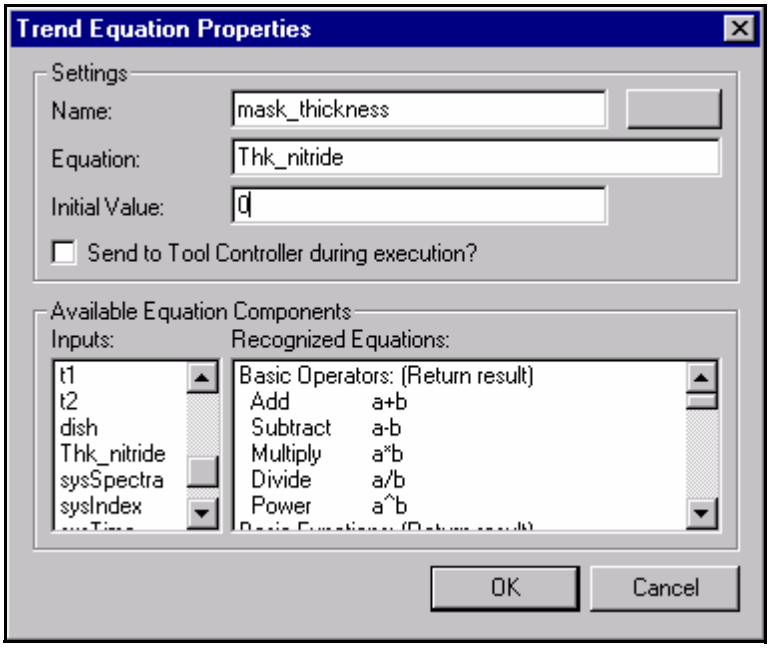


Figure 3-131. Tend Equation Properties Window

3.6.13 AMAT IEP-Etch

This equation is based on a fit-to-model method. It is applied to cases where the film stack is opened to the underlying substrate and trenches are etched in the substrates such as the STI. Both the thickness of the top layer in the film stack and the depth of the trench are determined simultaneously by fitting the reflection spectrum to that calculated by using the model.

The AMAT IEP-Etch equation can be accessed by selecting *insert equation* ==> *Advanced Euqations* ==> *AMAT IEP-Etch* (see Figure 3-132). The AMAT IEP-Etch Properties window then shows up as shown in Figure 3-133.

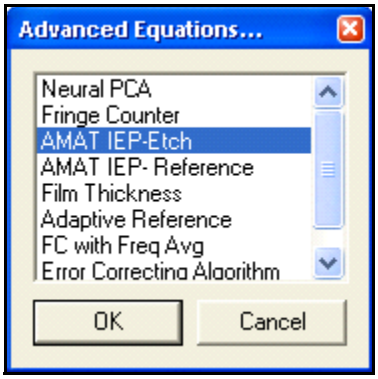


Figure 3-132. Add an AMAT IEP-Etch equation.

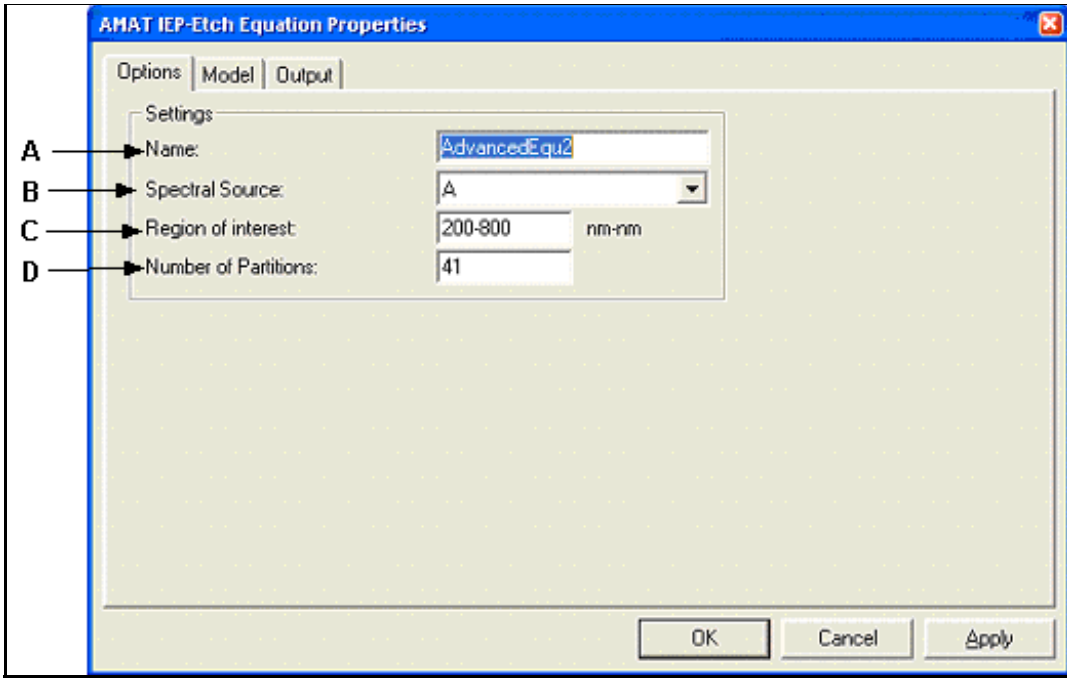


Figure 3-133. AMAT IEP-Etch Properties Window

This window has three pages as indicated by the three tabs on the top. They are the Options page, the Model page, and the Output page. The following figures and associated text provide details of the implementation of the AMAT IEP-Etch dialog.

3.6.13.1 Options Page

The parameters available in the Options page are shown in Figure 3-133.

A. **Name:** Enter a unique name for the AMAT IEP-Etch equation being created.

B. **Spectral Source:** This is the name of the data or spectral equation that will be the input to this equation. The spectral input to this equation expects an absolute reflectance divided by a reference spectrum generated on a silicon wafer.

C. **Region of interest:** Type in the starting and ending wavelength from the input data that will be used in this equation.

D. **Number of Partitions:** This is the number of equally divided partitions in 1/ wavelength, between the start and end wavelengths.

3.6.13.2 Model Page:

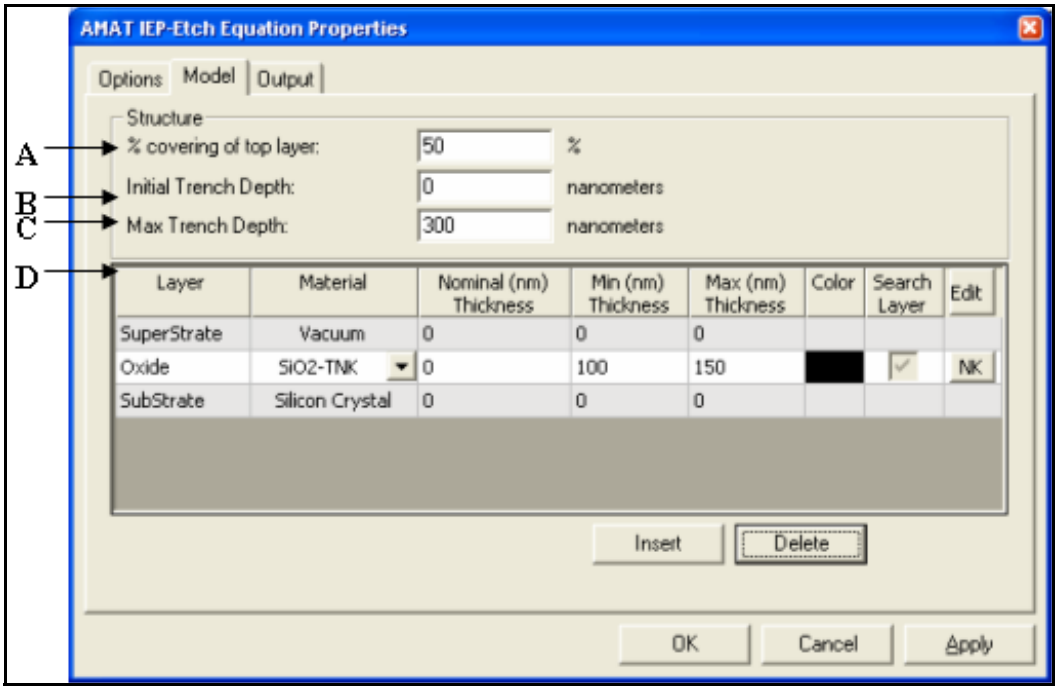


Figure 3-134. AMAT IEP-Etch Model Screen.

The Model screen allows the user to put in detailed information about the film stack on the wafer, which will be used in the optical model.

A. **% covering of top layer:** Is the percent of surface area covered by the top layer.

B. **Initial Trench Depth:** This is the depth in nanometers of the initial trench in the substrate (usually zero).

C. **Max Trench Depth:** This is the anticipated maximum depth of the trench.

D. **Grid Control:** The individual layer information is entered here. The superstrate and substrate information is required, and can be chosen by clicking on the **Edit** button at the end of the top row. Layers are inserted by either hitting the **Insert** key or by clicking on the **Insert** button. Deletion of layers is similar: either hit the **Delete** key, or click on the **Delete** button. The delete does not generate a warning.

D. **Layer:** Type in the name of the current layer. This must be unique for this stack. The name is seen in EyeD as the equation name and the stack name.

D. **Material:** A material chosen from the list of materials entered from the **Edit** button.

D. **Nominal Thickness (nm):** This is the nominal thickness of the layer. If no search is performed, this is the height of the layer.

D. **Min Thickness (nm):** This is the minimum thickness for search purposes. If Search Layer is not active, this is ignored.

D. **Max Thickness (nm):** This is the maximum thickness for search purposes. If Search Layer is not active, this is ignored.

D. **Color:** It decides the color used for displaying in the stack diagrams, and also for displaying in EyeD's trend graphs, if output thickness is chosen.

D. **Search Layer:** It determines if this layer is to be searched when compared to the input spectrum. If this is set and this is the top layer and the Min Thickness is set to zero and the layer below this does not have this box checked, then the layer below this is cascaded onto the end of this one. That is, the layer below this is searched when this layer thickness becomes zero. This continues down the stack until the first non-zero Min Thickness is encountered or this box is checked on any layer below this.

D. **NK:** This displays the N and K value of the material in the film.

3.6.13.3 Output page

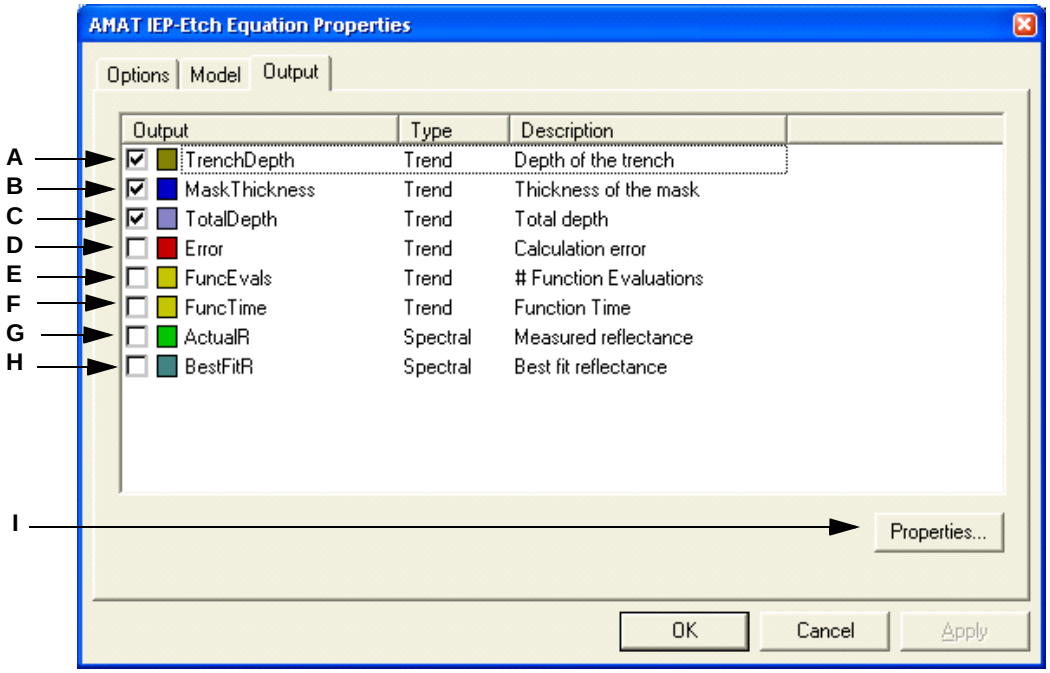


Figure 3-135. AMAT IEP-Etch Equation Output Screen.

Individual outputs are activated here. Additional entries will be available for each layer that is searched.

A. **Trend Depth:** It displays the trench depth below the substrate surface.

B. **Mask Thickness:** It displays the mask (top layer) thickness.

C. **Total Depth:** It displays the distance between the trench bottom and the top surface of the mask.

D. **Error:** It allows the user to view the unscaled residual error resulting from a search.

E. **FuncEvals:** It displays the number of function evaluations to find the best fit.

F. **FuncTime:** It displays the time required to do the search.

G. **ActualR:** It displays the actual reflectance of the input signal.

H. **BestFitR:** It displays the best fit reflectance, which are the computed spectral values obtained during the search. This should only be output when reprocessing because computing these values requires a significant amount of CPU time.

I. **Properties:** Push this button to edit the fields and colors displayed for each output.

In all three pages, pushing the **OK** button will save all the equation information If search options are selected, it will generate a table. Pushing the **Cancel** button will discard any changes made to the equation during the edit session.

3.6.14 IIR and FIR Filtering with Trend and Region Equations

For many trending events, it is a common practice to filter the data stream to alter the general temporal response. This filtering is commonly applied to reduce signal noise levels. In these cases, the simple application of an IIR (infinite-duration impulse response) or FIR (finite-duration impulse response) filter may be readily applied using the available trend equations within the EyeD application software provided by Verity for the SD1024 series of spectrographs.

The easiest method for understanding the application of an IIR or FIR filter is to derive the general forms of the difference equations for the filter.

$$y[n]=\sum_{l=1}^{N} a_l y[n-l]+\sum_{k=1}^{M} b_k x[n-k]$$

The {al} terms are the feedback weighting coefficients and the {bk} terms are the feed-forward weighting coefficients for the general difference equation of the filter. The filters may be sub-classified using the following definitions.

$$if\ a_l = 0\ .\ l\ \Rightarrow\ y[n].\quad FIR\ filter\ of\ order\ M$$

$$if\ a_l\ .\ 0\ .\ l\ \Rightarrow\ y[n].\quad IIR\ filter\ of\ order\ N$$

The simplest IIR filter is first-order. In this form, the filtered output is a linear combination of the current raw signal x[n] and the current filtered signal y[n]. A commonly used simplification is to define the coefficients in a form as a1 + b0 = 1 with both coefficients having a positive value less than unity. Since a1 is less than one, the recursion is stable and the magnitude of b0 directly controls the damping, (i. E., less damping for larger b0).

$$y[n]=a_1 y[n-1]+b_0 x[n]$$

The following figures show a EyeD configuration that performs this simple example filter. Filters that are more complex may be designed by explicitly adding the required difference equations. The serial evaluation of equations in EyeD provides innate support for first order recursion difference equations, i. E., y[n-1]. However for higher order difference equations

the EyeD function Recall(a,n) must be used. For example Recall(y,2) = y[n-2] and likewise Recall(y,0) = y[n].

Figure 3-136 shows a selected spectral region of interest. As an example this region may contain a spectral peak that the result of a defined atomic emission from an excited atom in a plasma. This region once defined is used as the input to the trend equations that are defined in the latter screen capture.

Region_Interest is a spectral region vector extending from 545 to 555 nanometers in wavelength.

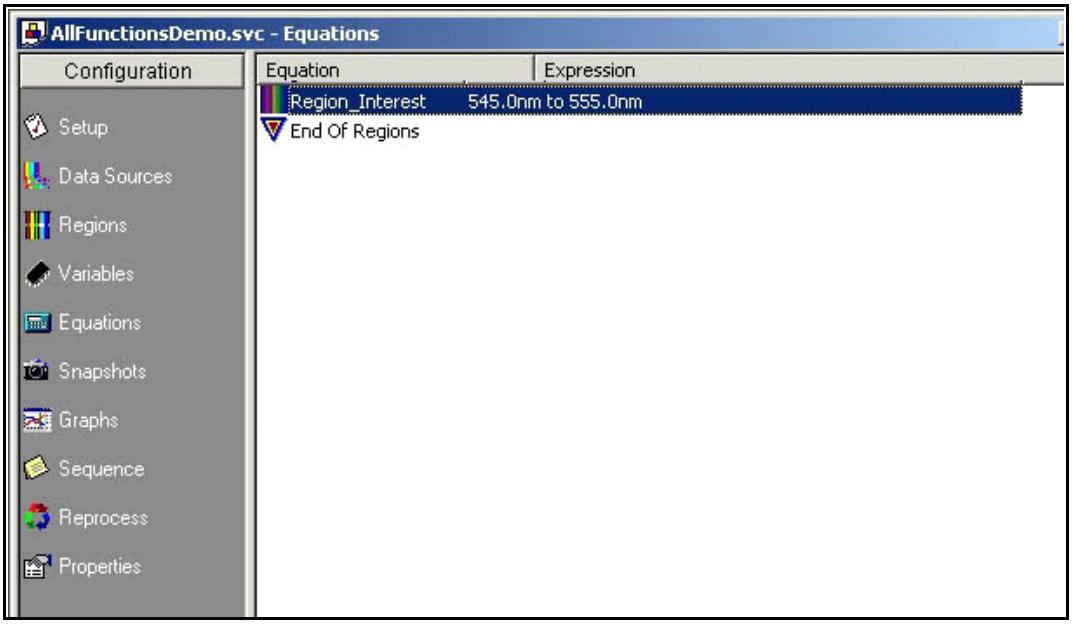


Figure 3-136. Region of Interest Defined

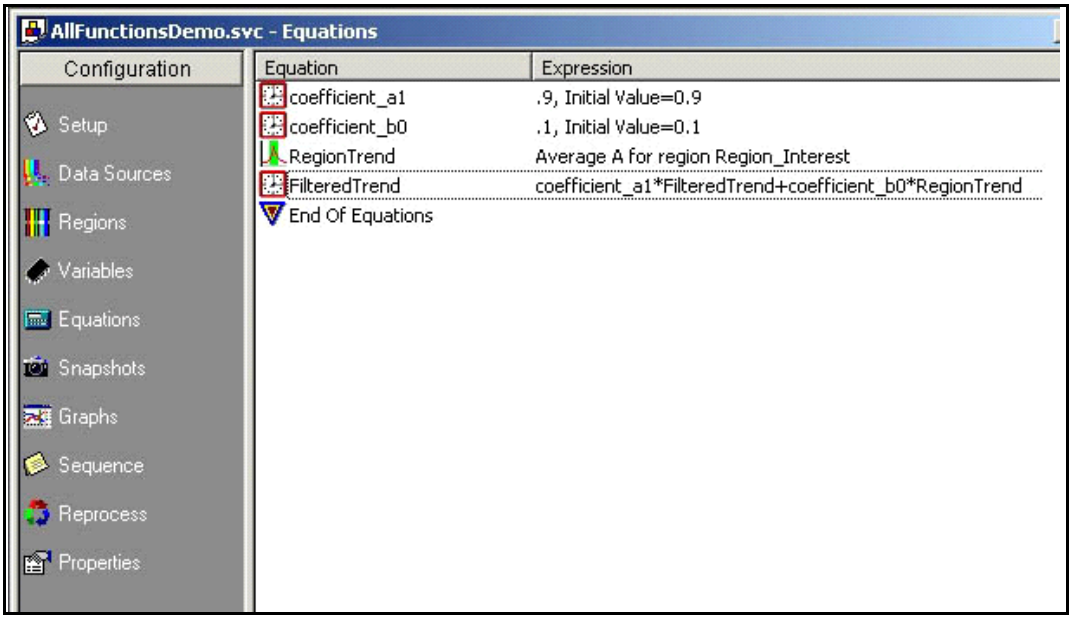


Figure 3-137. Required Region and Trend Equations

Figure 3-137 displays the region and trend equations required to incorporate the example IIR filter into EyeD.

- *coefficient_a1* is a trend equation that is used as the constant a1 with value = 0.9.
- *coefficient_b0* is a trend equation that is used as the constant b0 with value = 0.1.
- *RegionTrend* is a region equation that averages the chosen region of the spectral data from channel A to produce a trend value.
- *FilteredTrend* is a trend equation that is used as the current value of the filtered signal, y[n]. This equation provides first order recursion, y[n-1], during execution.

Figure 3-138 displays an unmodified trend and two different filtered outputs. The raw signal is in green and shows a considerable amout of variability. A lightly filtered (damped) signal is plotted in blue. This signal provides a reduction in variability with minimal temporal lag. The signal in red is highly filtered. This signal shows little variability, however; there is now considerable temporal lag in the signal.

The filters were both seeded with starting values of y[0] = 1. 0 and it is clear that the highly filtered signal shows a very significant transient response due to the starting conditions. Further modifications to the filter; e. g.; normalization and seeding via conditional equations may be used to correct for these transients. Contact EyeD support staff for further information.

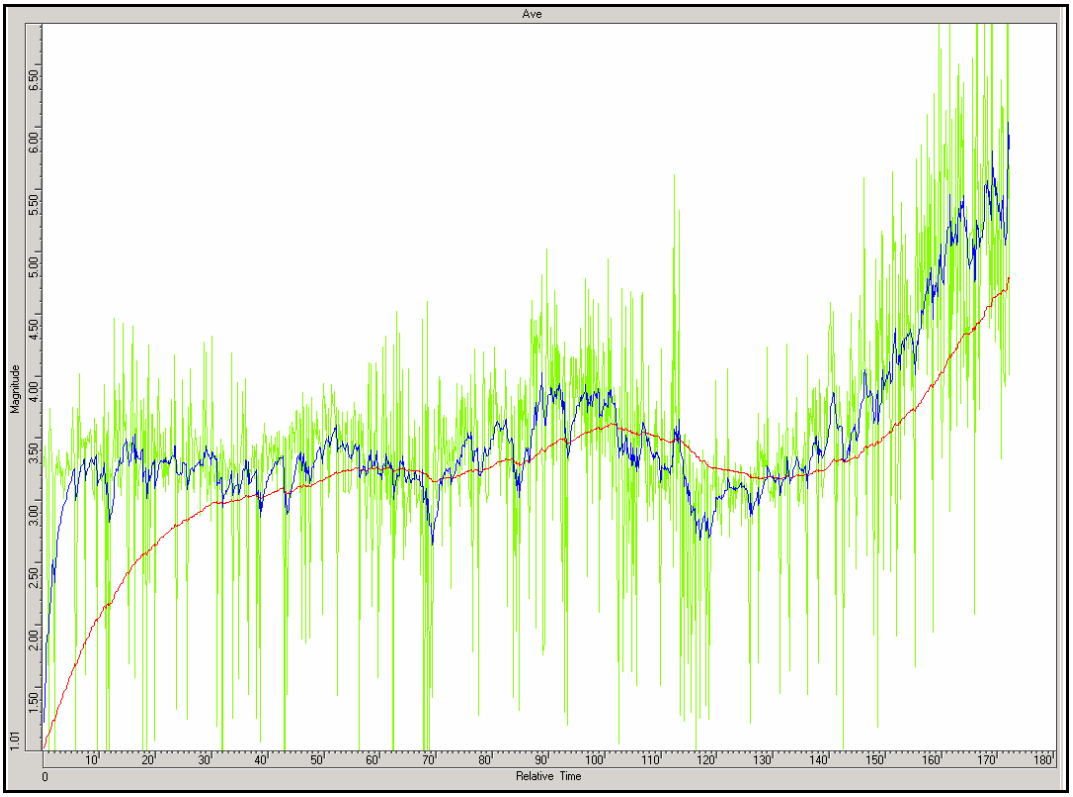


Figure 3-138. Unmodified Trend Line and Filtered Outputs

3.6.15 Calculation Order

Equations are calculated in the order in which they are listed in the Equations window. This order of calculations is followed regardless of the equation type. Any Spectral or Trend equation can reference another Spectral or Trend equation. A Region equation can reference any Spectral equation or raw data source that precedes it in the list.

3.6.16 Snapshots

Just as the name implies, the Snapshot captures a stop-action picture of a spectrum from a stream of real-time spectra. This spectrum is captured by setting the parameters on the Spectral Snapshot Properties screen. Three critical parameters must be specified:

1. The spectral source to be monitored (a spectral source being either a fiber optic source or the output of a spectral equation)
2. The delay between the start of the process and the moment the spectrum is captured from the stream of spectra being generated in real-time by that spectral source
3. The default value to load into all elements of the spectrum (vector) from the start of the process to the moment the snapshot is captured

The last parameter is required because the snapshot is available for calculations during the entire time the process is running. At the start of the process run, the snapshot spectrum is created immediately and every intensity value is set to the single value specified in parameter 3 above. (Applied recommends using the value 100, which is representative of the background from a spectrograph.) At the designated time, those initial identical intensities in the snapshot spectrum are replaced by actual spectral intensities observed from the source.

Recall that a file data source can be created in the Data Source part of the configuration. The snapshot and the file data source are both single, static spectra captured from a stream of spectral data being collected in real-time. The file (spectral) data source is selected from a EyeD data file that consists of spectra captured previously from an optical source. Once the data source is defined, that spectrum will never change. It is a mathematical representation of an instant of a spectrum from a static history, and is available at all times during the run.

When a snapshot is derived from an optical source, however, it begins each process run with the constant value for each wavelength (usually 100) specified in the initial setup. At the designated time, the snapshot function will replace the starting spectrum with whatever spectrum is observed from the designated source. Because of variance in the spectral source from run to run, the actual spectrum recorded in the snapshot will differ slightly from one run to the next. The intensities in a specific snapshot cannot be exactly determined until that spectrum is captured.

The file data source spectrum is useful as a standard for making absolute comparisons with all other spectra taken later. Within a single run, a snapshot captured early in the process is useful for making relative comparisons with later spectra in that run.

Snapshots are set up when building configuration files. With a configuration file open, select Snapshots from the configuration menu. This brings up the Snapshots window.

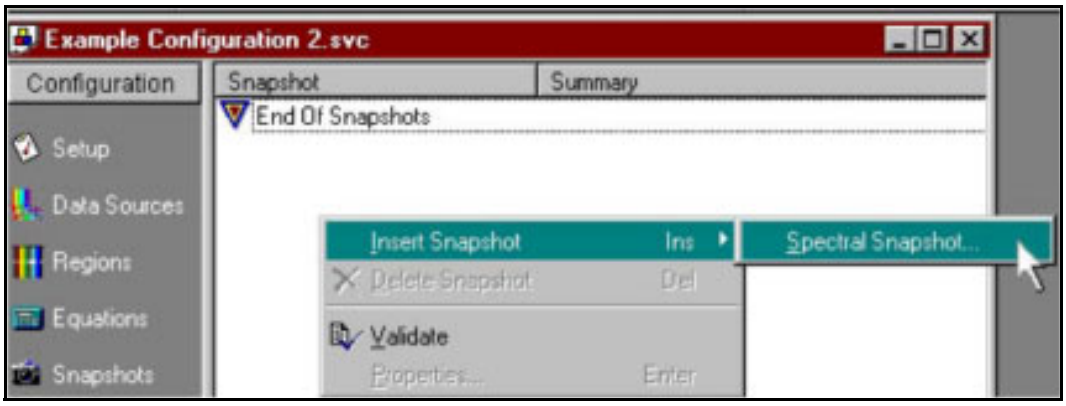


Figure 3-139. Insert Snapshot

Right click inside the window to bring up the Insert Snapshot popup box. Select the SpectralSnapshot tag to bring up the Spectral Snapshot Properties box.

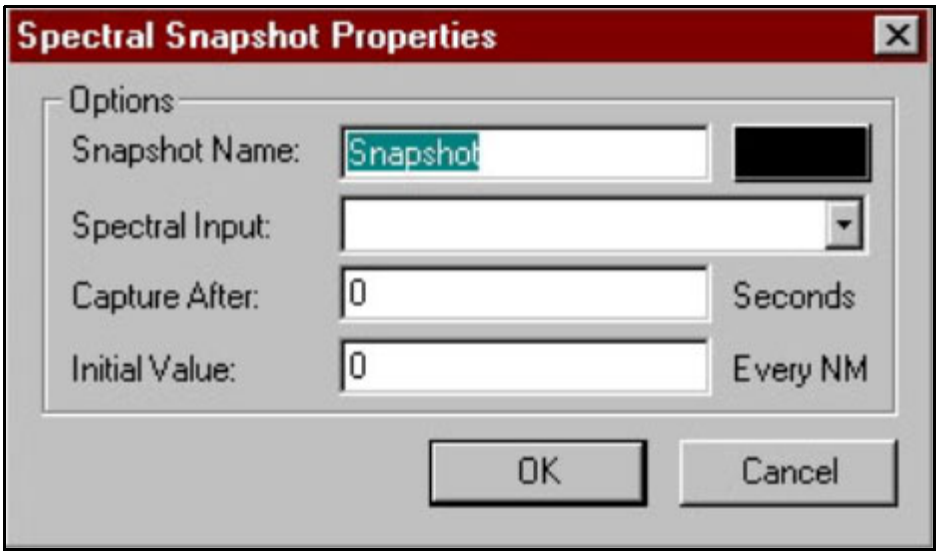


Figure 3-140. Snapshot Configuration

Enter a name for the snapshot.

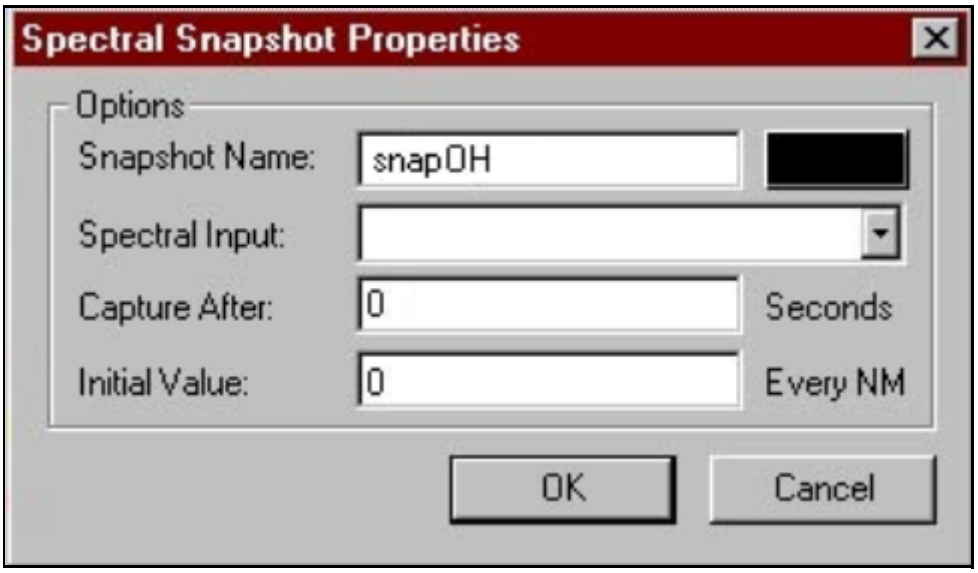


Figure 3-141. Name Snapshot

Click in the **Spectral Input** box to bring down the source-selection menu and select a spectralsource.

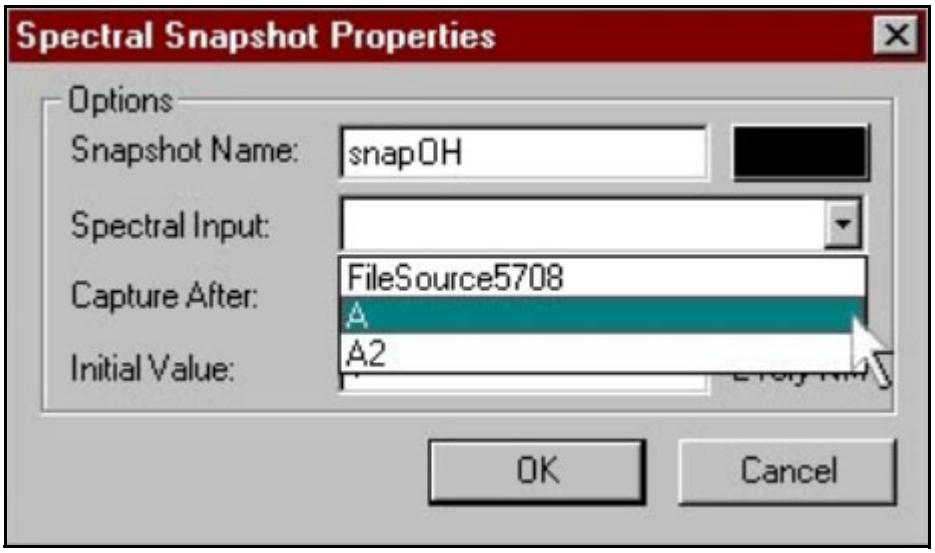


Figure 3-142. Snapshot Source

Available spectral inputs include all data sources set up from the Configuration menu.

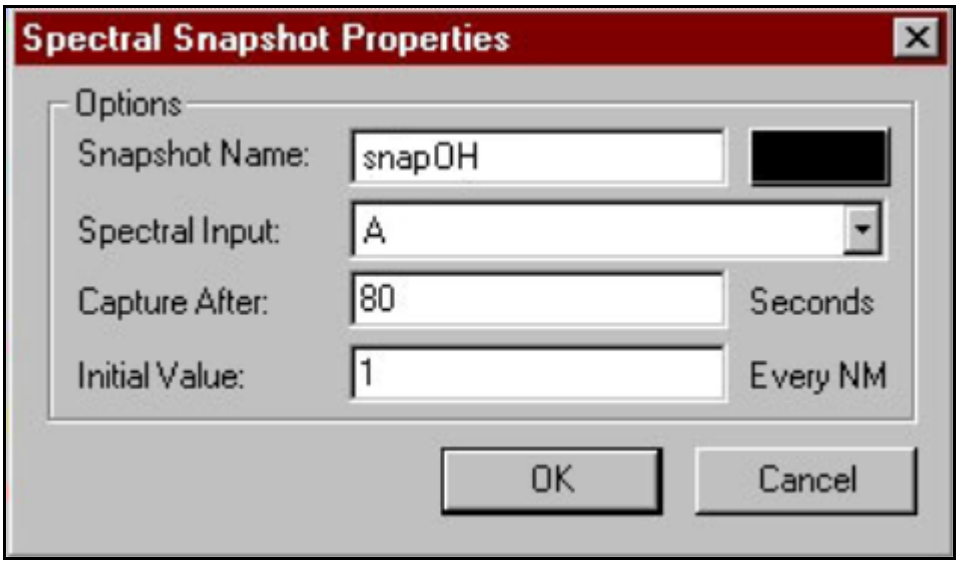


Figure 3-143. Snapshot Selections Completed

In the Capture After area, type a number of seconds after the beginning of a run to wait before acquiring the snapshot spectrum.

The initial value should be set to a non-zero number to avoid errors related to the use of zero as a divisor. The initial value is used across all wavelengths until the Snapshot is taken.

Entering an initial value of 100 is a practical choice (the background noise of an SD1024 series detector is approximately 100).

Select **OK** to complete the Snapshot command.

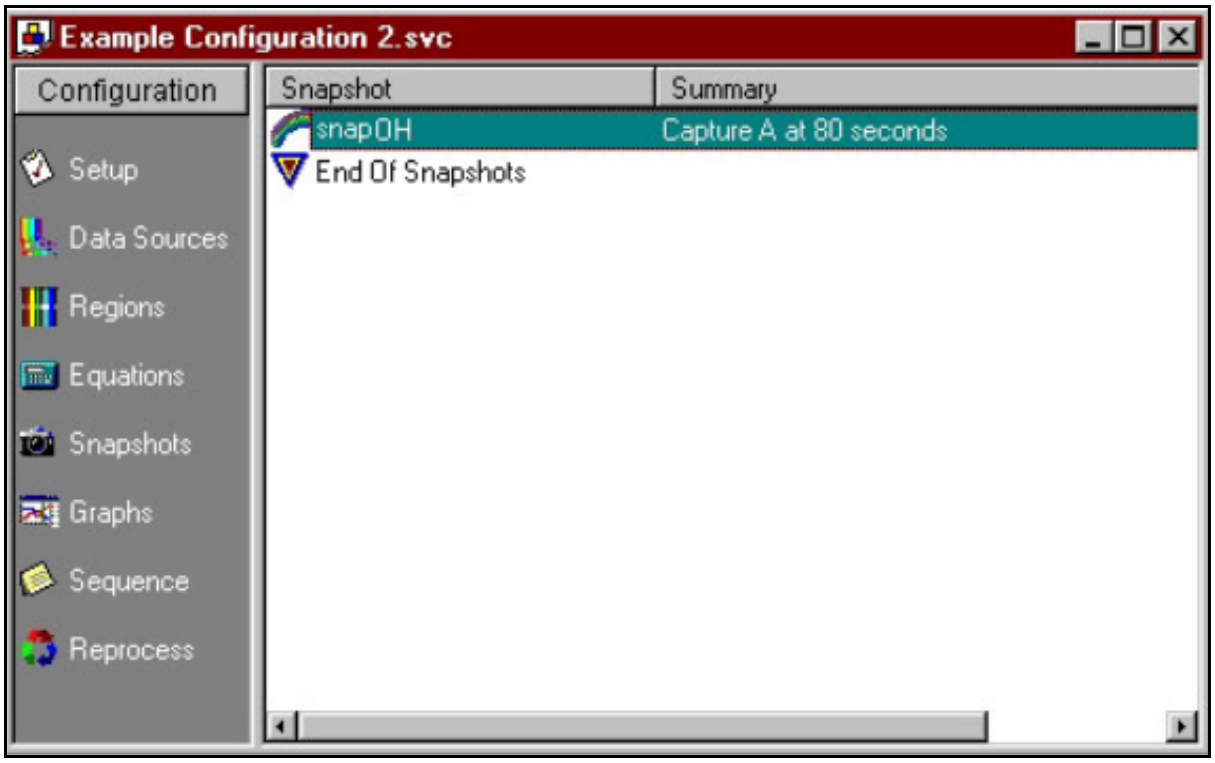


Figure 3-144. Completed Snapshot Command

In the example above, the equation A-snapOH becomes a difference vector, showing the difference between the current spectrum and the spectrum detected at 80 seconds during the run. The snapshot, however, is not automatically included in the equation. A snapshot can be used as a simple picture of each wafer run. This is most useful when spectral data files are not being maintained due to resource limitations.

3.6.17 Graph Types

3.6.17.1 Spectral Graphs

Spectral Graphs display dynamic real-time two-dimensional plots of:

- Data sources (the original spectral vectors produced by the detector and data file sources)
- Spectral Equations (the new spectral vectors that result from a spectral equation operation on a vector)
- Spectral Regions (defined by the user)

The horizontal axis plots the wavelength, while the vertical axis plots the intensity. The plot is updated at the end of the interval (Data Interval) specified for the detector in the Setup section of the current configuration. The spectra plotted are real-time spectral vectors or vectors calculated in real-time from the spectrum. These dynamic plots can be recreated by replaying the saved raw data, which reuses the equations saved in the EyeD configuration.

Figure 3-145 shows a Spectral Graph window with the accompanying color-coded, data source checkboxes and data origin. The data source checkboxes allow the selection of data source to view.

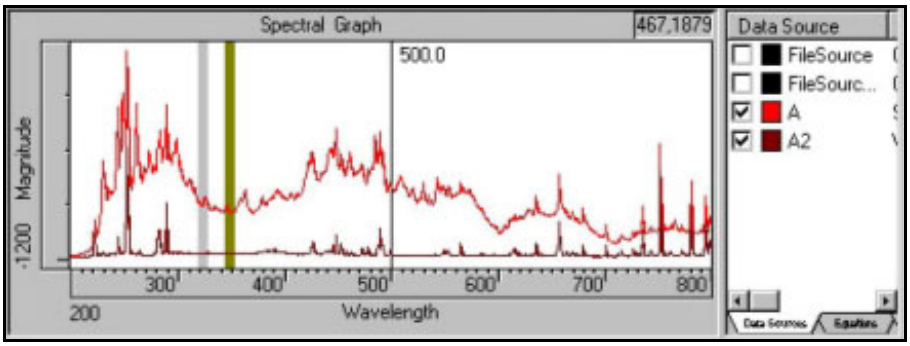


Figure 3-145.Spectral Graph Window

3.6.17.2 Trend Graphs

Trends are dynamic plots of scalar values calculated in real time. As stated previously in this section, scalar values result from Region Equations and Trend Equations. The vertical axis for the Trend Graphs plots the scalar value. The horizontal axis plots the time, thus showing the trend of scalar values developing over time. The EyeD software plots any scalar value from a Region Equation, Trend Equation, or Advanced Equation. A conditional event in the configuration can be defined and, when the event conditions are met, the Trend Graph will record the event using a non-movable labeled marker.

Figure 3-146 shows a Trend Graph window with the color-coded legend for the equation types and the equation's expression.

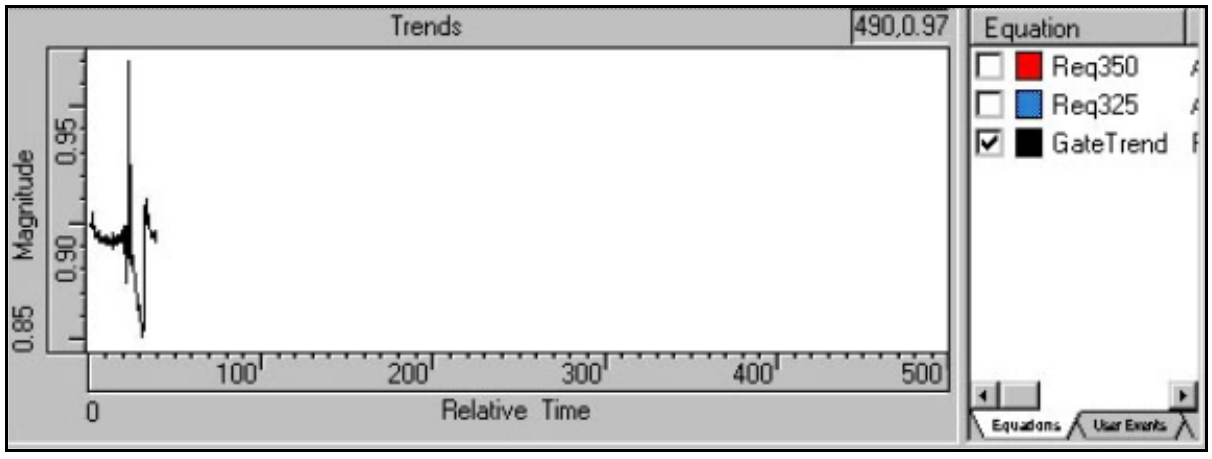


Figure 3-146. Trend Graph Window

3.6.17.3 Numerical Cursor Coordinates for Graphs Window

Numerical X and Y coordinates for the cursor position are displayed in the upper right corner of the graph window.

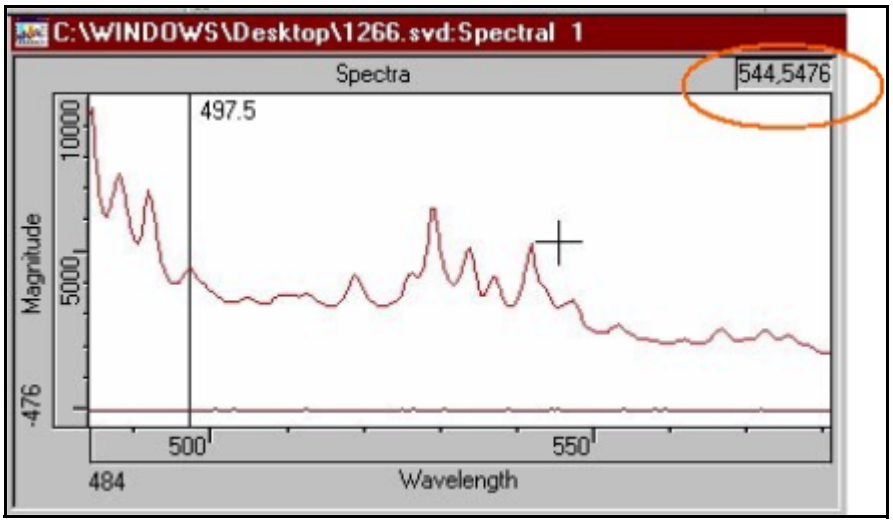


Figure 3-147. XY Coordinates Listed

Placing the cross hair cursor in any part of the graph area will cause the X and Y coordinates to be listed in the numerical display box.

Placing the cursor within the X-axis or Y-axis ruler bar will display the numerical coordinate for that position in the ruler bar. The cursor will change to a double-headed arrow as shown in Figure 3-148. By holding down the left mouse button and dragging this double-headed arrow, the view will move to image another part of the X-axis. When the right mouse button is held down and the arrow dragged, the scale of the X-axis is compressed or expanded.

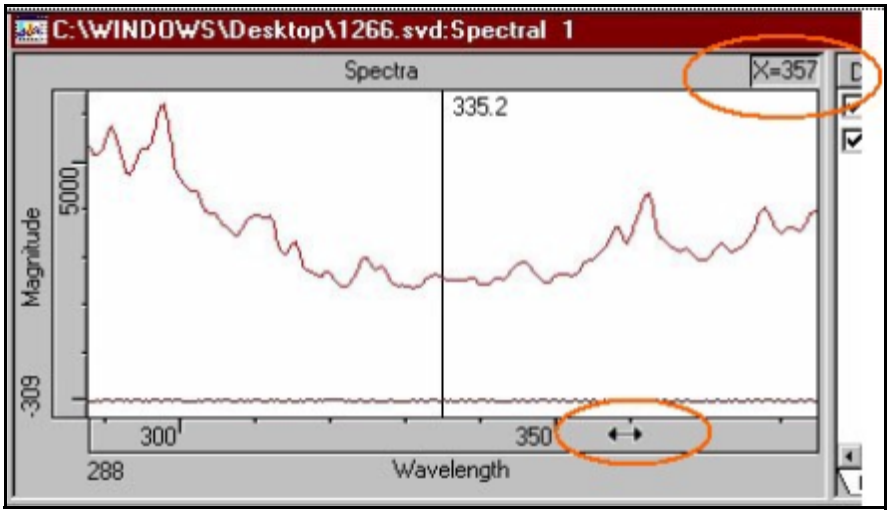


Figure 3-148. Coordinate and Scale Function

Using the Window-->Tile or the Window-->Cascade function, each graph can be placed in a separate window or all graphs can be shown in the MDI space, Figure 3-149.

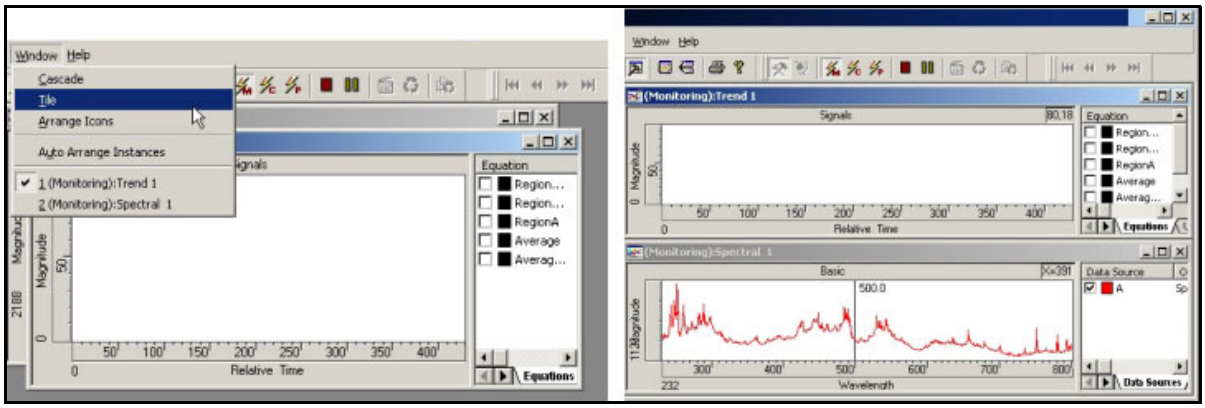


Figure 3-149. Graphs from Cascade to Tile

It is recommended that the number of graphs be kept to a minimum to avoid degrading system performance.

3.6.18 Using Endpoint Factors for Statistical Endpoint Backup

With Event Statistics enabled, a "backup" parallel endpoint sequence with statistical relevance (here, mean + 2s) can be easily added to any algorithm.

To use Event Statistics for endpoint backup, event statistics must be enabled. During EyeD installation, make sure to request to have event statistics used.

Caution; the event database is updated at the end of execution of each configuration. If you are using back-to-back mode with different configurations used in each process step, the updating of the event database can lead to excessive start delay for the next endpoint configuration.

The event database is updated at the end of execution of each configuration unless you select *cache events* in **TOOLS==>OPTIONS==>GENERAL**. If this selection is made, then the update to the database will not be made until the end of wafer message is sent by the mainframe.

Within a configuration, the *Endpoint Factors* function allow you to activate variables having the reserved names *EP_Time* and *EP_Deviation*. These variables, if activated, will be set equal to the mean (or median) and standard deviation values for historical production endpoint times as they are recorded in the event statistics database. Calling of the statistical values from the database occurs at the launch of the configuration at the beginning of the endpointed step.

NOTE

The endpoint factors capability is intended for use only when each endpoint algorithm/configuration is used on a single product application.

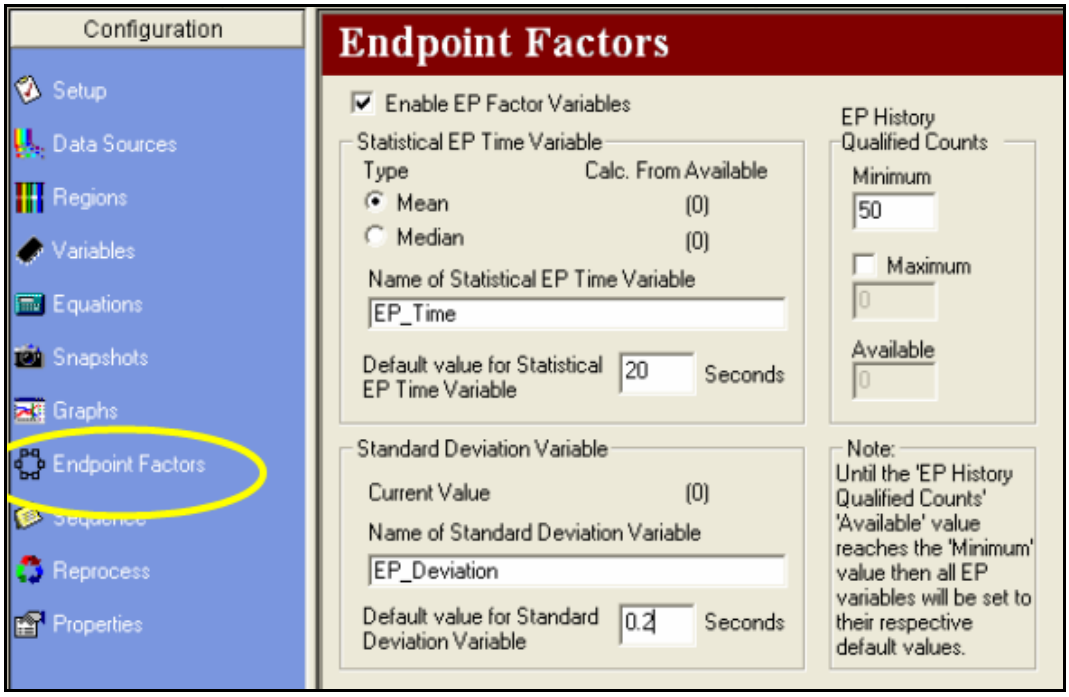


Figure 3-150. Endpoint Factors Window

After enabling and selecting mean or median, default values and history qualified counts, then build a trend comparing system data time with the maximum allowable run time (for instance here, EP_BACKUP = EP_Time + 2*EP_Deviation) as shown in Figure 3-151.

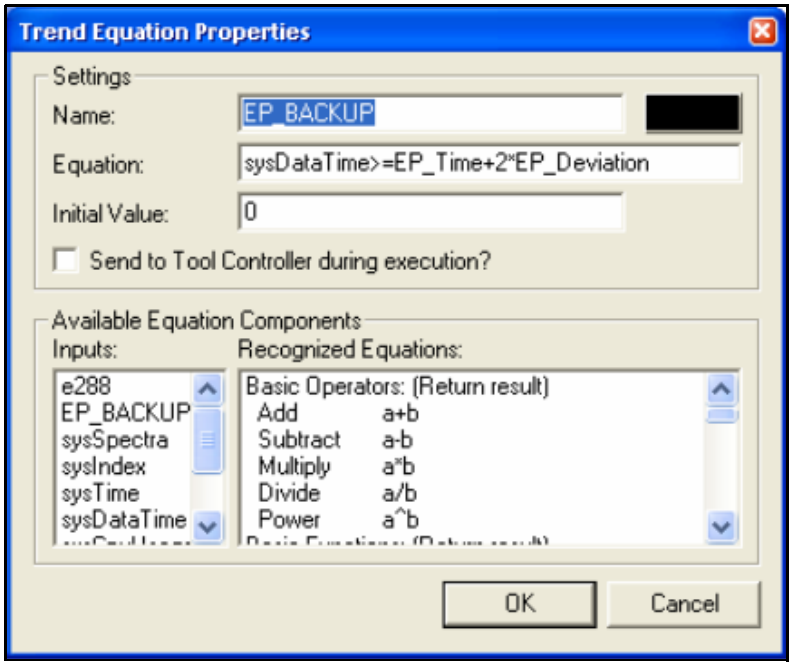


Figure 3-151. Trend Equation Properties Window

This equation will have the value of 1 whenever the system data time (sysDataTime) is greater than or equal to the maximum allowable run time. Next, create parallel sequences with the *EP branch* set to find endpoint, and *EP backup branch* set to call endpoint if *EP_BACKUP* rises above a value of 0.

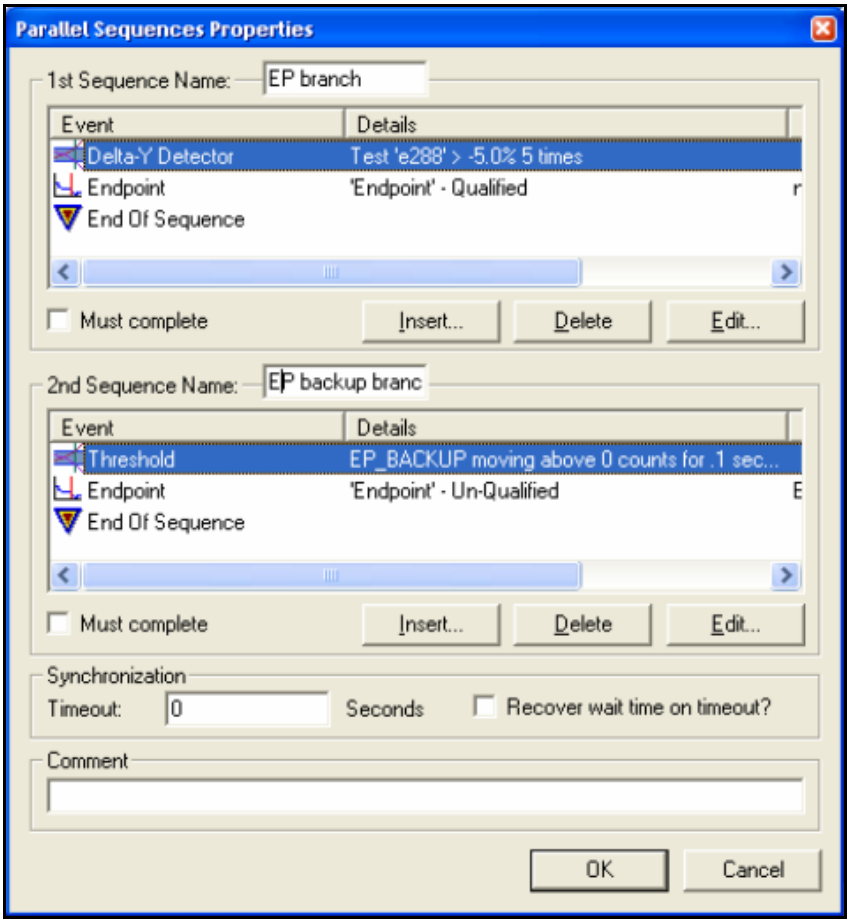


Figure 3-152. Parallel Sequences Properties Window

3.6.19 Sequence Definition

Endpoint detection is directly related to the Sequence portion of the Configuration file. In real-time, after the Equations and Graphs are completed, the Sequence is executed by EyeD. The Sequence is a list of procedures that will be sequentially performed during the process. These sequence items can be thought of as conditions that are examined one by one. Once a condition is satisfied, the next listed condition is evaluated, but the process halts when a condition is not satisfied. It is that same point in the sequence list where testing will resume after the Equations and Graphs are updated following receipt of the next spectrum. Many of the items that are set up under other parts of the Configuration (such as regions, equations and variables), are applied through commands in the Sequence.

Note the difference between the Sequence command and all of the other commands in EyeD. All other commands, such as Equations, Regions, Graphs, and Snapshots in the Configuration, are executed each time a spectrum is received from the spectrograph. On the other hand, the commands and conditions in the Sequence are examined only once during a

process step. Once evaluated, a condition in the sequence will not be revisited during that step, unless that condition is contained within a logic loop.

3.6.19.1 Delay

A Delay item in the Sequence simply halts the progression of the Sequence until the specified amount of time has elapsed. To set a Delay, from the Sequence window, right click on the item, before which the Delay should be inserted. Follow the menus Insert Item-->Delay to bring up the Delay Properties window.



Figure 3-153. Set Delay Time in Seconds

3.6.19.2 Automatic Gain Control (AGC)

The Automatic Gain Control (AGC) algorithm automatically adjusts CCD integration time, readjusting spectral intensity to a consistent level despite window clouding and other conditions that impact signal strength over time. AGC is optional, as analyzing a spectrum with a snapshot is just as effective and faster.

AGC works by sampling a specified equation and comparing it to a predetermined level and tolerance. If the equation value is lower than the target intensity, the integration time is made larger. If the equation value is higher than the target intensity, the integration time is made smaller. New data is taken and the process is repeated until the equation value is within the tolerance of the level, or:

- The algorithm times out
- CCD limitations, such as the minimum CCD integration time, are reached.
- The data interval is reached (The data interval effectively sets the maximum integration time).

A settling time can be set to hold off testing the equation against the level. This is useful if averaging is used, which adds response delay to the equation.

NOTE

To use AGC, the Data Interval must be in terms of milliseconds and not integrations. See Section 3.6.4, Setup.

AGC is added to EyeD as a sequence item. To access this feature, open the endpoint configuration to be used and select Sequence. Right click on the item prior to which an AGC algorithm is to be inserted. That is, determine the position where the AGC should be located in the list and right click the item that currently holds that position. When the AGC is inserted, that item will move down one space in the list.

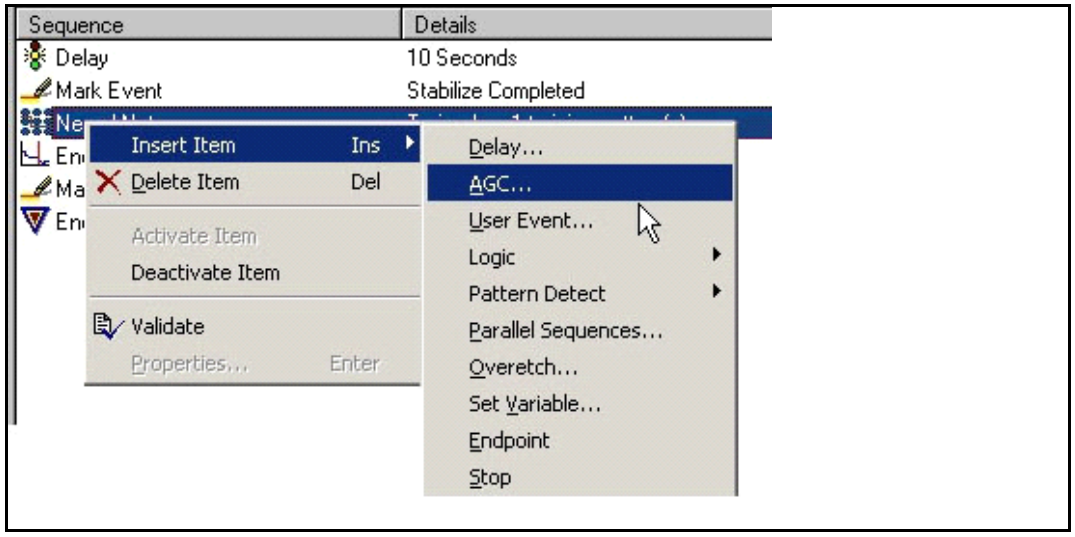


Figure 3-154. Select AGC from Sequence

This brings up the AGC configuration window. Select the equation to be used and parameters for the algorithm.

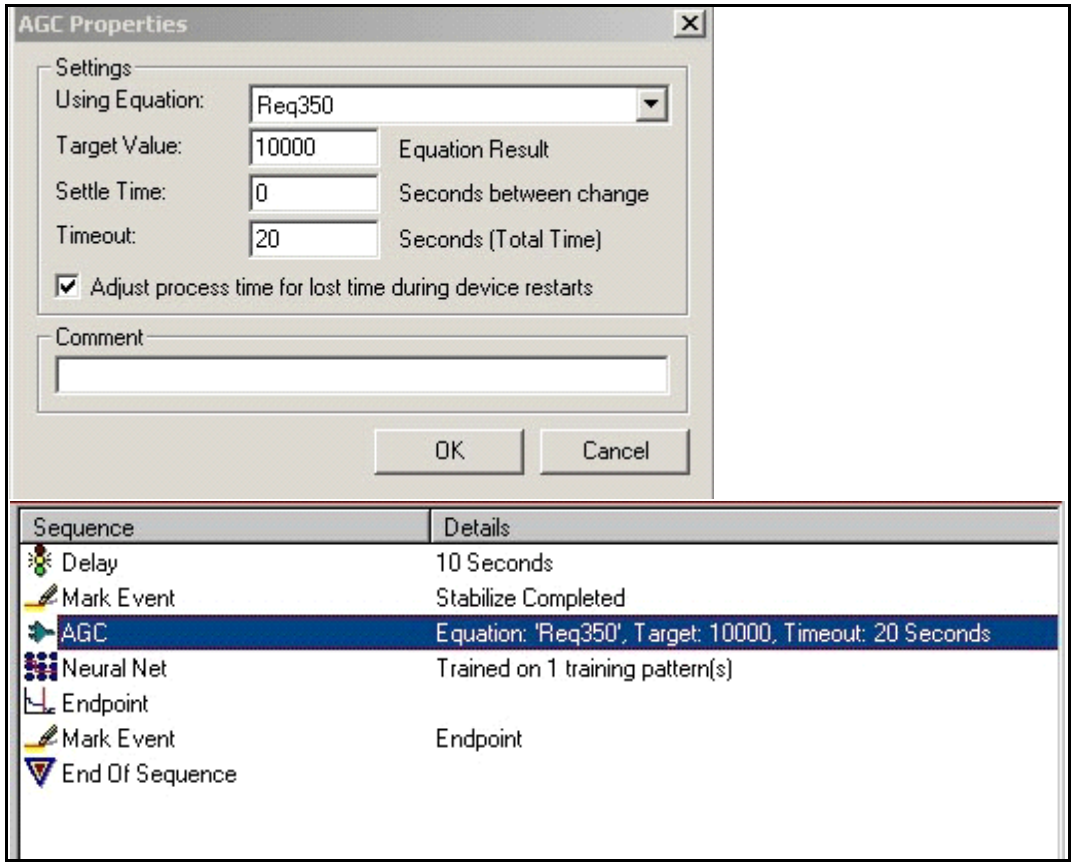


Figure 3-155. Insert AGC Algorithm in Sequence List

3.6.19.3 AGC Parameters

Five parameters control AGC as shown in Figure 4-91.

1. Using Equation: This parameter specifies the equation that will be compared to the target value. The equation must be a region equation or a trend equation, not a spectral equation. Typically, a region equation will be used that is set to cover a region of interest. The AGC algorithm is designed with the expectation that the equation will go up as the integration time gets larger and go down as the integration time gets smaller. The relationship between the magnitude of the equation and the integration time is expected to be roughly linear.

NOTE

Selecting Max. operation for the Region Equation will avoid saturating a spectral line when Avg,Sum or Min. are selected.

2. Target Value: This is the level to which the AGC is trying to set the equation. Every time the settling time expires, the equation is tested against the target value. Target value is specified in counts, which are the generic units read out of the CCD.

3. Settle Time: This sets a delay, pausing the AGC algorithm between tests of the equation to the target value. It is used to compensate for delays in the equation due to filtering that may be applied. Setting the settling time to zero will cause AGC to adjust after each sample is received at the end of the data interval.

4. Timeout: This sets the maximum runtime for the algorithm. When timeout expires, AGC completes, and the current integration time is kept.

5. Adjust process time for lost time during device restarts: This resynchronizes EyeD time to adjust for the period lost in the AGC sequence.

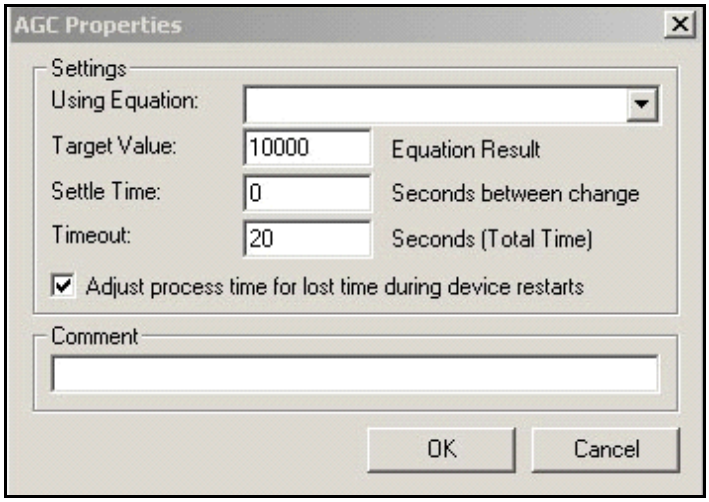


Figure 3-156. Automatic Gain Control Screen

3.6.19.4 Setup Parameters

Set the data interval in the configuration setup to the rate (in milliseconds) desired for data transferred out of the spectrograph. This also will be the maximum value to which AGC will increase integration time. Set the number of averages to one.

Next, add the AGC sequence item to the sequence. Typically, it will immediately follow the initial delay in the sequence to postpone AGC activity until the process has settled. Open the AGC sequence item by double clicking it. Set up the five parameters (described above), close down all windows and save the configuration. AGC is now ready to run.

The AGC algorithm will vary the integration time down to the device's minimum integration time or up to the full data interval. If the integration time is set to either of these limits and still does not satisfy the target criteria, the AGC routine will stop and pass control to the next sequence item. AGC adjustments are no smaller than one millisecond. In cases where an exceptionally tight tolerance is set, AGC could match two successive integration calculations and determine that the tolerance could not be met. In this case, the routine would move to the next sequence item. Other events that will cause the AGC to complete include:

The equation value falling within the tolerance of the target value after the settling time has passed

Timeout being exceeded

3.6.19.5 CCD Saturation

As the intensity of a spectral line increases to 65000 counts and beyond, pixel columns become saturated. Once saturation occurs at a given pixel column, the reading from that column drops to near zero. If the reading from this pixel column is among those being used to establish AGC, then the AGC function will read this as a lower number and could increase integration time to compensate. If integration time is increased, then more pixel columns could become saturated and be read by the software as very low, potentially causing a further increase in integration time.

This effect could result from using a Min command with no upper limit on counts for a specific wavelength. When setting an upper limit for a region (or range of wavelengths) used in a Sum or Avg. command, this upper limit sometimes must be greater than 65000 counts. In these cases, it is important to make sure no wavelength in the region exceeds a maximum intensity of perhaps 50,000 counts. It is often safer to use Max in the region equation.

NOTE

AGC assumes that the calculated value of the selected equation increases when the amplitude of the spectra increases. AGC will fail if the calculated value in the selected equation decreases when the amplitude of the spectra increases.

3.6.19.6 User Event

In designing a process sequence, text messages can be inserted to mark the chronology of certain events. The User Event function allows simple text messages to be inserted into the sequence. During real-time execution of the sequence, the User Event command will plot an event marker into all trend graphs. This event marker will consist of a vertical line and associated text specified in the following setup steps. To access the User Event function, open the Sequence window. Right click on any item to place the User Event immediately before that item in the sequence.

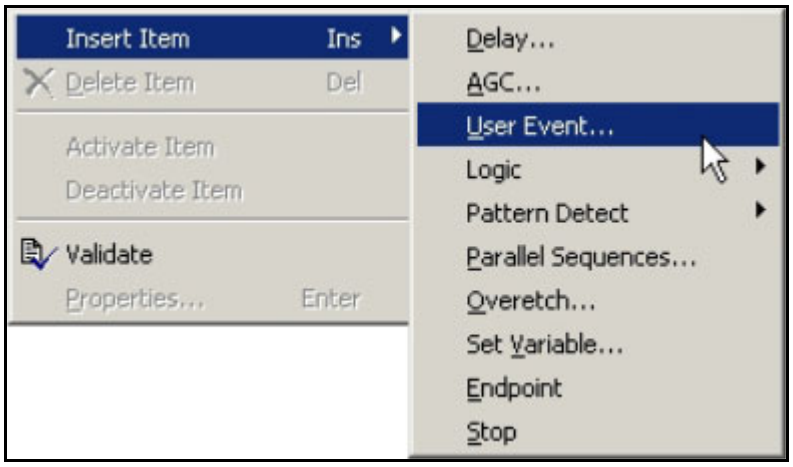


Figure 3-157. Select User Event

User Event commands will place a text message on all Trend graphs. The Label area of the User Event window is where this text is entered. Font color can be changed to the right of

this area. The position of the User Event in the sequence will determine when this text message will be plotted on the Trend graph.

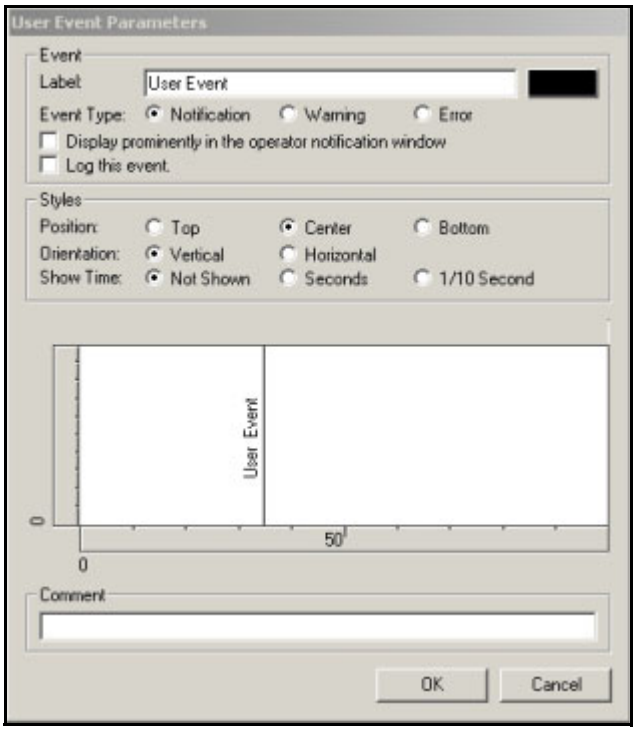


Figure 3-158. User Event Window

Positioning of the text message within the trend graph is done by selecting the appropriate buttons in the User Event Parameters window.

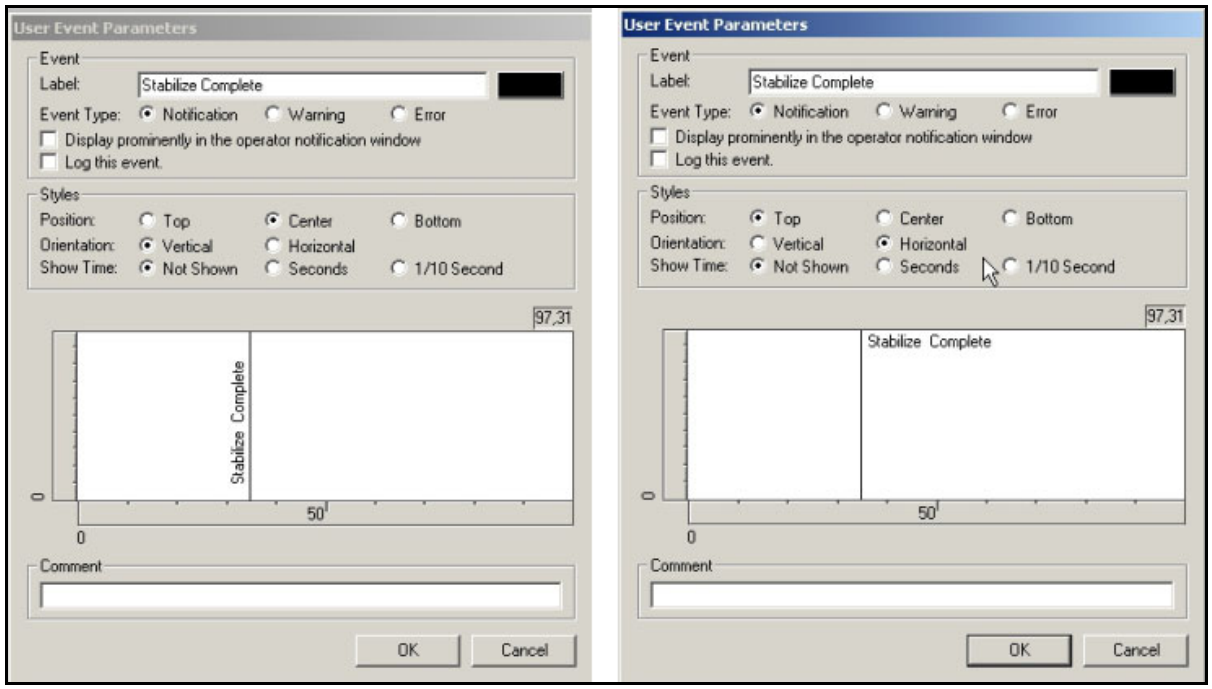


Figure 3-159. User Event Text

The message text entered (above) will be displayed as details of the sequence item (below).

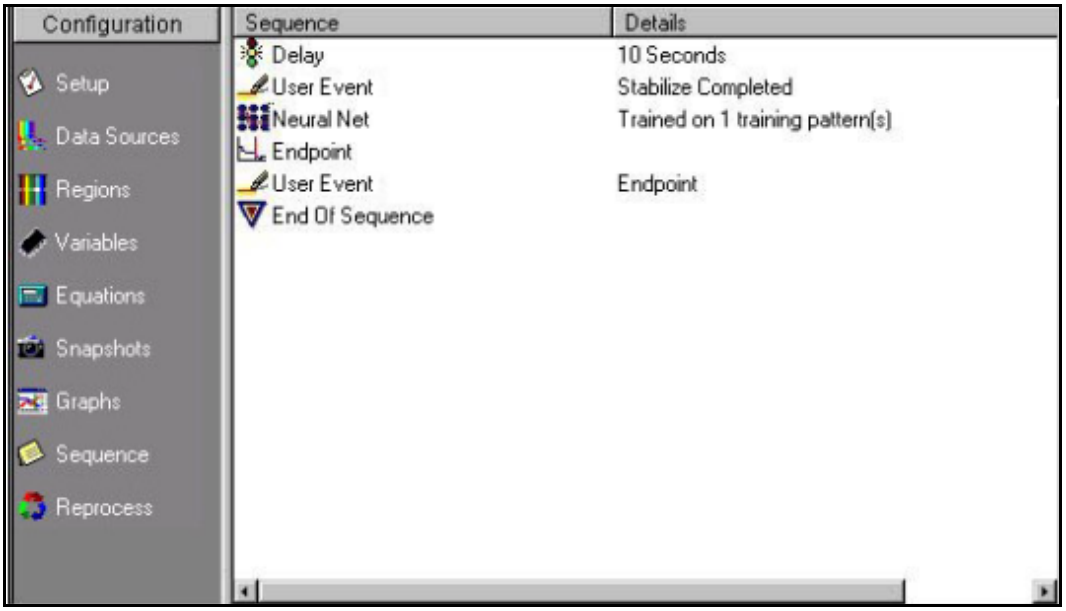


Figure 3-160. User Event Follows Delay

In Figure 3-161, the vertical line and Stabilize Completed text are not plotted until the first item in the sequence, a 10-second delay, is completed.

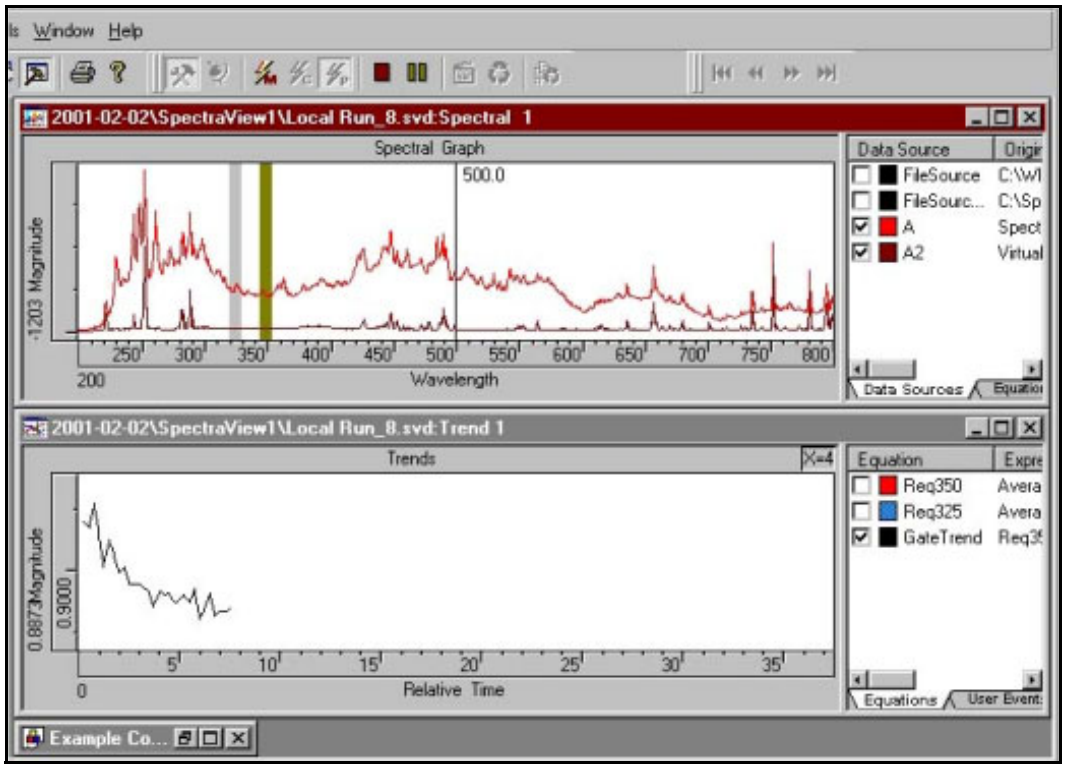


Figure 3-161. Trend Graph

In the example, message text appears at 10 seconds into the run.

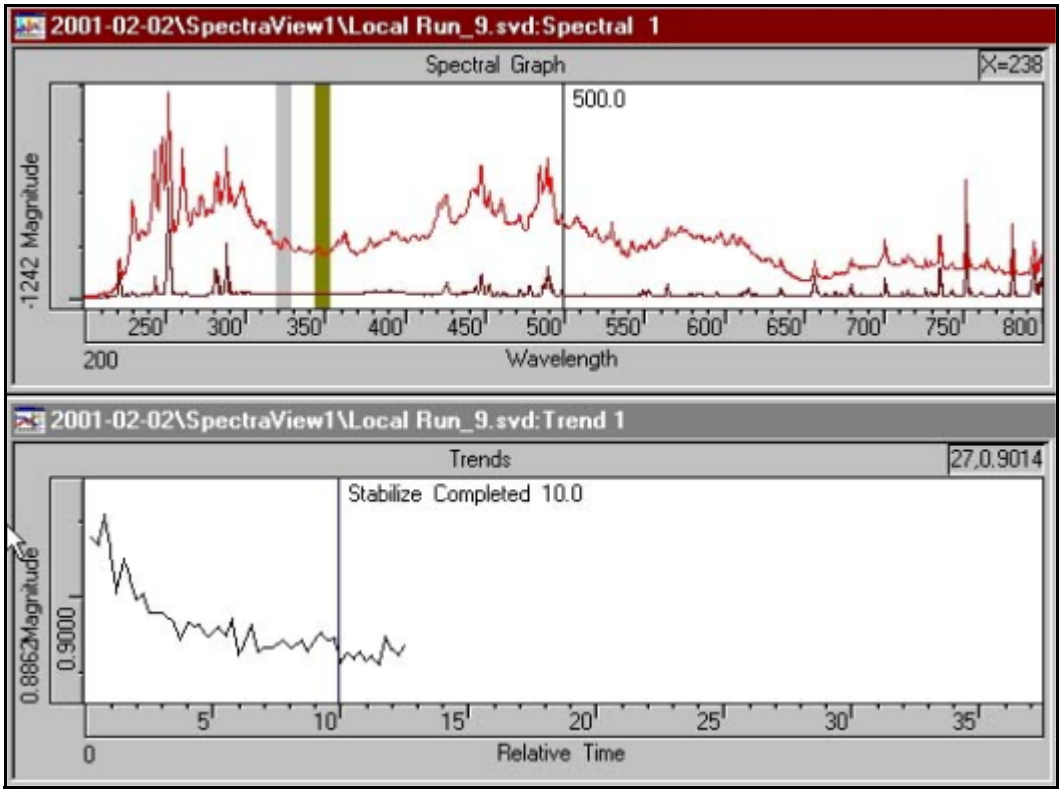


Figure 3-162. Event Marked

Message text is viewable as long as its portion of the X-axis remains in the window.

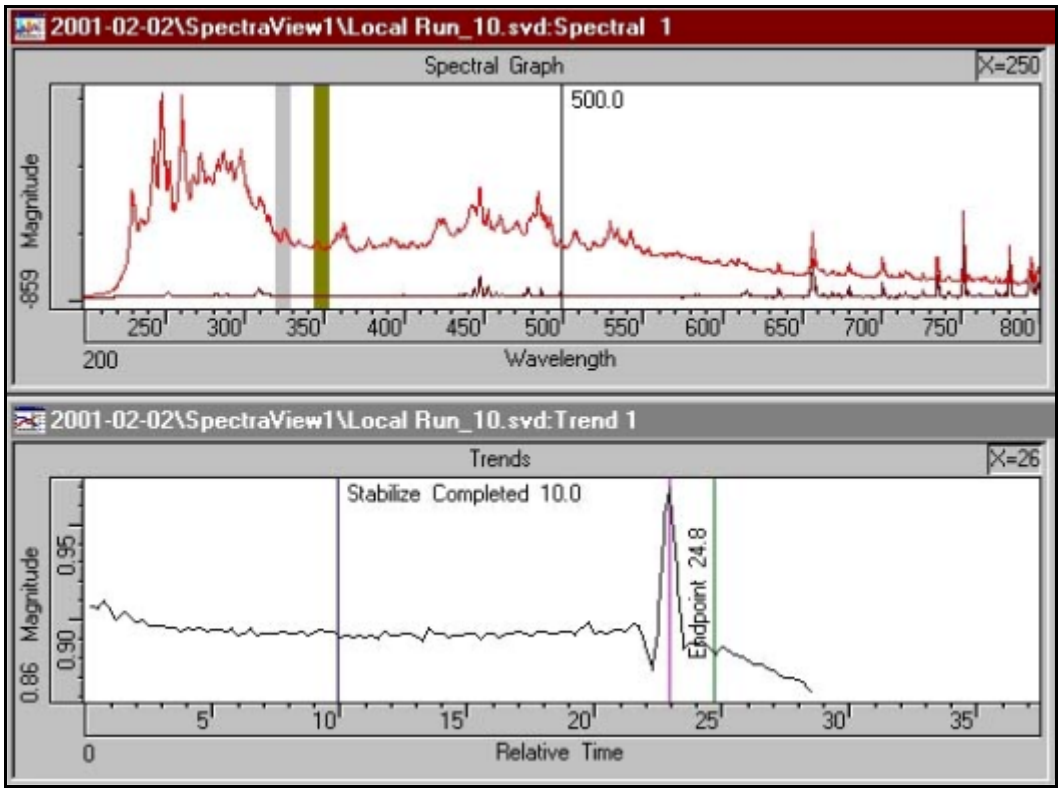


Figure 3-163. Events Marked

Note that the beginning of the Neural Net pattern algorithm was marked just prior to the final endpoint mark, which is the last (right most) of three events marked in Figure 3-163.

3.6.19.7 Operator Notification Window

This window is activated by User Events that have the *Display prominently in the operator notification window* check box is selected.

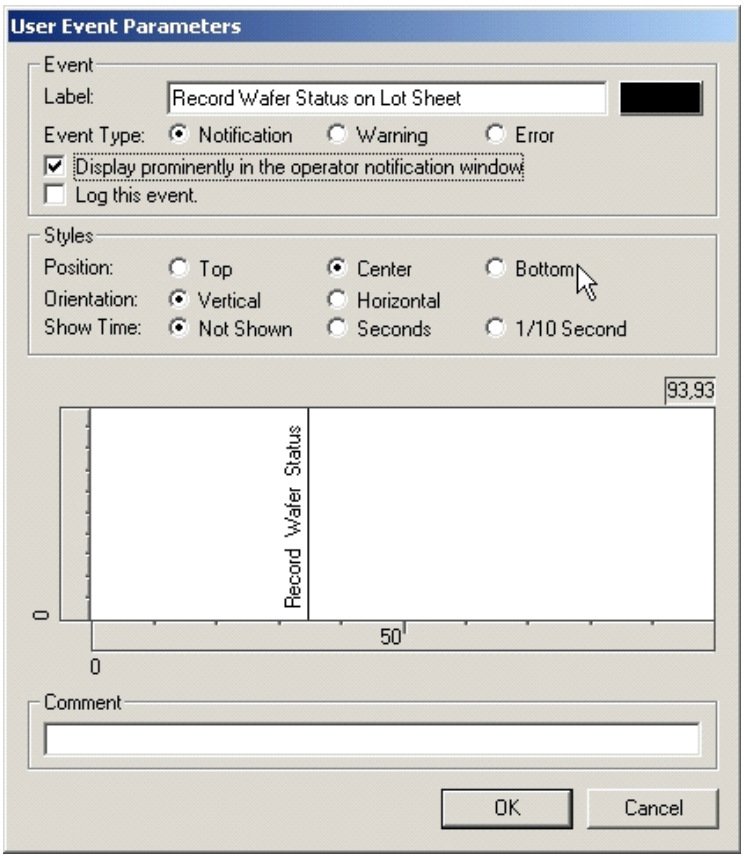


Figure 3-164. Enable Operator Notification

The *Event Type* options are Notification, Warning, and Error. The operator notification window stays displayed until acknowledged by the operator. If the window is already displaying a message, it is only updated if the new event is greater than or equal to the current message in severity. If a warning or error is being reported, a simple notification will only be logged in the activity log and marked in the graph, but the current more severe issue will remain in the Operator Notification Window.

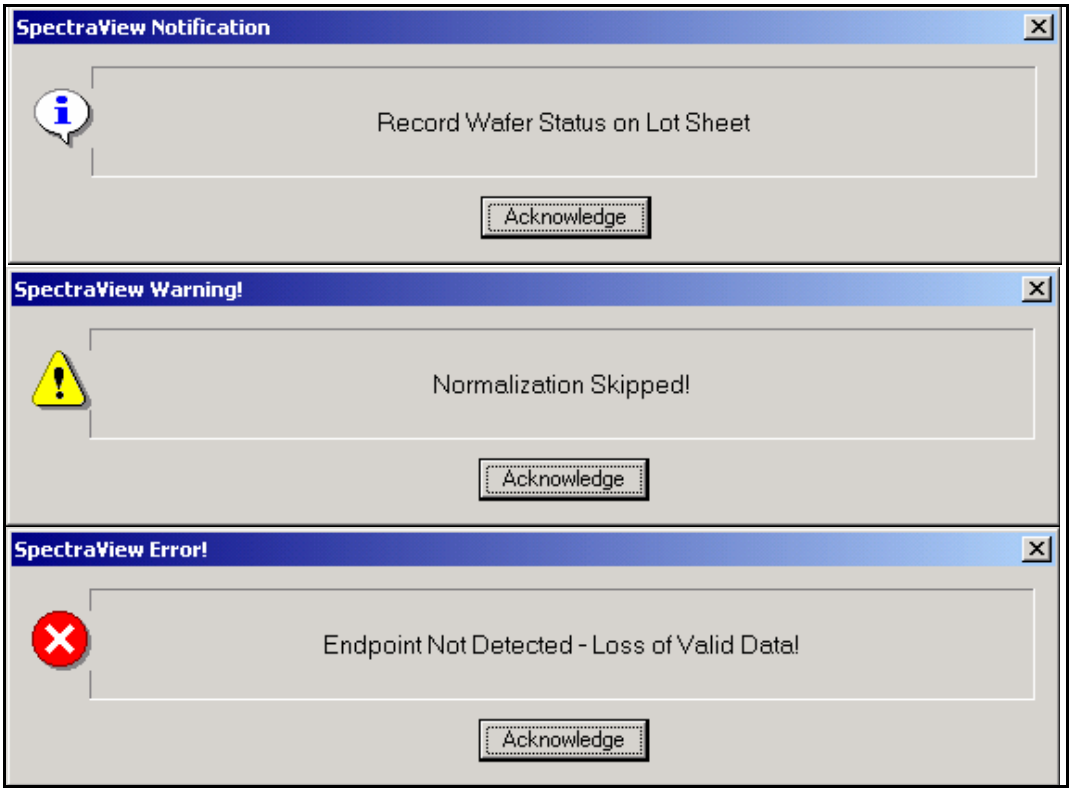


Figure 3-165. Windows for Notification, Warning, and Error

In Figure 3-165, The text in the center of these three windows is the User Event text. If the event is considered an Error, then the next health check query will be refused until the **Acknowledge** button is pressed.

3.6.19.8 Log Event

Checking box marked Log This Event, will place information related to this event in a database of event statistics (See Section 3.2.1.1, Event History Viewing).

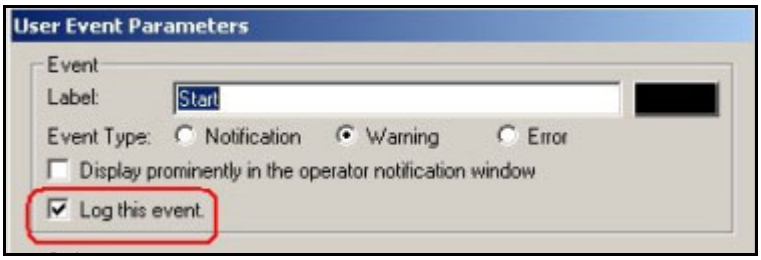


Figure 3-166. Log Event Checkbox

3.6.19.9 Activation/Deactivation of Sequence Items

Each sequence item can be *Activated* (executed) or *Deactivated* (skipped) during configuration editing so that debugging or testing of a sequence would no longer require deleting an entry then re-adding it.

Activation/Deactivation is done by Right-clicking in the sequence window. See Figure 3-167.

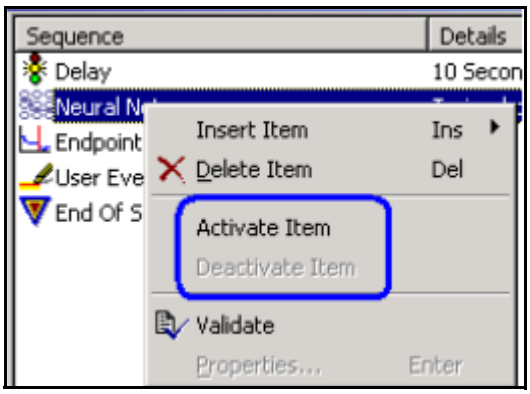


Figure 3-167. Activating/Deactivating Sequence Items

3.6.19.10 Comment Fields

Comment statements can be added to every sequence item to allow the user to comment sequences. Double-click on the sequence item and enter the comment at the bottom of the dialog window that pops up. The comment added appears in the main sequence window.

3.6.20 Logic Expressions

EyeD supports simple logic flow control of activities in sequences. Parallel sequences, combined with If and While statements within the sequences, provide flexibility in reacting to changing conditions during a process run. The following diagrams illustrate the way these logical expressions work.

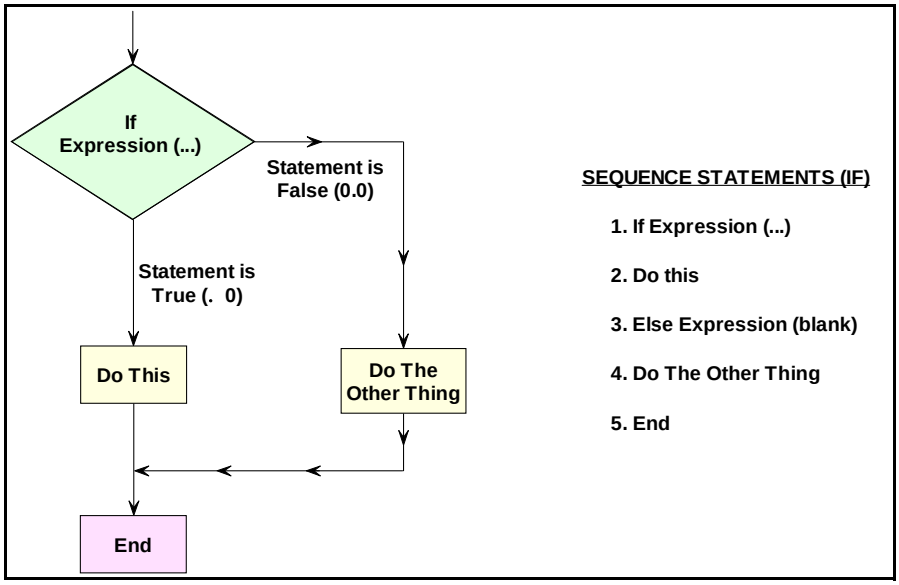


Figure 3-168. Simple Sequence Branch Using an If Statement

The If statement compares the value returned by the expression with zero. Any non-zero value returned by the expression causes processing to proceed immediately to the sequence

line below the If statement. When the expression returns exactly zero, processing skips to the next Else command line. The End command designates the end of the alternative sequence path and the end of the If series.

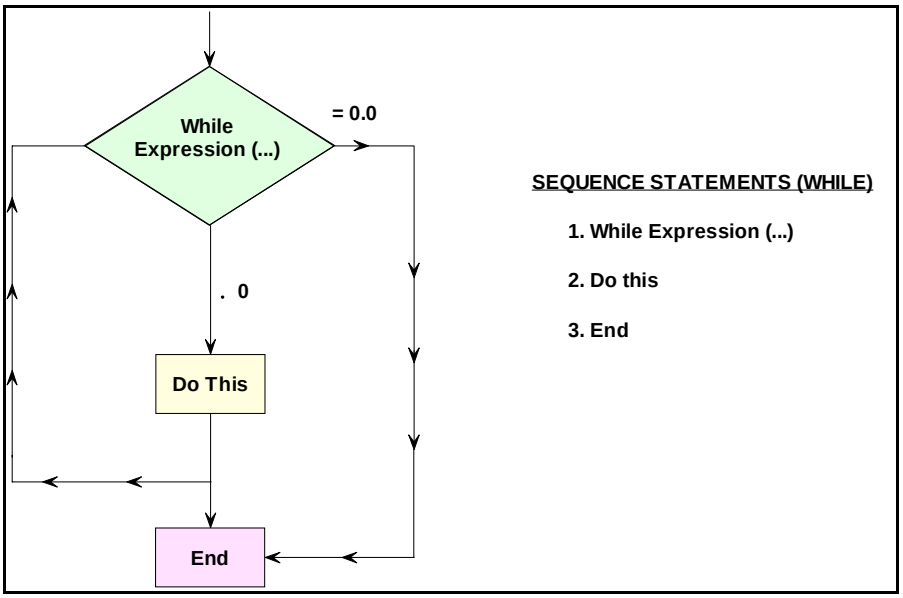


Figure 3-169. While Sequence Statement

The While logic statement enables the sequence to loop through a string of commands as long as the numerical value returned from the While expression is not zero. The first time that the expression returns exactly zero, execution goes to the End statement and proceeds on.

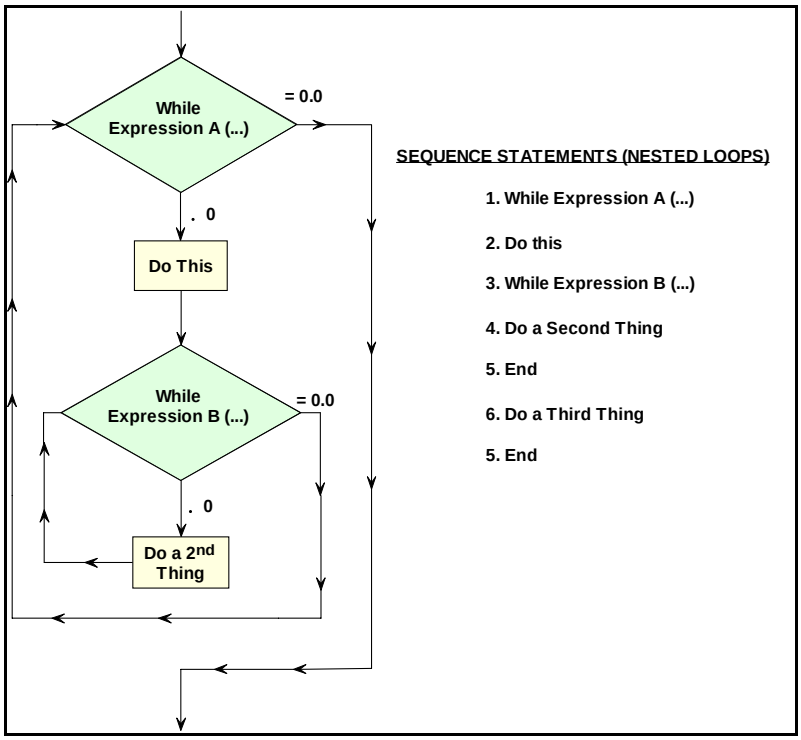


Figure 3-170. Nested Loops Logic Flow

If, then, else, and while commands can be used multiple times in the sequence to create complex decision trees (see manual for more details regarding Sequences). The name of any scalar value can be used as a variable in these logic expressions.

Figure 3-171 illustrates the logic flow of a sequence where nested logic expressions and comparison operators are combined to add versatility to the endpoint algorithm. In this hypothetical sequence, it is known that the value of equation 1 will not exceed 10,000 unless endpoint is reached. However, it is possible that etch depth could be reached without exceeding this threshold. Therefore, two different Neural Net pattern recognition methods will be employed to continually search for these two contingencies.

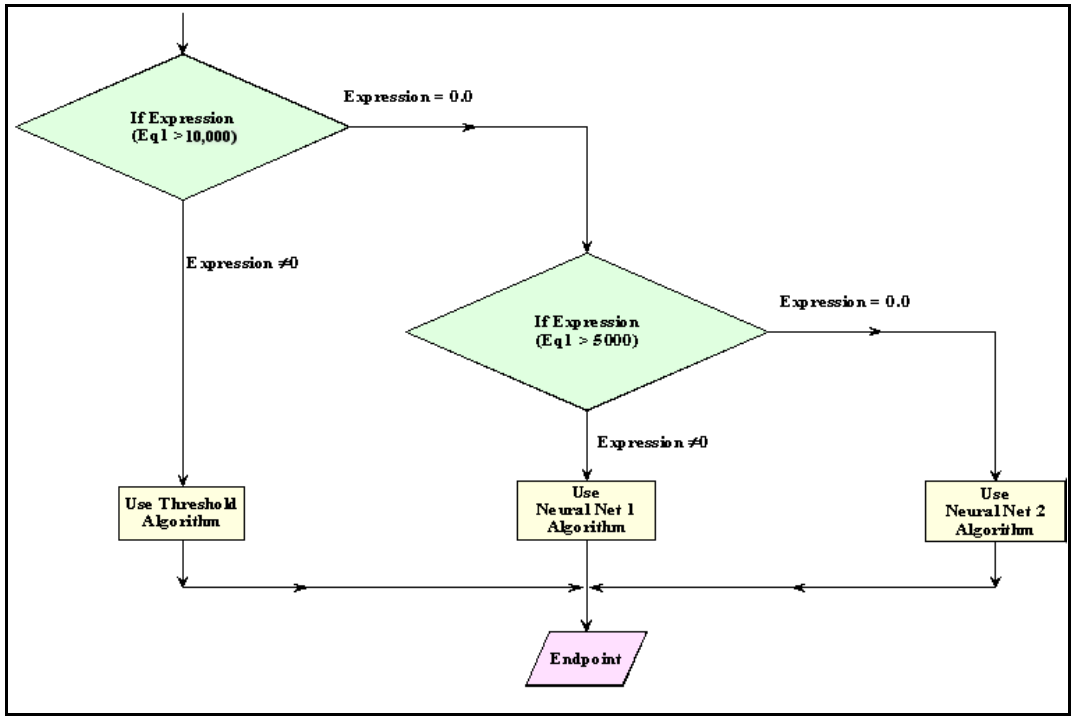


Figure 3-171. Example Sequence Configuration

Figure 3-171 illustrates a process loop where a Neural Net pattern recognition algorithm is employed if the value of Eq1 is equal to or less than 10,000. In addition, a second Neural Net is attempted if Eq1 is less than half the threshold value.

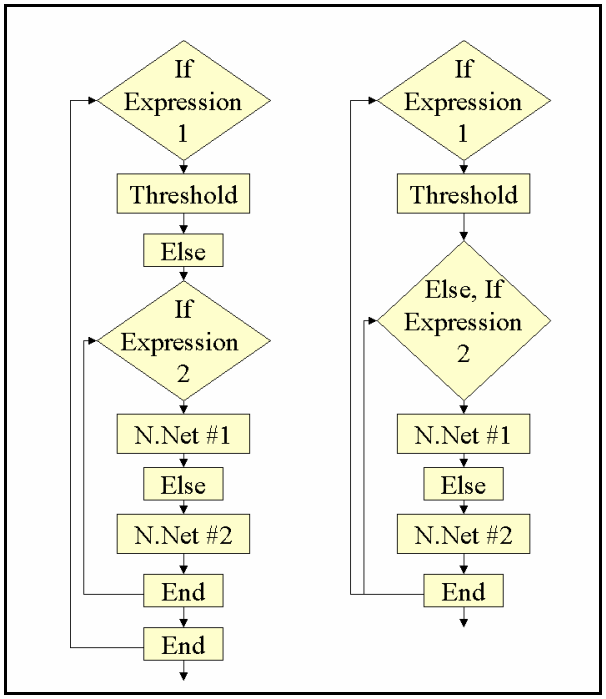


Figure 3-172. Two ways to Implement Nested IF Statements in EyeD

While either method in Figure 3-172 will perform the same function, the method on the right has fewer steps. To implement this function as illustrated in the shorter method, complete the following instructions.

To access EyeD logic expressions select Sequence from the Configuration menu to enter the sequence setup window. Right click in the white portion of the window. This brings up the Insert Item selection. A menu of sequence expressions extends, and from that a second pull out, select from the available logic terms.

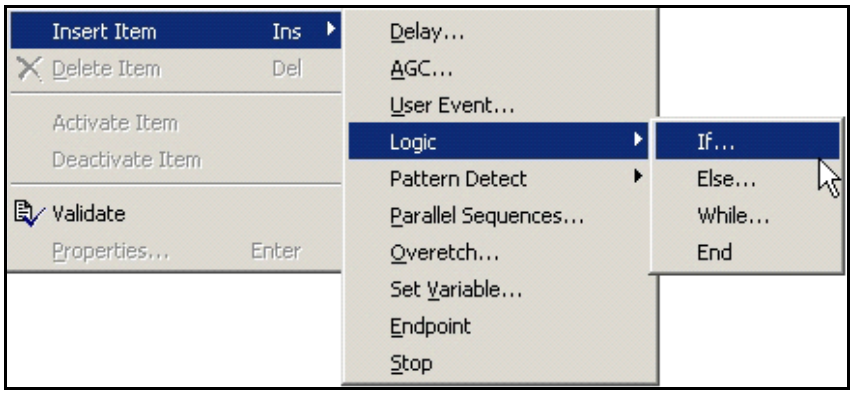


Figure 3-173. Selecting Logic Item

To configure the sequence cascade illustrated in Figure 3-171, select If from the logic terms to bring up an If Properties box. Enter an expression to be compared to zero.

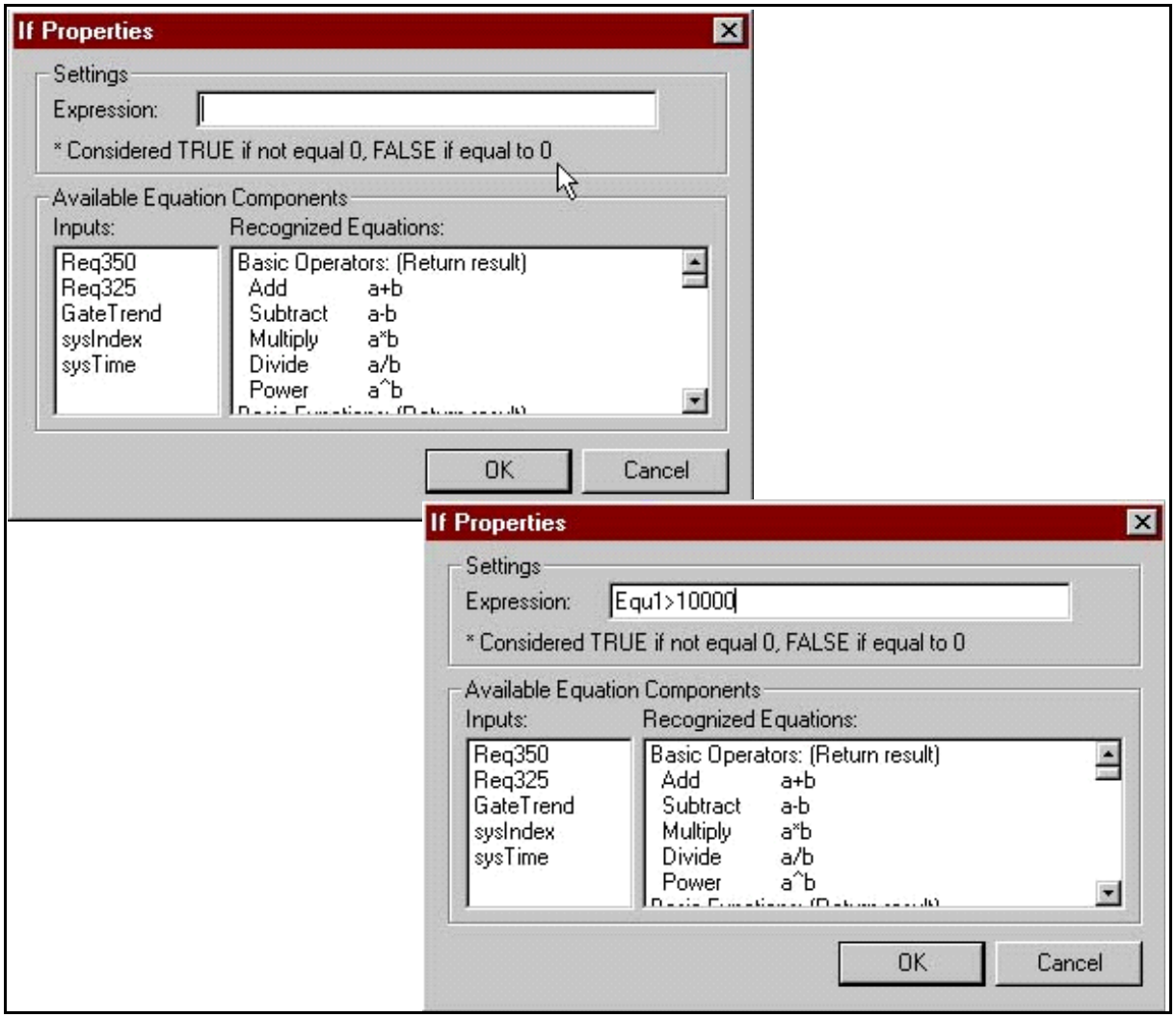


Figure 3-174. Enter an If expression

An equation with an inequality comparison operator (equ1>10000) is used here to calculate the value of the expression. When the inequality is true, the integer 1 is returned to the expression. When the inequality is false, the integer 0 is returned to the expression. It is important to remember that the decision of the If statement is based on a comparison of the expression value to zero, regardless of how the expression value was derived. When the value returned to the If expression is 1 (not zero), the next sequence item entered after the If item will be executed. Select OK to add the If command to the sequence list. Then right click on the End of Sequence icon to enter the next item.

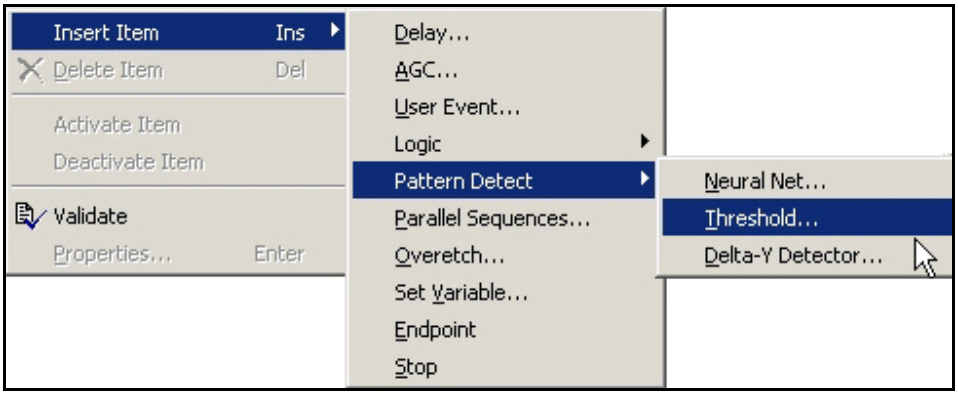


Figure 3-175. Enter Threshold pattern

Select the type of pattern detection algorithm to be used when the If expression is not equal to zero. To recreate the example sequence, select *Insert Item Pattern Detect Threshold* to display the Threshold Parameters window.

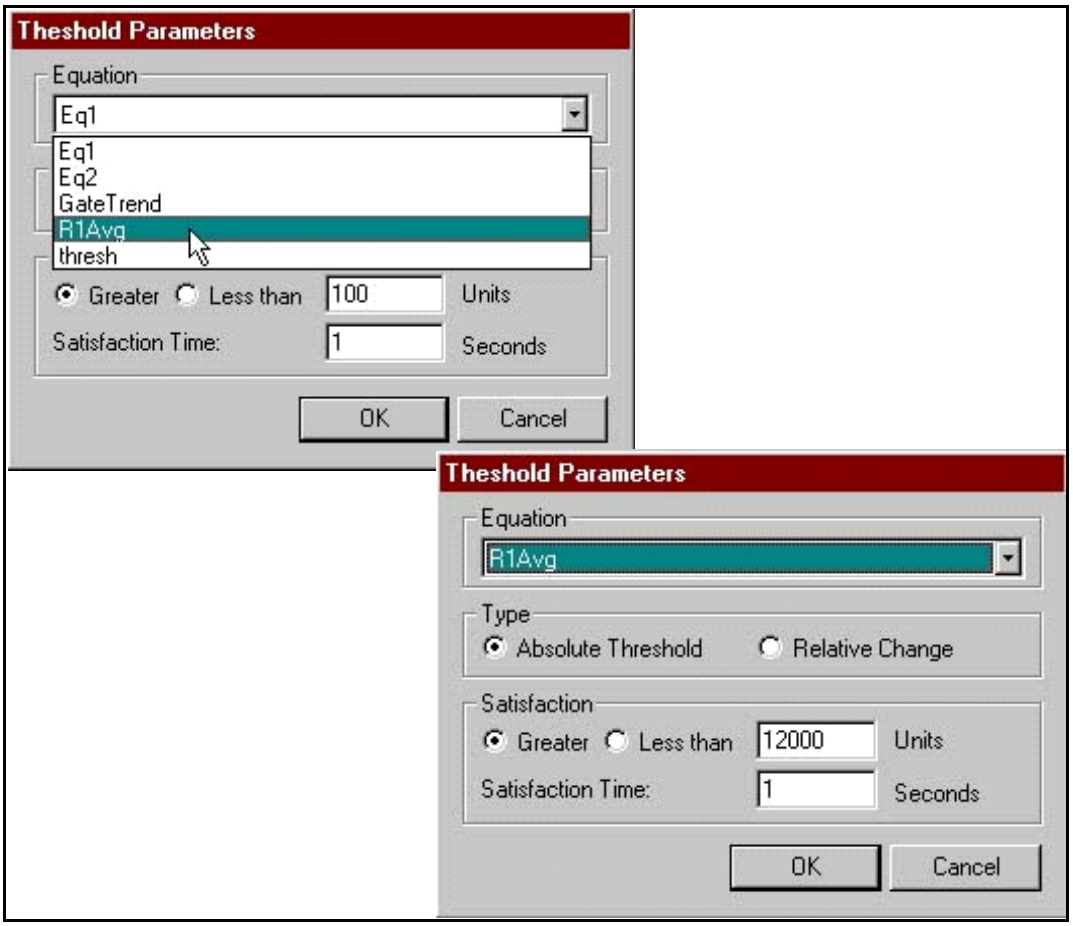


Figure 3-176. Select an equation for the threshold function

The value of equations available for the threshold pattern recognition includes all region and trend equations previously set up under the Equations portion of the configuration menu (see

Section 3.6.8, Equations for more information). After selecting the equation, enter satisfaction criteria for the threshold. Select OK to enter the sequence item to the list of sequence commands. Then right click on the End of Sequence icon to insert the next item.

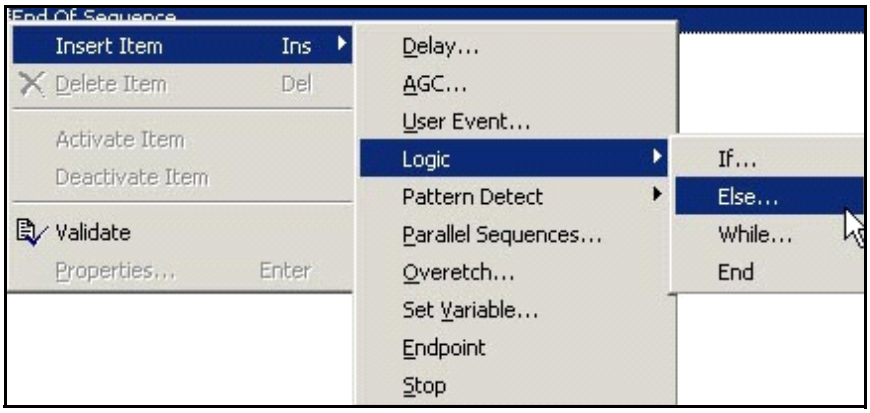


Figure 3-177. Else Statement

Entering an Else sequence item acts as a separator between the threshold test and the alternate path for the If statement.

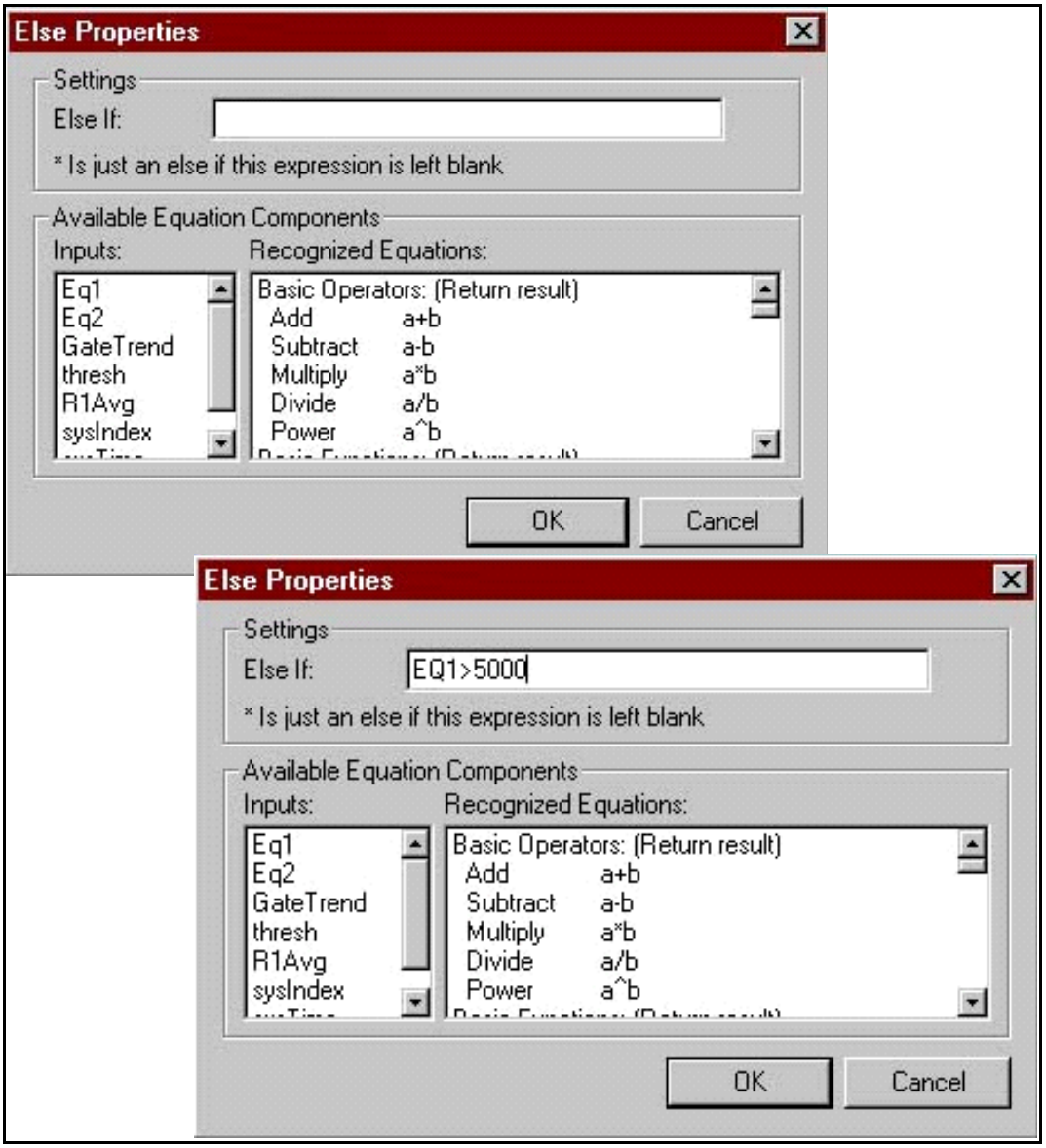


Figure 3-178. Else If Statement

By entering an expression in the field, an If function is added following the Else. Again, a comparison operator is entered into the Else If expression field. When Eq1 is greater than 5000, the comparison operator will return the integer 1. The If function will recognize this non-zero number and move to the next sequence command below the Else If statement.

Insert an item to follow the Else If statement; in this case, a Neural Net pattern is selected (see manual for information regarding Neural Net properties and training).

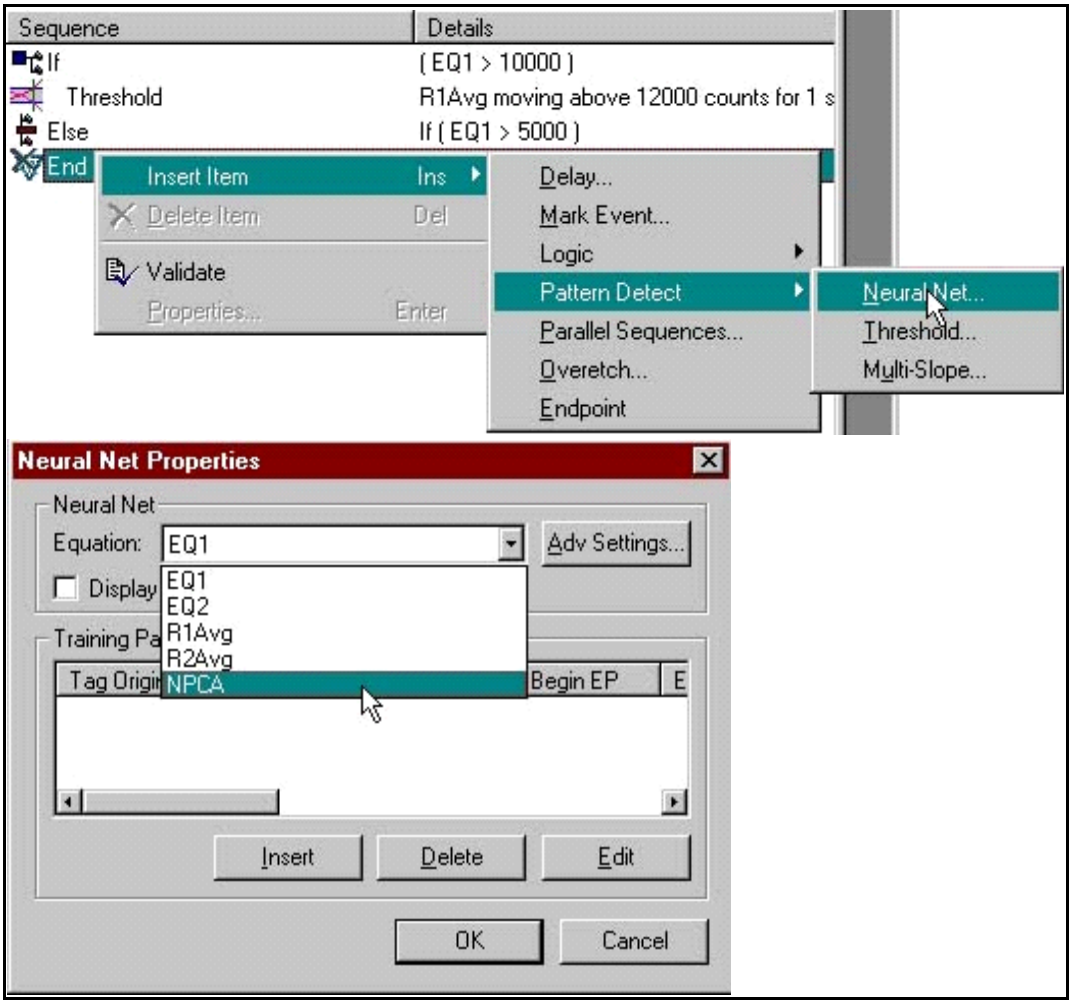


Figure 3-179. Select Neural Net Pattern Recognition and Associated Neural Net File

In the example sequence, another Else statement is entered with no text entered into the expression field. This is followed by a second Neural Net selection. The last two items entered are an End command followed by an Endpoint command to complete the sequence configuration. The resulting sequence in Figure 3-180 will perform the logic function shown in Figure 3-171.

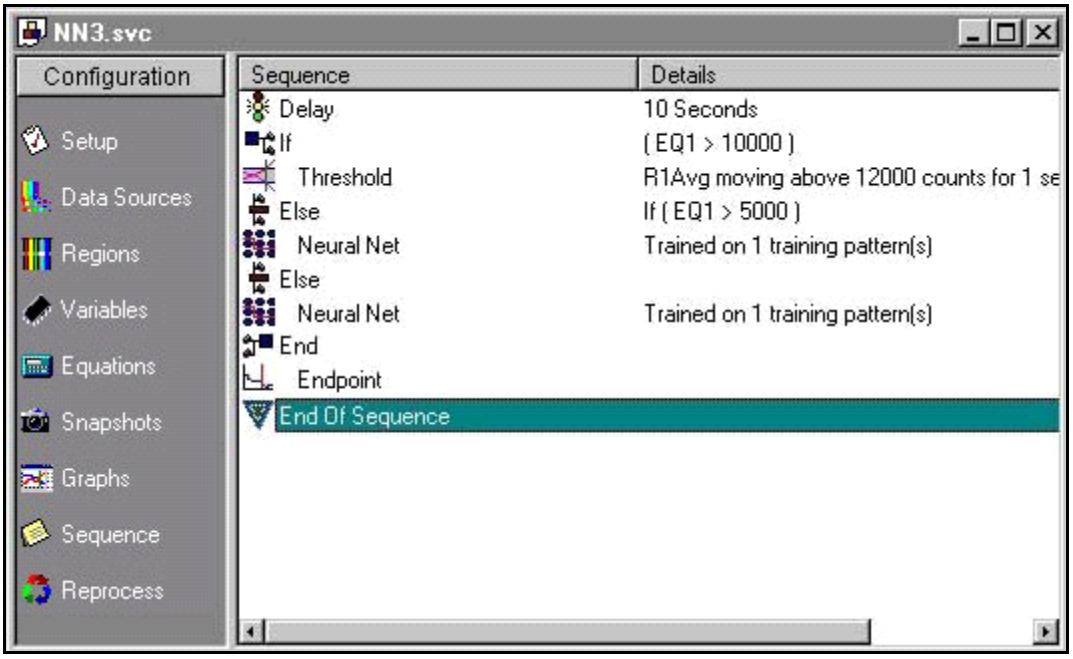


Figure 3-180. Sample Sequence Configuration

In the above example sequence, EyeD will delay 10 seconds after start to allow the chamber environment to stabilize. It will then test if equation 1 is greater than 10000. If this is so, the application will begin to employ a threshold algorithm for endpoint. If Eq1 = 10,000, at that time, the application will employ the first Neural Net algorithm, but only if equation one is greater than 5000. It will employ Neural Net algorithm 2 if equation 1 is equal to or less than 5000. This logic flow will be followed by the above sequence each time a new spectrum is received. Once endpoint is found, the sequence ends.

3.6.21 Automatic Flash Lamp Intensity Control

The Auto Flashlamp Intensity Control (AFIC) feature is accessed during sequence definition as follows:

After creating / selecting a configuration and defining an equation for AFIC to use, select the **Sequence Definition** section.

Right click in the sequence list, causing the following menus to be shown:

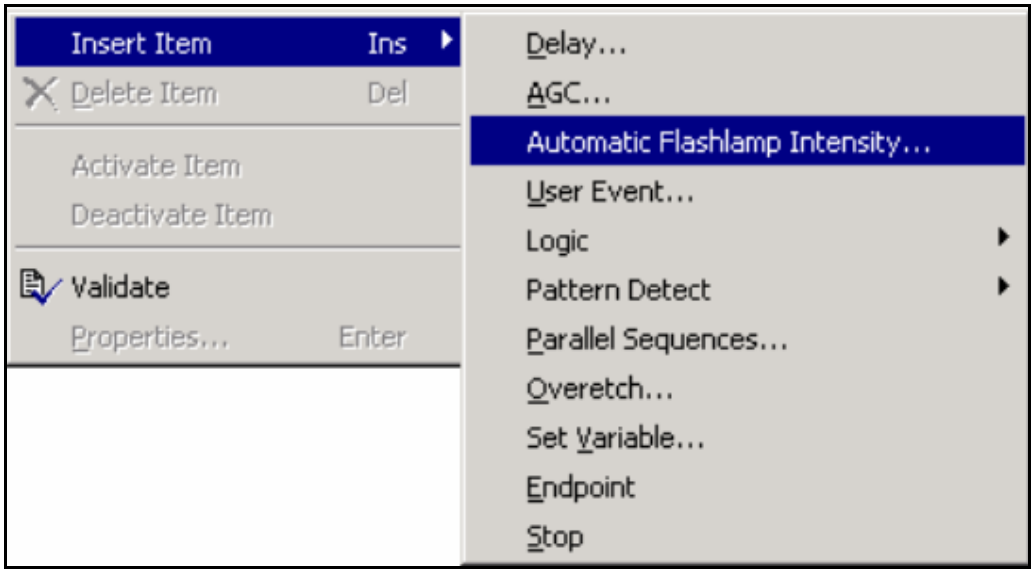


Figure 3-181. Sequence Definition Drop-down Menu

Select **Auto Flashlamp Intensity,** as shown in Figure 3-181, and the dialog shown in Figure 3-182 will be displayed. The entries in Figure 3-182 are the defaults.

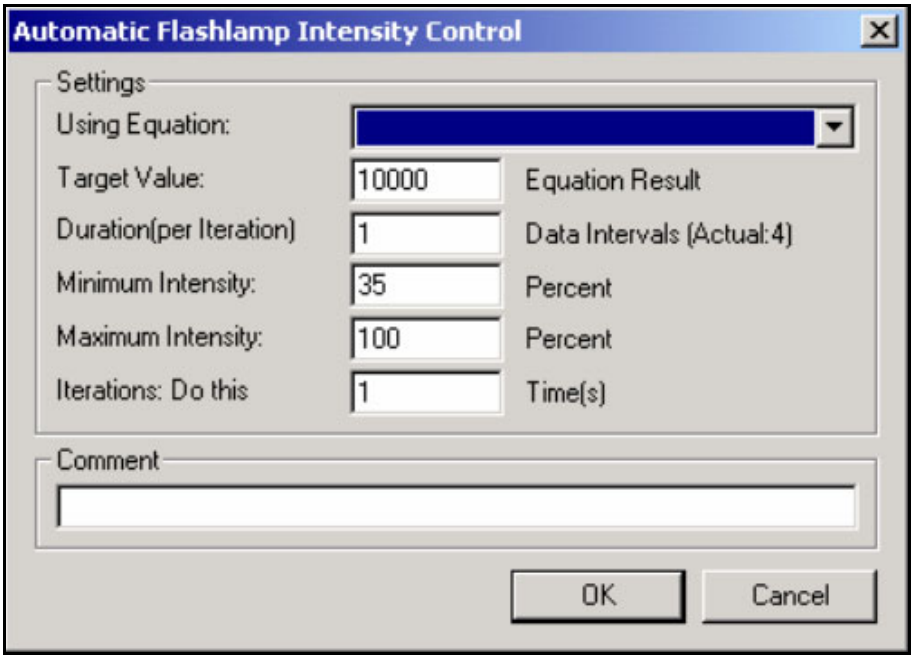


Figure 3-182. Automatic Flash Lamp Intensity Control Window

Using Equation: - Define a trend equation which is to be controlled. The user will be responsible for ensuring that the equation does in fact depend on the associated control parameter in a way that makes sense.

Target Value: - This is the value that the trend equation should have after the sequence completes.

Duration (per iteration) - At the beginning of the sequence item, a new value of the control parameter is computed based on the current value of the trend equation and the target value. The new value is communicated to the spectrograph. Since this process may be repeated, we have to wait until the effect of the change is felt in the trend equation. At minimum, this will be due entirely to system latency. The user may build in further latency by, for example, using a trend equation which is the result of averaging. The minimum allowed value for the duration may be zero. However, a wait of the *Actual* intervals will still occur to allow for inherent timing of data collection cycles.

Minimum Intensity: - The control parameter is integration time, lamp intensity, attenuation factor. The user may care to override the inherent limit on the minimum value for this parameter.

Maximum Intensity: - The control parameter is integration time, lamp intensity, attenuation factor. The user may care to override the inherent limit on the maximum value for this parameter.

Iterations: Do this - At minimum, there will be a single correction computed from the initial value of the trend equation. The user has the option of repeating this process. The number of iterations is one if the process is not repeated.

3.6.22 Pattern Detection

Endpoint detection software is directly related to the Sequence portion of the configuration file. EyeD provides a powerful suite of endpoint algorithms such as Neural Network pattern recognition, Neural Principal Components Analysis and threshold-based software. In addition, it is possible to combine these approaches for maximum robustness.

3.6.22.1 Threshold-Based Software

Threshold-based endpoint recognition software relies upon the output rising above or below a preset limit for a predetermined period of time. The output being traced is not raw optical data, but is the output of user-selectable wavelength(s) that can be mathematically refined to produce a clear endpoint threshold. This software permits simple mathematical functions as well as more sophisticated functions accessed through the EyeD equation parser.

To set a threshold, right click in the Sequence window and select Insert *Item'Pattern Detect'Threshold* to display the Threshold Parameters window.

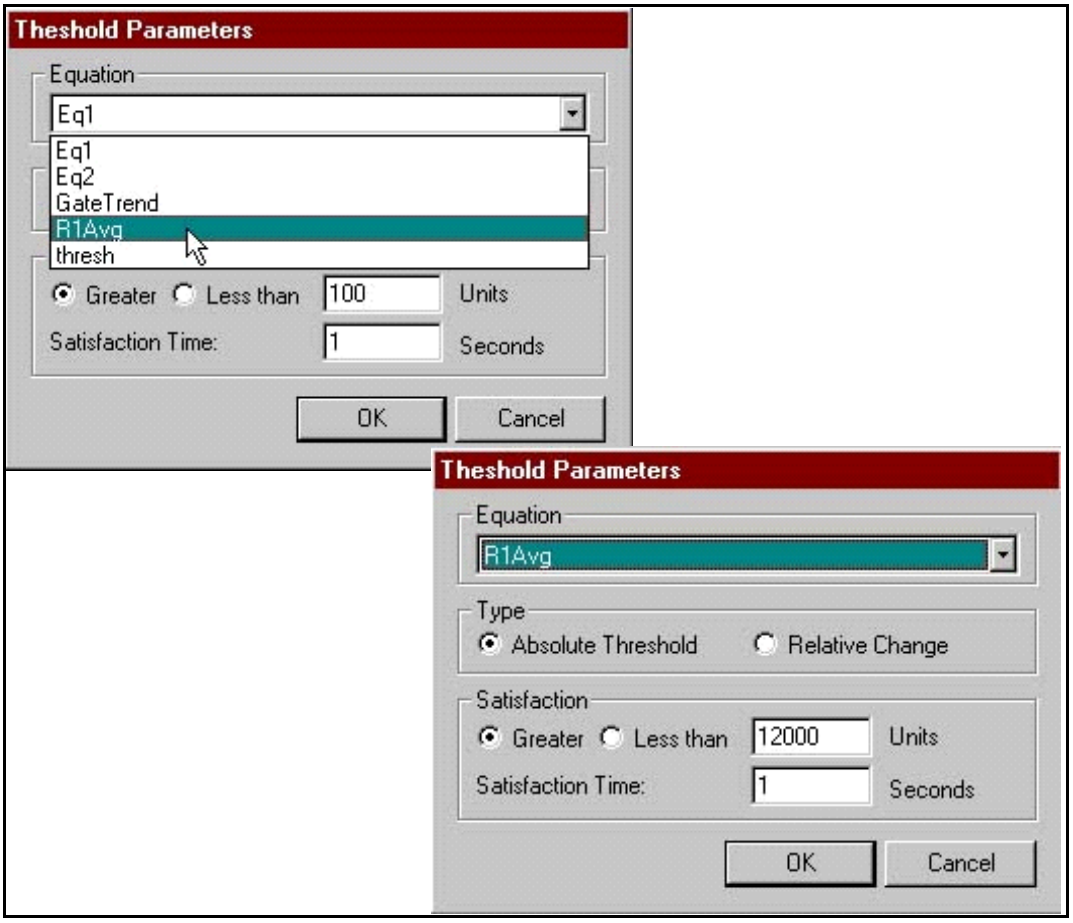


Figure 3-183. Setting a Threshold function

The value of equations available for the threshold pattern recognition includes all region and trend equations previously set up under the Equations portion of the configuration menu. The selections for the Satisfaction area of the Threshold Parameters window can be the value for an established variable (See 4.5.6 Variables) as well as a numerical entry of units/seconds. After selecting the equation, enter satisfaction criteria for the threshold. Select OK to enter the sequence item to the list of sequence commands.

3.6.22.2 Neural Network Software

EyeD's Neural Net endpoint algorithm is a pattern-matching algorithm designed to pick an endpoint pattern out of a complex signal by first training on preselected data. During training the neural net generates a suite of grids of varying pixel sizes and overlays them on the training data. From that process, patterns are saved for comparison to the real-time data. During real-time operation, when any of the trained patterns match the real-time data over a specified period of time, endpoint is indicated and the process is complete.

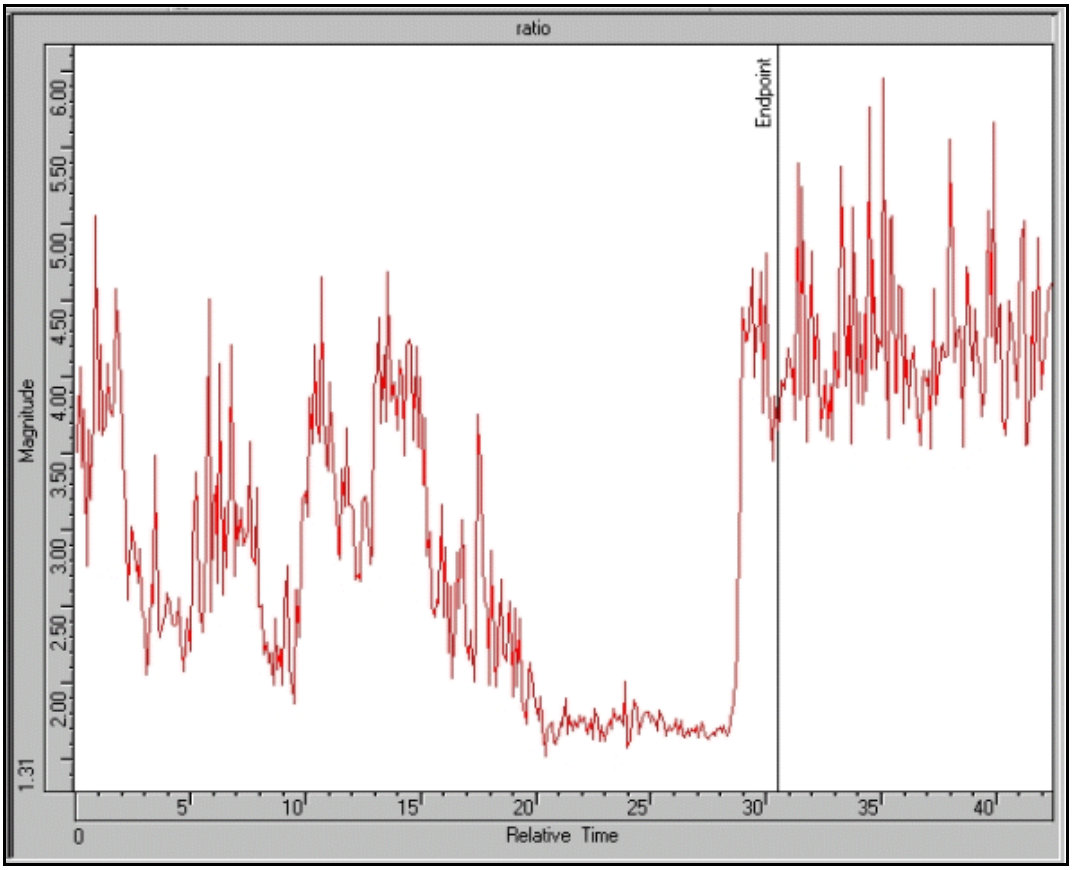


Figure 3-184. Neural Network Graph

A Neural Network algorithm greatly improves the sensitivity of all endpoint schemes, as pattern recognition is inherently more dependable than processing the same data through a threshold-based endpoint determination process. This is because it is looking for a general shape and not an absolute numerical value. In addition, the processing inside the algorithm serves to filter out a great deal of the noise on the incoming signal. Secondly, the neural net can recognize a much more complex signature. A threshold can only recognize when a signal crosses a specific value. The neural net looks for a distinctive pattern. This provides a significant advantage to the process engineer, especially when working with advanced techniques. Thirdly the neural net is much less sensitive to variations in amplitude. The pattern-matching algorithm by its nature looks at the delta change in amplitude, not absolute amplitude. This is an advantage when fluctuations in signal intensity are anticipated.

Input to the Neural Network is a single stream of data, which is typically the result of various mathematical formulas. The algorithm can be applied in real-time to any single parameter that varies over time such as:

- Spectral intensity of a single wavelength;
- Output of any equation applied to the spectra (e. g., average intensity of several wavelengths, ratio of two average intensities, etc.).

Unlike other types of neural networks, EyeD requires only a few training runs for operation. If a false positive or negative is found, it can easily be added to the training set for improved

dependability. In addition, the data can be analyzed in real time, or stored data can be reviewed or reprocessed.

3.6.22.3 How Neural Net Works

The neural net works in three stages as shown in Figure 3-185. The first stage is the delta Y test. For the delta Y test, the neural net scans the data to be pattern matched looking for the highest and lowest data points. The difference between these two points is delta Y. The resultant delta Y is then compared to the delta Y computed during training. If the delta Y of the live data is within a tolerance of the delta Y from training, the delta Y test passes and the neural net proceeds to the pattern match test.

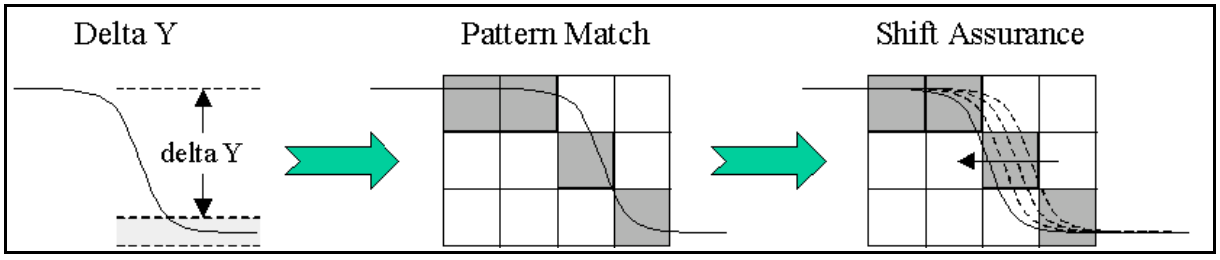


Figure 3-185. Neural Net Stages

For the pattern match test, the neural net generates a suite of grids determined during training. It superimposes each grid over the data and generates a pattern. It then compares the generated pattern with the corresponding pattern created during training. It repeats this test with each of the grids in the suite. If an exact match is found, the neural net proceeds to the shift assurance test.

The shift assurance test looks for a pattern match to be found with several consecutive data points. As each new data point is acquired, it is added to the data and passed through the neural net effectively shifting the pattern back in time. If enough consecutive matches are detected, a match is declared, the neural net completes and control is passed to the next sequence item.

An additional benefit of EyeD's Neural Network is that it can be applied by those without extensive mathematical knowledge of algorithmic function. A Neural Network algorithm is simply added to the training set to improve endpoint robustness.

The operator collects data and then reprocesses the data to obtain the trend that is desired for endpoint detection. That data is then fed into the neural net, the endpoint pattern is identified and neural net parameters are adjusted to adapt the training to the unique pattern.

The key to success with the neural net is training in a way that is unique enough to distinguish endpoint from noise or process artifacts and general enough to account for process variations.

Figure 3-186 is a EyeD window showing a Neural Net pattern-recognition algorithm followed by a five second delay command and a User Event command.

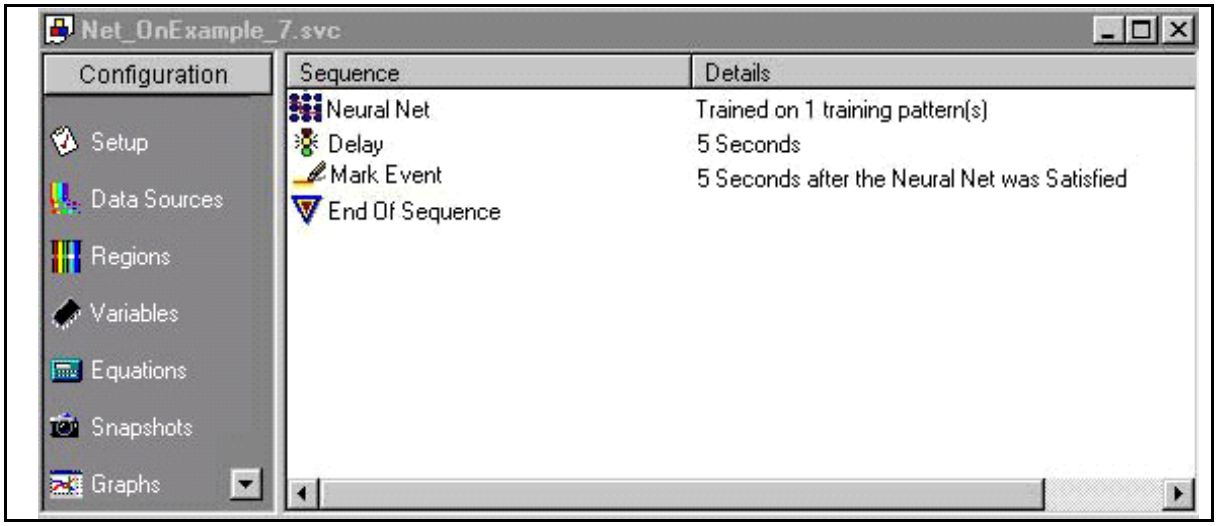


Figure 3-186. Neural Net Sequence

In this example, the same data file (*.svd) used to train the Neural Net algorithm was reprocessed using the Configuration that contained the trained neural net. This simple example is one method for testing a Neural Net. When it is reprocessed back over the file that created it, endpoint should be detected at virtually the same point in the file.

The neural net used is accessed by double clicking on the file name in the Training Patterns window. This brings up the file used to train the neural net.

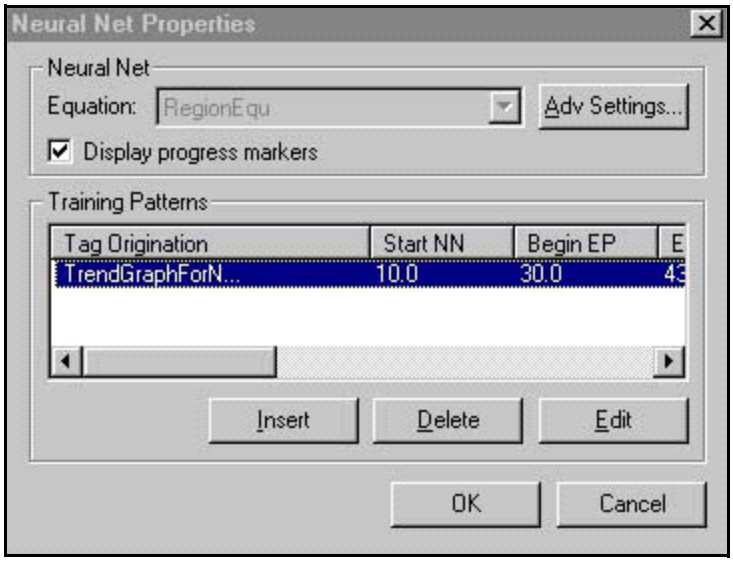


Figure 3-187. Selecting a file for Neural Net training

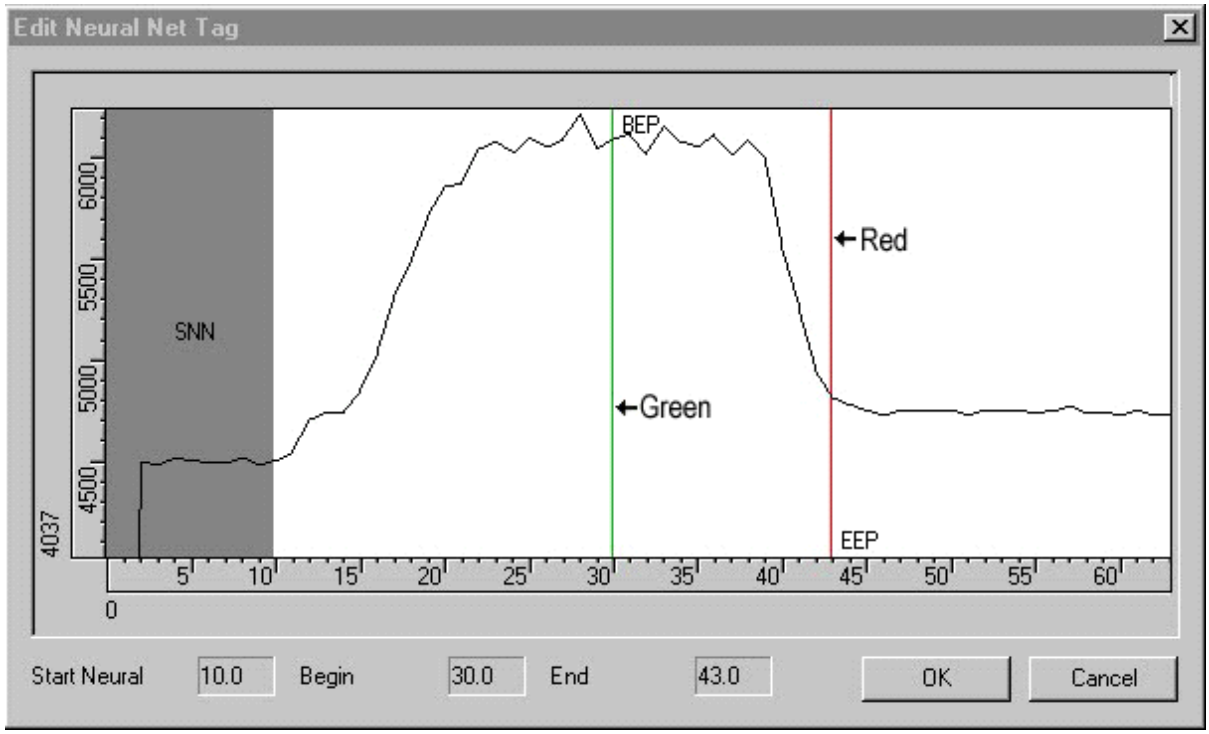


Figure 3-188. Setting Indicators to Train a Neural Net

Figure 3-188 shows the training file and settings used to define the endpoint pattern for the Neural Net. The green and red lines define a 13 second time window in which endpoint occurs. This interval is used to test that the change in magnitude, or delta Y, falls within an acceptable range. The delta Y is defined as the maximum minus the minimum Y value in this window on this graph. By default, the range is +/- 20% of that value. In this curve, the absolute value of delta Y is 1350 units. The acceptable delta Y will be between 1080 and 1620.

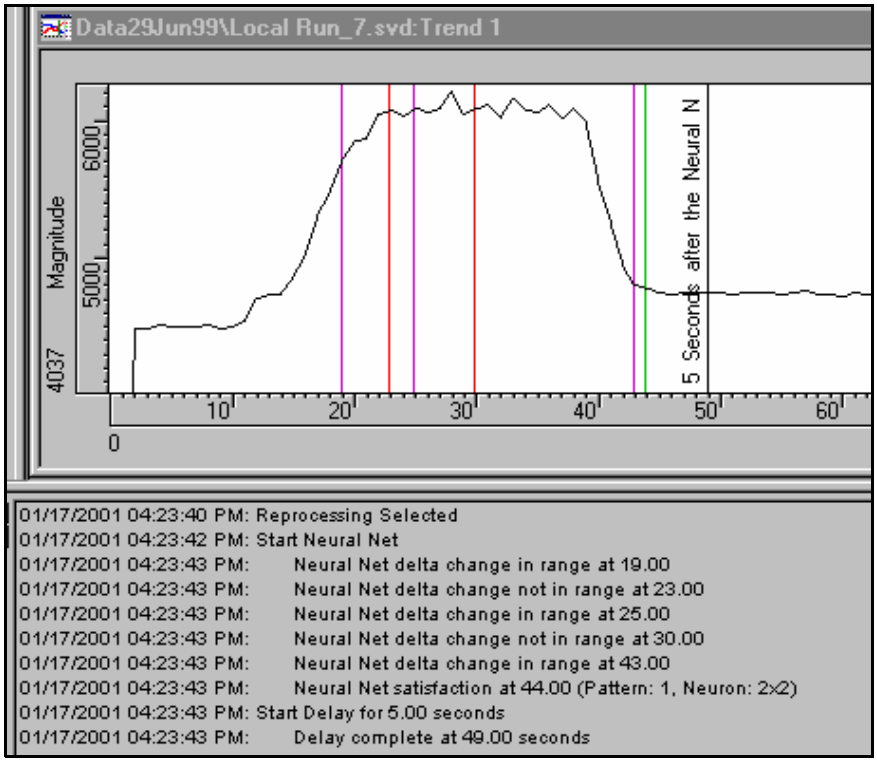


Figure 3-189. Progress Bars

The configuration in Figure 3-186 was used to reprocess the same file that was used to train the neural network. The configuration is the sum of all choices made under the Configuration menu in the left of Figure 3-186. In the graph shown in Figure 3-189 above, the various Neural Network test results were depicted as the real-time trend value was plotted

The colored upright bars, perpendicular to the X-axis, are the progress bars. From left to right they indicate:

- 19 Seconds (blue) - The delta Y test was satisfied and the pattern match test was started. Since the signal went from low to high, the pattern match was not satisfied.
- 23 Seconds (red) - The time window now includes a delta Y value that is outside of the +/-20% range for the delta Y that was defined in the training file. The red marker indicates when the delta Y went out of range.
- 25 Seconds (blue) - The left side of the time window has climbed up the rising curve enough to have the delta Y test satisfied. The purple line indicates the time when the delta Y came back into range. Again, the pattern match test was started.
- 30 Seconds (red) - The left side of the time window has moved up the rising part of the curve until the delta Y value is too small. The red marker shows when this failure happened.
- 43 Seconds (blue) - The time window again includes a satisfactory delta Y value. The purple line shows the time when this delta Y test was satisfied. The pattern match test was immediately started.

- 44 Seconds (green) - Both the delta Y and pattern match tests have been satisfied. The green marker shows the time when this occurred. The next sequence command of a five second delay was immediately started.
- 49 Seconds (user assigned color) - The delay is satisfied and the black User Event line and text is displayed.

3.6.22.4 Preparing for Neural Net Training (Step 1)

To prepare to use the neural net, the endpoint trend is created and normalized and the neural net sequence item is inserted in the sequence list. To begin, create the trend to be trained on by using the equations and functions provided in the EyeD application. If phenomena such as window clouding or solarization are an issue, the trend should be normalized. To normalize the trend, select a time period early in the etch where the intensity value is not changing rapidly (representative of normal etching). Divide all subsequent intensity values by this reference value to generate the normalized endpoint trace.

The endpoint trend to be used for training must be saved in the data file. To save the trend, reprocess the data file with the configuration containing the desired trend or region equation. Once reprocessing is complete, use the 'Save As' feature to save the data with a new data filename.

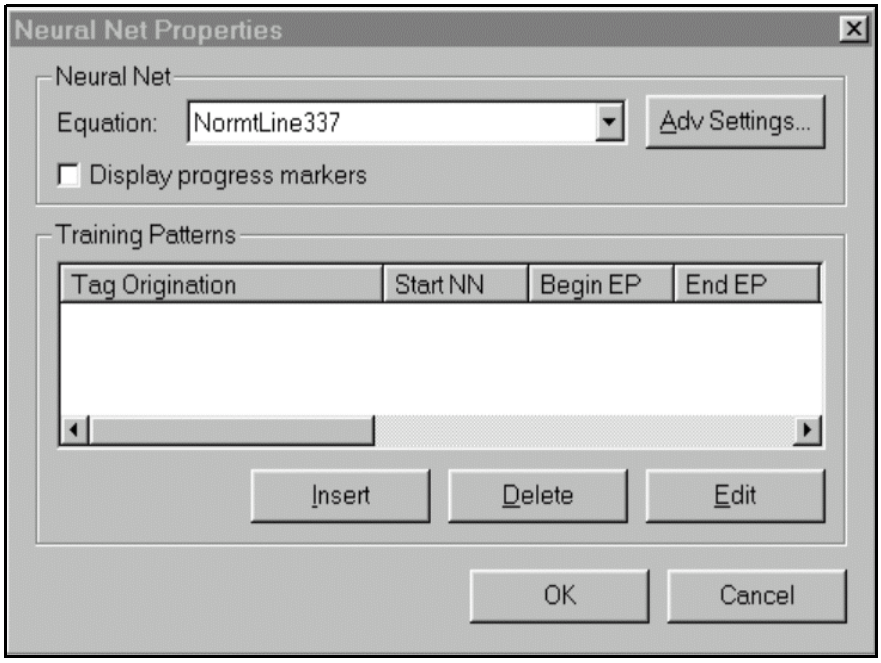


Figure 3-190. Neural Net Properties Window

Once the endpoint trend is ready, add a Delay sequence item to the sequence list. Set the time delay in the Delay sequence item to delay past early events in the process where the process is settling and endpoint could not possibly occur. It is also recommended to add a Mark Event sequence item after the Delay sequence item to indicate to the operator that the delay is complete.

Finally, insert the Neural Net sequence item into the sequence list after the Mark Event. Open the Neural Net sequence item and select the equation to be endpoint on as shown in Figure 3-191.

3.6.22.5 Identifying the Endpoint Pattern (Step 2)

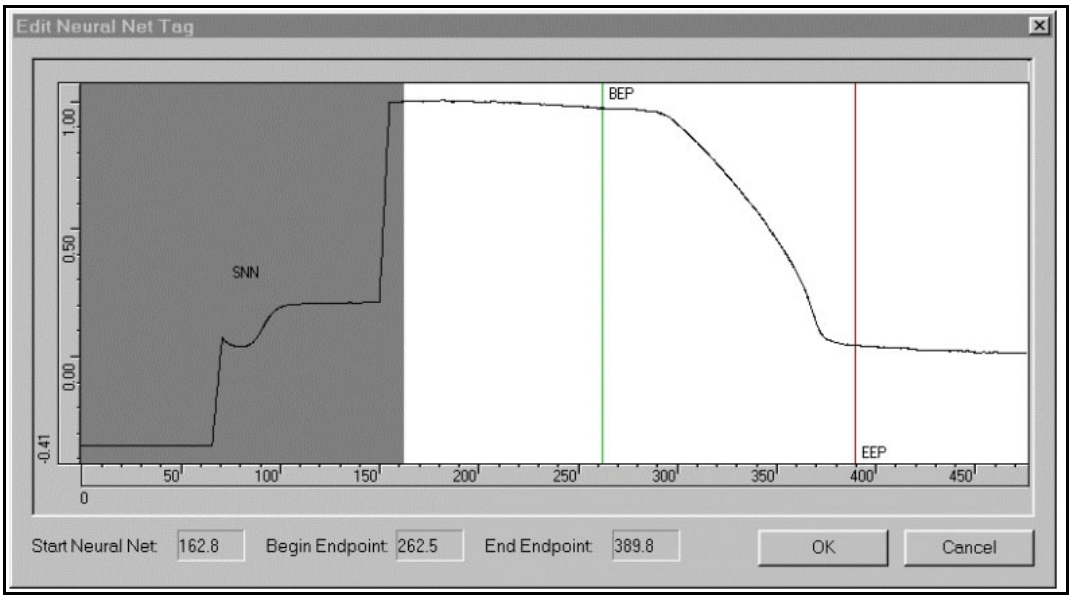


Figure 3-191. Edit Neural Net Tag Window

In Step 2 the trend plot stored in Step 1 is used to train the neural network to recognize the endpoint pattern. In the Neural Net Properties window select a file to train on by clicking Insert, browsing for the file to train on, selecting it and clicking OK. Once the file is selected, the *Edit Neural Net Tag* window will appear as shown in Figure 3-191.

In the this window, three graphical markers are used to designate the endpoint pattern: 1) the transition of gray background to white background designates when the neural network will begin searching for the endpoint trace pattern in the white background area, 2) the green line (Begin Endpoint) designates the beginning of the endpoint pattern, 3) the red line (End Endpoint) designates the end of the endpoint trace--the point in the trace that endpoint is declared. All three markers can be adjusted by dragging them with the mouse.

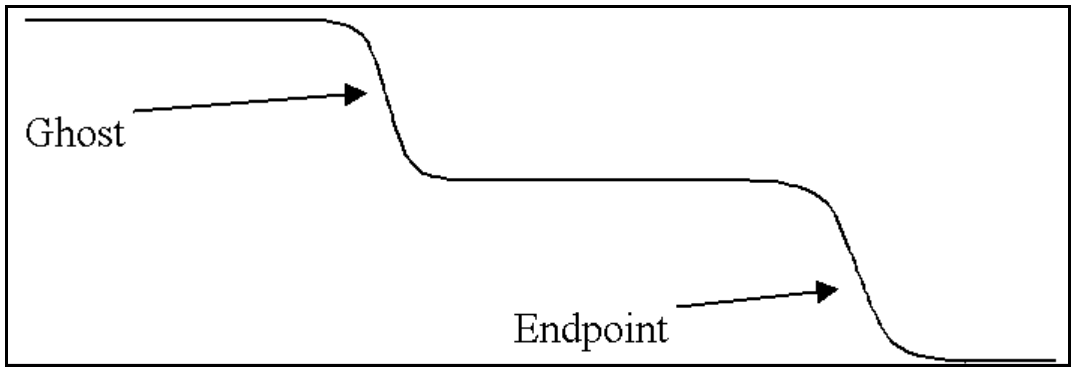


Figure 3-192. Ghost Pattern

Start by dragging Start Neural Net significantly to the left of the pattern to be selected for endpoint. Next drag the Begin Endpoint line to the left most boundary of the endpoint pattern. After that, drag End Endpoint to the right most boundary of the endpoint pattern.

For proper operation, ensure there are at least 13 data points between Begin Endpoint and End Endpoint.

Finally, position Start Neural Net. The existence of a *ghost* endpoint transition will influence the correct positioning of the Start Neural Net marker. A ghost is a pattern in the endpoint trend that resembles the actual endpoint pattern and may be mistaken by the neural net as the endpoint transition as shown in Figure 3-192. The simplest way to avoid ghosts is to increase the time delay in the Delay sequence item prior to the Neural Net sequence item. The time delay should be increased so the neural net does not begin operation until after the ghost has occurred. However, due to process variations, this is sometimes not possible. If the ghost cannot be avoided with a delay, the Start Neural Net marker can be set to eliminate misinterpreting the ghost as the endpoint.

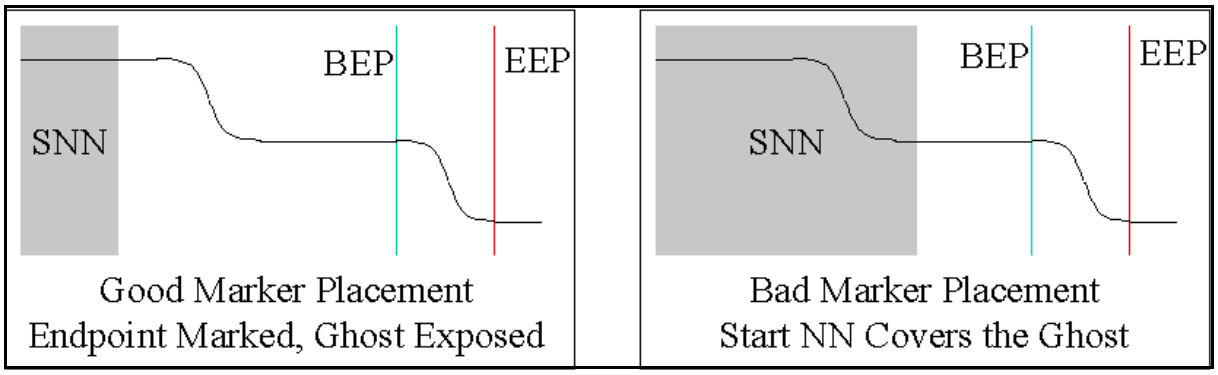


Figure 3-193. Start Neural Net Marker Placement

During training, the neural net will not see anything to the left of Start Neural Net. To help the neural net avoid a false alarm on the ghost, drag Start Neural Net to the left of the ghost. Figure 3-193 shows proper and improper placement of the Start Neural Net marker. Proper placement of the Start Neural Net marker exposes the ghost to the neural net during training. Upon detecting the ghost during training, the neural net makes the pattern grid finer and discard grids that detect the ghost in order to distinguish the ghost from endpoint and not call a false alarm on the ghost. The pattern grid will be discussed in more detail in Step 4. Once Begin Endpoint, End Endpoint and Start Neural Net are set, click **OK** to complete Step 2.

Neural net training occurs automatically when **OK** is clicked on the Neural Net Properties window.

3.6.22.6 Endpoint on Multiple Wafers

After completing steps 1 and 2, the neural net sequence item can be closed and the neural net can be used to detect endpoint. Steps 1 and 2 are sufficient for many endpoint applications. To test the neural net, collect multiple data files and add them to the reprocess list (not the endpoint tag file list). Run the reprocess list and observe how the neural net performs. Once the reprocess list is setup, changes to the neural net can be easily tested by simply rerunning the reprocess list.

In some cases all of the files in the reprocess list will not endpoint correctly. Steps 3 through 6 discuss how the neural net can be adapted to work with processes that vary significantly from the training data.

3.6.22.7 Adjusting For Amplitude Variation (Step 3)

One of the largest variations of the signal will be signal amplitude. This is why it is recommended that the endpoint trend be normalized prior to processing by the neural net. Effects such as window clouding and sensor solarization can be compensated for by normalization. In some cases normalization alone is not enough to insure correct endpoint detection in all cases.

During training, the neural net measures the difference in amplitude (delta Y) and difference in time (delta T) between Begin Endpoint and End Endpoint. As data is fed to the algorithm real-time, it looks at all the data between the current data point and the current data point minus delta T. It compares the difference in amplitude of the largest data point to the smallest data point. If that variation is not within a tolerance of the difference in amplitude of the training data, the delta Y test fails and neural net does not attempt to match real-time data to the training data.

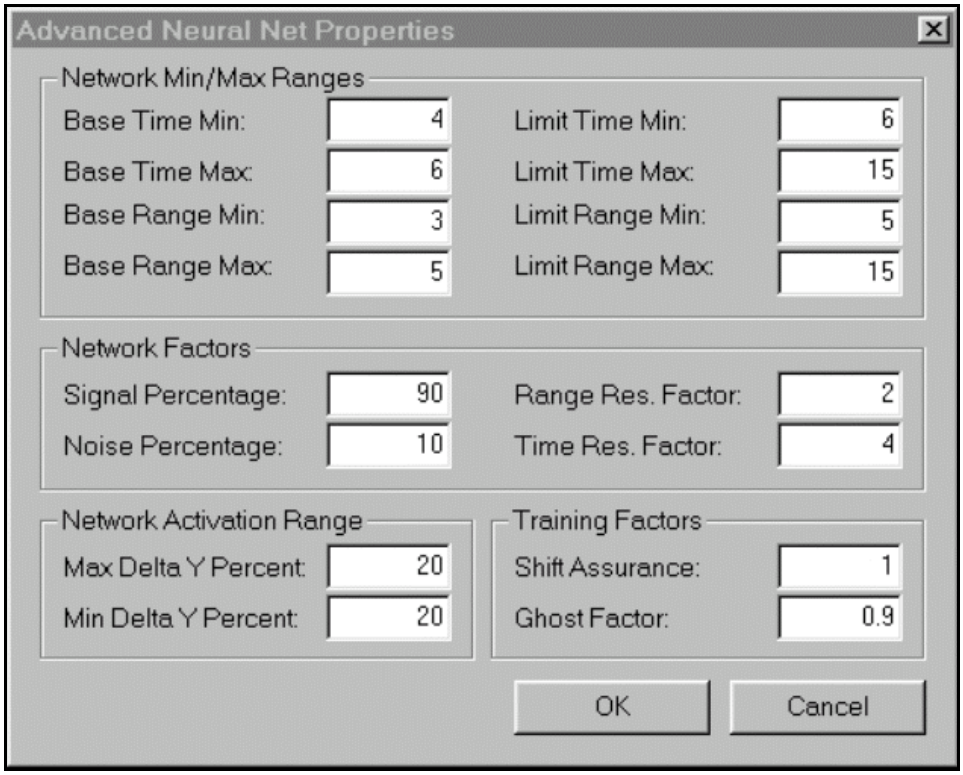


Figure 3-194. Advanced Neural Net Parameters Window

This tolerance can be adjusted by opening the neural net sequence item, clicking the **Advanced Parameters** button and changing the *Max Delta Y Percent* and *Min Delta Y Percent* values as shown in Figure 3-194. The *Max Delta Y Percent* is the percent of delta Y that the real-time signal can grow from the training data. The *Min Delta Y Percent* is the

percent of delta Y that the real-time signal can shrink from the training data. *Max Delta Y Percent* and *Min Delta Y Percent* can be adjusted from 1 to 100%.

3.6.22.8 Adjusting the Grid Resolution (Step 4)

Another way to compensate for variations in the endpoint signal is by adjusting the grid resolution. To match the training data, a suite of grids are overlaid on the data and tests are performed in each pixel to see whether data crosses through it. This is how the pattern is created.

Each pattern has a unique grid resolution. The grid resolution is the number of pixels in the grid. The grids can be adjusted to match the application. If a grid is too coarse, false alarms can result causing endpoint to be indicated when endpoint has not been reached. If a grid is too fine, endpoints can be missed because the endpoint pattern did not exactly match the training data. The neural net automatically discards grids and adjusts the grid resolution to avoid ghosts during training. A range of grid resolutions are available to the user to help compensate for variations in wafer patterns.

The trade-off between a course grid and a fine grid is analogous to pattern matching with a 35mm camera. An out of focus picture corresponds to a course grid and a sharply focused picture corresponds to a fine grid. Imagine taking a picture of a cat and trying to match the pattern to small four legged animals. If the picture is sharply focused (a fine grid) a small dog will not match. If the picture is unfocused, a small chair will match. Somewhere in between is the right amount of focus that will match small four legged animals and not match a chair.

To adjust the grid resolution, open the neural net sequence item and click the **Advanced Parameters** button. The parameters: Base Time Min., Base Time Max, Base Range Min., Base Range Max, Limit Time Min., Limit Time Max, Limit Range Min., Limit Range Max can be used to adjust the range of grid resolutions (number of pixels) during training. Simply put, all of the parameters that start with *Base* control the grids with the fewest pixels in the suite. All of the parameters that start with *Limit* control the grids with the largest number of pixels in the suite. The neural net automatically fills in grids in-between the smallest and largest grid resolutions.

For a Base Time Minimum of 3, a Base Time Maximum of 6, a Limit Minimum of 8 and a Limit Time Maximum of 15, the grid with the fewest pixels in the suite will have a time grid resolution of from 3 to 6. The grid with the most pixels in the suite will have a time grid resolution of from 8 to 15. In this case, if ghost detection determines that grid resolutions of 3, 4, 5, and 6 are no good, a grid of resolution 6 will be kept because the Base Time Maximum of 6 demands it. Because the Limit Time Minimum is set to 8 and the Limit Time Maximum is set to 15, all suites will contain a grid with a resolution of at least 8 and may go as high as 15.

The same rules that adjust the time grid resolutions of the *Time* parameters apply to the grid resolutions in amplitude for the *Range* parameters.

3.6.22.9 Caution About Grid Resolutions

A word of caution: a 2x2 grid may endpoint on many patterns that are not desired and a 15x15 grid may never endpoint. A 2x2 grid is the lowest resolution grid. Any grid resolution in the suite matching the pattern will cause endpoint to be detected. Looking at Figure 3-195, a 2x2 may generate the same pattern for condition 1 and condition 2. In this case, the neural

net will rely strictly on the delta Y measurement to indicate endpoint. In the case of condition 2, endpoint will be called as soon as delta Y is satisfied. To avoid this problem the minimum grid resolution can be increased as in condition 3. With this resolution, the neural net can recognize the flat spot at endpoint.

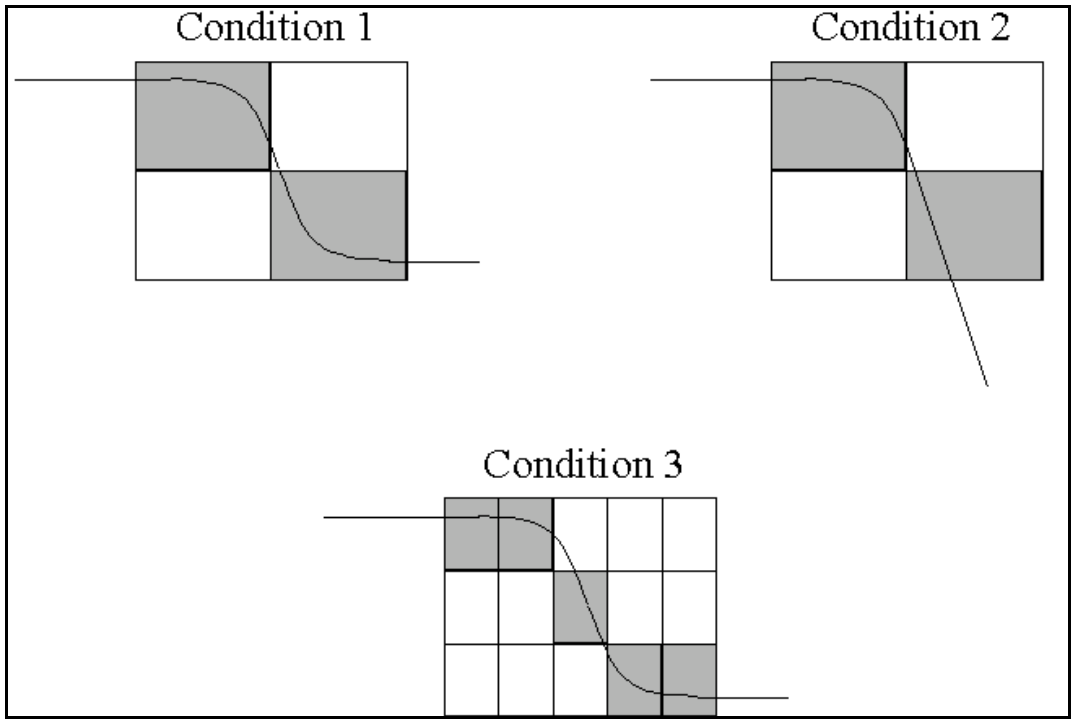


Figure 3-195. Adjusting The Grid Resolution

In many cases, higher resolution grids like a 15x15 will probably not endpoint on a file other than the file it was trained on. This is because the pixel size is so small that any variation in the signal due to noise or process variation will cause the pattern match to fail. In addition, if there are large grids or a lot of grids, more CPU time will be required. This can be significant in some cases.

3.6.22.10 Adjusting the Shift Assurance (Step 5)

Shift assurance is the last test performed by the neural net prior to declaring a valid pattern match. The purpose of shift assurance is to prevent ghosts from being declared as endpoint. It works by requiring the pattern match to be maintained over consecutive data samples. If enough consecutive data samples do not pattern match, the shift assurance counter restarts. Once sufficient consecutive data samples pattern match, the neural net declares the pattern as found. To adjust the shift assurance, open the neural net sequence item and click the **Advanced Parameters** button. The *Shift Assurance* parameter can be adjusted from 0.1 to 1 where 0.1 requires the least shift and 1 requires the most shift.

3.6.22.11 Training On Multiple Tag Files (Step 6)

If steps 3, 4 and 5 have failed to detect endpoint for all cases, multiple tag files can be trained. In the Neural Net Properties window, multiple tag files can be inserted. So, if 99 of 100 files

endpoint correctly, the 100th file that does not endpoint can be added to the list and trained on. This will cause the 100th file to endpoint as well.

The only cautionary note here is that training with multiple tag files adds another complete suite of grids for each file in the list. The more grids in the training set, the more chances of getting a ghost detection and signaling endpoint early. This is especially true if the shape of the endpoint traces are significantly different from each other. Furthermore, the neural net does not compare grids between tag files to eliminate ghosts. To help avoid ghosting, increase the resolution of the grids as described in Step 4.

3.6.22.12 Other Neural Net Advanced Parameters

The remaining neural net advanced parameters should not be adjusted without consulting with Applied Materials personnel. Please contact Applied Materials for assistance.

3.6.22.13 Troubleshooting

As discussed above, the neural net works in three stages. The first stage ensures the data is within a range of amplitudes, the delta Y test. The second stage checks for a pattern match. The third stage ensures the pattern match is seen using consecutive data samples. The three stages are shown in Figure 3-196. Understanding which stage the neural net is failing can greatly aid debugging of a neural net sequence.

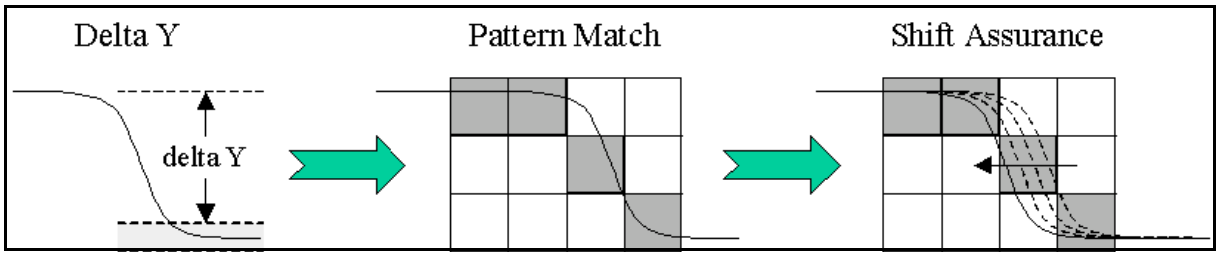


Figure 3-196. Neural Net Stages

To understand which stage the neural net last passed, open the neural net properties window and check the **Display progress markers** box as shown in Figure 3-197. Checking the box, places visual markers on the screen to give the user insight into which stage the neural net was executing as each data point was processed. The markers have specific colors and meanings as specified in Table 3-4.

Table 3-4. Neural Net Marker Color Definitions

Color	Meaning
Purple	Delta Y has passed
Blue	A pattern has matched
Green	Shift Assurance has been met (neural net complete)
Red	Failed delta Y

By looking at the markers, the progress of the neural net can be seen. Based on the progress observed, changes can be made as described in the steps above to help the neural net detect endpoint properly.

To better illustrate the operation of the progress markers, an example is shown in Figure 3-197. In this example, delta Y first passed at about 312 seconds as indicated by the first purple marker. At 359 seconds, the change in signal was too great and failed delta Y as indicated by the red marker. Delta Y passed again at 386 seconds as indicated by the second purple marker. The pattern matched for the first time at 387 seconds as indicated by the blue marker. Finally, the shift assurance passed at 391 seconds, as indicated by the green marker, completing the neural net sequence.

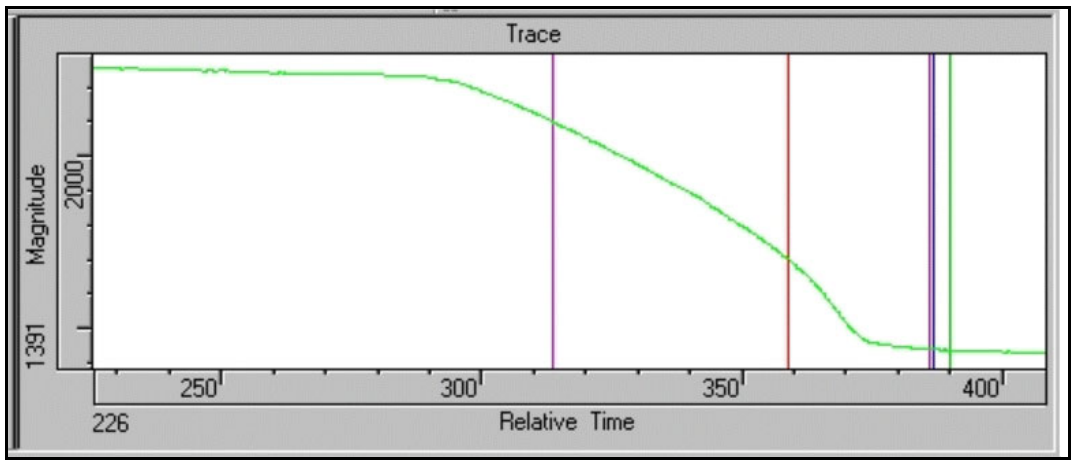


Figure 3-197. Neural Net Progress Markers

In addition to the progress markers, information is available in the Activity Log at the bottom of the EyeD window as shown in Figure 3-198. The entries in the Activity Log document each of the markers and the grid resolution of the neuron that called endpoint. The marker events with event times can be helpful if there are a lot of progress markers on the screen and the actual events are not clear. The neuron resolution can be useful in making decisions about adjusting grid resolution if endpoint was called early.

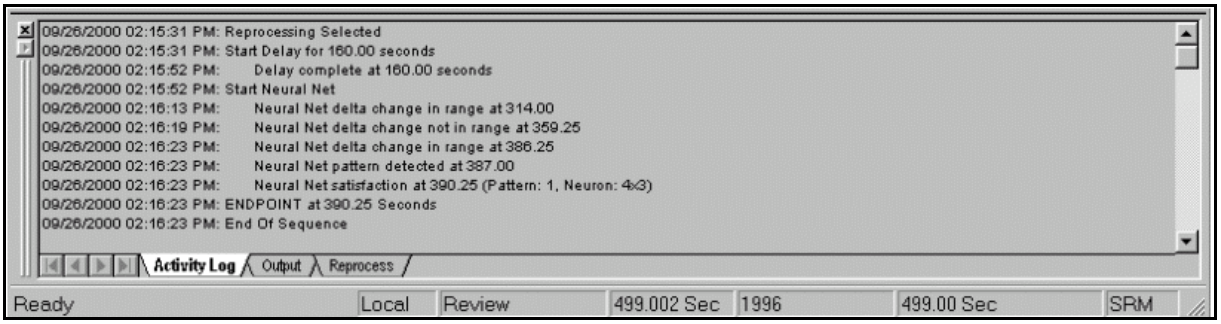


Figure 3-198. Neural Net Activity Log Entries

Two problems are common when working with the neural network: some wafer files not reaching endpoint and some wafer files reaching endpoint early. These problems and the possible solutions are discussed in the table below.

Table 3-5. Common Neural Network Problems

Problem	Solution
Not endpointing all wafers	Generally, the neural net misses endpoint because, delta Y is not met, the grids are too fine or the range of signals required to endpoint vary too much. Try increasing delta Y values to account for variations in the amplitude of the different signals. Reduce the grid resolution by setting Base Time Minimum and Base Range Minimum to lower values. Add some of the signals that won't endpoint to the training set.
Endpointing early on some wafers	Generally, the neural net endpoints early because the pattern is not well enough defined. Increase the grid resolution by increasing Base Time Minimum and Base Range Minimum. Adjust the Begin and End Endpoint markers to better define the endpoint pattern.

3.6.22.14 Examples of Marker Placement

Figure 3-199 shows examples of good and bad marker placement. How well markers are placed dramatically effects the performance of the neural net.

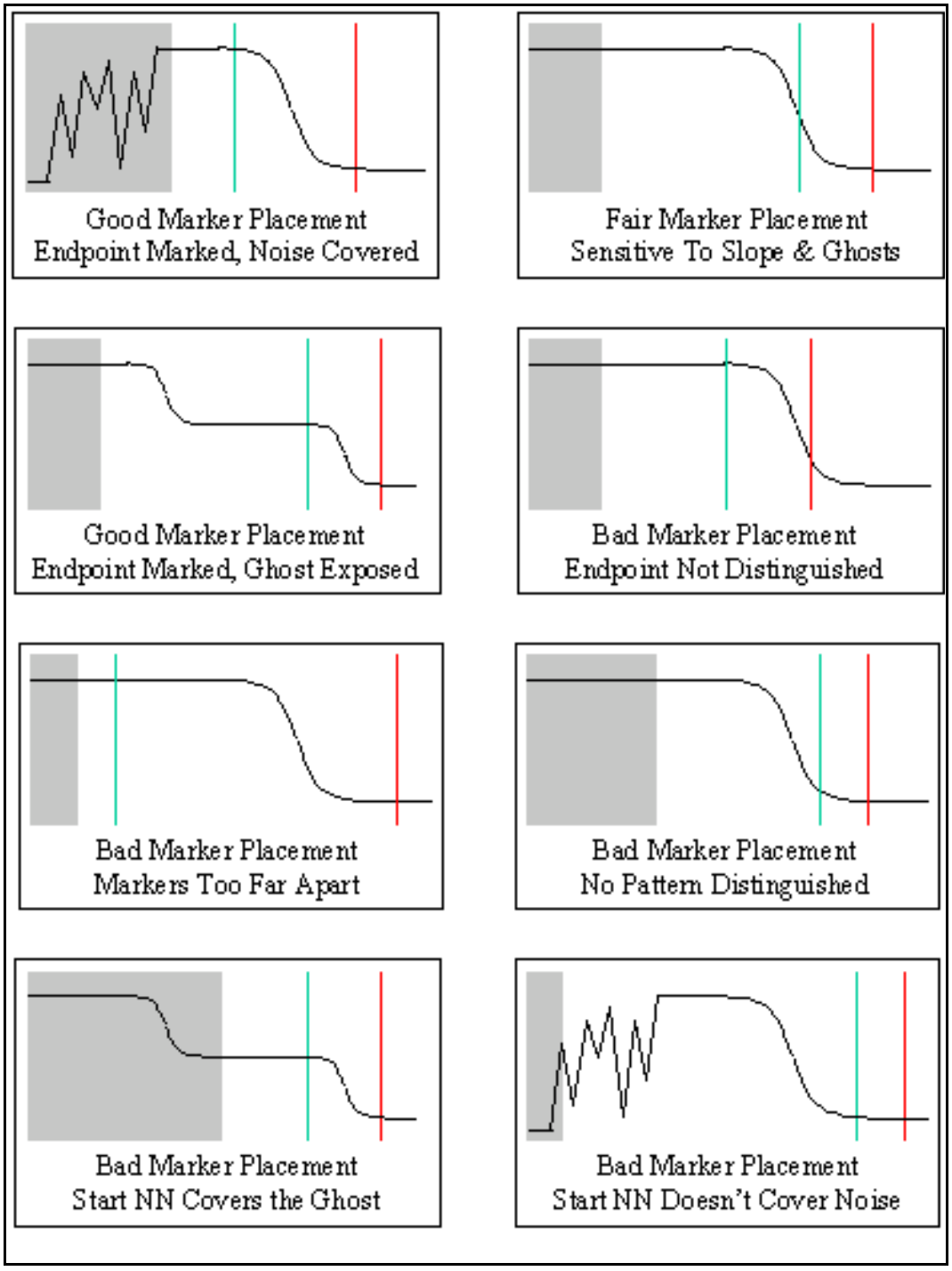


Figure 3-199. Marker Positioning

3.6.23 Delta-Y Detector

The Delta-Y Detector replaces an older pattern recognition algorithm called Multi-Slope. In later releases of EyeD, the Multi-Slope function is no longer visibly accessible in the pattern recognition section. However, the application is backwards compatible and old configurations that use Multi-Slope will remain functional in the latest release of EyeD. The most noticeable difference in the two algorithms is that the Delta-Y Detector performs only one test for a trending change in Y-value. If two or more trends are to be detected, as in the old Multi-Slope algorithm, multiple Delta-Y Detectors can be configured in the sequence item setup.

From the Sequence items window, right click and follow the path: Insert *Item'Pattern Detect'Delta-Y Detector.* This will bring up the Delta-Y Detector window.

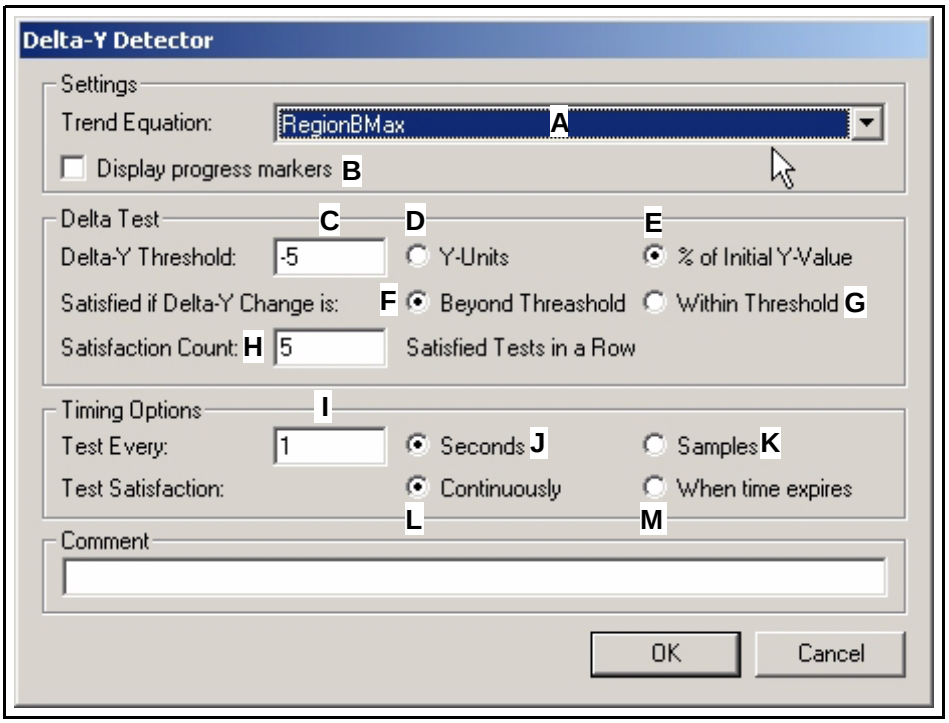


Figure 3-200. Delta-Y Detector Window

Settings in the Delta-Y Detector window include:

Settings Group Box

A. **Trend Equation -** use this drop-down menu to select the trend equation in which the Delta-Y test will be added.

B. **Display progress markers -** cause the results of sequential tests to be indicated with a colored vertical time marker.

Delta Test Group Box

C. **Delta-Y Threshold -** should be a positive or negative decimal number indicating the magnitude and direction of the threshold from the starting Y-value. This

selection can be the value for an established variable (See Section 3.6.26, Set Variable) as well as a numerical entry.

D. **Y-Units -** specifies the Delta-Y in units of signal counts. In many cases, the units are not CCD intensity units, but rather arbitrary units from the algebraic equation (trend equation).

E. **% of Initial Intensity -** changes the Delta-Y Threshold to a percentage of the Y-value when the Delta-Y Detector begins.

F. **Beyond Threshold -** Delta-Y Detector threshold satisfaction is declared if the Y-value changes to a point that exceeds the magnitude and direction indicated in the Delta-Y Threshold field.

G. **Within Threshold -** satisfaction is declared if the Y-value changes less than the magnitude and direction indicated in the Delta-Y Threshold field. Note: This test is always satisfied if the sign of the Y-value change is opposite that of the Delta-Y Threshold.

H. **Satisfaction Count -** this number of sequential items will be tested before satisfaction can be declared and the application proceed to the next item in the sequence. This selection can be the value for an established variable (See 4.5.6 Variables) as well as a numerical entry.

Timing Group Box

I. **Test Every -** a decimal number specifying the magnitude of the time period, either in seconds or samples. This field can be the value for an established variable (Section 3.6.7, Variables) as well as a numerical entry.

J. **Seconds -** specifies the time period in seconds. Note: EyeD calculates all relative time values using the integration time, data interval and sample number.

K. **Samples -** specifies the time interval as a number of samples that are equally spaced in time. Only integers should be entered in this field. If a decimal fraction is entered, the fraction is truncated to leave the integer.

Test Satisfaction

L. **Continuously -** starts a clock when the test begins and looks for the Y-value to satisfy the threshold test within the specified time period. Success is declared if the threshold test is met before time expires. Once a success or failure is declared, the next test begins. Using this option, success markers can appear at any point in the interval. Failure markers will only appear at the end of the time period.

M. **When time expires -** starts a clock and allows the specified time to elapse before performing the test. This technique guarantees the tests will be equally spaced in time.

Figure 3-201 is an example of a continuous Delta-Y Detector setup.

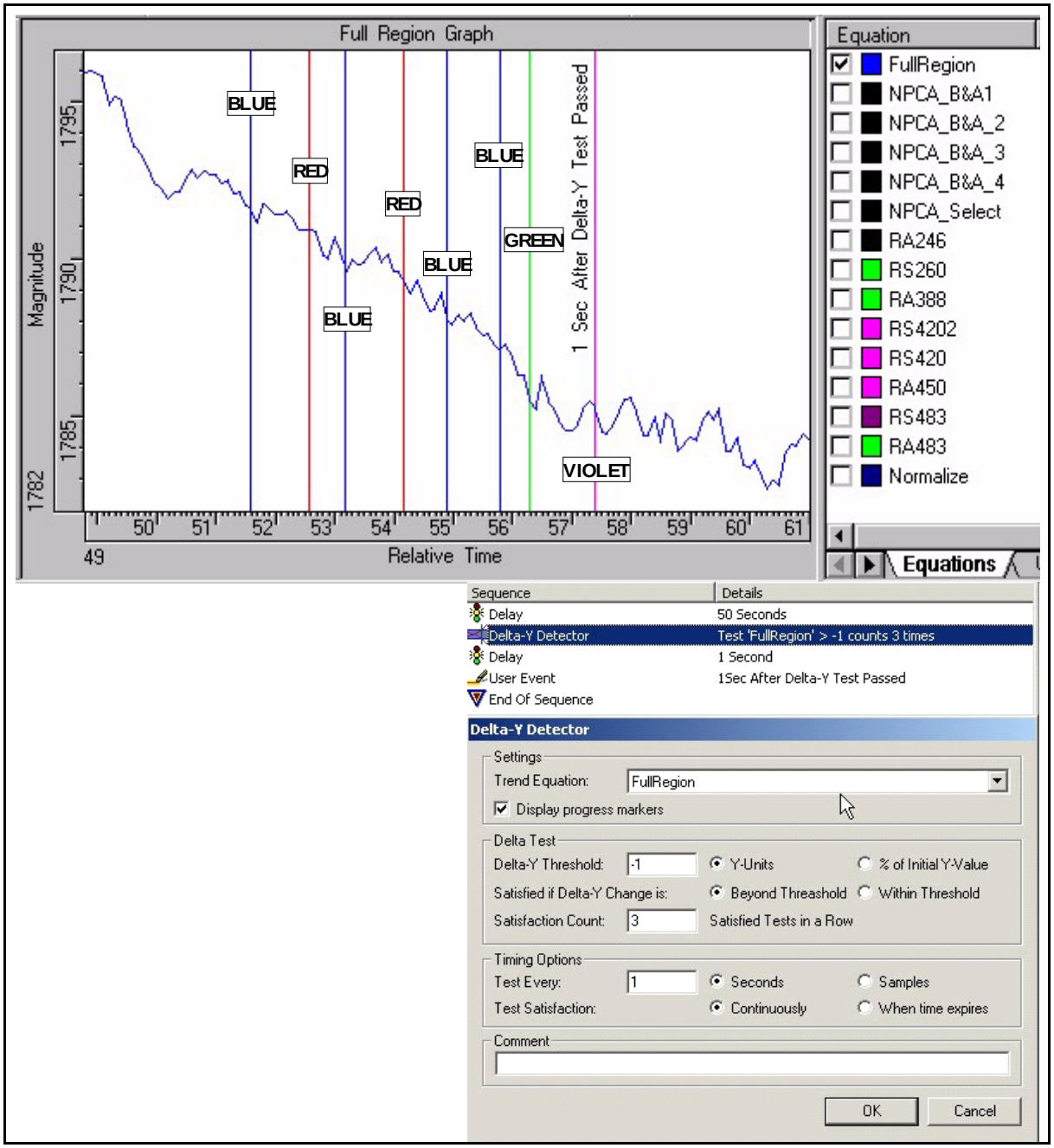


Figure 3-201. Delta-Y Continuous Test

In Figure 3-201:

- Red Line- indicates the Y-value has not changed the specified amount in the specified time
- Blue Line - indicates the Y-value has changed the specified amount in the specified time period

- Green Line - means that the last test of the change in Y-value has been satisfied and the Delta-Y Detector is satisfied

Progress markers begin to appear after the first successful threshold test. No marker is displayed at all if the threshold test fails immediately after the start of the Delta-Y Detector test.

Table 3-6. Progress Marker Table

Time (sec.)	Description of Event (refer to Figure 3-201)
50.0	The Delta-Y Detector (the second item in the sequence) started at the end of the 50 second delay (the first item in the sequence).
51. 0	The Delta-Y Threshold test failed because the 1. 0 second timer expired before the Y-value had decreased 1. 0 unit below the starting (50.0 sec.) Y-value. A new series of tests was started immediately. (No progress marker was printed. The algorithm begins printing progress markers after the first successful test.)
51. 6	The Delta-Y Threshold test was satisfied because the Y-value decreased 1.0 unit below the starting (51.0 sec.) Y-value. The second test in the series was started immediately. A blue progress marker was printed to mark the first successful test.
52. 6	The Delta-Y Threshold test failed because the 1.0 second timer expired before the Y-value ever decreased 1.0 unit below the starting (51.6 sec.) Y-value. A new series of tests was started immediately. A red progress marker was printed to mark the end of the time period in which the test failed.
53. 2	The Delta-Y Threshold test was satisfied because the Y-value decreased 1.0 unit below the starting (52.6 sec.) Y-value. The second test in the series was started immediately. A blue progress marker was printed to mark the first successful test in this new series of tests.
54. 2	The Delta-Y Threshold test failed because the 1.0 second timer expired before the Y-value ever decreased 1.0 unit below the starting (53.2 sec.) Y-value. A new series of tests was started immediately. A red progress marker was printed to mark the end of the time period in which the test failed.
54. 9	The Delta-Y Threshold test was satisfied because the Y-value decreased 1.0 unit below the starting (54.2 sec.) Y-value. The second test in the series was started immediately. A blue progress marker was printed to mark the first successful test in this new series of tests.
55. 8	The Delta-Y Threshold test was satisfied because the Y-value decreased 1.0 unit below the starting Y-value (at 54.9 sec.). The third test in the series was started immediately. A blue progress marker was printed to mark the second successful test in this series of tests.

Table 3-6. Progress Marker Table (Continued)

Time (sec.)	Description of Event (refer to Figure 3-201)
56. 3	The Delta-Y Threshold test was satisfied because the Y-value decreased 1.0 unit below the starting (54.9 sec.) Y-value. A green progress marker was printed to mark the third successful test in this series of tests. This third successive satisfaction of the threshold test satisfied the Delta-Y Detector. The next item in the sequence (a 1.0 second delay) was started immediately.
57. 3	The magenta User Event message was printed at the end of the 1.0 second delay. (If no delay had preceded the User Event in the sequence, the last green marker in the Delta-Y Detector would have been over written by the User Event line. The technique used here allows the user to see the green marker that is printed at the end of the Delta-Y Detector.

The next example shows how the same test is performed at the end of each time period (1 sec.) by selecting the Time Option *When time expires*. Notice that the tests and corresponding progress markers are equally spaced one second apart. The conditions that satisfy this test are slightly different from the previous examples.

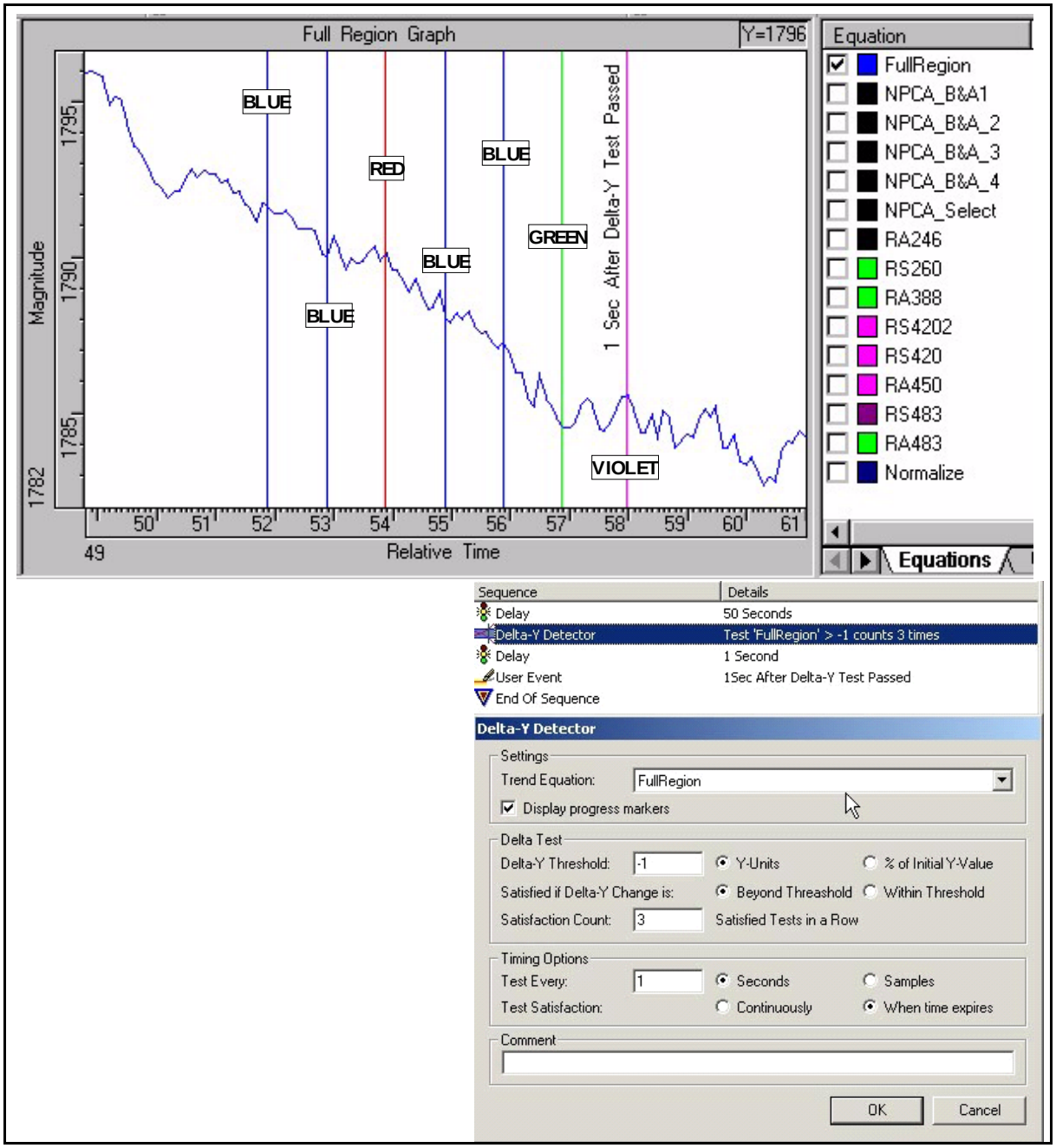


Figure 3-202. End of Time Interval Test

The next example shows how the units of measure of the Delta-Y Test can be expressed as a percentage of the starting Y-value. This method makes the Y-value change relative to the magnitude of the signal. The Delta-Y Test started after the 50-second delay. At 50 seconds, the Y value was 1792. Since 1/1792 = 0.000558, specifying the Delta-Y Threshold as 0.0558% of the Initial y-value, we get the same performance as when we set the Delta-Y Value = 1.0 Y-Units. The advantage of using the percentage option is that the delta-y value being sought is scaled to the current intensity value. This feature is used to accommodate optical window clouding which decreases light intensity over a long period of time.

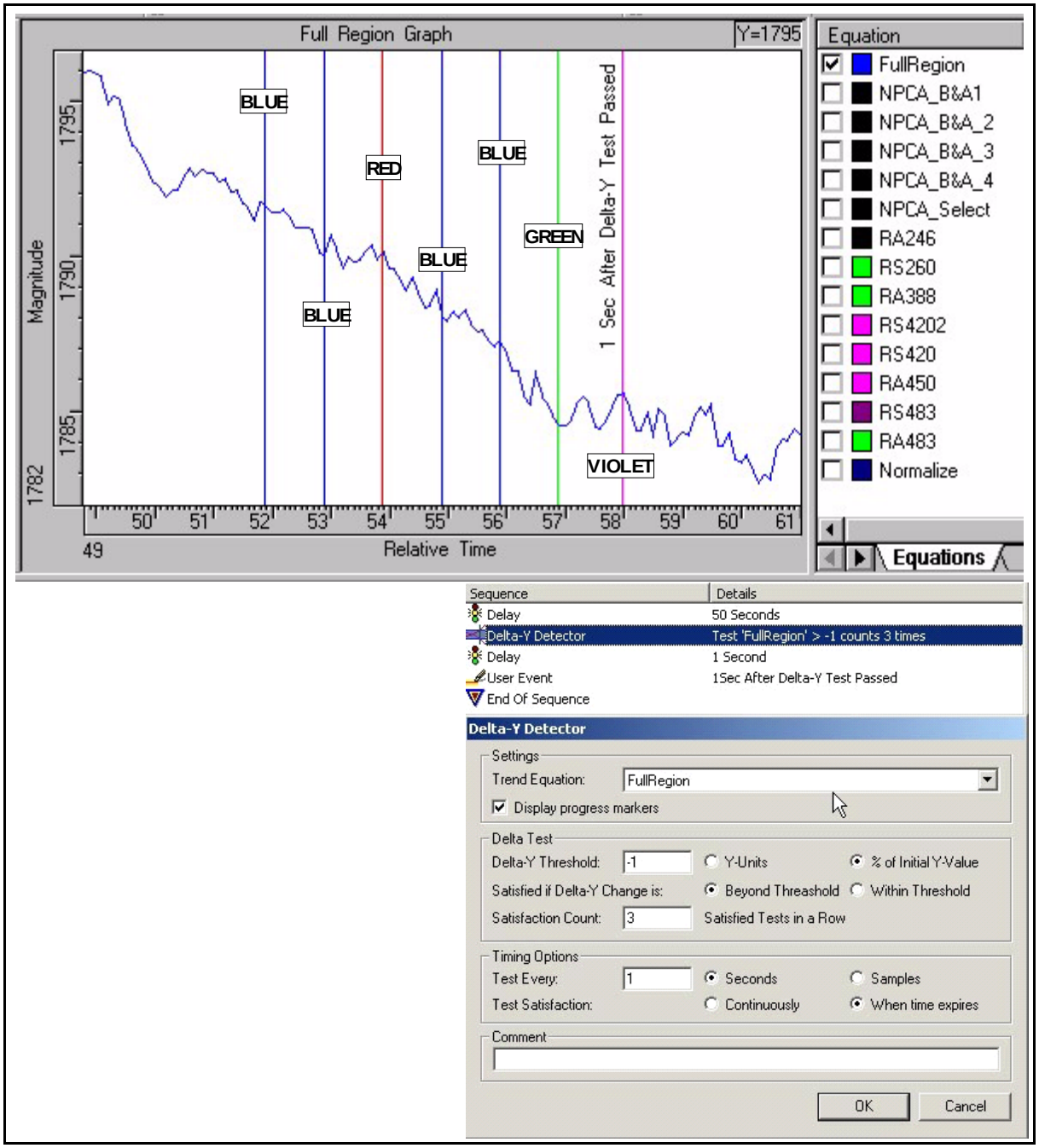


Figure 3-203. Percentage of Y Value

3.6.24 Parallel Sequence

3.6.24.1 Review of Sequence Attributes

In real-time, after the Equations and Graphs are completed, the Sequence is executed. The sequence is a single thread of tests and commands that are executed one by one, as conditions are satisfied. If a condition is not satisfied, a pointer is left at that place in the list indicating

the place where sequence evaluation will resume after the Equations and Graphs are updated following receipt of the next spectrum.

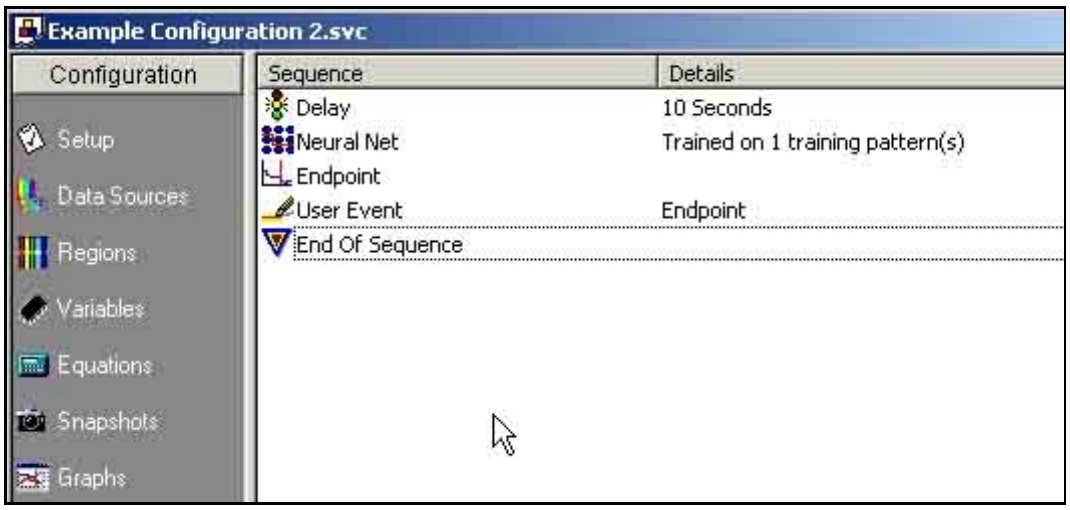


Figure 3-204. View Sequence List

At any point in the list of sequence conditions, the user can insert a Parallel Sequence command to create two threads of conditional processing. Each of these sequence threads will be executed after the Equations are completed following the receipt of each new spectrum. For example, a Parallel Sequence can be inserted after the Set Variable command by right clicking and selecting **Insert Item / Parallel Sequences**.

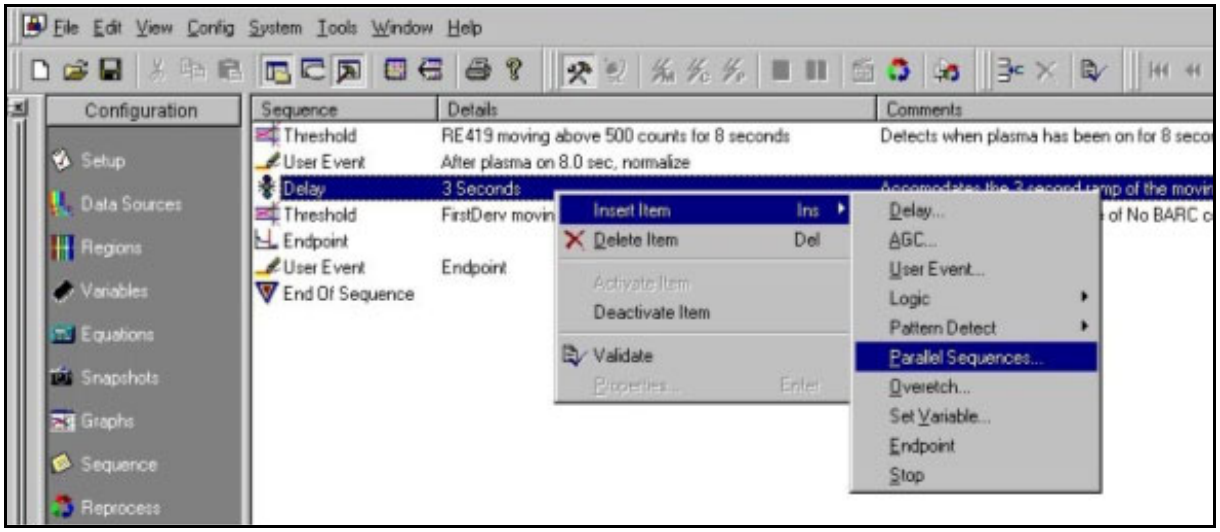


Figure 3-205. Insert Parallel Sequence

This brings up the Parallel Sequences Properties window.

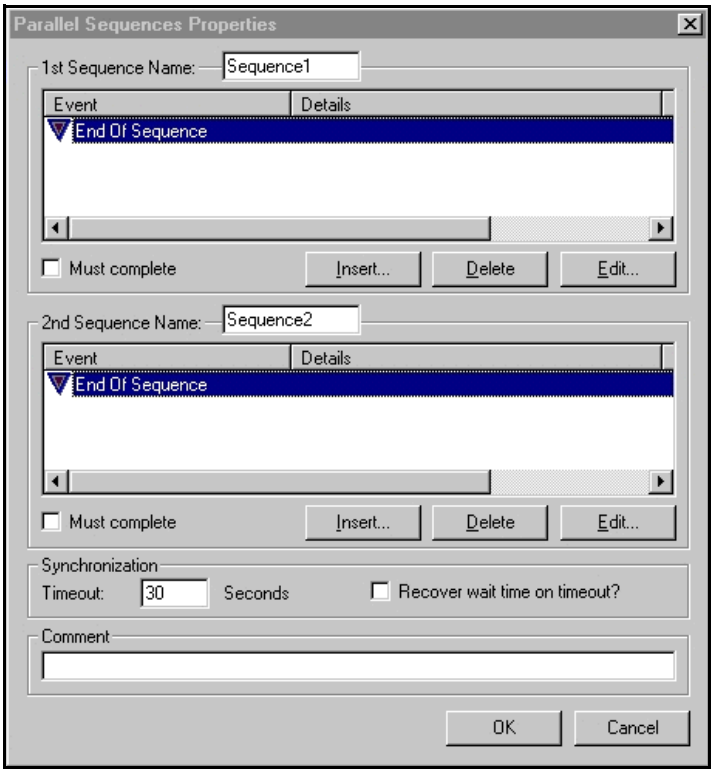


Figure 3-206. Parallel Sequences Properties Window

Selecting the Must Complete checkbox associated with each parallel sequence will indicate that the sequence thread must progress to the end for the Parallel Sequence to be declared finished.

When the Sequence pointer arrives at the Parallel Sequence line, both the 1st Sequence and the 2nd Sequence will become active, providing two threads of commands that will be executed.

Further control and flexibility is provided with the Synchronization options at the bottom of the Parallel Sequences Properties window. The Synchronization options set a time limit (time-out) for the completion of any parallel sequence thread that does not have the Must Complete checkbox selected. The Time-out can be the value for an established variable (See 4.5.6 Variables) as well as a numerical entry of seconds. These options are inactive if both of the Parallel Sequence threads have the Must Complete checkbox selected. If neither of the Must Complete boxes are checked, the Parallel Sequence will be declared finished at time-out and the process will move on to the next item in the main sequence window.

If a Delay is the next command in the main Sequence window, any time consumed waiting for the time-out in the Parallel Sequence will be applied toward satisfying that delay if the *Recover Time on Time out* box is checked.

3.6.24.2 Parallel Sequence Example

Parallel Sequence options selected:

1st Sequence

MUST Complete box is checked

2nd Sequence

Must Complete box is NOT checked

Time-out = 10 seconds Recover wait time on time out is selected

Delay = 15 seconds (Sequence command that follows the Parallel sequence in the main sequence thread)

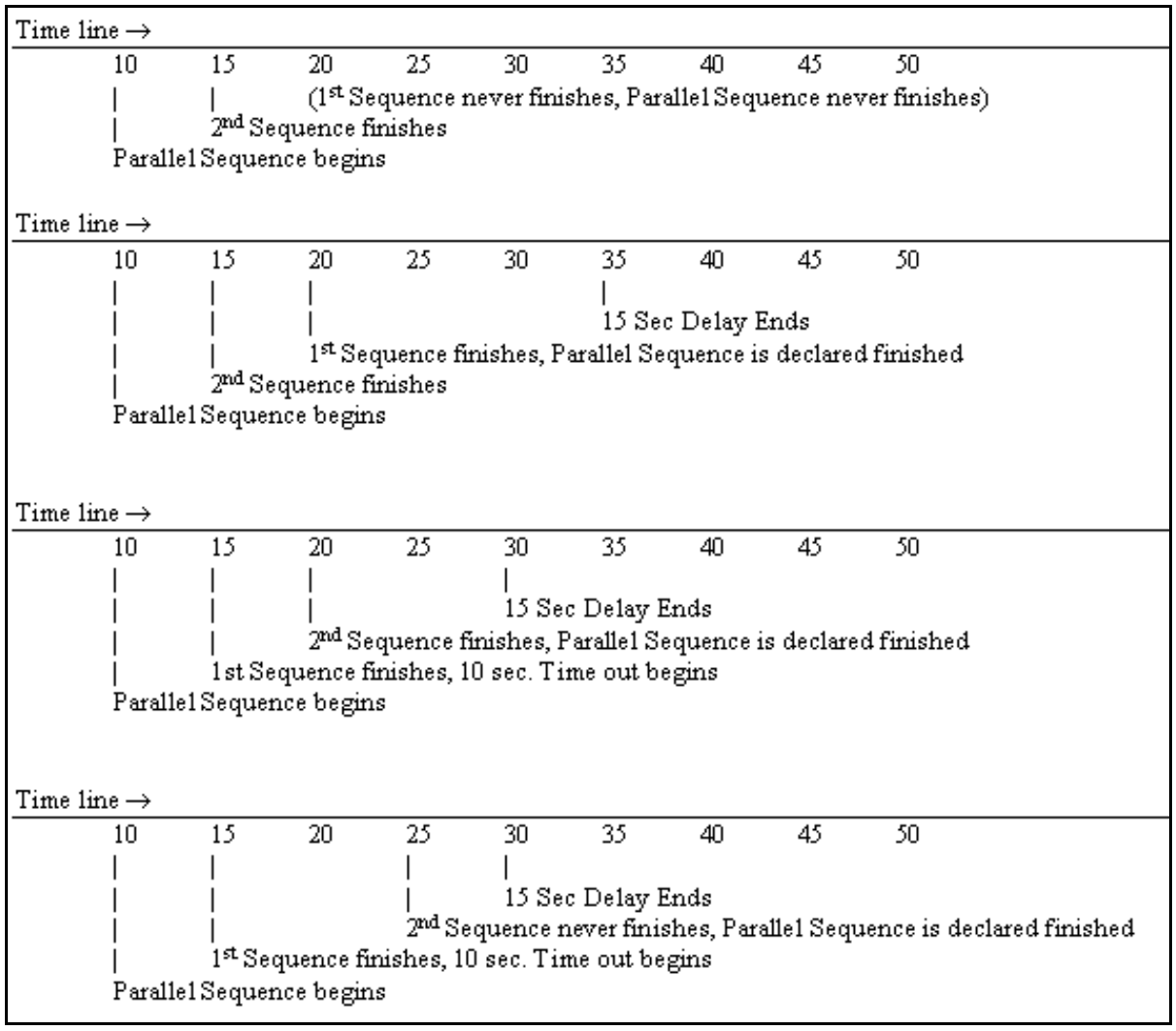


Figure 3-207. Parallel Sequence Example

3.6.25 Overetch

Some semiconductor etch processes are deliberately run past the detected endpoint to ensure the removal of all material. To continue processing past the time that endpoint is determined, the Overetch sequence item is used to define the length of the delay and how the delay will be calculated.

In the Sequence window, right click on the item before which the Overetch should be placed and follow the *Insert Item-->Overetch* menu to bring up the Overetch window.

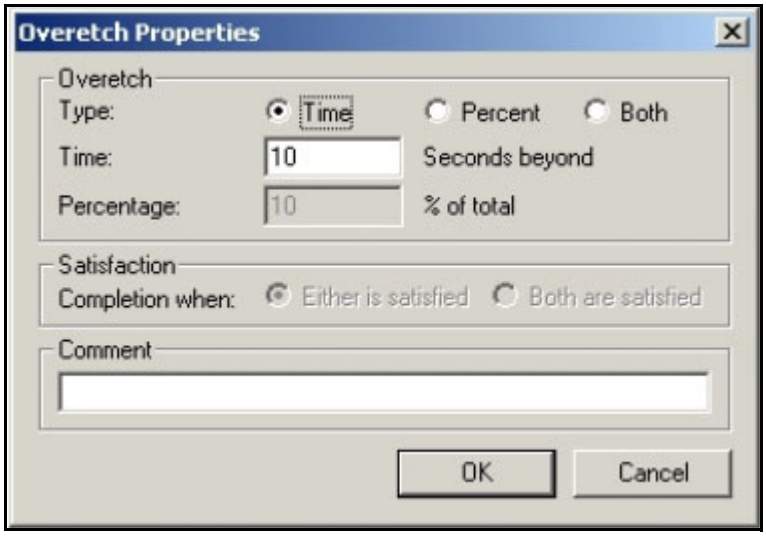


Figure 3-208. Overetch Properties Window

The default type of Overetch is a time interval in seconds. This can be changed to percent of the total run time. Selecting Both requires parameters in both fields to be supplied and a method for determining completion (satisfaction).

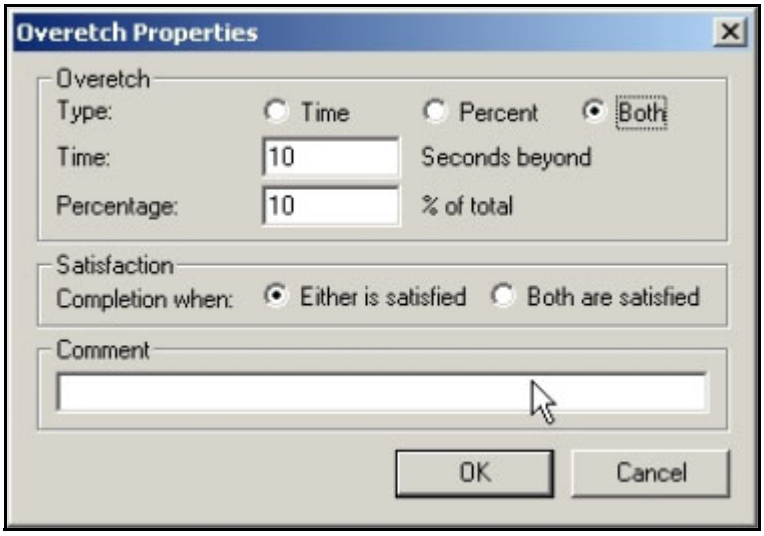


Figure 3-209. Set Overetch Type

3.6.26 Set Variable

Any Variable that is defined in the Configuration file can be set as part of the Sequence. To set a variable in the sequence, complete the following steps:

1. Select Sequence from the Configurations list and right click on the item in the sequence that the Variable update should precede.

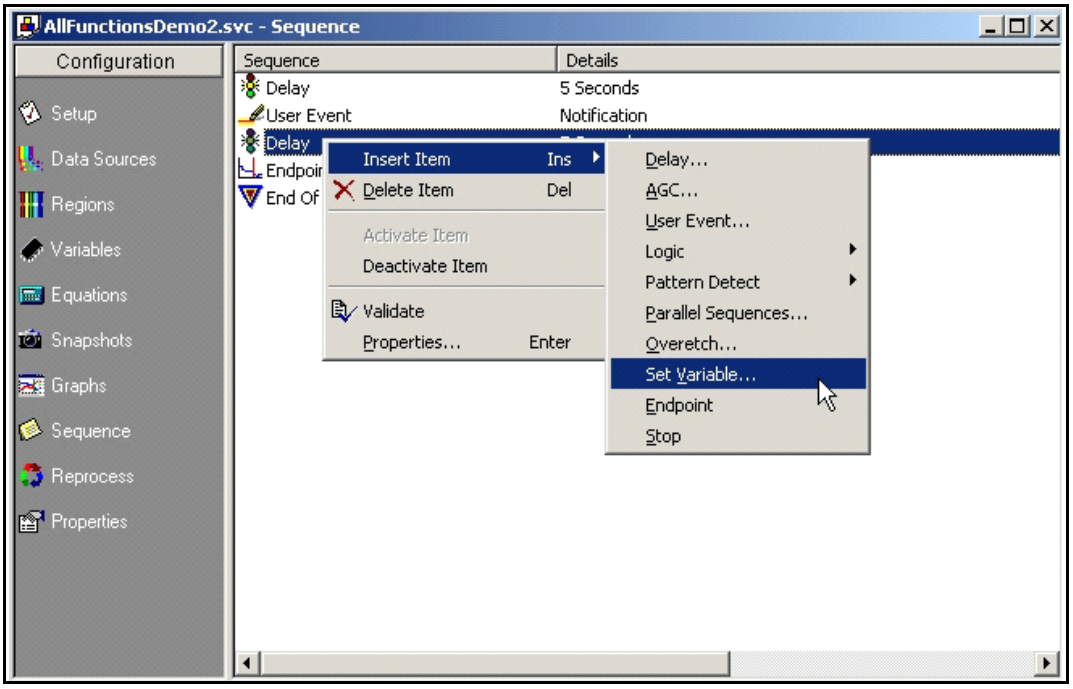


Figure 3-210. Set Variable Sequence Item

2. The first field is a drop menu that allows the selection of any variable previously defined in the Configuration file.

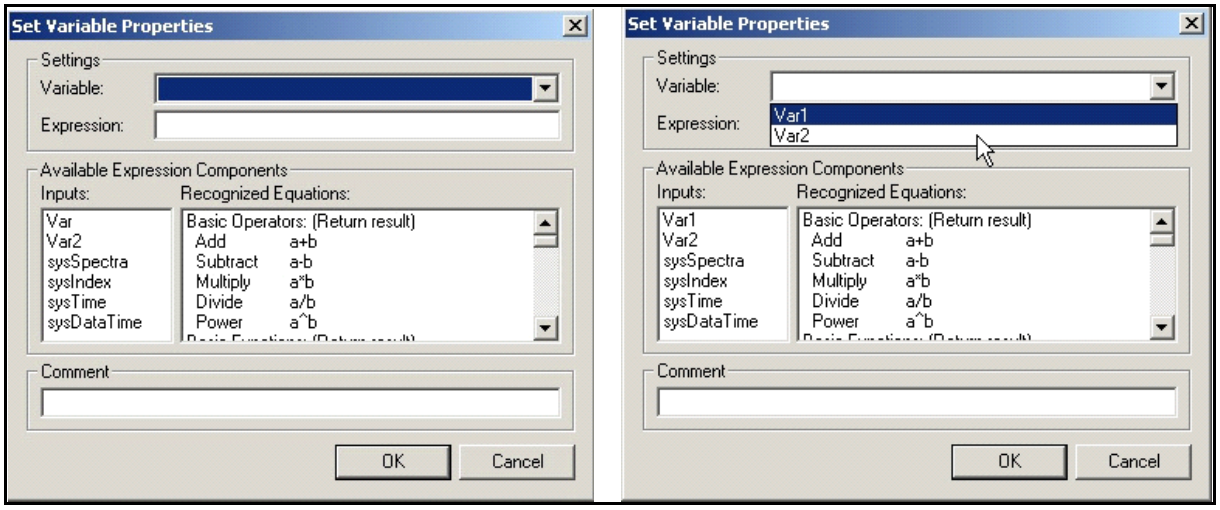


Figure 3-211. Select Variable from List

3. Enter the scalar value or equation expression that will be used to set the variable. The list of inputs on the left are all trend and region scalars that have been defined in the Configuration. The list of Recognized Equations on the right displays the equation functions that may be used to calculate the new value for the variable. These are the same equations detailed in Section 4.6 Equations.

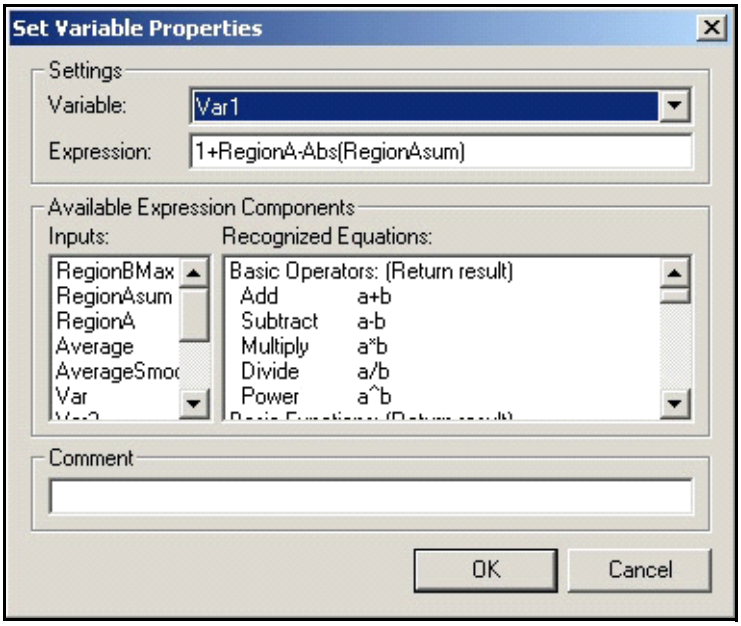


Figure 3-212. Enter Equation Expression for Variable

4. Select OK to return to the Sequence list.

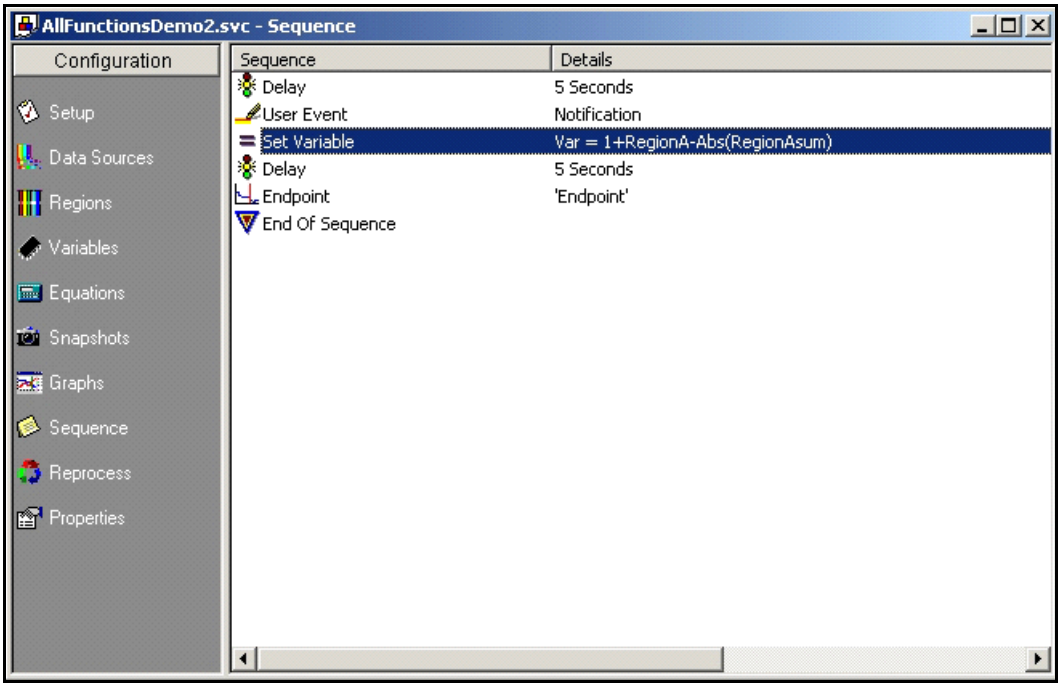


Figure 3-213. Variable Listed in Sequence

5. The Variable will be updated with the listed expression. This will happen when the Set Variable command is reached in the Sequence.

3.6.27 Endpoint

The Endpoint item in the sequence directs EyeD to issue a command to the Centura mainframe. The instant that Endpoint is reached in the Sequence list, a message that process endpoint has been found is sent from EyeD to URI and from URI to the Centura. The one option to set up in the Endpoint item is the selection of whether it is qualified for the event history or not.

3.6.28 Stop

The Stop item in the Sequence list is a method for halting the endpoint algorithm. Adding the Stop item will keep EyeD from running continually and filling the drive with data in instances when, for some reason, the mainframe fails to send a **Stop** command to EyeD. The Stop is useful when paired with an If logic statement to halt execution when the readings for a region indicates that the system is saturated.

3.6.29 Activation/Deactivation of Sequence Items

Each sequence item can be *Activated* (executed) or *Deactivated* (skipped) during configuration editing so that debugging or testing of a sequence would no longer require deleting an entry then re-adding it.

Activation/Deactivation is done by Right-clicking in the sequence window. See Figure 3-214.

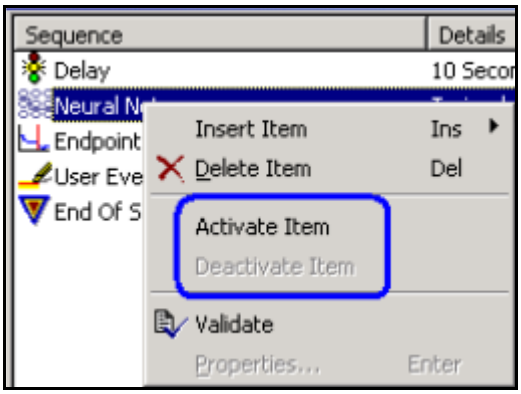


Figure 3-214. Activating/Deactivating Sequence Items

3.6.30 Comment Fields

Comment statements can be added to every sequence item to allow the user to comment on sequences. Double-click on the sequence item and enter the comment at the bottom of the dialog window that pops up. The comment added appears in the main sequence window.

3.7 Reprocess List

The Reprocess List function automatically tests several data files in a list against a configuration to see how each performs. Reprocess List is among the icons listed in the left of the Configuration window. This function uses the configuration selected as Current to operate on each file in the list. The function also can be accessed by the Reprocess button at the tool bar at the top of the screen. While reprocessing the data files, a notation is made in

the form of a check mark or an X at the left of the file name. This is to identify whether a detectable endpoint exists in the file when using the selected configuration.

The ability to test the success or failure of an endpoint algorithm is especially useful when fine-tuning a Neural Network or NeuralPCA algorithm to detect endpoint reliably on many files that represent the range of variation expected throughout a production run.

To access this feature, select Reprocess List from the column of Configuration icons. Right-click on the End of Files marker to access the drop-down menu. From that menu, select Insert Data File to insert a single data file or Insert Directory Data Files to insert all of the files listed in a directory.

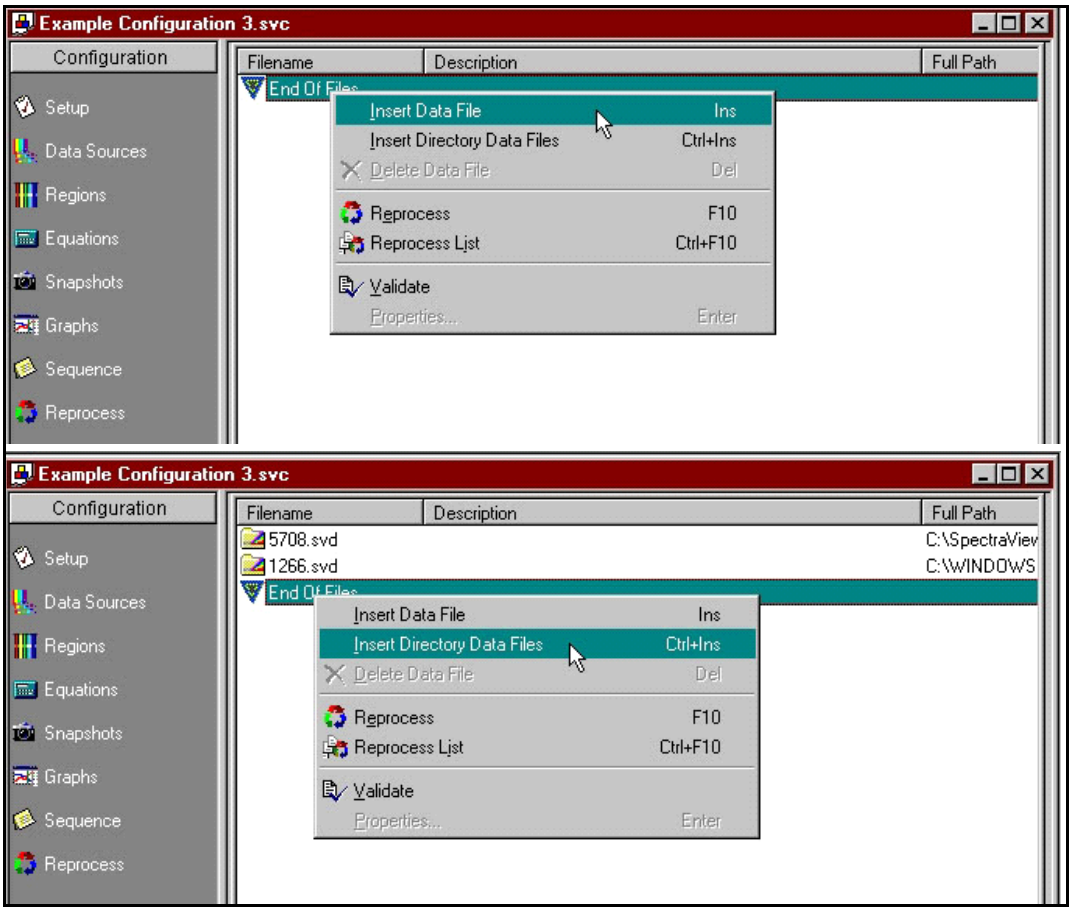


Figure 3-215. Insert Data File or Insert Directory

Browse for data files according to the selections made for data file storage. See Section 3.3.2, Directories.

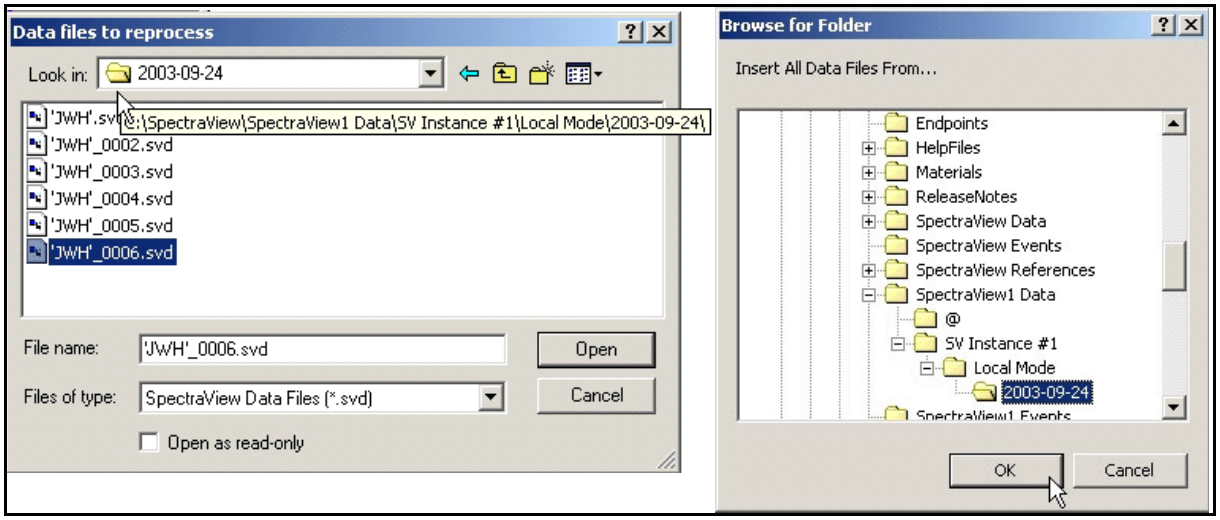


Figure 3-216. Browsing Files (left) or Directories (right)

Select **Open** or **OK** to add the highlighted file or directory of files to the reprocess list.

NOTE

Any data files intended for permanent storage should be moved out of the root data path (*C:\EyeD\Data* tree). Otherwise, the automatic delete utility could remove them to clear drive space.

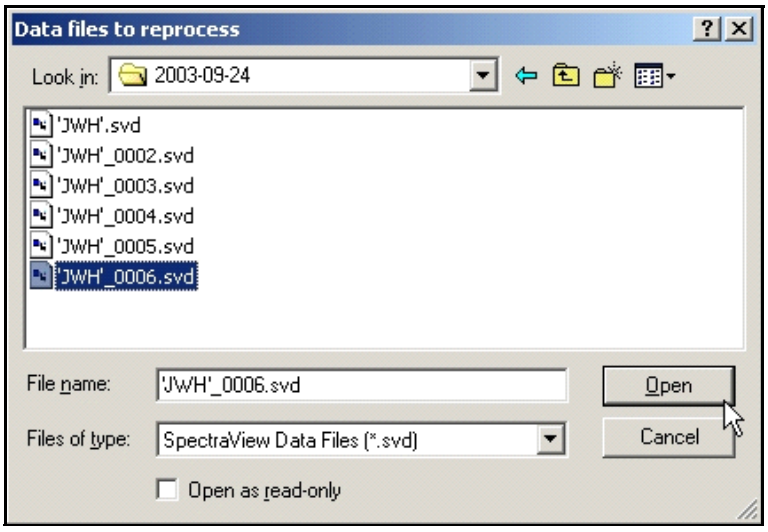


Figure 3-217. Listed Files for Reprocessing

There are a number of ways to activate the Reprocess List function. Right click in the reprocess window, select the Reprocess List icon  in the toolbar or select Reprocess List from the System menu, Figure 3-218.

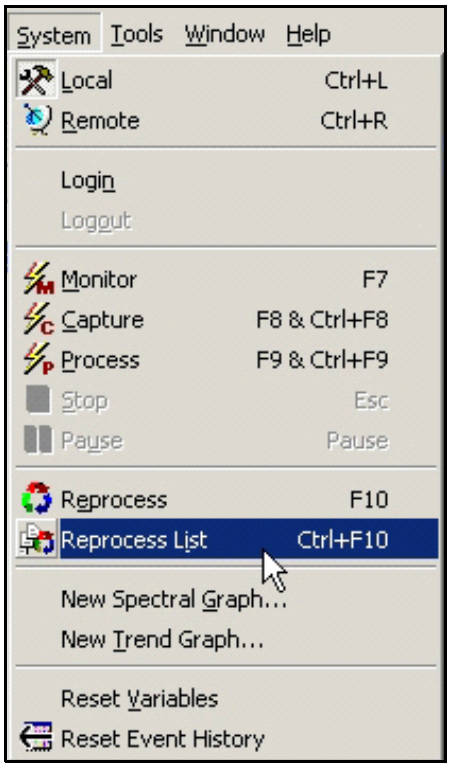


Figure 3-218. Select Reprocess List

All data files listed under the current configuration will be reprocessed, and information for each will be displayed in the activity log area in the bottom of the EyeD window.

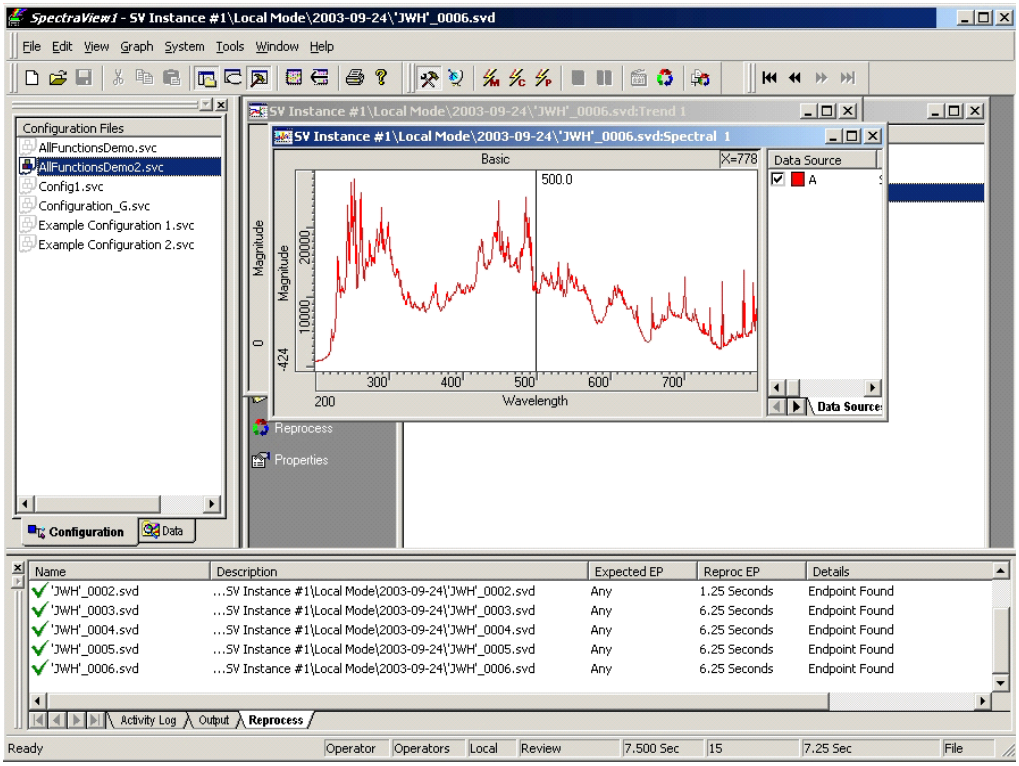


Figure 3-219. List reprocessed

If a pattern recognition algorithm is improperly trained, a given spectral pattern could be mistaken for endpoint. A selection in the file properties window can assist in identifying a case of a mistaken endpoint signature. Select any file listed in the Reprocess window to view and/or change its properties.

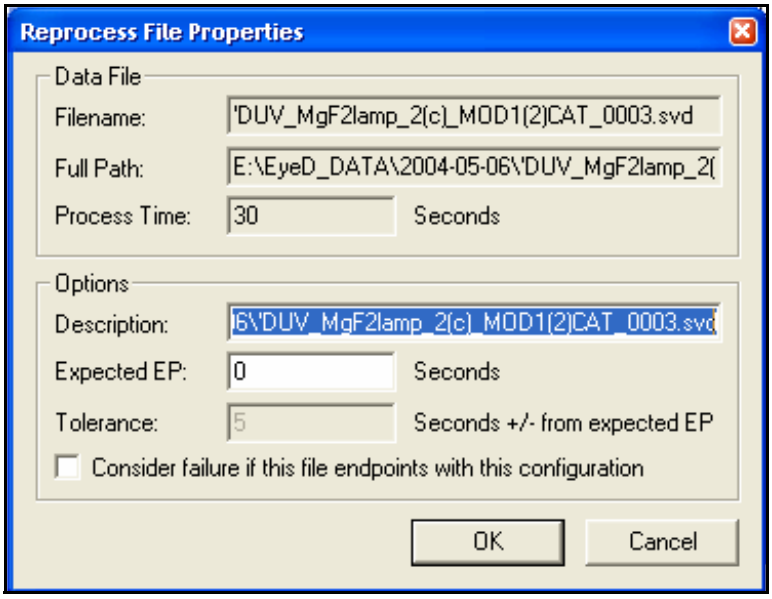


Figure 3-220. Reprocess File Properties Window

By default, endpoint is anticipated at some time during the run. In Figure 3-129, a file is marked for failure if the endpoint pattern is recognized during its reprocessing. Once the checkbox is selected, the Expected EP and Tolerance fields have no significance.

In the default state, the Description field displays the file path, but this is a user-defined area. Enter any information useful for identifying particulars of the file being reprocessed.

3.8 Configuration Properties Window

The Properties selection in the column along the left of the main configuration window brings up the Properties window. See Figure 3-221. The Properties window displays history information in three regions:

A. The Initially Created region includes the date and time the configuration file (.svc) was created. The login name of the user who created and saved the file also appears in this area.

B. The Last Modified region of the window includes the data and time of the last saved modification to the configuration, as well as the login name of the user making the change. The number of times a given .svc file has been modified is saved under the Revisions field.

C. The Notes field holds text entered by any user. Potentially useful history text could include the reason for modifications, extra system or process information, etc.

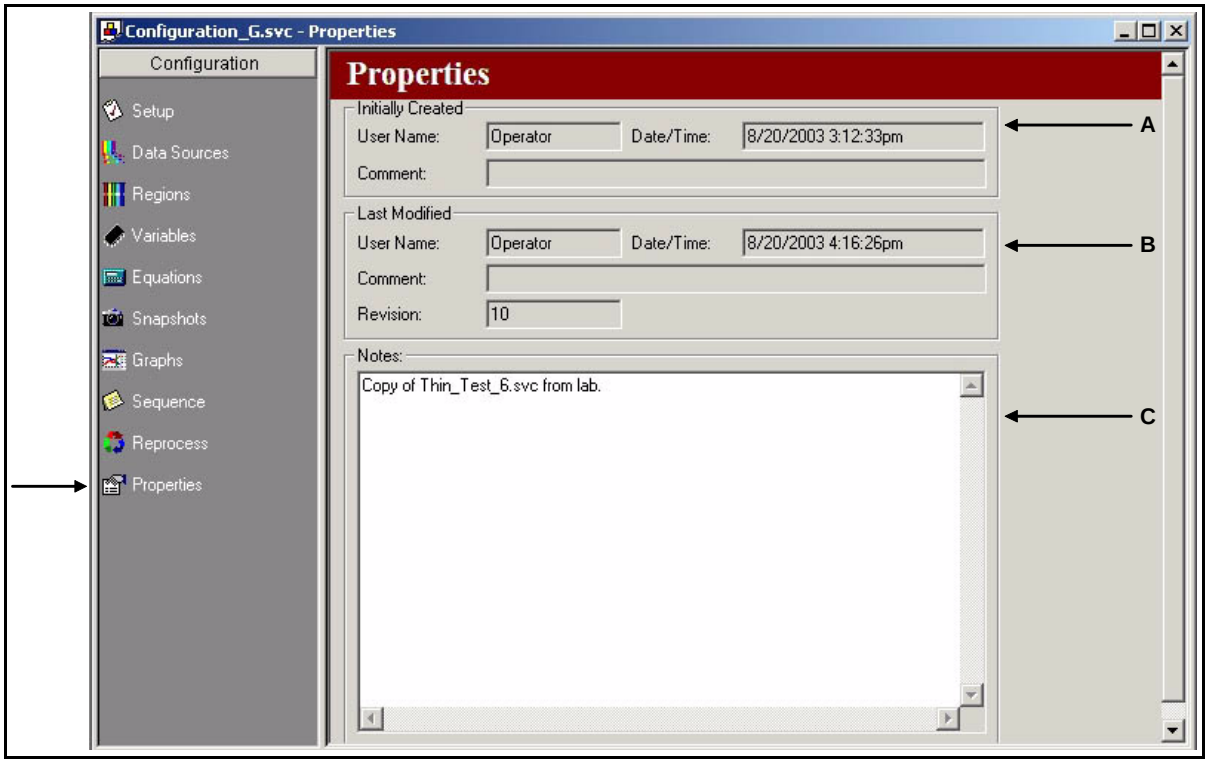


Figure 3-221. Configuration History Properties

3.9 Application Features

3.9.1 Back-to-Back Sequence Timing Response Time Adjustment (RTA)

There are multiple clocks tracking time in the endpoint system and they all differ. Communications, file access, CPU speed, processor administration, and software execution times all add to variation primarily during starting and stopping the system.

Significant time variation may occur when a mainframe controller does not account for the time needed to stop a previous step. This can be important since fundamental operation of the spectrograph requires that it first be stopped before changes can be made to data acquisition settings, which sometimes takes place prior to starting the next configuration. These back-to-back steps take longer to begin than the first step, since the system must be stopped before starting the next step. Advanced features such as Endpoint Statistics can also increase the amount of work the system must do when a step is stopped, further increasing response time for back-to-back steps. The RTA function overcomes timing issues inherent with using a single computer to process endpoint for multiple chambers.

The Universal Remote Interface (URI) tracks the time that EyeD and the spectrograph take to begin processing. This is done independent of protocol, or the manner in which the back-to-back steps are requested. The start/stop is accounted for and communicated to EyeD. Tracking and adjustment is performed as follows:

Start / Stop Delta > 1sec — Start is received more than 1 second since a stop was completed, RTA = Time between URI receiving the start and EyeD responding to URI that the system has started.

Start / Stop Delta <= 1sec — If a start is requested within one second of the system stopping, RTA = The time from initiation of stop (by URI) until start completion (EyeD responding to URI that the system has started).

These two ways of tracking time allow for accurate tracking of the response time for both the first step and back-to-back steps.

The following diagram, Figure 3-222, illustrates graphically the conditions specified above

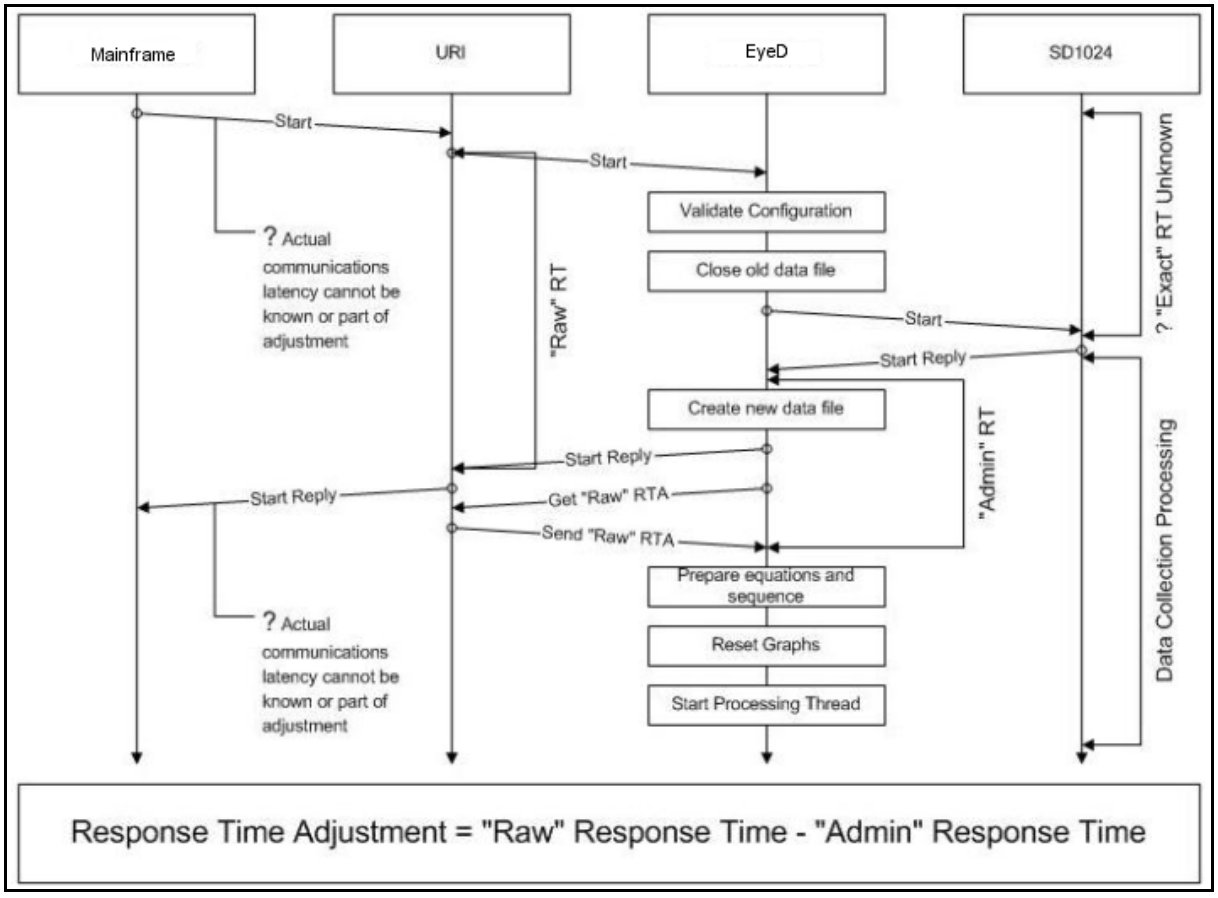


Figure 3-222. Response Time Adjustment Definition Chart

Using timing as the determination of back-to-back steps allows the system to accommodate the Response Time Adjustment for all protocols supported by URI.

RTA is an attempt to achieve a real-time, systematic approximation of the exact response time. This approximation is then used to compensate or adjust the spectra time-base, as received during *Data Collection Processing*.

Both *Raw RT* and *Admin RT* are determined by taking the difference between the EyeD computer system clock time (with millisecond resolution) from the reception interval, and sending of the messages indicated above. However, tolerance must be allowed for the actual communication latency, which could range from 20ms to 120ms depending on communication messaging.

NOTE

The *Close old datafile* message occurs due to the prior STOP resulting in a Data Review of the last step. The last data file has been completely written already, but is now just open.

The RTA is saved in the data files so that when the file is reprocessed, the response time from the original data capture is seen. This reproduces a more real-world response and recreates the same situation during reprocessing that was encountered during processing.

3.9.2 Data Analysis List

This feature allows large numbers of files to be analyzed simultaneously. By contrasting spectral data files against one another, a variety of equations and parameters can be measured over time. By adjusting the imaging or the data input, a substantial history of effects can be illustrated in a single image.

To access this feature, select **File'New** from the main toolbar. Select **Data Analysis** to begin building a file list for multiple processing.

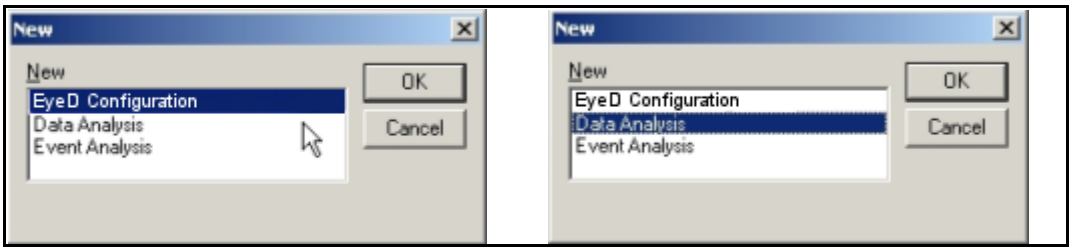


Figure 3-223. Select Data Analysis

This brings up the Data Analysis window. Files can be selected singly, by right clicking on the End of Files icon and selecting Insert Data File, or, the contents of an entire directory of data files can be added.

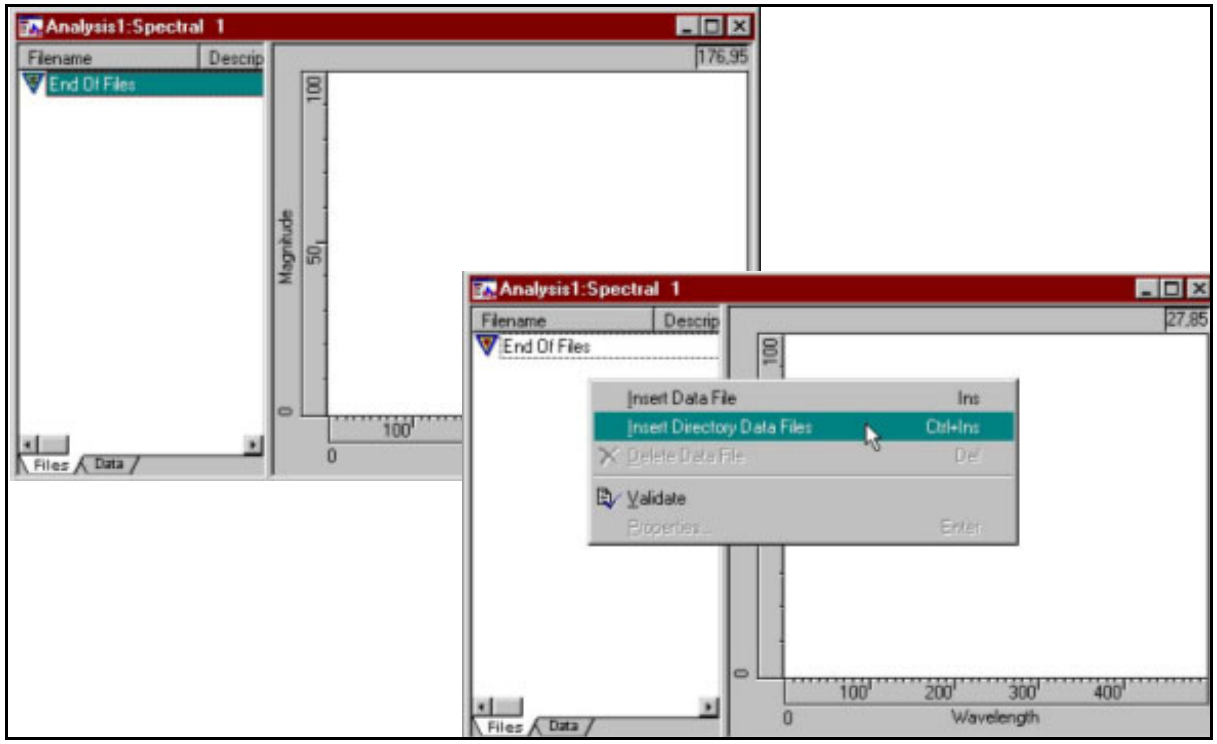


Figure 3-224. Selecting File Browser

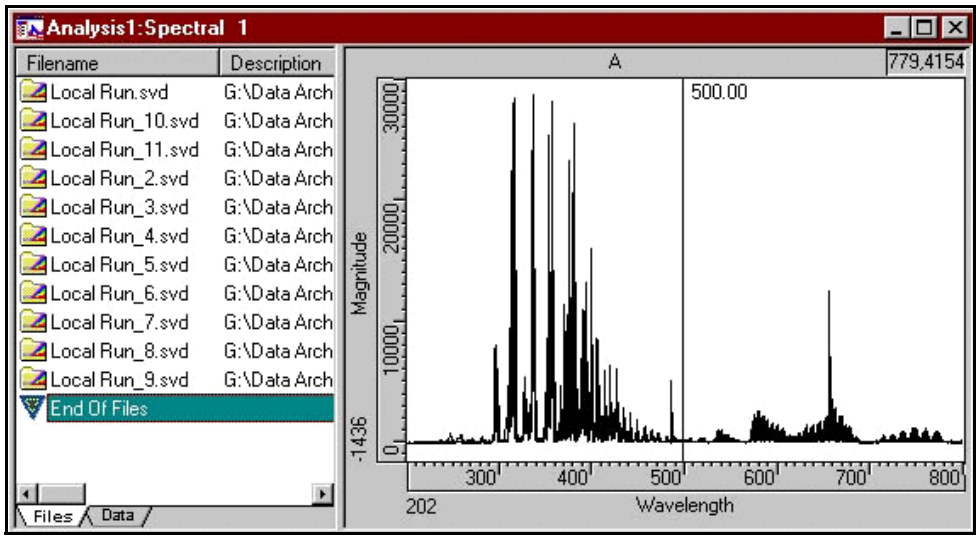


Figure 3-225. Files Selected

As an example, Figure 3-225 contains 11 files with all fiber-input A sources being viewed simultaneously in the graph window. This number of files could much greater if necessary.

When the Data tab is selected, it shows the data source of the files being viewed. Any equation used when collecting the data can be viewed as a separate data source. This is true for all listed files that utilized that equation during the data capture process.

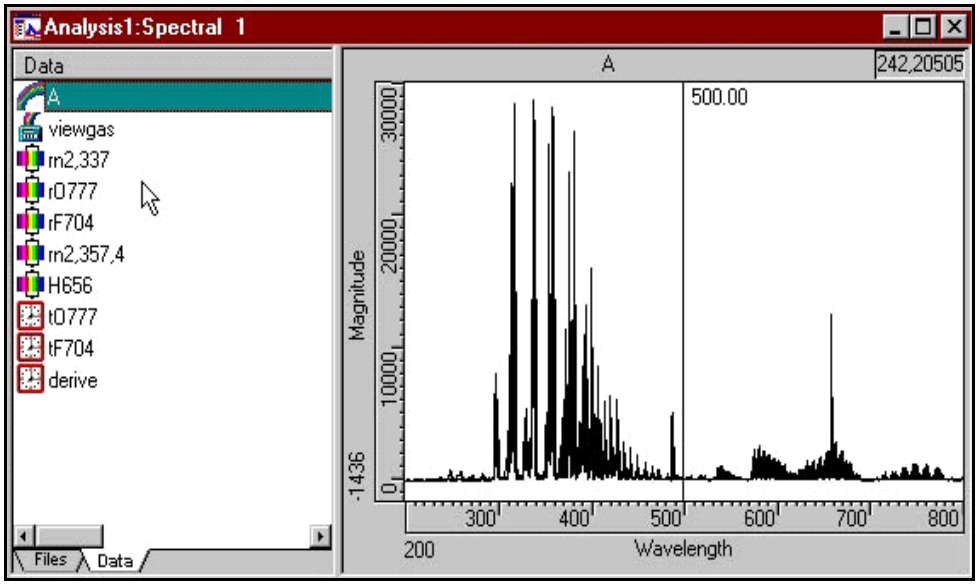


Figure 3-226. Fiber Input A Viewed for All Files

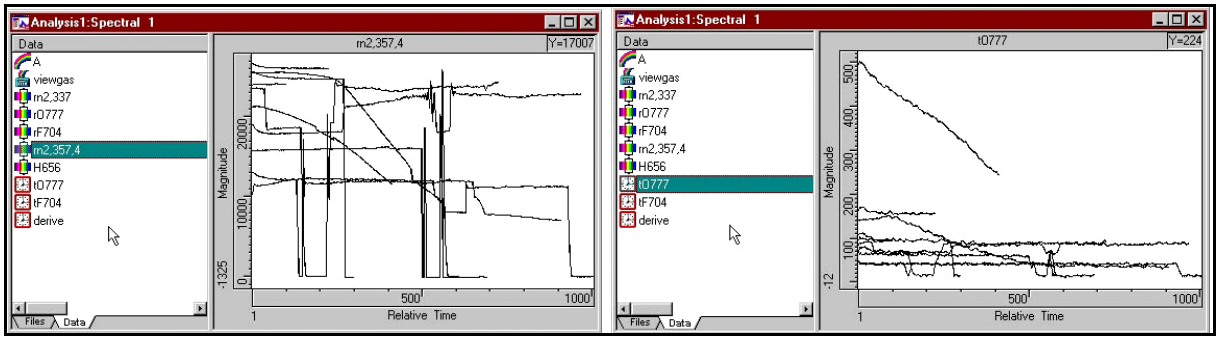


Figure 3-227. Data Source Equation Options

With a full-spectrum view, all spectral lines can appear to be one. The graph lines can, of course, appear markedly different when the equation is changed. With fiber input A selected, enlarging a desired section of the spectra will reveal multiple file sources being imaged.

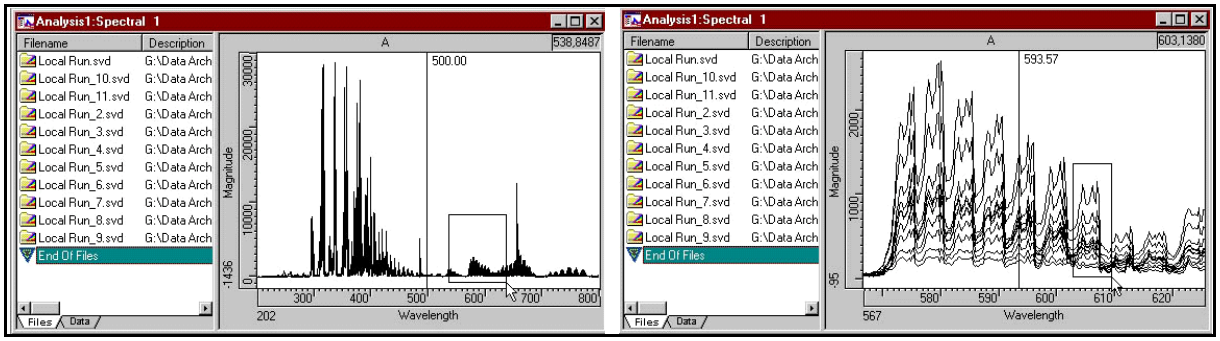


Figure 3-228. Use Zoom feature to enlarge spectral region

When enlarged to a point where only a few nanometers are visible in the graph window, separate lines corresponding to each file can be clearly seen.

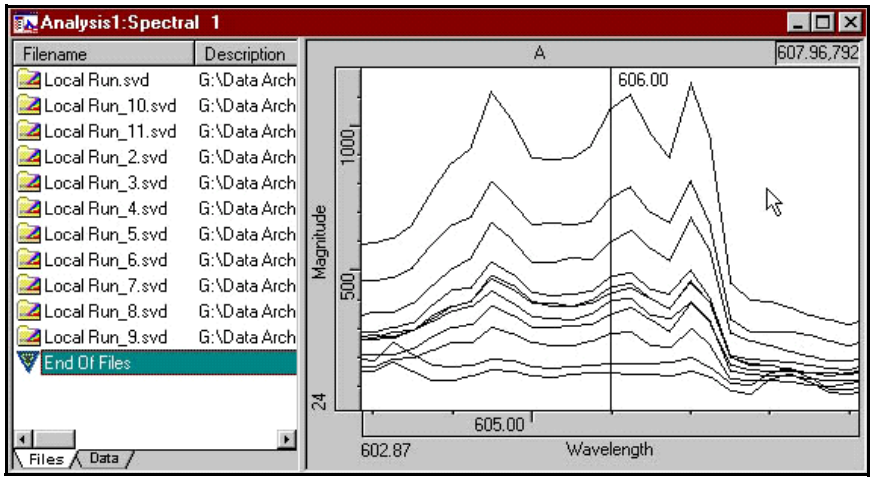


Figure 3-229. Six Nanometers of Spectra Showing 11 Files

By selecting individual files (at left), the corresponding spectral line will become highlighted in red (at right).

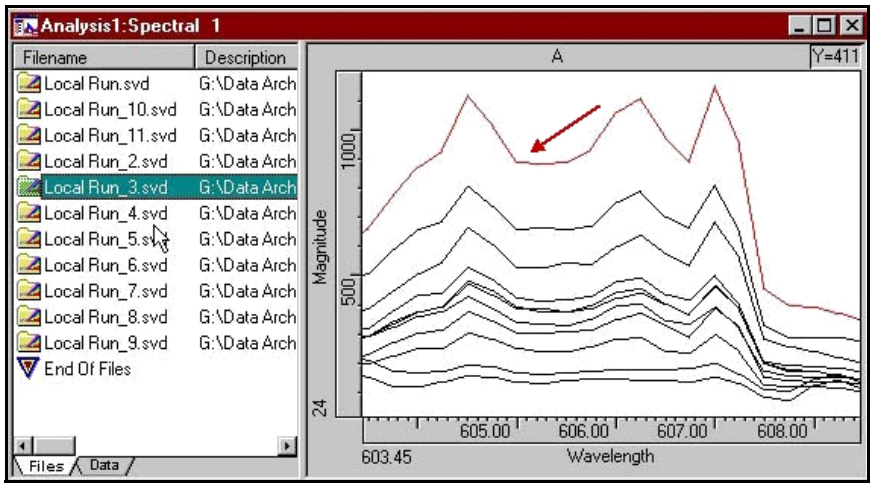


Figure 3-230. Local Run_3 Highlighted

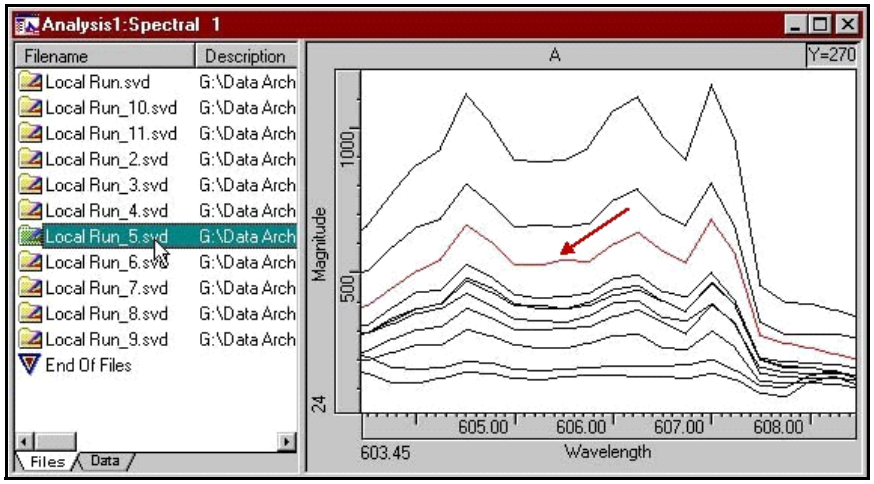


Figure 3-231. Local Run_5 Highlighted

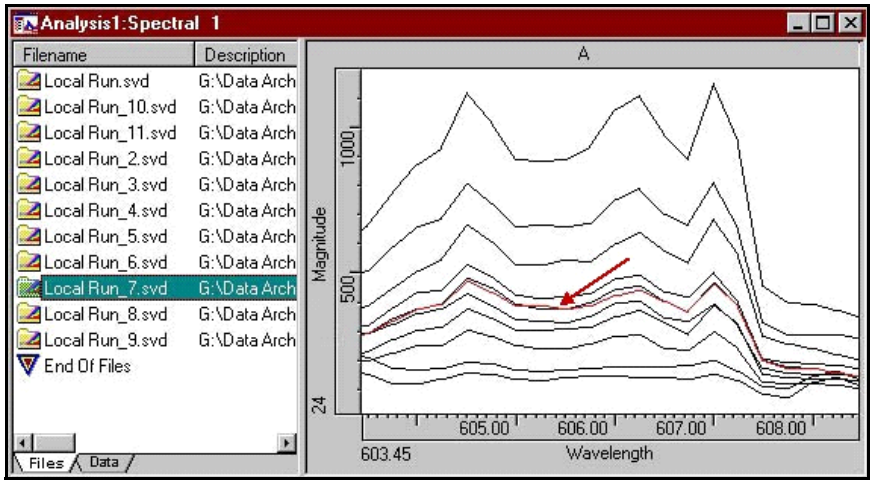


Figure 3-232. Local Run_7 Highlighted

The above illustrations are an example of one way in which this data analysis feature can be applied.

3.9.3 Creating an Endpoint Report

Right clicking in the Left Pane of the Data Analysis window displays analysis options including Reports. Clicking on Reports will then show Endpoint Report. Click on this option and a dialog similar to the following figure (Figure 3-233) should be displayed:

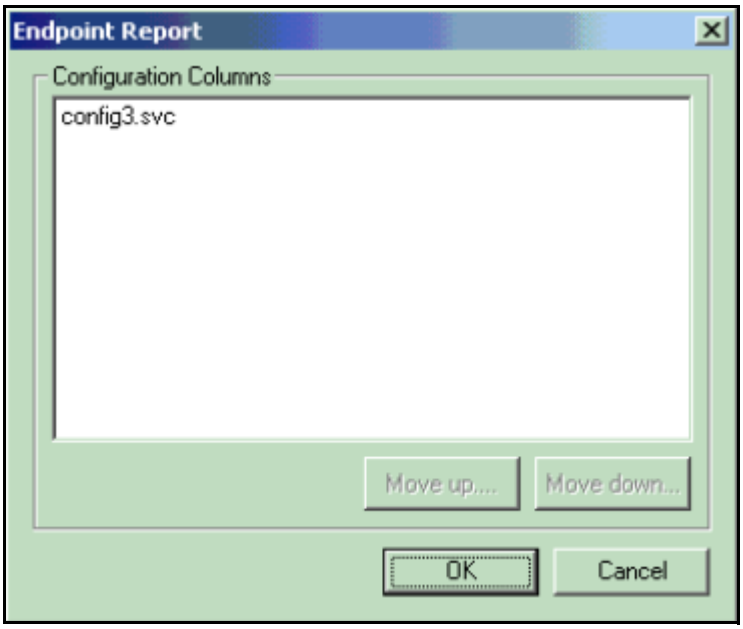


Figure 3-233. Endpoint Report Dialog

The Configuration Columns List will show all configurations used to create the inserted data files. If there is more than one available the Move up and Move Down buttons will allow you to re-order the list by moving the highlighted entry up or down.

NOTE

The order of the configuration file list defines the order of the columns in the endpoint report (comma delimited text file) from left to right.

Click **OK** and the following dialog (Figure 3-234) request appears, requesting specification of the location to store the report (text file extraction):

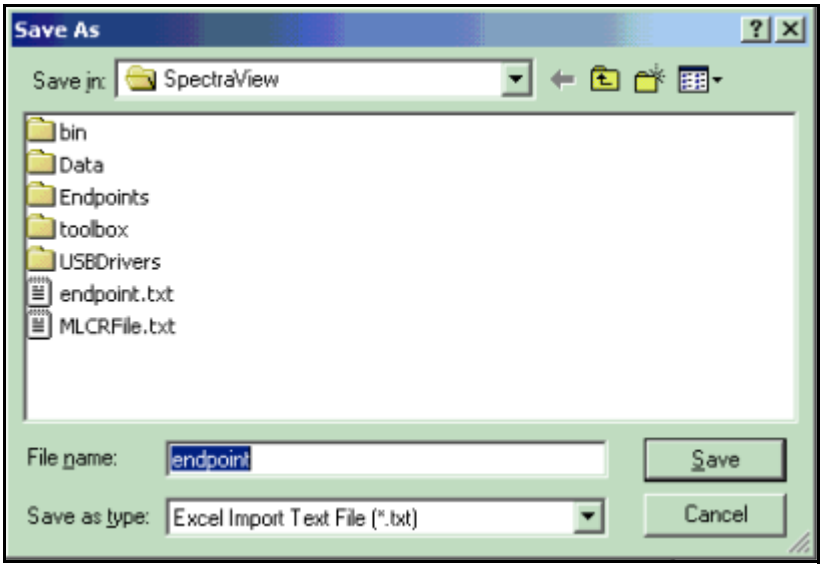


Figure 3-234. Specify Location to Save Endpoint Report

When ready click **Save** and the report will be generated

The data just saved to the specified file and location may now be analyzed with Excel or another data analysis package capable of comma delimited importing of data. If using Excel, the default delimiter is a TAB character. Before completing the import, this delimiter must be changed. In addition, the dat/time column should be formatted.

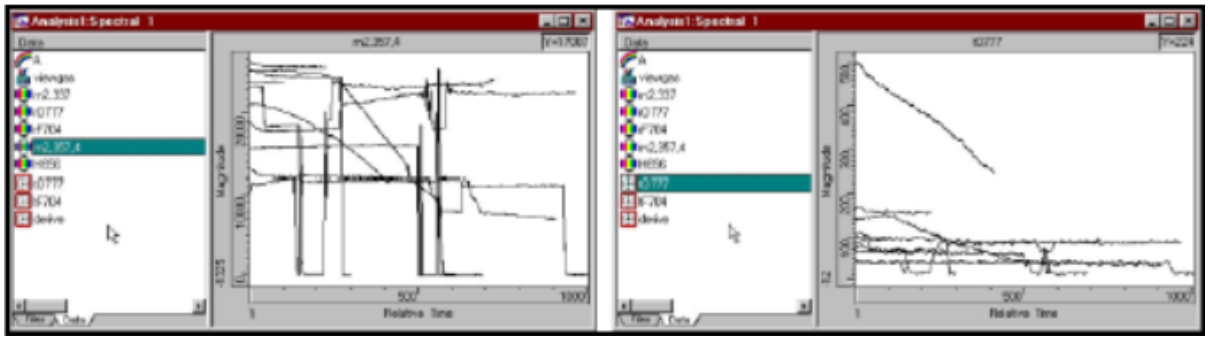


Figure 3-235. Data Source Equation Options

3.9.4 Transpose Data Matrices

EyeD data files (*. svd) can be exported as ASCII text for use in other applications. EyeD data files, however, export columns of spectra numbering as many as 1,201. Some software applications, such as Microsoft Excel®, cannot support this many columns. By selecting to export the text transposed, the data is shifted to read number of samples as columns and wavelengths as rows. To access this feature, open the data file to be exported transposed. Be sure to select only the necessary data source checkboxes on the right. When multiple spectra are selected here, each is represented in alternating rows of data and can lead to large and unwieldy ASCII files.

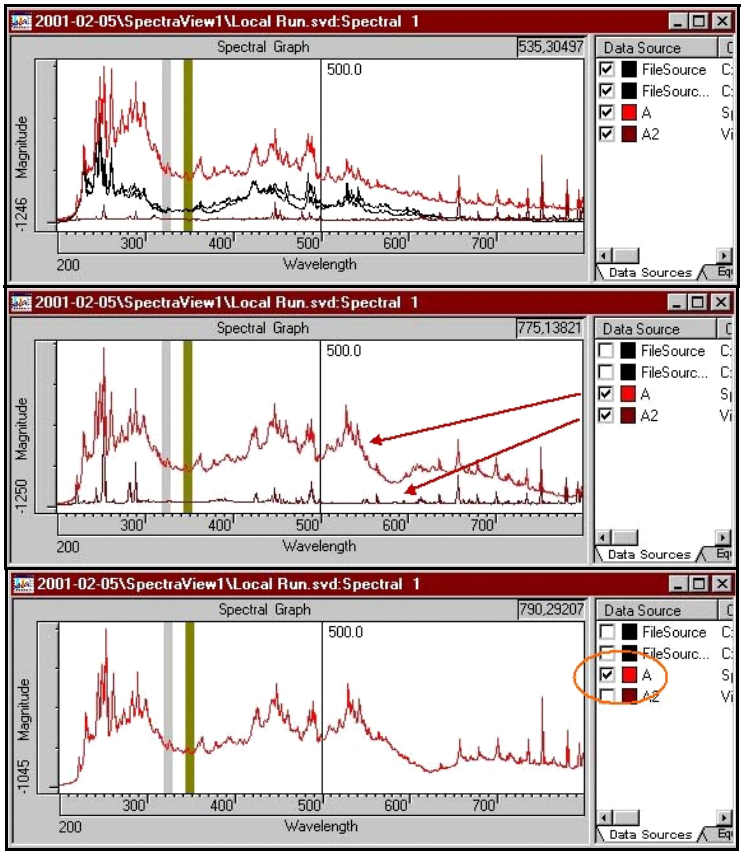


Figure 3-236. Select only desired spectra

Right click in the window to bring up the export selection.

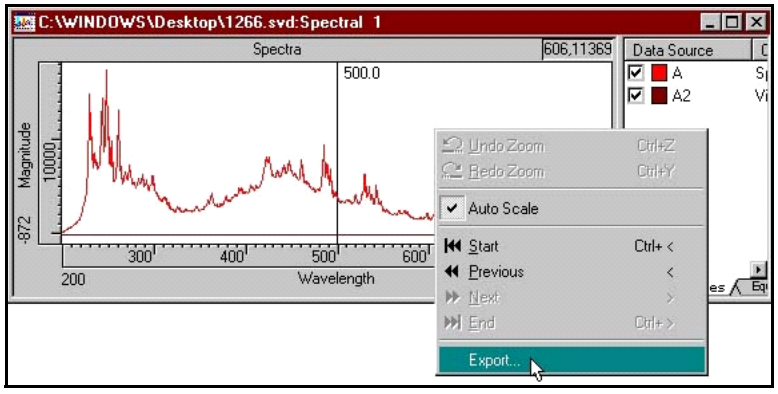


Figure 3-237. Select Export

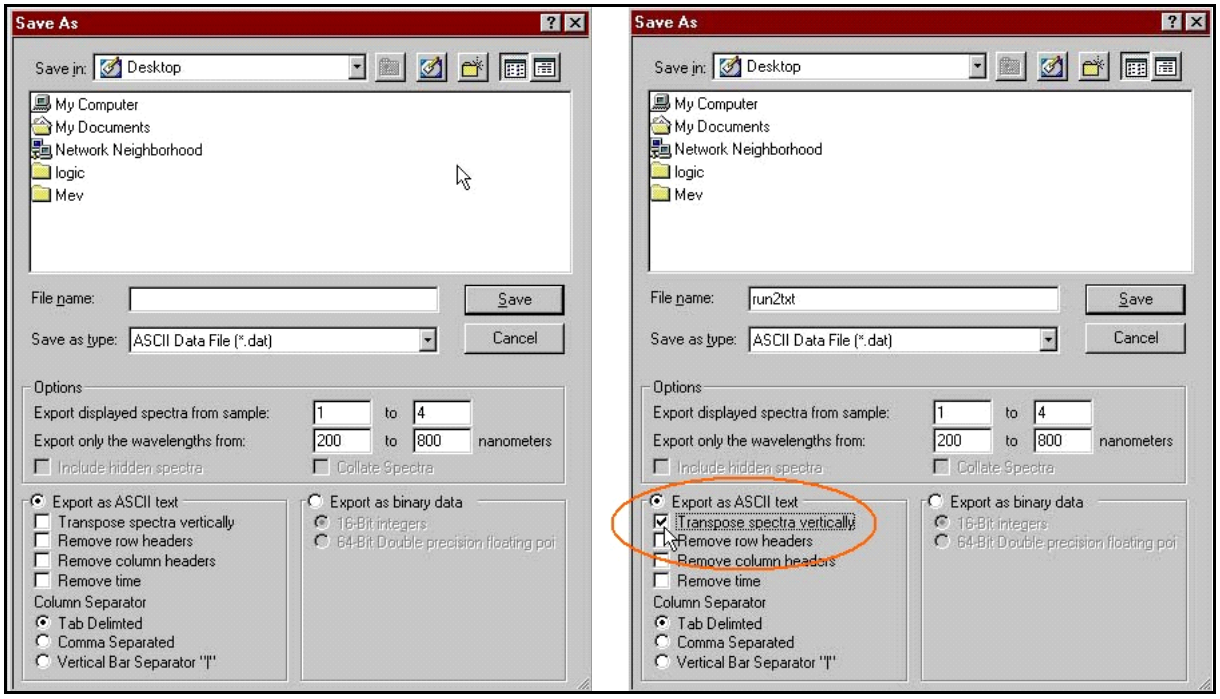


Figure 3-238. Name File and Select Transpose Spectra Vertically

The Export window defaults to Export as ASCII text, but the Transpose Spectra Vertically button can be checked to make exported data more readily accessible by other software.

3.10 Using Event Statistics to Review Production:

The database can be opened and analyzed with Microsoft Access. Details on the use of MS Access are beyond the scope of this manual. Within EyeD however, there is a straightforward utility called an *Event Analysis*, which is accessed under *FILE ==> NEW…* which opens this window.

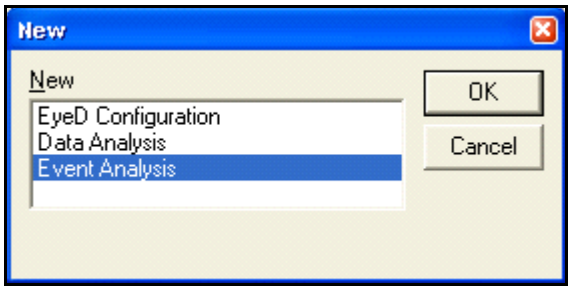


Figure 3-239. Opening Event Analysis

Browse to the DB that is to be interrogated, then click **Execute…**.

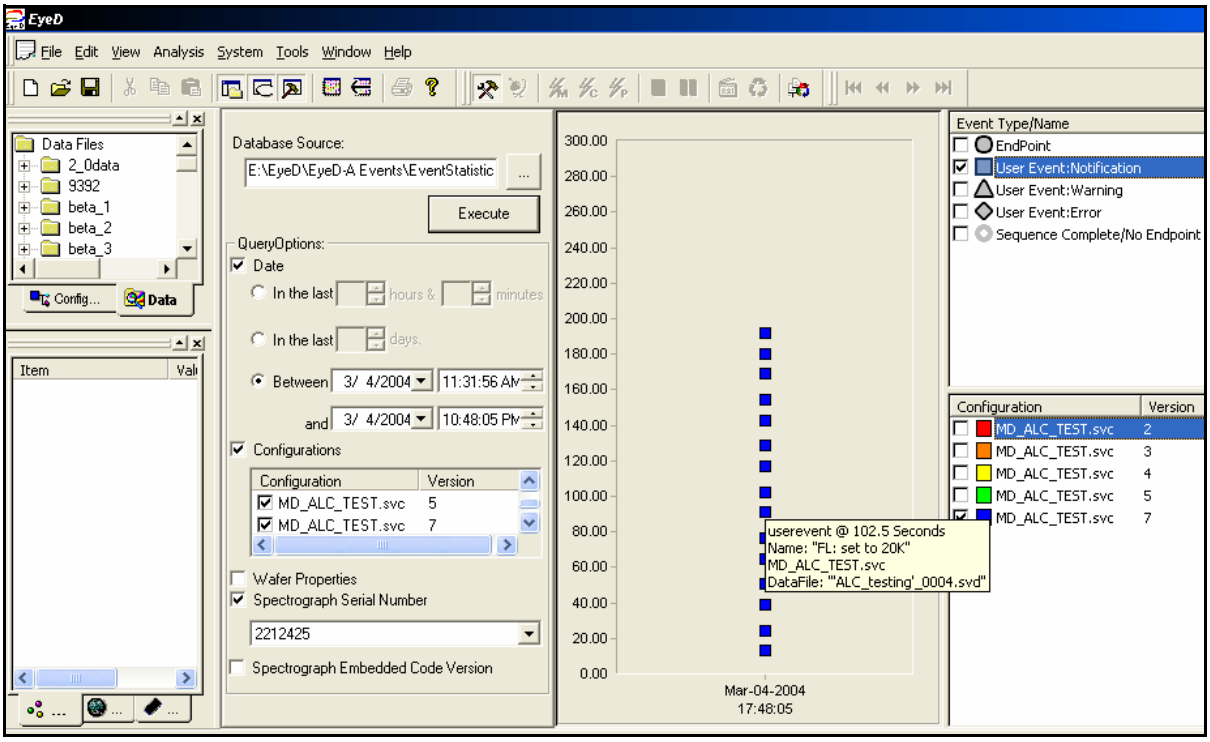


Figure 3-240. Select Database to Test

The event type and the configuration in use (i.e, process step) may be selected with the checkboxes in the right panes. The time the event occurred is on the vertical axis. Individual event markers may be pointed to, and specifics on the event appear in a pop up window, including the data file name.

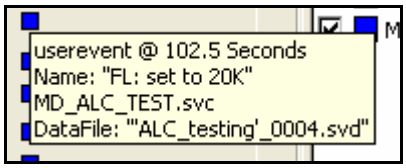


Figure 3-241.

For this search method to provide rapid identification of the wafer/lot information for a particular event, users should configure data file naming so as to include lot name and other wafer information.

4 200mm Hardware Installation

4.1 Introduction

The EyeD advanced feature endpoint system comes in two overall configurations:

1. EyeD-OES. This configuration is intended for use in optical emission spectroscopic (OES) applications only. It can be used in virtually any chamber (silicon etch DPS, MxP, dielectric eMax, etc.) that has an endpoint window, but is most commonly used with the eMax chamber. The detector used in this configuration has a single input channel. It is located remotely from 200mm process chambers in a rack with optical coupling through a long fiber optic cable. The detector is referred to as a Single Channel Spectrometer (SCS), and has a reference model number SD1024DLC.

2. EyeD-IEP. This configuration allows the user to operate in either the interferometer endpoint (IEP) mode or the OES mode as required in a particular (silicon DPS, initially) etch chamber. The detector has two input channels, one for OES (chamber side view) and one for IEP (chamber top view). The detector is called the Dual Channel Spectrometer (DCS), which is also referenced by SD1024D-2-S. This configuration employs an integrated Modulated High Intensity Full spectrum (MHIF) light source, which is also referenced by FL2002 Flashlamp. Both the detector and the light source are attached to the chamber using a quick release bracket, and are optically coupled to the chamber with a short, bifurcated fiber optic cable (see Figure 4-1).

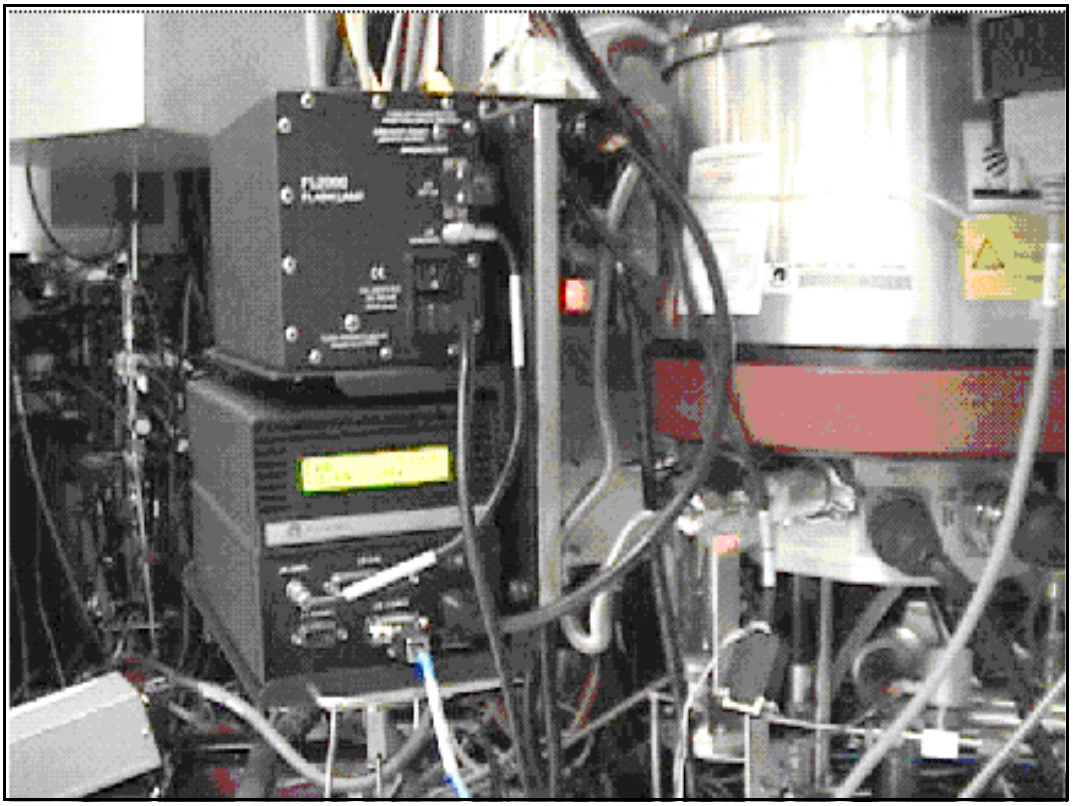


Figure 4-1. EyeD-IEP 200mm DPS Chamber Assembly with DCS and Flashlamp

4.2 EyeD-OES Hardware Overview

The EyeD-OES endpoint system consists of a computer assembly (computer, hub), an SCS for each chamber, and optical fiber cables. On the 200mm Centura, the computer assembly mounts to the mainframe rails above the chamber E location, Figure 4-3. The SCS detector (SD1024DLC) is located remotely from 200mm process chambers in a rack with optical coupling through a long fiber optic cable. Ethernet cables run from the detectors to the computer. A second Ethernet port in the computer allows the computer to be connected to the fab LAN. The computer digital cables run to each chamber and there is only one serial cable (SECS) for the tool, which runs to the system controller. The basic system elements are shown in Figure 4-2.

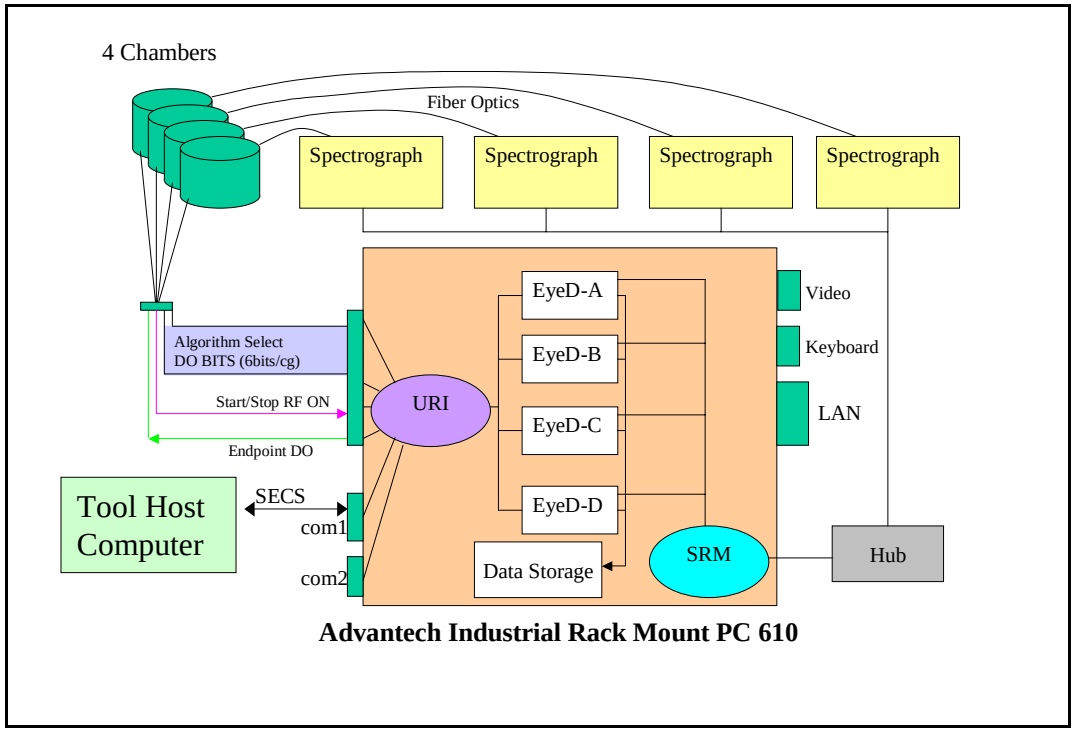


Figure 4-2. 200mm EyeD-OES Software/Hardware Communication Overview



Figure 4-3. Computer and Ethernet Hub Attached to Mainframe - New Systems Use Ethernet Switch Instead of Hub (See Figure 4-19)

The EyeD software descriptions that follow in later chapters of this manual may not distinguish between the specific hardware sets described above, as the software has been coded to be universal to any configurable detector. When a DCS EyeD-IEP detector is configured using the Spectra Resource Manager (SRM), there will be two available data sources for building algorithm configurations: data source A (top view IEP data) and data source B (side view OES data). When an SCS is configured using the SRM, then there will only be a single available data source: data source A (side view OES).

4.3 200mm EyeD-IEP Hardware Overview

The EyeD-IEP endpoint system consists of a computer assembly (computer, hub), a chamber assembly (FL2002 Flashlamp, DCS) for each chamber, and optical fiber cables. On the 200mm Centura, the computer assembly mounts to the mainframe rails above the chamber E location (Figure 4-3). The DCS detector (SD1024D-2-S) is quick mounted to the chamber to keep the optical fiber length as short as possible (Figure 4-2 and Figure 4-3). Ethernet cables run from the detectors to the computer. A second Ethernet port in the computer allows the computer to be connected to the fab LAN. The computer digital cables run to each chamber and there is only one serial cable (SECS) for the tool, which runs to the system controller. The basic system elements are shown in Figure 4-4.

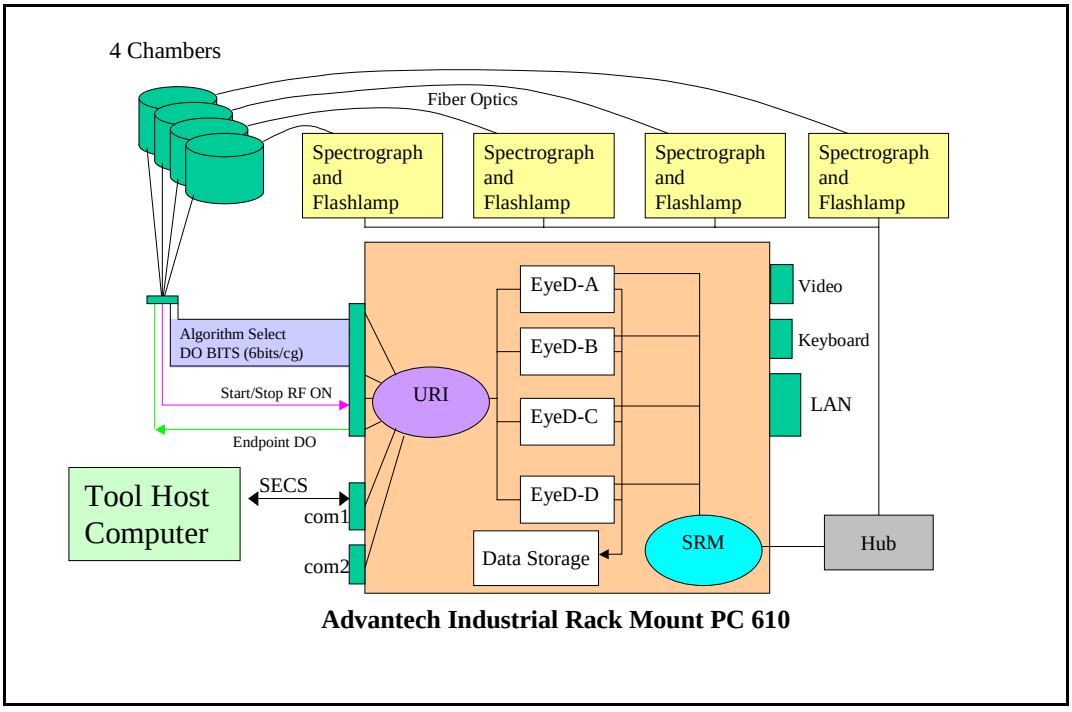


Figure 4-4. 200mm EyeD-IEP Software/Hardware Communication Overview

4.4 Power

For 200mm applications, the computer assembly requires 120VAC at 5A, 280W is required for the computer, and 100W is required for the monitor. Power is provided at the AC box. On Centura II, there are dedicated endpoint 120VAC outlets, but on Centura I/Phase 2, the AC box must be upgraded with a new circuit breaker kit (0240-12714) to provide the necessary power. Each detector and lamp assembly is powered from 208VAC.

4.5 Safety

Labeling must be added to some of the DPS chamber and EyeD IEP components during retrofit installation in order to comply with safety requirements.

These include:

- **Hazardous Voltage**: P/N 0060-76128 rev B: exterior of each DCS, SCS and FL2002 lamp housing.
- **Hot Surface Inside**: P/N 0060-21446 rev A: exterior of each FL2002 lamp housing.
- **Ultraviolet Radiation**: P/N 0060-18004 rev A: exterior of each FL2002 lamp housing and on side of DTCU.
- **Heavy Object**: P/N 0060-76188 rev B: exterior of control computer.

Whenever any procedures are performed on the DPS chamber that require removal of the IEP probe from the DTCU, the following procedures MUST be observed to prevent inadvertent exposure to levels of ultraviolet (UV) radiation in excess of established limits within SEMI S2-93.

To eliminate the possibility of UV exposure, BOTH of the following steps are necessary:

1. Software: Close the instance of EyeD on the control computer for the chamber that is to be serviced. The lamp cannot produce UV radiation unless commanded by the control computer to do so. By exiting the chamber instance, software commands to the lamp cannot be issued.
2. Hardware: Power down the DCS and lamp. Remove AC power plugs from the chamber AC panel and secure them with appropriate Lock Out Tag Out (LOTO) devices as necessary to eliminate the possibility of another worker re-energizing the lamp.

4.6 EyeD Computer and Monitor Installation for 200mm DPS and eMAX

Validate that AC box is upgraded to sufficient capacity. For Centura 1/Phase 2 mainframes, it will be necessary to install upgrade kit P/N 0240-12714 to increase the current capacity of the outlets from 2A to 5A.

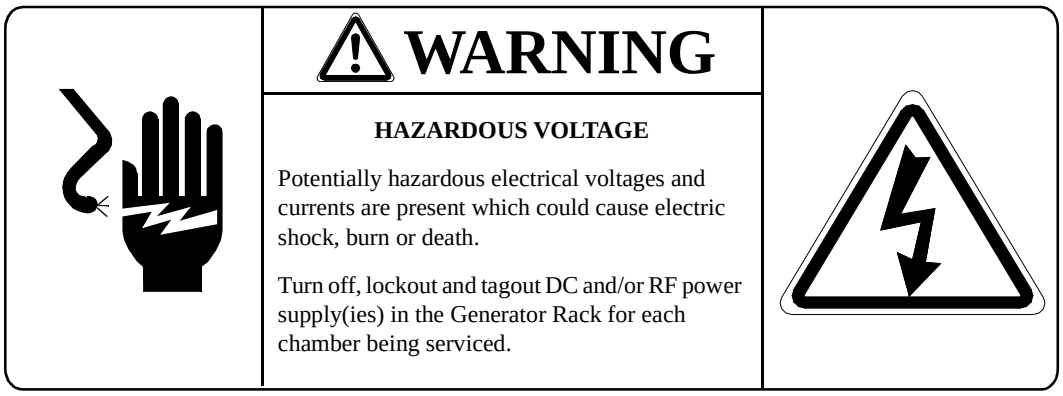
NOTE

There is not enough power capacity in the standard Centura 1 AC box to support the new endpoint computer. Use of old outlets will result in unreliable operations. Upgrade the Centura AC box to accommodate the increased power usage.

For Centura 1/Phase 1 mainframes without an AC box, install kit P/N 0240-12715, this is the standard Centura 1/Phase 2 AC box with the power upgrade already installed.

4.6.1 Upgrading the Centura 1 AC Box

Use the following procedure to upgrade to the Centura I AC box if it is required:



WARNING

HAZARDOUS VOLTAGE

Potentially hazardous electrical voltages and currents are present which could cause electric shock, burn or death.

Turn off, lockout and tagout DC and/or RF power supply(ies) in the Generator Rack for each chamber being serviced.

1. Power off the breaker that supplies the AC box. IMPORTANT: observe Lock Out Tag Out procedures, as hazardous voltage levels exist within this enclosure.



Figure 4-5. AC Box Showing Location F3

2. Open top cover of AC box and pull spade lugs to F3 (F3-1, F3-2; bottom row center).

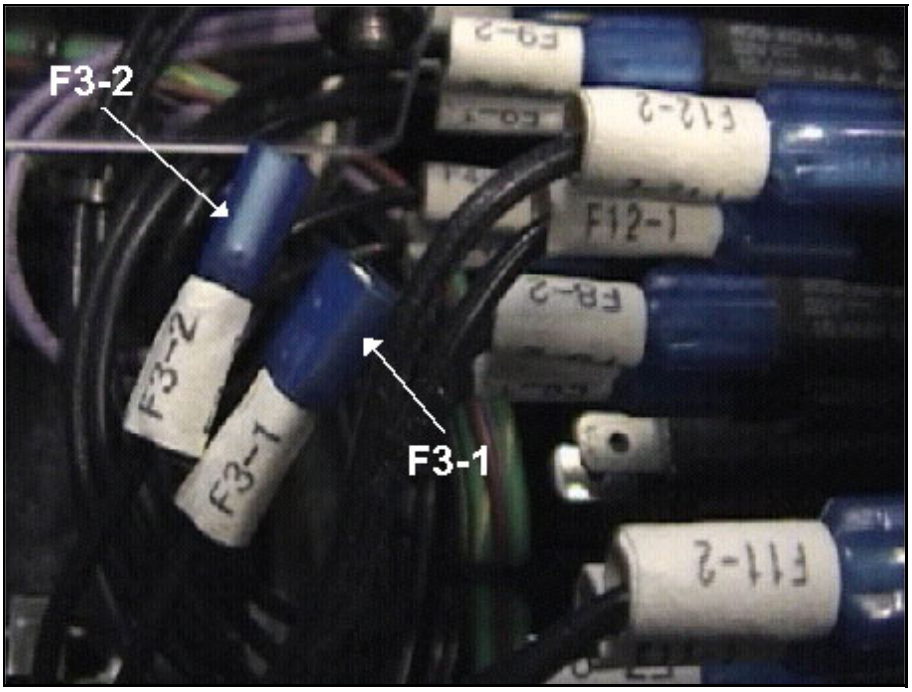


Figure 4-6. Spade Lugs F3-1 and F3-2

3. Use two small screwdrivers to compress the spring clips that hold in the existing 2-Amp rated F3 and remove by pulling out the front of the fuse panel.

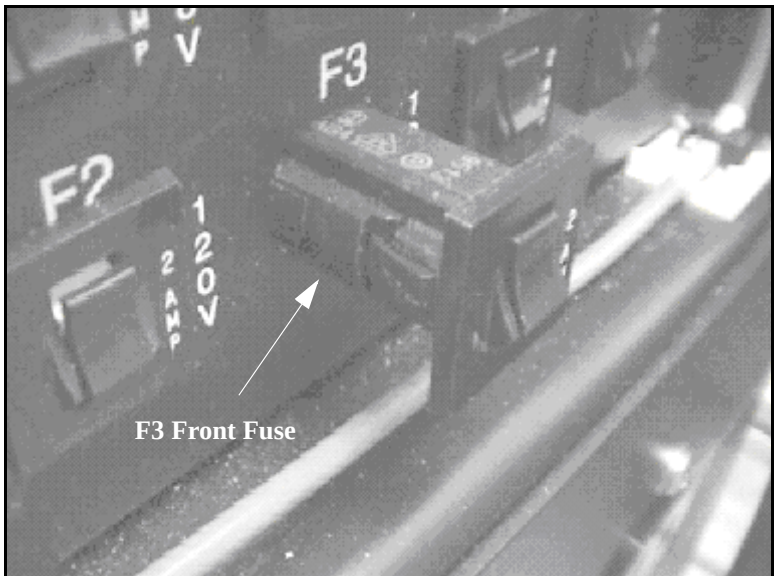


Figure 4-7. F3 Front Fuse Panel

4. Insert a 5A fuse.
5. Reconnect the spade lugs.
6. Reverse the steps 3 to 1 to finish the AC box upgrade.

7. The duplex power connector is located on the panel opposite the fuses, directly under LLA, and is hidden. Plug the computer power strip and the VGA monitor into this hidden outlet.

4.6.2 EyeD-IEP 200mm Computer Installation

1. Loosen the three "L" clamps on the top mount shelf (p/n 3480-00129), then lift the shelf onto the top of the mainframe rails from the inside of the frame. Place it on top of the front and side rails. See Figure 4-8 and Figure 4-9. The computer will face the right side of the mainframe when viewed from the back situated over the Chamber E facet.



Figure 4-8. L-Clamp on Support Shelf

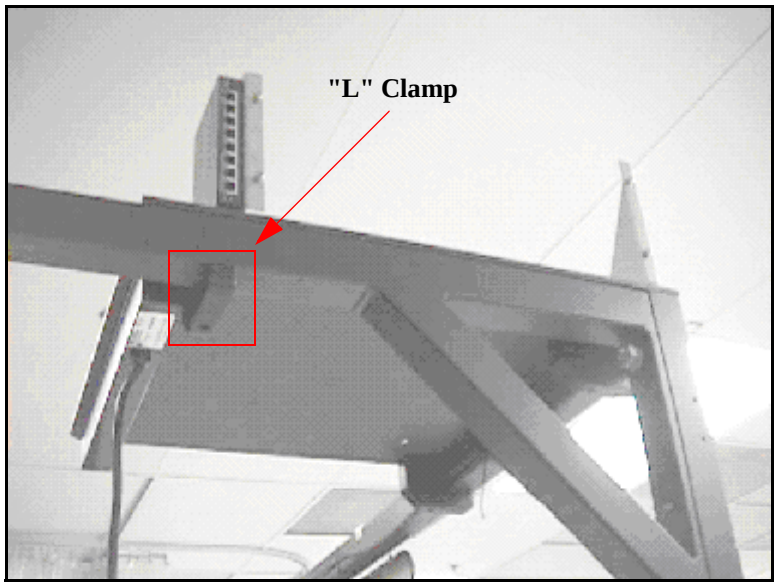


Figure 4-9. 200mm Mainframe Side View Showing Computer Shelf

2. Tighten the three "L" clamps firmly to the mainframe rails to secure the shelf.
3. Route the AC power cord which comes off the bottom of the shelf power strip to AC box along brace and upright, and secure it with cable ties.
4. Connect the power to the duplex connector on the back of the MF AC box (Centura 1) or on the front of the AC box (Centura 2).

NOTE

If the computer is supplied attached to the shelf, dismount it prior to lifting the shelf to the side rails. Do this by removing the four rack-mount screws holding the computer to the shelf.

5. Lift the computer and Ethernet Switch onto the shelf and secure with the four rack-mount screws. See Figure 4-10.



Figure 4-10. Computer and Ethernet Hub - New Systems Include Ethernet Switch as Shown in Figure 4-19

4.6.3 200mm Ergotron Cart Installation

6. Install an ergonomic cart mounted monitor and keyboard in the appropriate location.

7. Plug the monitor power cable into the power strip on the computer assembly. Secure with ties if needed.

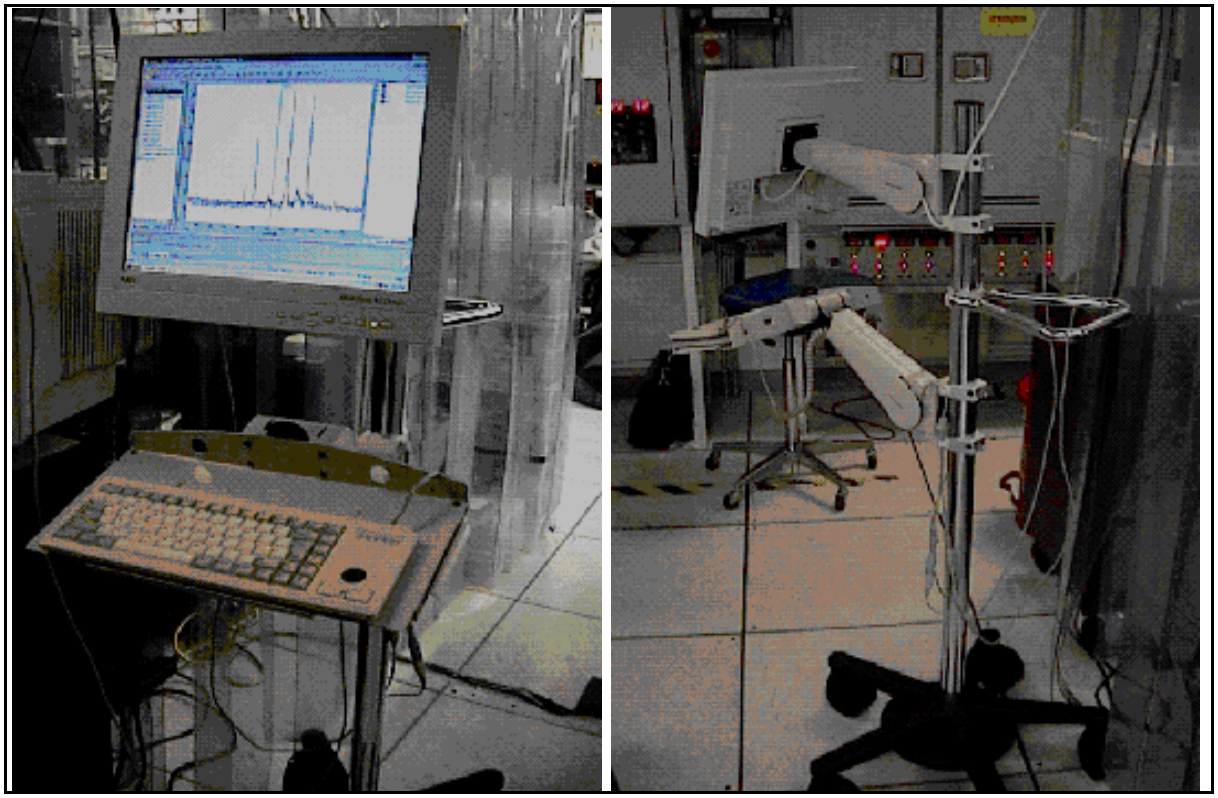


Figure 4-11. 200mm Ergotron Cart with Mounted Monitor and Keyboard

8. Slide the SP2000 Shelf (p/n 0040-50432) into place, Figure 4-12, on the left side of the chamber and secure it to the chamber AC Box with 4 screws on top and one on the side. See Figure 4-13.

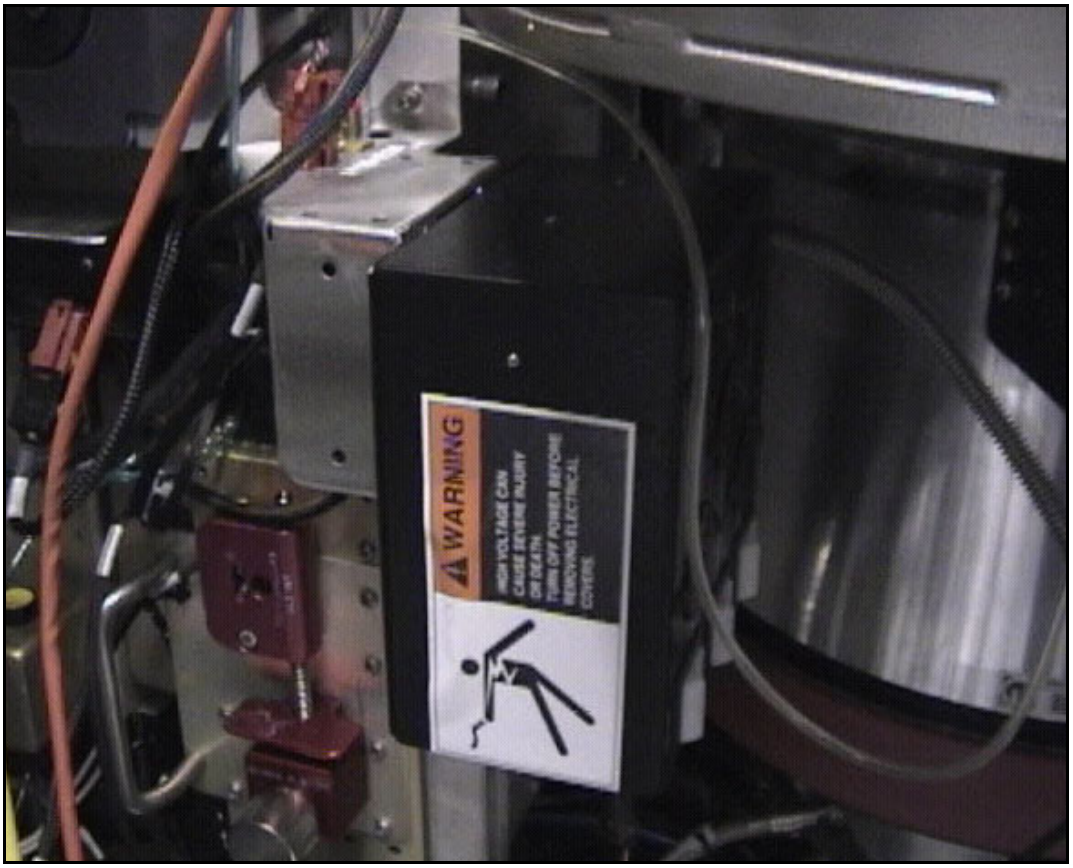


Figure 4-12. Location of DCS Shelf on 200mm DPS, DPS+ Chamber

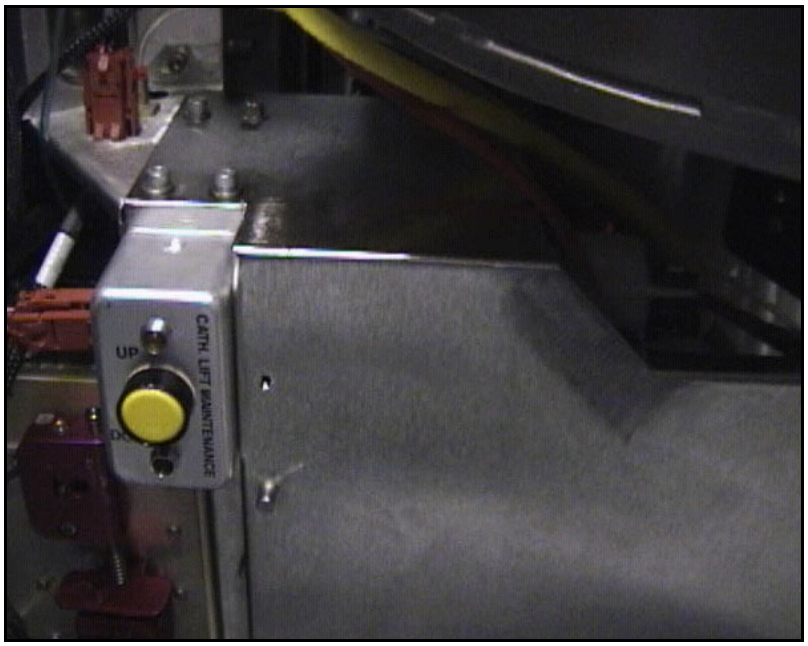


Figure 4-13. Front View of DCS Shelf on 200mm DPS, DPS+ Chamber

9. The side arm fits on the right side by attaching one end to the mounting bracket (2 screws) and one end to the gate valve (one screw). See Figure 4-14.

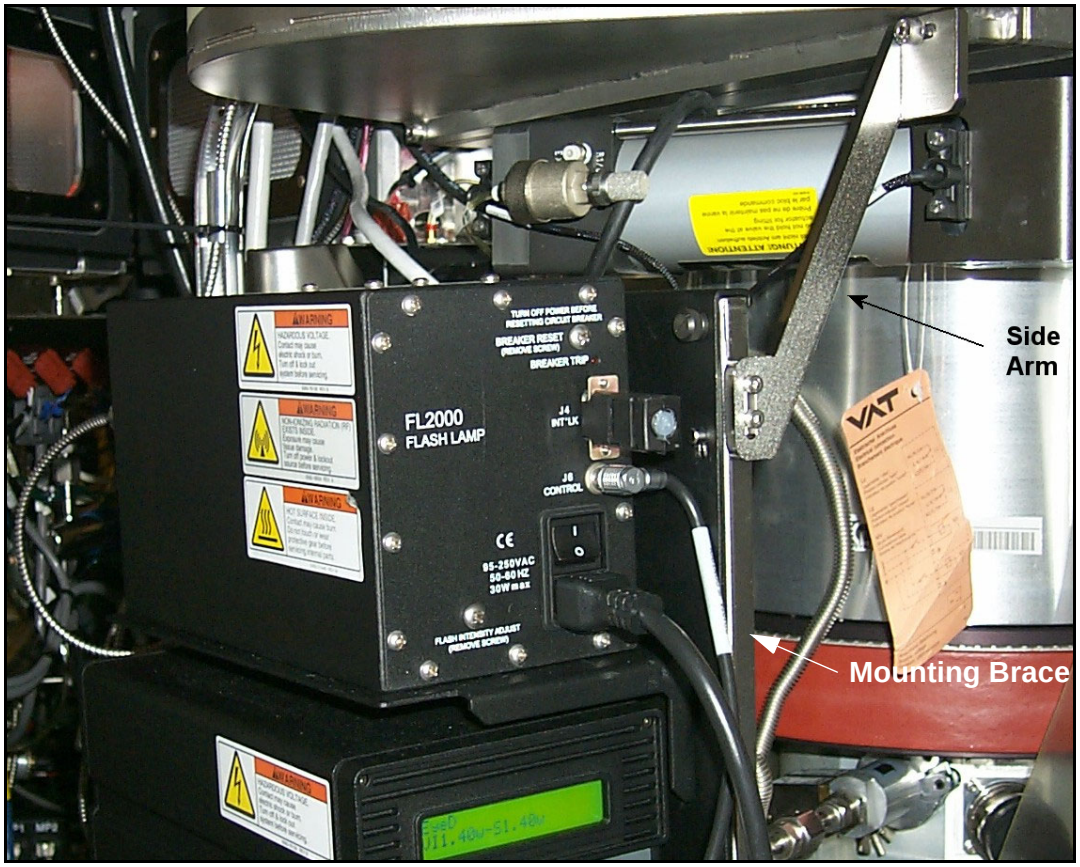
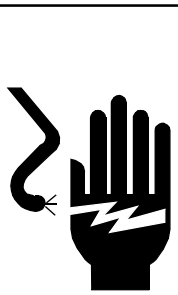


Figure 4-14. Side View of DCS Shelf (Mounting Bracket) with Arm

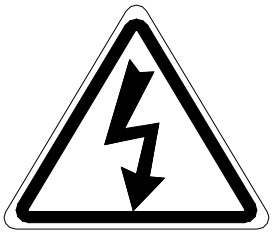


⚠ WARNING

HAZARDOUS VOLTAGE

Potentially hazardous electrical voltages and currents are present which could cause electric shock, burn or death.

Turn off, lockout and tagout DC and/or RF power supply(ies) in the Generator Rack for each chamber being serviced.



10. Hang a DCS Shelf Assembly (p/n 0010-10047) on the DCS Shelf. The shelf assembly includes the SD1024D-2-S detector and the FL2002 Flashlamp, and is attached by 4 captive screws.

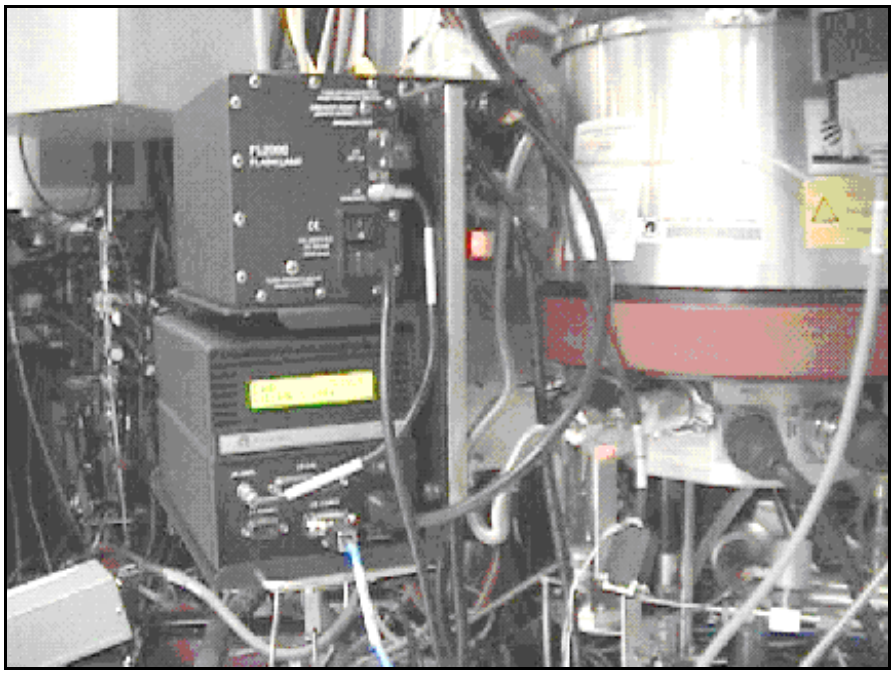


Figure 4-15. Installed EyeD-IEP Detector and Lamp on 200mm DPS Chamber

1. Insert a 208 VAC NEMA L6-15 connector into both the flashlamp and the DCS. Plug the connector in to the chamber AC box near the turbopump. If only one power receptacle is available, a power strip (p/n 0620-00569) may be attached to the bottom of the chamber AC box by 3 double-sided, self-adhesive strips. See Figure 4-16. Each shelf assembly is then plugged into this strip.

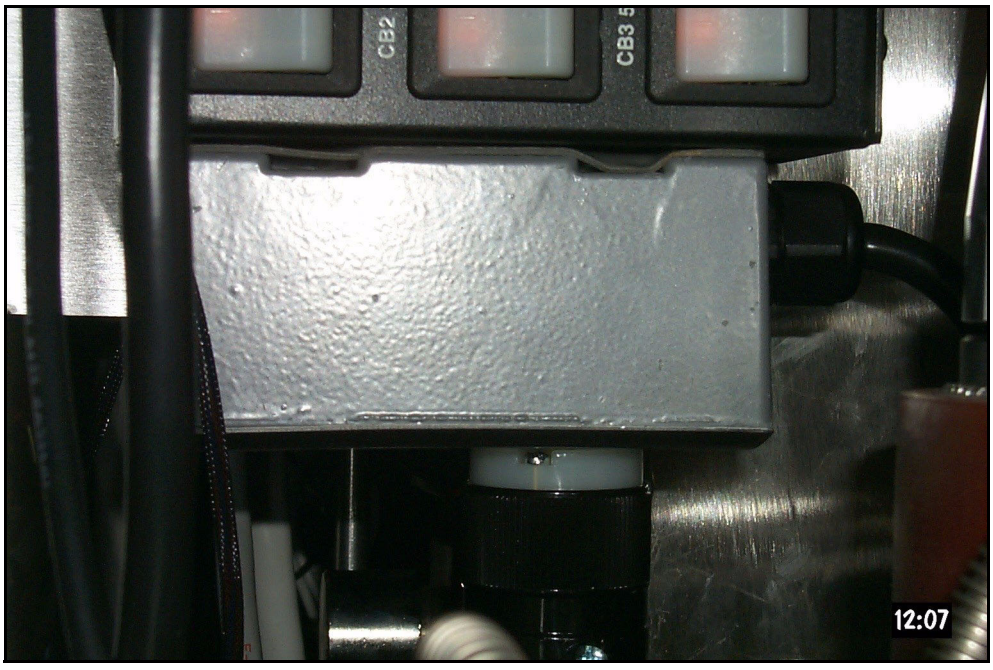


Figure 4-16. Power Strip Attached to the Bottom of the Chamber AC Box

2. Attach a Support Conduit for the fiber optic cable. This contains 3 parts:

   a. A half open tube that connects from the mounting bracket to the underside of the chamber

   b. A straight enclosed tube that runs underneath the pump channel of the chamber

   c. A half open tube that connects from the underside of the chamber to the IEP window (this piece will need to be removed when opening the chamber, so it is equipped with a quick-release captive screw on the end that attaches to the underside of the chamber)

3. Each piece of the Support Conduit is attached at both ends. See Figure 4-17 for a picture of the installed Support Conduit.

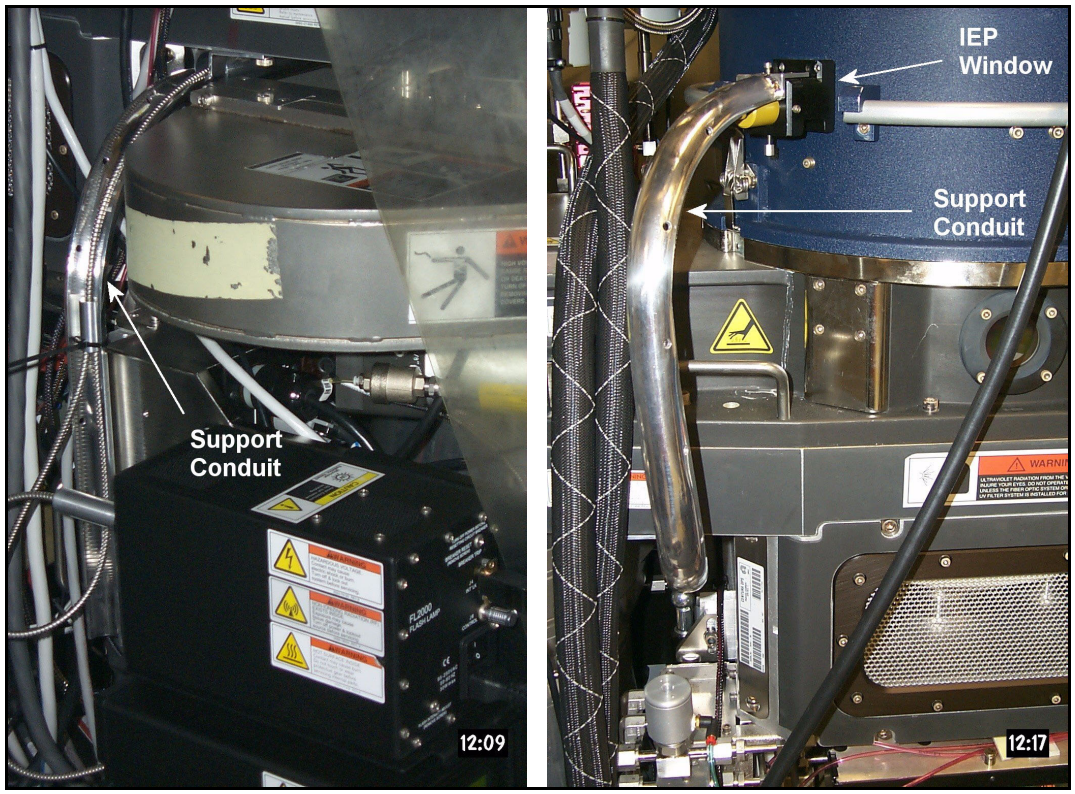


Figure 4-17. 200mm IEP Fiber Optic Cable Support Conduit on System

4. Repeat for each chamber that is to receive a detector and lamp.

4.7 EyeD-OES Installation of SCS Remotely from 200mm eMAX Chamber

4.7.1 Install SCS Assembly

1. Install spectrograph bracket on top of mainframe next to the computer.
2. Install one spectrograph per chamber.

4.7.1.1 Install Magnet Synchronous Detection Module Hardware

1. Install the magnet synchronous detection module.
2. Install the magnet synchronous interface harness between the magnet driver and the magnet driver control harness.
3. Route the magnet synchronous detect harness from the magnet interface harness to the magnet synchronous detect module.
4. Install the synchronous module to spectrograph module harness.

4.8 Connecting Cables

4.8.1 200mm Computer Assembly

1. Connect the computer power cord to the surge filter.
2. Route the keyboard/mouse cable to the computer and attach an adaptor to the keyboard and mouse connectors so that they combine to plug into the PS/2 Port. This is the same card as the VGA port. Secure the cable with cable ties if needed.

NOTE

The keyboard will not work with a PS/2 extension cable longer than 12 feet.

3. Route the VGA extension cable to the computer. Secure with ties if needed.
4. Connect the hub power supply to the power strip using the uplink supplied with the hub.
5. Connect an Ethernet cable, P/N 0620-01529, between the Ethernet Switch and the Main Ethernet Port on the computer.
6. Connect the 75ft null modem (pins 2 and 3 are swapped, pin 5 is grounded) 9-pin D-sub female serial cable to Com 1 Port on the computer. The part number is 0620-00527.
7. On 200mm systems, there is an option for digital communication. If this mode of communication is used, install the four-way interface cable, P/N 0620-00566, to the 100-pin connector on the Digital I/O card on the back of the computer.
8. There should be an Ethernet cable (p/n 0620-00567) for each spectrograph. Use ports 2 - 5 to connect the installed spectrographs to the Ethernet hub. However, only one unconfigured spectrograph may be connected at a time. All unconfigured

spectrographs are shipped with the same IP address, so connecting more than one of them before they have been configured for the different chambers (with different IP addresses) will lead to communications conflicts. Refer to Chapter 5 for instructions on installing the EyeD software and to set up the communications between the spectrographs and the computer.

9. Route the fab network cable, P/N 0620-01324, if required, to the global networking port on the computer.

> **⚠ CAUTION**
>
> ***IMPORTANT***: *DO NOT* connect the fab Ethernet to the hub at this time because this will cause the detectors to be unreliable.

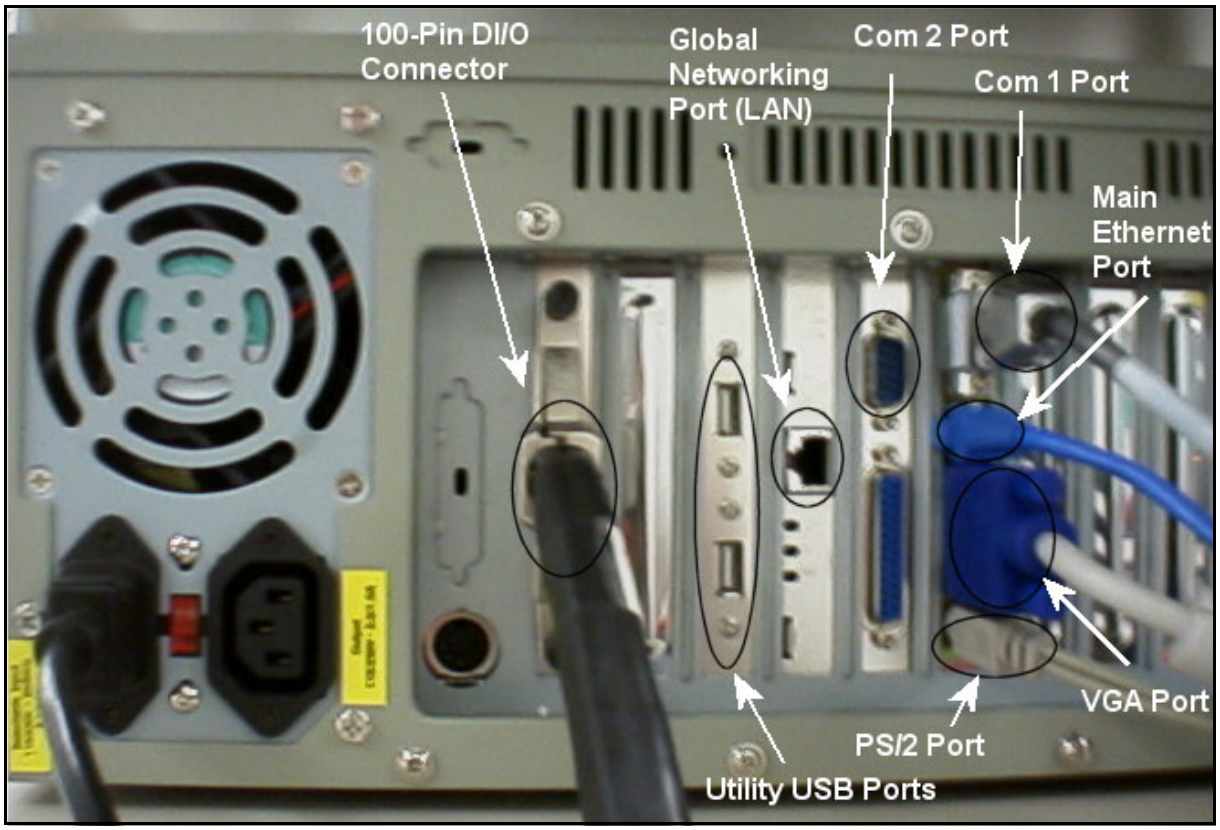


Figure 4-18. 200mm Control Computer Connections

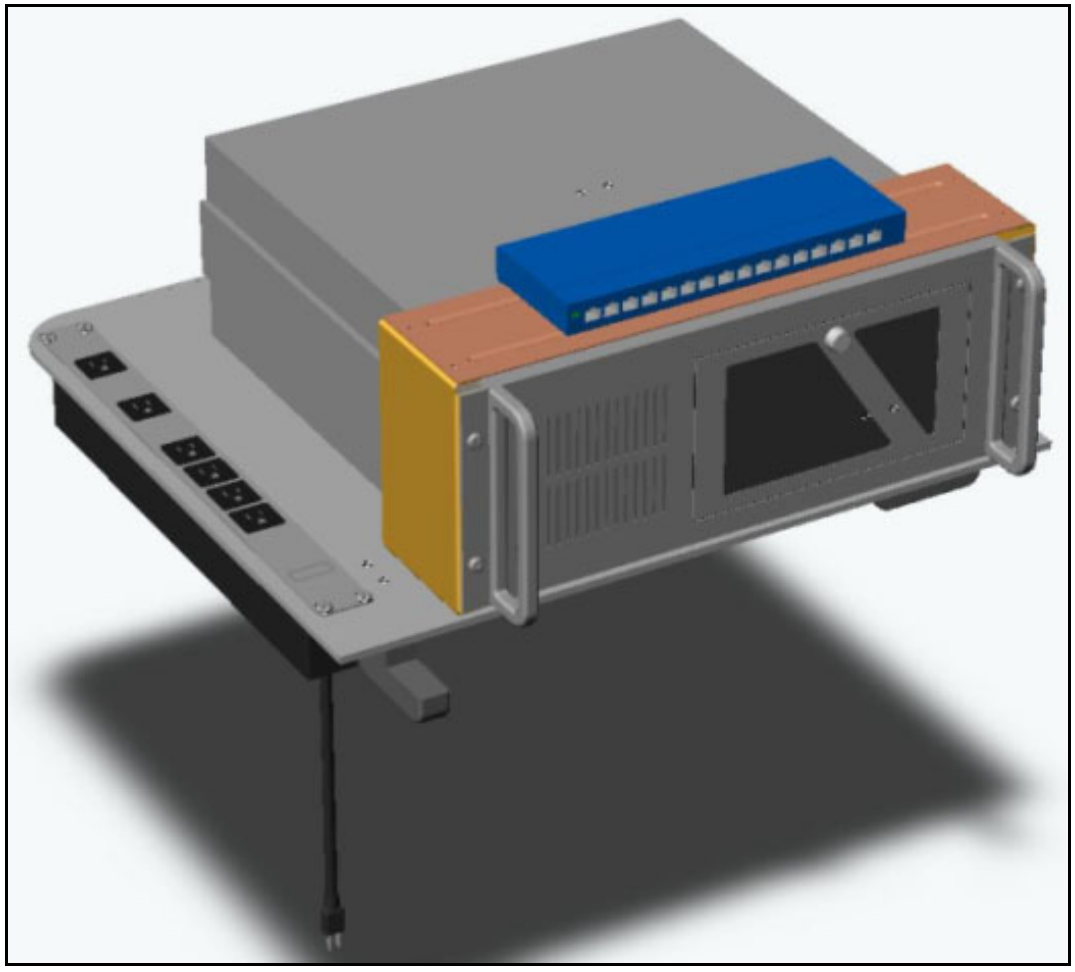


Figure 4-19. 200mm Ethernet Switch

4.8.2 Spectrograph Assembly

1. Route Ethernet communication cables from the Ethernet switch to the J2-Com2 port on the spectrographs.
2. Secure the cables with cable ties, and label each cable for the particular chamber designation using a permanent marker.

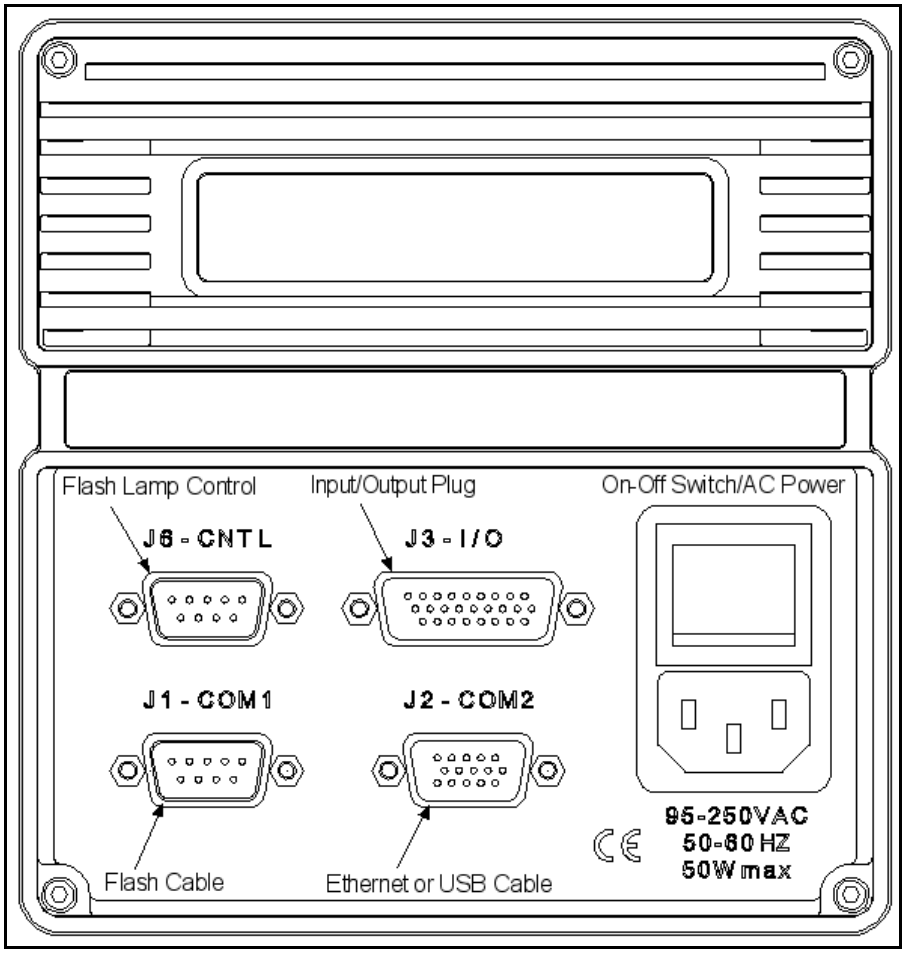


Figure 4-20. Cable Connections to Spectrograph

4.8.3 Mainframe

1. Route digital I/O cables from the flat D-sub connector (J6) in the chamber tray PCB for each chamber to the back of the control computer along mainframe rails using tie wraps and labeling. Connect the individual chamber cables to the four-way interface cable appropriately (This is necessary only if EyeD will use DI/O to communicate with the Centura).

2. Route the serial cable from the computer to VP6/Com1 in the system controller. See Figure 4-21.

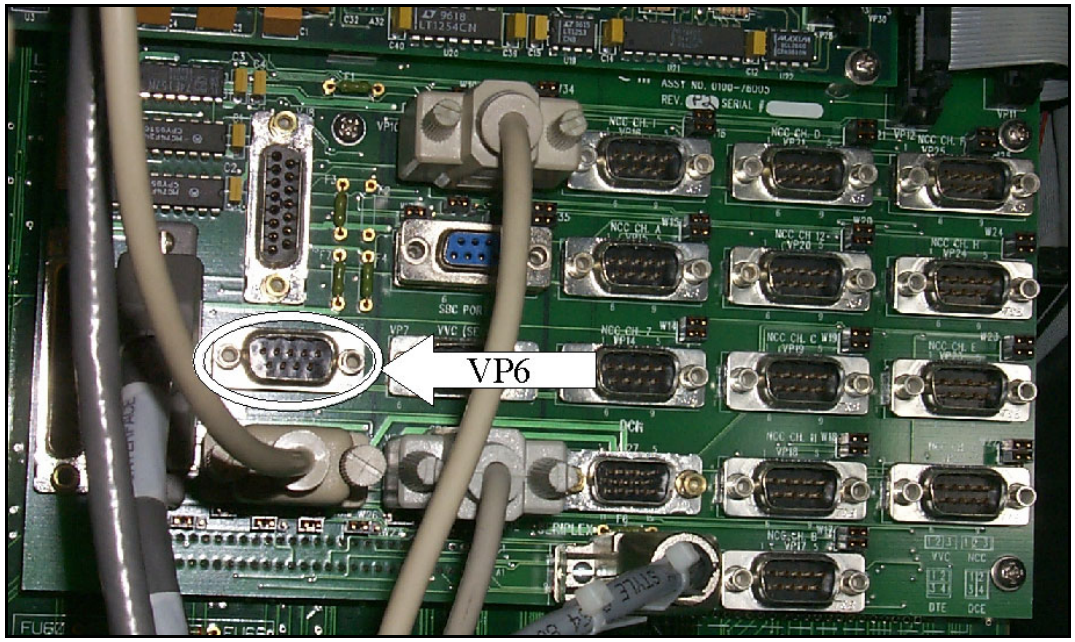


Figure 4-21. Port VP6/Com1 in the System Controller for 200mm Systems

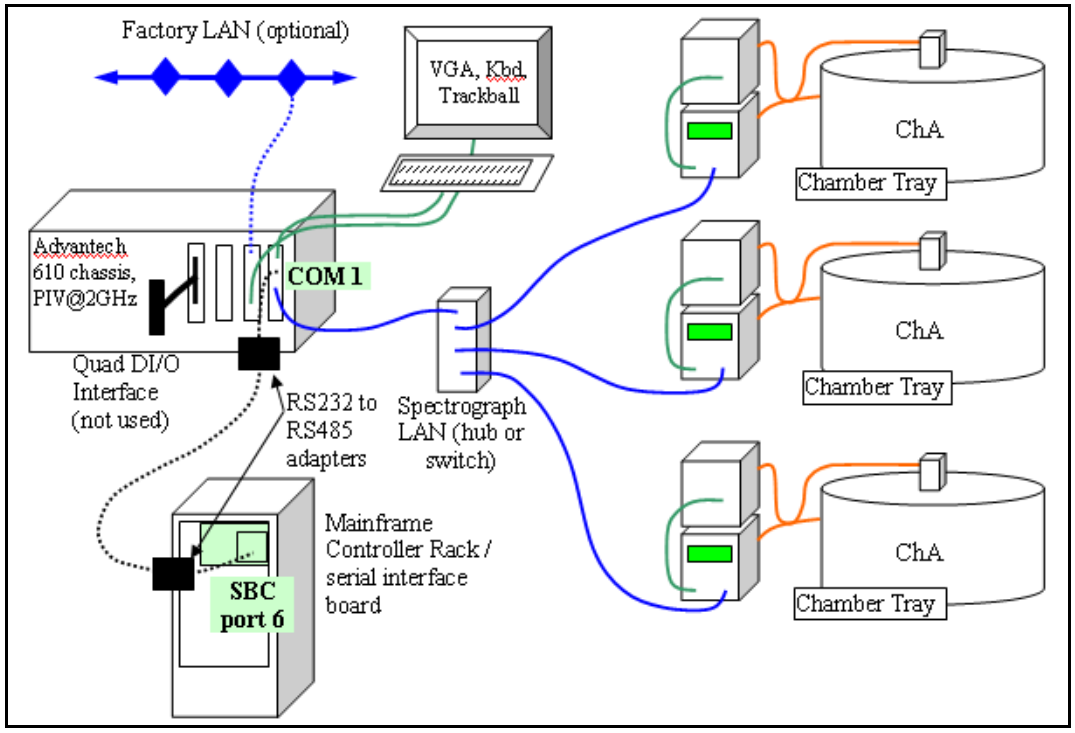


Figure 4-22. EyeD-IEP AMAT IDEC/SECS Interconnect Diagram

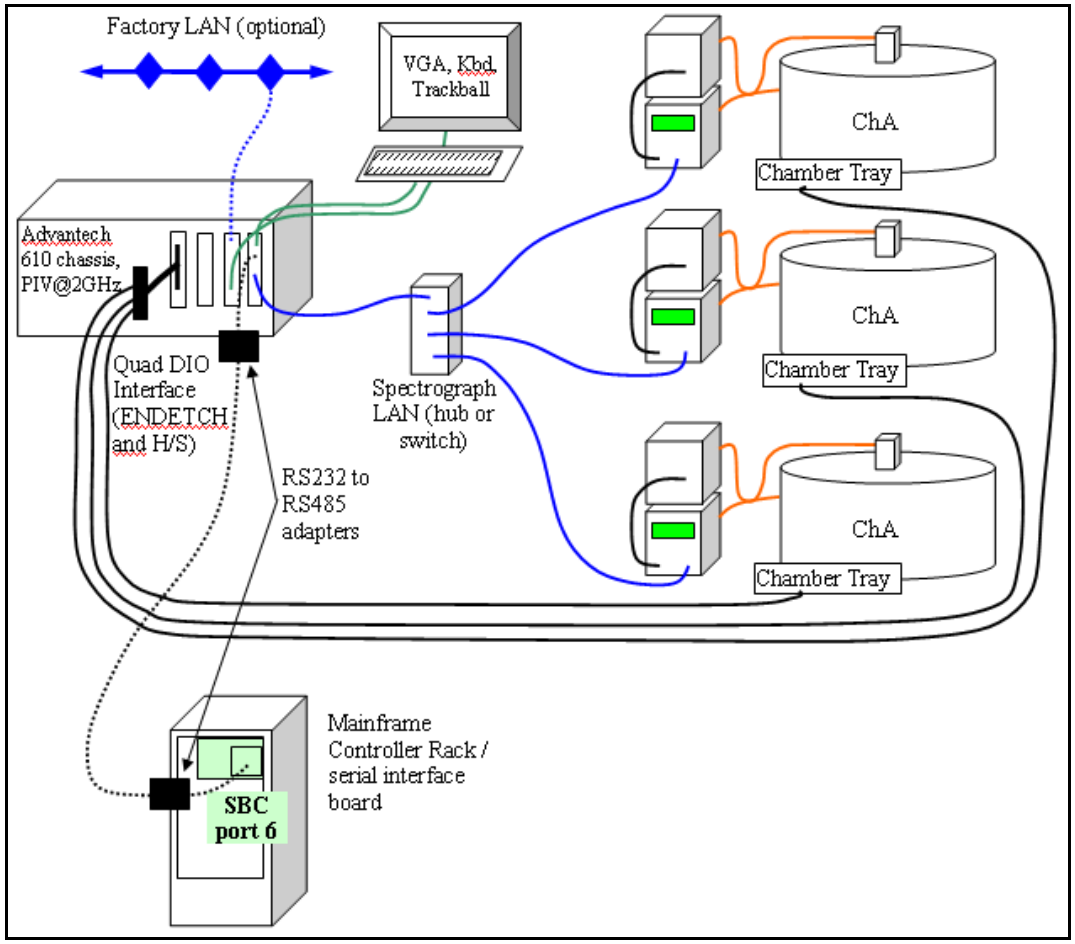


Figure 4-23. EyeD-IEP Mixed Serial / DI/O Interconnect Diagram

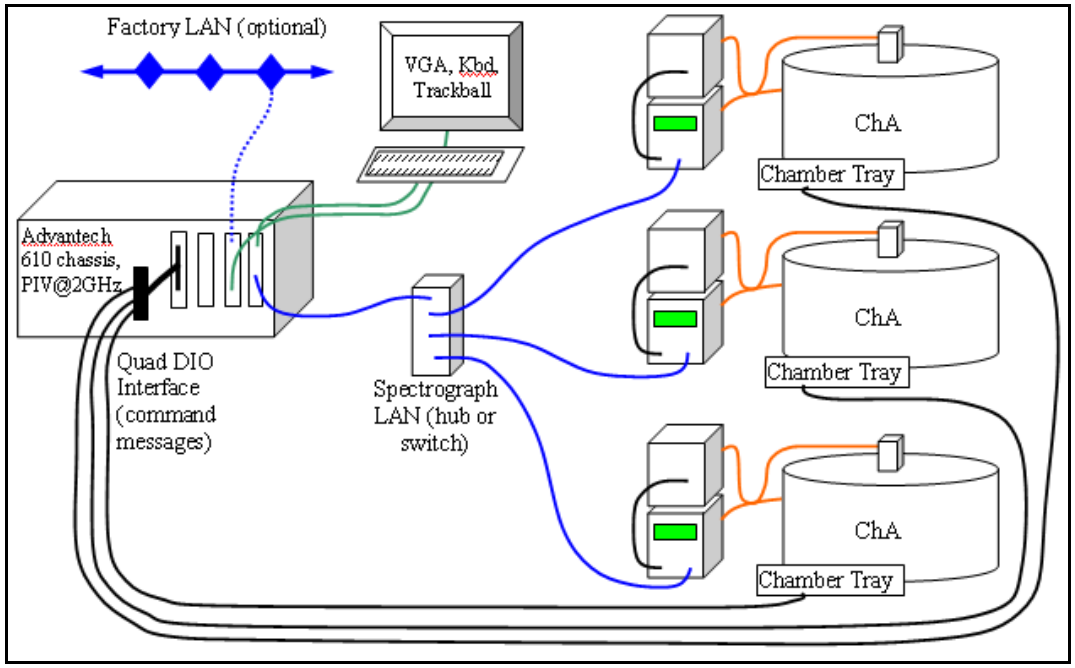


Figure 4-24. EyeD-IEP Optional DI/O Interconnect Diagram

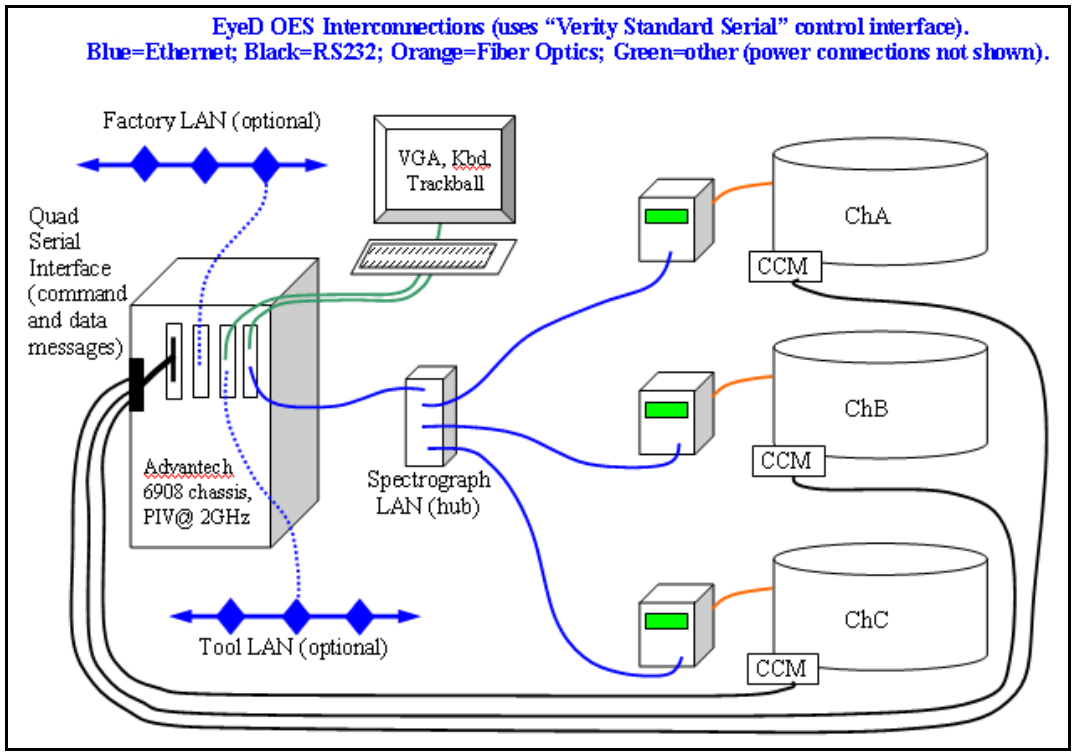


Figure 4-25. EyeD-OES Interconnect Diagram

4.8.4 Installing the RS-232/RS-485 Converter

The RS232/485 communications option requires field installation. Use the following procedure to install this option. The RS232/RS485 Converter kit is Applied Materials Part Number 0240-42328. The kit is shown in Figure 4-26.

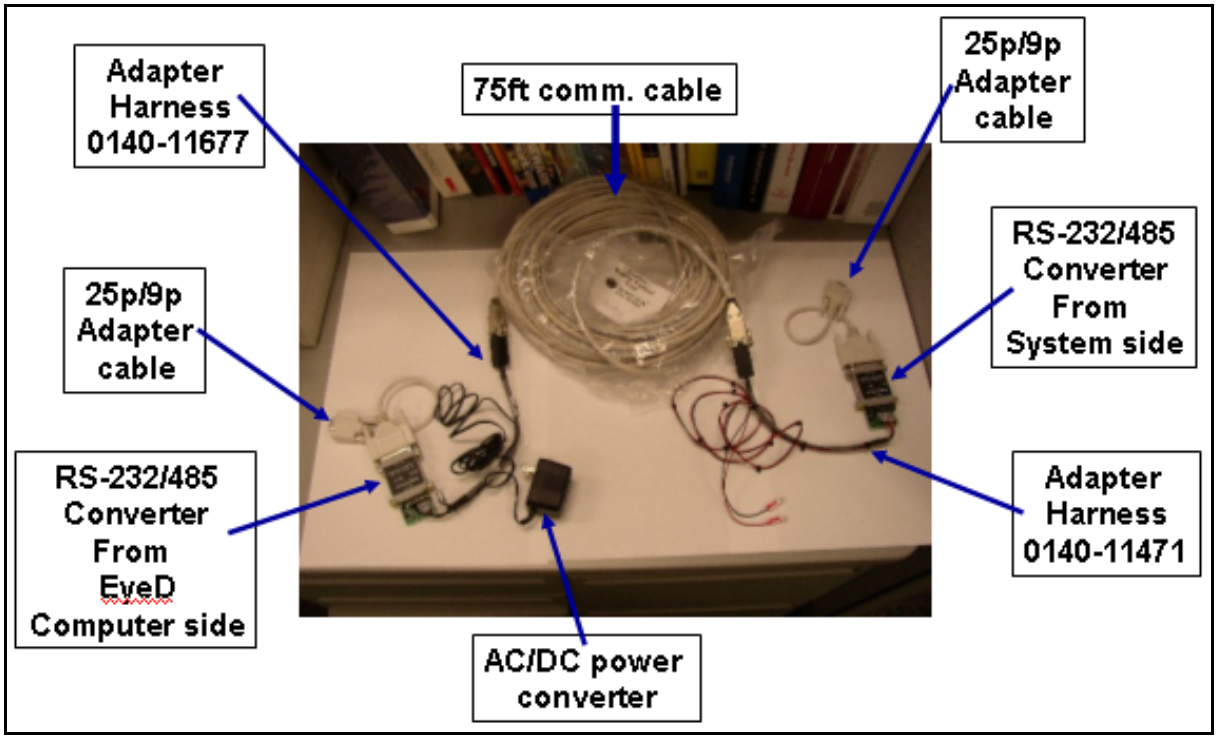


Figure 4-26. RS485 Converter Equipment, Kit P/N 0240-42328

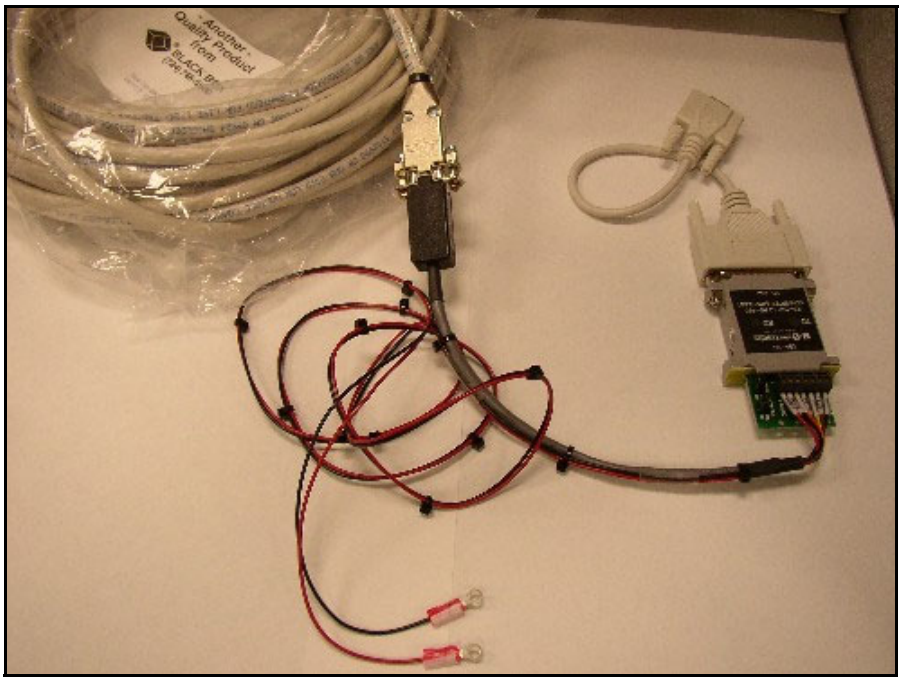


Figure 4-27. System Side Converter

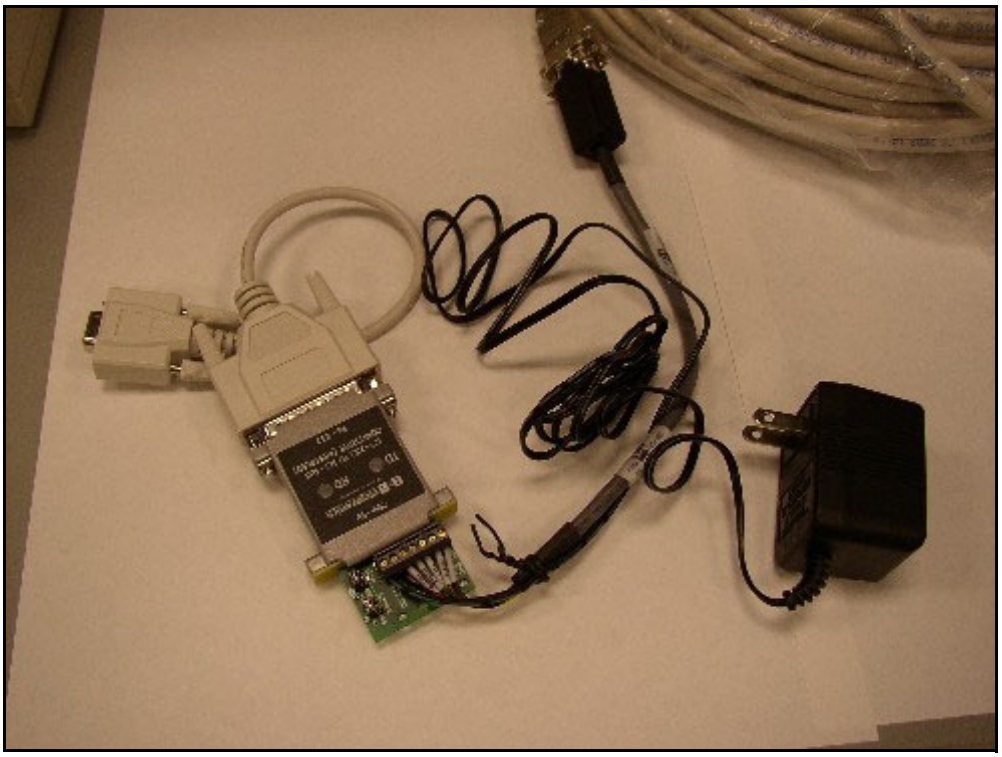


Figure 4-28. EyeD Computer Side Converter



Figure 4-29. 75-Foot Communication Cable Between Converters

1. Follow Lock Out Tag Out procedures and turn off the system power.

2. Turn off the EyeD computer.
3. Remove the existing RS-232 communication cable.
4. Connect the mainframe side cable to the mainframe side converter per drawing and photograph shown in Figure 4-30 and Figure 4-31.

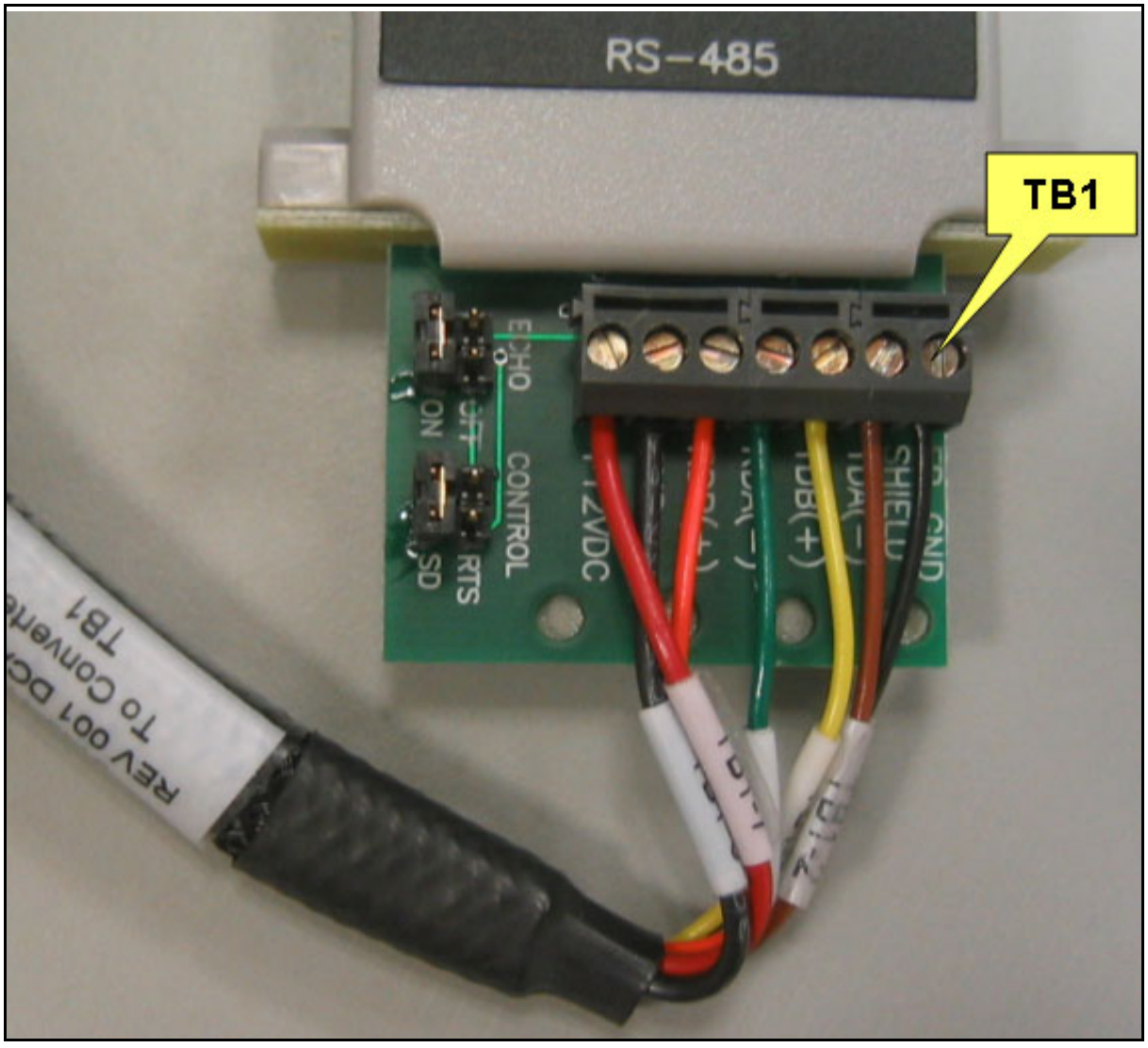


Figure 4-30. RS485 Connections From Mainframe to RS485 Converter

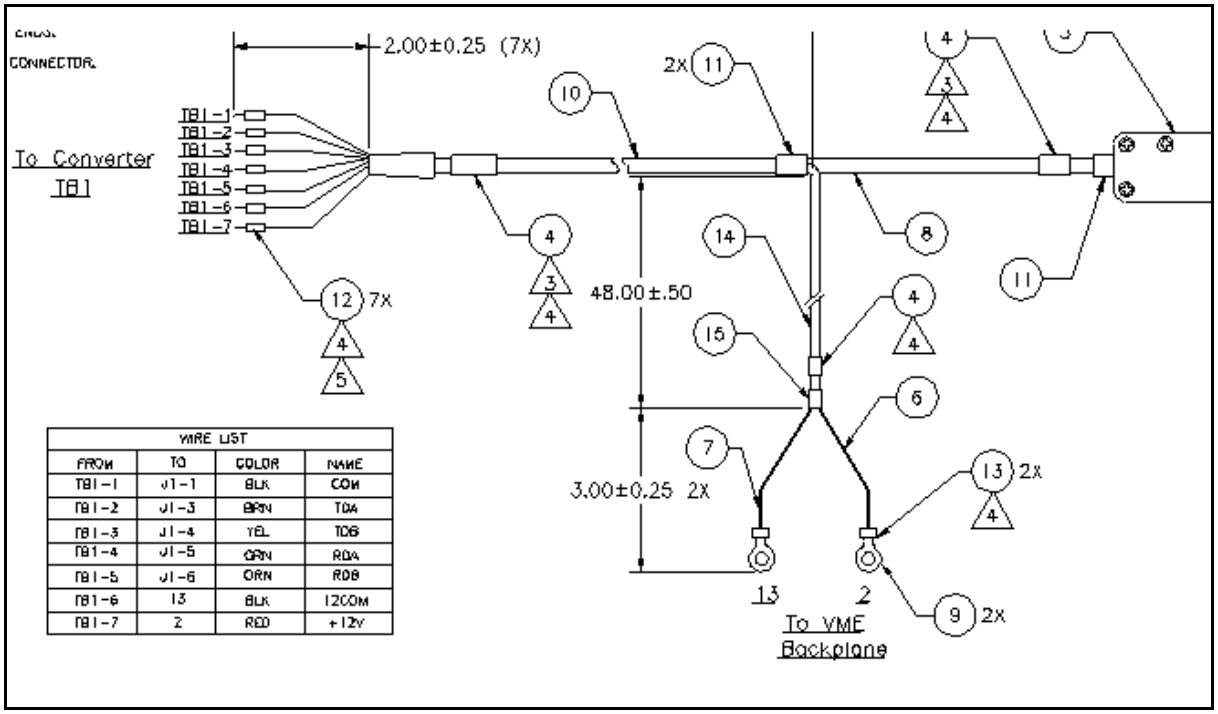


Figure 4-31. RS232/RS485 System Side Cable

5. Connect the RS485 EyeD side cable to the EyeD side converter as shown in Figure 4-32 and Figure 4-33

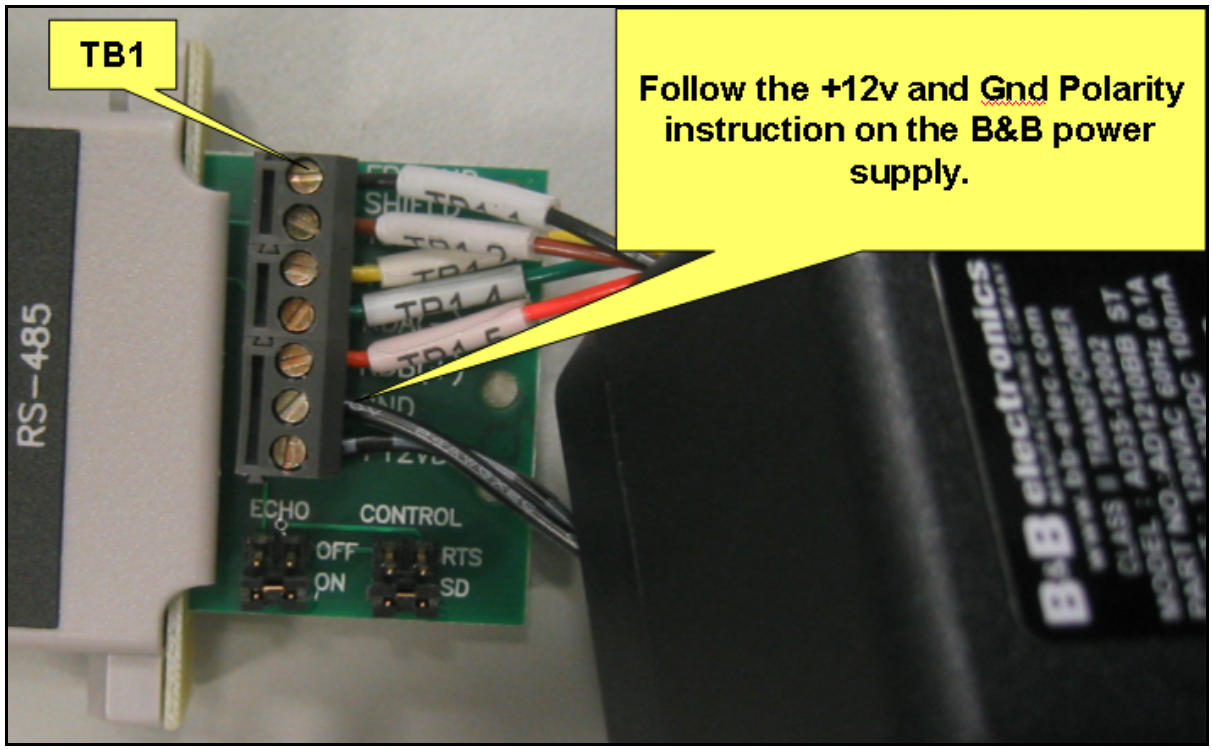
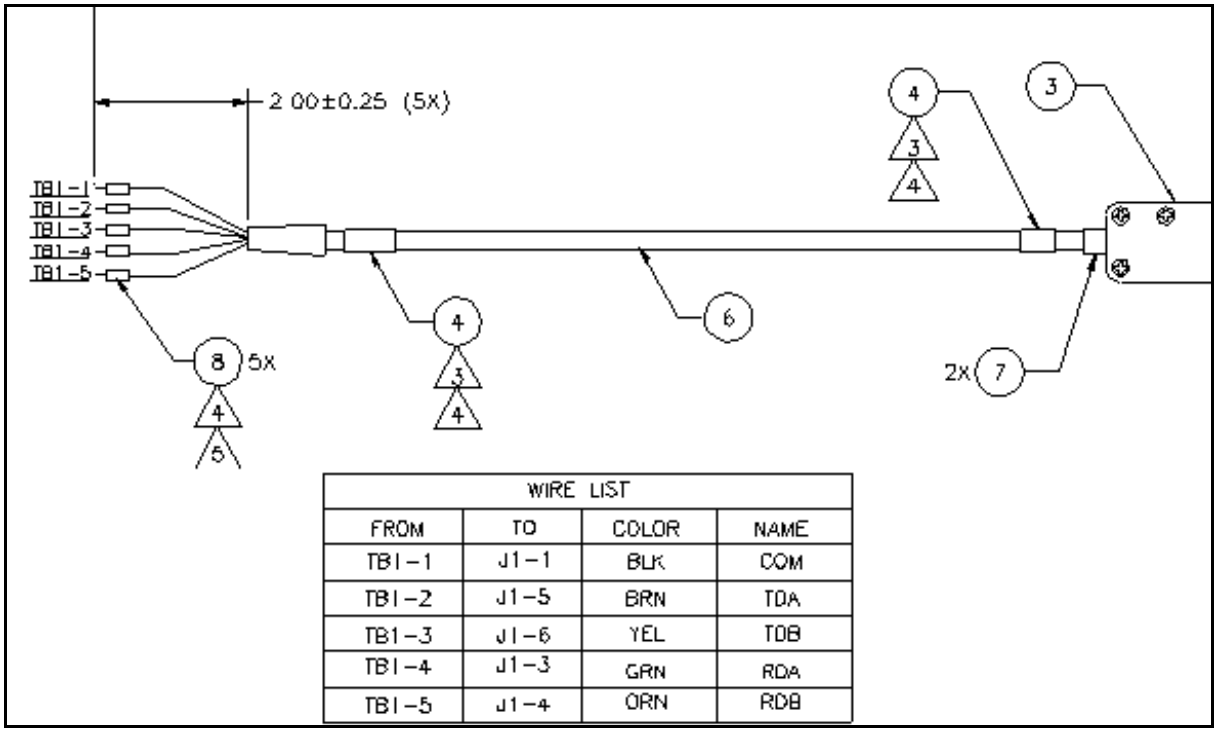


Figure 4-32.



WIRE LIST			
FROM	TO	COLOR	NAME
TB1-1	J1-1	BLK	COM
TB1-2	J1-5	BRN	TDA
TB1-3	J1-6	YEL	TDB
TB1-4	J1-3	GRN	RDA
TB1-5	J1-4	ORN	RDB

Figure 4-33. RS232/RS485 EyeD Side Cable

6. On the system side, install the 9-pin connector to VP6 (SPC Port 6 on the serial board). See Section 4-34.

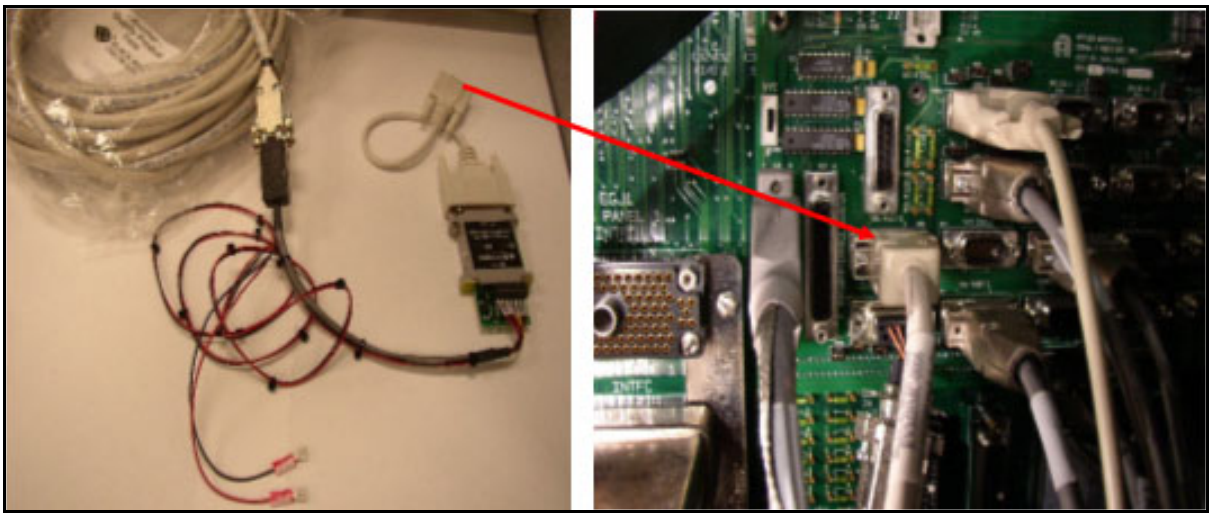


Figure 4-34. Connecting Converter to System Serial Board

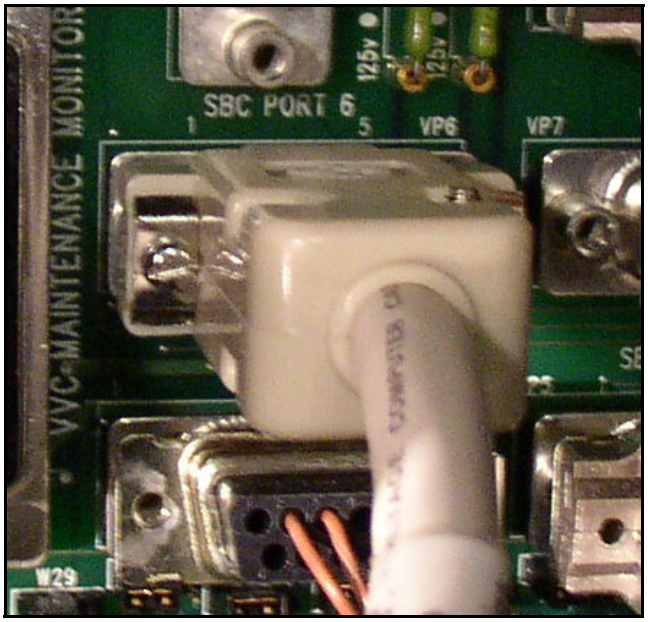


Figure 4-35. Connect to SBC Port 6 (VP6)

7. Install black wire ring lug (0140-11471) to TB1-13 of VME power bus.
8. Install red wire ring lug (0140-11471) to TB1-2 of VME power bus. See Figure 4-36 and Figure 4-37.

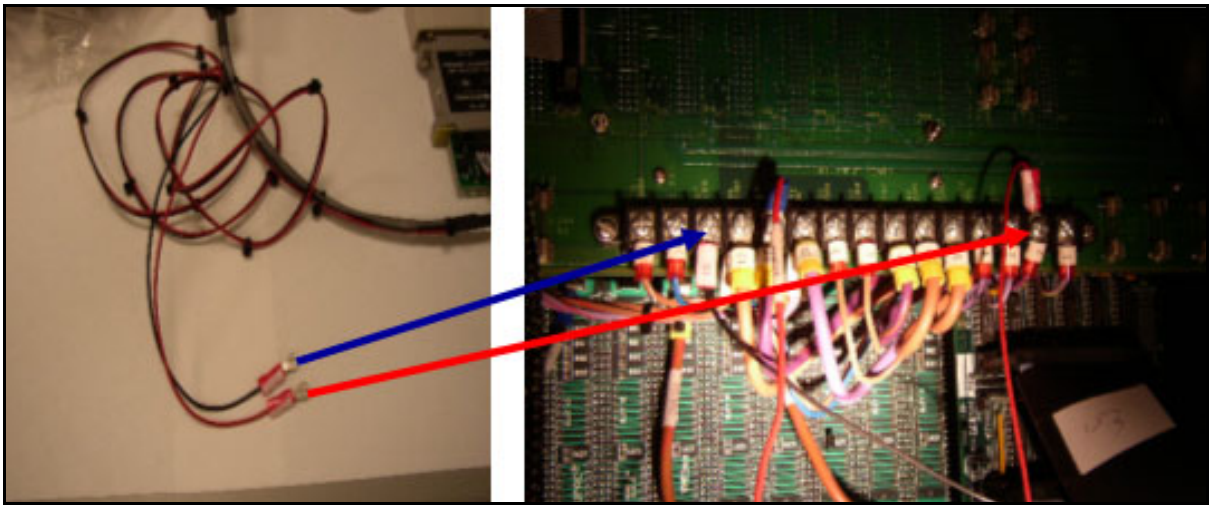


Figure 4-36. Attach Power Wires

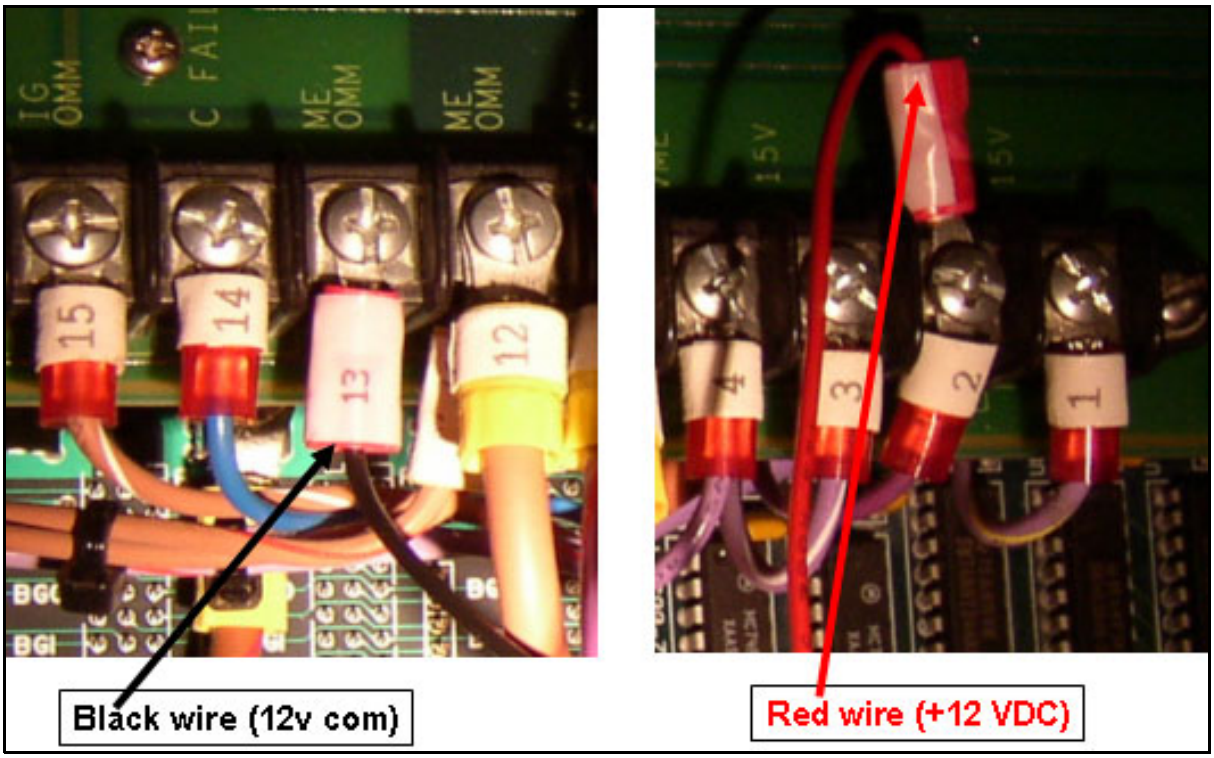


Figure 4-37. Detail of Power Wire Connections

9. Install converter and cable to the EyeD computer side as shown in Figure 4-38.

   a. Install 9 pin connector to com 1 of the Eyed computer (same com port as before).

   b. Plug the AC adapter to EyeD power strip.

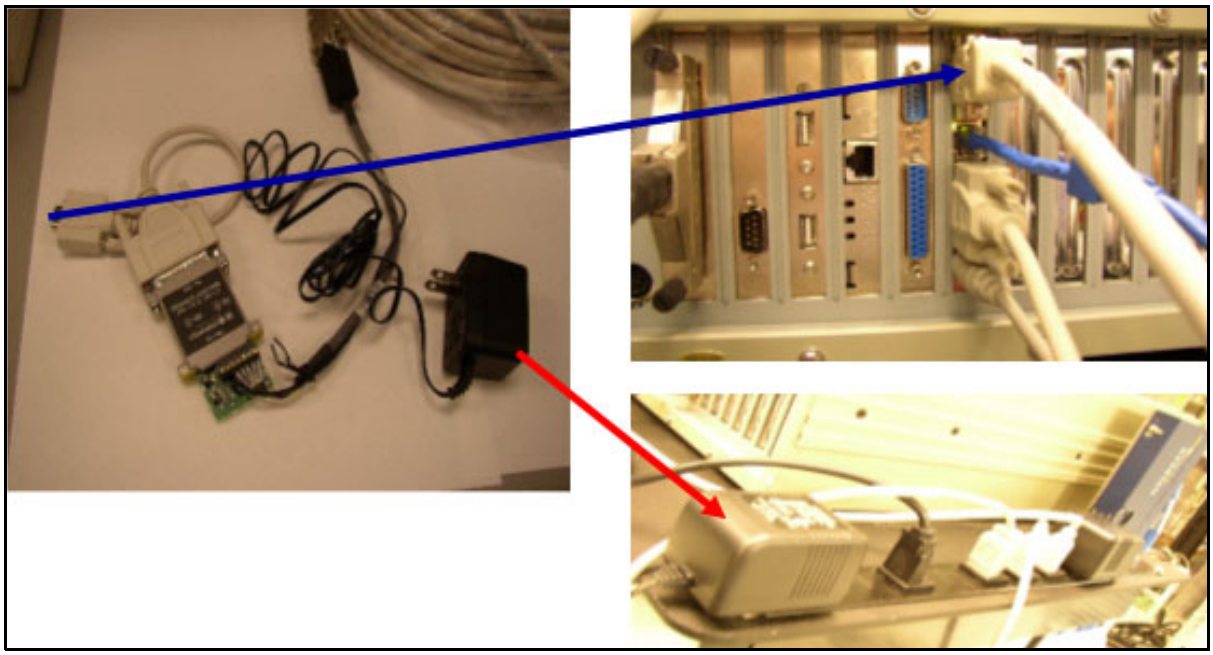


Figure 4-38. Install EyeD Connections

10. Connect the 75-foot communication cable to the System RS485 converter and the EyeD side RS485 converter.

11. Set and verify converter jumpers as shown in Figure 4-39.

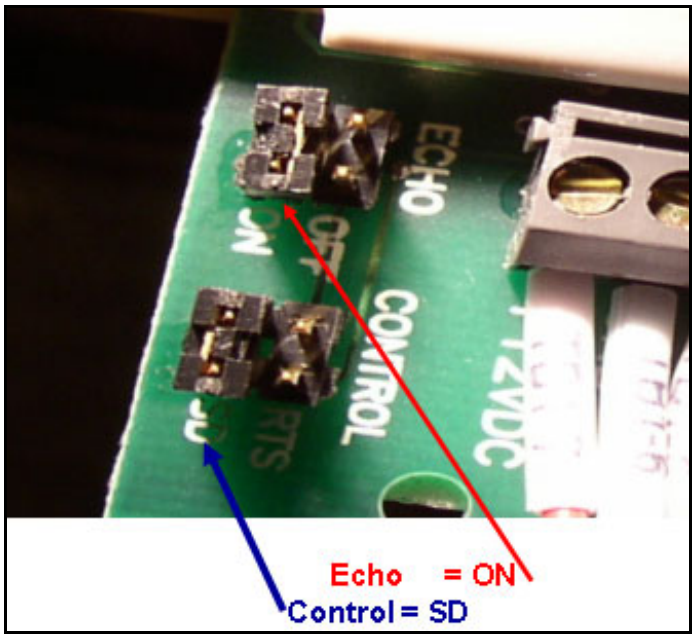


Figure 4-39. Set Converter Jumpers

4.9 Power Up System

Power up all of the detectors first. Each of the detectors performs a self-check on power up, and will indicate if there are any errors detected on the LCD screen. If a failure message appears, cycle the power on the unit again.



Figure 4-40. Spectrograph Correctly Powered Up

Proceed to install the software and setup in Chapter 5.

4.10 Basic Functionality Check of Spectrograph Using Room Light

NOTE

Before proceeding with this section, complete the installation of the EyeD software. This section should be completed before installing the fiber optic cables to the chamber assembly.

If the test algorithms are not installed, the download them from *http://amat.mis.amat.com/sietch/engineering/index.htm* prior to the EyeD system installation. They are: *genericROOM_LIGHT.svc*, *genericLAMP_SETUP.svc* and *genericDIO_TEST.svc*. Save them in the folder *c:\EyeD\endpoints*.

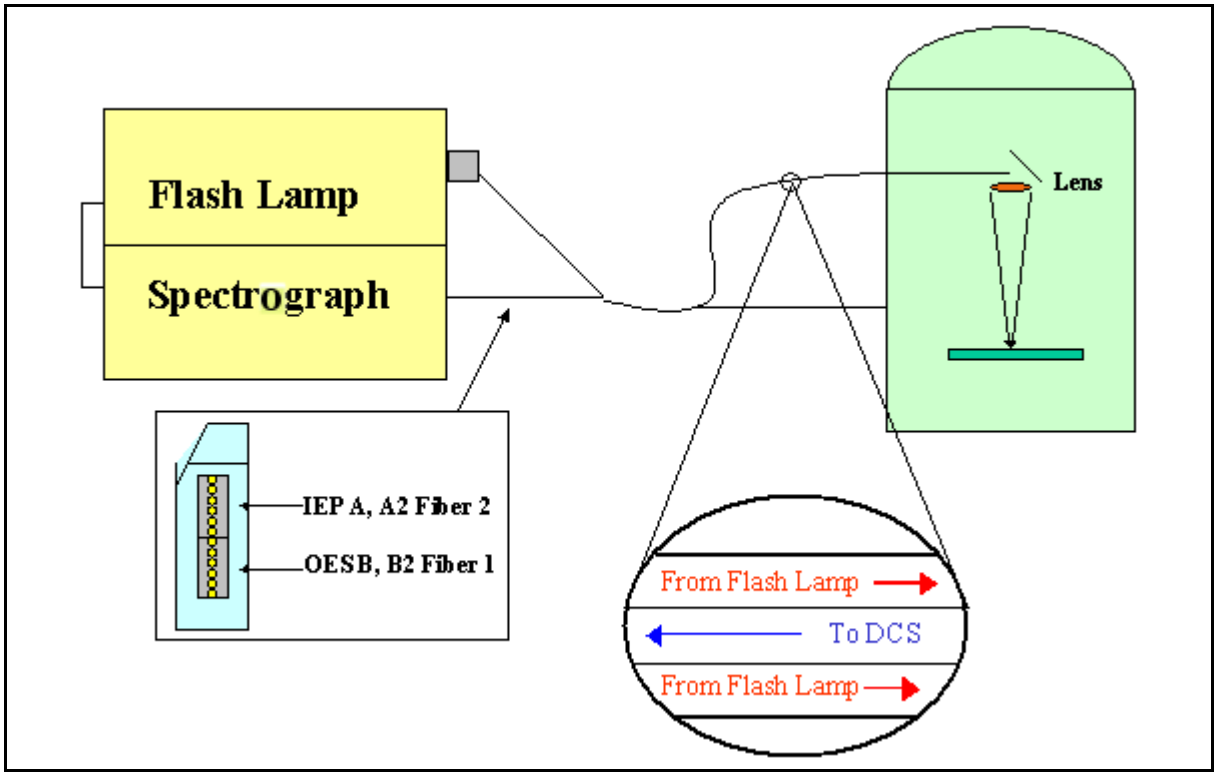


Figure 4-41. EyeD-IEP Fiber Optic Cable Diagram (arrows show direction of light propagation)

1. Install the fiber optic (FO) signal cable firmly into the chamber A spectrograph input coupler on the back of the spectrograph and secure with the 5/64" setscrew. See Figure 4-42. Do not insert the FO source cable in to the lamp at this time.

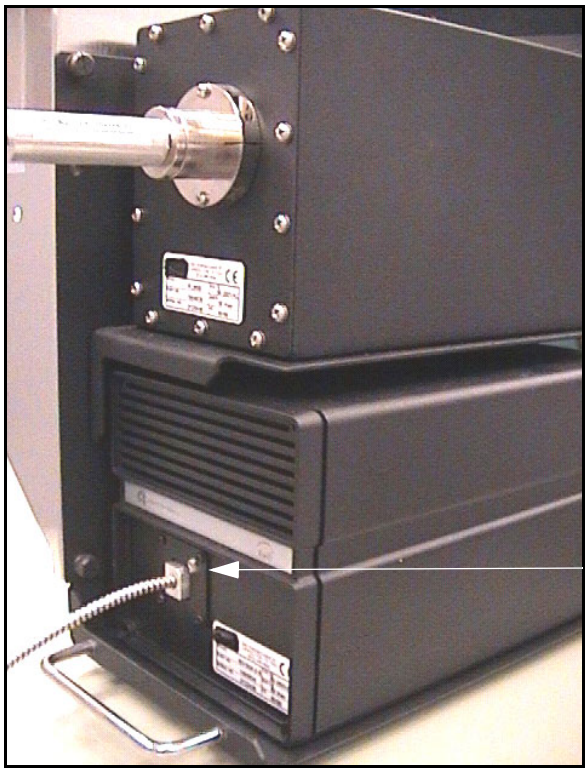


Figure 4-42. Fiber Optic Cable Installed on DCS (Rear Bezel)

2. For the moment, leave the biconic chamber ends of the cables (OES side view and IEP top view) disconnected from the chamber and open to room light.

⚠ CAUTION

Handle the fiber-optic cables carefully. They are delicate and can be broken. Do not twist or make sharp bends in them. Minimum bend radius is 3.5"

3. Maximize the EyeD-A window. Use the configuration tab on the left window of the screen display to gain access to the system configuration list. Right-click on *genericROOM_LIGHT* and *set as current*. Next, execute *genericROOM_LIGHT* in monitor mode by clicking on the **lightning bolt-M** button in the task bar, which is just below the menu bar. This will start the detector acquiring spectra with a 50msec integration time, and with a data interval of 200msec. Two graphs will appear, one having a spectrum of the available light, and the other will be the time trend of the 577nm spectral line, which is a weak spectral component of fluorescent lighting. Maximize the graphs by selecting **window** and **tile**.

4. For OES, the Trend Monitor should only have one line (OES), but for IEP, ensure that the Trend Monitor displays the average for both IEP and OES by doing the following:

a. Double-click on the configuration file to open the Configuration Editor

b. Click on Equations

c. There should be two equations listed - one for IEP (average A) and one for OES (average B). See Figure 4-43.

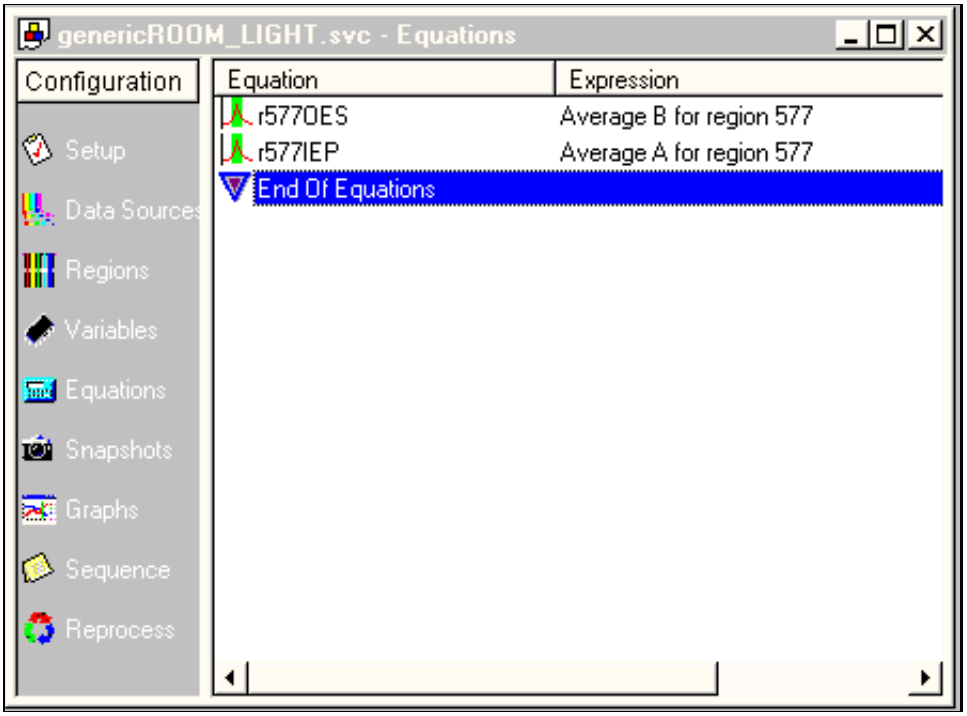


Figure 4-43. *genericROOM_LIGHT Equations* Menu of the Configuration Editor

d. To change an equation, double-click on it. To add a new equation, right-click on End of Equations and select Insert Equation then Region Equation.

e. Enter the fields as shown in Figure 4-44 and click **OK**.

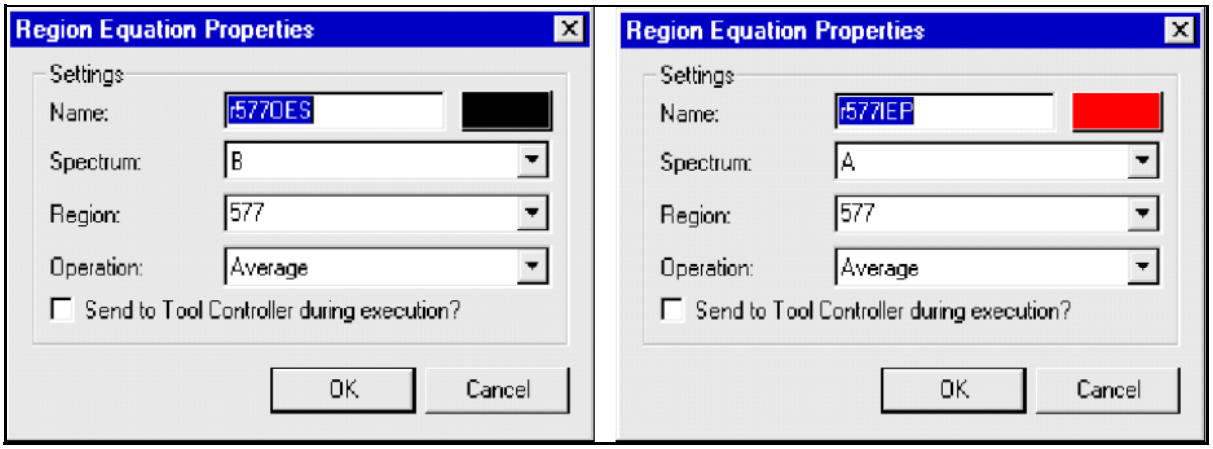


Figure 4-44. OES and IEP Time Average Trend Equation Properties of the 577nm Spectral Line

5. Move around the chamber end of the ChA OES fiber branch (the short FO cable that goes to the side endpoint window) by pointing it at room lights and then away from the lights. Moving the fiber around will cause the level of detected light to change, this will help validate that system real time operations are correct.

6. For IEP systems, move around the chamber end of the ChA IEP fiber branch (the long FO cable that goes inside the IEP probe) again by pointing it at room lights and then away from the lights.

7. Monitor the trend lines for the r577OES and the r577IEP regions in the trend graph: they will rise and fall in intensity depending on whether the FO cable is pointed at a light or not. If the response to the motion of both of the fiber branches is similar to what is shown in the screen example below (only the response for motion of the OES cable is shown), then basic functionality for both input channels of the spectrograph is established and the test is complete. See Figure 4-45.

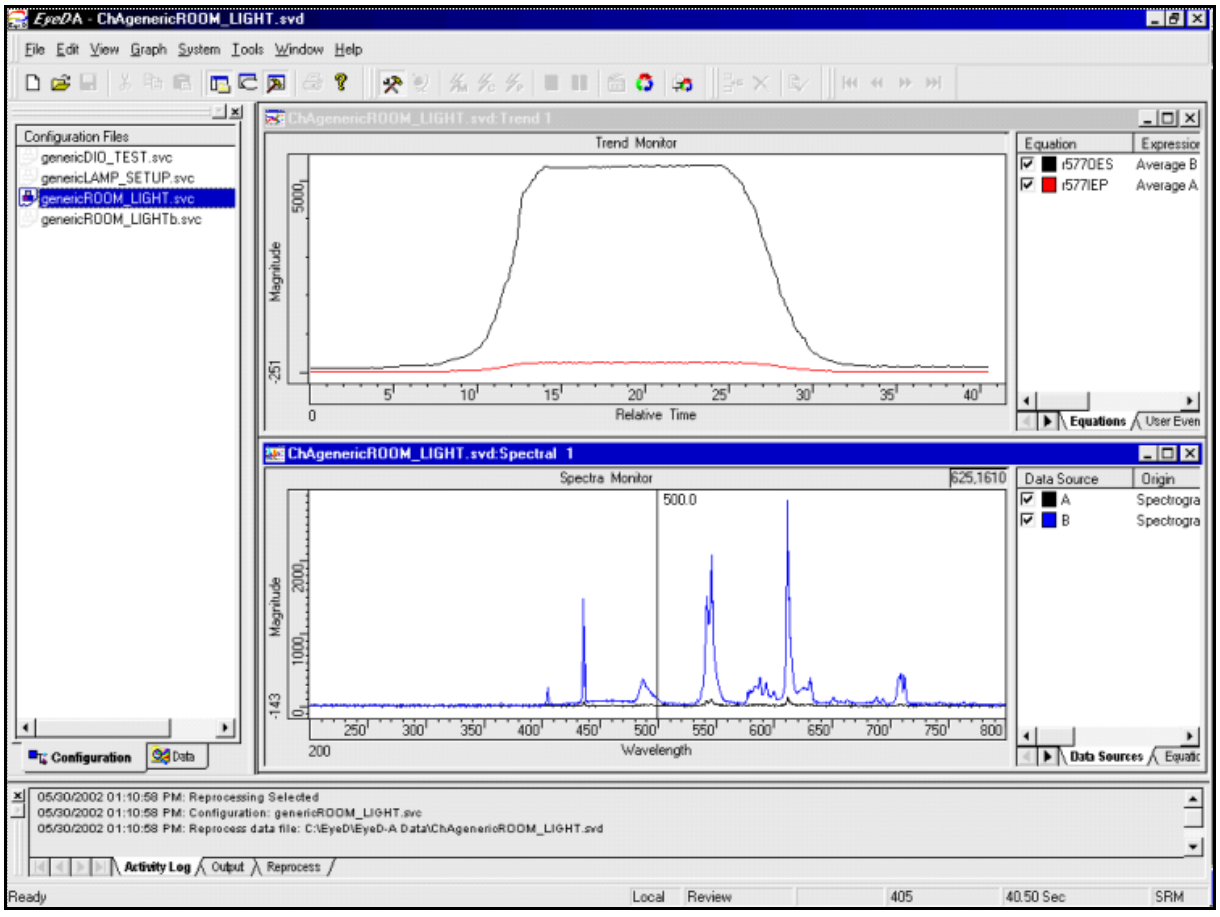


Figure 4-45. Response to Motion Graph for OES Cable

4.11 Installation Complete

Hardware for the EyeD system should be fully installed with the completion of this chapter. For software installation and set-up, see Chapter 5. Some software installation must be done in order to complete the tasks outlined in this chapter.

5 200mm Software Installation and Set-Up

This chapter details the installation of the EyeD Spectrograph software to a process chamber and computer. Before proceeding with the EyeD software installation, be sure to complete the hardware installation. See Chapter 4 for 200mm Hardware Installation.

5.1 EyeD Software Installation

NOTE

Before proceedings with this procedure, remove the cables from the hub. Make sure all spectrographs are turned off. All the hardware should be set up according to the instructions.

Installation of EyeD on Win NT and 2000 requires the user to log in with Administrator Privileges. Please ensure Administrator level access is enabled before starting the installation.

The EyeD software can be installed on both the EyeD computer in a production environment, or on a personal computer for offline use of data analysis. Both installations are shown here.

NOTE

Contact Applied Materials if the default directory is not C:\. Installation affects the Windows registry files making it necessary to alter specific lines to properly register the EyeD software in the Windows registry file when using a drive designation other than C:\.

⚠ CAUTION

Certain computer features must be disabled for the proper operation of the EyeD system.

The following features of the Windows Operating system should be disabled to insure stability of EyeD software:

- Screen Saver
- Power Saver
- Find Fast (not normally installed on system computer, but may be on a desktop PC)

To disable these features use the following instructions:

1. Access the Display Properties window with the selections: *Start\Settings\Control Panel\Display.*

2. On the Screen Saver tab, set Screen Saver to (None) and then click Apply to activate this selection.
3. Click on **Power** to access the Power Management Properties window.
4. Select the Power Schemes tab.
5. Select **Never** for the Turn off monitor and Turn off hard disks options in the Power Schemes tab.
6. Press the **Save As** button to access the Save Scheme window. Type the new name **RequiredForEyeD** into the field. See Figure 5-1.

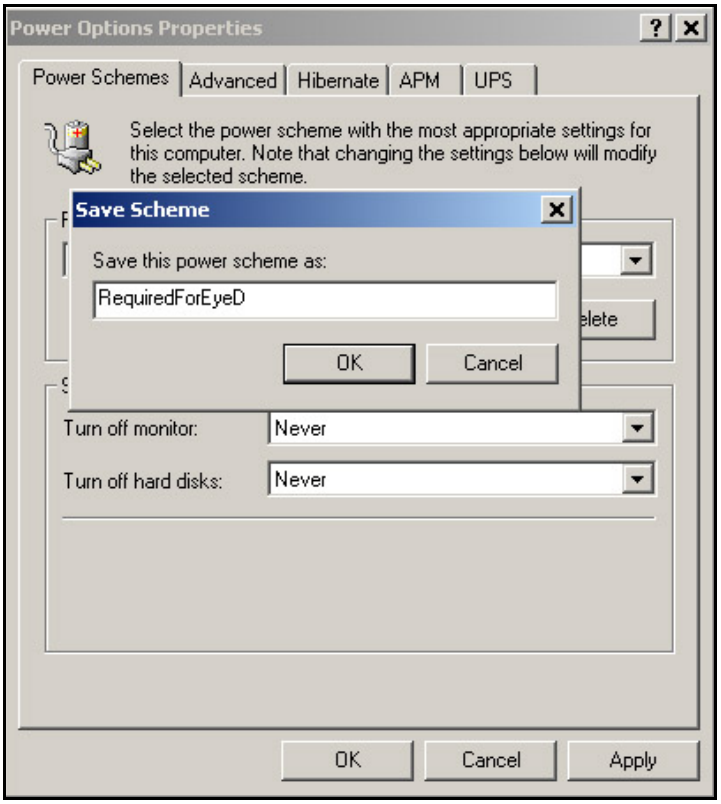


Figure 5-1. Saving Power Scheme

7. Click **OK** to return to the Power Schemes tab. The Power Scheme RequiredForEyeD will be displayed.
8. Click **Apply** to begin using the *RequiredForEyeD* power scheme. Then click **OK** to exit back to the Display window and **OK** again to exit and save all changes.

5.1.1 Installing EyeD Software onto the EyeD Computer

The 200mm Centura may operate with either IDEC communications or DIO or mixed IDEC/DIO communications. The hardware installed determines which communications setup to use. See Figure 5-2, Figure 5-3 and Figure 5-4.

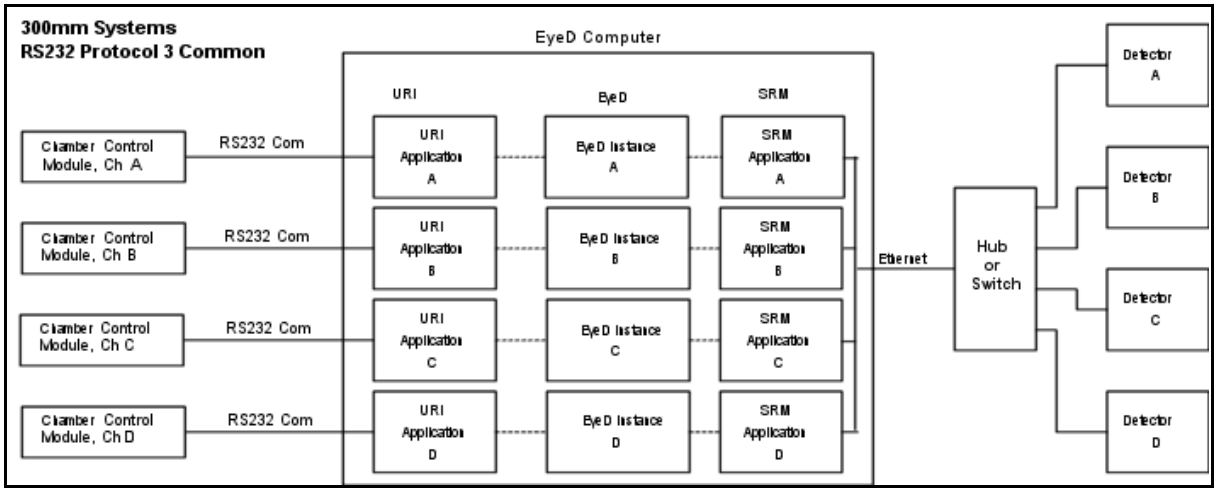


Figure 5-2. RS-232 IDEC Hardware and Software Configuration

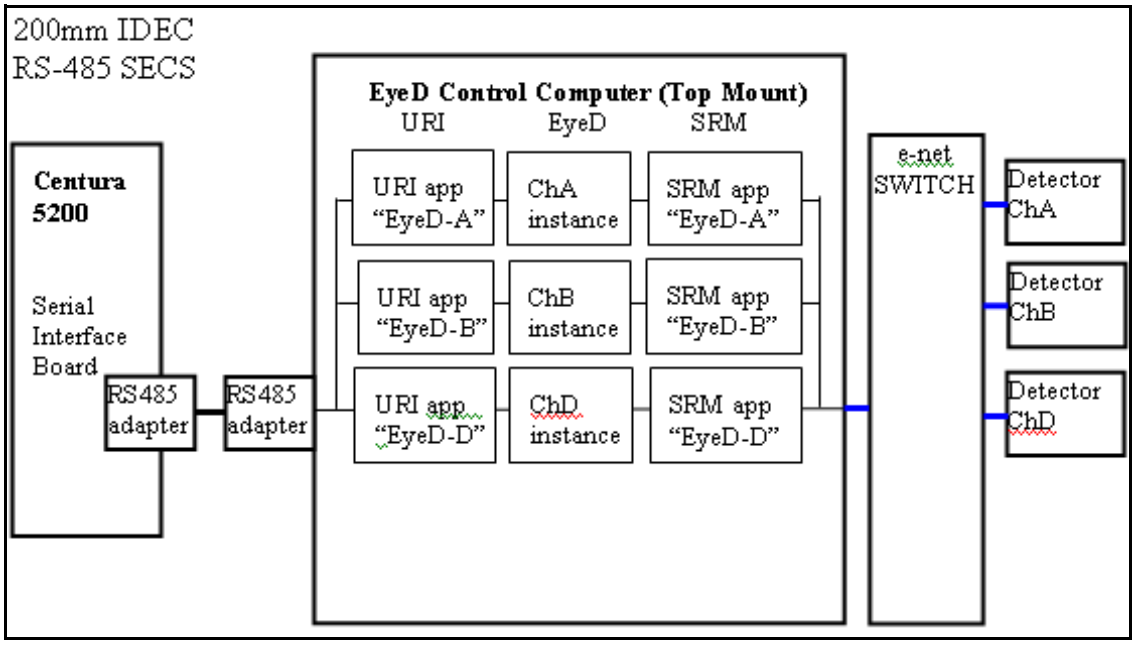


Figure 5-3. RS-485 IDEC Hardware and Software Configuration

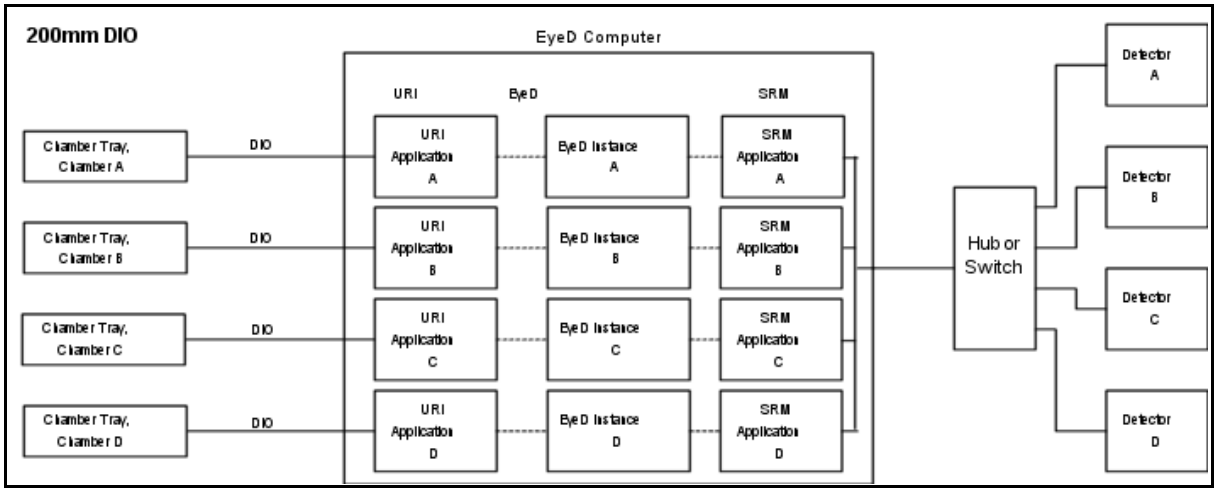


Figure 5-4. DI/O Hardware and Software Configuration

1. Insert the EyeD installation CD-ROM. If you do not have the CD-ROM, all components of the installation may be found on the Silicon Etch Intranet Site, under *Engineering/Adv. Modules/Software Updates*. Your AMAT Account Representative will obtain this for you.
2. Create and copy all files into a new folder: *C:\EyeD Installs*.
3. Double-click on *C:\EyeD Installs\EyeDXXXInstall.exe* (the installation file with the .exe extension). The Install wizard starts.



Figure 5-5. EyeD Install Wizard

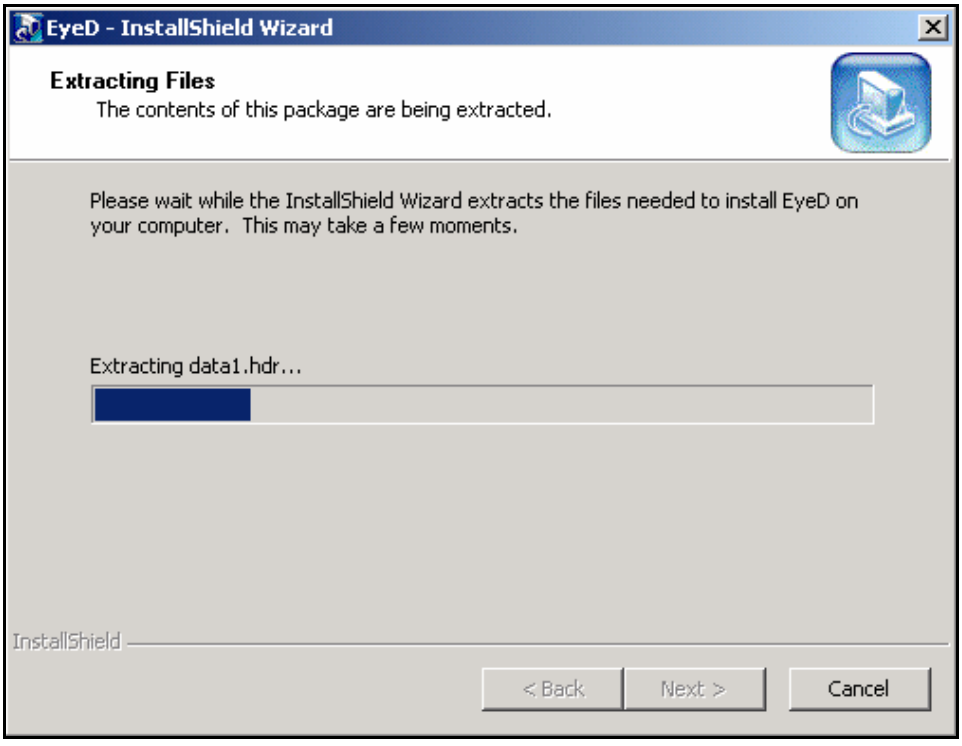


Figure 5-6. InstallShield Wizard: First Working Screen

4. The Install Fundamentals window, as shown in Figure 5-7, should pop up. Read the window and click **Next**.

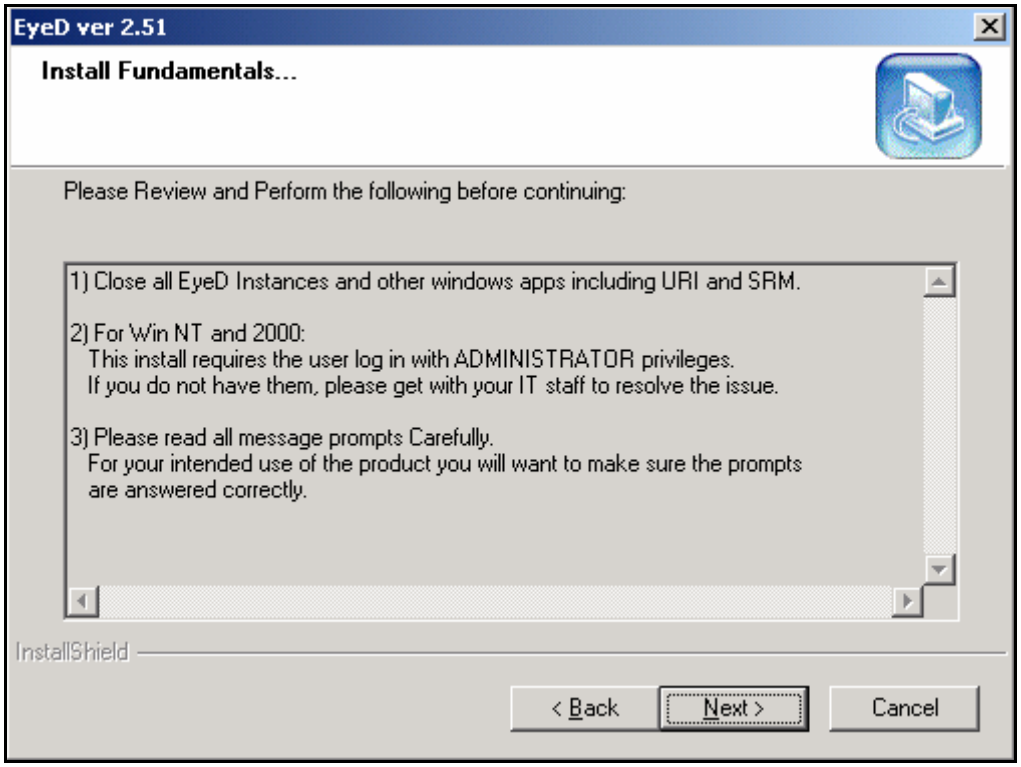


Figure 5-7. Install Fundamentals

5. If no previous version of EyeD is already installed on the computer, proceed to Step 6. If an existing version of EyeD is already installed on the system, the first window that pops up provides the option of Repairing or removing the installation. See Figure 5-8. Select **REMOVE-perform a complete uninstall** and click **Next**. Then click **Yes** on the Confirm File Deletion Dialog that follows to uninstall the existing installation. Repeat Step 4 once the uninstall process completes.

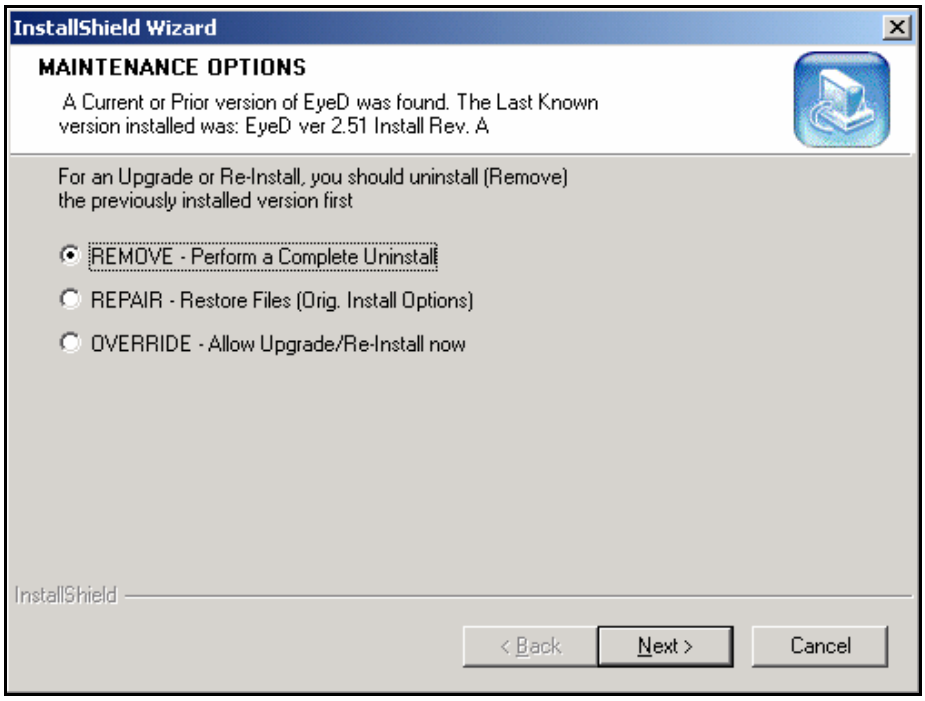


Figure 5-8. Remove, Repair, or Override Existing EyeD Installation

- **Remove:** uninstalls system components (.dll dynamic libraries, etc) of prior EyeD versions
- **Repair:** replaces all files of a particular installation
- **Override:** installs without performing an uninstall first.

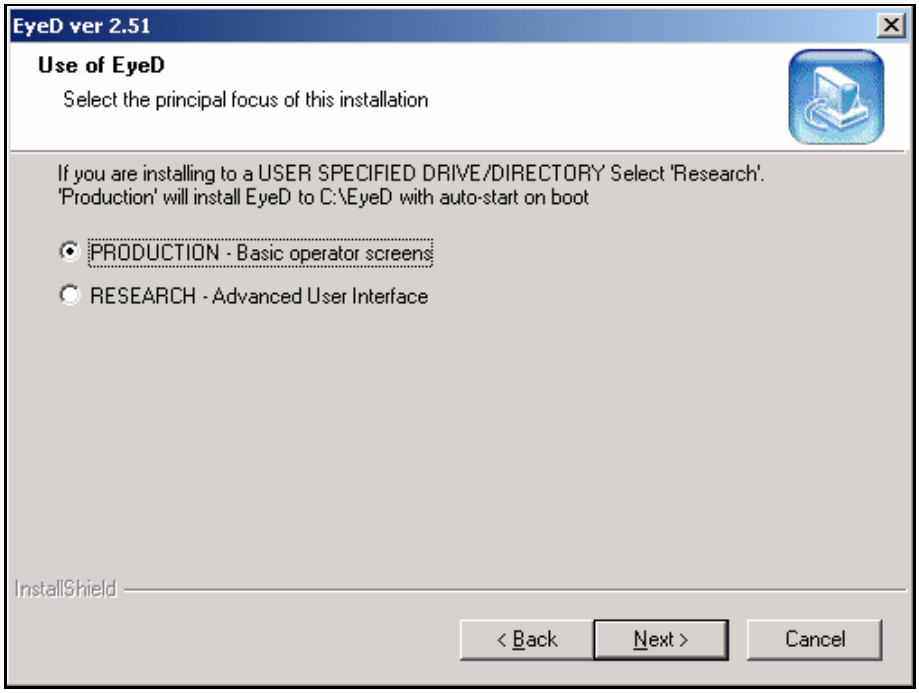


Figure 5-9. Select Mode: Research or Production

6. Click on **PRODUCTION - Basic operator screens** or **RESEARCH - Advanced User Interface** as the operating mode for the installation. Figure 5-10 shows the recommended setting for Production mode. To continued with Production mode, go to Section 5.1.1.1, Production Mode Installation. For Research Installation Mode, go to Section 5.1.1.2, Research Mode Installation

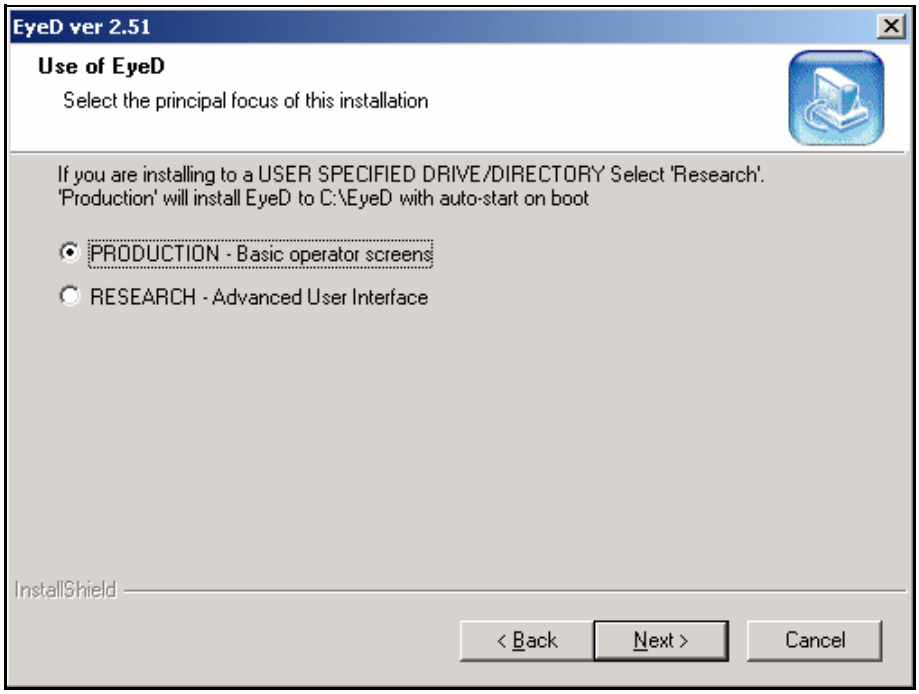


Figure 5-10. Select Mode: Research or Production

5.1.1.1 Production Mode Installation

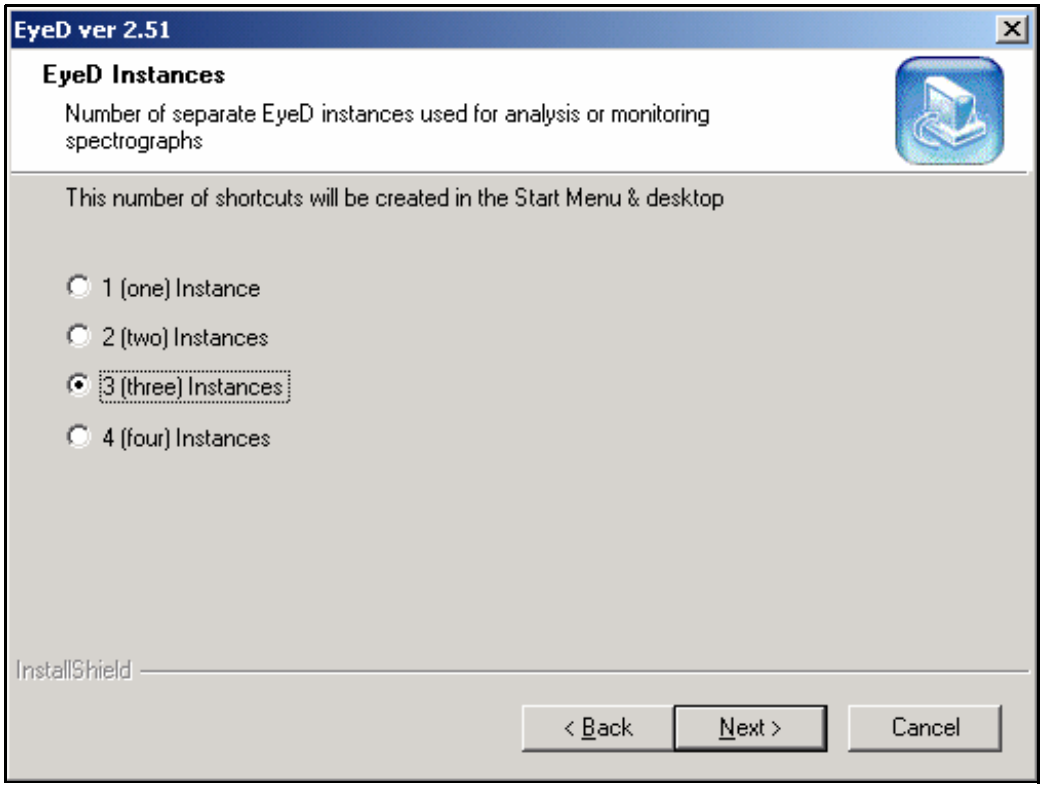


Figure 5-11. Select Number of EyeD Instances

1. Choose the number of EyeD instances to install, as shown in Figure 5-11. This will determine the number of instances that will be created on the Start menu and the number of icons on the desktop.

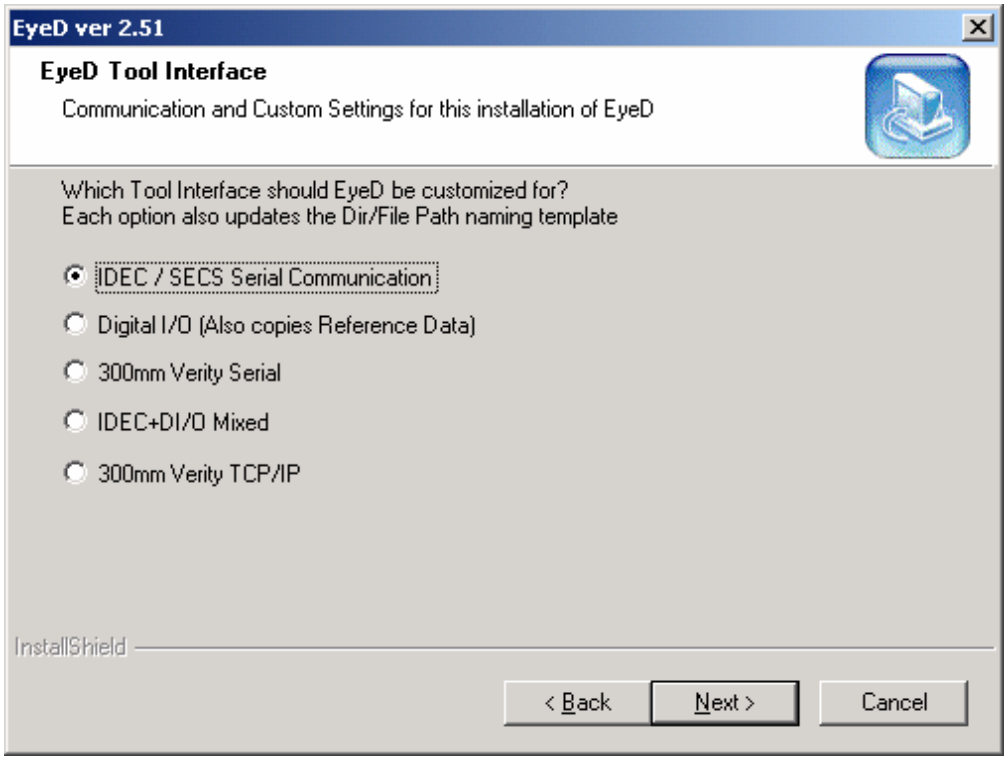


Figure 5-12. Select Communication Interface

2. Next, select the interface method for communication with the tool, as shown in Figure 5-12. For 200mm choose one of either IDEC/SECS Serial Communication, Digital I/O, or IDEC + DI/O mixed.

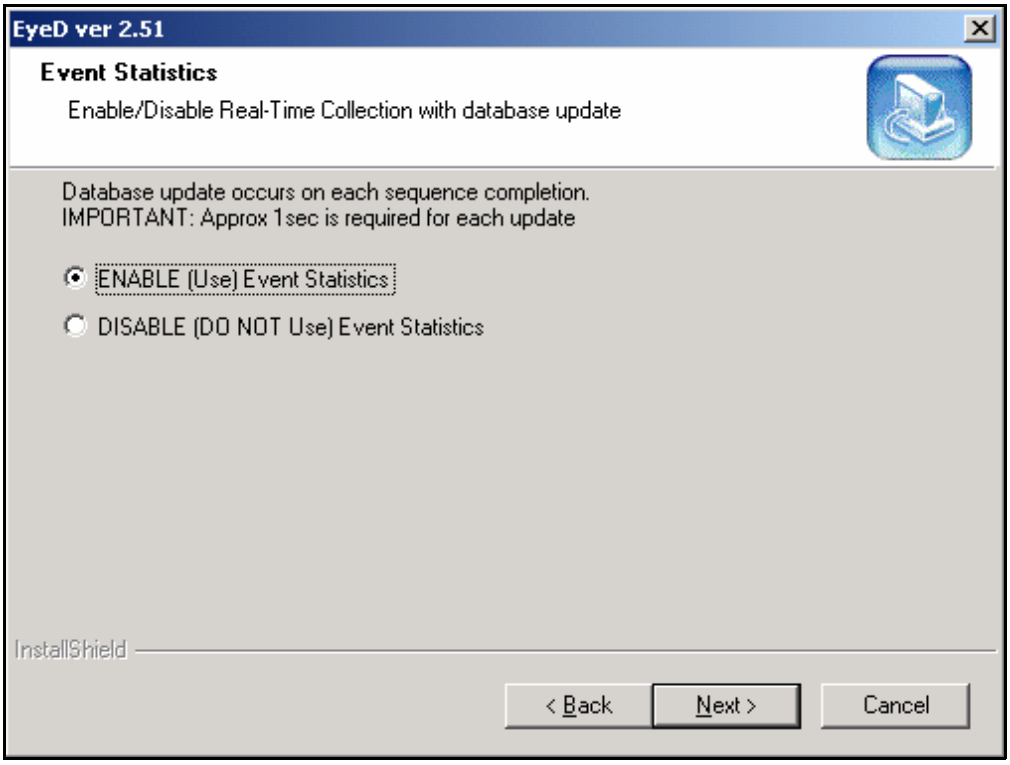


Figure 5-13. Even Statistics Selection Screen

3. Select an option for Event Statistics. Click on **ENABLE (Use) Event Statistics** to make this functionality available (see Section). Select **DISABLE (DO NOT Use) Event Statistics** if it is not required. See Figure 5-13.

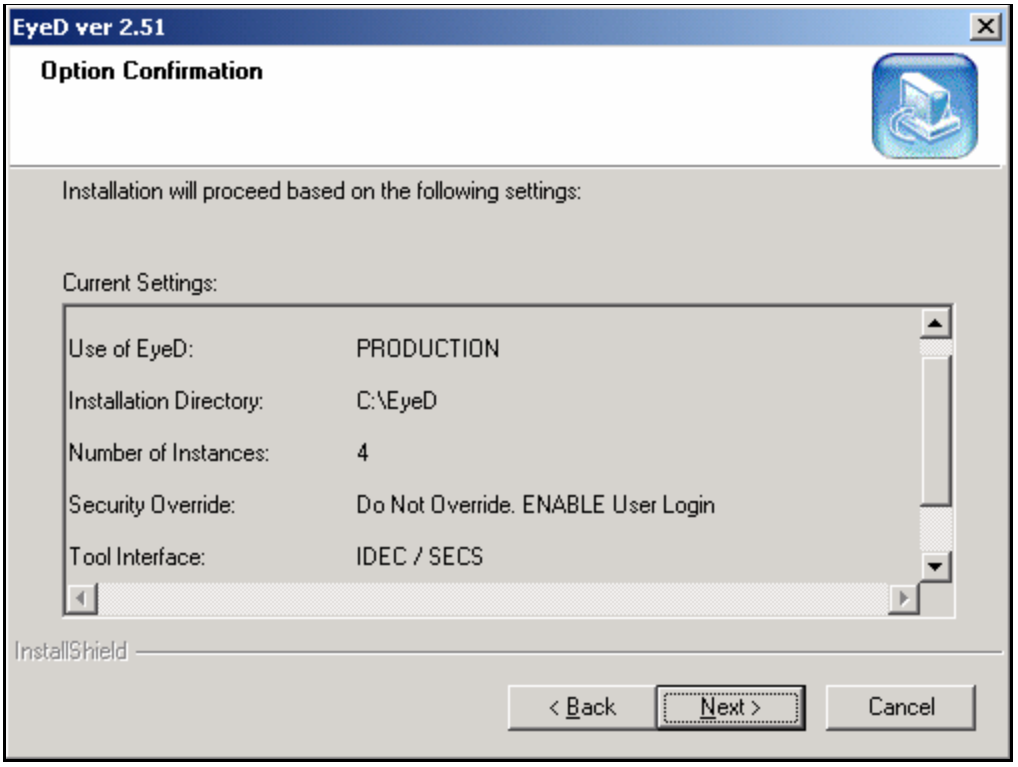


Figure 5-14. Option Confirmation Screen

4. At this point a dialog box will pop up summarizing the EyeD setup that will be installed, Figure 5-14. Review this carefully. Return to steps 5 - 11 above to make changes as necessary. Click **Next** to proceed with the installation.

   Go to Section 5.1.1.3, Installation Status for completion of the Installation

5.1.1.2 Research Mode Installation

The Research mode is the recommended mode for algorithm development. Once algorithm is complete, EyeD may be reinstalled in the Production mode.

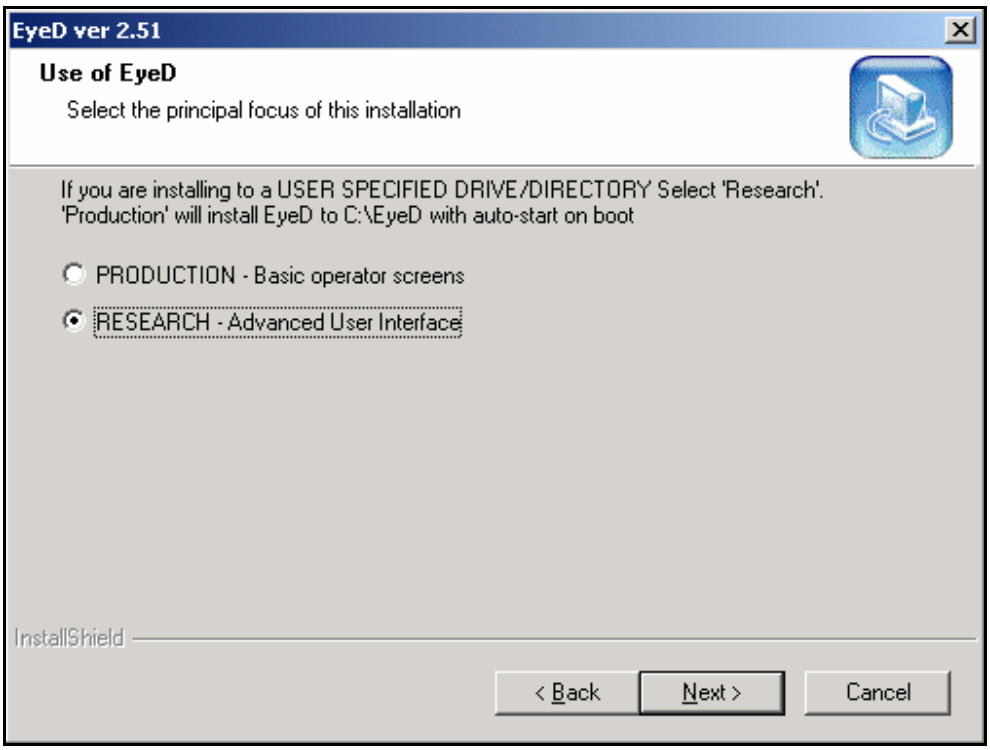


Figure 5-15. Select Research Mode for R&D.

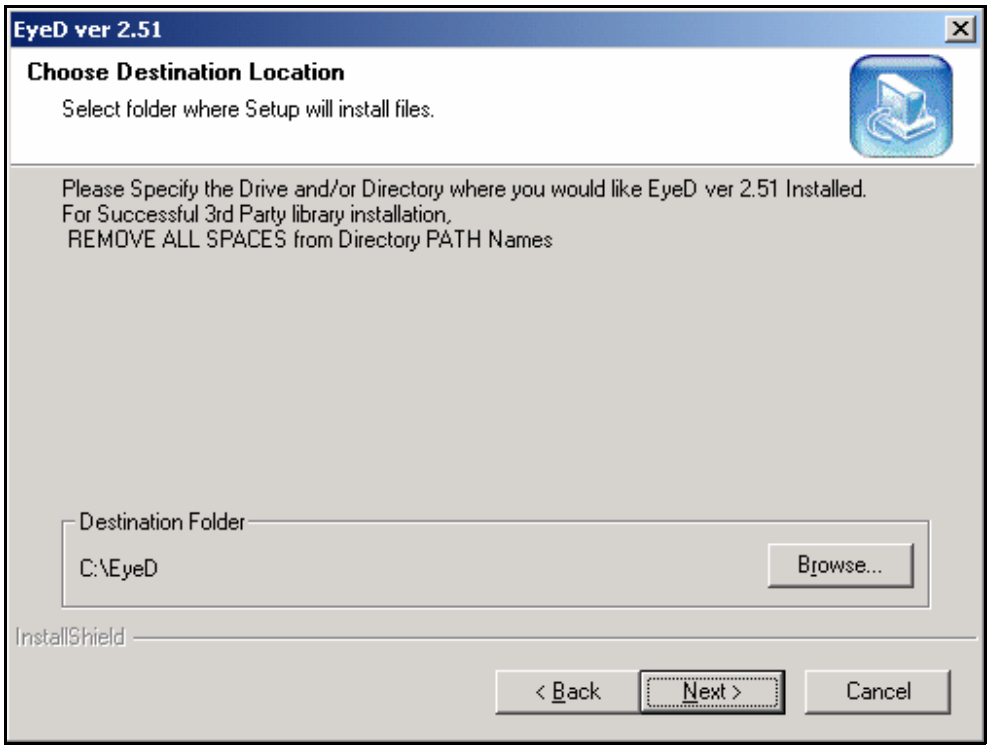


Figure 5-16. Location Selection Screen

1. In Research mode, the user has the option to specify the installation location. See Figure 5-16. Specify the desired installation location. Be careful when choosing an alternate installation location. If the default directory location for EyeD is not C:\ please contact Applied Materials. Installation affects the Windows registry files making it necessary to alter specific lines to properly register the EyeD software in the Windows registry file when using a drive designation other than C:\.

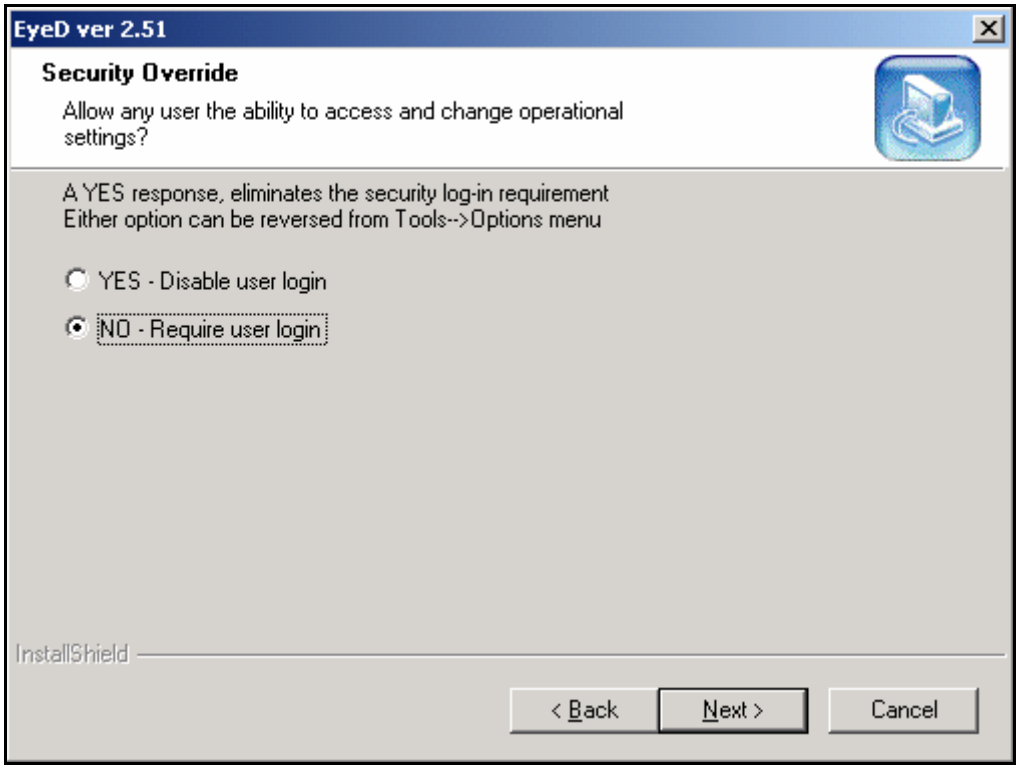


Figure 5-17. Security Override Screen

2. Choose whether or not to enable Security override. If you select **Yes** then logins will not be required and users will not be password-prompted for access to the software. Select **No** to require users to login before using the software. See Figure 5-17.

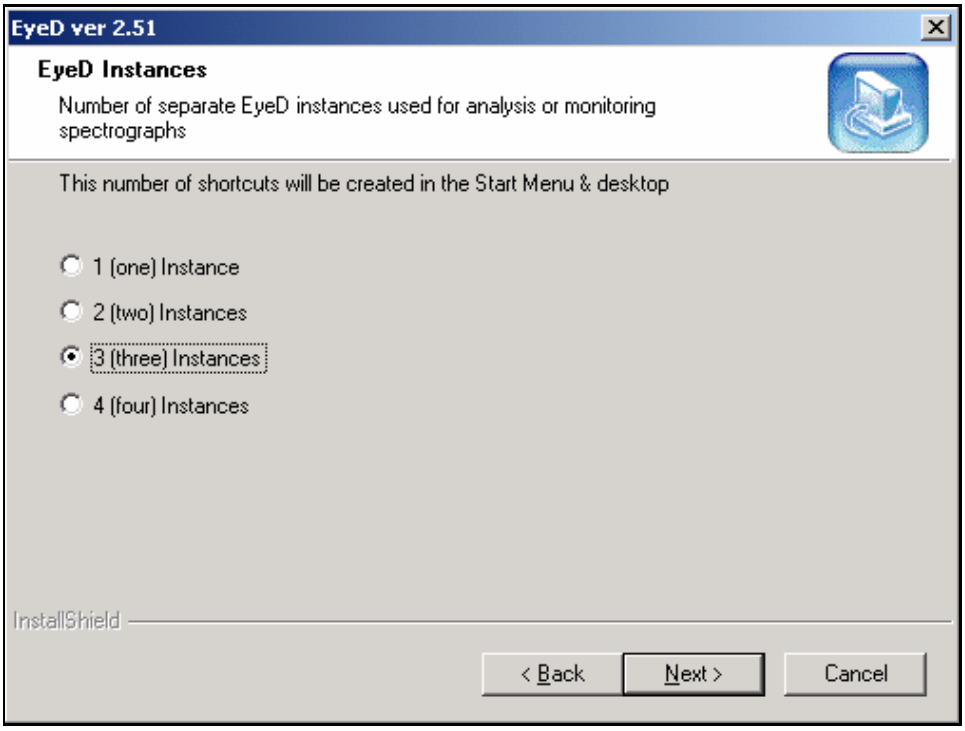


Figure 5-18. Select Number of EyeD Instances

3. Choose the number of EyeD instances to install, as shown in Figure 5-18. This will determine the number of instances that will be created on the Start menu and the number of icons on the desktop.

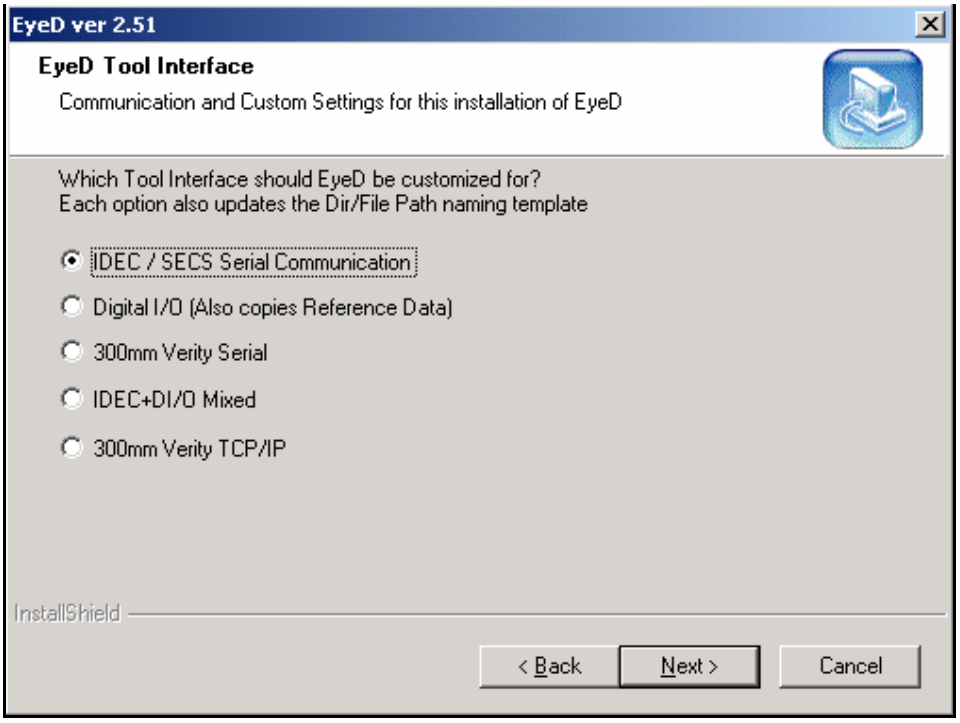


Figure 5-19. Communication Interface Selection Screen

4. Select the communication interface method for communication with the tool, as shown in Figure 5-19. For 200mm choose one of either IDEC/SECS Serial Communication, Digital I/O, or IDEC + DI/O mixed.

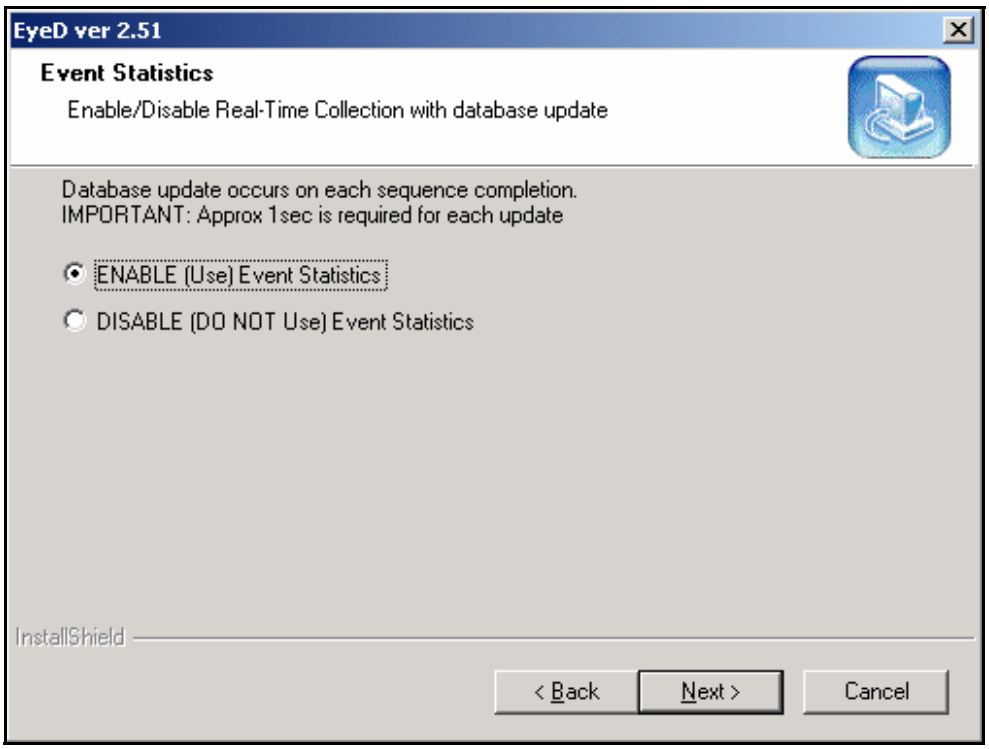


Figure 5-20. Event Statistics Selection Screen

5. Select an option for Event Statistics. Click on **ENABLE (Use) Event Statistics** to make this functionality available (see Section). Select **DISABLE (DO NOT Use) Event Statistics** if it is not required. See Figure 5-20.

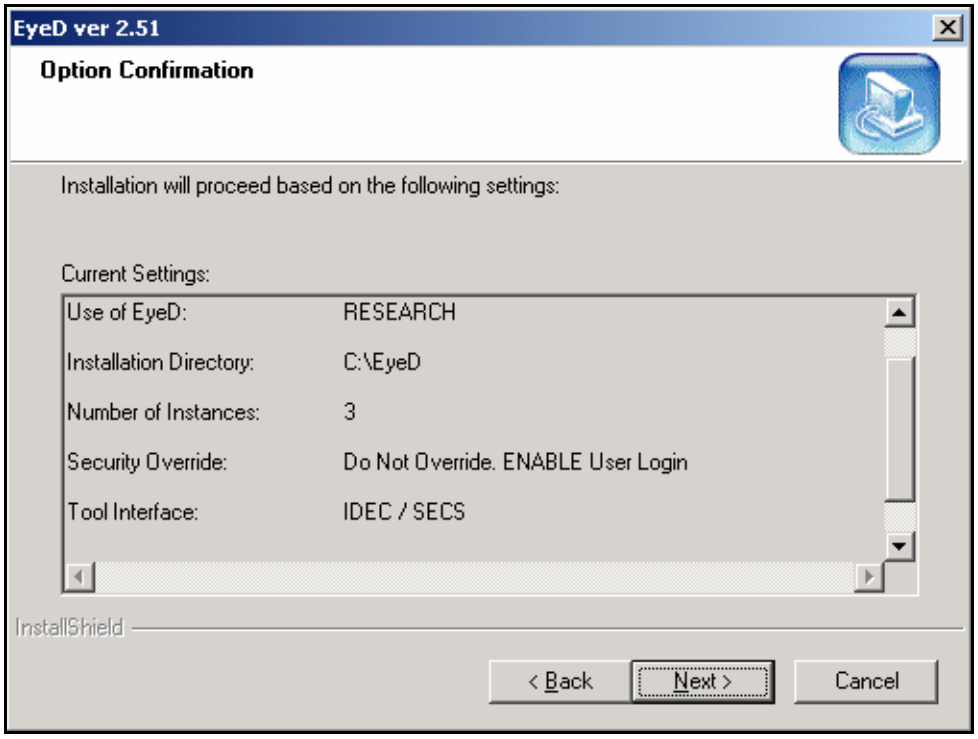


Figure 5-21. Option Confirmation Window

The Option Confirmation window appears when all the available options for the Research mode have been selected. To change any of these options, return to Section 5.1.1.2, Research Mode Installation. If the selected options are correct, proceed with Section 5.1.1.3, Installation Status.

5.1.1.3 Installation Status

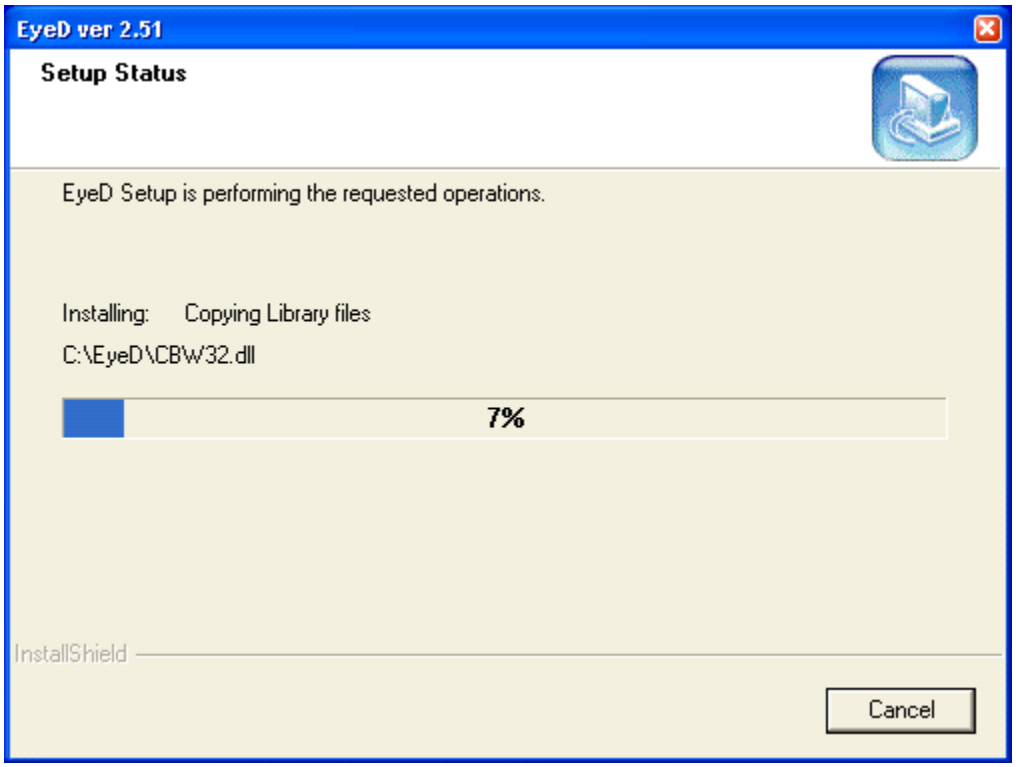


Figure 5-22. EyeD Software Installation Status

After the files are installed, the user will be presented with the options to retain the previous user preferences if this computer had EyeD installed before this installation. These screens will *NOT* appear in new installations in which EyeD has never been installed.

If EyeD was previously installed on the computer, you will see Dialog boxes (Figure 5-23, Figure 5-24 and Figure 5-25) requesting permission to overwrite Activity Logs, Auto Delete/Archive settings and Data File Template settings. If you select **Yes** at each prompt the existing data will be overwritten. The only reason to do this is if you wish to do futher analysis on the data, or there is another reason to retain settings from the prior EyeD installation.

The screen asks if the user desires to keep the preferences found under *TOOLS==>OPTIONS==>GENERAL==>Activity Log*.

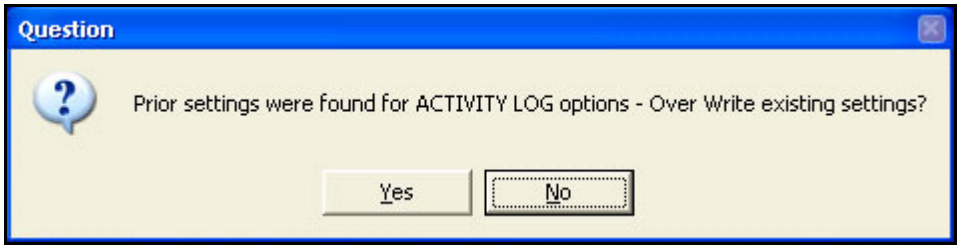


Figure 5-23. Overwrite Activity Log Options: Yes or No

The screen asks if the user desires to keep the preferences found under *TOOLS==>OPTIONS==>AUTO DELETE*.

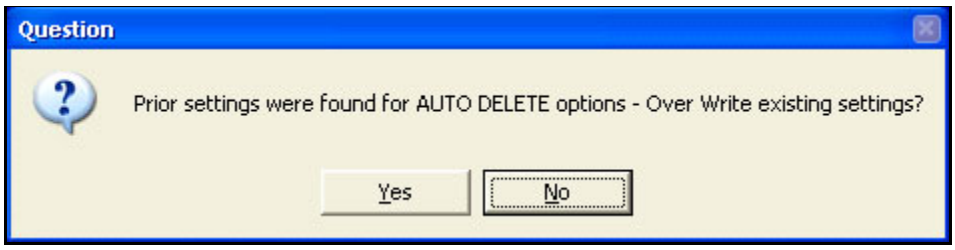


Figure 5-24. Overwrite Auto Delete Options: Yes or No

The screen asks if the user desires to keep the preferences found under *TOOLS==>OPTIONS==>DIRECTORIES*.

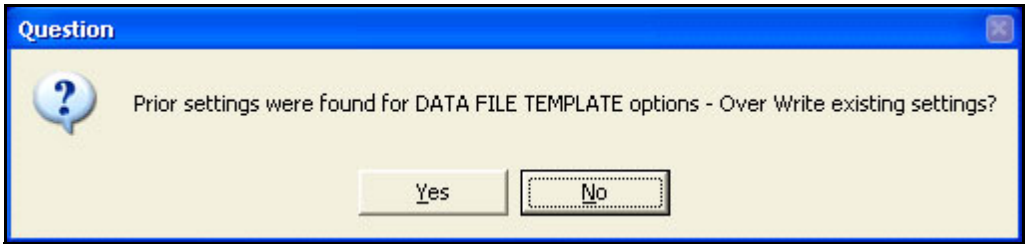


Figure 5-25. Overwrite Data File Template Options: Yes or No

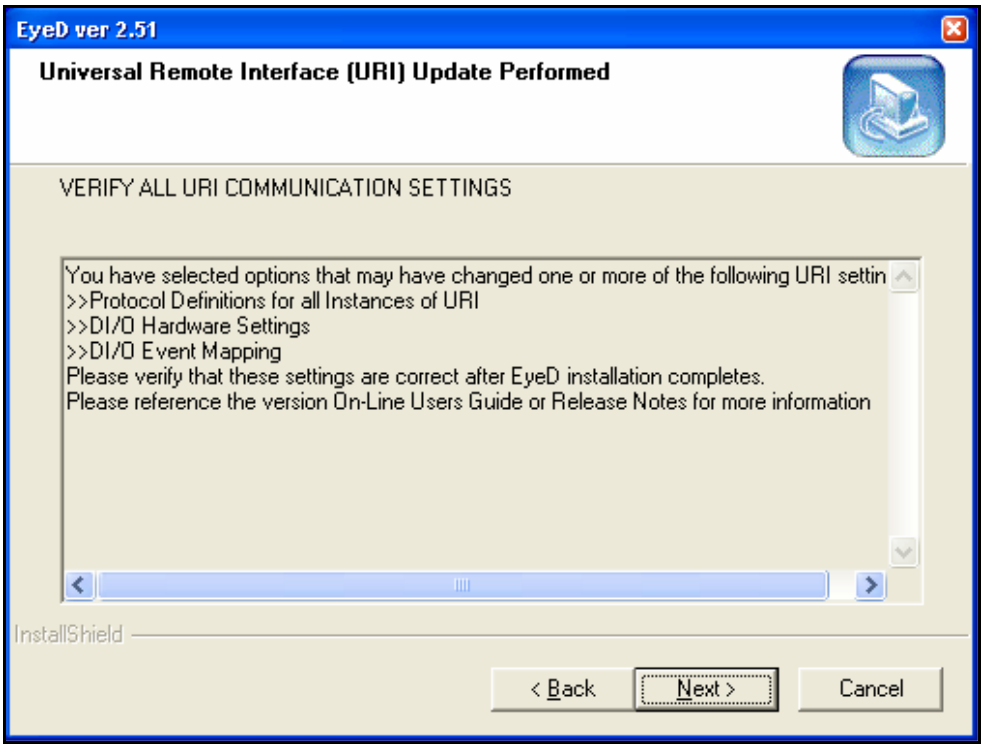


Figure 5-26. URI Verification Window

After these dialog boxes, the final installation screen is presented.

6. Once the installation is complete, you will be prompted to restart the computer to finalize the installation. Reboot the computer to complete the installation. See Figure 5-27

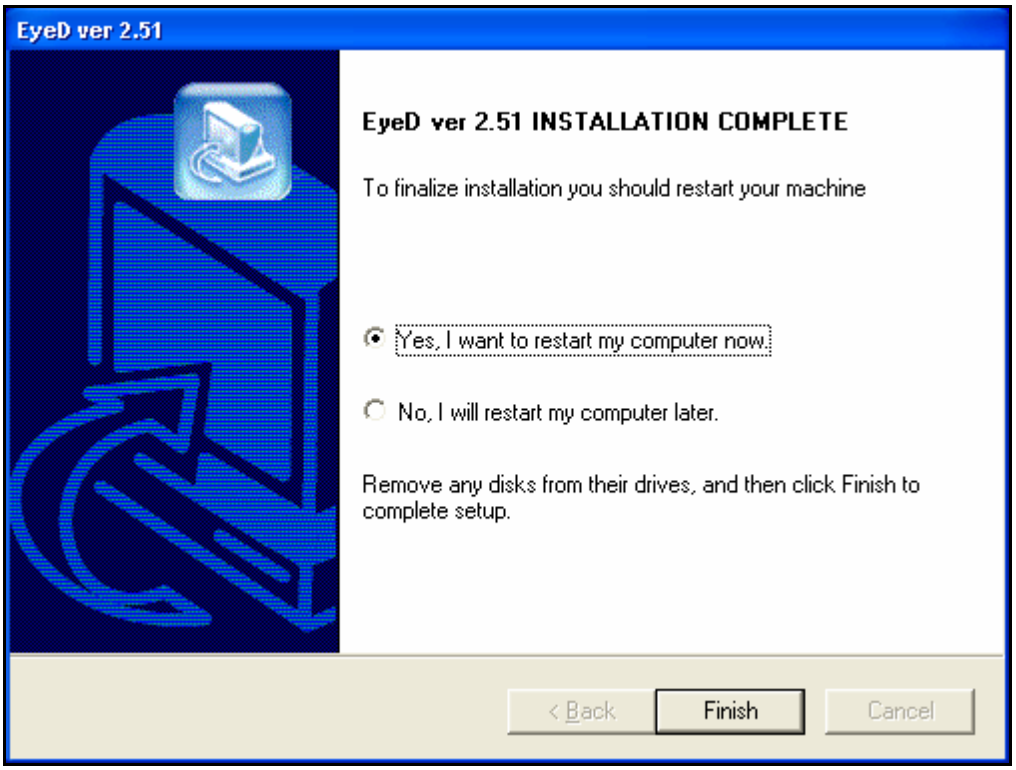


Figure 5-27. Reboot the Computer to Complete the Installation

When installation is completed, then the URI settings will be automatically made for either DIO or IDEC serial communications, and there will be no need to alter user preference parameters within URI and EyeD. Start all EyeD instances and place each into REMOTE mode for the following communications test.

Note that the auto-remote feature of EyeD is not enabled until each instance is initially set to remote after EyeD application launch. Thereafter, if a user switches an instance to local mode for reprocessing or for editing an algorithm, then EyeD will automatically go to remote (production) mode if an endpoint handshake request comes from the Centura. If the initial switch to remote is not made, then the handshake request will not be answered by EyeD, and the chamber will fault.

At the end of the installation, the EyeD directory should resemble the following screen:

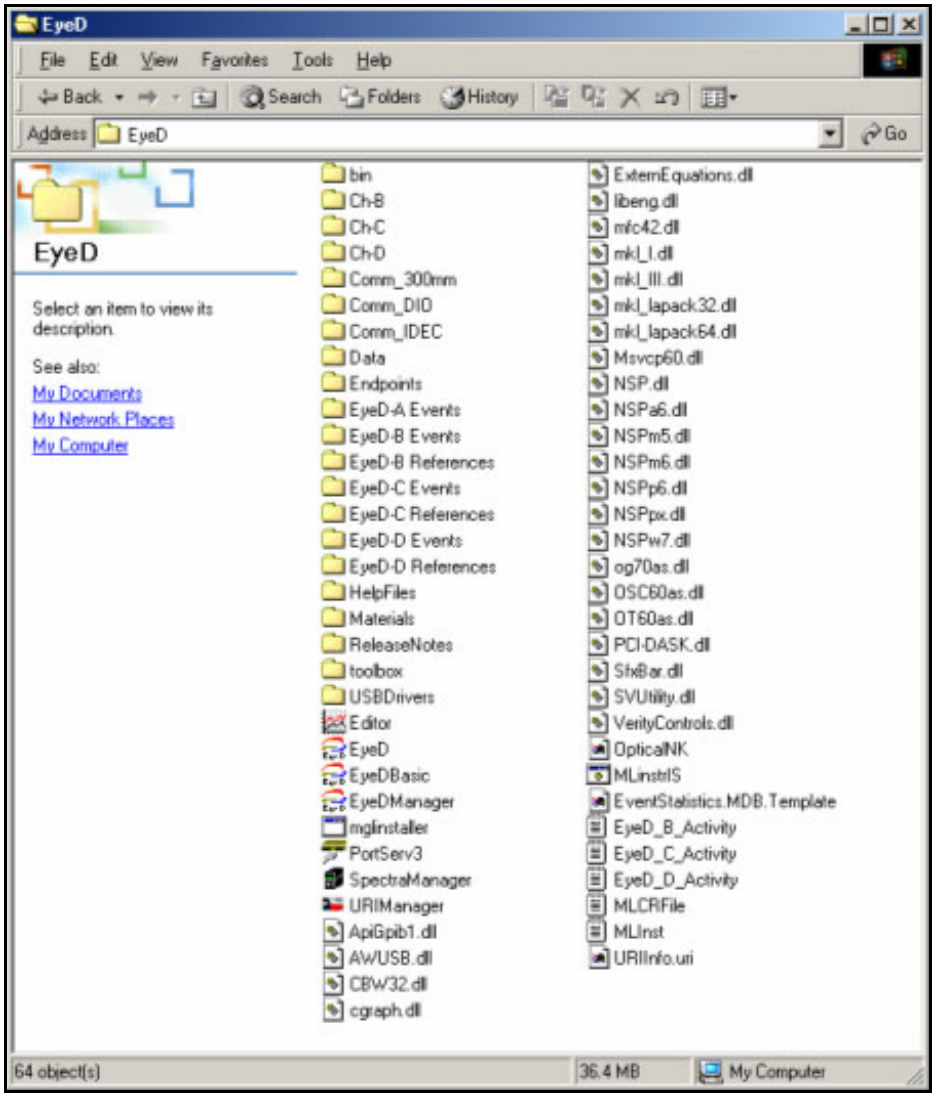


Figure 5-28. EyeD Directory

5.1.2 Installing EyeD Software onto an AMAT K-Station (Windows NT)

When installing EyeD on a Windows NT (K Station) computer, some required dynamic link libraries (DLLs) will not have been installed automatically. These installations are completed by launching *MLinstr.bat* manually, and manually launching *mdac-XXX.exe*. To install EyeD on a K-Station, the installer ***must*** be logged in as an Administrator in order to have the Windows Registry update properly. The Windows version must be NT 4.0 with Service Pack 6, or later. Also, an *EyeD.bat* file must be included in the shortcut, and not *EyeD.exe*. The .bat file properly sets the Win NT environment (path) prior to starting *EyeD.exe*.

1. Insert the disk containing the desired version of EyeD software. The MDAC file and the *EyeD.bat* file are included on the disk. Also, they may be downloaded from *http://amat.mis.amat.com/sietch/engineering/index.htm.*
2. Launch the **MDAC** executable (i.e. *mdac_typ2.50.exe*)

3. Launch *EyeDXXXINSTALL.exe*.
4. Now the EyeD software may be installed. Follow the steps described in the previous section, typing **R** in the open field in the **EyeD Usage** window.
5. Once the installation is complete, open the CD-ROM EyeD directory and copy the *EyeD.bat* file into the EyeD directory (*C:\EyeD*).
6. Right click on the EyeD icon on the desktop and select **Properties**. Click on the **Shortcut** Tab and enter *C:\EyeD\EyeD.bat* in the **Target** field. See Figure 5-29.

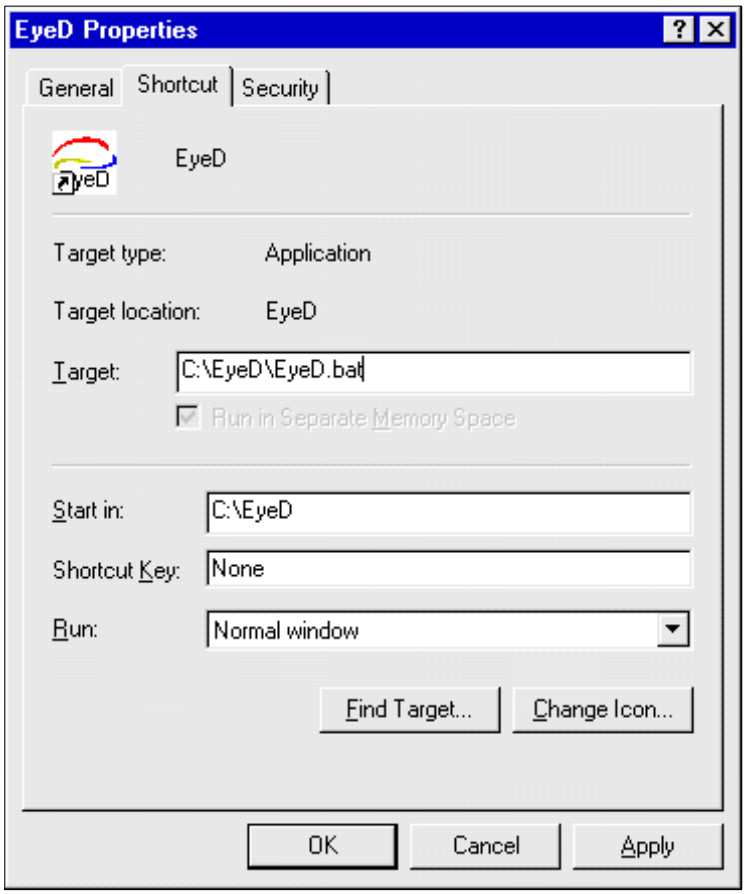


Figure 5-29. Changing the EyeD Instance Target to the *EyeD.bat* File

5.2 Inserting Multiple Spectrograph Icons

EyeD software is designed to function with multiple instances of itself when controlling more than one spectrograph from a single computer. When initially installed there will be four EyeD Icons. If during installation, testing, and algorithm development it is necessary to delete any of the icons, they may be recreated.

5.3 SRM and URI

The Spectra Resource Manager (SRM) is a separate program in the EyeD software that integrates the control computer with all of the EyeD spectrographs. The Universal Remote Interface (URI) is a similar application linking the software with the Centura.

5.3.1 Spectra Resource Manager Setup

All spectrographs are shipped with the same default IP address. To avoid communications conflicts, only one spectrograph at a time should be configured for communication. This involves setting the IP address so that it is unique for that particular spectrograph on the system: during the process, the cables for all other spectrographs yet to be configured should be disconnected from the Ethernet hub. Figure 5-30 and Figure 5-31 illustrate the configuration process. The steps are outlined below for a spectrograph installed on chamber A.

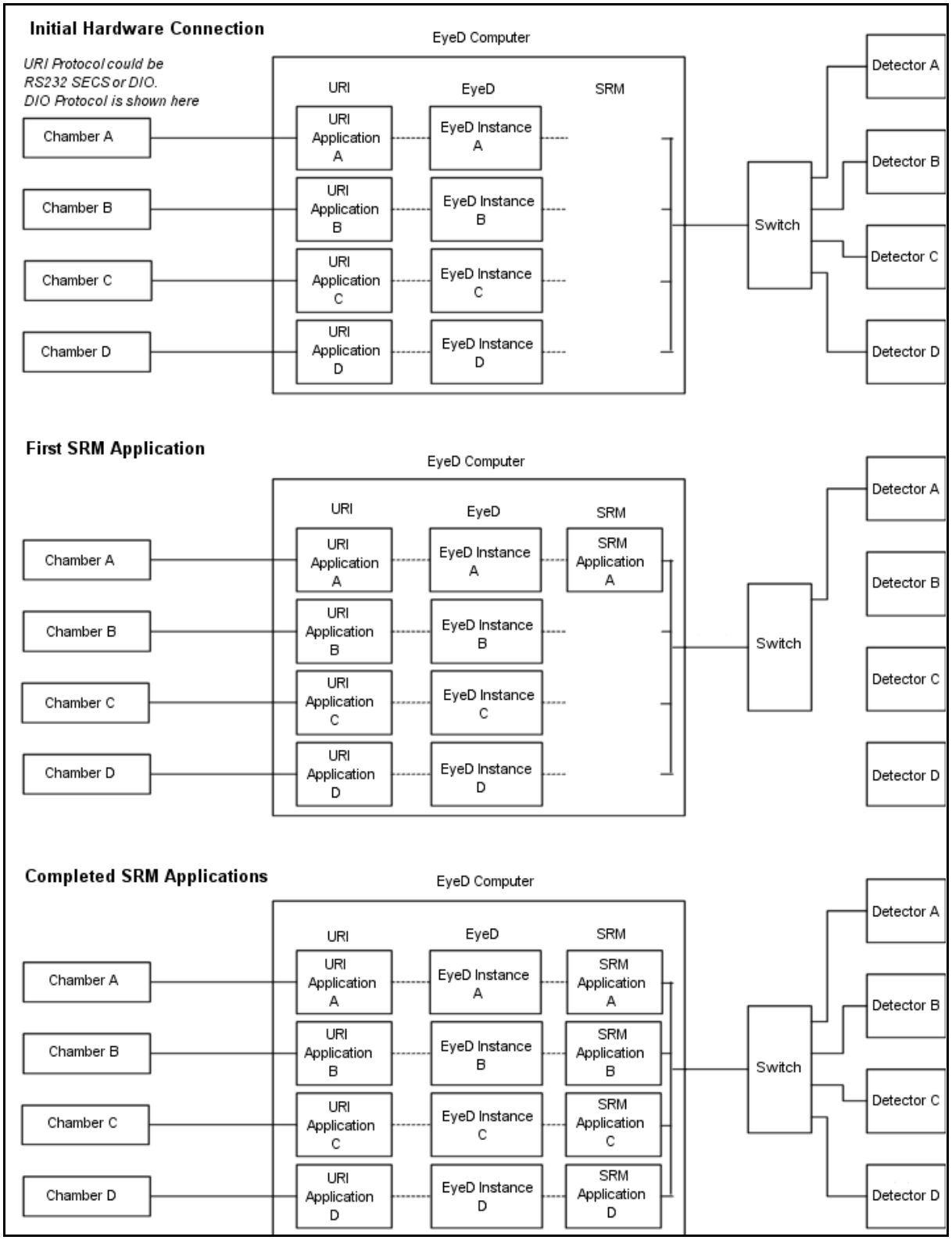


Figure 5-30. SRM Setup Diagram

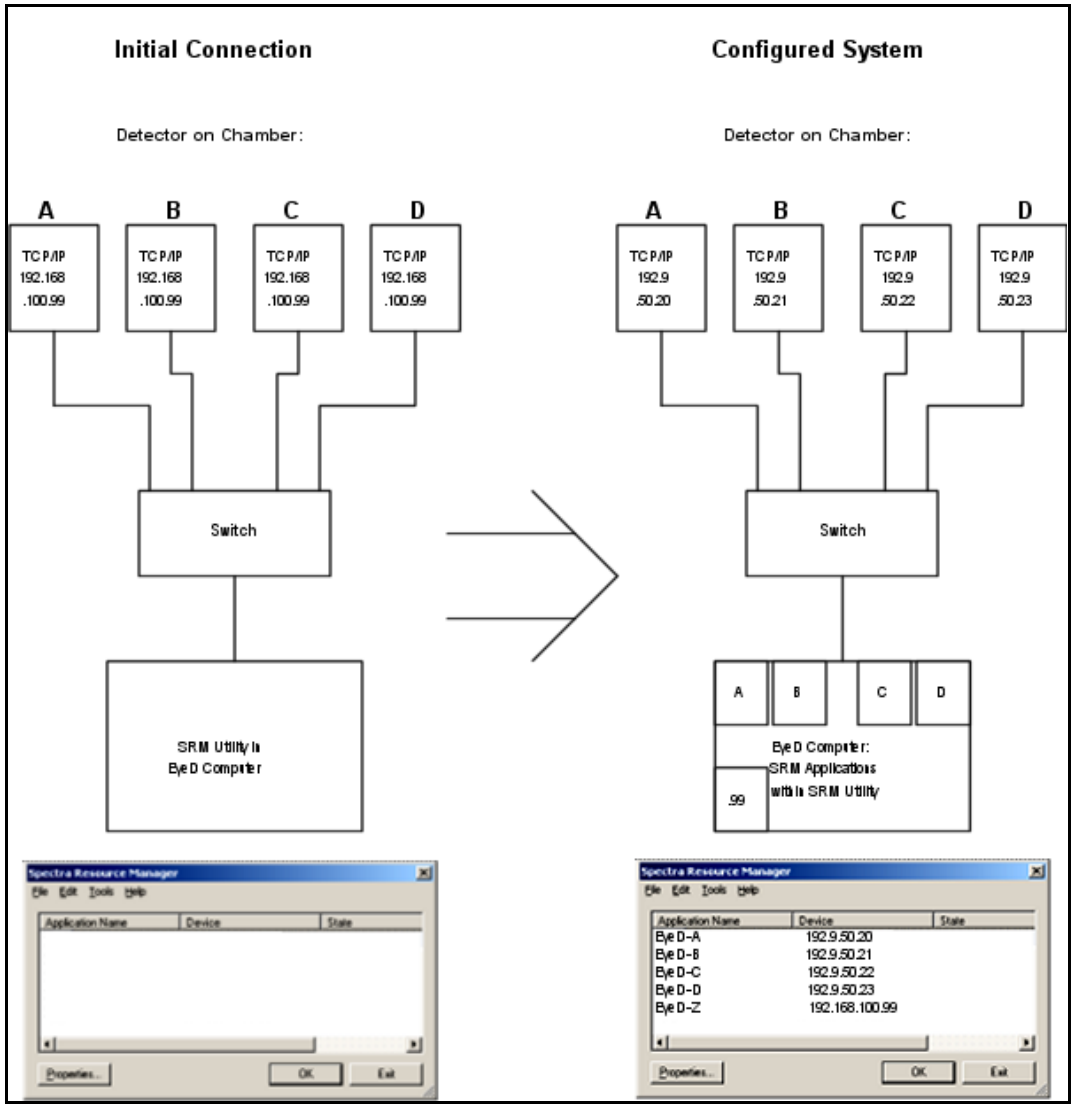


Figure 5-31. SRM Configuration Overview

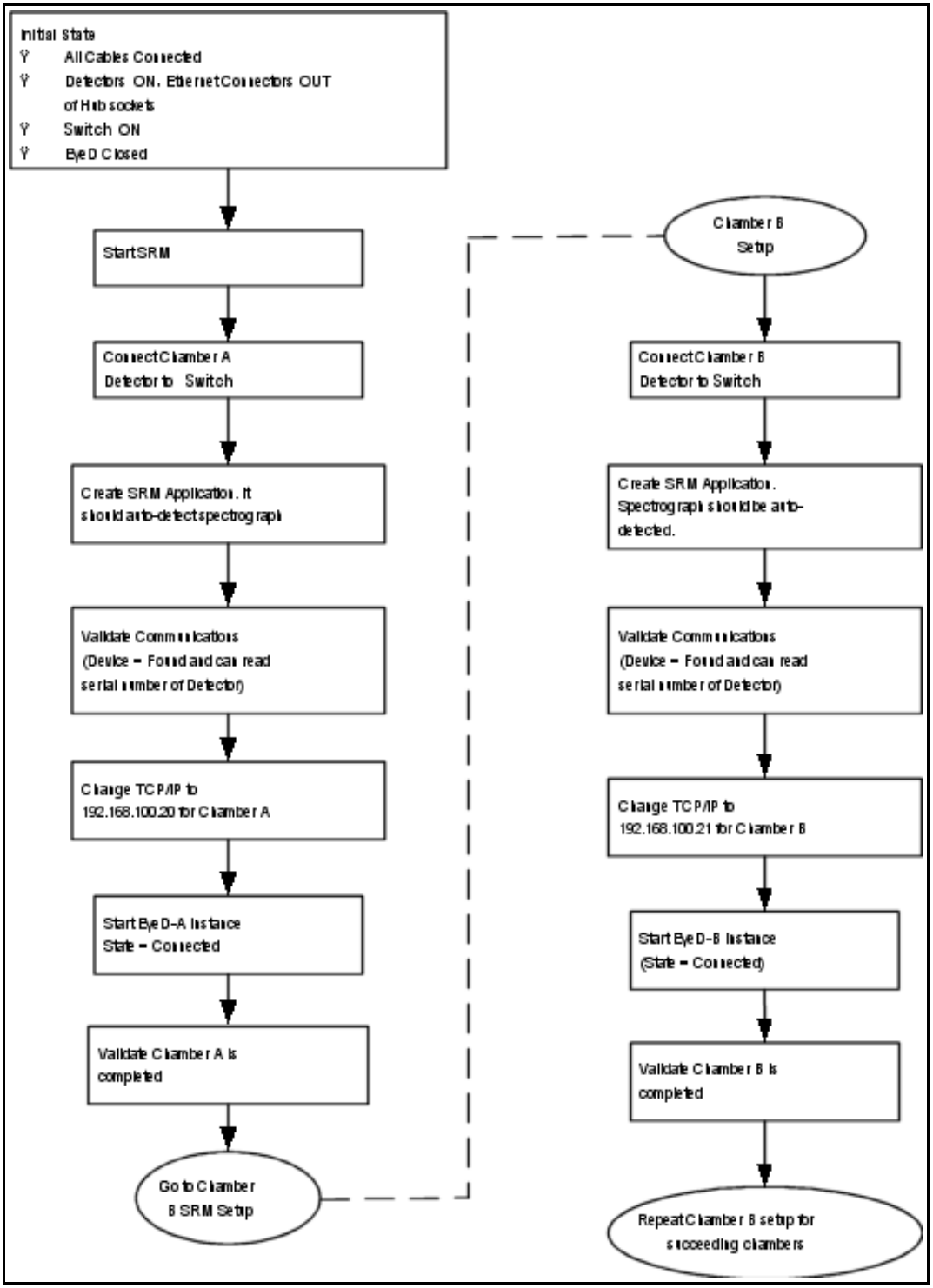


Figure 5-32. Flowchart for Configuring SRM - New Software

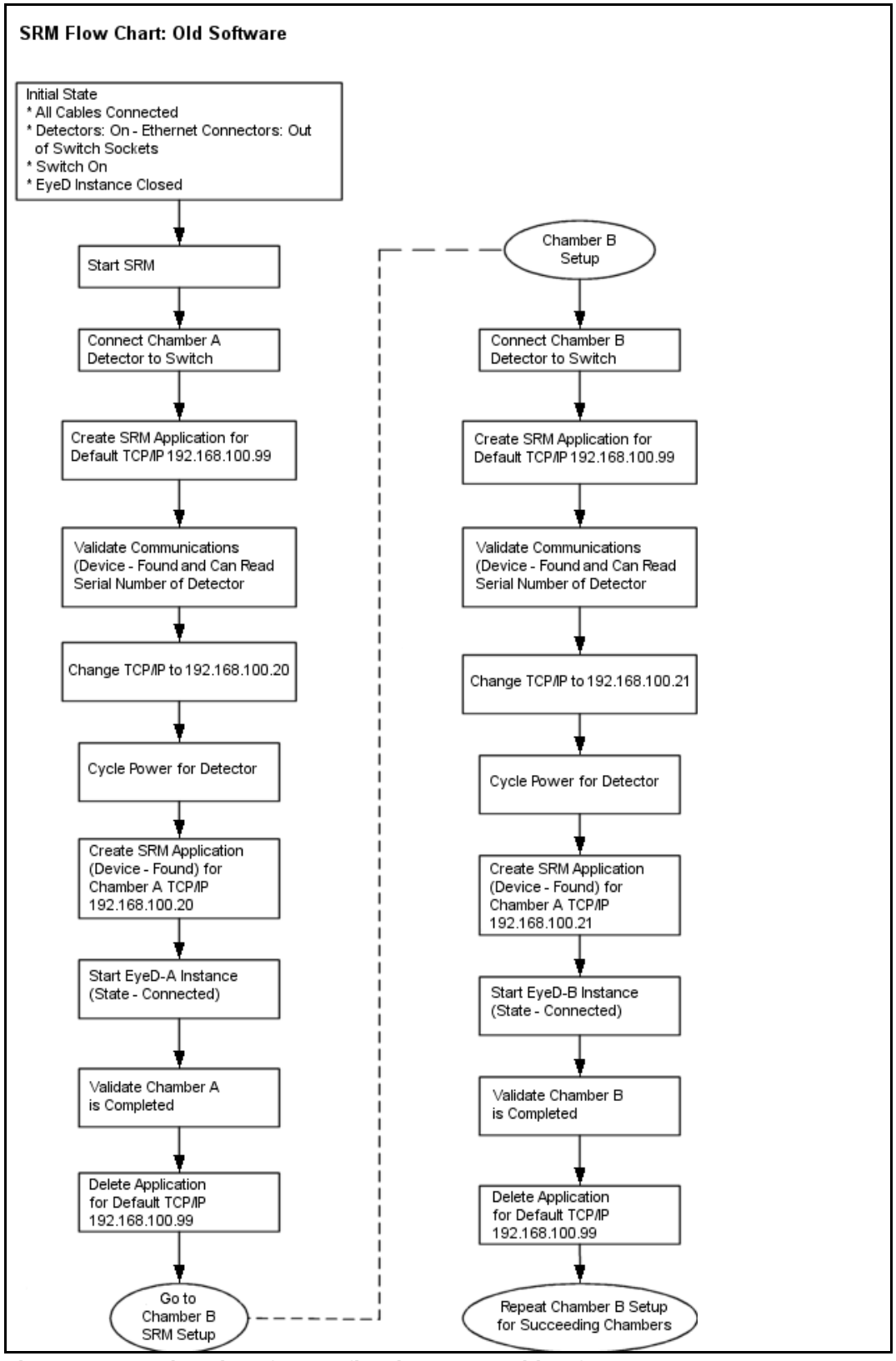


Figure 5-33. Flowchart for Configuring SRM - Old Software

Configure the Spectra Resource Manager (SRM) by completing the following steps:

1. Close the EyeD application.
2. Leave Spectrograph A connected to the Ethernet hub. Disconnect all other spectrographs from the hub. Ensure the hub and spectrograph are both on.
3. Run C:\EyeD\SpectraManager.exe or double click on the SRM icon in the system tray (lower right hand corner of the screen). The SRM window appears, see Figure 5-34.



Figure 5-34. Spectra Resource Manager Window

4. If no spectrographs have been configured, there should be no applications shown in SRM. Delete any that are. Right click on the application to be deleted and select Delete an Application.
5. Right-click in the white area of the window. Select **Insert New Application**.

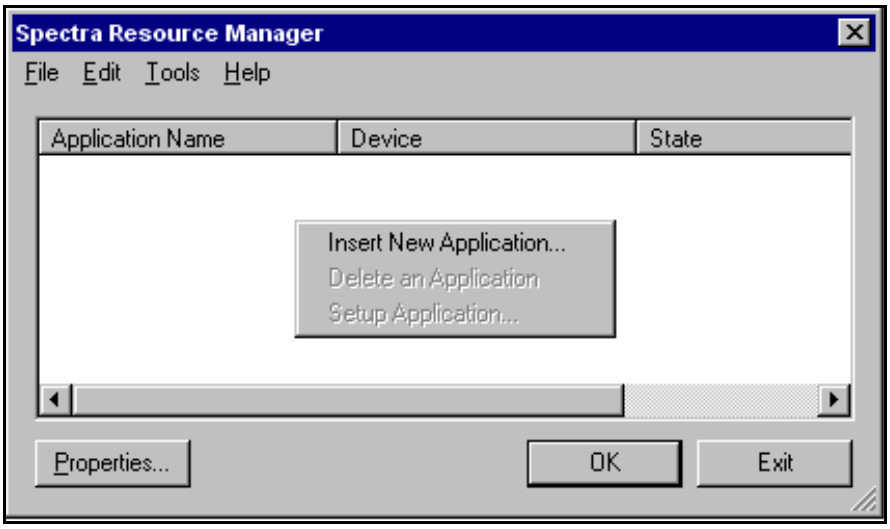


Figure 5-35. Insert Application Pop Up Within SRM

6. If password protection is enabled, (see Section 3.2.4) the Login Window will open. Login as Admin, using the password: 752762.
7. The Application Setup window opens.
8. Enter the name EyeD-A for Chamber A. Use the appropriate designation for succeeding chambers.
9. Select **TCP/IP** as the connection and click on the OK button.
10. Newer versions of SRM should detect the spectrograph automatically, at which point the serial number should be displayed in the Device combo box as in Figure 5-36. Data sources may also be assigned automatically. See step 15 to verify that they are correct or to assign data sources, if none are assigned. Refer to Section 5.3.1.1 if the Spectrograph is not automatically detected, for instructions on how to set the IP address manually.

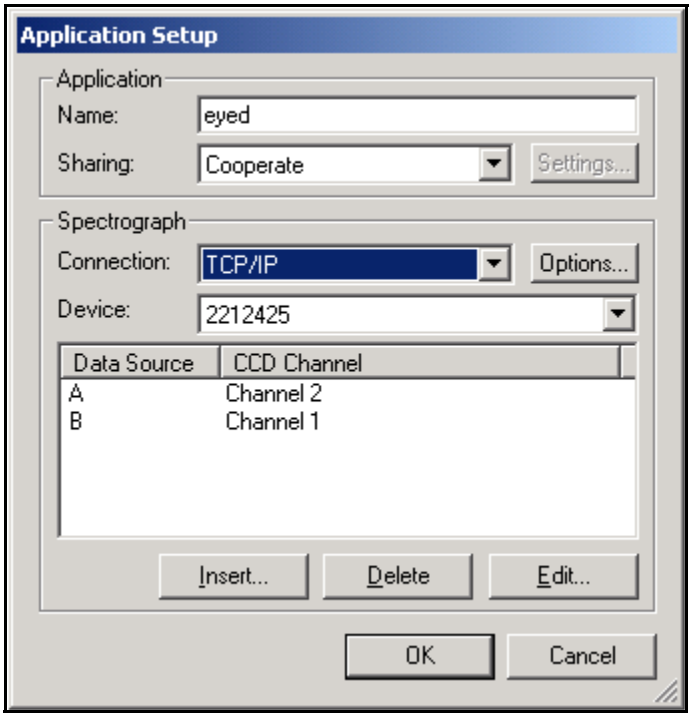


Figure 5-36. Application Setup Window showing a detected Spectrograph

11. Click **OK** to exit the Application Setup Dialog. The main SRM window is left with a dialog asking whether the IP address will be changed from the default value at this point, see Figure 5-37. The IP address will need to be changed in order to configure additional spectrographs.

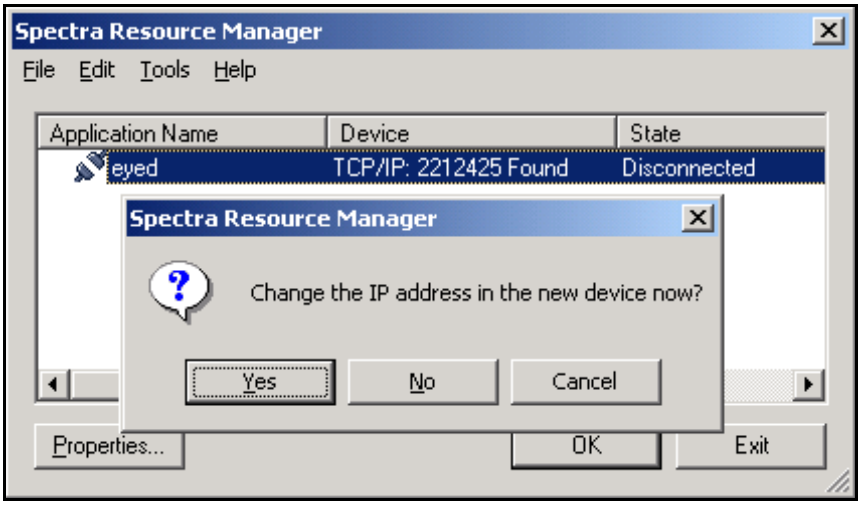


Figure 5-37. Dialog to change IP Address

12. Click YES to change the IP address. In the dialog that is brought up, shown in Figure 5-38, the IP address should be changed according to the Chamber location and the type of EyeD system being configured. All addresses should have the format 192.168.100. xx, where xx is one of the following pairs of digits depending on the Chamber and EyeD Type:

Table 5-1. IP Address Last Digits

	OES	IEP
Chamber A	10	20
Chamber B	11	21
Chamber C	12	22
Chamber D	13	23

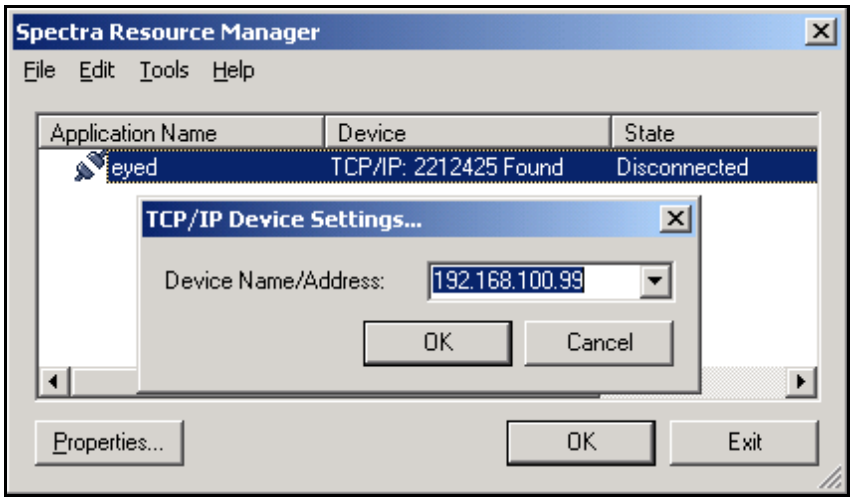


Figure 5-38. Changing the Spectrograph IP Address

13. Click **OK**.

14. See Figure 5-39. The State field should say Disconnected, even though the spectrograph has been identified by SRM. It will remain listed as Disconnected until SRM is closed and the EyeD application is restarted. State refers to communication status between the EyeD Instance and the SRM Application

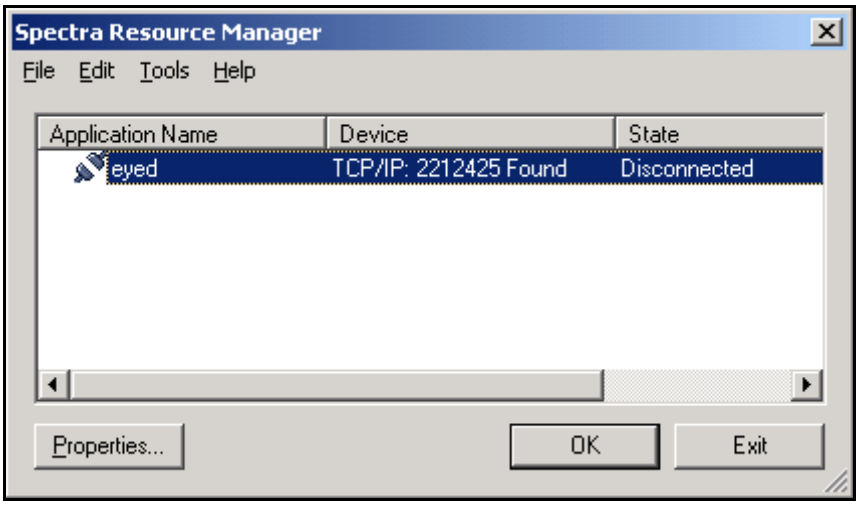


Figure 5-39. SRM Main Window with Application EyeD-A Listed

15. If data sources do not come up automatically when the spectrograph is detected, they need to be assigned. Right click on the Application in the main SRM window, and select Setup Application. This will bring up the Application Setup Window. Click on Insert to assign data sources. If the system is EyeD OES, then assign Data Source A to Channel 1. If the system is EyeD IEP, then assign Data Source A (IEP) to Channel 2 and Data Source B (OES) to Channel 1. See Figure 5-40 and Figure 5-41.

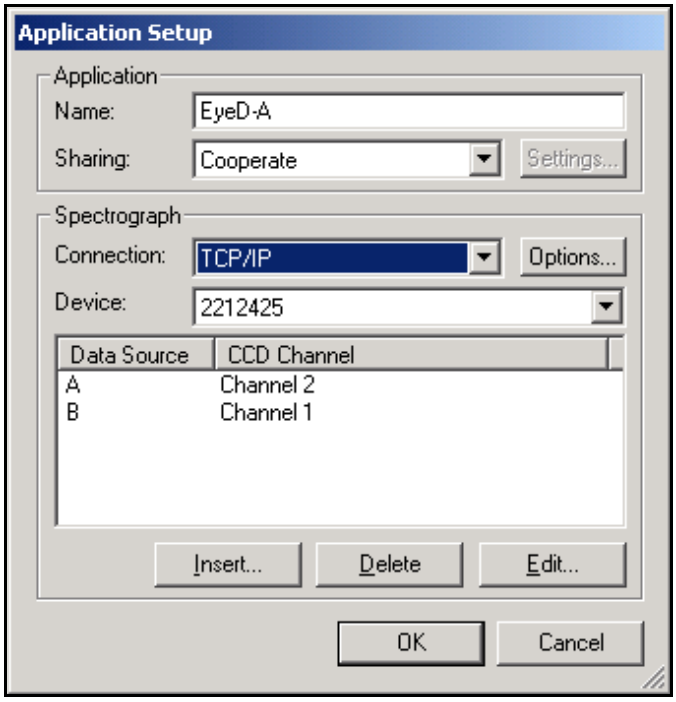


Figure 5-40. SRM Application Setup for EyeD-IEP

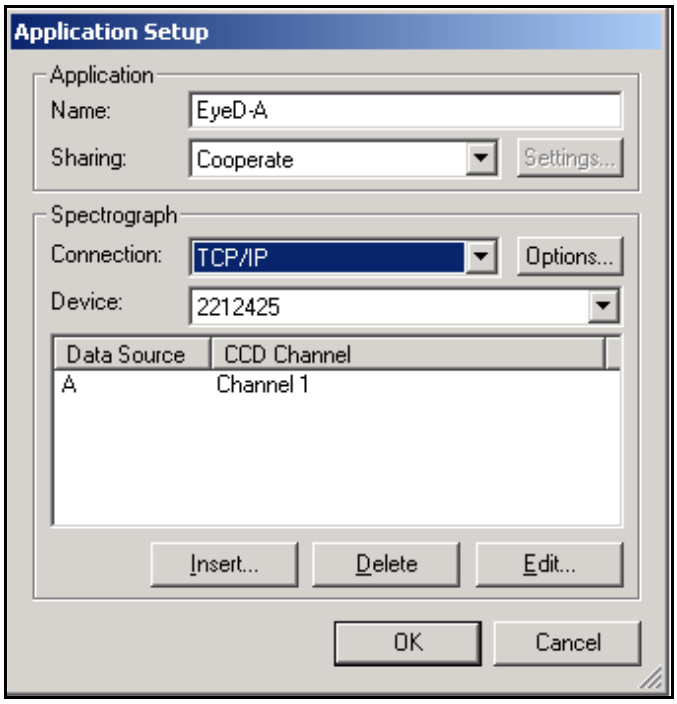


Figure 5-41. SRM Application Setup for EyeD-OES

16. Verify that the IP address of the spectrograph has been changed correctly. Click on the Options button, and confirm the IP address.

17. Click **OK** to return to the main spectrograph window.

18. Configure additional spectrographs, one at a time, by repeating steps 1 through 17. It is not necessary to disconnect spectrographs that have already been configured, as they have already been assigned unique IP addresses.

5.3.1.1 Manually setting the IP address for a Spectrograph

A spectrograph may not be automatically detected as described in Section 5.3.1. Step 10. This may be because the IP address of the spectrograph being configured is not the default 192.168.100.99, or because an older version of EyeD is being used. The IP address can be determined if unknown, using a USB cable. See Section 5.9. Once the IP address is known, perform the following steps to detect and configure the IP address.

1. Ensure that the spectrograph to be detected and configured is connected to the hub and that both are powered on. Spectrographs that have already been configured need not be disconnected.
2. Open SRM and right click to insert a new application (Figure 5-34).
3. If password protection is enabled, (see Section 3.2.4) the Login Window will open. Login as Admin, using the password: 752762.
4. The Application Setup window opens.
5. Name the Application Default Connection.
6. Select **TCP/IP** as the connection and press the **OK** button.
7. The message box shown in Figure 5-42 may appear. Click **OK** to dismiss the box.

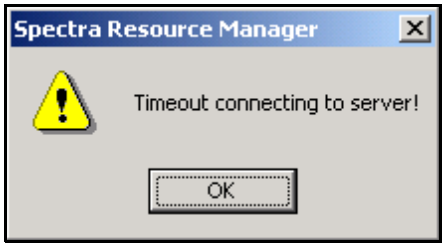


Figure 5-42. Message Indicating SRM Has Yet to Detect Spectrograph

8. The selection of TCP/IP as the connection method may also bring up the TCP/IP Device Settings dialog where the device IP address can be entered. See Figure 5-43.To bring this dialog up manually - after dismissing the time-out message, or if the dialog is not brought up - click on the **Options** button. Enter the default IP address of 192.168.100.99 and press the **OK** button. If this does not work, the message in Figure 5-42 will pop up after a few seconds. Make sure the unit is switched on. Check the hub by cycling the hub power briefly to ensure communication/registration. If the default IP address is still not accepted, then refer to Section 5.9 to obtain the actual IP address with a USB cable. When communication is established, the serial number will be displayed.

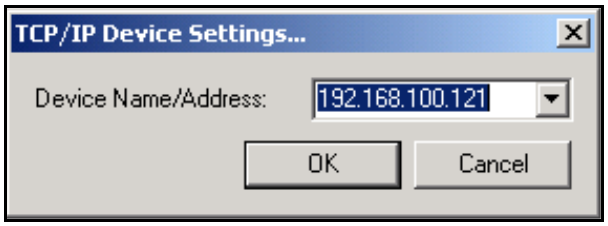


Figure 5-43. TCP/IP Device Settings Dialog

9. Click **OK**.
10. The spectrograph should be detected, and its Serial Number displayed under the Device heading. Insert and assign Data sources as described in section 3.5.1 step 15 (see Figure 5-36, and Figure 5-37).
11. Click **OK** to return to the SRM main window.
12. The application should appear in the SRM main window with the Serial Number found under the Device column and a status that reads Disconnected (Figure 5-39).

    Change the IP address of the device to the assigned address of that particular EyeD location and instance. Select the application, then from the Tools menu select Change IP Address. Enter the appropriate IP address. It should have the format 192.168.100. xx, where xx is one of the following pairs of digits depending on the chamber and EyeD Type:

Table 5-2. IP Address Final Digits

	OES	IEP
Chamber A	10	20
Chamber B	11	21
Chamber C	12	22
Chamber D	13	23

13. With the IP address for the default application changed, insert a new application. Repeat steps 1-7, but name the Application for the EyeD instance it is intended for, e.g. EyeD-A.
14. For the IP address, enter the address specific to the EyeD instance. It should be the same as the address to which the initial Default connection application was changed.
15. The spectrograph should be detected as before. Assign the data sources and click **OK** to return to the main SRM window.
16. The particular instance is now configured and detected in SRM. The default connection is no longer needed. Delete the Default Connection SRM by right-clicking on it and selecting Delete an Application.

17. Configure additional applications as needed by following steps 1-17. Each time an initial connection will need to be made with the default IP address (or the one obtained with the USB cable). The connection must be reset to the designated IP address. Then finally the actual instance application should be created with its assigned IP address. The default connection may then be deleted.

5.3.2 Universal Remote Interface (URI) Setup for Centura 5200

There are three supported methods of communications that are used between Centura 5200 and EyeD. The standard interface is "IDEC/SECS Serial Communication". The other options are DIO, and "Mixed EyeD" Serial/DIO. A final possibility is COMBINATION interfacing of both EyeD and a PC Endpoint (monochromator) system.

- IDEC/SECS communications allow wafer information to be used in the EyeD controller to set up data file storage according to wafer information (Lot, Slot, Recipe, Step etc). This information and all control commands share a single RS-232 or RS-485 communications line. See Section 5.3.2.1
- DIO communications use the "recipe select" DIO bits for each chamber to select recipe and control START, STOP, ENDPOINT. No wafer information transfer is possible. The overall system delay is shortest using DIO, as there are multiple parallel lines. See Section 5.3.2.4.
- MIXED EyeD communications blend the wafer information of IDEC/SECS with the quick response possible with DIO for the time-critical ENDPOINT command. This is the newest interface, and is optional. See Section Section 5.3.3.2.
- COMBINATION interfacing allows a user to use one of two endpoint systems (EyeD or PC Endpoint) for the endpoint call of a step, with the other endpoint system used for monitoring. This mode is useful for qualifying EyeD for production while continuing to endpoint with the original monochromator system. Only one of the two endpoint systems will have wafer information in this mode.

5.3.2.1 URI Setup for IDEC (for Reference Only)

This section is for reference only. The EyeD Installer automatically configures the URI correctly for IDEC communications

EyeD on a 200mm Centura has two options for communication: DI/O and IDEC. Integrated Data Exchange Control, or IDEC, uses Standardized Equipment Communication Specification (SECS), which is a type of serial communication, to communicate between the EyeD computer and the Centura mainframe.

NOTE

If DI/O was originally setup on the computer for a 200mm system, you will need to update the software to SECS.

To configure the Universal Remote Interface (URI), complete the following steps:

1. Run *C:\EyeD\URIManager.exe*, or double click on the **Remainder** icon (red, white and blue flag) in the EyeD folder.
2. Double click the '**URI**' tray icon in the lower right corner of the screen. This brings up the URI main window.
3. Double-click on any application to configure it. See Figure 5-44

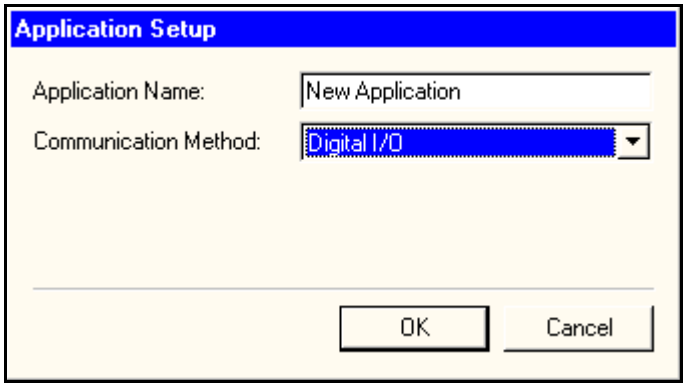


Figure 5-44. Application Setup Window

4. Ensure that RS232 SECS is selected as the Communication Method.
5. Ensure that Com 1 port is selected (unless a different port is being used for that particular system).
6. Click on **Properties**. The **Protocol Settings** should be as shown in Figure 5-45.

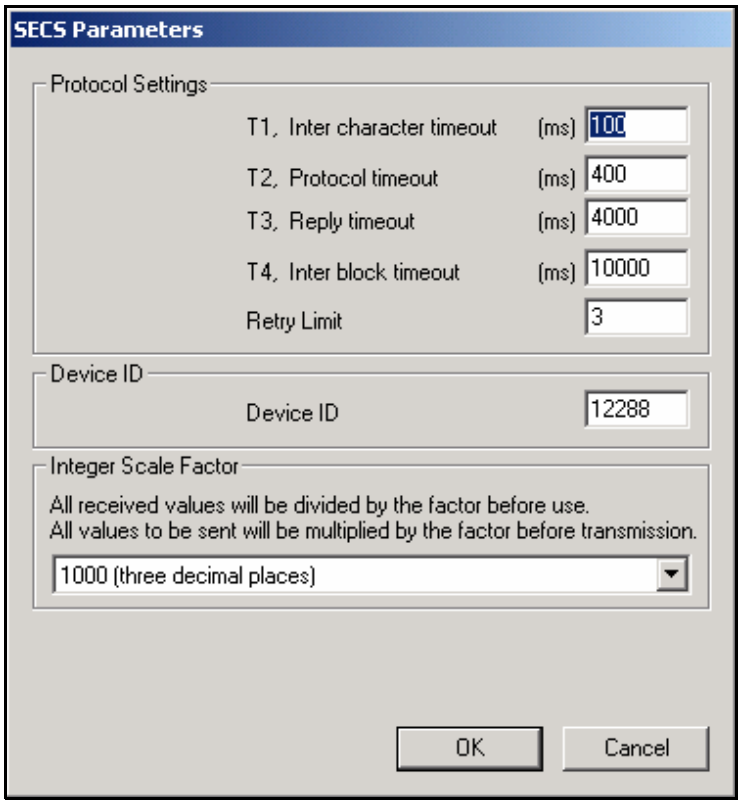


Figure 5-45. Parameter Settings for SECS Communication

7. Enter the **Device ID** as follows:

   Chamber A = 12288

   Chamber B = 12289

   Chamber C = 12290

   Chamber D = 12291

8. Close the **Parameters** window, and select **Configure**.
9. Set the values to those shown in Figure 5-46.

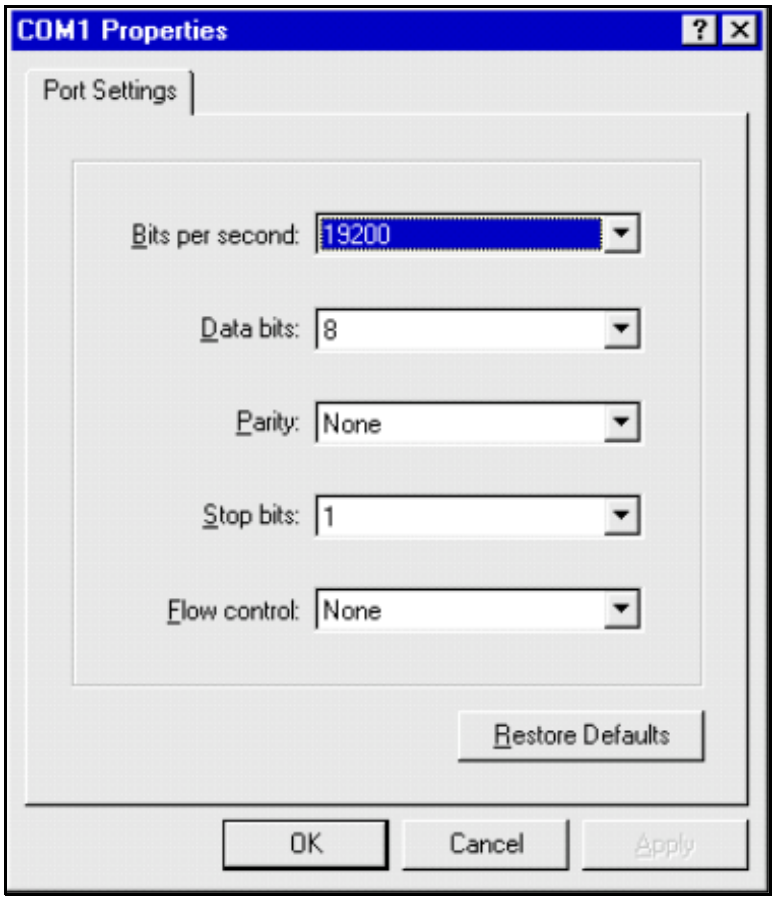


Figure 5-46. Com Port Settings for SECS and RS232 Communication

10. Click **OK** on the Application Setup window. The main URI window is left. The State field should say one of the following:

    a. Ready means a DAS card is detected (verify).

    b. Connected means the EyeD instance is communicating with the URI Application.

5.3.2.2 URI Setup for Digital Communication

To configure the Universal Remote Interface (URI) on a 200mm system for digital communication, complete the following steps:

1. Run C:\EyeD\URIManager.exe, or double click on the URI Manager icon (red, white and blue flag) in the EyeD folder.

2. Double click the *URI* tray icon in the lower right corner of the screen. This brings up the *URI* main window.

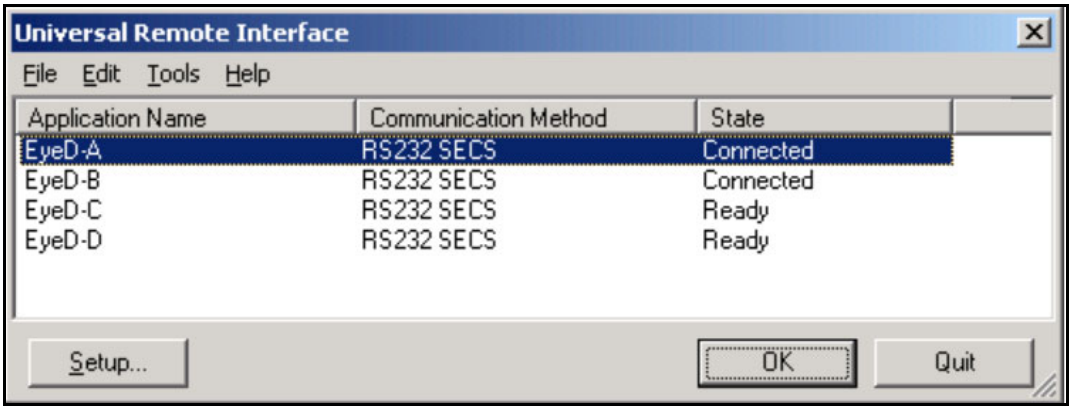


Figure 5-47. URI Main Window

3. The applications should be listed in the window. Double-click on an application to configure it.
4. The Application Setup window opens. See Figure 5-48.

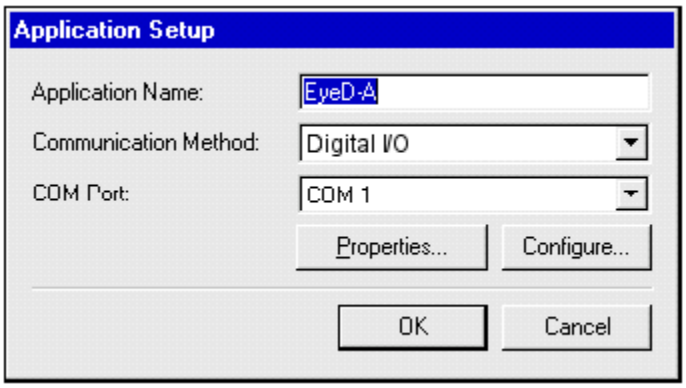


Figure 5-48. Application Setup Window for Digital Communication

5. Ensure that Digital I/O is selected for **Communication Method**.
6. Click **OK** on the Application Setup window. The main *URI* window is left. The State field should say one of the following:
   a. *Not Initialized* means a card is not detected (DI/O only).
   b. *Ready* means a DAS card is detected (verify).
   c. *Connected* means the instance is active (Remote mode).
7. Repeat Steps 1 - 6 for all applications of EyeD.
8. Under the Tools pull-down menu, select **Digital I/O Setup**, then **Configure Hardware**.
9. Select **DAS7432 (PCI) 64 Channels** and click **Close**.

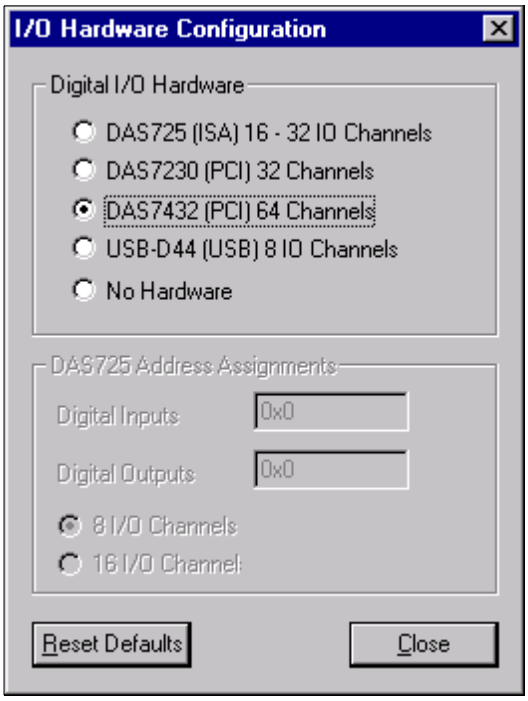


Figure 5-49. DI/O Hardware Configuration Window

10. Next, validate that all connections between the Centura DI/O and the URI DI/O are made correctly. Select **Tool**s, then **Digital I/O Setup**, and finally **Diagnostic**s. The window will show the status of both the input and output channels of the URI.



Figure 5-50. URI Diagnostics Window

Table 5-3 and Table 5-7 show the associations between the Centura D-I/O and the endpoint URI. D-I/O channels. Validate that all connections are made correctly by activating the seven Centura DOs for each chamber are under Misc --> Maintenance --> Dig.I/O on the Centura computer. Validate that the URI responds appropriately. Activate the output channels by using the mouse to click within the URI window for output channels on the outputs corresponding to the *endpoint* or *endetch* Centura DIs; validate that the DI value toggles appropriately on the Centura D-I/O screens.

Table 5-3. Association Between Centura DI/O and URI DI/O

	Chamber A		Chamber B		Chamber C		Chamber D	
	DIO	**URI Channel**	**DIO**	**URI Channel**	**DIO**	**URI Channel**	**DIO**	**URI Channel**
Rfon (endpoint)	8-41	input 7	10-41	input 15	12-41	input 23	14-41	input 31
endetch	7-6	output 1	9-6	output 9	11-6	output 17	13-6	output 25
bit0	8-34	input 1	10-34	input 9	12-34	input 17	14-34	input 25
bit1	8-35	input 2	10-35	input 10	12-35	input 18	14-35	input 26
bit2	8-36	input 3	10-36	input 11	12-36	input 19	14-36	input 27
bit3	8-43	input 4	10-43	input 12	12-43	input 20	14-43	input 28

Table 5-3. Association Between Centura DI/O and URI DI/O

	Chamber A		Chamber B		Chamber C		Chamber D	
bit4	7-35	input 5	9-35	input 13	11-35	input 21	13-35	input 29
bit5	7-32	input 6	9-32	input 14	11-32	input 22	13-32	input 30

5.3.2.3 Mapping Digital Signals (for Reference Only)

EyeD mapping is pre-configured prior to shipment. This section is just for user reference.

The control computer contains a 32-channel board. URI allows each channel to be mapped to a different event or command. Each digital signal is mapped so that it has meaning to the application, with output signals mapped as events to the host and input signals mapped as commands to the endpoint application. Once setup has been completed, all DI/O signals will be listed in the Map Digital Signals dialog box.

Access the Map Digital Signals window in URI by selecting **Tools**, then **DI/O Setup,** and finally **Map Signals**.

The Map Digital Signals dialogue box appears. Reference to “PM” in this screen means Process Module in the Centura Etch System.

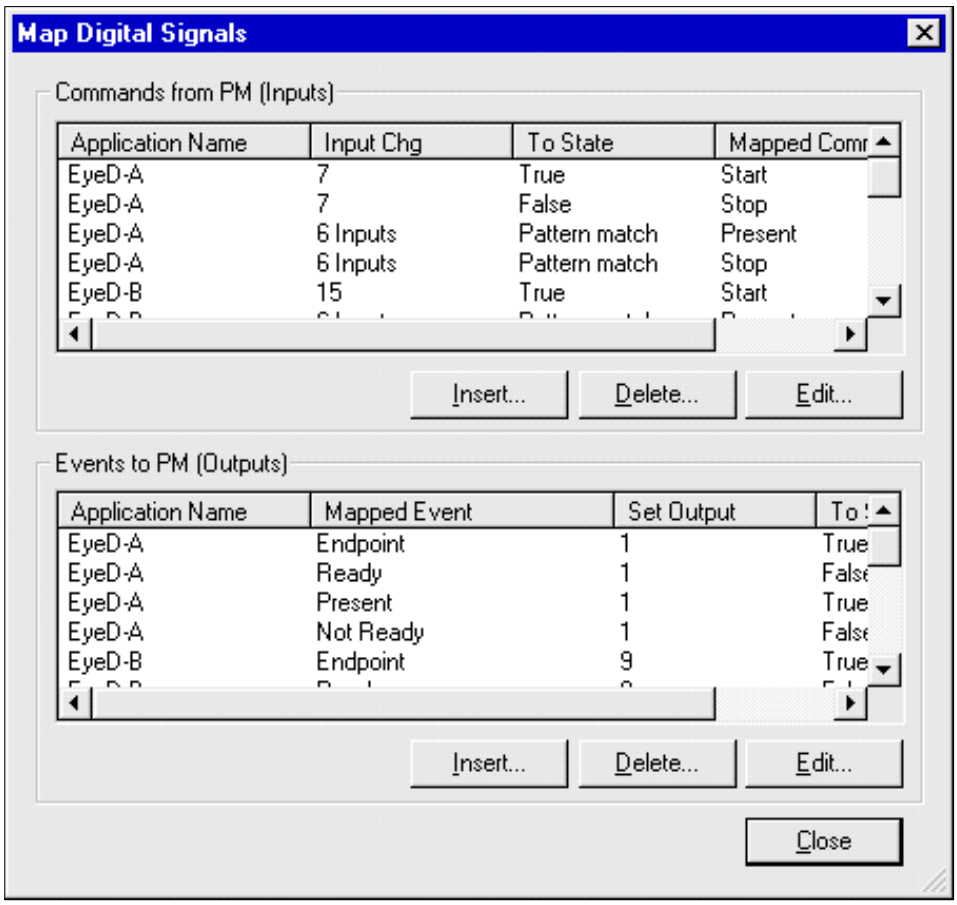


Figure 5-51. Map Digital Signals Window

In the lower half of the window, Events include all DI/O signals generated by each instance of EyeD and sent to the Centura. The upper half of the window lists all commands generated by the process module to every instance of EyeD. Each of these fields includes a column marked Application Name (i.e. EyeD-A, EyeD-B, etc.). Because URI can be used with multiple instances of EyeD, it is important that the correct application name be listed in this column.

The 32 DI/O channels are assigned as shown in Table 5-4. The term 'bit' is analogous to 'channel'. For each command or event, any combination of **Recipe Select Bits** may be selected from those that are assigned to the instance in which the command or event takes place. For example, for a command with application name "EyeD-A", the assigned input channels could be any combination of channels 1-6.

Table 5-4.Distribution of the 32 DI/O Channels

Instance	Recipe Select Bits	RF On (Start)	Blank
EyeD-A	1-6	7	8
EyeD-B	9-14	15	16
EyeD-C	17-22	23	24
EyeD-D	25-30	31	32

Left-click on the upper **insert** button to insert a new command, or **edit** to edit an existing command. Choose the **Application Name** and the **Command** that you wish to map (Digital I/O commands recognized by EyeD are included in Table 5-6). Input one or more valid channel numbers (see Table 5-5), and choose the state. The state is either '**true**' or '**false**', and depends on the structure of the individual Centura DI/O System. A true command is a command from the process module that causes EyeD to perform a task or begin a sequence (A relay that is normally open will close and cause a task to halt upon receiving a true command). A false command signals EyeD to end a task. In other terms, a true command is an assertion of a command from the process tool, while false command is the removal of a previously asserted command.

Table 5-5. Events Table for Mapping

Event	Cause of the Event
Endpoint	Sent when the endpoint application detects endpoint.
Error	Sent when the endpoint application detects an error.
Local Mode	Sent when the application goes offline to local mode for normal use.
Ready Mode	Sent when the application goes offline to remote mode allowing remote use.
Not Ready	Sent when the application begins a run sequence.
Ready	Sent when the application is not running a sequence, in remote mode, and waiting for a command from the host (PM).
Running	Sent when the application starts running a sequence and is the same as Not Ready.

Table 5-6. Commands Recognized by EyeD

Command	Invoked Function
Start	Starts the endpoint application running if it is in Remote Mode.
Stop	Stops the endpoint application running if it is in Remote Mode.
Recipe	Sends the associated recipe name to the endpoint application.
Test	Sends a test command - used for testing communications.

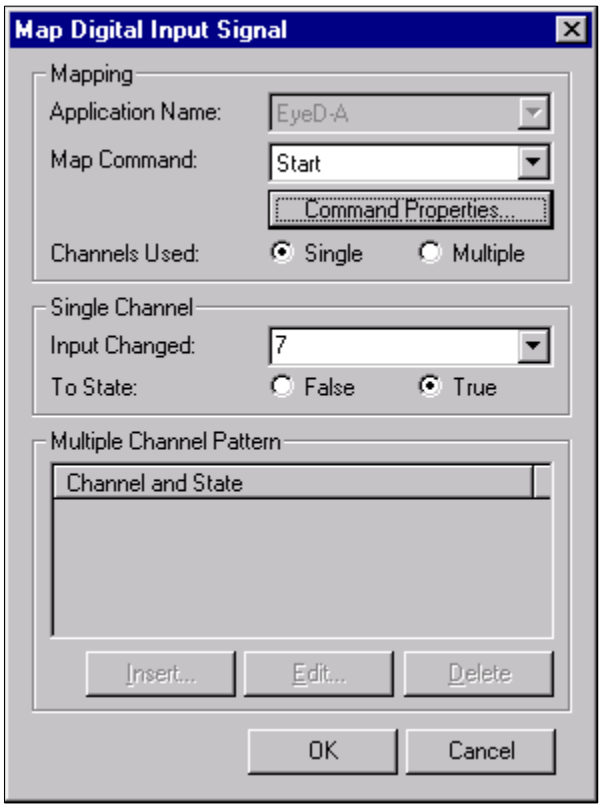


Figure 5-52. Map Digital Input Signal Dialogue Box

For the command ‘start’, click on **Command Properties** to configure the algorithms that will be used. Enter the range of recipe select bits for the specific EyeD instance (see Table 5-5) in the spaces following *Configuration ID Bits*. Set URI to automatically restart when configurations bits change. The *Configuration Name* corresponds to the algorithm name. It should be saved under *C:\EyeD\Endpoints*. The *ID Number* is the number that algorithm corresponds to. A total of 62 possible algorithms can be saved for each instance (algorithms 0 and 63 are reserved for handshake).

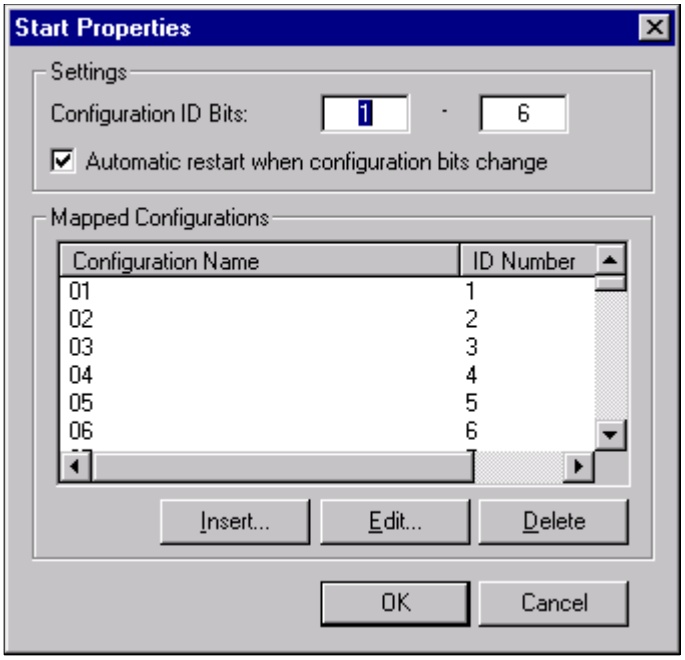


Figure 5-53. Properties for 'Start' Command

Left-click on the lower **Insert** button to map a new event. Configure the event as was done for the commands. Table 5-8 lists the events that can be mapped. Note that true events are events from the application that will cause the digital output to be active or true (A relay that is normally open will close and cause a task to halt upon receiving a true event). Alternately, a false event will cause the digital output to be inactive or false (A relay that is normally open will open upon receiving a false event).

Mapping commands and events are flexible and the configuration depends on the needs of the host computer. If the host software requires a ready signal indicating the endpoint detection system is operating, then the event 'ready' should have a true state and 'not ready' should have a false state. Both states of each signal must be mapped. For example, if Channel-1 is mapped to be true when ready, yet no false state is mapped, the ready signal would be present at all times. Therefore, if using a ready signal, the not ready signal for the opposite state of the same channel must be mapped.

All of the Centura standard events and commands are saved in *Recipe.map* and *Digital.map*, which are located in *C:\EyeD* for each chamber instance. URI is directed to the correct map file through *URI Info.uri.*

5.3.2.4 URI Setup for DIO Interfacing

Install EyeD with the following selection within the installer dialog

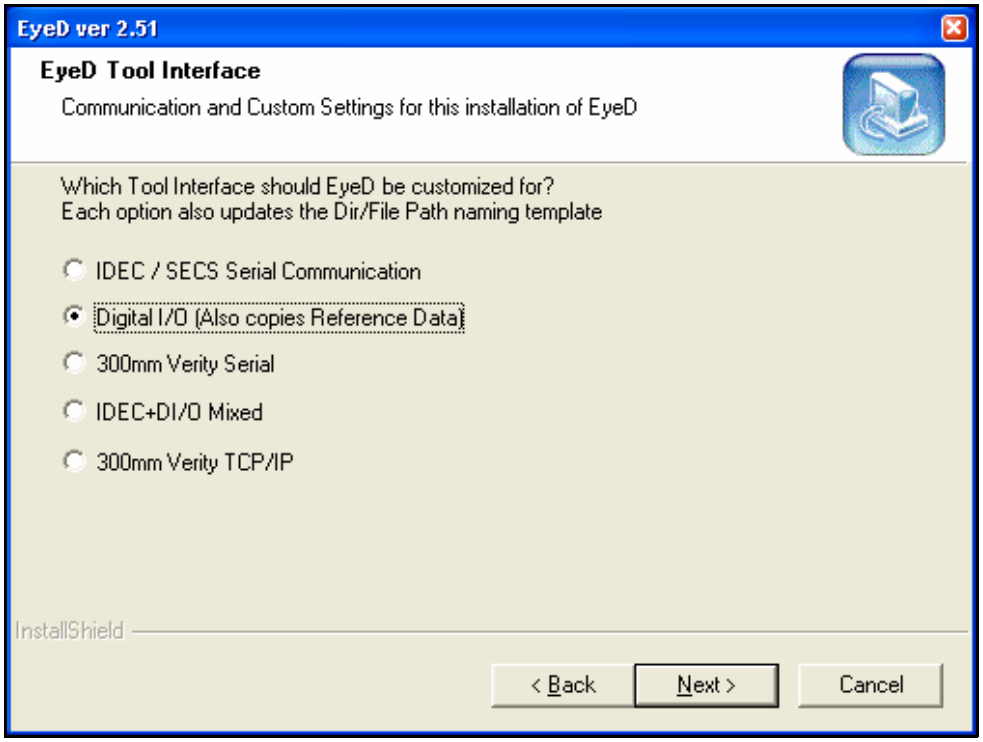


Figure 5-54. EyeD Tool Interface: Communication and Custom Settings

NOTE

If a previous installation was configured for serial communications, the selections for data file naming will not be preserved; these settings will be set to default values.

5.3.2.5 Mixed EyeD/Serial Communications Option

(Available with EyeD 2.34 and MF Software B4.8_18 and later.)

Serial Communication (IDEC) provides the ability to store wafer information such as Lot, Cassette, Slot, and recipe information with the endpoint data file. In the mixed mode interface, a number of serial commands and information messages have been merged with DIO communication for the sending of the ENDOINT command. This reduces any delay between the determination of an endpoint condition and actual RF-OFF to a minimum value.

Example of Mixed Mode Communications Flow

1. MF Parallel Heath Check to test the DIO line HW/SW links to EyeD
   a. 6 mainframe recipe select DO's turned ON by MF software.
   b. MF ENDETCH DI is "asserted" by EyeD
   c. 6 mainframe recipe select DO's turned OFF by MF software.
   d. MF ENDETCH DI is "unasserted" by EyeD

2. MF Serial Health Check is sent to test serial line HW/SW link to EyeD
   a. Low level handshaking occurs
3. MF Sends the "Wafer Info" to the EyeD instance
   a. Lot, Cassette, Slot, recipe, step and variables
4. MF Sends the Start command via IDEC to the particular EyeD instance
   a. EyeD validates config from wafer info, starts spectrograph,
   b. EyeD Starts the configuration sent to it in the "wafer Info" message
5. EyeD Sends the Endpoint via the MF ENDETCH DI
   a. Mainframe ENDETCH DI is "asserted" by EyeD
   b. Mainframe ENDETCH DI is "unassarted' when the serial acknowledge to the Endpoint DO is received
6. MF sends a stop message to EyeD
   a. EyeD closes the data file
   b. Variables are cleared when the wafer complete is sent

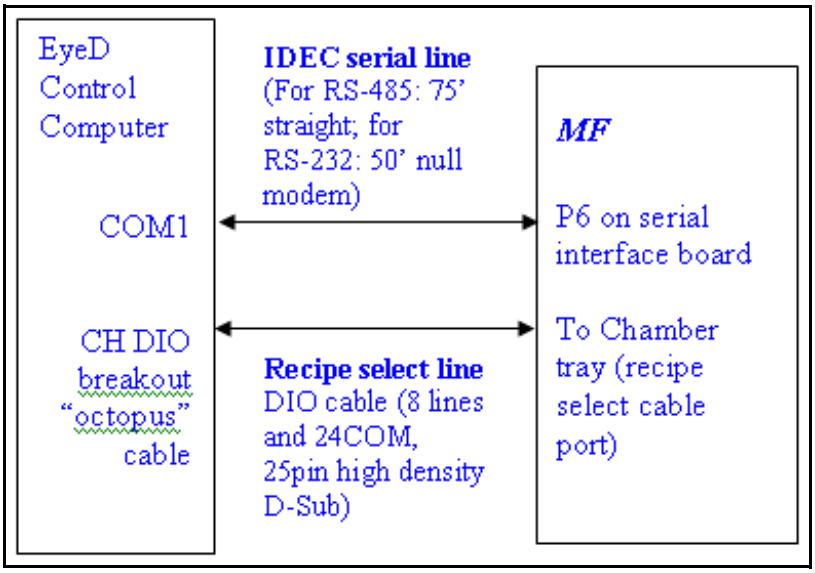


Figure 5-55. IDEC Cable Connection Diagram

5.3.3 Mixed Interface Setup Procedure

5.3.3.1 Setup the Mainframe System Constants

The MF has the capability to select Pure D/IO, Pure Serial or a Mixed Mode communication link. By Setting the system constants for a Mixed Mode operation manner the MF health Check will act as an AND condition and the integrity of the Serial line and the Parallel line will be verified.

By changing syscon 5110-5113 to 1 the user will be nabling that Endpoint is to be called by DI/O. Thus the serial endpoint will be ignored by the MF.

1. Change the following syscons on the MF

Table 5-7. Syscons to Change

Syscon	Description	Value
5109	Parallel Channel to Monitor Endpoint Trace	1
5110-5113	Parallel Channel to Call Endpoint/chamber	1
11164-11167	Health Check Serial Mode Enable/chamber	1
11168-11171	Health Check Parallel Mode Enable	1
10955	Endpoint DeadTime for B2B	3 seconds

2. Ensure IDEC is enabled on the Configure Process screen of the MF SW.
3. Ensure Serial Health Check is enabled on the MF SW Configure Process screen.

5.3.3.2 Setup EyeD URI for Mixed Mode Operation

1. Install EyeD 2.34 or greater. At the Communication Interface screen, select **IDEC+DI/O Mixed**.

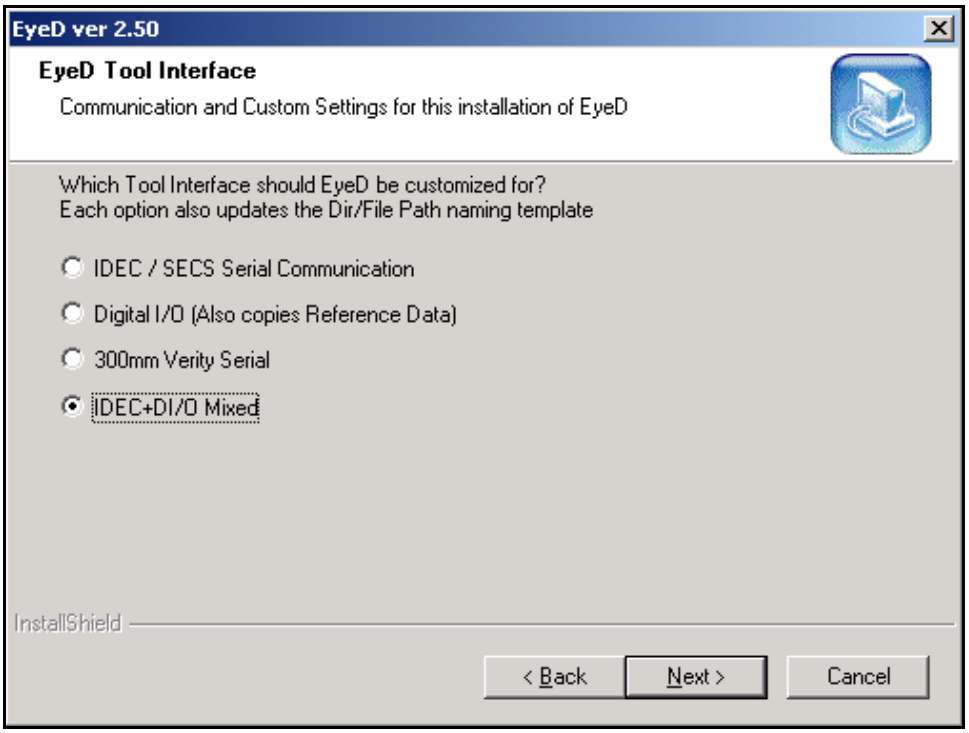


Figure 5-56. Communication Interface Screen: IDEC+DI/O Mixed

2. Follow the Installation Wizard until the data path template options window appears. Select **Yes** to overwrite the settings.

   Note 1: This must be done in order for the *Wafer Info* message to be saved with the data file.

   Note 2: If IDEC was being used previously, and custom settings have been setup for the data path template and those are still desired, Select **No**.

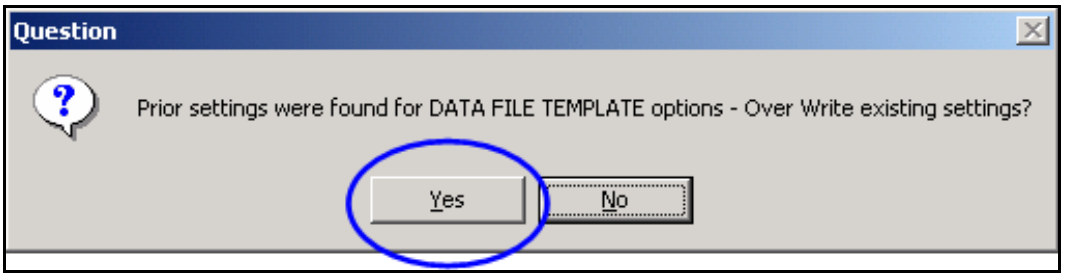


Figure 5-57. Data File Template Prior Settings Question

3. Reboot the computer Once the installation is complete.

5.3.3.3 Verify Mixed Mode Settings in URI

1. Open URI, by selecting **Start** ==> **Programs** ==> **EyeD** ==> **URI**.

   The following window should appear.

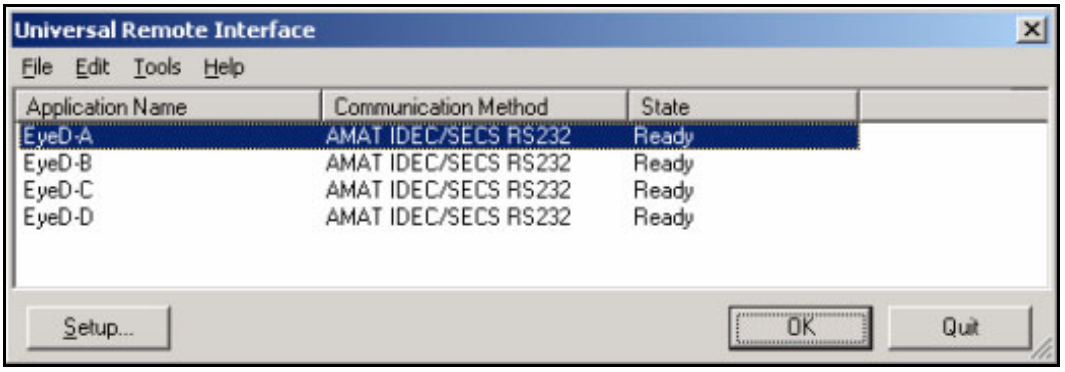


Figure 5-58. Universal Remote Interface Window

2. Select **Tools** ==> **DIO Setup** ==> **Config Hardware**. Ensure that the DAS 7432 board is selected and close the window

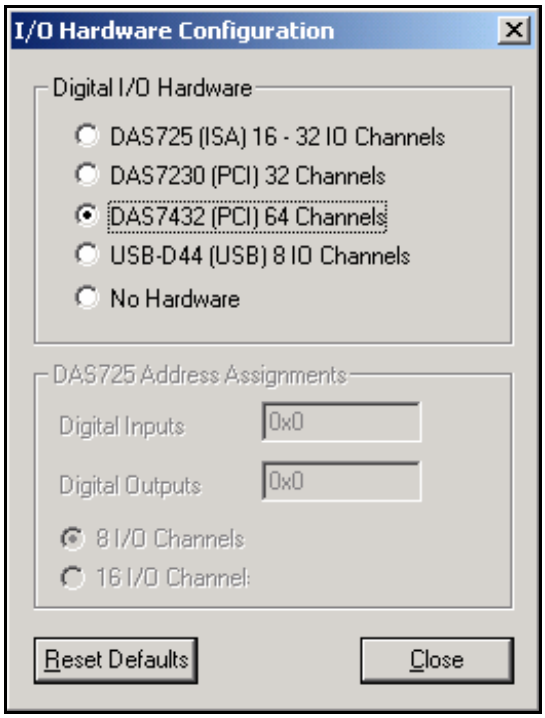


Figure 5-59. I/O Hardware Configuration Window

3. Select **Tools ==> DIO Setup ==> Map Signals**.

NOTE

The following DIO settings will Only work for Mixed Mode Operation. Pure DIO operation requires a different set of DIO mapping.

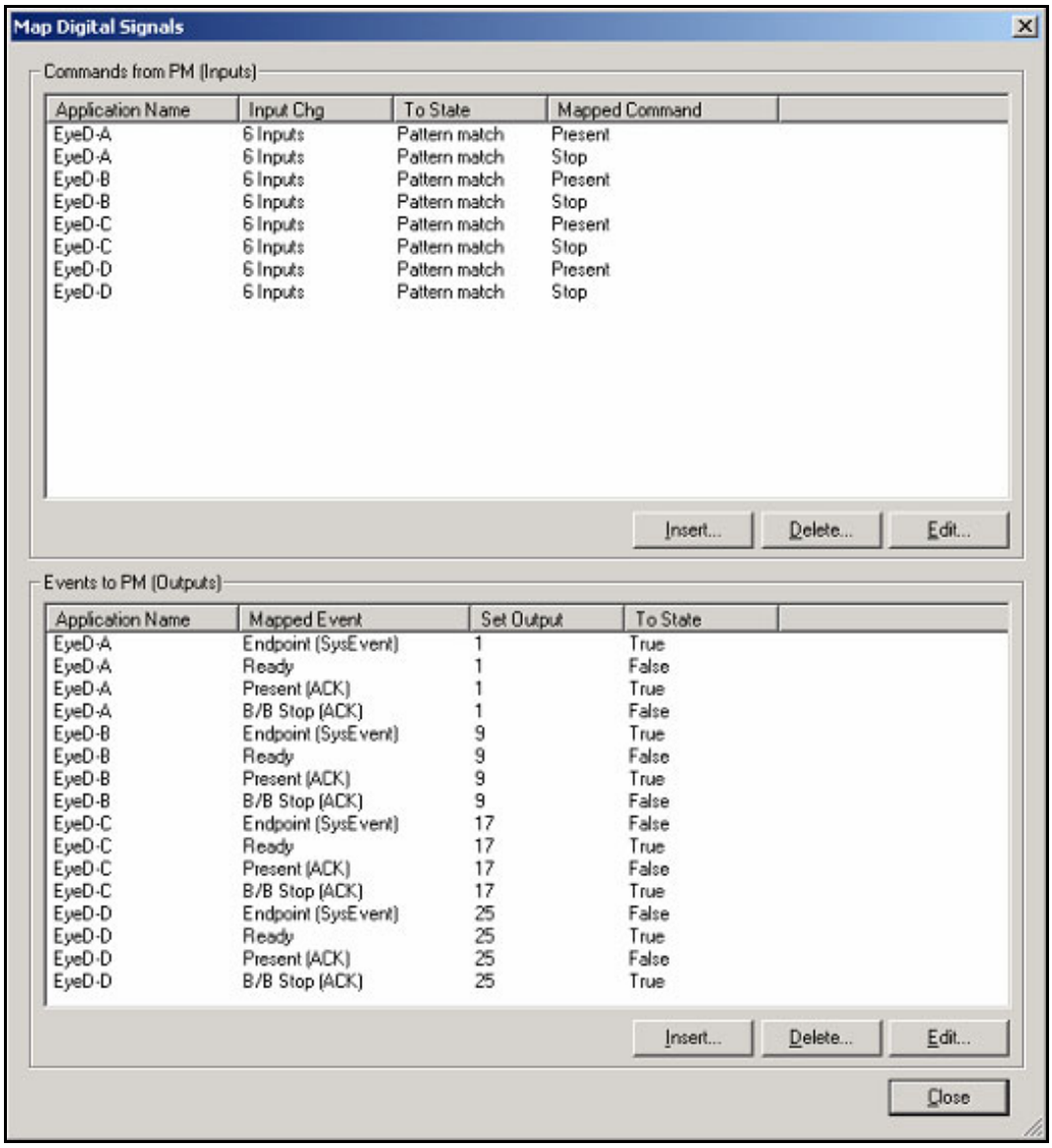


Figure 5-60. Mapped Digital Signals

4. Verify Serial Port Settings by double clicking on the instance name
5. Verify the Com port is Com1 for all instances and that the device ID is correct.

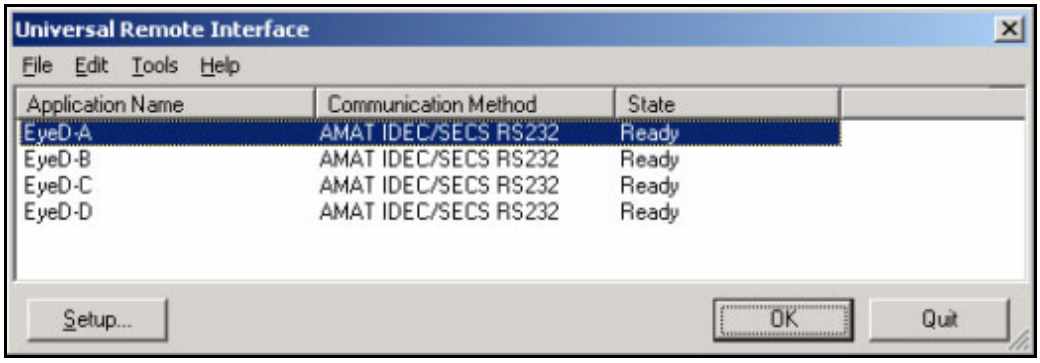


Figure 5-61. URI Window

6. Verify the Device ID is correct for each instance/chamber.

   EyeD-A 12288

   EyeD-B 12289

   EyeD-C 12290

   EyeD-D 12291

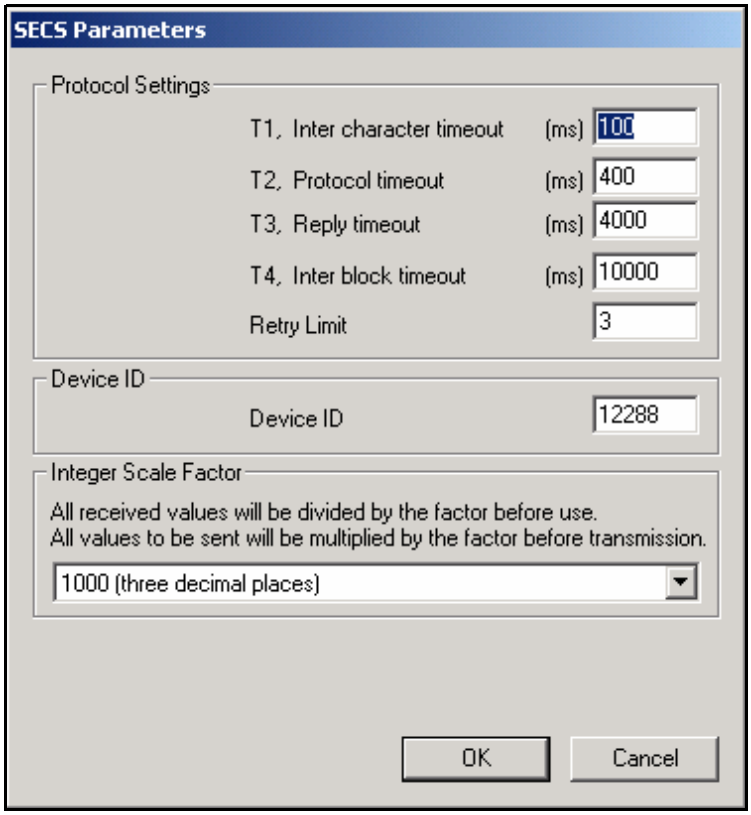


Figure 5-62. SECS Parameters

5.3.3.4 Final DI/O Check

This check will use full remote control to test handshake, recipe selection, and that the endpoint command is correctly received by the Centura. Validate that endpoint health check is active on the Centura. The screen item that enables/disables endpoint health check is found under *MISC>SYSTEM CONFIG>Configure System>Configure Process*.

1. Make sure that the algorithm *genericDIO_CHECK.svc* is installed in *C:\EyeD\endpoints*. Double click to open the configuration, and then use the "save as" command to save it as "62.svc". The recipe map that associates Centura DIO algorithm numbers to the EyeD algorithm names requires that production algorithms be saved with numerical names to be called during etch recipe execution. This test will require that the algorithm number entered in the Legacy recipe be "62".

2. Create a test recipe with inert gas flow only (no plasma), ESC voltage = 0, He backside pressure = 0 Torr on the Centura. Make one of the recipe steps have the step end control selection of "endpoint". Set the maximum step time to 30 seconds. The minimum time for EP should be set to 10 seconds. In the endpoint field, click to open and insert algorithm 62. Make sure that the bias RF power in this step is set to at least 1W, or the Centura will not issue an "endpoint RF on" signal when the step begins.

   Example recipe:

   Step1: STAB, step end BY TIME, 8sec, 20mT, 100Ar, 0Ws, 0Wb, He 1 Torr, ESC 0V

   Step2: EPTST, step end ENDPOINT (alg 62, min EP time 10sec), max step time 30sec, 20mT, 100Ar, 0Ws, 1Wb, He 1Torr, ESC 0V

3. Make sure that the EyeD instances for each chamber to be tested with this recipe are all active. Use both SRM and URI to validate communications status within the EyeD system and with the Centura. Put each instance into Remote mode using the "dish antenna" icon in the center of each task bar.

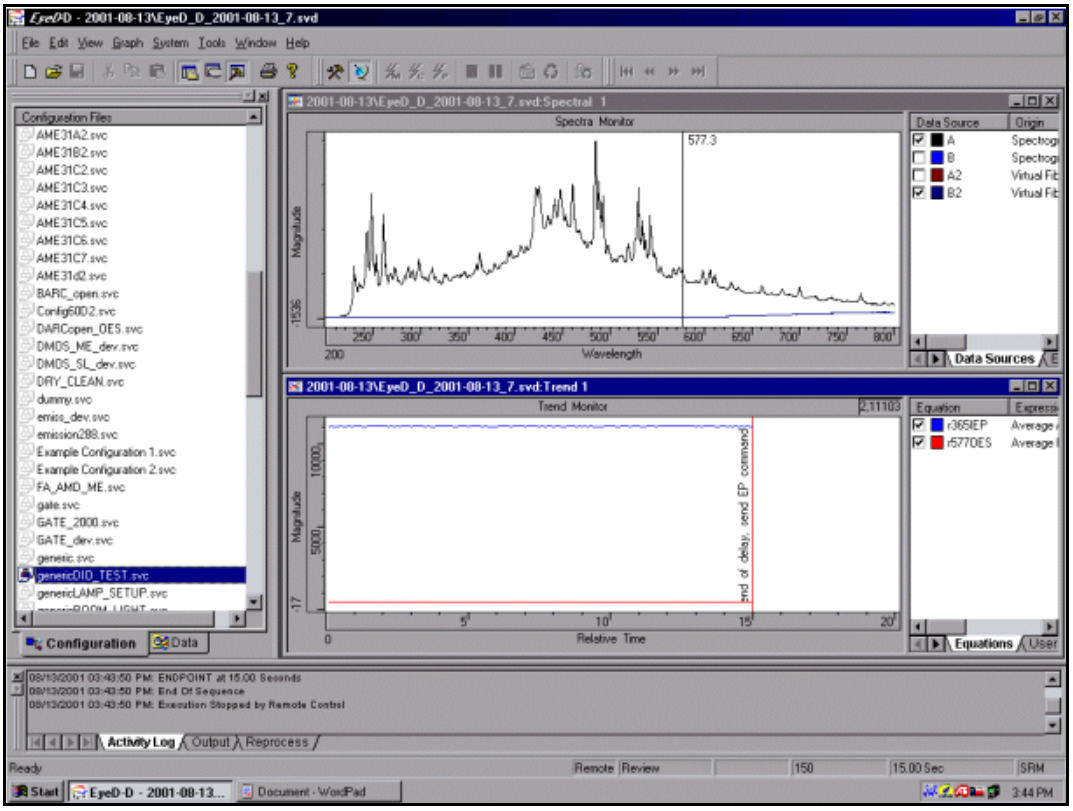


Figure 5-63. Spectral Plot for D-I/O Functionality

4. Place a bare Si wafer in the test chamber, and execute the test recipe. The EyeD interface screen should respond with a spectral plot and a trend plot similar to those shown above. After 15 seconds, the EyeD algorithm will issue an endpoint command back to the Centura, stopping the step execution there. If the process step execution stops at 15 seconds as shown above, then DI/O functionality is established.

NOTE

EyeD has an automatic restart feature when accidentally left in Local mode operation.

In order for this feature to work properly, the URI state must be put as *connected* first.

The scenario for an automatic restart is:

1. The EyeD instance is opened in local mode. URI status is *Ready.*
2. A health check is performed by the tool (alg 63). URI will not respond and the health check will fail.
3. Place the instance in remote mode, URI status is *Connected.*

4. A health check is performed and URI will now pass the health check test made by the Centura.
5. Place the instance back in Local mode. Now the URI state stays as *connected*.
6. A health check is performed by the Centura, URI recognizes it as an attempt to start and will automatically switch the instance from Local to Remote mode.

5.3.3.5 Validating Communication to the Centura

NOTE

Setup the Centura software before checking the communication. See Section 5.4

Open **URI**, select **Tools**, then **Show Log Windows**. A window for each instance of EyeD named "Communications Log for Application EyeD__" and a window named "SECS Communications Log" are all created at the desktop level. If serial communications are active, the SECS Communications window will show continual updating with serial messaging traffic with the mainframe, such as ping requests/acknowledgements.

The initial log window for ChA after successful connection will look like Figure 5-64.

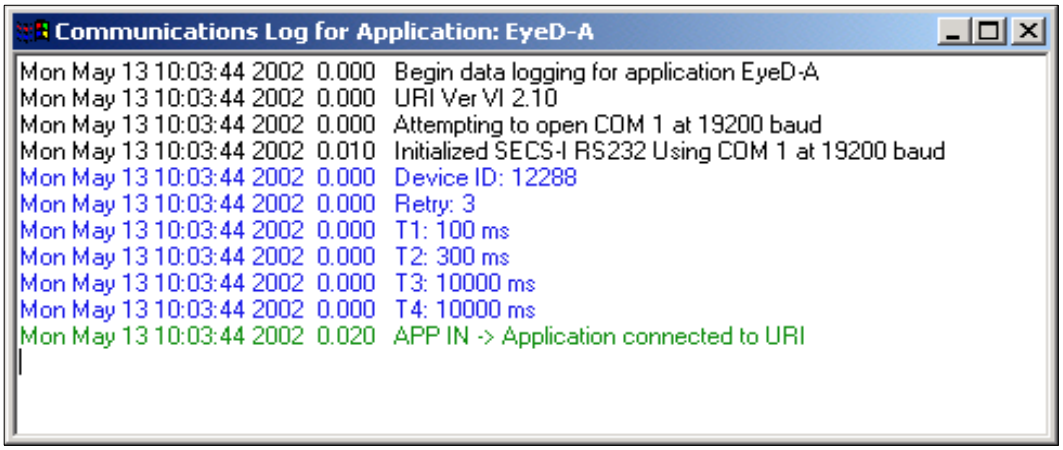


Figure 5-64. Initial Communications Log for Chamber A

The device ID designation in the URI communications log refers to the Etch chamber. Designations are 12288 for Chamber A through 12291 for Chamber D.

The green "APP IN -> Application connected to URI indicates that the EyeD-A application and EyeD-URI software modules are correctly communicating with each other. Note that the EyeD instance must be open for this to occur.

When running, each significant communication event between EyeD-A and URI is logged with a time stamp in the Communications Log window. An example is shown in Figure 5-66.

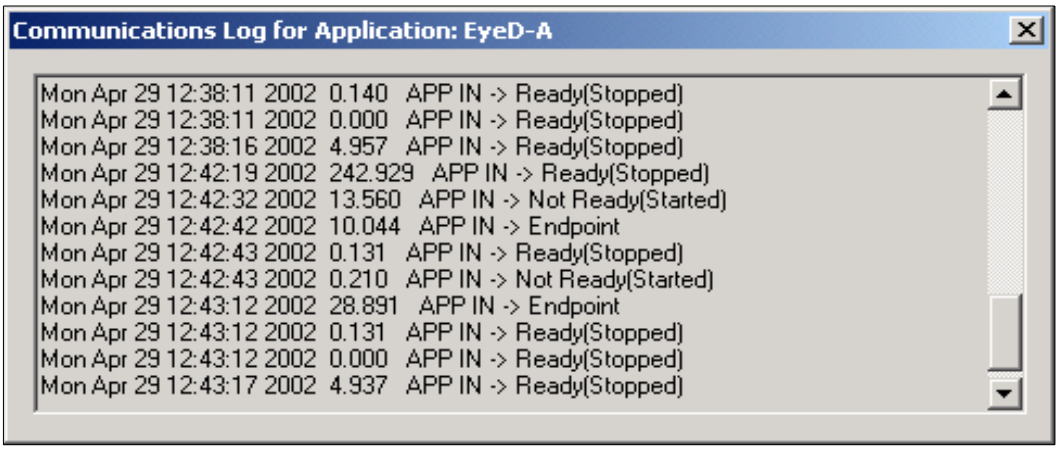


Figure 5-65. Communications Log for Active Chamber A

Log messages are color coded, and the logging can be useful for troubleshooting. EyeD can be set to record all of the entries on these log screens, however this should not be enabled except in cases of troubleshooting, as file sizes can become very large, and logging needlessly loads the CPU during normal operations.

If the log windows show that the SECS message traffic is active, then the system is ready for further testing. If messages indicating that time-outs have occurred, or if messages like those shown in Figure 5-66 are present in the SECS Communications Log, then the serial link is not made or not enabled on either the EyeD/URI side or the Centura side. Notice that the time-outs are indicated, but no acknowledgements of application connection are present. Recheck that the serial cable is connected to the correct ports and recheck all other steps in this procedure.

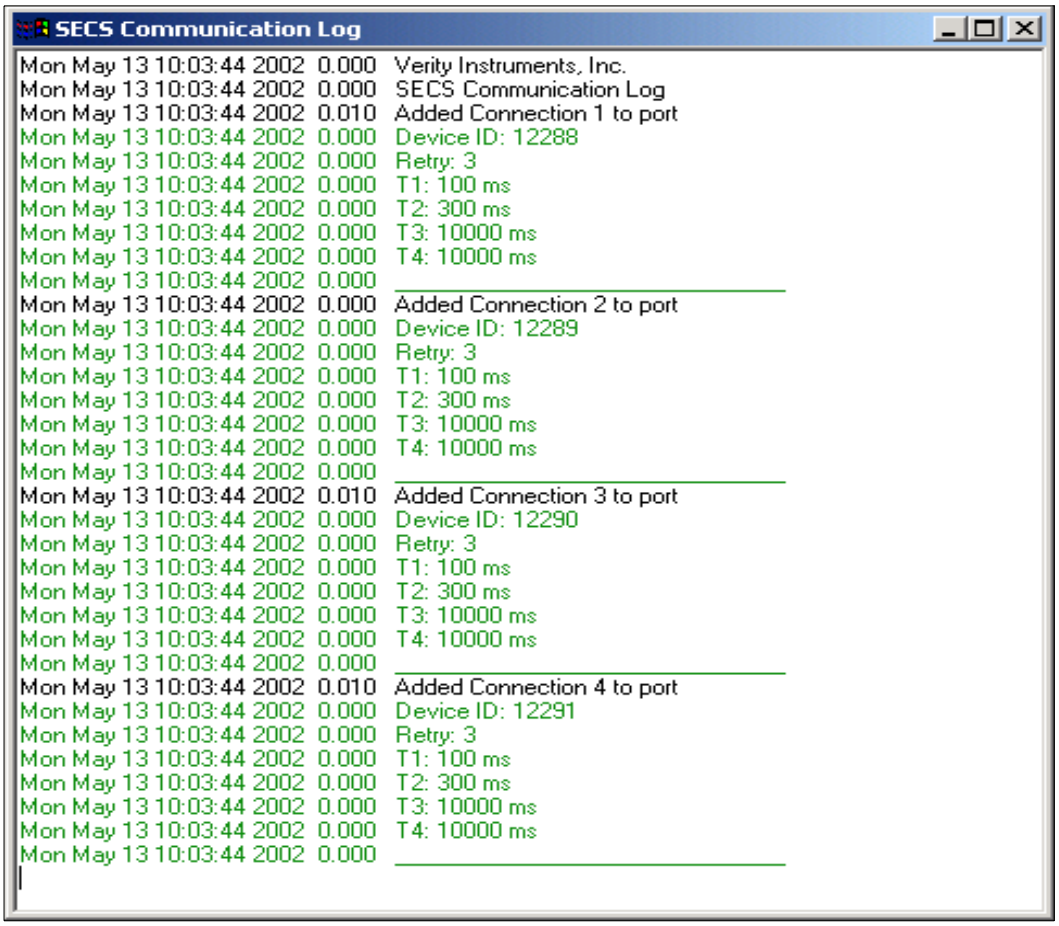


Figure 5-66. Communications Log Window Where There is a Serial Cable Problem

5.3.4 EyeD IDEC Communications Lockups

This section pertains only to EyeD versions 2.34A and 2.34B. To solve the irratic communication lockup problem, the mainframe must be using version 4.7_19 or later and the URI version 2.38 be used. This section describes the process of implementing this software. EyeD version 2.5 and above operates without any lockup problems.

5.3.4.1 Background

Certain installation of EyeD on Centura 5200 mainframes operating with IDEC (Integrated Data Exchange and Communications) have been observed to lockup occasionally.

These lockups are ultimately due to noise-generated framing errors in the SECS communications messages creating a "wait" state in the low-level COM port driver code that controls the UART chips within the EyeD computer. The COM port wait state interferes with URI receiving confirmation of previously transmitted messages to the mainframe, and thus URI also gets stuck in a "wait" state. The resolution approach is to have URI issue a port reset command if the problem condition is detected.

5.3.4.2 Applicable Software Versions

URI version 2.38 resolves the communication issue for EyeD 2.34A and 2.34B.

URI 2.38 is only compatible with mainframe software versions 4.7_19 and later.

5.3.4.3 Detailed Problem

In a tool installation, serial communication framing errors can result from electrical noise being present on the line. Noise sources can be due to RF, induced currents, high frequency noise from phase-switched power circuits, or insufficient mainframe/controller grounding. In practice, a framing error is only one type of all of the possible noise-induced message faults, however it is the only type of fault that was found to create port lockups in extensive lab tests.

A further difficulty in troubleshooting is that only one in hundreds of framing errors causes port lockups; the reasons for these rare failures are not presently known. Below is a serial log that shows an example of a framing error generated port lockup that was forced by deliberate transmission of many message framing errors:

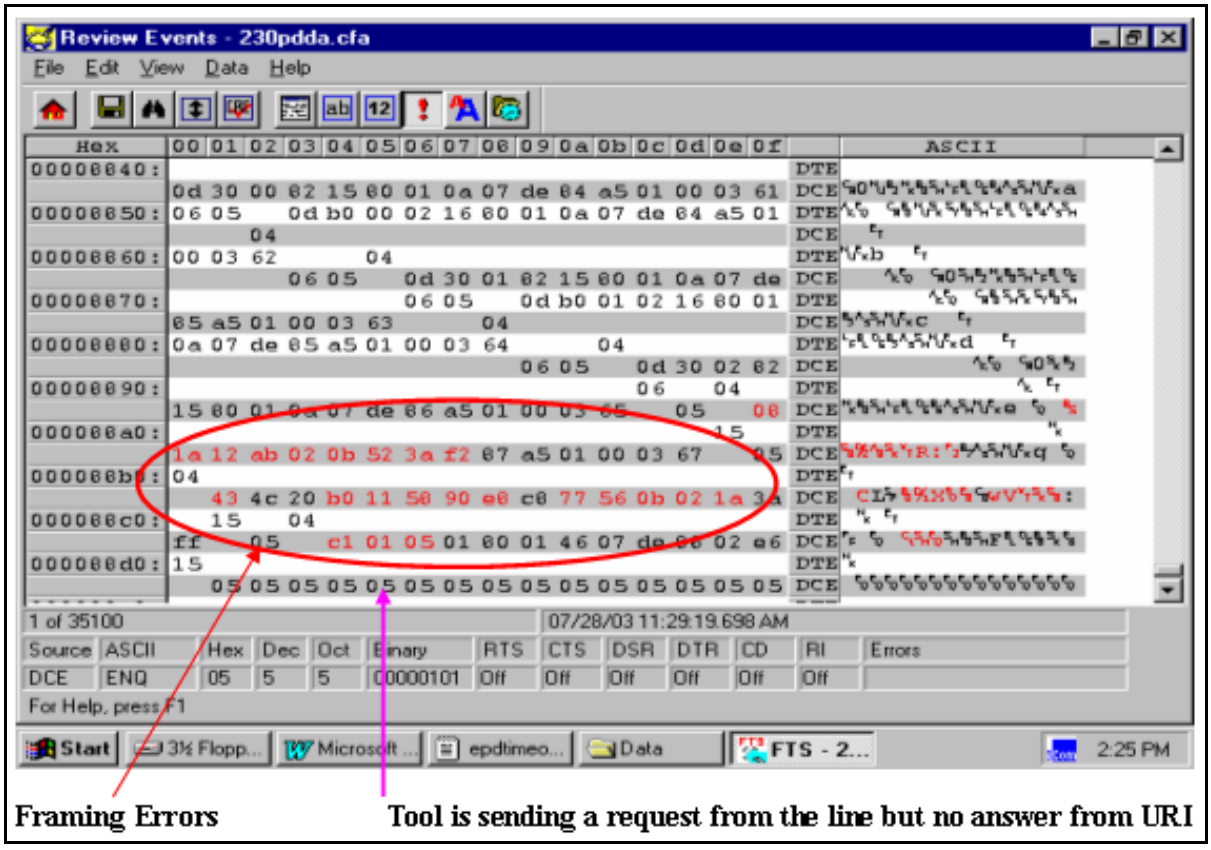


Figure 5-67. Serial Log Showing Framing Error Generated by Port Lockup

Since the ultimate root cause of the port failure rests in low level driver code, the strategy used to resolve the issue is one of 1) detecting a COM failure, 2) resetting the port and 3) retrying the message transmission/response up to three times before declaring a fault.

The port reset feature included in URI 2.38 will be included in all EyeD installs for versions 2.34C, 2.41C and later. Until the distribution of the full install packages, it is necessary to manually install the URI communications resource directly within the EyeD directory.

5.3.4.4 Procedure for URI 2.38

1. Delete or rename old URI

   a. Open EyeD folder and delete or rename the 2.34 level URI (the name of the URI resource in the folder is URIManager.exe)

   b. Copy the 2.38 level URI (also called URIManager.exe) into the EyeD folder

   c. Launch URI. Verify that in the help section you see URI Version 2.38

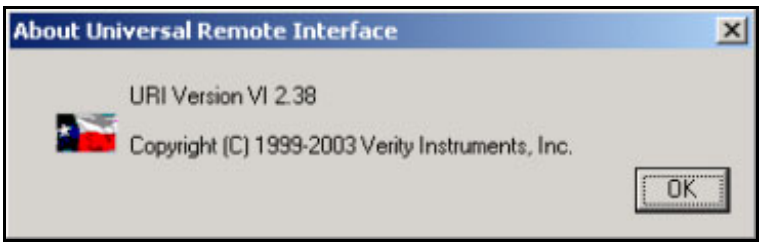


Figure 5-68. URI Version Window from Help Menu

2. Assure that the mainframe setup for Endpoint SECS message channel, baud rate, timeouts and retries are set to match those of URI. (Syscons 7368..7376)

   - Channel ID = 14
   - Baud Rate = 19200
   - Retries = 3
   - T1 = 100 msec
   - T2 = 400 msec
   - T3 = 10 sec
   - T4 = 10 sec
   - T5 = 45 sec

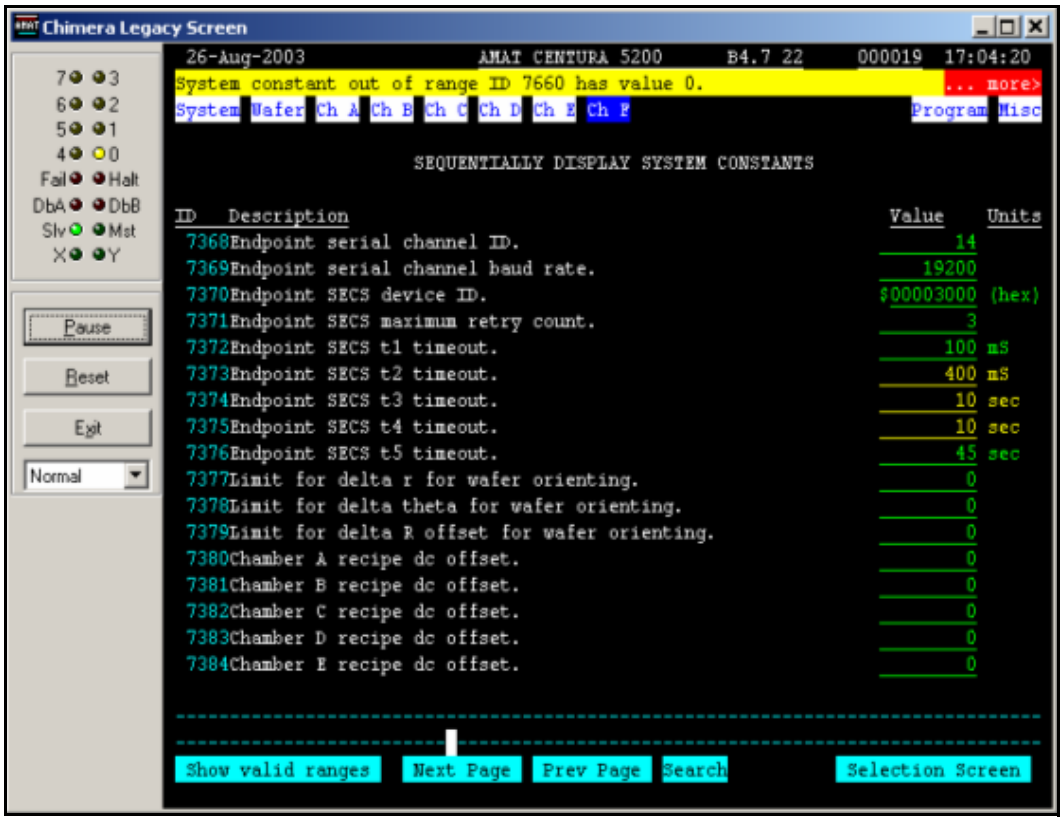


Figure 5-69. System Constant List

3. In Software versions E4.7 and later assure that the mainframe setup for Endpoint SECS Ping rate is 1 second (Syscon 10956).

5.3.4.5 Troubleshooting and SECS logging

As installed, URI 2.38 will auto launch whenever an EyeD instance is launched. Under auto launch, the SECS message logging will be non-verbose, which means that the content of the log will only contain essential messages. For detailed troubleshooting, URI can be set for *verbose* logging by creating a shortcut on the desktop, with the properties of the shortcut extended with *-verbose*, and launching URI with this shortcut icon before launching the EyeD instances that will run. The properties window for the desktop URI icon is shown in Figure 5-70.

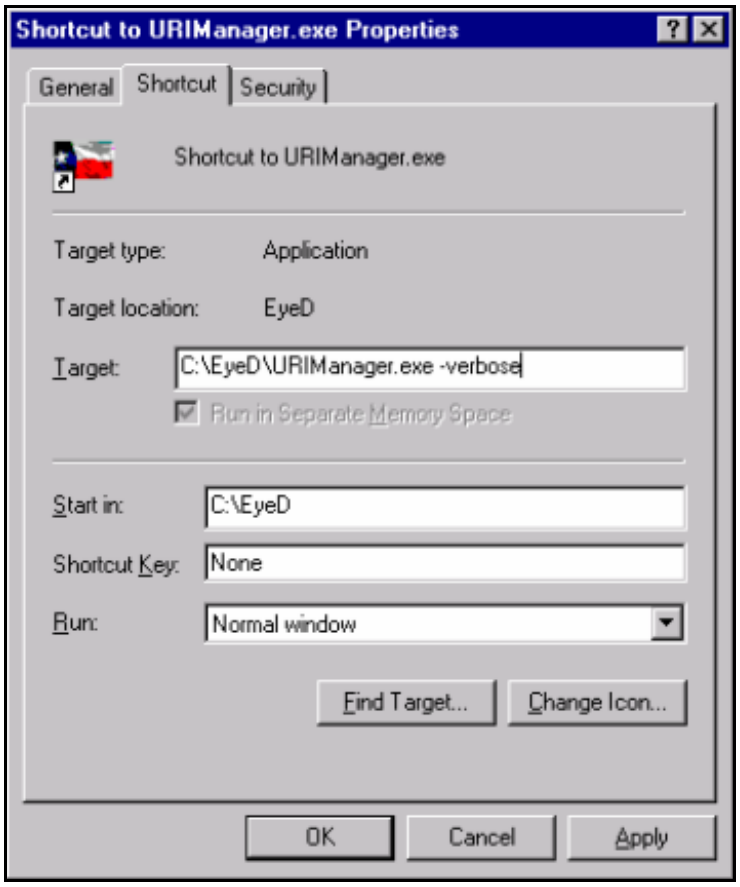


Figure 5-70. URI Icon Properties

Please note that verbose logging will create very large log files. In this case, URI should be exited and restarted on a daily basis so as terminate the existing, and restart new log files.

For EyeD 2.34x level SW, there is no capability to start new log files on a daily basis (EyeD 2.41 level software and above will have this capability). Because of this, it is recommended to close and restart all EyeD instances at least once a week to keep relatively small log files on the system in the non-verbose mode.

5.4 Set File Management

5.4.1 Setup and Verify Automatic File Naming

Setup and verify file naming for both local and remote modes. Refer to Section 3.2.2.

5.4.2 Setup and Verify Auto Delete and Archive Options

Setup and verify the Auto Delete and Archive options for each configured EyeD instance. Refer to Section 3.2.3.

5.4.3 Mainframe Setup

The Centura mainframe can be configured to run both PCEP and EyeD at the same time on different chambers. One endpoint may be set to DI/O, and the other to serial. Operating both

with digital communication requires special hardware, and is not recommended. It may cause communication errors resulting in dropped endpoint signals.

When serial communications are selected in the configure process screen, then the PRIMARY endpoint mode is serial and DI/O endpoint communication bits are deactivated. Monitoring with the SECONDARY endpoint computer in parallel mode is not possible.

The DI/O bits for the parallel endpoint communications channel are activated by setting SYSCON 5109 from 0 to 1 for mainframe SW version 4.5_19 and later. With SYSCON 5109 set, then the DI/O bits for ENDPOINT RF ON and for RECIPE SELECT are activated; the mainframe will ignore an ENDPOINT command sent over the parallel channel unless other SYSCONS are also set, enabling endpoint monitoring.

In SW versions 4.5_2_x_ and later, the selections for which endpoint communications channel to use for endpoint, and which endpoint communications channel(s) should be health-checked prior to process run are fully selectable. A health-check is generally performed only for the endpoint computer that is to call endpoint, however it is possible to configure the tool to perform a health check prior to process start on both the endpoint and monitor EP computers.

Selection of which endpoint channel to use for endpoint is made by selecting values for *SYSCONs 5110-5113 (ChA-ChD)*. When the value is left at 0, and the system serial endpoint communications option is enabled, then endpoint is called by the computer on the serial channel. When the value for a chamber is changed to 1, then that chamber will only look for the endpoint command from the parallel channel.

It is important that the user set the endpoint health check to only check the status of the endpoint computer that is used for making the endpoint call. Selection of which communications channel(s) to use for health checking are made using *SYSCONs 11164 - 11171*. 11164-11167 (ChA-ChD) designate serial health check when set to 1. 11168-11171 (ChA-ChD) designate parallel health check when set to 1. The default values for all eight is 1, which means that the SW will health check BOTH the serial and parallel EP channels whenever the system mode is set for the serial endpoint communications option.

Table 5-8. Endpoint Communications Channel Setup

Connection	Centura Mode	Want EP Control By	Monitor EP In	Health Check On	SYSCON 5109 (DIO enable)	SYSCON 5110-5113 Ch EP mode: 0=serial 1=parallel	SYSCON 11164-11167 Serial health check? 0=no 1=yes	SYSCON 11168-11171 Parallel health check? 0=no 1=yes
EyeD serial, PCEP parallel	Serial enabled	EyeD serial	PCEP parallel	EyeD (serial only)	Set to 1	Each EyeD chamber = 0	Each EyeD chamber = 1	Each PCEP chamber = 0
EyeD serial, PCEP parallel	Serial enabled	PCEP parallel	EyeD serial	PCEP (parallel only)	Set to 1	Each PCEP chamber = 1	Each EyeD chamber = 0	Each PCEP chamber = 1
EyeD serial, PCEP parallel	Serial enabled	EyeD serial	PCEP parallel	**BOTH** EyeD and PCEP	Set to 1	Each EyeD chamber = 0	Each EyeD chamber = 1	Each PCEP chamber = 1
EyeD serial, PCEP parallel	Serial enabled	PCEP parallel	EyeD serial	**BOTH** PCEP and EyeD	Set to 1	Each PCEP chamber = 1	Each EyeD chamber = 1	Each PCEP chamber = 1
EyeD parallel, PCEP parallel (must use special split DIO cable)	Serial **disabled**	EyeD **OR** PCEP	PCEP **OR** EyeD	EyeD and PCEP (parallel only)	N/A	N/A	N/A	N/A
PCEP serial, EyeD parallel	Serial enabled	PCEP serial	EyeD parallel	PCEP (serial only)	Set to 1	All = 0	Each PCEP chamber = 1	Each EyeD chamber = 0
PCEP serial, EyeD parallel	Serial enabled	EyeD parallel	PCEP serial	EyeD (parallel only)	Set to 1	All = 1	Each PCEP chamber = 0	Each EyeD chamber = 1

5.5 Communication Validation

1. Power up the computer/hub. Login as administrator with no password.
2. Launch EyeD-A icon.
3. Check the communication status between EyeD-A and the Ch A DCS using the Spectra Resource Manager (SRM). Double click on the black spectrometer icon in the system tray (lower right corner of the Windows interface) to launch SRM. Ensure that the EyeD-A application is listed and it is indicated that the Device is Found rather than Missing, and the State is Connected and not Disconnected. If the SRM indicates otherwise, the TCP/IP address expected by the chamber instance of EyeD does not match the actual address. Change the TCP/IP address for that instance of EyeD as described in Section 5.3.1.

NOTE

Whenever a change to physical Ethernet connections is made to the tool LAN (swapping, connecting, disconnecting spectrographs, etc.), be sure to:

a. Cycle the power on the spectrograph

b. Exit and restart the SRM.

This procedure will reestablish the spectrograph-to-hub Ethernet link, and then re-read the communications status in the SRM. The SRM will not necessarily indicate a status change automatically; it must be restarted to obtain the most current communications status. If both of these approaches fail, try cycling the power to the hub (briefly unplug the AC adaptor powering the hub) and restarting Windows and EyeD.

4. Close the EyeD-A instance.
5. Repeat steps 4-6 for each instance of EyeD.

5.6 Chamber Performance Validation and Lamp Setup (EyeD-IEP Only)

The EyeD flashlamp is shipped with a factory-preset intensity level and the lamp intensity is computer-controlled. It will be necessary to adjust the light output of the new lamp so that the total light in IEP operations (flashlamp + plasma) does not saturate the CCD detector in the brightest spectral regions with plasma on. This procedure outlines the adjustment to an appropriate level for most processes.

1. Install the source fiber in to the lamp output coupler as shown. Install the IEP probe on to the end of the long fiber optic branch if it was not shipped with a probe (IEP systems only).

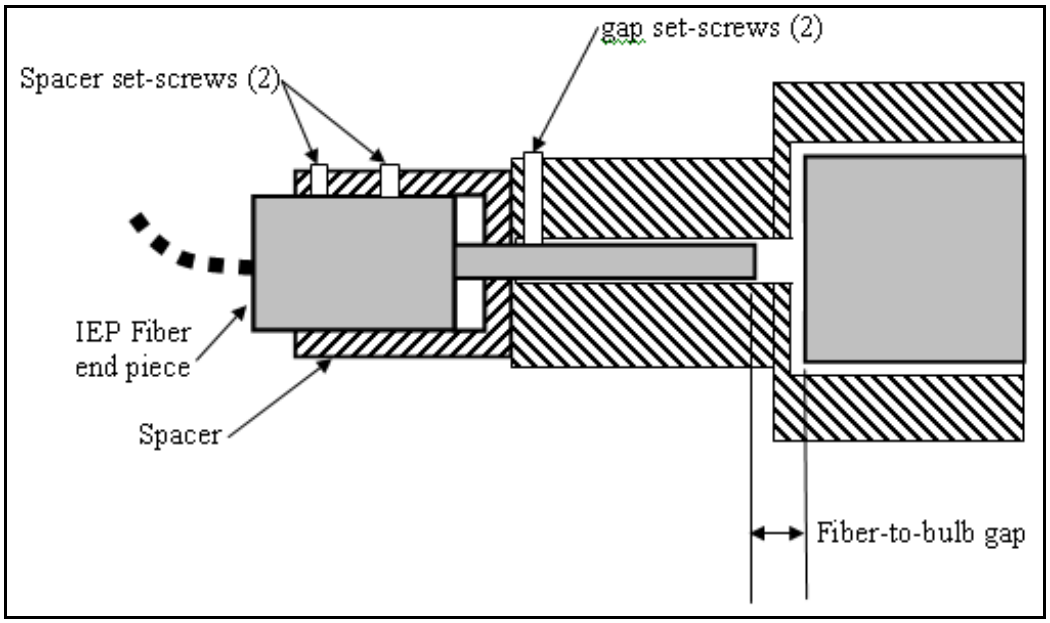


Figure 5-71. Source Fiber Branch IEP Cable Connection Detail

2. Connect the chamber ends of the fiber optic cables. On 200mm chambers, route the short end to the side endpoint (OES) window and screw into the window. Route the long end under the pump channel of the chamber, up and then in to the IEP access port in the HR-DTCU in DPS R1 or ES-DTCU in DPS+. See Figure 5-73. Secure the probe with the clamp mechanism on the side of the DTCU, and secure the cable to the support conduit using tie wraps.

⚠ CAUTION

The IEP fiber optic probe must be secured by the clamp screws in the DTCU during EyeD endpoint operations. The flashlamp creates short pulses of potentially hazardous levels of ultraviolet light.

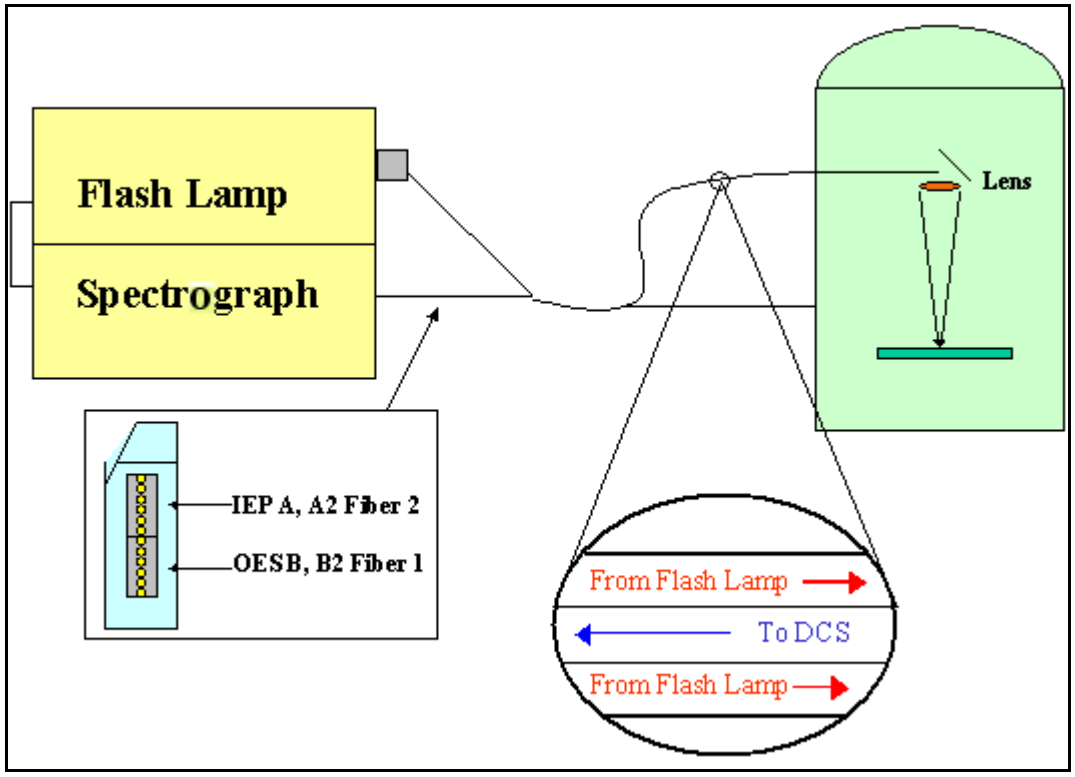


Figure 5-72. IEP Fiber Optic Cable Distribution

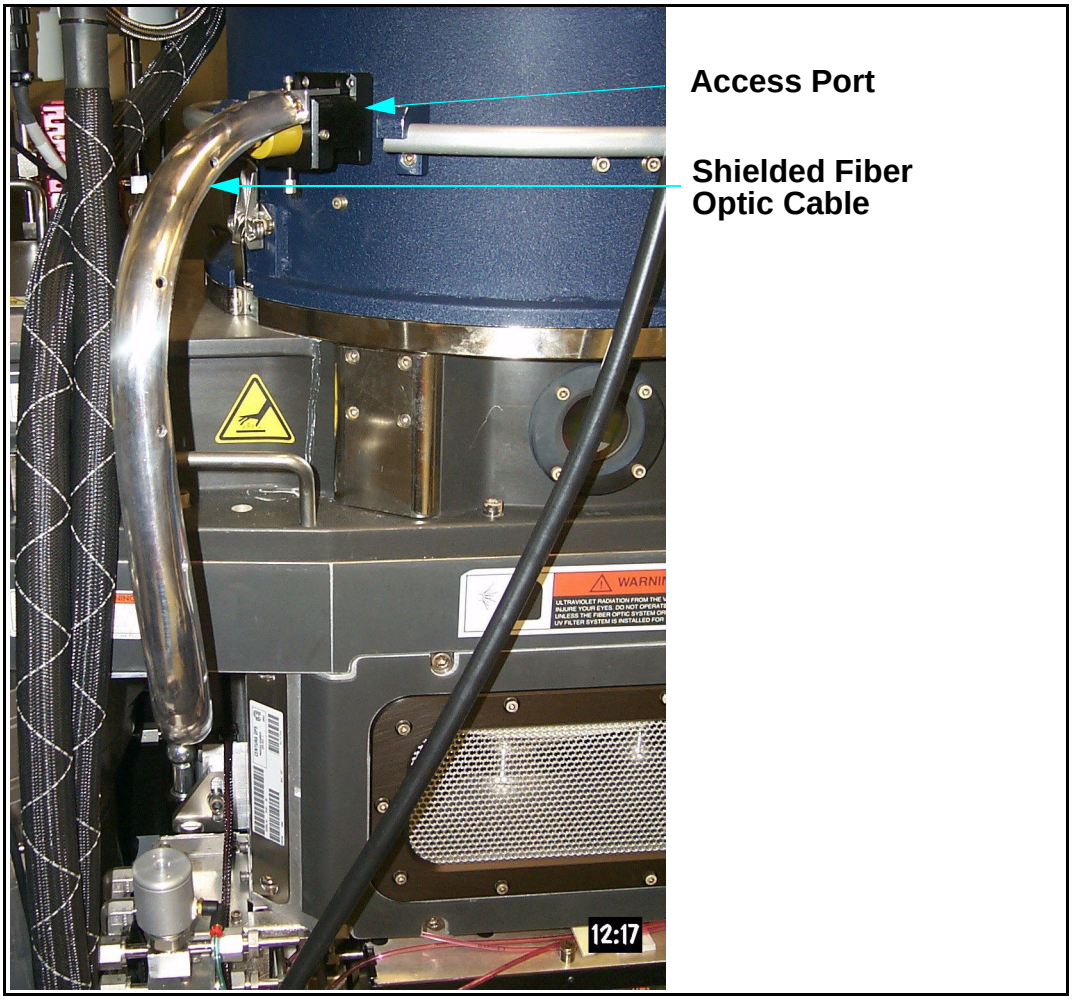


Figure 5-73. Fiber Optic Cable Routed to IEP Access Port on 200mm DPS Chamber

3. Move an unetched blank Si wafer (a particle wafer will work well here) in to the chamber that is to be set up. Put the cathode to process position. This wafer will act as a mirror to reflect the maximum amount of light back up in to the IEP chamber optics.

4. Open the SRM window to adjust the lamp intensity level. Click on **Tools**, then **Adjust Flash Lamp Intensity** to open the window shown in Figure 5-74. The flash intensity can be set only if the associated EyeD instance is closed.

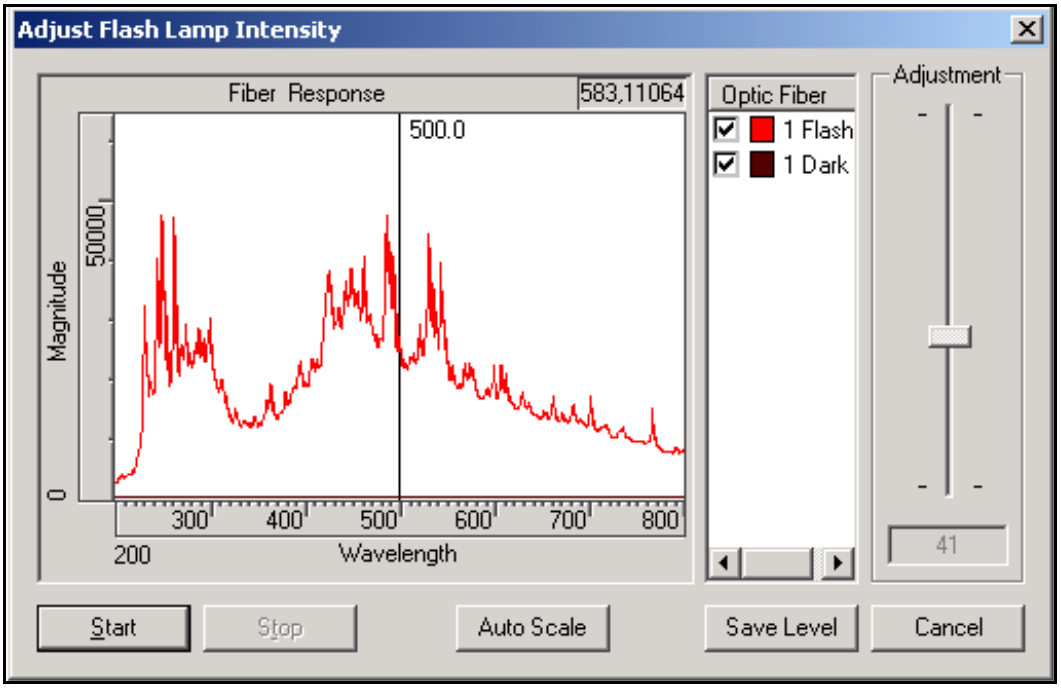


Figure 5-74. Flash Lamp Intensity Adjustment Window

5. Click on **Start** to begin monitoring the intensity. A warning window will pop up asking that the light source be properly contained. Make sure the Fiber optic cable is secured and click on **Yes**.

6. The LCD screen on the DCS will say *Acquire Data*.

7. The default lamp intensity level can be adjusted using the sliding bar at the right side of the window. The level set by this utility will be the one that is automatically used by every algorithm which does not use "lamp intensity override" in its configuration setup. A default lamp intensity of 50,000 +/- 2000 counts usually works well. However, for cases where plasma luminance is especially bright, the level should be turned down to avoid saturation near wavelengths which are used for endpointing. The lowest lamp level that can be saved is 35%. Although you can see the effect for lower settings using the slider, values below 35% would lead to reduced flash repeatability.

   If a value of 35% does not provide low enough intensity, then a mechanical means of attenuating the lamp signal is provided. Figure 5-71 shows the output coupler of the flashlamp housing in cross section along with the fiber optic end piece. The set screws for *fiber gap* locks the fiber optic end piece in position relative to the flashbulb with a particular gap. Repeatability from insertion to insertion of the fiber end piece is ensured by the spacer.

8. When it is necessary to change this gap, then first loosen the fiber gap set screws, and increase the spacing by millimeter increments until the desired reduction in lamp intensity is achieved.

9. Tighten the gap set screws.

10. Use a 0.050" allen key (inserting it through the red laquer that holds the spacer set screws in place) and loosen the spacer set screws.
11. Slide the spacer to its new position, then Reopen the associated EyeD instance.
12. Repeat this procedure for each of the other spectrographs.

5.7 Flashlamp Safety Interlock (EyeD-IEP only)

The flashlamp contains internal safety interlocks that prevent operation if the housing is compromised. In addition, the output coupler contains a spring-loaded shutter that prevents any light from escaping if the fiber-optic cable is removed. The lamp interlock circuit is connected to the DCS and monitored for integrity by the internal (embedded) computer. Therefore, if the interlock signal is interrupted, the DCS LED screen will display the following message:

```
STOP

FLASH LAMP DANGER!!
```

A different error message is displayed by the DCS if the unit is started without the interlock signal present:

```
CAN'T START

FLASH LAMP DANGER!!
```

To restart an operation following such a shut down, the interlock signal must be reestablished and a stop signal sent from the control computer running EyeD software. This stop signal clears the shutdown and a subsequent start signal will resume EyeD operation. A start signal can be any one of three commands from the application computer, including monitor, capture or process. In remote operation, the process module must send a digital or packet-based start command.



⚠ WARNING

Ultraviolet Light is present and can hurt your eyes.

Eye Protection is required when working on this device.

The FL2002 produces strong pulses of UV light and can damage vision if improperly configured. Attempting to bypass safety circuitry could result in injury.



Never operate the unit without a leak-proof light seal at the fiber optic port and the distal end of any fiber optic cable connected to the port. Contact Applied Materials technical personnel for process-specific safety procedures.

For the flashlamp to function, the interlock connector BNC Stub on (J4) must be present.

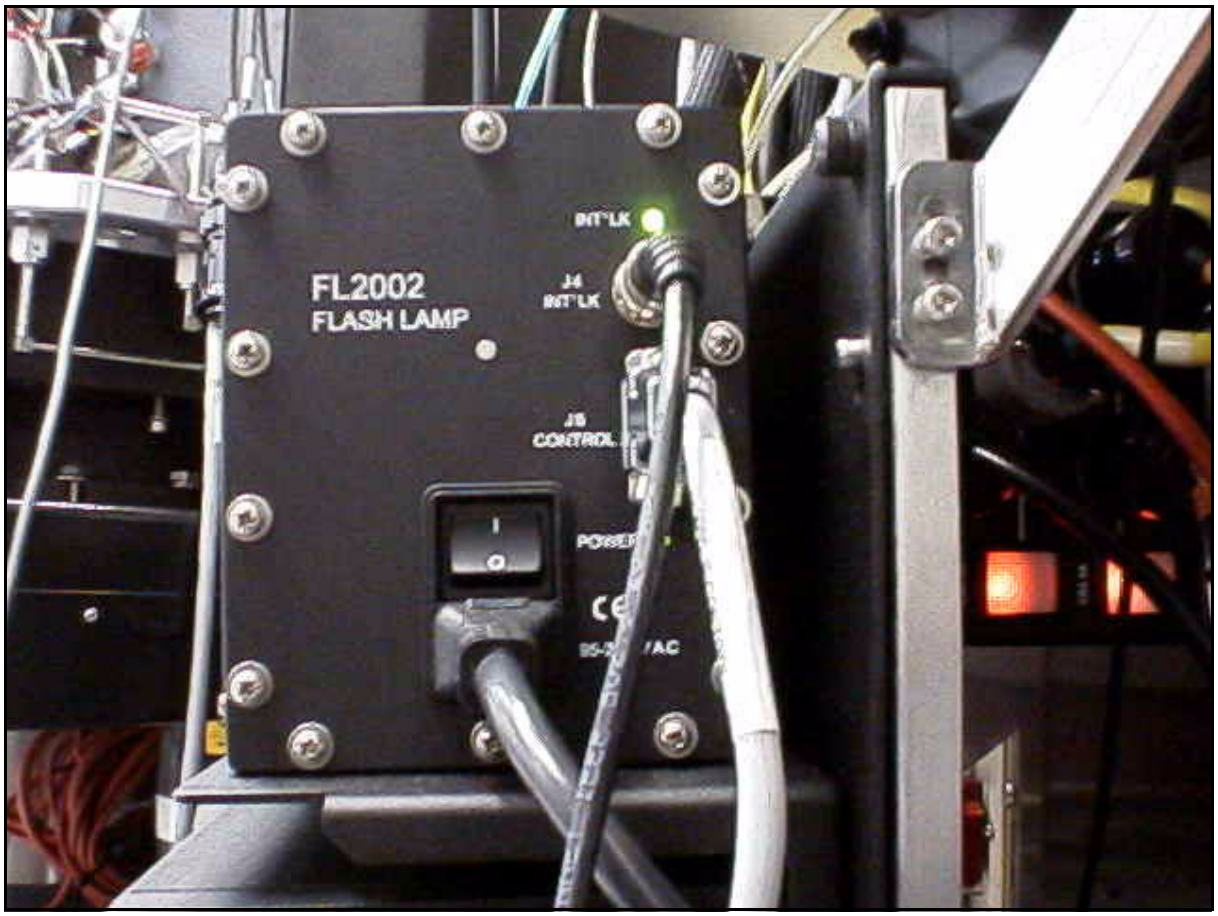


Figure 5-75. FL2002 Interlock Connectors

5.8 Local Area Network (LAN) Setup

The 200mm EyeD controller is configured with 2 network adapters: Spectrograph LAN and Factory LAN. When integrating the EyeD controller within Tool and/or Factory Local Area Networks (LANs), a user may need to configure either the Factory or Tool LAN network interface card (NIC) to have specific TCP/IP settings. Each EyeD controller is equipped with multiple network adapters so that a Factory LAN connection will not impose communications traffic on the isolated Spectrograph LAN, thereby reducing its bandwidth.

Note that there 2 network ports are on the main processor board on both 200 and 300mm computers, and that the 300mm computer has a third port on a separate PCI card. The diagram in Figure 5-76 and the following instructions apply regardless of the physical layout.

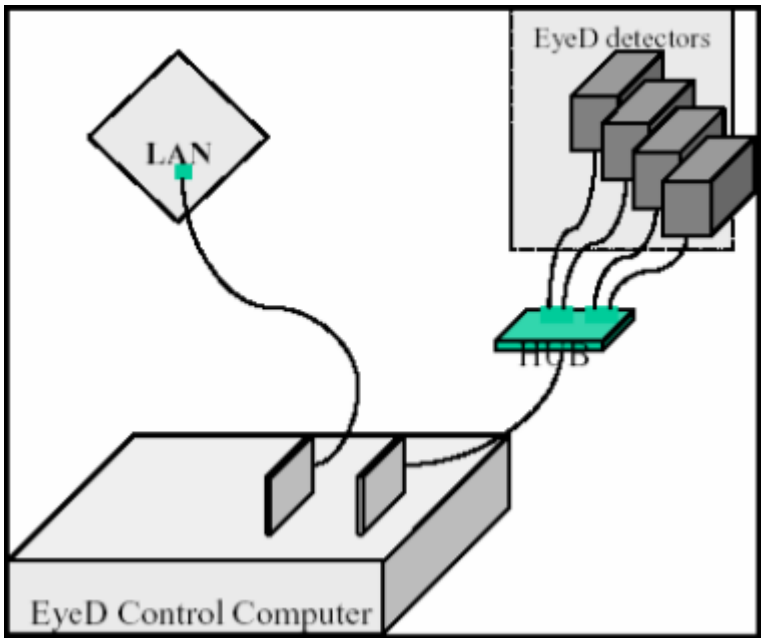


Figure 5-76. Network Diagram

It is recommended that the Spectrograph LAN always be on the "primary" network adapter in order to be the first one polled/detected if several are in use, and the one to get message priority. This will happen automatically if the computer is booted with the spectrographs and the spectrograph hub powered, active, and connected to the Spectrograph LAN port.

Ports are labeled on EyeD controllers. If the EyeD controller is brought up with the Spectrograph LAN disconnected and either of the other NICs connected, then the secondary NIC will be assigned priority.

Again, the possibility of the Spectrograph LAN receiving low priority is eliminated by ensuring that all physical connections are made prior to launching EyeD/Spectra Resource Manager, and ensuring that all spectrographs are powered on prior to booting the controller computer.

If a situation does arise causing the Spectrograph LAN to become disconnected, then one can force the Spectrograph LAN port to have priority by:

1. Disconnecting all Ethernet cables and wait for windows to recognize the disconnection (about 5 sec).
2. Re-connecting the spectrograph LAN only to the correct port; wait ~5 seconds and use SRM to verify the Spectrograph LAN. SRM should indicate that all spectrographs are Found.
3. Re-connect the other LAN cable(s), using Windows Explorer to verify existence of a valid LAN File/Directory.

5.8.1 Configuration of Network Connection Names

1. Navigate (using the Windows "Start" button) to Settings ==>Network and DialupConnections and double click. Do not select any item from the cascade if present.

   A screen similar to the Figure 5-77 should appear.

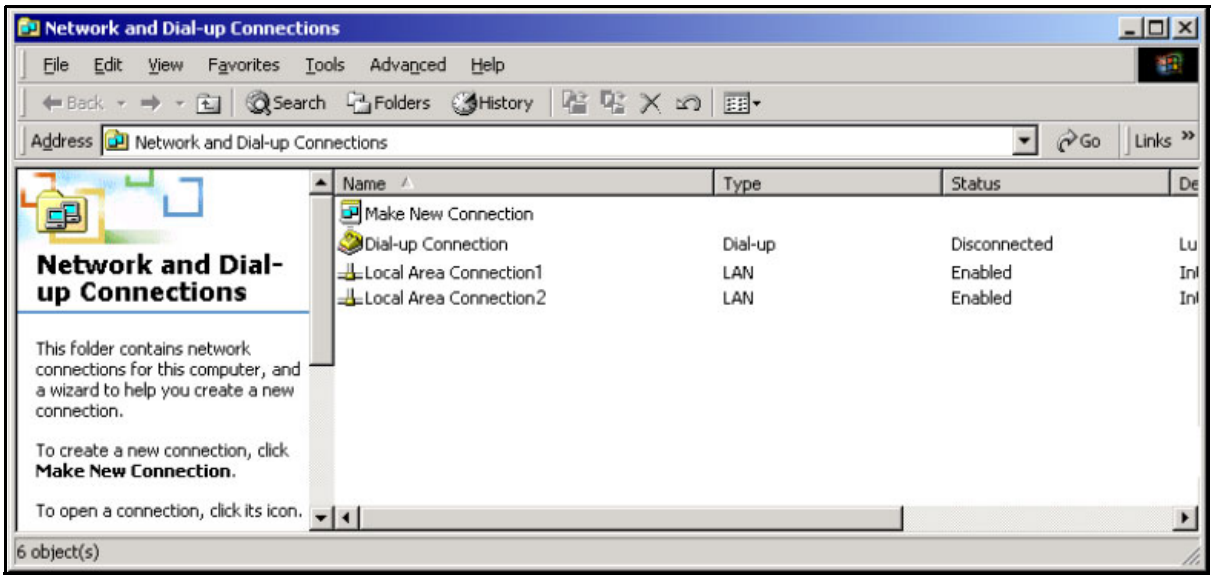


Figure 5-77. Network Dial-up Connections

2. Navigate (using the Windows "Start" button) to Settings ==>Network and Dialup Connections and double click. Do not select any item from the cascade if present.

   A screen similar to the Figure 5-78 should appear.

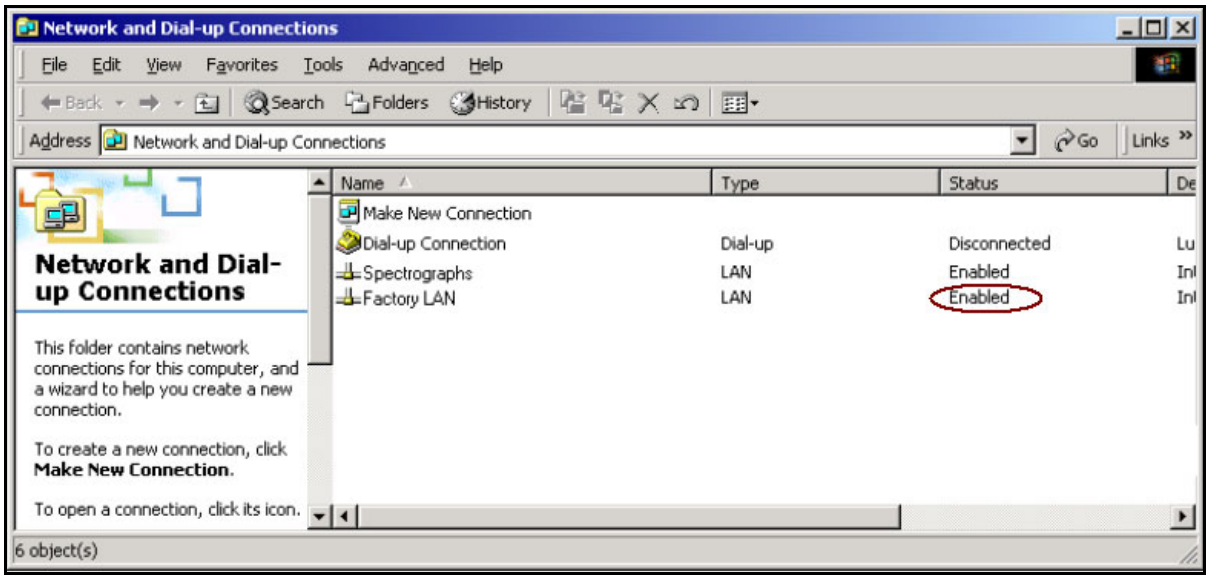


Figure 5-78. Network and Dial-up Connections

3. Ensure that the network cable of the associated card is properly attached to the interface described during the re-name. In windows 2000 this is easy to accomplish simply by disconnecting and re-connecting the cable and watching the "Status" column above.

5.8.2 Configuring the Spectrograph LAN Ethernet Adapter

1. In the Network and Dial-up Connections RIGHT-click the "Spectrographs". You should be presented with a pop-up menu with the last item being "Properties".

2. Click on **Properties**.

   A dialog similar to the one in Figure 5-48 should appear.

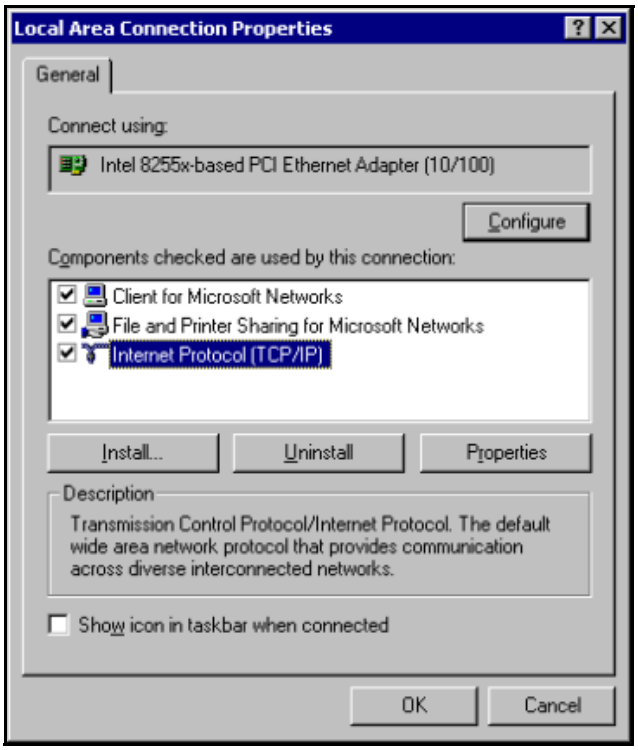


Figure 5-79. Local Area Connection Properties

NOTE

Only TCP/IP settings for the Ethernet card being used for Spectrograph communication should be changed. If there is not a "TCP/IP" protocol entry for the Ethernet card to be used, you will need to press the "Install…" button and define one.

3. Disable the Client for Microsoft Networks entry by clicking on the check mark.There must be no check mark in this entry.

4. Disable File and Print Sharing for Microsoft Networks by ckicking on the check mark. There must be no check mark in this entry. The dialog should now resemble Figure 5-80.

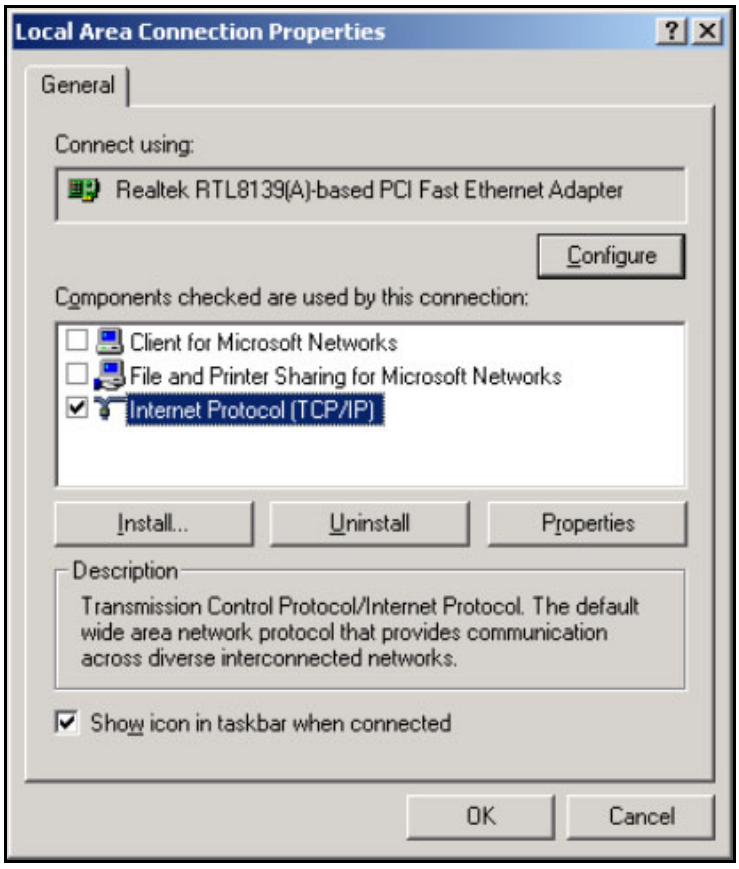


Figure 5-80. Local Area Connection Properties Showing Selection

You may click Properties, with Internet Protocol selected, to view a window as shown in Figure 5-50. Only the IP address and Subnet mask are necessary to communicate with the spectrographs.

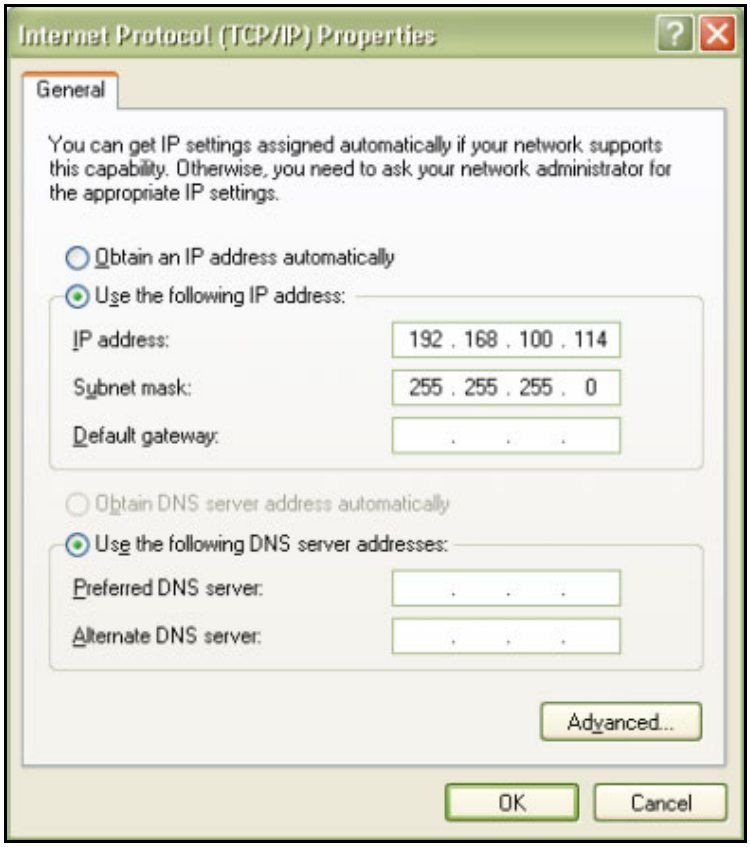


Figure 5-81. TCP/IP Properties

5.8.3 Default NIC TCP/IP Addresses

Ethernet port PCA-6186 LAN # 1: Spectrograph LAN, IP address 192.168.100.100.

Ethernet port PCA-6186 LAN # 2: Factory LAN, Obtain an IP address from DHCP server.

5.9 Finding the IP Address of a Spectrograph

If the IP Address of the spectrograph is unknown, it may be found by following these steps:

1. Power off the spectrograph.
2. Remove the Ethernet cable from the J2-Com2 Port. Insert a USB cable in its place. A USB cable is supplied with each EyeD Detector, and should be saved for this use.
3. Plug the other end of the USB cable into the USB Port on the PC (either USB port is acceptable).
4. Turn on the Power to the spectrograph.
5. Install the USB on the PC:
   a. An install wizard should automatically pop up. Install it under *C:\EyeD\USBDrivers*.
   b. If nothing pops up, go to *Start\Settings\Control Panel\Add/Remove Program*. Install USB.

6. Create an SRM application that utilizes USB rather than TCP/IP for communication mode. The IP Address and Serial number can be found under: *Tools\Device Param* in the SRM menu bar.

NOTE

Consult the fab IS&T Administrator if any fab LAN interconnection issues are encountered.

5.10 Installation Complete

The total installation of the EyeD system is now complete. All hardware installation instructions are found in Chapter 4. Software installation and setup of SRM, URI and the EyeD instances, including setting up DI/O and serial communication, has been explained in this chapter. For maintenance, troubleshooting, and upgrades see Chapter 8.

THIS PAGE INTENTIONALLY LEFT BLANK

6 300mm Hardware Installation

6.1 Introduction

The 300mm EyeD advanced feature endpoint system comes in two overall configurations:

1. **EyeD-OES**. This configuration is intended for use in optical emission spectroscopic (OES) applications only. It can be used in virtually any chamber (silicon etch DPS, MxP, dielectric eMax, Enabler) that has an endpoint window, but is most commonly used with the eMax chamber. The detector used in this configuration has a single input channel. It is mounted to the 300mm chambers. The detector is referred to as a Single Channel Spectrometer (SCS), and has a reference model number SD1024DLC. See Figure 6-1.



Figure 6-1. EyeD-OES Chamber Assembly with SCS on 300mm Enabler

2. **EyeD-IEP**. This configuration allows the user to operate in either the interferometer endpoint (IEP) mode or the OES mode as required in a particular (silicon DPS, initially) etch chamber. The detector has two input channels, one for OES (chamber side view) and one for IEP (chamber top view). The detector is called the Dual Channel Spectrometer (DCS), which is also referenced by SD1024D-2-S. This configuration employs an integrated Modulated High Intensity Full spectrum (MHIF) light source, which is also referenced by FL2002 Flashlamp. Both the detector and the light source are attached to the chamber

using a quick release bracket, and are optically coupled to the chamber with a short, double-bifurcated fiber optic cable. See Figure 6-2.

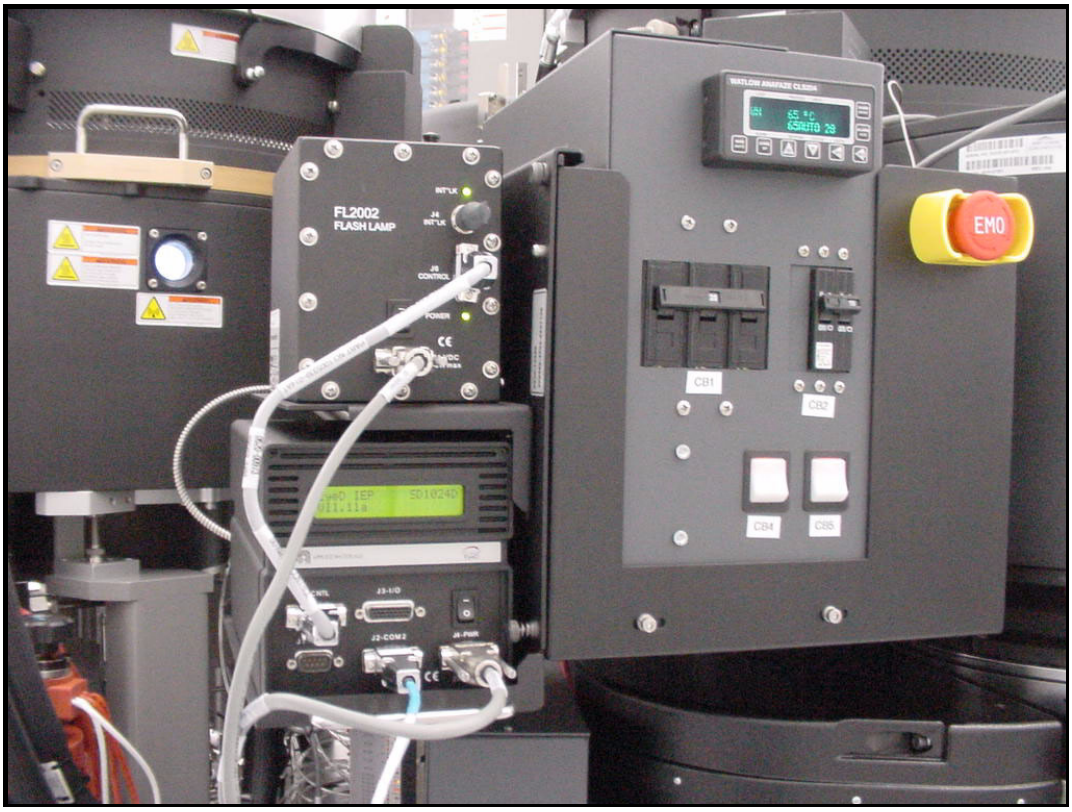


Figure 6-2. EyeD-IEP Assembly with DCS and Flashlamp on 300mm DPS II

The EyeD software descriptions that follow in later chapters of this manual may not distinguish between the specific hardware sets described above, as the software has been coded to be universal to any configurable detector. When a DCS EyeD-IEP detector is configured using the Spectra Resource Manager (SRM), there will be two available data sources for building algorithm configurations: data source A (top view IEP data) and data source B (side view OES data). When an SCS is configured using the SRM, then there will only be a single available data source: data source A (side view OES).

6.2 EyeD-OES Hardware Overview

The EyeD-OES endpoint system consists of a computer assembly (computer, hub), an SCS for each chamber, and optical fiber cables. On the 300mm Centura, the computer assembly is integrated into the monitor. The SCS detector (SD1024DLC) is mounted to 300mm chambers (Figure 6-2 and Figure 6-3). Ethernet cables run from the detectors to the computer. A second Ethernet port in the computer allows the computer to be connected to the fab LAN. In 300mm there is no option for digital communication; the serial cables (RS232) run from the computer to each chamber. The basic system elements are shown in Figure 6-3.

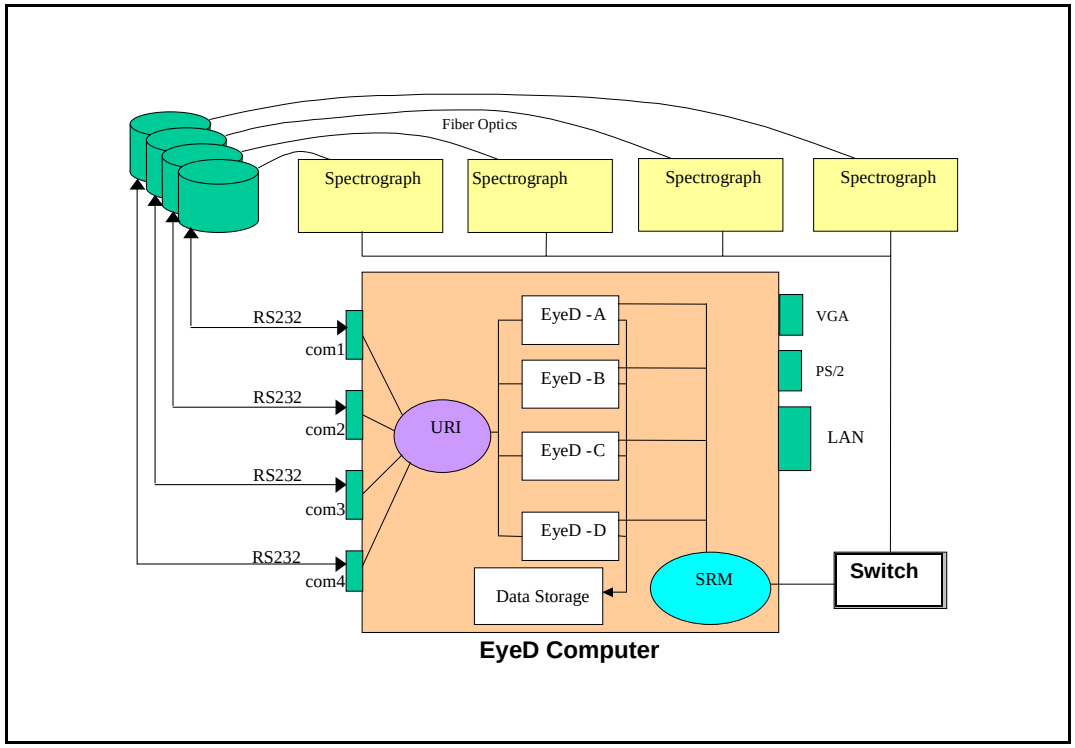


Figure 6-3. 300mm Software and Hardware Communication EyeD-OES Overview



Figure 6-4. 300mm Ergotron Computer Assembly

6.3 EyeD-IEP Hardware Overview

The EyeD-IEP endpoint system consists of a computer assembly, a chamber assembly (FL2002 Flashlamp, DCS) for each chamber, and optical fiber cables. On the 300mm systems

the computer assembly is mounted on a stand-alone, Ergotron cart (Figure 6-4). The DCS detector (SD1024D-2-S) is quick mounted to the chamber to keep the optical fiber length as short as possible (Figure 6-2 and Figure 6-3). Ethernet cables run from the detectors to the computer. A second Ethernet port in the computer allows the computer to be connected to the fab LAN. In 300mm, there is not an option for digital communication and the serial cables (RS232) run from the computer to each chamber. The basic system elements are shown in Figure 6-3 and Figure 6-5.

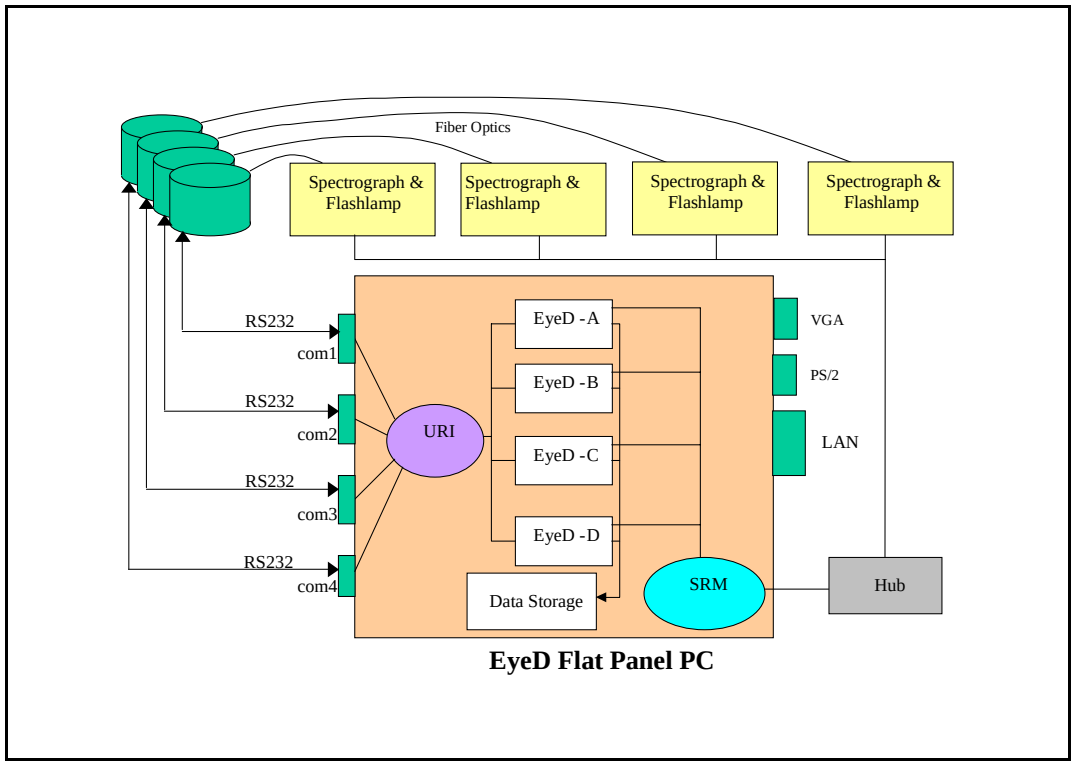


Figure 6-5. 300mm Software and Hardware Communication EyeD-IEP Overview

6.4 Power

For 300mm applications, power for the ergonomic computer stand is provided by 120VAC convenience outlet, either an unused outlet of the Factory Interface, or a customer provided bay outlet. The spectrograph and flashlamp chamber assemblies are each powered by a 24VDC, 9-pin D-sub, power connection, both of which are on the chamber harness.

6.5 Safety

Labeling must be added to some of the DPS chamber and EyeD IEP components during retrofit installation in order to comply with safety requirements.

These include:

Hazardous Voltage: 0060-76128 rev B: *exterior of each DCS, SCS and FL2002 lamp housing.*

Hot Surface Inside: 0060-21446 rev A: *exterior of each FL2002 lamp housing.*

Ultraviolet Radiation: 0060-18004 rev A: *exterior of each FL2002 lamp housing and on side of DTCU.*

Heavy Object: 0060-76188 rev B: *exterior of control computer.*

Whenever any procedures are performed on the DPS chamber that require removal of the IEP probe from the DTCU, the following procedures MUST be observed to prevent inadvertent exposure to levels of ultraviolet (UV) radiation in excess of established limits within SEMI S2-93.

To eliminate the possibility of UV exposure, BOTH of the following steps are necessary:

1. Software: Close the instance of EyeD on the control computer for the chamber that is to be serviced. The lamp cannot produce UV radiation unless commanded by the control computer to do so. By exiting the chamber instance, software commands to the lamp cannot be issued.
2. Hardware: Power down the DCS and lamp. Remove AC power plugs from the chamber AC panel and secure them with appropriate Lock Out Tag Out (LOTO) devices as necessary to eliminate the possibility of another worker re-energizing the lamp.

6.6 EyeD Installation of Ergotron Stand with Computer for 300mm DPSII and eMAX

The 300mm tower computer with a with flat panel monitor is installed on its own freestanding Ergotron stand. Figure 6-4 shows this option.

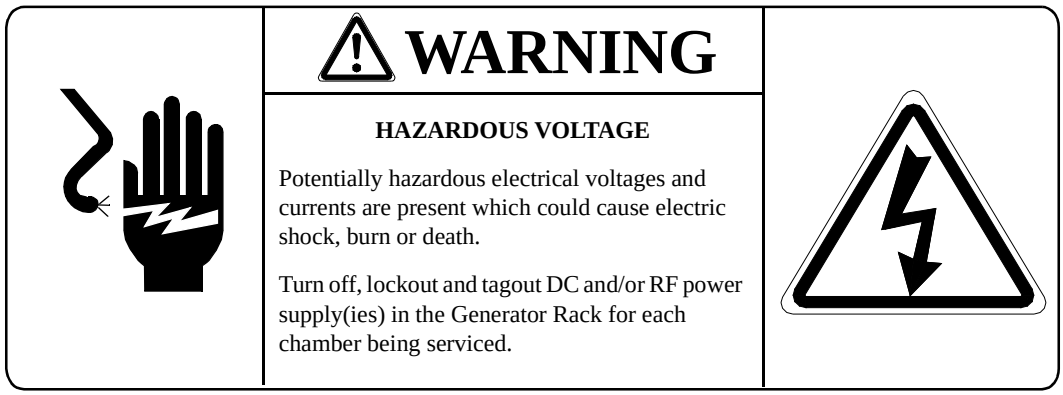
6.7 EyeD-IEP Flashlamp and DCS Installation on 300mm DPSII Chamber

When adding EyeD-IEP to an existing system, the manometer assembly and the tray that holds the Lid Heater PID Control and Monochromator, need to be retrofitted to allow access to the OES Endpoint window. This procedure includes these retrofits.

1. Unplug all cables connected to the Lid Heater PID Control and Monochromator, and remove these two boxes from the tray.
2. Lockout/tagout power to the EMO button.
3. Remove the EMO button attached to the tray.
4. Remove all screws mounting the tray and save them for the new tray installation.
5. Install the new tray (P/N 0040-49259) using the screws from the old tray. Place the Lid Heater PID Control in the new tray and plug all the cables back in. Reinstall the EMO Button onto the tray. The Monochromator will not be reinstalled, as it is not needed with the EyeD system. The installed tray should look like that is Figure 6-6.



Figure 6-6. Retrofitted Tray with Lid Heater PID Control on 300mm DPS II Chamber



6. Install the SP2000 Shelf Assembly (P/N 0010-11690), containing the flashlamp and DCS, to the tray by tightening the 4 captive screws. See Figure 6-7.

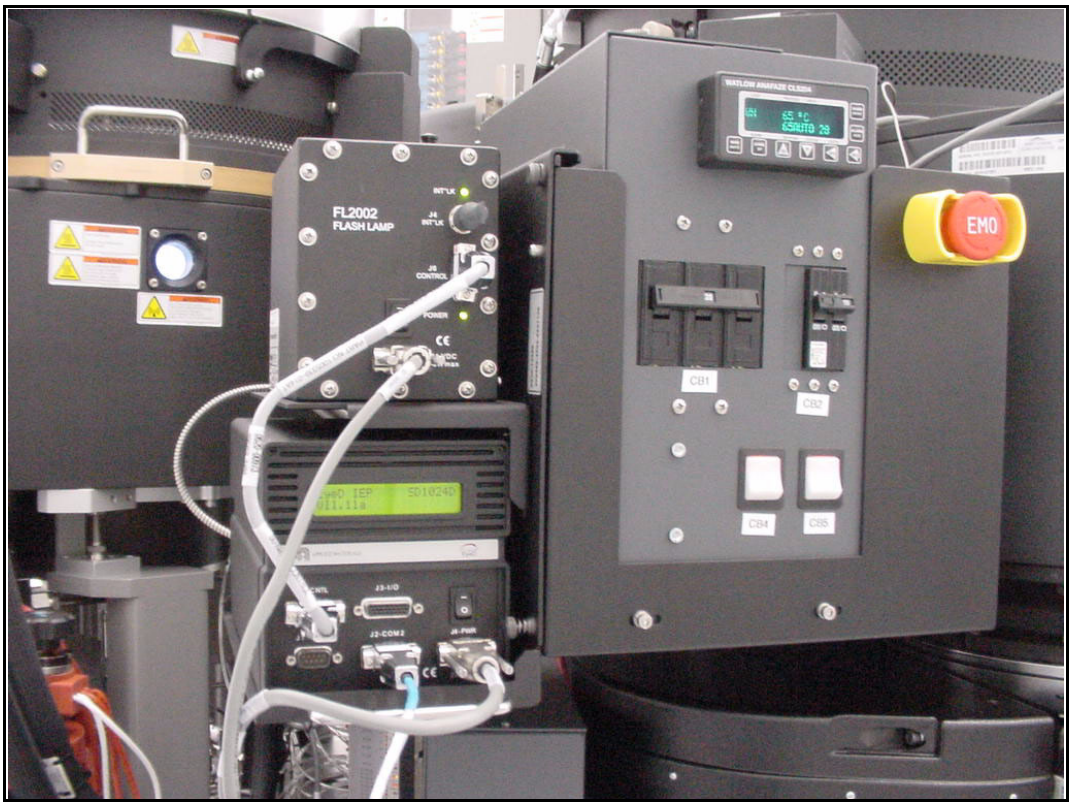


Figure 6-7. Installed EyeD-IEP Detector and Lamp on 300mm DPSII Chamber

7. Remove the dual manometer assembly. Install the Manometer Iso Valve Assembly (P/N 0190-07704); is it keyed so that will only fit in one direction. Insert the new O-Ring (P/N 3700-02025) into the assembly before attaching to the chamber.

8. Attach the two new manometers to the assembly using VCR Gaskets (P/N 3320-01166). The 100mTorr manometer (p/n 1350-00098) attaches to the upper branch and the 10Torr manometer (p/n 1350-00097) attaches to the lower

branch. Cover the upper branch with the black cover that comes with the Iso Valve Assembly. The installed manometer assembly is shown in Figure 6-8.

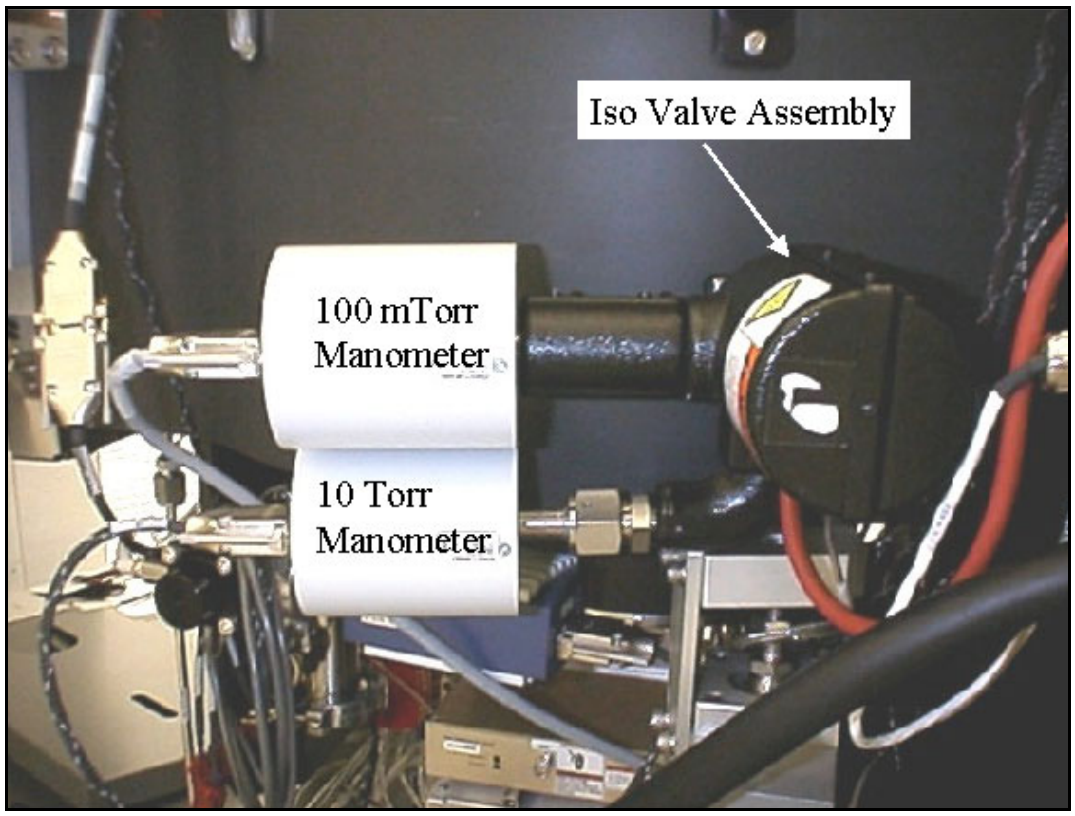


Figure 6-8. Retrofitted Dual Manometer Assembly on 300mm DPSII Chamber

9. Remove the bracket and sapphire piece from the OES window (lower window). Insert the new sapphire piece (p/n 0200-02160) and the window bracket (p/n 0021-23337)

10. Install the bracket to hold the fiber optic cable to the IEP window (upper window). It consists of 2 parts: the bottom (p/n 0021-18312) and the top (p/n 0021-18313). Attach the bottom part first, using 2 shoulder screws (p/n 3690-04051) on the sides. Then use a shoulder screw (p/n 3690-01794) on the right side to attach the top part to the bottom. One more screw is used to secure the two pieces together on the left. See Figure 6-9 for the bracket holding the fiber optic cable.

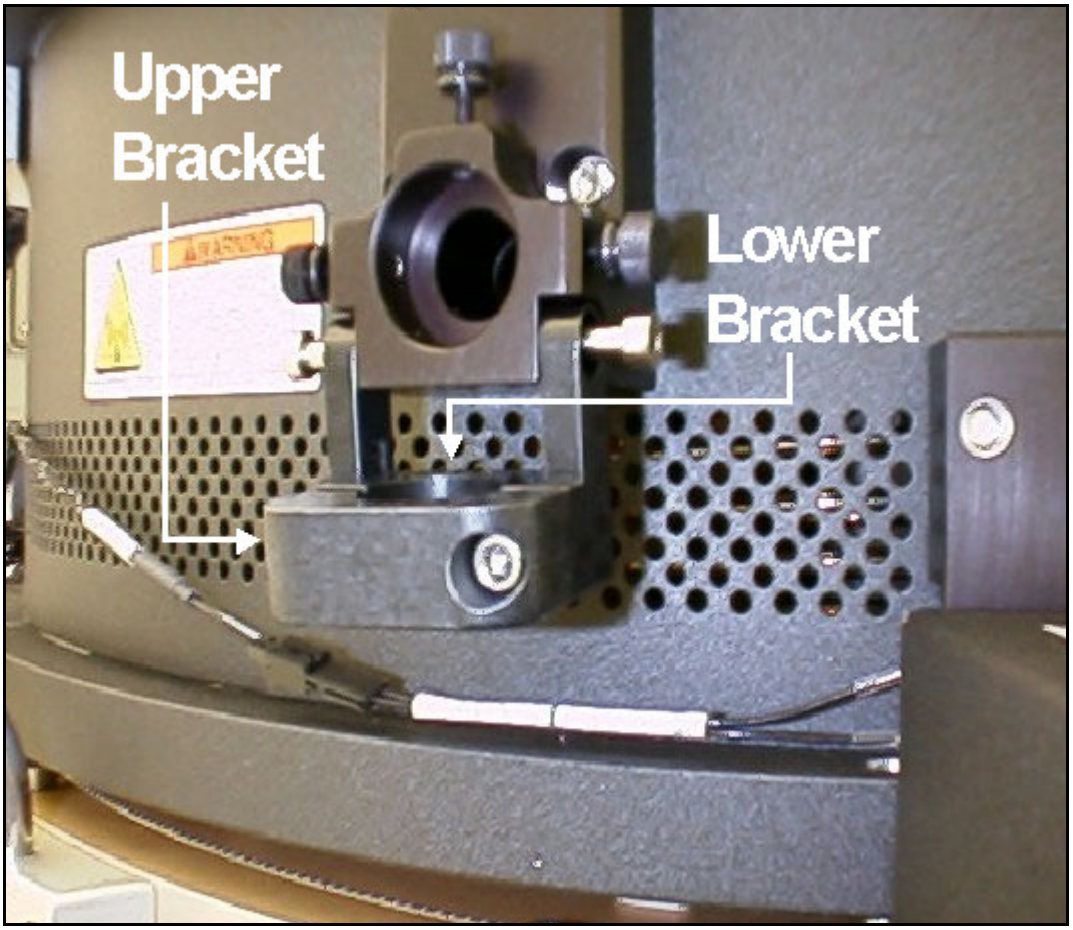


Figure 6-9. Bracket for Fiber Optic Cable on 300mm DPS II Chamber IEP Window

11. Lift the chamber lid to install the IEP viewing window. Remove the existing centerpiece and install the window containing the mirror assembly (0010-11368). See Figure 6-10.

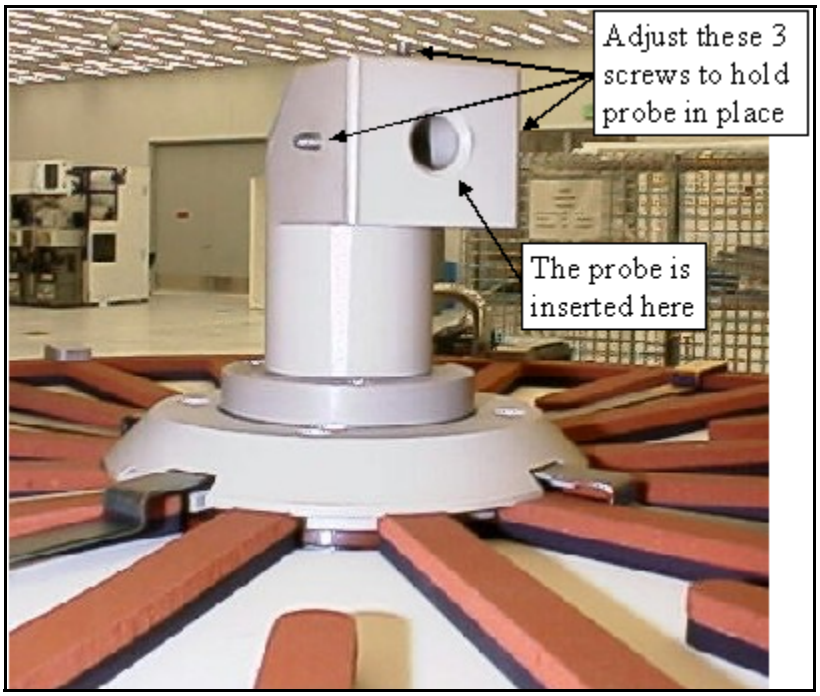


Figure 6-10. IEP Mirror Assembly on 300mm DPSII Chamber

6.8 EyeD-OES Installation of SCS on 300mm eMAX Chamber

1. Attach the Eye-D detector module bracket to the chamber magnetic shield. If this is a retrofit on a 300mm chamber, it will be necessary to remove the left side magnet shield and install the new shield. The new shield will have 3 holes drilled and tapped for attachment of the spectrograph bracket.

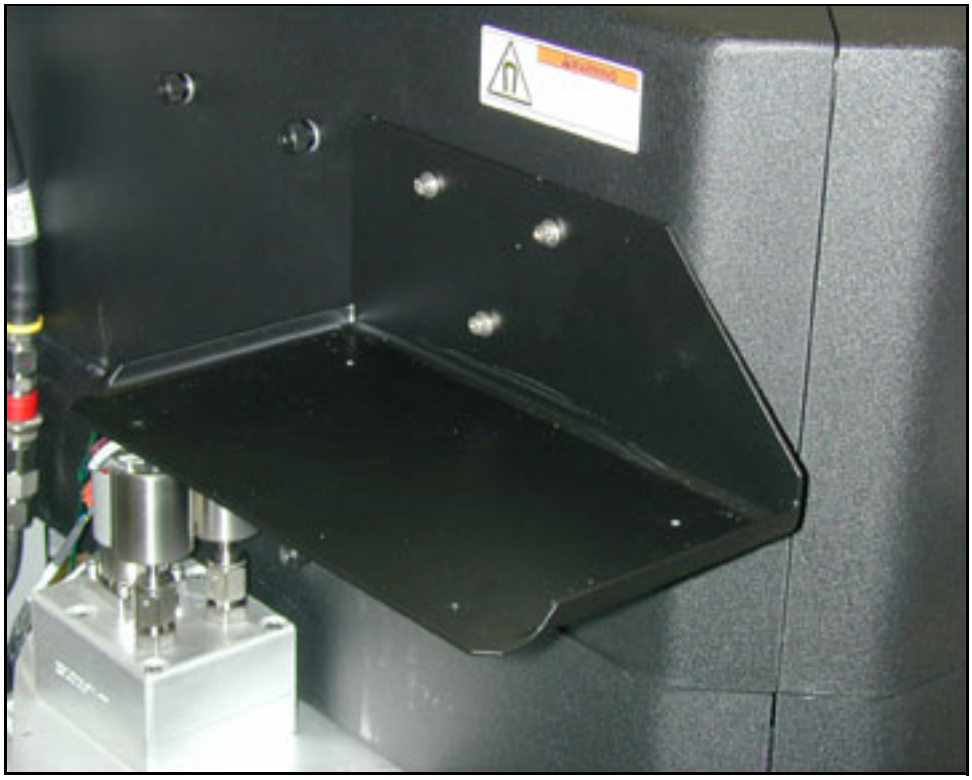


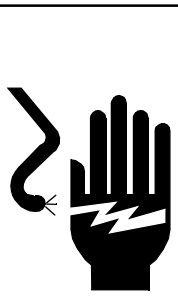
Figure 6-11. Location for Bracket Installation

2. Attach the spectrograph detector module to the bracket.



Figure 6-12. Front View of Installed Detector Module on 300mm Enabler

3. Repeat this step for each chamber that is to receive an EyeD-OES spectrograph.

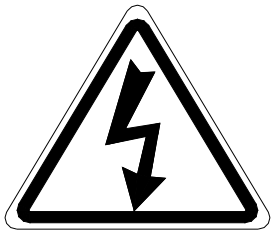


⚠ WARNING

HAZARDOUS VOLTAGE

Potentially hazardous electrical voltages and currents are present which could cause electric shock, burn or death.

Turn off, lockout and tagout DC and/or RF power supply(ies) in the Generator Rack for each chamber being serviced.



4. Install a spectrograph module to each fixed chamber bracket. Connect power to the spectrograph via the 24VDC 9-pin D-sub connector on the front of the module.

6.9 Connecting Cables

6.9.1 Computer Assembly

1. Connect the computer power cord to the surge filter.
2. Route the keyboard/mouse cable to the computer and attach an adaptor to the keyboard and mouse connectors so that they combine to plug into the PS/2 Port. Secure the cable with cable ties if needed.
3. Connect the hub power supply to the power strip using the uplink supplied with the hub.
4. Connect an Ethernet cable (p/n 0620-01529) between the Ethernet Hub port 1 and the Main Ethernet Port on the computer.
5. Connect the 9-pin D-sub female RS232 Protocol 3 common 50ft cable(s) (p/n 0620-02823) to the computer.

   Chamber A = 3

   Chamber B = 4

   Chamber C = 5

   Chamber D = 6
6. Connect 1 Ethernet cables (p/n 0620-00567) to one of the lower 4 ports on the Ethernet Hub, Ports 2-5. If there is more than one spectrograph, route all the Ethernet cables to the hub, but plug in one only.

   The spectrographs will be connected t the EyeD computer via ports 2 - 5 of the Ethernet hub. However, do not connect the cables yet. the spectrographs need to be configured for communication with the computer. This must be done one at a time, as all the units are shipped with the same IP address. Refer to Chapter 7 for instructions on installing software and setting up communications between the spectrographs and the computer.
7. Route the fab network cable (p/n 0620-01324), if required, to the global networking port on the computer.

NOTE

IMPORTANT: *DO NOT* connect the fab Ethernet to the spectrograph hub because this will cause the detectors to be unreliable.

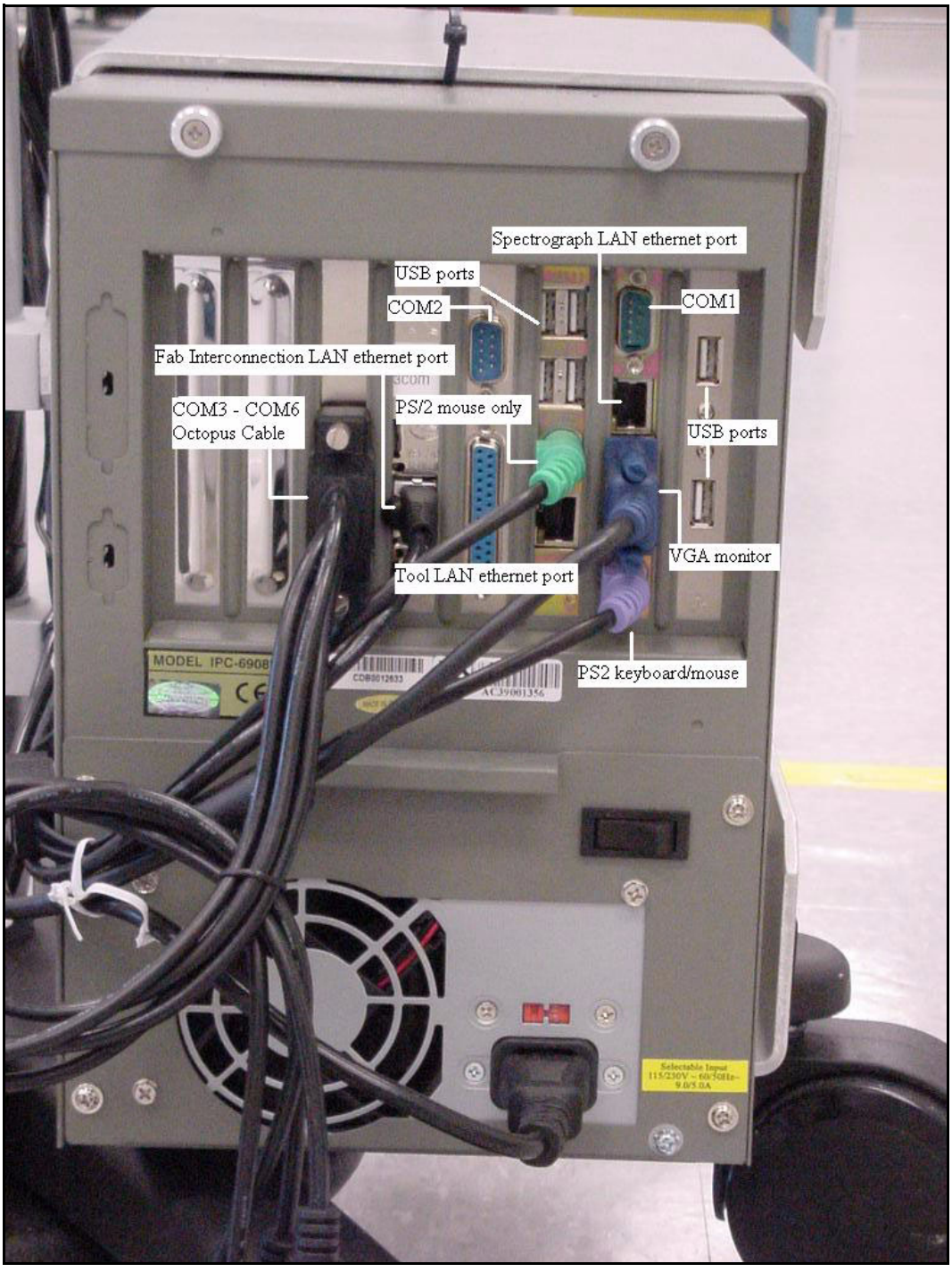


Figure 6-13. 300mm Control Computer Connections



Figure 6-14. 300mm Ethernet Hub

6.9.2 Spectrograph Assembly

1. Route Ethernet communication cables from the Ethernet hub to the J2-Com2 port on the spectrographs.

2. Secure the cables with cable ties, and label each cable for the particular chamber designation using a permanent marker.

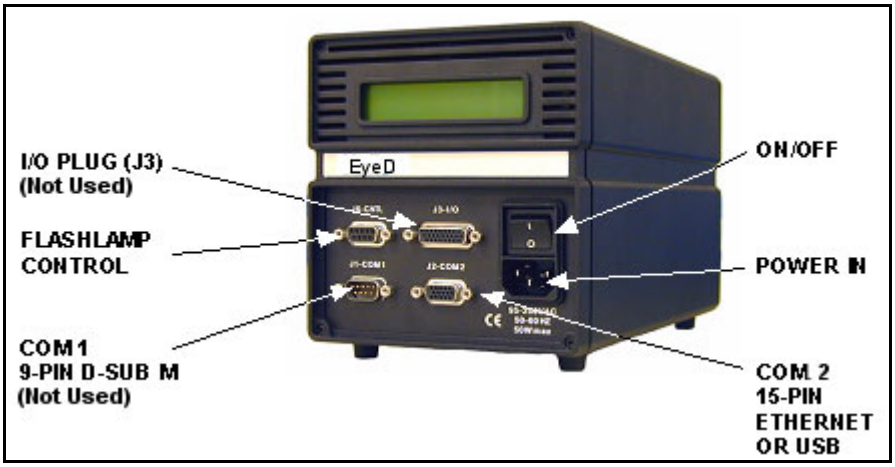


Figure 6-15. Cable Connections to Spectrograph

6.9.3 Mainframe

1. Route the serial cables from the computer to P4/Com1 Ports under the Main Ethernet Port for the corresponding chamber. Follow the port designation from Section 6.9.1.



Figure 6-16. Port 4/Com1 under the 300mm DPSII Chamber

2. The completed system will have interconnections similar to those in Figure 6-17 for EyeD-IEP and Figure 6-19 for EyeD-OES.

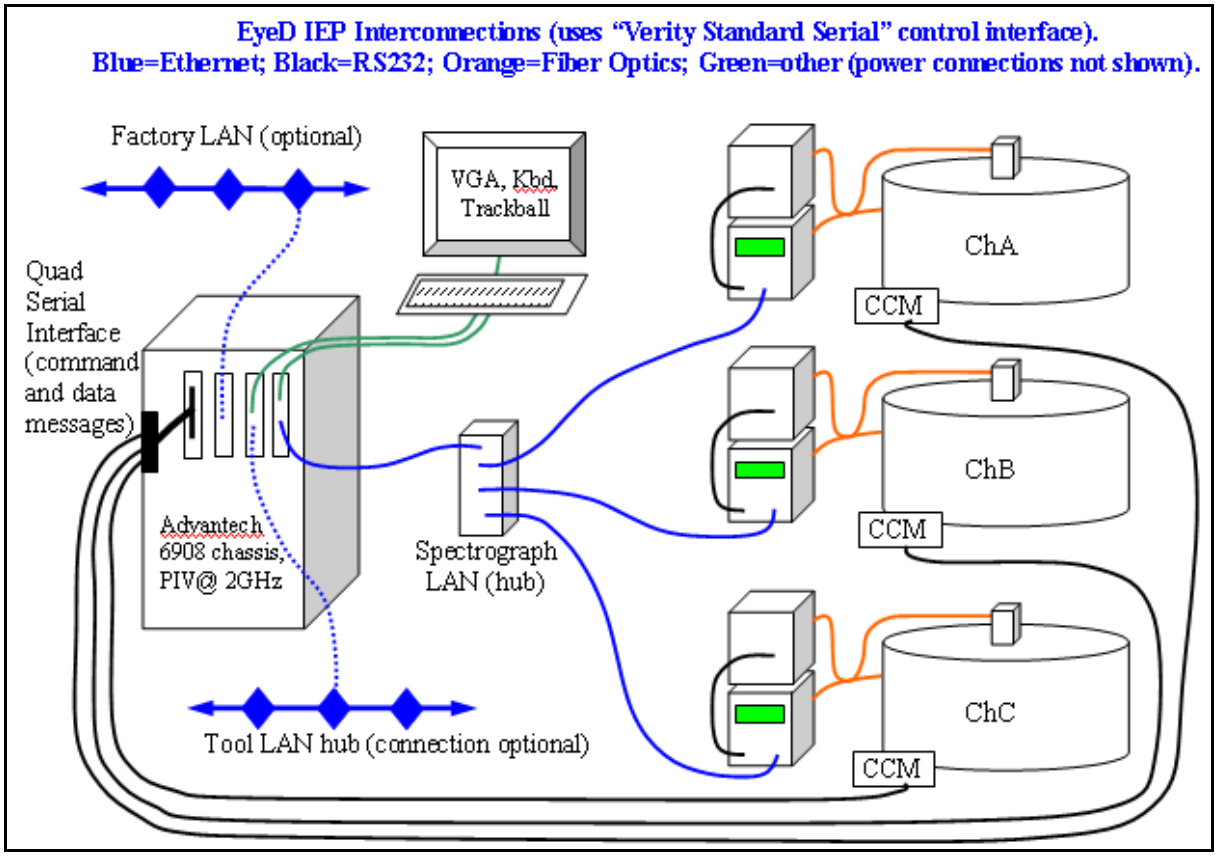


Figure 6-17. EyeD-IEP Interconnect Diagram

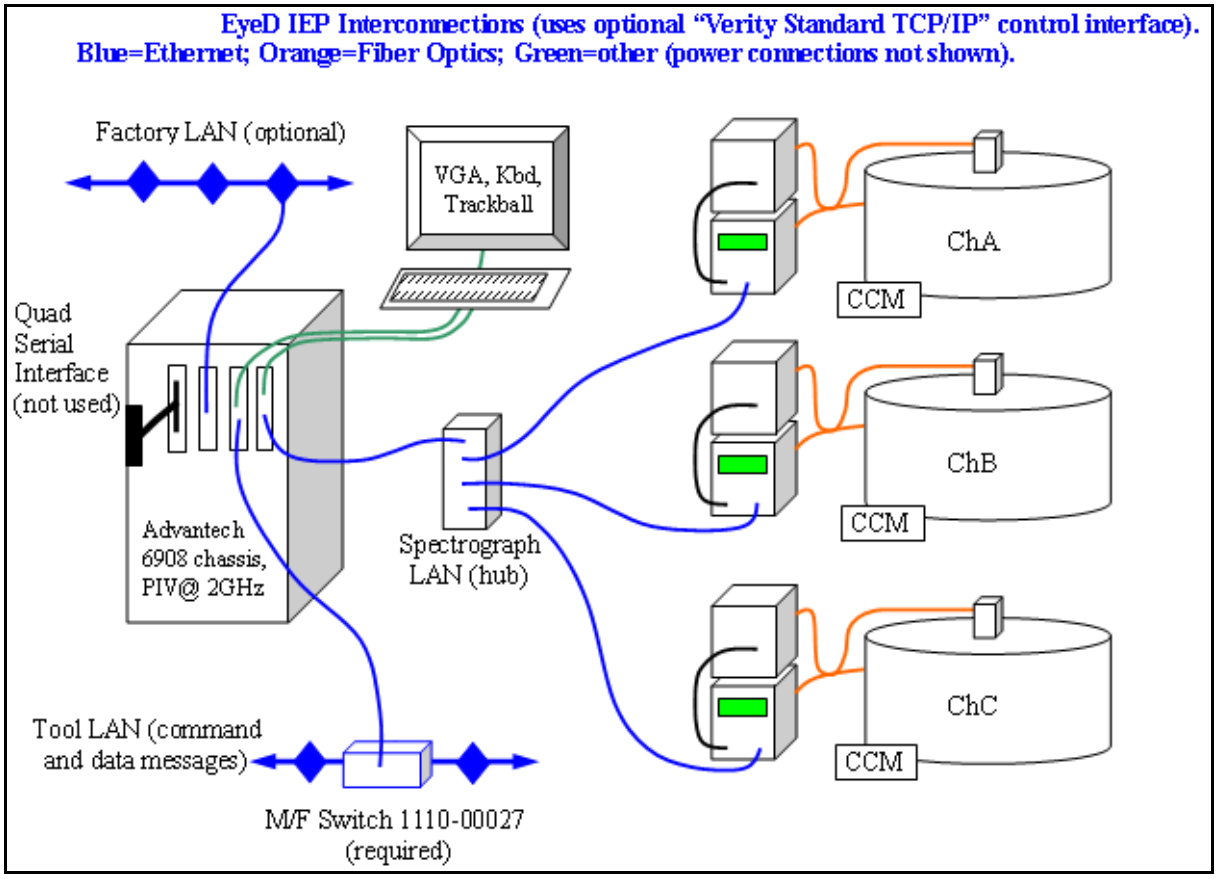


Figure 6-18. IEP Interconnect Diagram Showing TCP/IP Control Interface

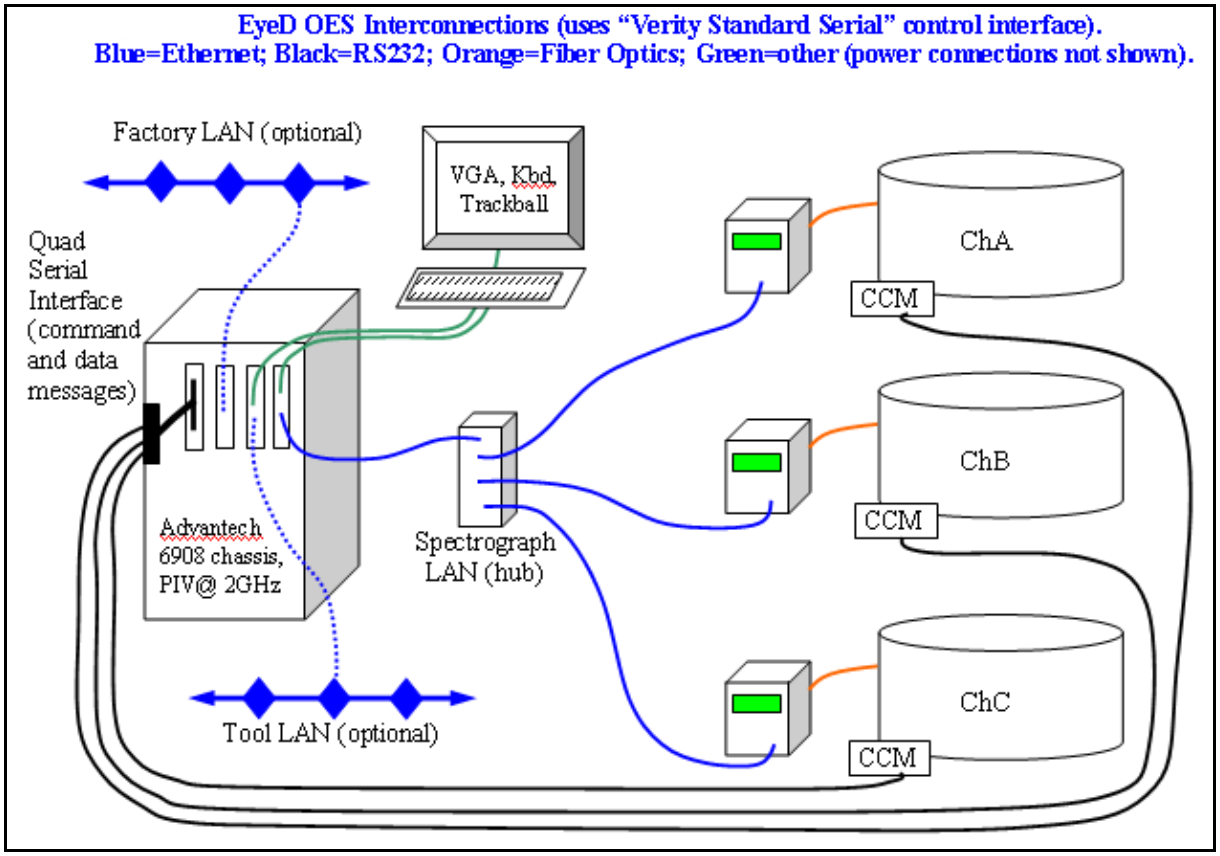


Figure 6-19. EyeD-OES Interconnect Diagram

6.10 Power Up System

Power up all of the detectors first. Each of the detectors performs a self-check on power up, and will indicate if there are any errors detected on the LCD screen. If a failure message appears, cycle the power on the unit again.

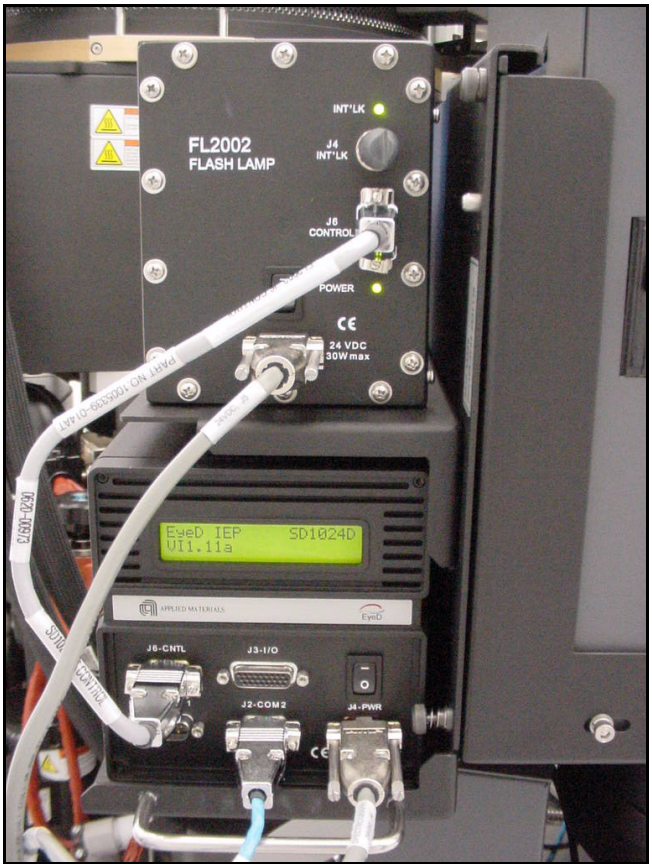


Figure 6-20. Spectrograph Correctly Powered Up

Proceed to install the software and setup in Chapter 7.

6.11 Basic Functionality Check of DCS using Room Light

NOTE

Before proceeding with this section, complete the installation of the EyeD software. This section should be completed before installing the fiber optic cables to the chamber assembly.

If the test algorithms are not installed, the download them from Applied Materials eDocs Web Site prior to the EyeD system installation. They are: *genericROOM_LIGHT.svc*, *genericLAMP_SETUP.svc* and *genericDIO_TEST.svc*. Save them in the folder *c:\EyeD\endpoints*.

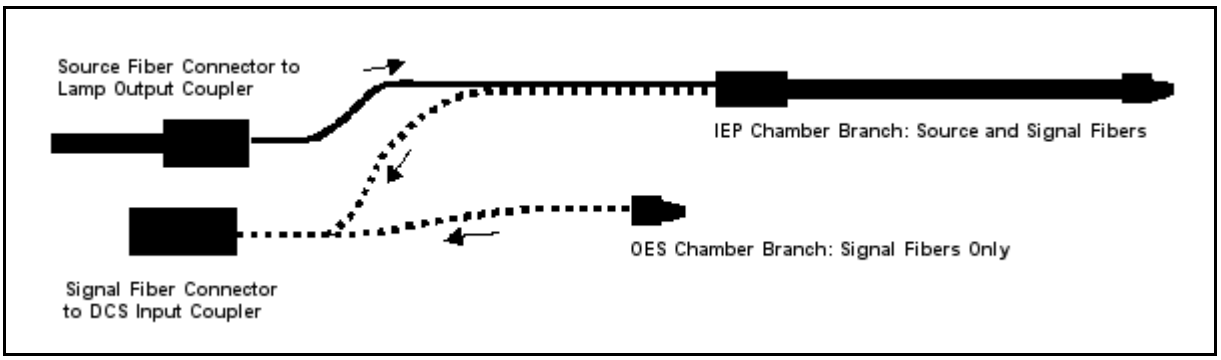


Figure 6-21. EyeD-IEP Fiber Optic Cable Diagram With Arrows Noting Light Direction

1. Install the fiber optic (FO) signal cable firmly into the chamber A spectrograph input coupler on the back of the spectrograph and secure with the 5/64” setscrew. See Figure 6-22. Do not insert the FO source cable in to the lamp at this time.

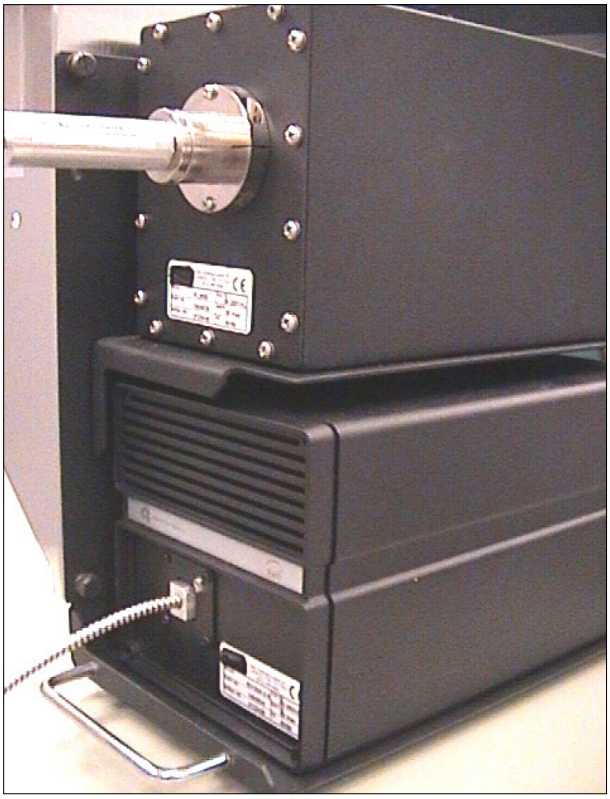


Figure 6-22. Fiber Optic Cable Installed on DCS Rear Bezel

2. For the moment, leave the biconic chamber ends of the cables (OES side view and IEP top view) disconnected from the chamber and open to room light.

⚠ CAUTION

Fiber-optic cables are delicate. Do not make sharp bends or twists in the cable.

3. Maximize the EyeD-A window. Use the configuration tab on the left window of the screen display to gain access to the system configuration list. Right-click on *genericROOM_LIGHT* and *set as current*. Next, execute *genericROOM_LIGHT* in monitor mode by clicking on the **lightning bolt-M** button in the task bar, which is just below the menu bar. This will start the detector acquiring spectra with a 50msec integration time, and with a data interval of 200msec. Two graphs will appear, one having a spectrum of the available light, and the other will be the time trend of the 577nm spectral line, which is a weak spectral component of fluorescent lighting. Maximize the graphs by selecting tile from the window menu.

4. For OES, the Trend Monitor should only have one line (OES), but for IEP, ensure that the Trend Monitor displays the average for both IEP and OES by doing the following:

a. Double-click on the configuration file to open the Configuration Editor

b. Click on **Equations**

c. There should be two equations listed – one for IEP (average A) and one for OES (average B). See Figure 6-23.

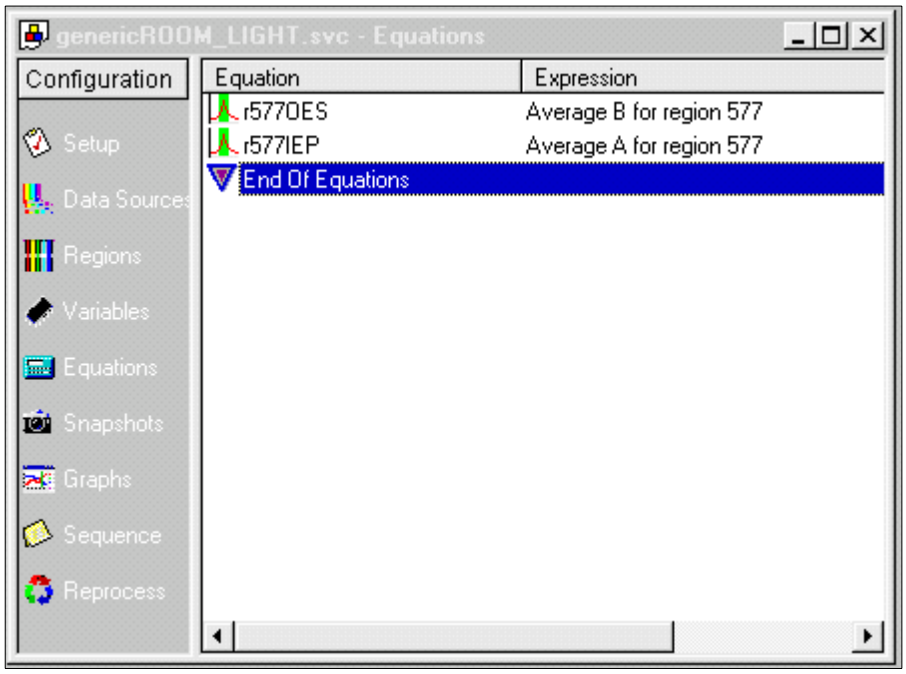


Figure 6-23. Equations Menu for *genericROOM_LIGHT* in Configuration Editor

d. To change an equation, double-click on it. To add a new equation, right-click on **End of Equations** and select **Insert Equation** then **Region Equation**.

e. Enter the fields as shown in Figure 6-24 and click **OK**.

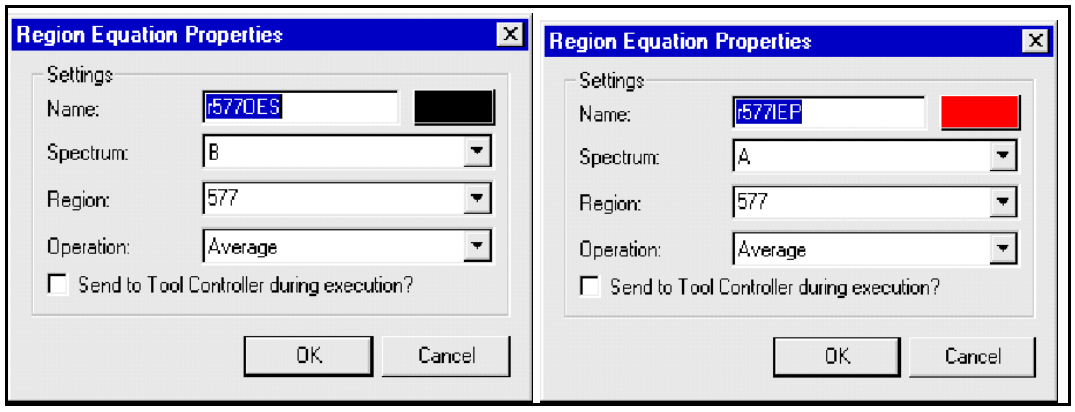


Figure 6-24. OES and IEP Time Average Trend Equation Properties for 577nm Spectral Line

5. Move around the chamber end of the ChA OES fiber branch (the short FO cable that goes to the side endpoint window) by pointing it at room lights and then away

from the lights. Moving the fiber around will cause the level of detected light to change, this will help validate that system real time operations are correct.

6. For IEP systems, move around the chamber end of the ChA IEP fiber branch (the long FO cable that goes inside the IEP probe) again by pointing it at room lights and then away from the lights.

7. Monitor the trend lines for the r577OES and the r577IEP regions in the trend graph: they will rise and fall in intensity depending on whether the FO cable is pointed at a light or not. If the response to the motion of both of the fiber branches is similar to what is shown in the screen example below (only the response for motion of the OES cable is shown), then basic functionality for both input channels of the spectrograph is established and the test is complete.

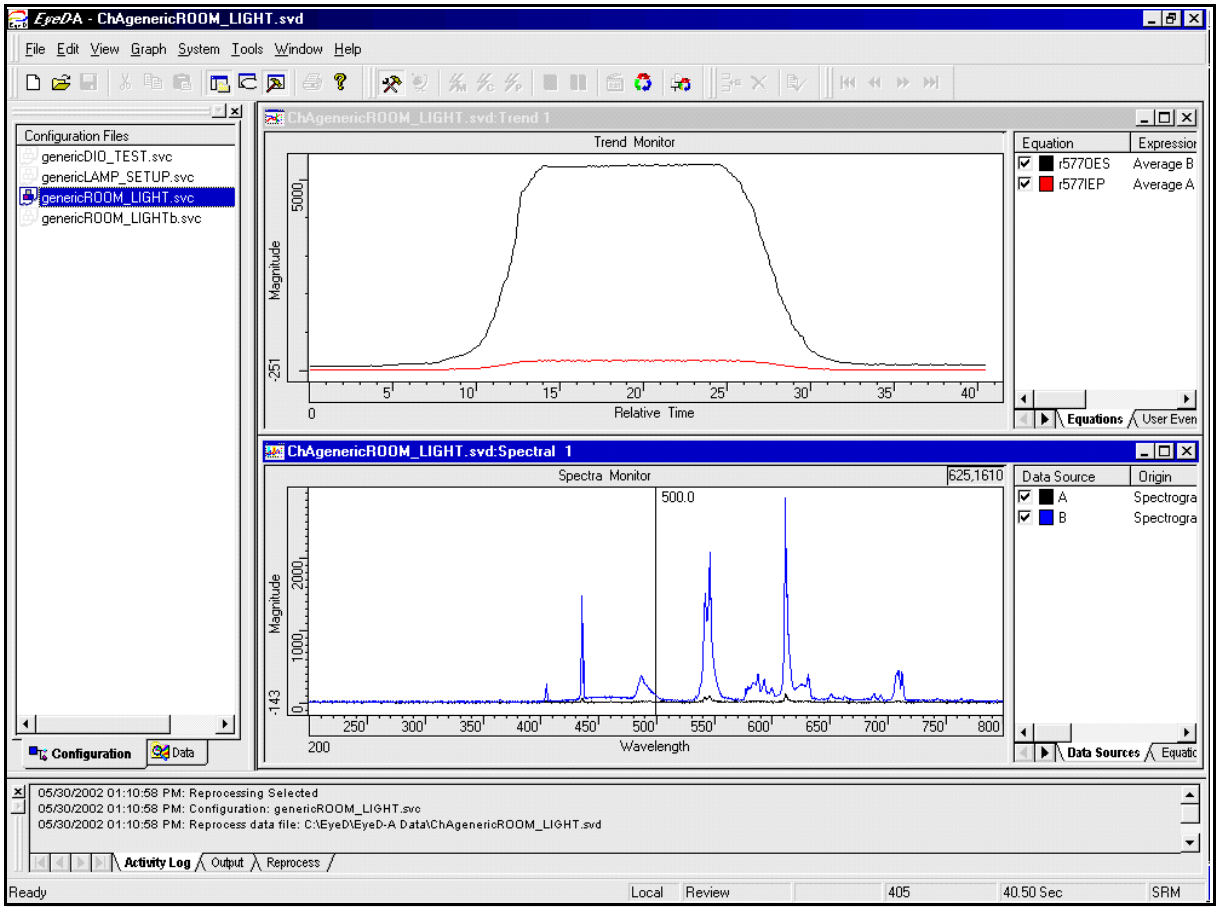


Figure 6-25. Response to Motion Graph for OES Cable

6.12 Installation Complete

Hardware for the EyeD system should be fully installed with the completion of this chapter. For software installation and set-up, see Chapter 7. Some software installation must be done in order to complete the tasks outlined in this chapter.

THIS PAGE INTENTIONALLY LEFT BLANK.

7 300mm Software Installation and Set-Up

Installation of an EyeD Spectrograph to a process chamber and computer, and then to a mainframe, is accomplished through a few simple steps. Some hardware installation is necessary before proceeding with the EyeD software setup. See Chapter 6 for 300mm Installation.

7.1 EyeD Software Installation

NOTE

Before proceedings with this procedure, remove the cables from the hub. Make sure all spectrographs are turned off. All the hardware should be set up according to the instructions.

Installation of EyeD on Win NT or 2000 requires the user to log in with Administrator Privileges. Please ensure Administrator level access is enabled before the installation is started.

The EyeD software can be installed on both the EyeD computer in a production environment, or on a personal computer for offline use of data analysis. This Chapter provides instructions for both installations.

⚠ CAUTION

Certain computer features must be disabled for the proper operation of the EyeD system.

The following features of the Windows Operating system should be disabled to insure stability of EyeD software:

- Screen Saver
- Power Saver
- Find Fast (not normally installed on computer)

These features can be disabled as follows:

1. Access the Display Properties window with the selections: **Start\Settings\Control Panel\Displa**y.
2. On the Screen Saver tab, set Screen Saver to (None) and then click Apply to activate this selection.
3. Click on **Power** to access the Power Management Properties window.

4. Select the Power Schemes tab.

5. Select **Never** for the Turn off monitor and Turn off hard disks options in the Power Schemes tab.

6. Press the **Save As** button to access the Save Scheme window. Type the new name **RequiredForEyeD** into the field (see Figure 7-1).

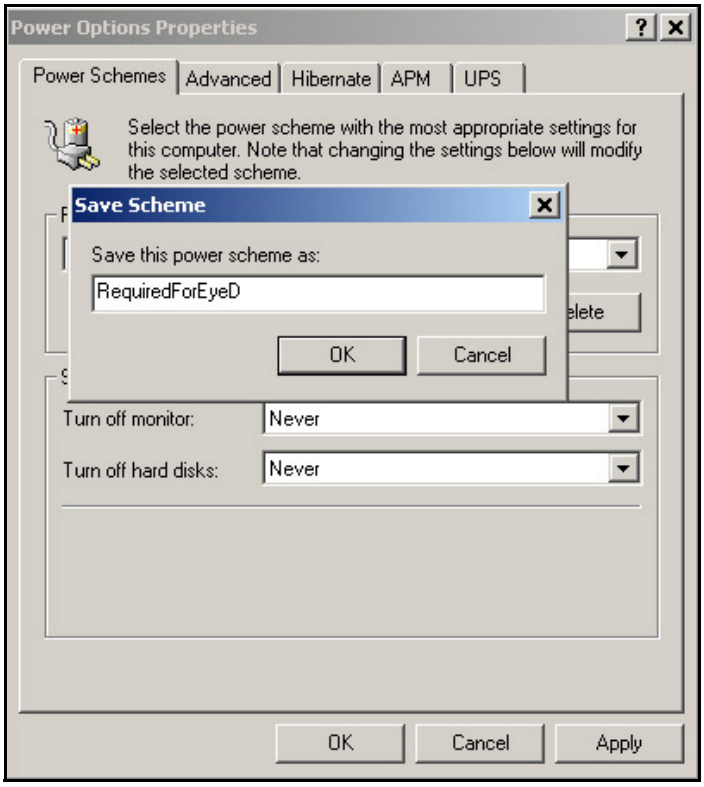


Figure 7-1. Saving Power Scheme

7. Click **OK** to return to the Power Schemes tab. The Power Scheme RequiredForEyeD will be displayed.

8. Click **Apply** to begin using the RequiredForEyeD power scheme. Then click **OK** to exit back to the Display window and **OK** again to exit and save all changes.

In case the IP address on the 300mm tower PC computer is not configured when shipped, use this procedure to configure the IP address on the 300mm PC:

1. Click on **Start**, then **Settings**, then **Control Panel**, then **Network and Dial Up Connections**.

2. Select one of the network cards and name it Spectrograph LAN

3. Open the TCP/IP Properties window and select **Use the Following IP Address** and change it to **192.9.50.100**

4. Enter the Subnet Mask as **255.255.255.0**.

You are now ready to install the EyeD application software.

7.1.1 Installing EyeD Software onto the EyeD Computer

Updates to EyeD software must be installed on the EyeD computer. After EyeD software installation, URI and SRM must be configured so that there is communication between each instance of EyeD software and the respective Detector and Chamber Control Module (CCM). See Figure 7-2.

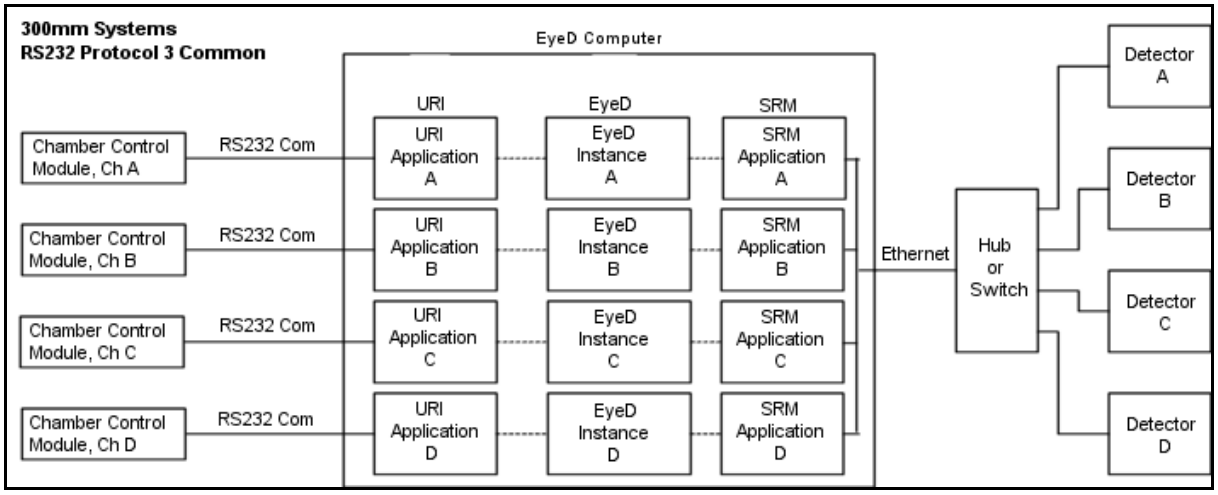


Figure 7-2. EyeD 300mm Hardware and Software Configuration

Use the following procedures for installation and configuration of the software.

1. Insert the EyeD installation CD-ROM. If you do not have the CD-ROM, all components of the installation may be found on Applied Materials EyeD Web site.
2. Copy all files into a new folder: *C:\EyeD Installs*.
3. Double-click on ***C:\EyeD Installs\EyeDXXXXInstall.exe*** (the *EyeD_.exe* install file). The Install wizard starts, as shown in Figure 7-3.

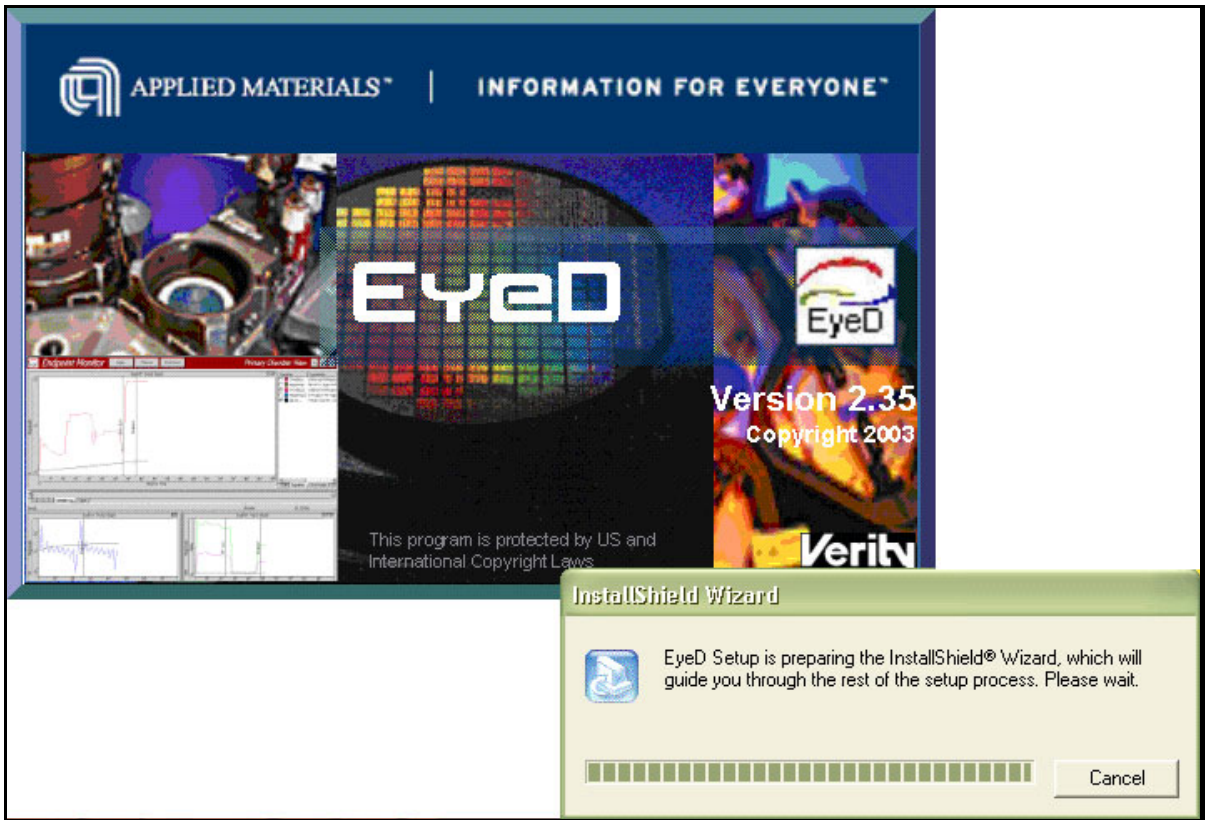


Figure 7-3. EyeD Install Wizard

The InstallShield Wizzard then begins opening files as shown in Figure 7-4.

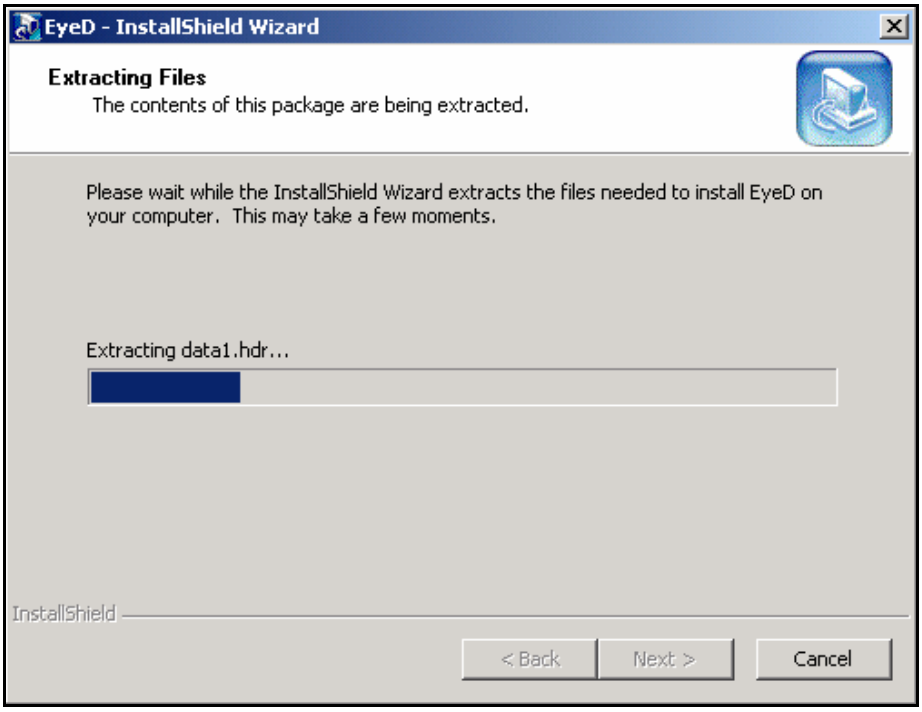


Figure 7-4. InstallShield Wizard Extracting Files for Installation

4. The Install Fundamentals should pop up. Read the window, as displayed in Figure 7-5, and click **Next**.

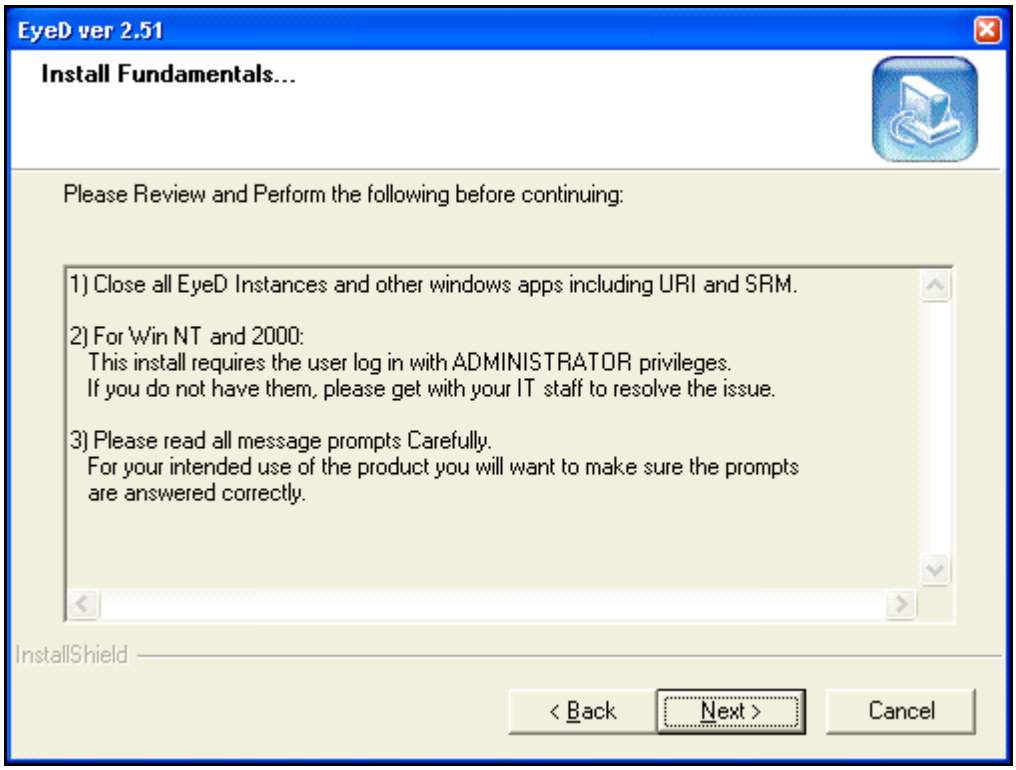


Figure 7-5. Install Fundamentals Window (Read before proceeding)

5. If no previous version of EyeD is already installed on the computer, proceed to Step 6. If an existing version of EyeD is already installed on the system, the first window that pops up provides the option of Repairing or removing the installation. Select **REMOVE-perform a complete uninstall** and click **Next**. Then click **Yes** on the Confirm File Deletion Dialog that follows to uninstall the existing installation. See Figure 7-6. Repeat Step 4 once the uninstall process completes.

NOTE

Uninstall affects only registry settings and system files. Data files, configurations, and user selections/user preferences are *NOT* affected.

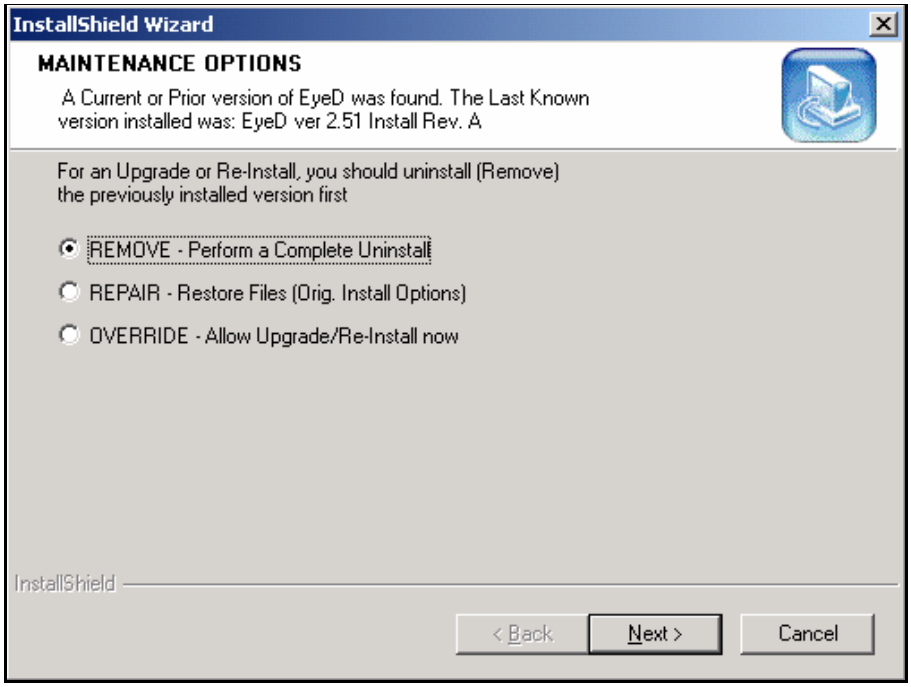


Figure 7-6. Remove Existing EyeD Installation Before Installing New Version

- **REMOVE:** uninstalls system components (.dll dynamic libraries, etc) of prior EyeD versions
- **REPAIR:** replaces all files of a particular installation
- **OVERRIDE:** install without performing an uninstall first

6. Choose **RESEARCH** or **PRODUCTION**, depending upon usage level. See Figure 7-7, below. Research provides more access to underlying configuration function, and is most suited to R&D Fabs. Production provides a graphical interface with limited data presentation for production operators to quickly monitor whether production is *normal* or not.

7.1.1.1 Production Mode Installation

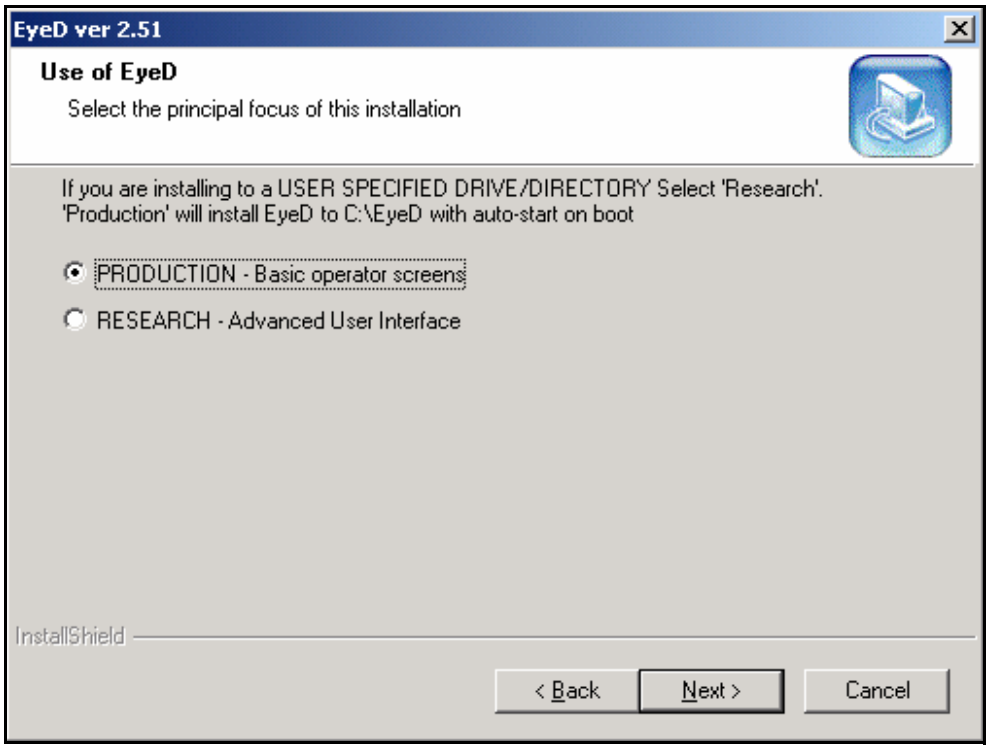


Figure 7-7. Select Research Mode for EyeD Installation

7. Choose the number of EyeD instances to install. See Figure 7-8. This will determine the number of instances that will be created on the Start menu and on the desktop. There is typically one (1) instance per chamber.

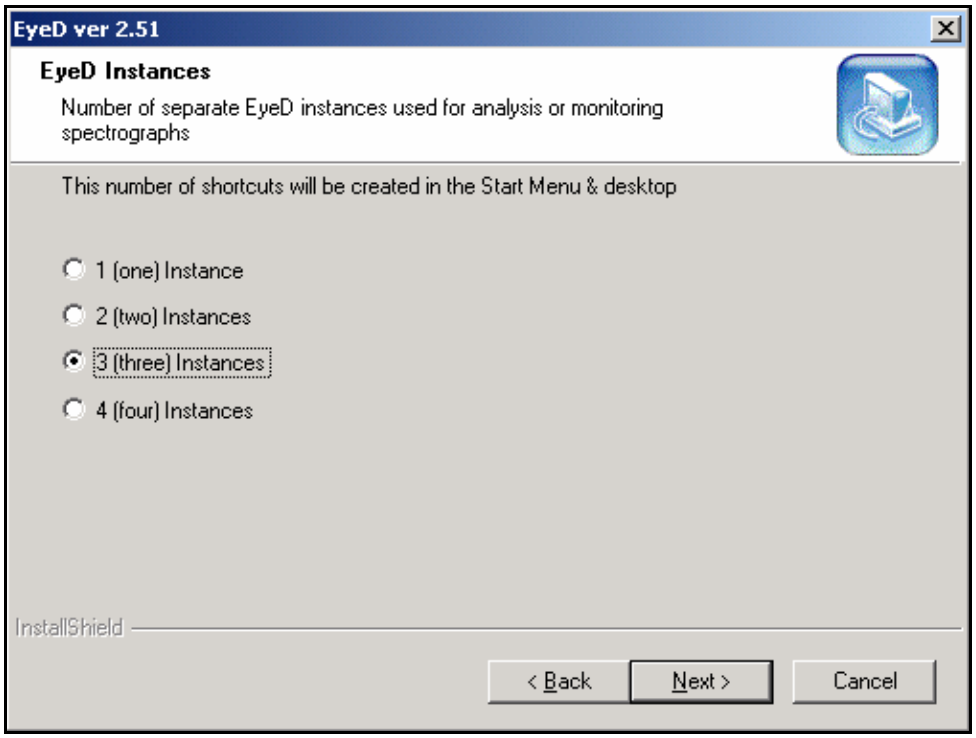


Figure 7-8. Select Number of EyeD Instances

8. Next select the Tool Interface. see Figure 7-9.

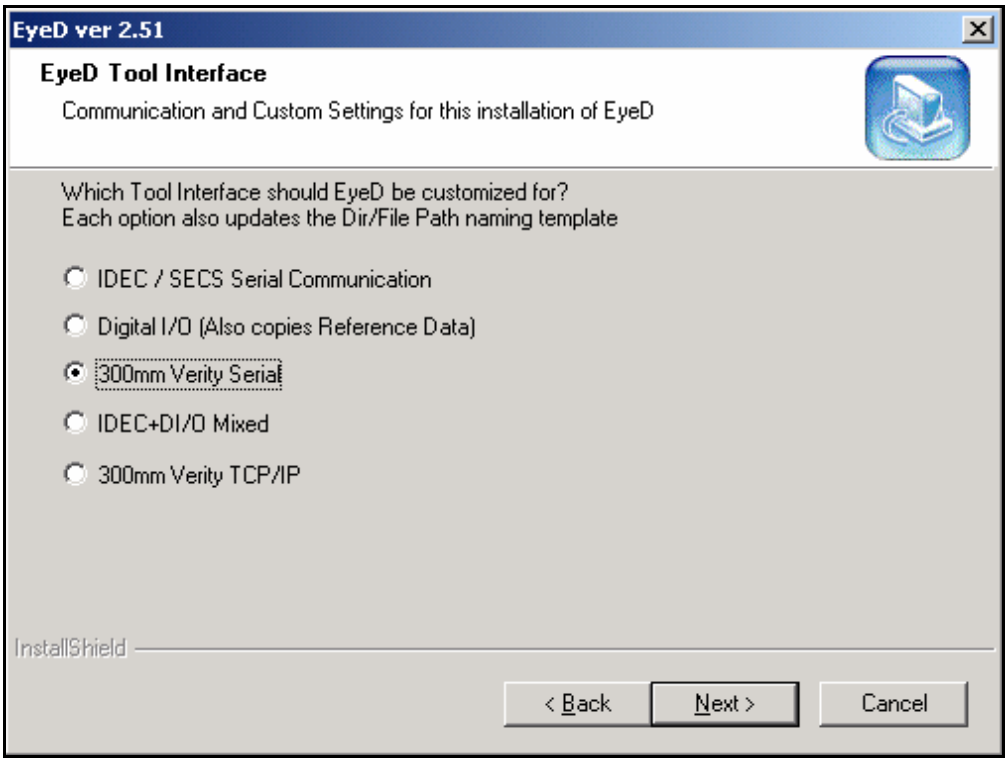


Figure 7-9. Select Tool Interface

Only the *300mm Verity Serial* interface and the *300mm Verity TCP/IP* interface are valid for 300mm installations.

9. Select an option for Event Statistics. Click on **ENABLE (Use) Event Statistics** to make this functionality available (see Section). Select **DISABLE (DO NOT Use) Event Statistics** if it is not required. See Figure 7-17.

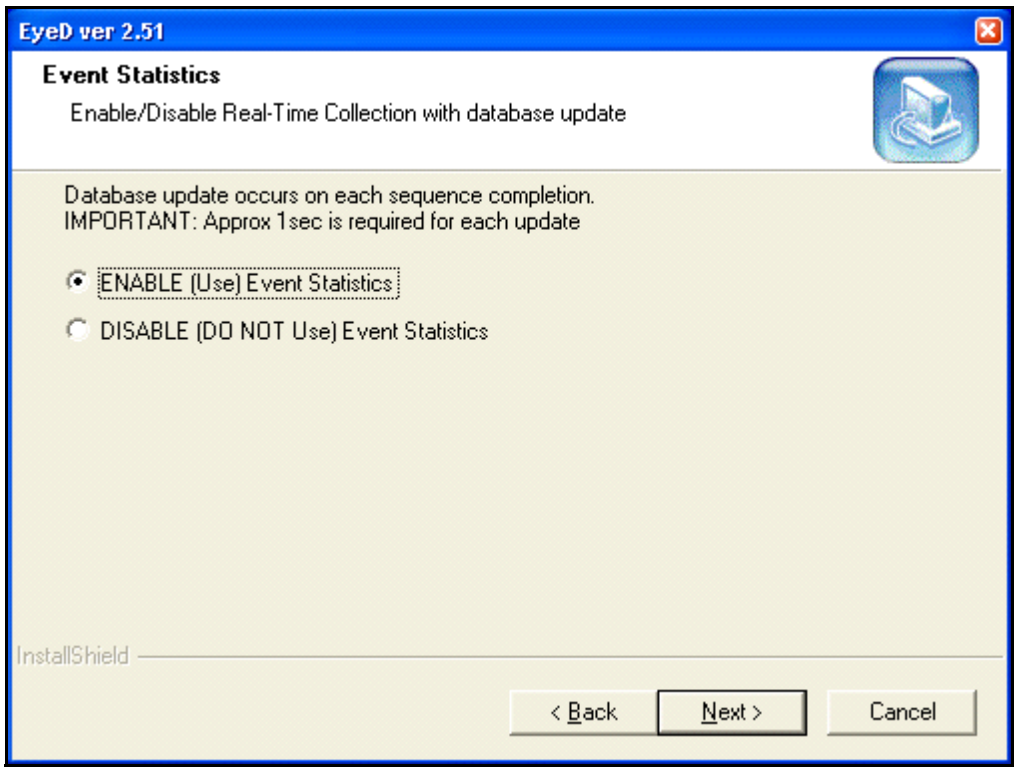


Figure 7-10. Set Event Statistics Mode

10. At this point a dialog box will pop up summarizing the EyeD setup that will be installed, as shown in Figure 7-11. Review this carefully. Return to Section 7.1.1.2, Research Mode Installation above to make changes as necessary. Click **Next** to proceed with the installation.

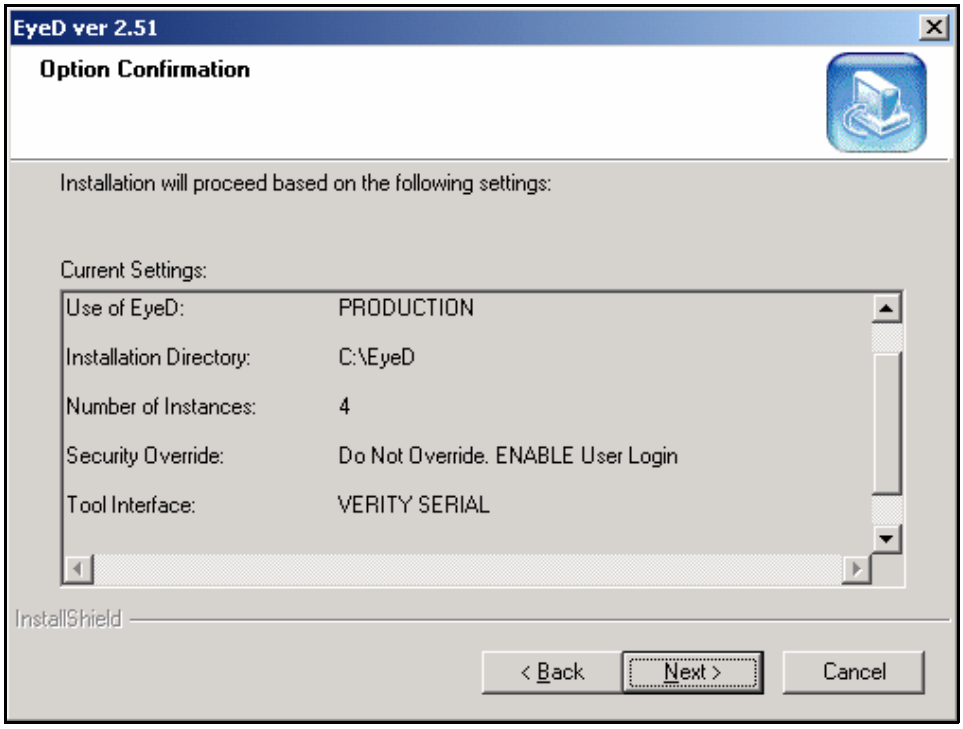


Figure 7-11. Option Confirmation

If the option selections are correct go to Section 7.1.1.3, Setup Completion.

7.1.1.2 Research Mode Installation

Research provides more access to underlying configuration function, and is most suited to R&D Fabs.

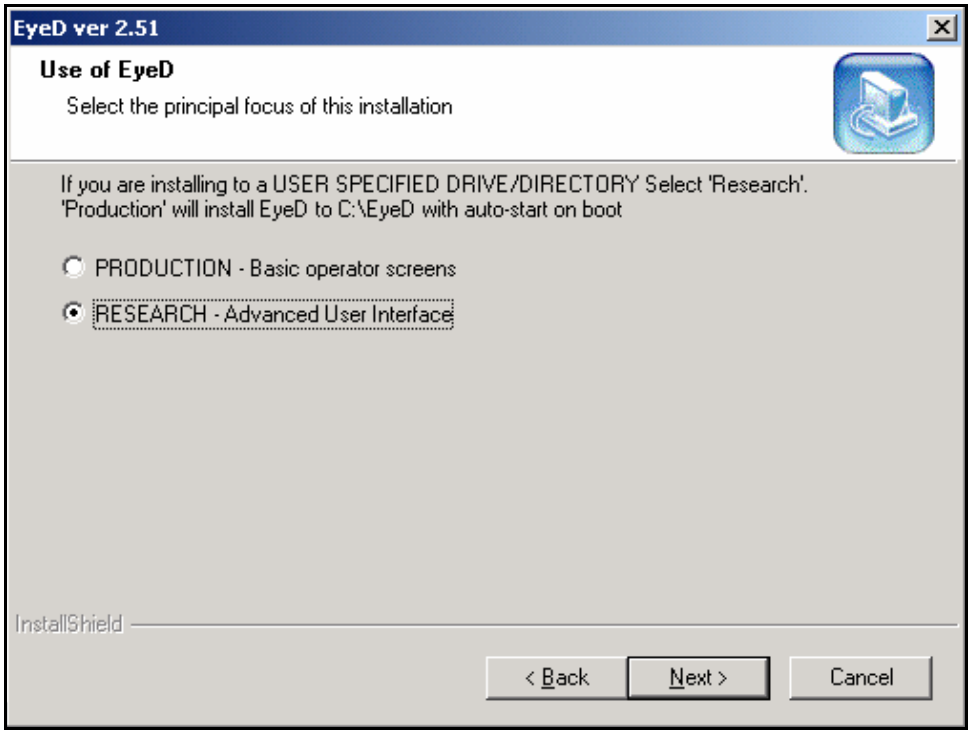


Figure 7-12. Selecting Research Mode Installation

1. In Research mode, the user has the option to specify the installation location. See Figure 7-13. Specify the desired installation location. Be careful when choosing an alternate installation location. If the default directory location for EyeD is not C:\ please contact Applied Materials. Installation affects the Windows registry files making it necessary to alter specific lines to properly register the EyeD software in the Windows registry file when using a drive designation other than C:\.

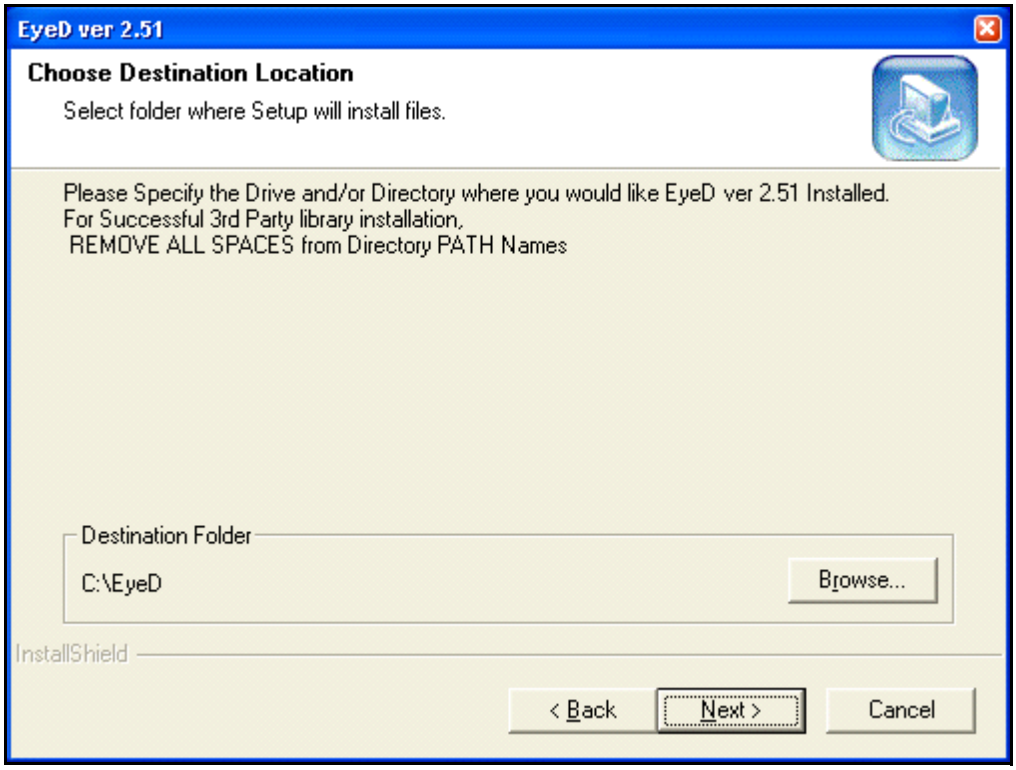


Figure 7-13. Select Installation Location

2. Choose whether or not to enable Security override (Figure 7-14). If you select **Yes** then logins will not be required and users will not be password-prompted for access to the software. Select **No** to require users to login before using the software.

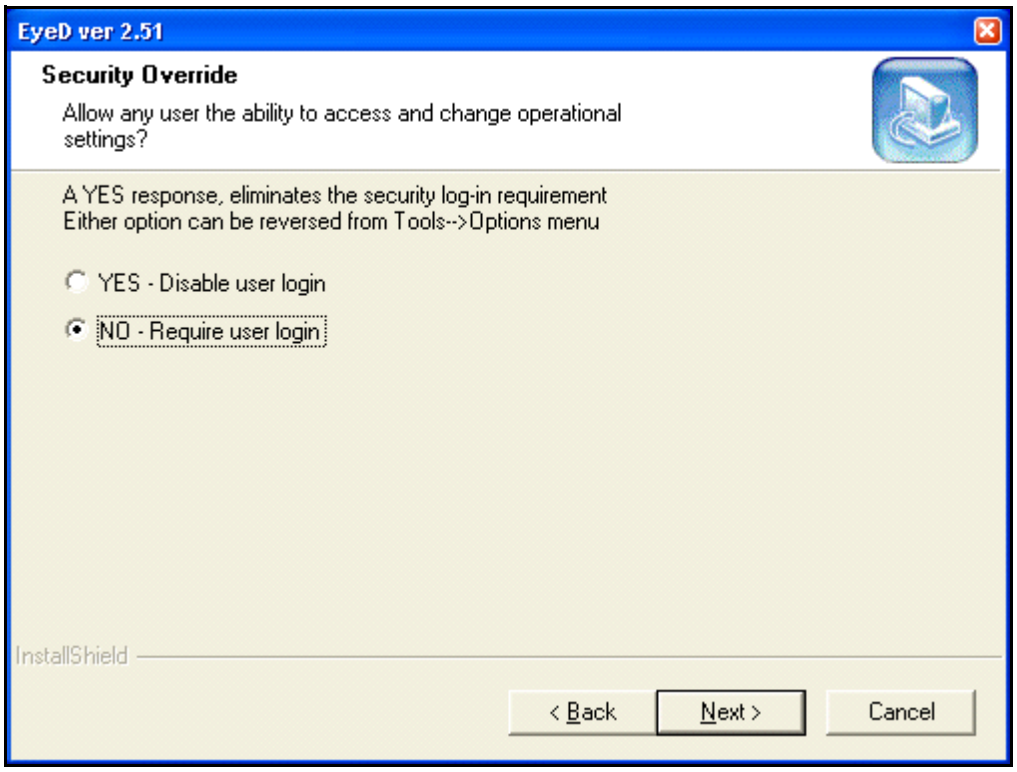


Figure 7-14. Choose Security Access Level

3. Next, select the interface method for communication with the tool. See Figure 7-15 for 300mm EyeD choose 300mm Verity Serial. See Figure 7-16 for 300mm Verity TCP/IP. These are the only two communication interfaces applicable for 300mm systems.

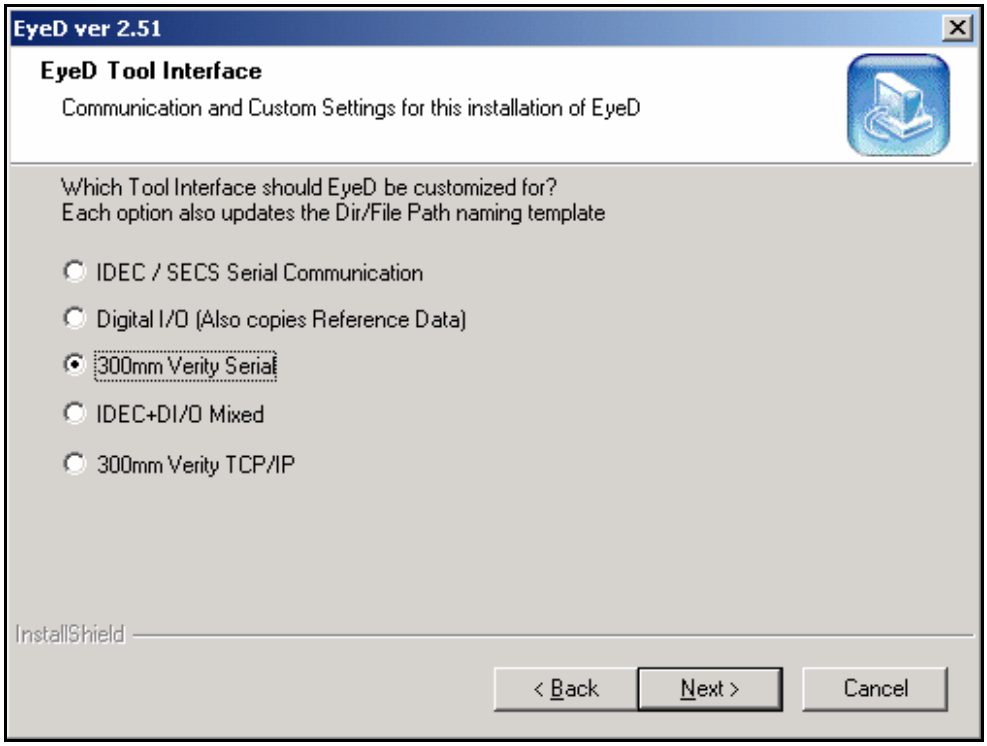


Figure 7-15. 300mm Verity Serial Interface Selection

Figure 7-16 shows the optional 300mm Verity TCP/IP Interface selection.

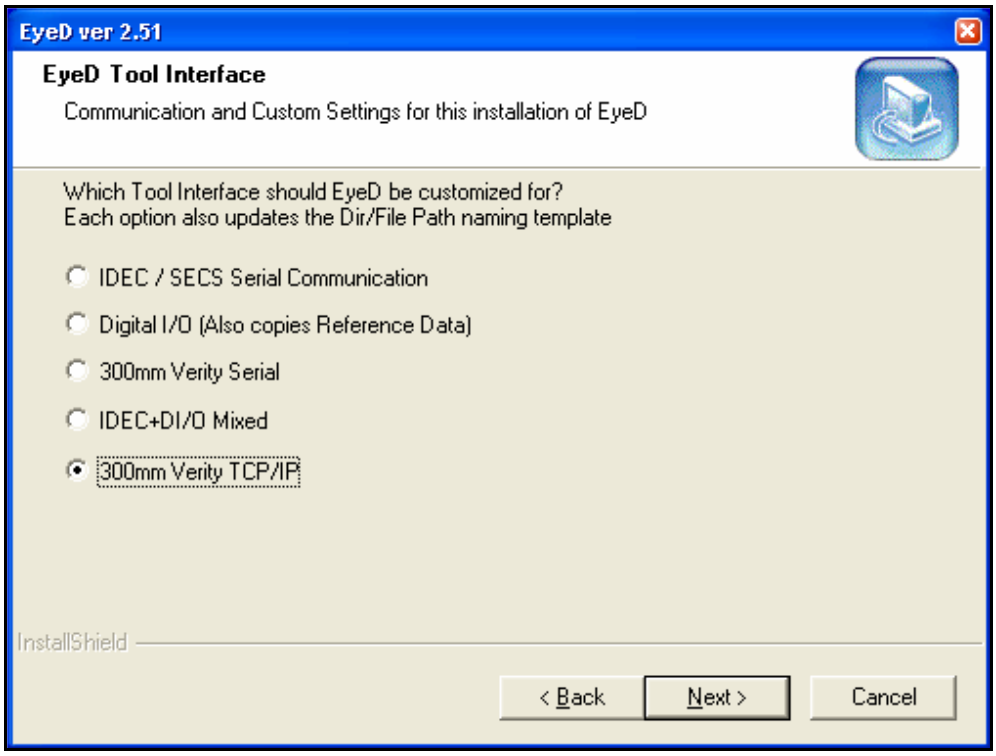


Figure 7-16. Optional 300mm Interface Selection: High Speed TCP/IP

4. Select an option for Event Statistics. Click on **ENABLE (Use) Event Statistics** to make this functionality available (see Section). Select **DISABLE (DO NOT Use) Event Statistics** if it is not required. See Figure 7-17.

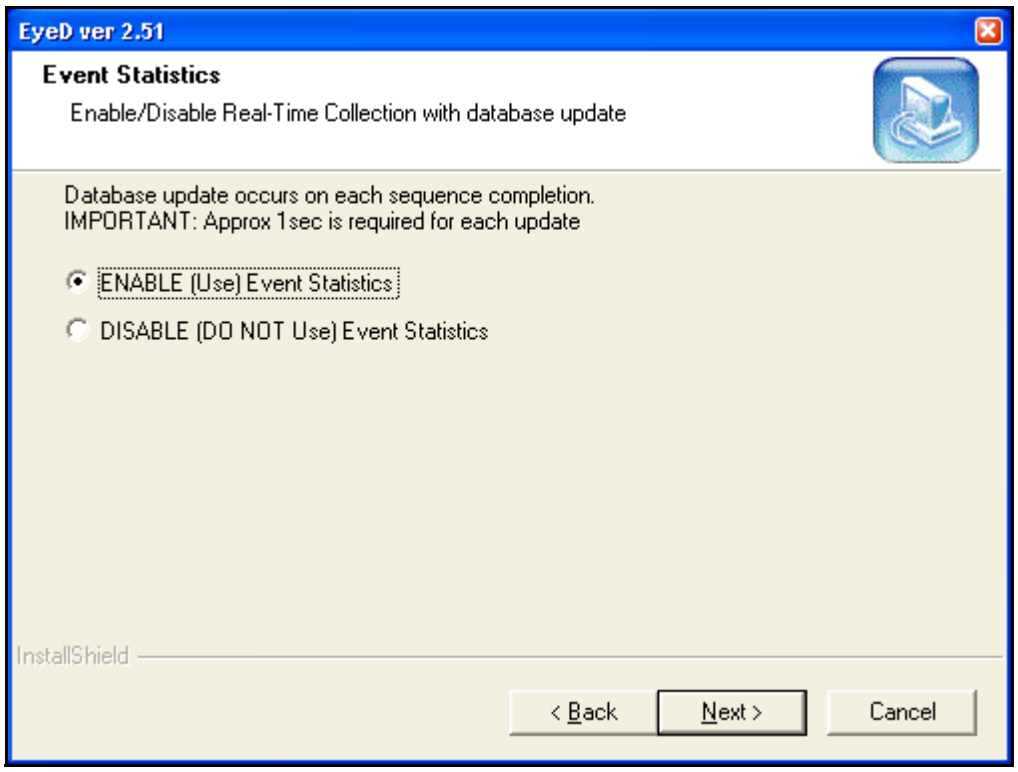


Figure 7-17. Set Event Statistics Mode

5. At this point a dialog box will pop up summarizing the EyeD setup that will be installed, as shown in Figure 7-18. Review this carefully. Return to Section 7.1.1.2, Research Mode Installation above to make changes as necessary. Click **Next** to proceed with the installation.

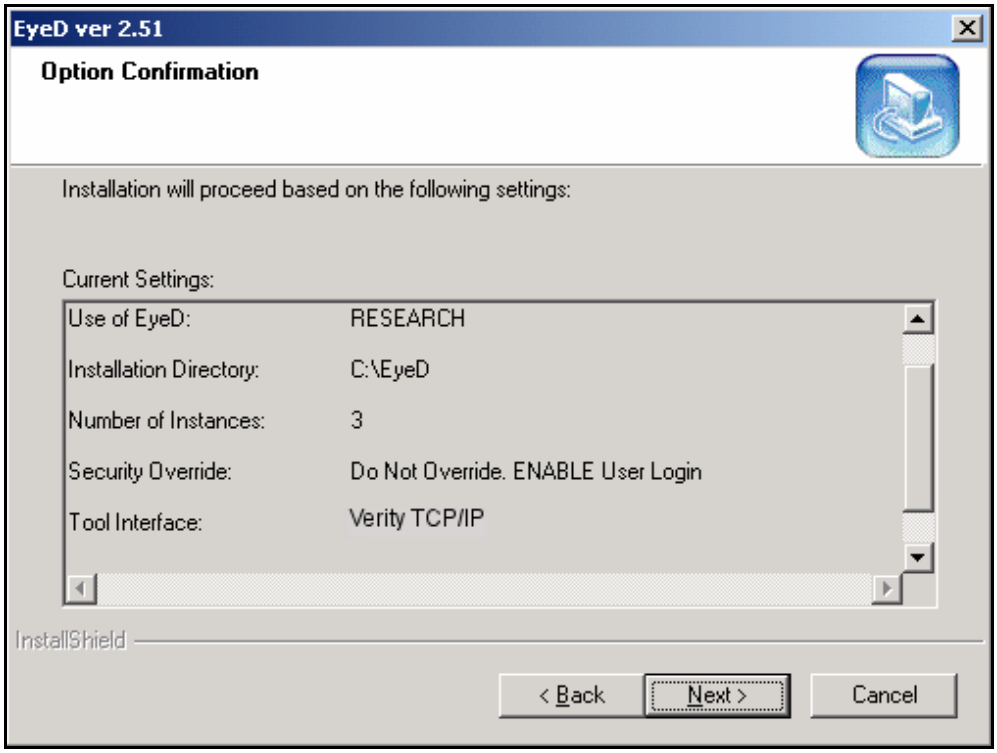


Figure 7-18. EyeD Install Option Confirmation Window

Press **Next** and the installer will install the EyeD software with the selected options.

Go to Section 7.1.1.3, Setup Completion.

7.1.1.3 Setup Completion

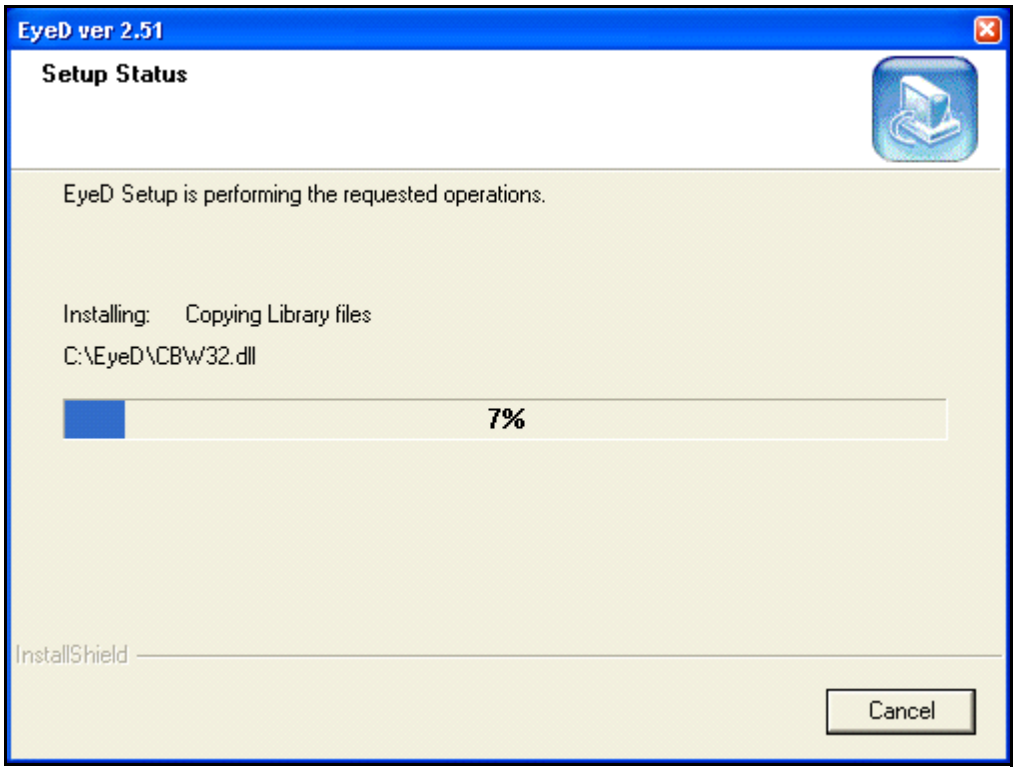


Figure 7-19. EyeD Software Installation Status

1. After the files are installed, the user will be presented with the options to retain the previous user preferences if this computer had EyeD installed before this installation.If you choose to keep the preferences, the answer will be **No**.

   For updates of the EyeD application, there are a number of user preferences which can be selectively retained. The following screens will NOT appear in new installations in which EyeD has never been installed.

   The screen asks if the user desires to keep the preferences found under *TOOLS==>OPTIONS==>GENERAL==>Activity Log,* Yes or No.

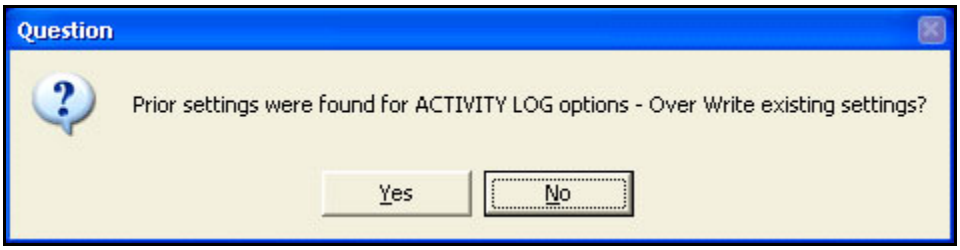


Figure 7-20. Select Yes to Overwrite Activity Log Options

   The screen asks if the user desires to keep the preferences found under *TOOLS==>OPTIONS==>AUTO DELETE,* Yes or No.

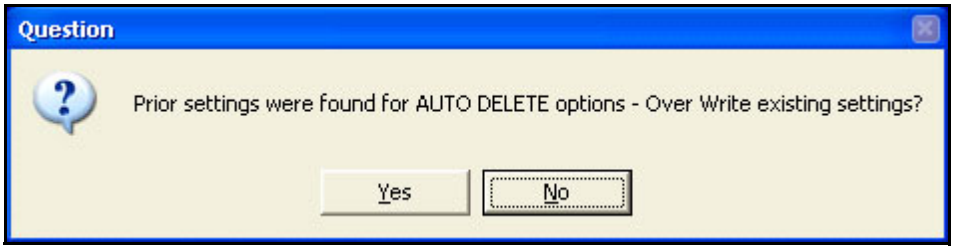


Figure 7-21. Select Yes to Overwrite Auto Delete Options

The screen asks if the user desires to keep the preferences found under *TOOLS==>OPTIONS==>DIRECTORIES,* Yes or No.

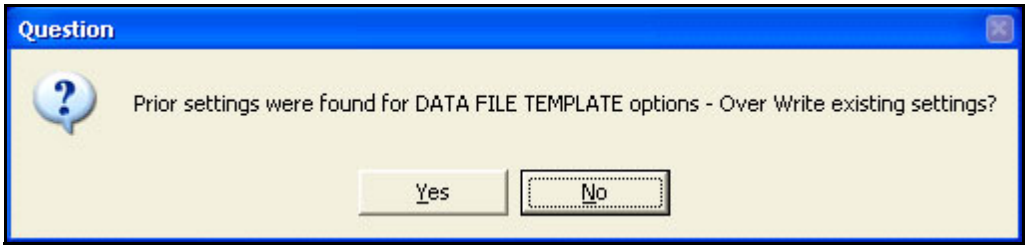


Figure 7-22. Select Yes to Overwrite Data File Template

2. Once the installation is complete, you will be prompted to restart the computer to finalize the installation, as shown in Figure 7-24. Reboot the computer to complete the installation.

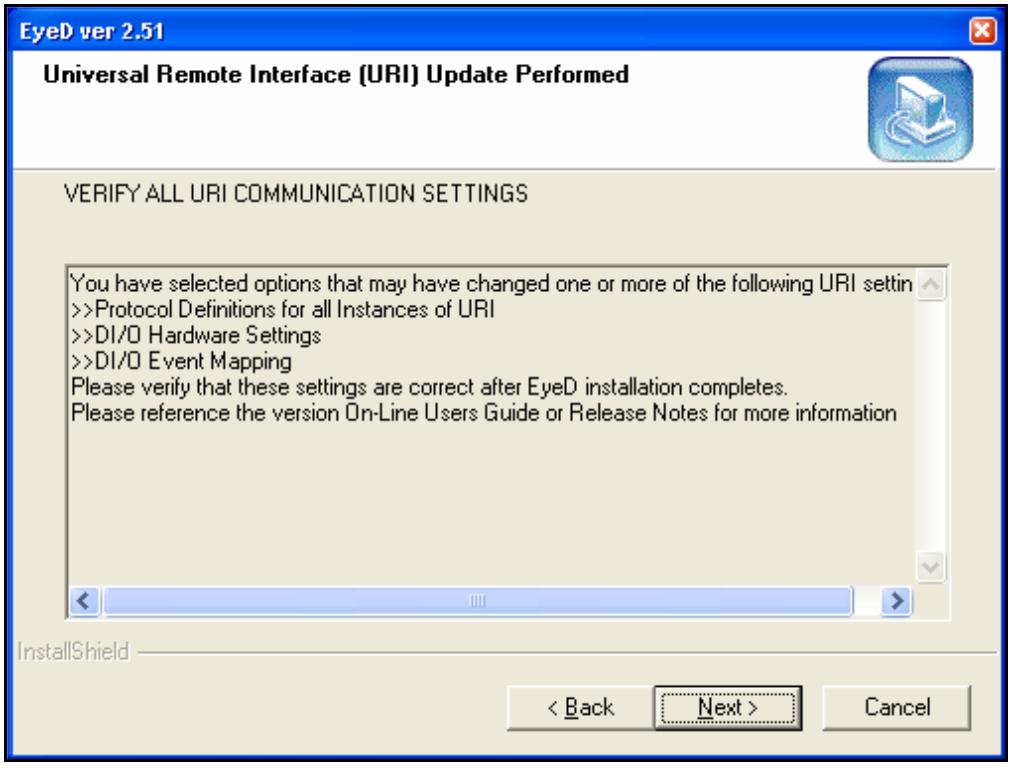


Figure 7-23. URI Update Complete Window

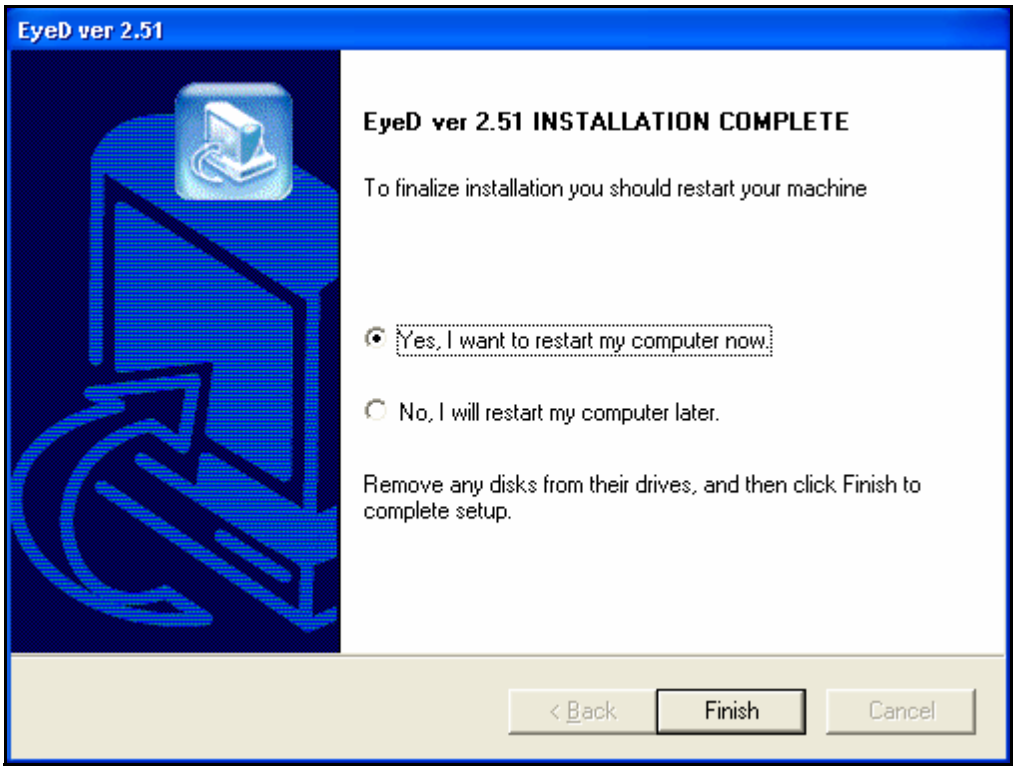


Figure 7-24. Reboot the Computer to Complete the Installation

3. If *Production Mode* was selected, then the Endpoint Monitor will automatically pop up. Click **OK** on the Spectra Resource Manager (SRM) screen.

7.1.2 Installing EyeD Software onto an AMAT K-Station

When installing on a computer with NT or XP, some required Dynamic Link Libraries (DLLs) will be missing. To compensate, first install Microsoft Data Access Components (MDAC) onto the computer. This file contains event statistics for the DLLs that were missing. An *EyeD.bat* file is required to launch the EyeD instance on a K-Station. In order for the installation to install properly, the installer must have **Administrator** rights and be logged in as an administrator so that the software can make the necessary registry updates. The K-Station must have at least service pack 6 installed, if still running NT.

1. Download the Mdac-typ2-50.exe and EyeD.bat files from the Silicon Etch Internet site (http://amat.mis.amat.com/sietch/engineering/index.htm).
2. Open the *MDAC* file (i.e. *mdac_typ2.50.exe*)
3. Click **Install**.
4. Now the EyeD software may be installed. Follow the steps described in Section 7.1.1, Installing EyeD Software onto the EyeD Computer, typing **R** in the open field in the *EyeD Usage* window.
5. Once the installation is complete, open the EyeD directory and copy the *EyeD.bat* file into the EyeD directory (*C:\EyeD*).

6. Right click on the EyeD icon on the desktop and select **Properties**. Click on the **Shortcut** Tab and enter *C:\EyeD\EyeD.bat* in the **Target** field (see Figure 7-25).

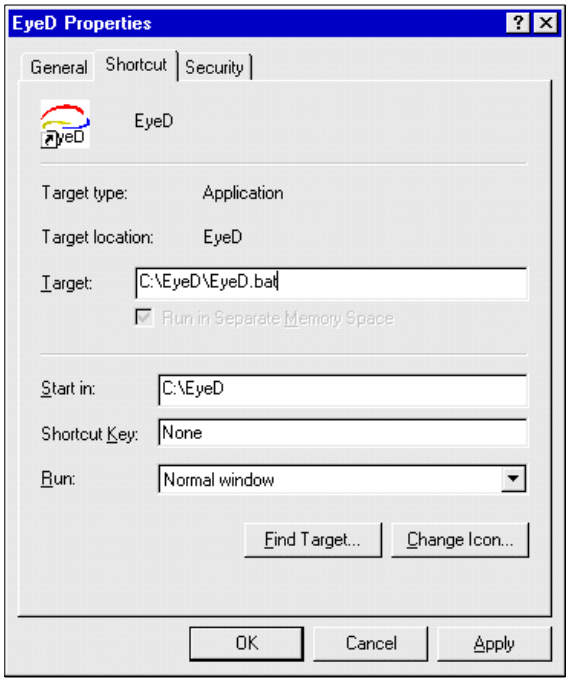


Figure 7-25. Changing the EyeD Instance Target to the *EyeD.bat* File

7.2 Configuring Multiple Spectrographs

EyeD software is designed to function with multiple instances of itself, controlling individual spectrographs from a single computer. When initially installed there will be as many EyeD Icons as were selected in the installation.

7.3 SRM and URI

The Spectra Resource Manager (SRM) is a separate program in the EyeD software that integrates the control computer with all of the EyeD spectrographs. The Universal Remote Interface (URI) is a similar application linking the software with the Centura. These will not function on a K-Station

7.3.1 Spectra Resource Manager Setup.

All 300mm spectrographs are shipped with the same default IP address - 192.9.50.99. To avoid communications conflicts, only one spectrograph at a time should be configured for communication. This involves setting the IP address so that it is unique for that particular spectrograph on the system: during the installation process, the cables for all other spectrographs yet to be configured should be disconnected from the Ethernet hub. Figures 7-7 and 7-8 illustrate the configuration process. The steps are outlined below for a spectrograph installed on chamber A.

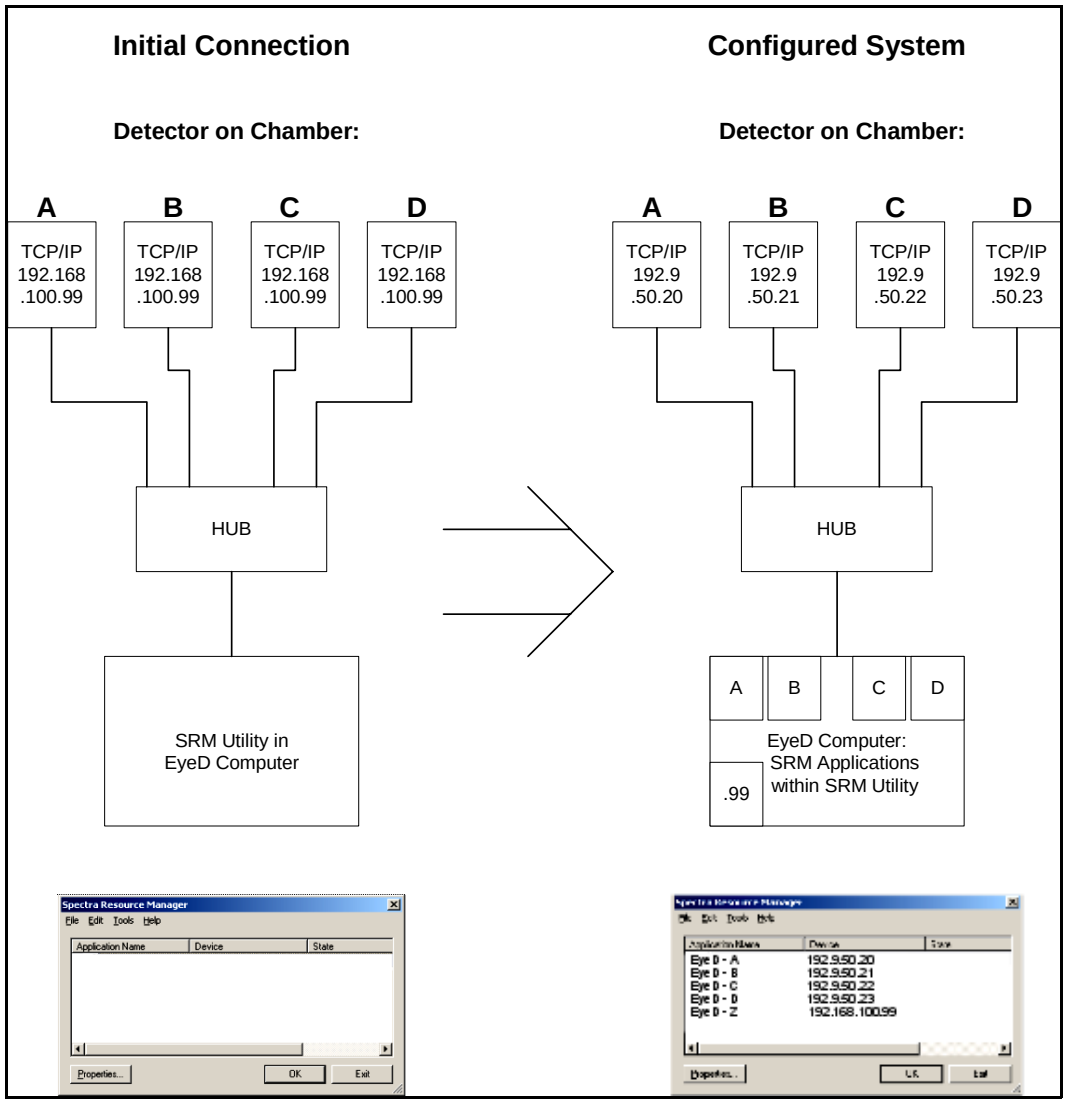


Figure 7-26. SRM Configuration Overview

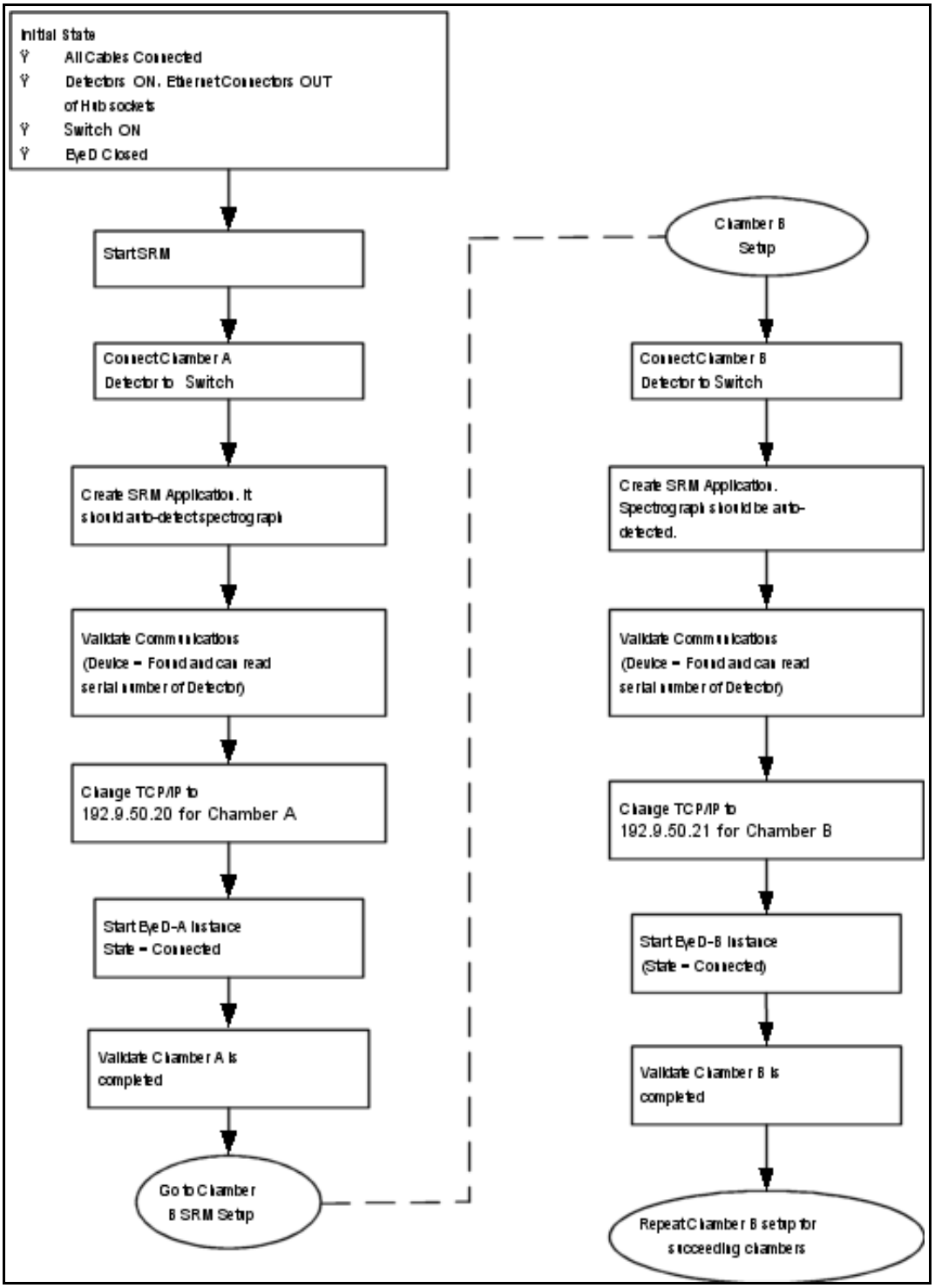


Figure 7-27. Flowchart for Configuring SRM - New Software

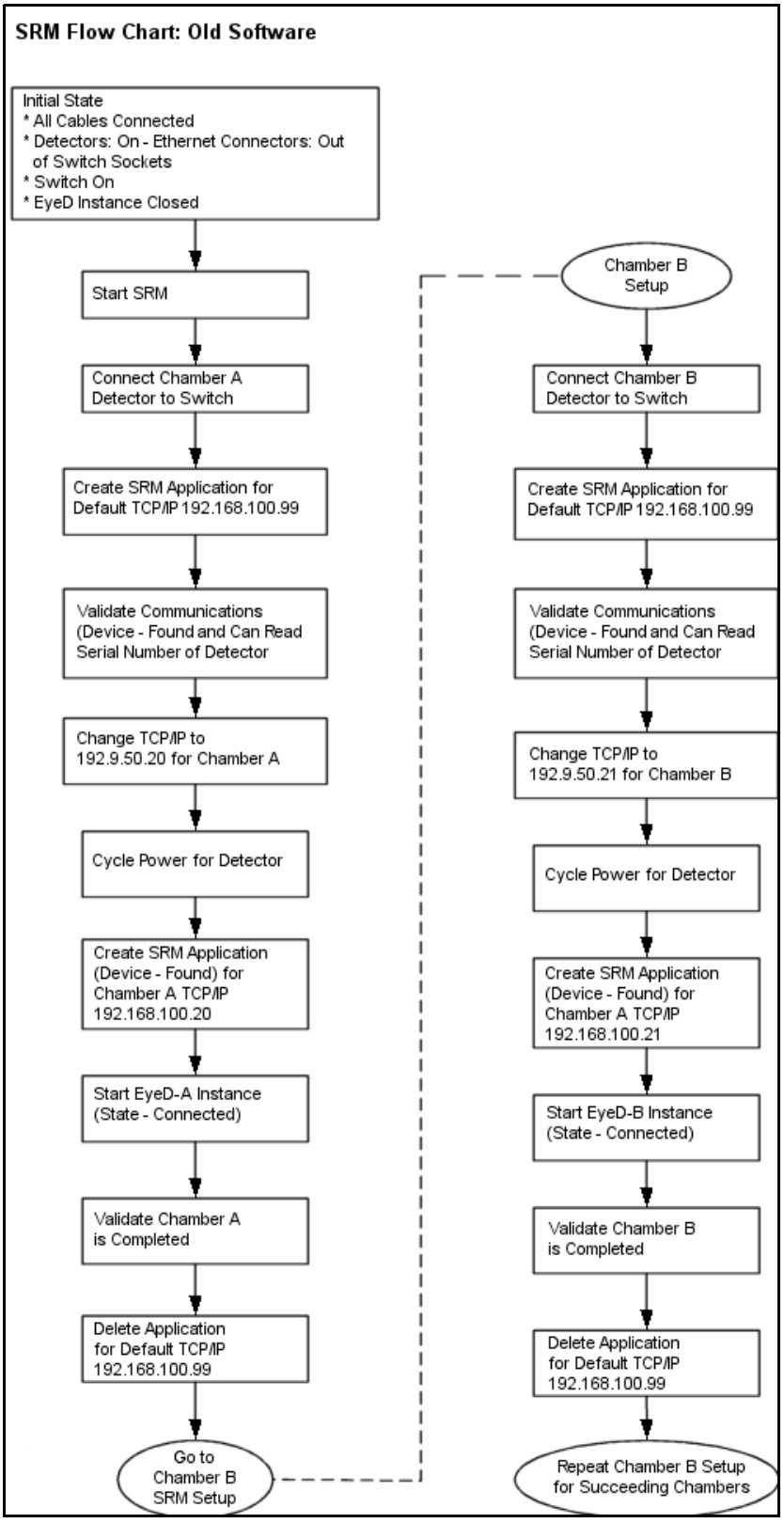


Figure 7-28. Flowchart for Configuring SRM - Old Software

Configure the Spectra Resource Manager (SRM) by completing the following steps:

1. Close the EyeD application.
2. Leave Spectrograph A connected to the Ethernet hub. Disconnect all other spectrographs from the hub. Ensure the hub and spectrograph are both on.
3. Run C:\EyeD\SpectraManager.exe or double click on the SRM icon in the system tray (lower right hand corner of the screen). The SRM window appears, see Figure 7-29.

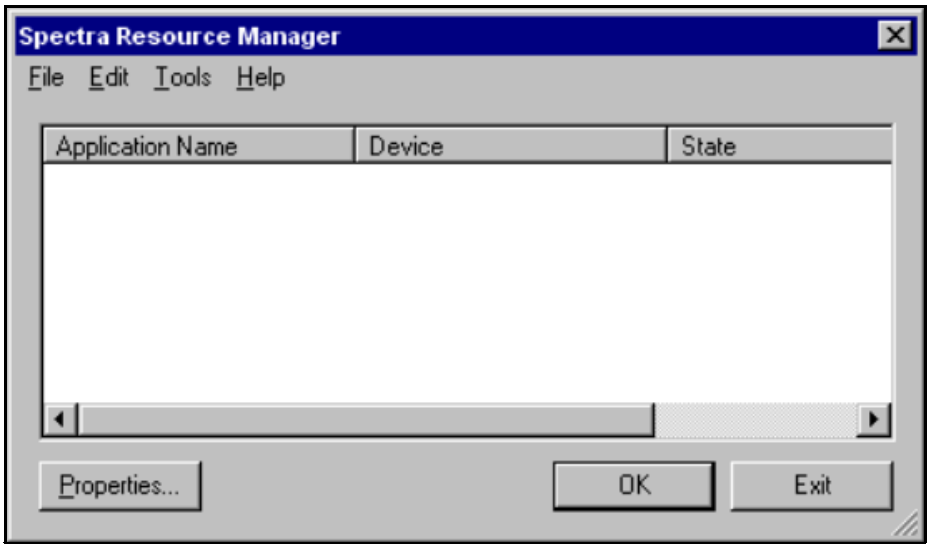


Figure 7-29. Spectra Resource Manager Window.

4. If no spectrographs have been configured, there should be no applications shown in SRM. Delete any that are. Right click on the application to be deleted and select Delete an Application.
5. Right-click in the white area of the window. Select Insert New Application.



Figure 7-30. Insert Application Pop Up Within SRM

6. If password protection is enabled, (see Section 3.2.4) the Login Window will open. Login as Admin, using the password: 752762.
7. The Application Setup window opens.
8. Enter the name EyeD-A for Chamber A. Use the appropriate designation for succeeding chambers.
9. Select TCP/IP as the connection and click on the OK button.
10. Newer versions of SRM should detect the spectrograph automatically, at which point the serial number should be displayed in the Device combo box as in Figure 7-31. Data sources may also be assigned automatically. See Step 15 to verify that they are correct or to assign data sources, if none are assigned. Refer to Section 7.3.1.1 if the Spectrograph is not automatically detected, for instructions on how to set the IP address manually.

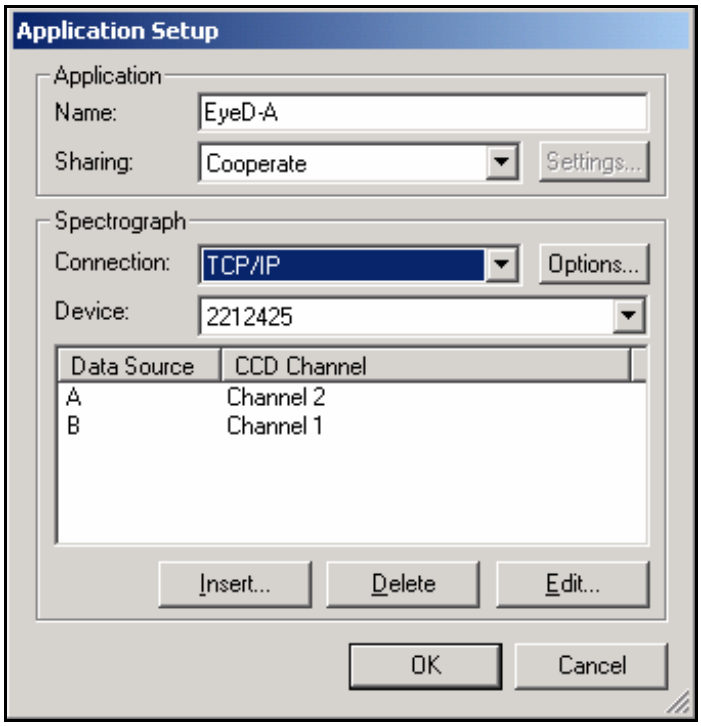


Figure 7-31. Application Setup Window showing a detected Spectrograph

11. Click on **OK** to exit the Application Setup Dialog. The main SRM window remains, with a dialog asking whether the IP address will be changed from the default value at this point, see Figure 7-32. The IP address will need to be changed in order to configure additional spectrographs.

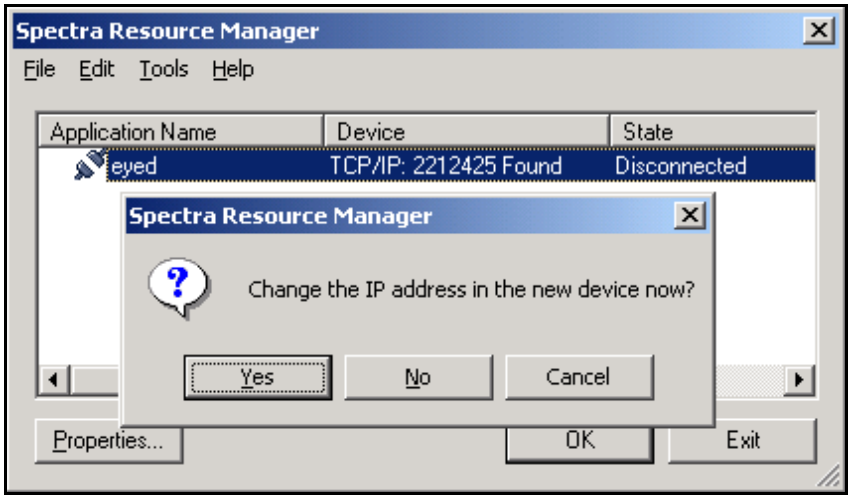


Figure 7-32. Dialog to change IP Address

12. Click **YES** to change the IP address. In the dialog that is brought up, shown in Figure 7-33, the IP address should be changed according to the Chamber location and the type of EyeD system being configured. All addresses should start with 192.9.50. and end with the following digits:

Table 7-1. IP Address Final Digits

	OES	**IEP**
Chamber A	10	20
Chamber B	11	21
Chamber C	12	22
Chamber D	13	23

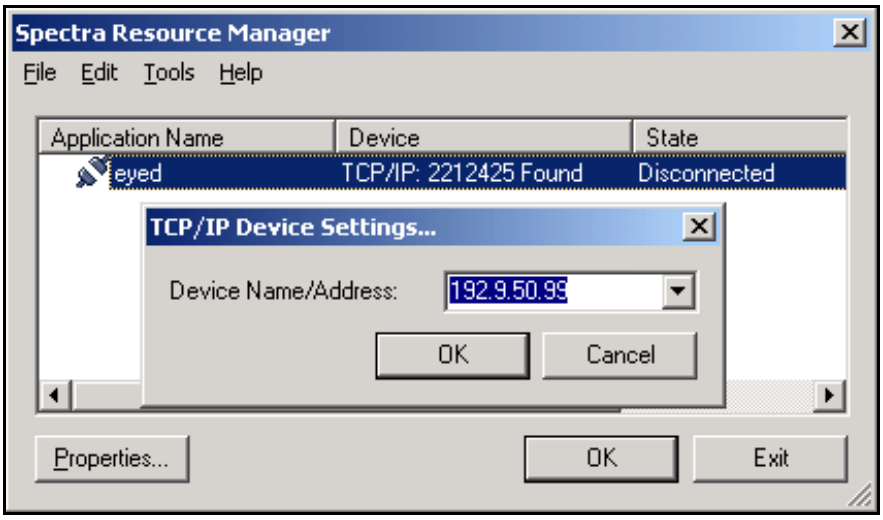


Figure 7-33. Changing the Spectrograph IP address

13. Click **OK**.

14. See Figure 7-34. The State field should say Disconnected, even though the spectrograph has been *found* by SRM. It will remain listed as Disconnected until EyeD-A is restarted.

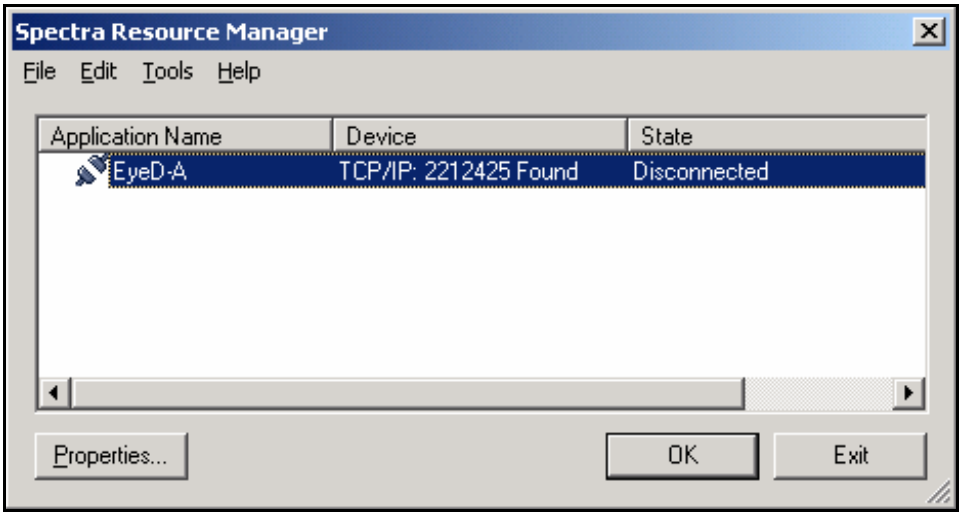


Figure 7-34. SRM Main Window with Application EyeD-A Listed

15. If data sources do not come up automatically when the spectrograph is detected, they need to be assigned. Right click on the Application in the main SRM window, and select Setup Application. This will bring up the Application Setup Window. Click on Insert to assign data sources. If the system is EyeD OES, then assign Data Source A to Channel 1. If the system is EyeD IEP, then assign Data Source A (IEP) to Channel 2 and Data Source B (OES) to Channel 1. See Figure 7-35 and Figure 7-36.

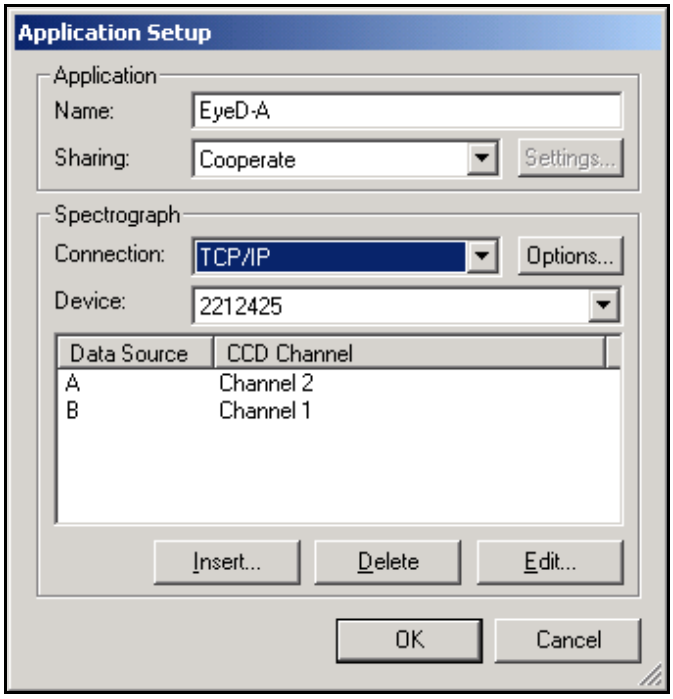


Figure 7-35. SRM Application Setup for EyeD-IEP

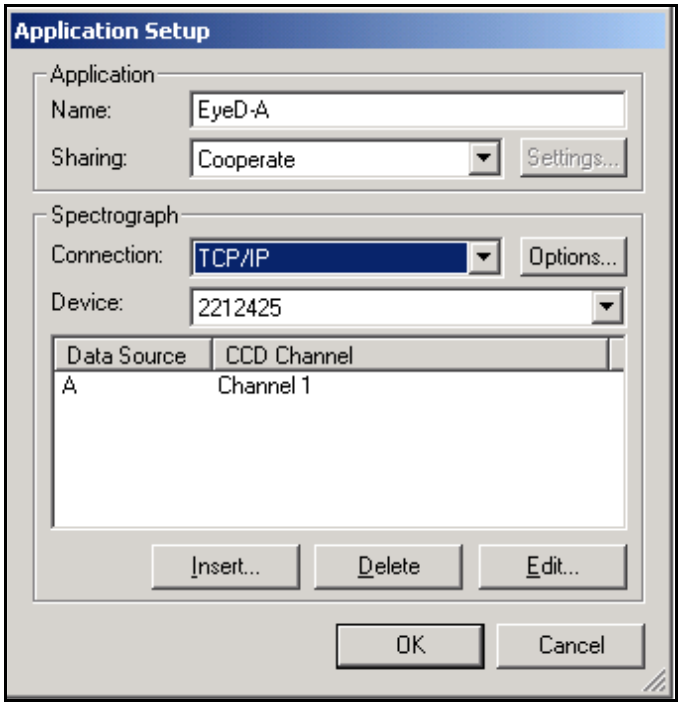


Figure 7-36. SRM Application Setup for EyeD-OES

16. Verify that the IP address of the spectrograph has been changed correctly. Click on the Options button, and confirm the IP address.

17. Click OK to return to the main spectrograph window.

18. Configure additional spectrographs, one at a time, by repeating Steps 1 through 17. It is not necessary to disconnect spectrographs that have already been configured, as they have already been assigned unique IP addresses.

7.3.1.1 Manually setting the IP address for a Spectrograph.

A spectrograph may not be automatically detected as described in Section 7.3.1. Step 10. This may be because the IP address of the spectrograph being configured is not the default 192.9.50.99, or because an older version of EyeD is being used. The IP address can be determined if unknown, using a USB cable. See Section 7.10. Once the IP address is known, perform the following steps to detect and configure the IP address.

1. Ensure that the spectrograph to be detected and configured is connected to the hub and that both are powered on. Spectrographs that have already been configured need not be disconnected.
2. Open SRM and right click to insert a new application (Figure 7-30).
3. If password protection is enabled, (see Section 3.2.4) the Login Window will open. Login as Admin, using the password: 752762.
4. The Application Setup window opens.
5. Name the Application Default Connection.
6. Select TCP/IP as the connection and press the **OK** button.
7. The message box shown in Figure 7-37 may appear. Click **OK** to dismiss the box.

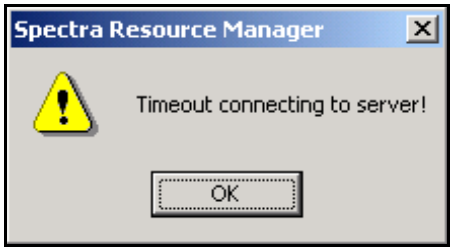


Figure 7-37. Message Indicating SRM Has Yet to Detect Spectrograph.

8. The selection of TCP/IP as the connection method may also bring up the TCP/IP Device Settings dialog where the device IP address can be entered. See Figure 7-38. To bring this dialog up manually - after dismissing the time-out message, or if the dialog is not brought up - click on the Options… button. Enter the default IP address of 192.9.50.99 and press the OK button. If this does not work, the message in Figure 7-37 will pop up after a few seconds. Make sure the unit is switched on. Check the hub by cycling the hub power briefly to ensure communication/registration. If the default IP address is still not accepted, then refer to Section 7.10 to obtain the actual IP address with a USB cable. When communication is established, the serial number will be displayed.



Figure 7-38. TCP/IP Device Settings Dialog

9. Click **OK**.
10. The spectrograph should be detected, and its Serial Number displayed under the Device heading. Insert and assign Data sources as described in Section 7.3.1 Step 15 (see Figure 7-35 and Figure 7-36).
11. Click **OK** to return to the SRM main window.
12. The application should appear in the SRM main window with the Serial Number found under the Device column and a status that reads Disconnected (Figure 7-34).
13. Change the IP address of the device to the assigned address of that particular EyeD location and instance. Select the application, then from the Tools menu select Change IP Address. Enter the appropriate IP address, 192.9.50.xx where xx is one of the following pairs of digits. depending on the Chamber and type of EyeD system.:

Table 7-2. IP Address Final Digits

	OES	IEP
Chamber A	10	20
Chamber B	11	21
Chamber C	12	22
Chamber D	13	23

14. With the IP address for the default application changed, insert a new application. Repeat steps 1-7, but name the Application for the EyeD instance it is intended for, e.g. EyeD-A.
15. For the IP address, enter the address specific to the EyeD instance. It should be the same as the address to which the initial Default connection application was changed.
16. The spectrograph should be detected as before. Assign the data sources and click OK to return to the main SRM window.
17. The particular instance is now configured and detected in SRM. The default connection is no longer needed. Delete the Default Connection SRM by right-clicking on it and selecting Delete an Application.

18. Configure additional applications as needed by following Steps 1-17. Each time an initial connection will need to be made with the default IP address (192.9.50.99 or the one obtained with the USB cable). The connection must be reset to the designated IP address. Then finally the actual instance application should be created with its assigned IP address. The default connection may then be deleted.

7.3.2 Universal Remote Interface (URI) Setup

The Universal Remote Interface (URI) links the EyeD software to the Centura using either standard RS232 or TCP/IP communication. This section will explain how to setup URI communication for serial RS232 communications.

1. Click **OK** on the Application Setup window. The main URI window is left. The State field should say one of the following:
   a. *Not Initialized* means the serial port settings have not been selected.
   b. *Ready* means the serial expansion card is detected (verify).
   c. *Connected* means the instance is active and communicating with the spectrograph via SRM.
2. Launch URI. There should be four applications listed with the Communication **RS232 Protocol 3 Standard**. See Figure 7-39.

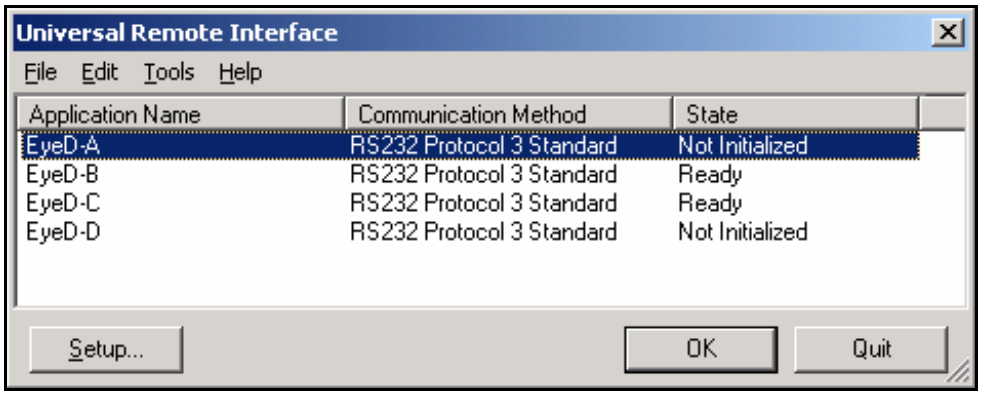


Figure 7-39. URI Window for SECS Communication

NOTE

A state of *Not Initialized* means that a particular COM port could not be accessed/opened by URI. All 300mm tower computers have their COM ports properly enabled in BIOS so this type of state will not normally be encountered. Old *flat panel* EyeD computers may come from spares without COM ports configured in BIOS, and will generate a *Not Initialized* state.

3. Double-click on any application to configure it.

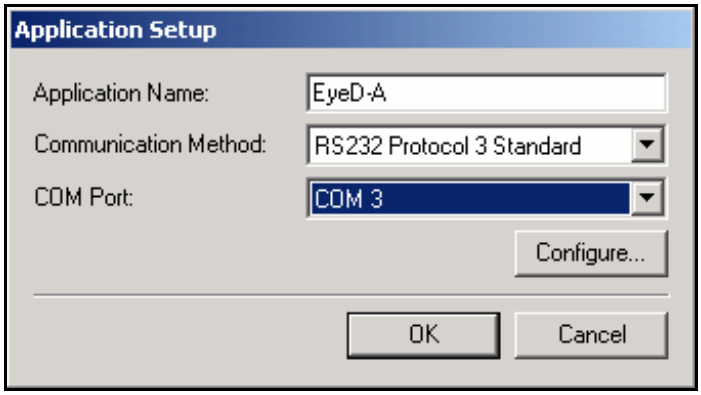


Figure 7-40. Application Setup Window

1. Confirm that the Communication Method is **RS232 Protocol 3 Standard**.
2. Confirm that the com port selections are as follows

   Chamber A = Com 3

   Chamber B = Com 4

   Chamber C = Com 5

   Chamber D = Com 6

NOTE

These are the com ports provided by the expansion card and the *octupus* cable on the EyeD tower PC.

3. Configure and set the values to those shown in Figure 7-41.

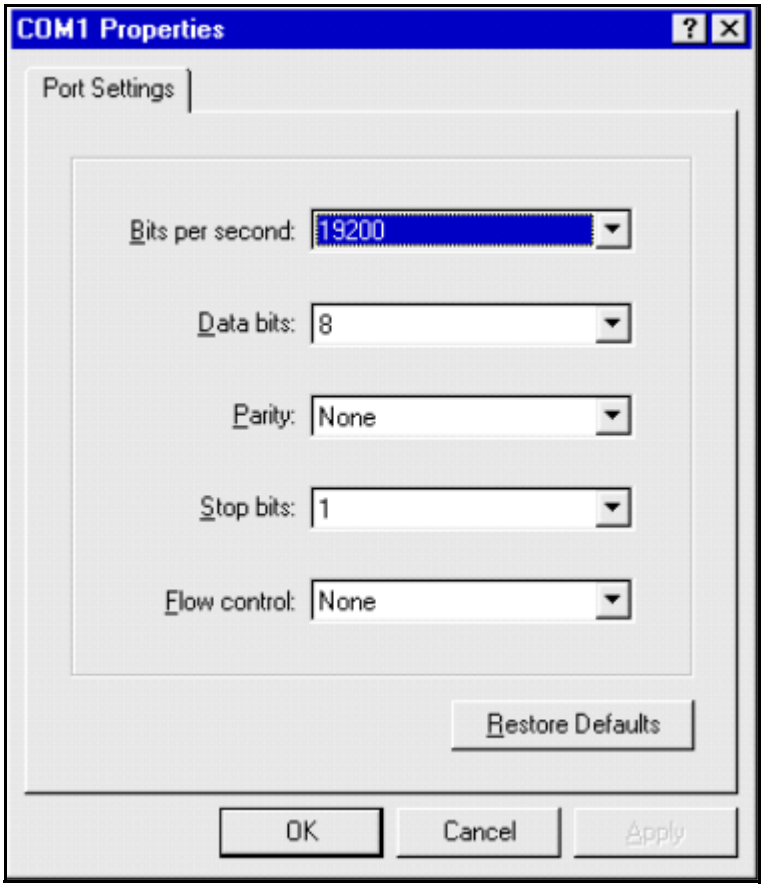


Figure 7-41. Com Port Settings for RS232 Communication

4. Exit **Application Setup**; all the applications should have the State *Connected*.
5. Test each of the applications as follows:
   - Launch the EyeD instance.
   - Create a sequence named algorithm number XX.
   - Set the delay to 10 seconds, and then send Endpoint.

7.3.2.1 Validating Communication to the Centura

NOTE

Setup the Centura software before checking the communication. See Section 7.4

Open **URI**, select **Tools**, then **Show Log Windows**. A window for each instance of EyeD named “Communications Log for Application EyeD__” and a window named “SECS Communications Log” are all created at the desktop level. If serial communications are active,

the SECS Communications window will show continual updating with serial messaging traffic with the mainframe, such as ping requests/acknowledgements.

The initial log window for ChA after successful connection will look like Figure 7-42.

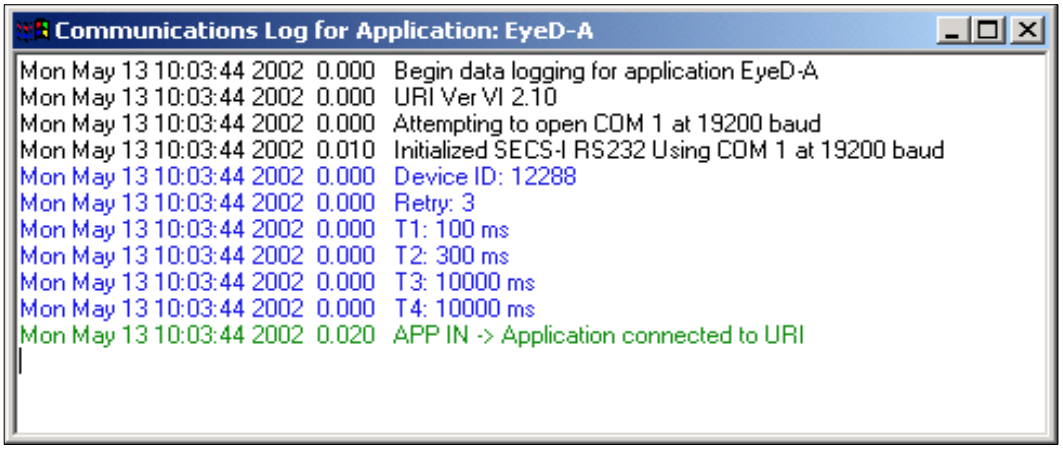


Figure 7-42. Initial Communications Log for Chamber A

The green "APP IN -> Application connected to URI" indicates that the EyeD-A application and EyeD-URI software modules are correctly communicating with each other.

When running, each significant communication event between EyeD-A and URI is logged with a time stamp in the Communications Log window. An example is shown in Figure 7-43.

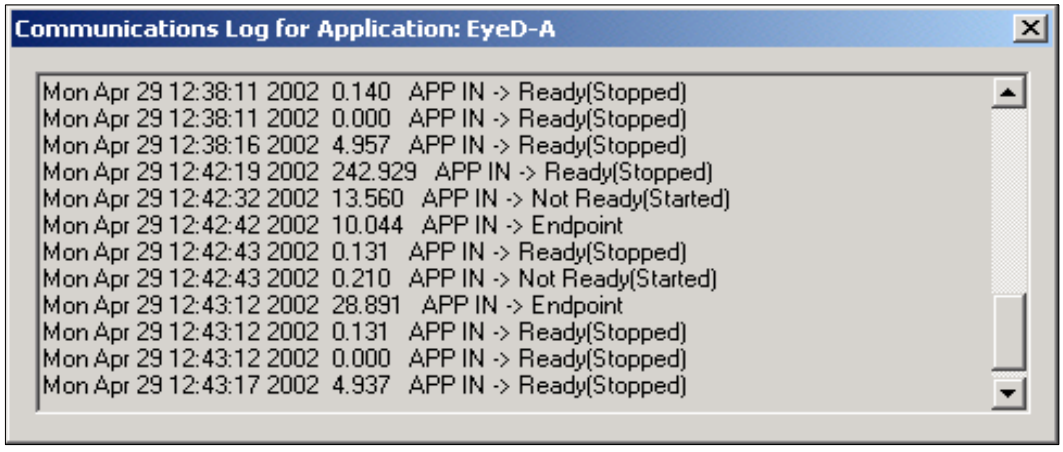


Figure 7-43. Communications Log for Active Chamber A

Log messages are color coded, and the logging can be useful for troubleshooting. EyeD can be set to record all of the entries on these log screens, however this should not be enabled except in cases of troubleshooting, as file sizes can become very large, and logging needlessly loads the CPU during normal operations.

If the log windows show that the SECS message traffic is active, then the system is ready for further testing. If messages indicating that time-outs have occurred, or if messages like

those shown in Figure 7-44 are present in the SECS Communications Log, then the serial link is not made or not enabled on either the EyeD/URI side or the Centura side. Notice that the time-outs are indicated, but no acknowledgements of application connection are present. Recheck that the serial cable is connected to the correct ports and recheck all other steps in this procedure.

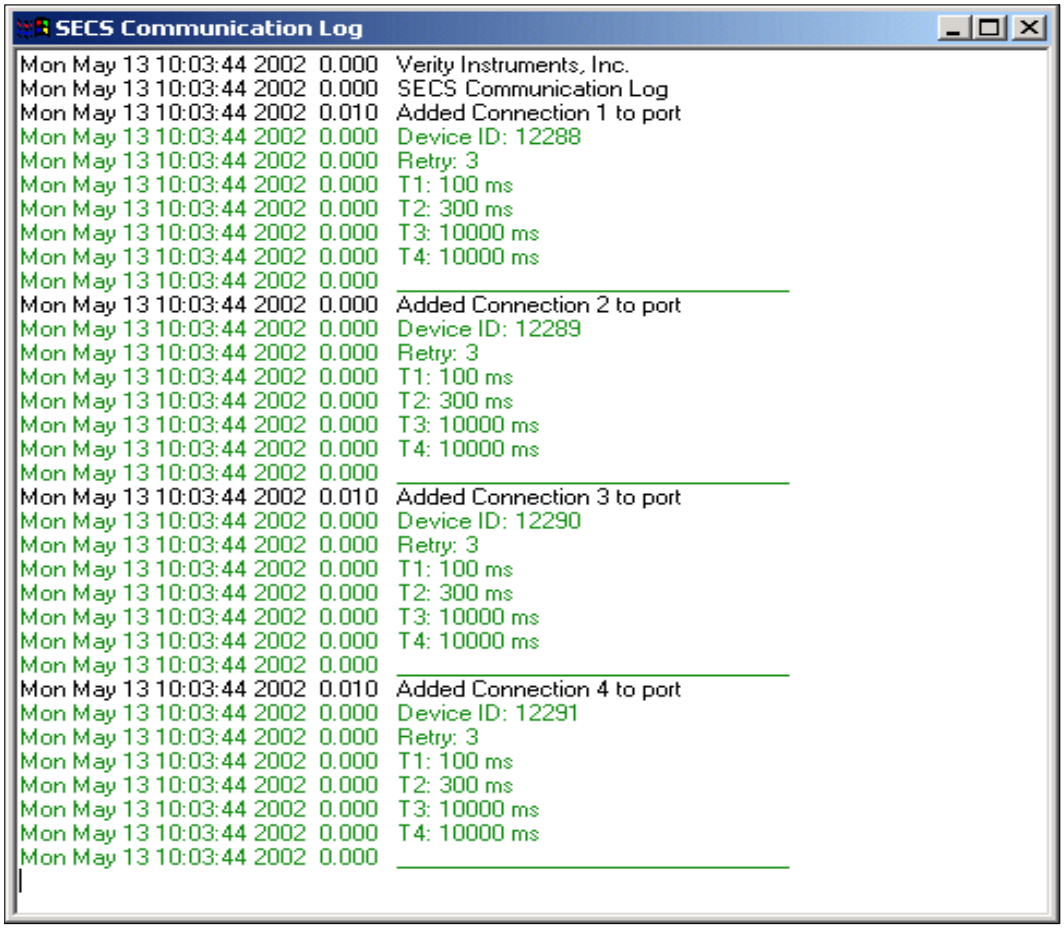


Figure 7-44. Communications Log Window where there is a Serial Cable Problem

7.4 Set File Management

7.4.1 Setup and Verify Automatic File Naming

Setup and verify file naming for both local and remote modes. Refer to Section 3.2.2.

7.4.2 Setup and Verify Auto Delete and Archive Options

Setup and verify the Auto Delete and Archive options for each configured EyeD instance. Refer to Section 3.2.3.

7.5 Mainframe Setup

The following instructions take the user through verifying communication between the mainframe computer running AMS software and EyeD. There is the option to set up different

endpoint detectors to monitor endpoint, though only one at a time will be able to actually send an endpoint signal.

7.5.1 Verifying Software communication

1. Check that the RS232 communication cable is connected between the CCM COM1 port and the assigned COM port on the computer (section 6.9).
2. Check the communication settings on EyeD (section 7.3.2):

   Eyed should be running URI with the option "Verity Protocol3 common" for the designated serial channel. The default baud rate of 19200 is used.
3. Check the Millennium (mainframe) software version. EyeD communication is supported from version 1.4 and up. Version 1.5_60 and above support multiple B-B steps on one endpoint graph.
4. Check the following EC constants in the software:
   a. Serial port baud rate (Chmb/endpoint/verity/baud_rate=19200)
   b. Serial port name (Chmb/endpoint/verity/Serial_port_name=tyco0)
   c. Cpu:cpu/integ_endpt=True
   d. Cpu:cpu/external_endpt=False
5. Check the connection status via the Millennium software
   a. Look at the Endpoint details (Misc>Details) screen. It will show *Not connected* and *Not Installed* if serial communication is not established.

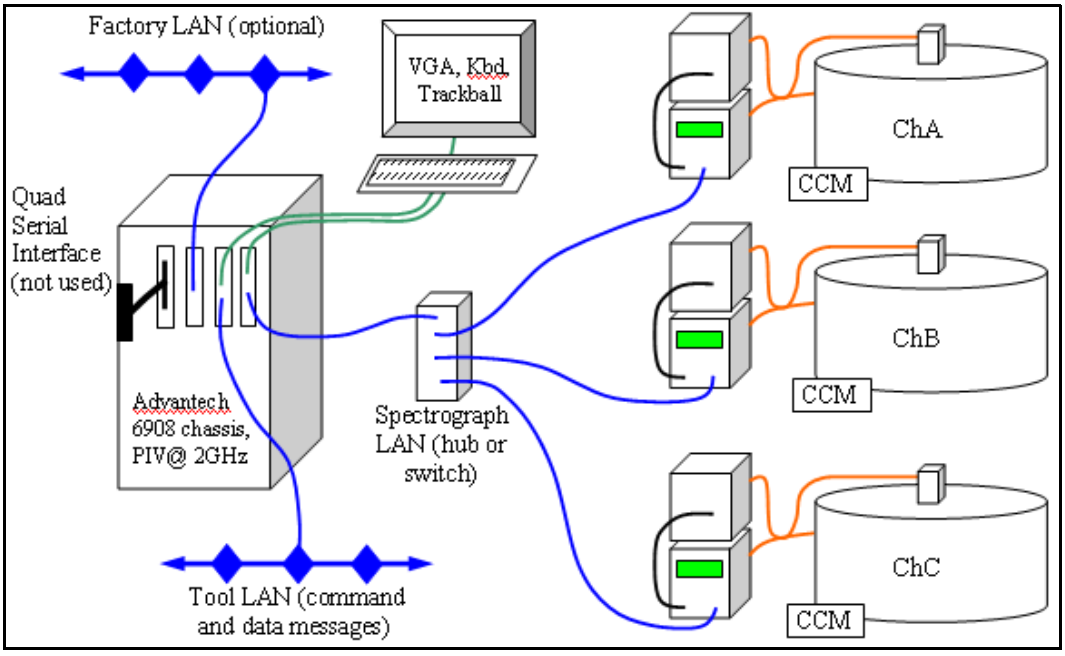


Figure 7-45. TCP/IP Connection Diagram

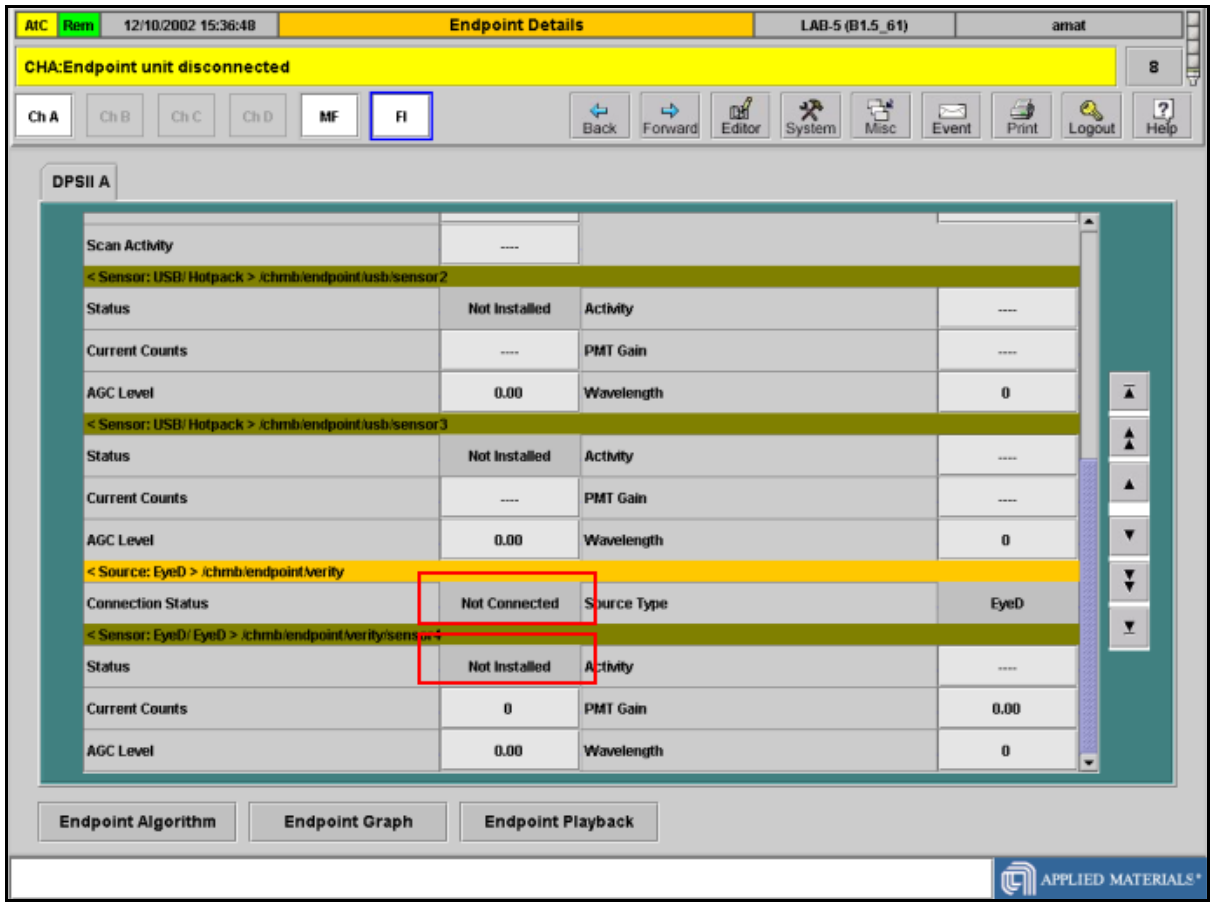


Figure 7-46. Mainframe Details Screen with Eyed Not Connected

6. Check communication status via the EyeD software.

   a. Remote communication should be enabled (Section 3.3)

   b. In the EyeD Activity window, the message *PM Connected* will appear. This indicates that communication is established. The mainframe Details screen will show *Connected* connection status and *Ready* status.

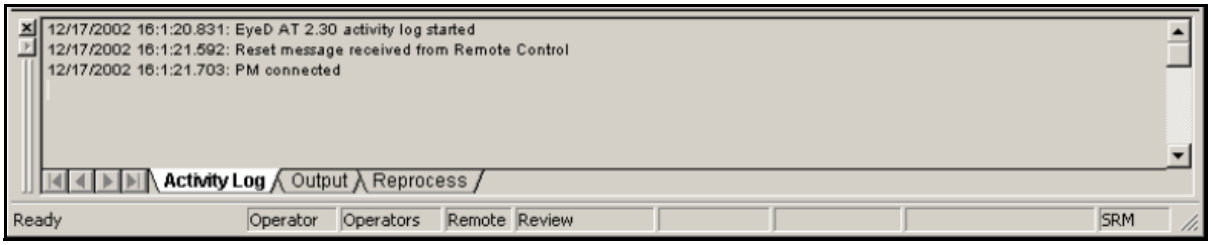


Figure 7-47. EyeD Activity Window Showing Communication Established

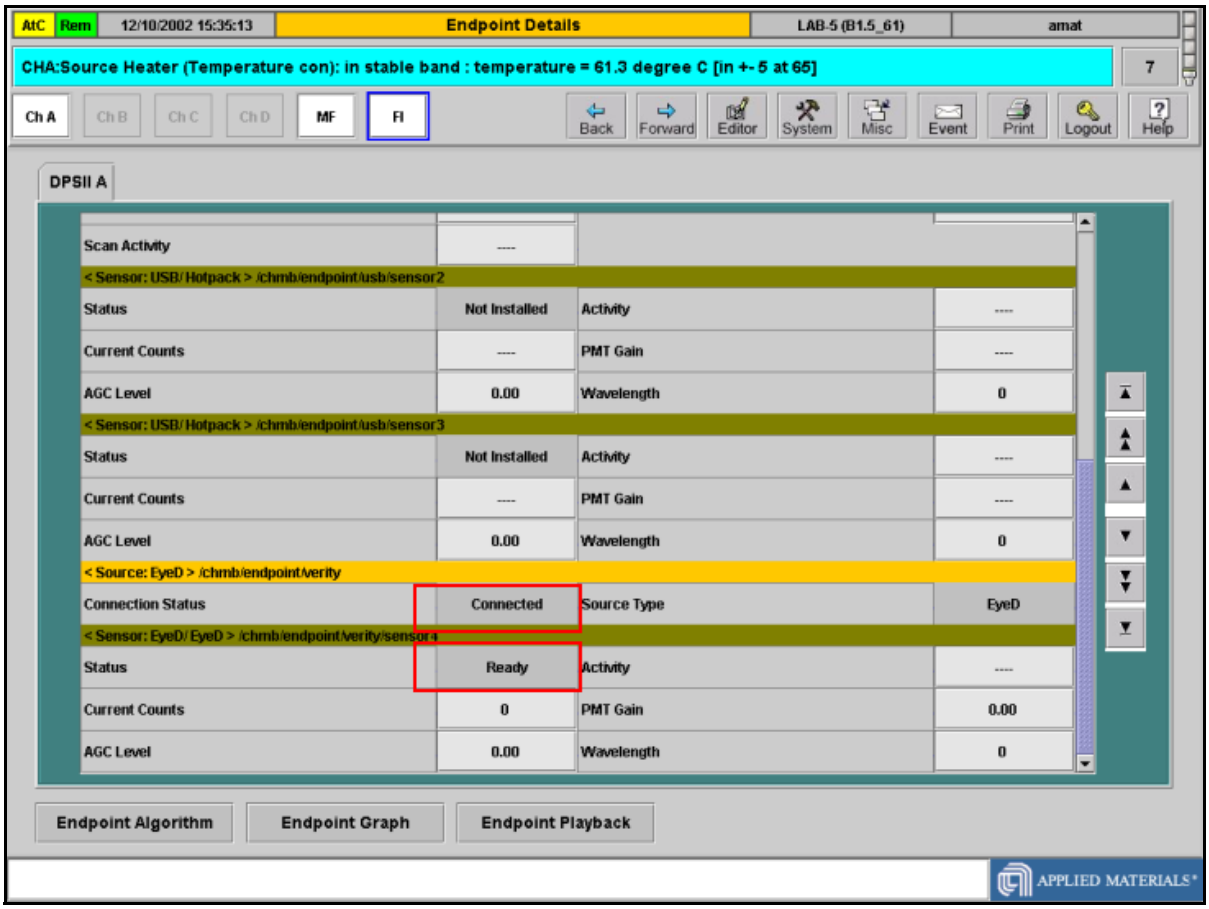


Figure 7-48. Mainframe Details Screen with EyeD Connected

NOTE

Troubleshooting tips: If no communication is established, recheck the Eyed remote/local status, recheck the RS-232 cable connection, or restart Eyed. A null modem adapter can be used to check for reversed wiring in either the cable or the CCM.

7.5.2 Configuring Millennium Software to use EyeD

1. Recipe steps which call EyeD must have the algorithm name in the step, and that algorithm name must correspond to an algorithm located within the EyeD endpoints folder. The extensions (.alg and .svc) are not used in the recipe.

   The mainframe algorithm to run Eyed can be set up as described below:

2. Open the Misc. menu on the GUI.

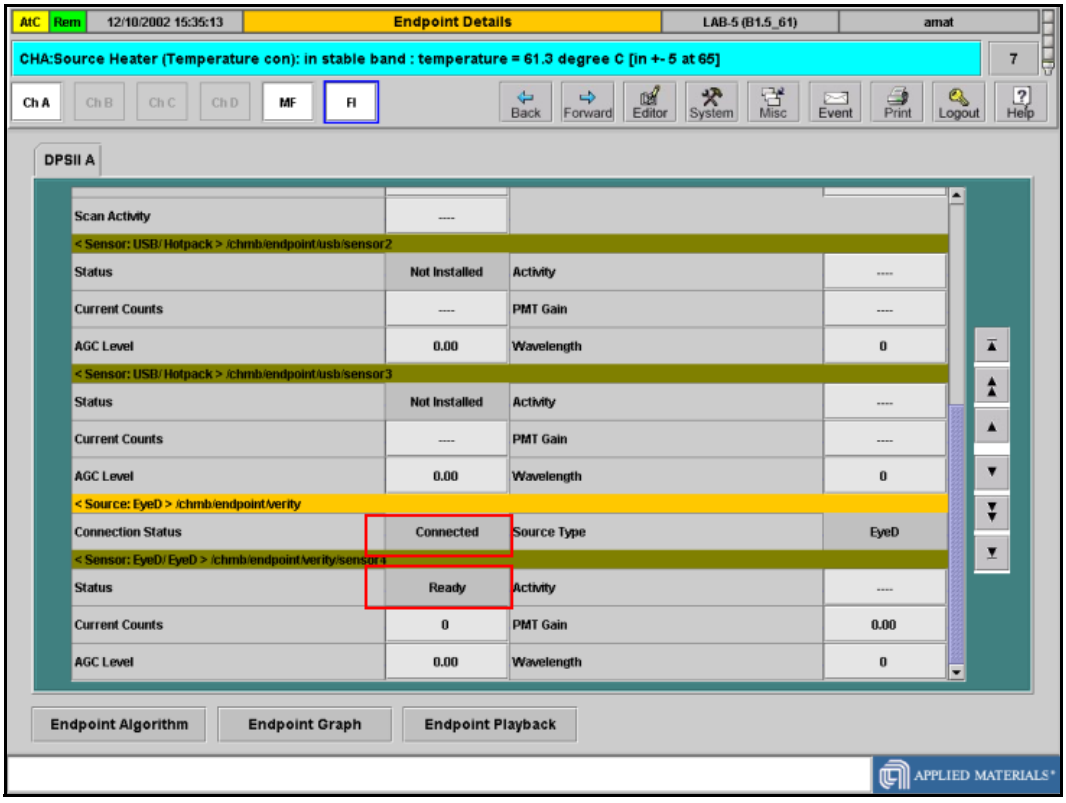


Figure 7-49. Misc. Menu

3. Click on **Endpoint Algorithm**.
4. Create a new algorithm for the DPSII chamber. The name will start out as *Untitled*.
5. Click on the **Sensor** tab and then **Add Sensor**.

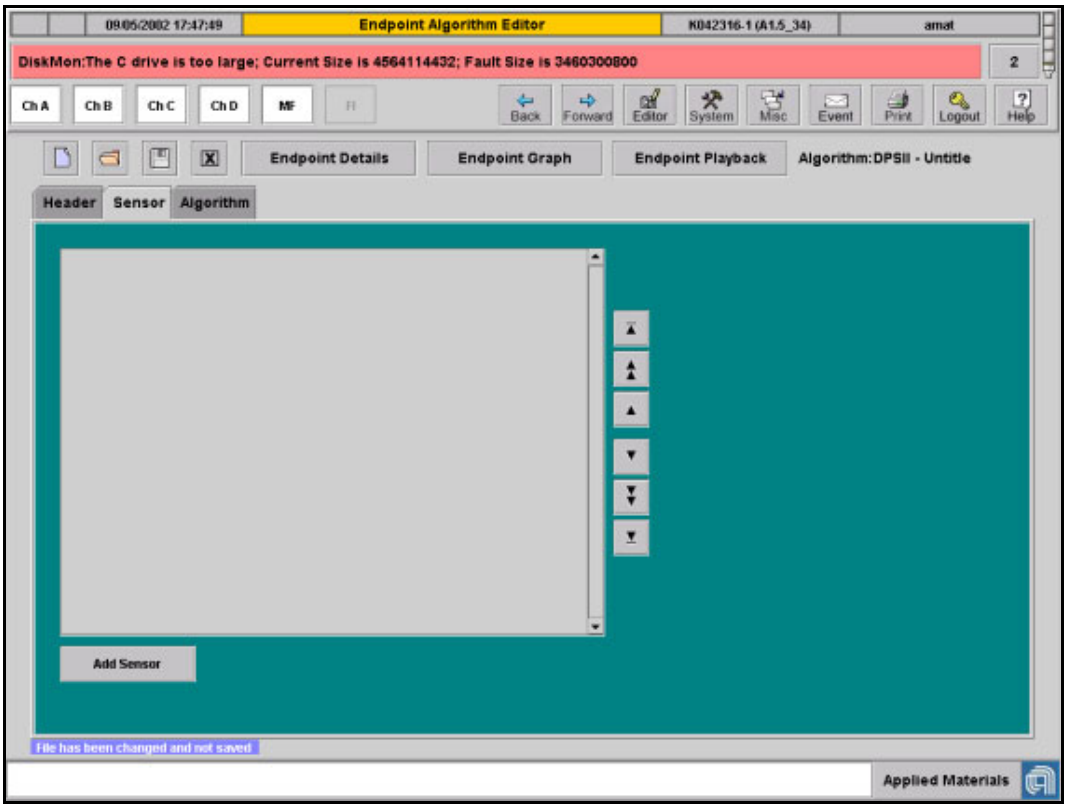


Figure 7-50. Setting Up the Sensor for New Algorithm

6. Sensor 1 will be added

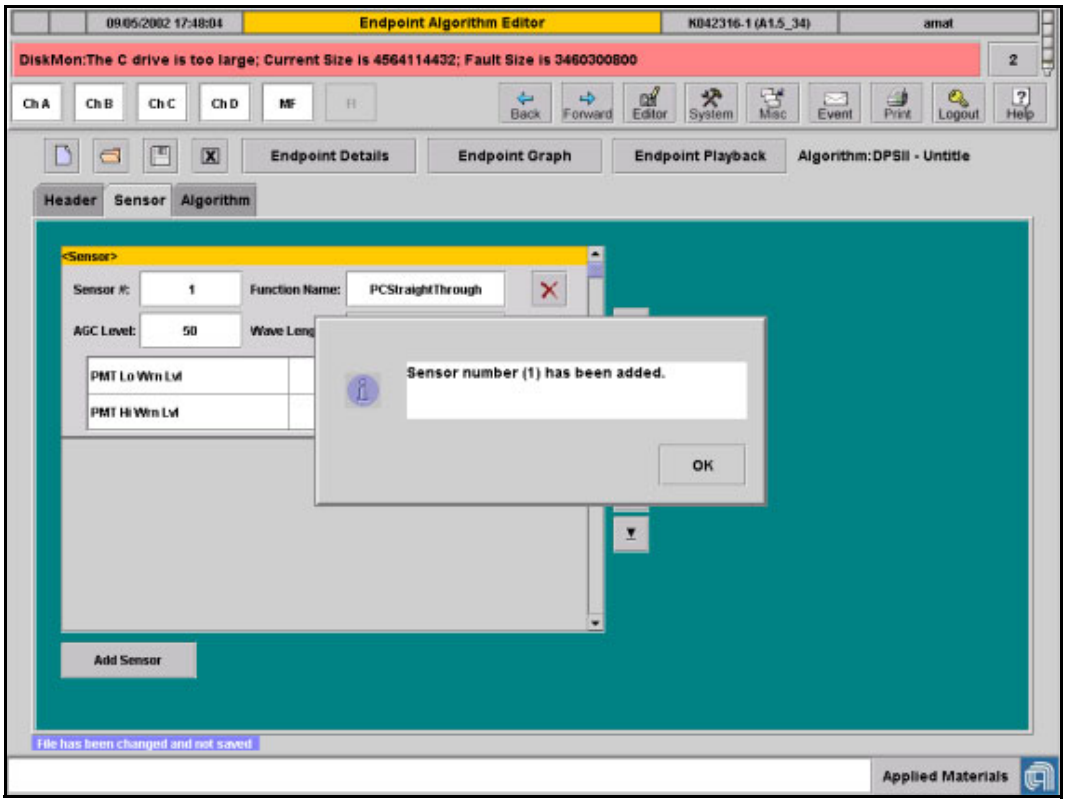


Figure 7-51. Sensor 1 is Automatically Added

7. Create a sensor for each type of endpoint system on the chamber. Sensor 1 corresponds to the Embedded OES (USB) endpoint; Sensor 2 corresponds to the embedded IEP (hot pack) endpoint; and Sensor 4 corresponds to EyeD. More than one sensor can be configured for each algorithm.

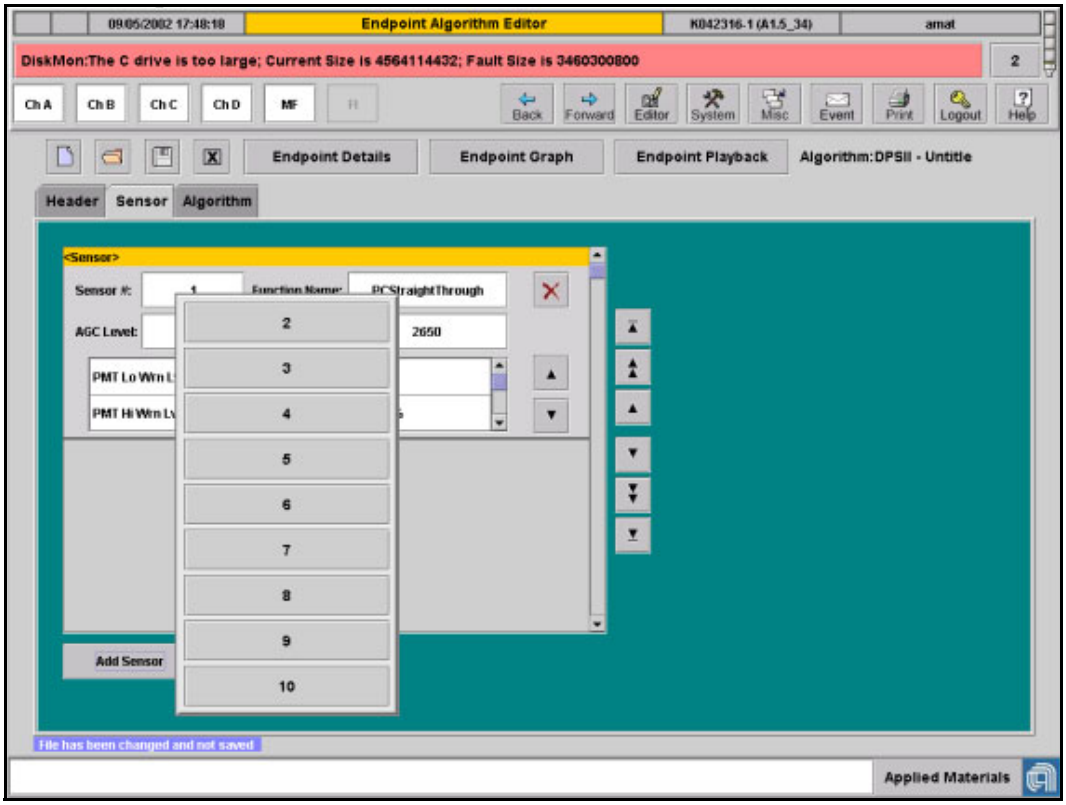


Figure 7-52. Selecting the Sensor Number

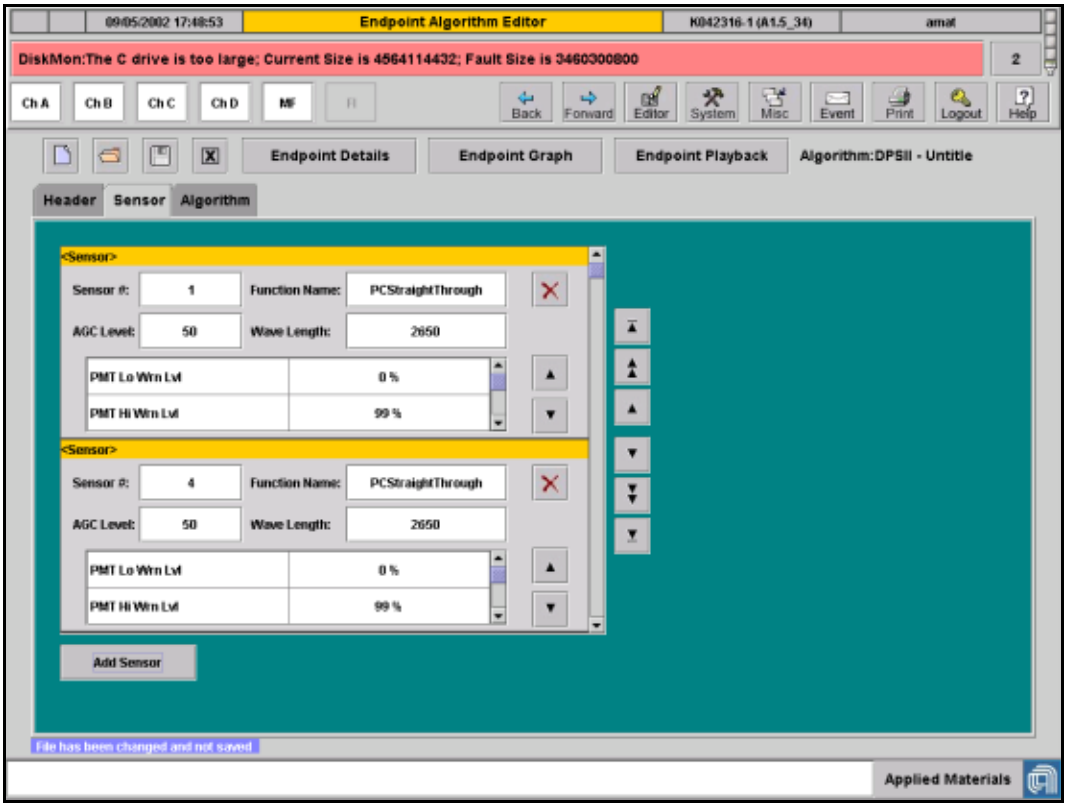


Figure 7-53. Sensors 1 and 4 are configured

8. Be sure that a nonzero wavelength is entered for each sensor used. A default value for Eyed (sensor 4) of 2650A is fine. This non-zero wavelength is used to enable sensor data collection. The value is not used by Eyed.

9. Next, click on the algorithm tab, and then click **Add**. This adds a mini-algorithm, which directs the data flow to a graph on the Millennium screen.

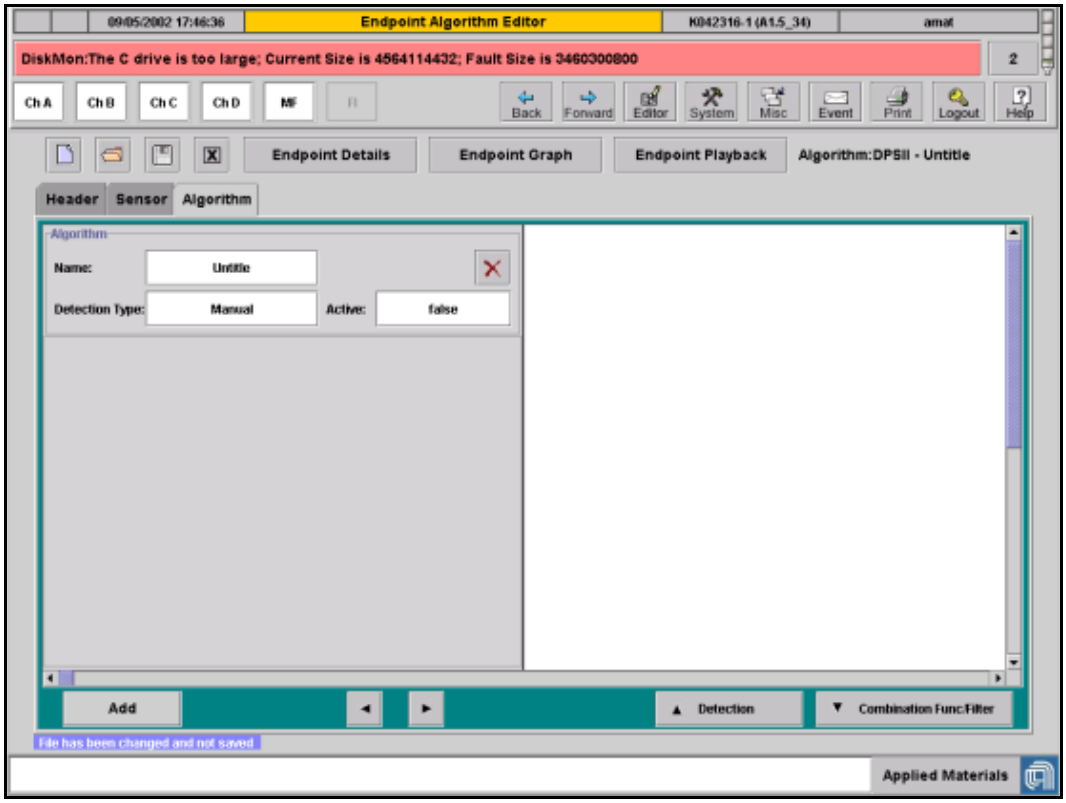


Figure 7-54. Creating a New Algorithm

10. Name the min-algorithm as desired. This will be the label for the Millennium screen endpoint graph.

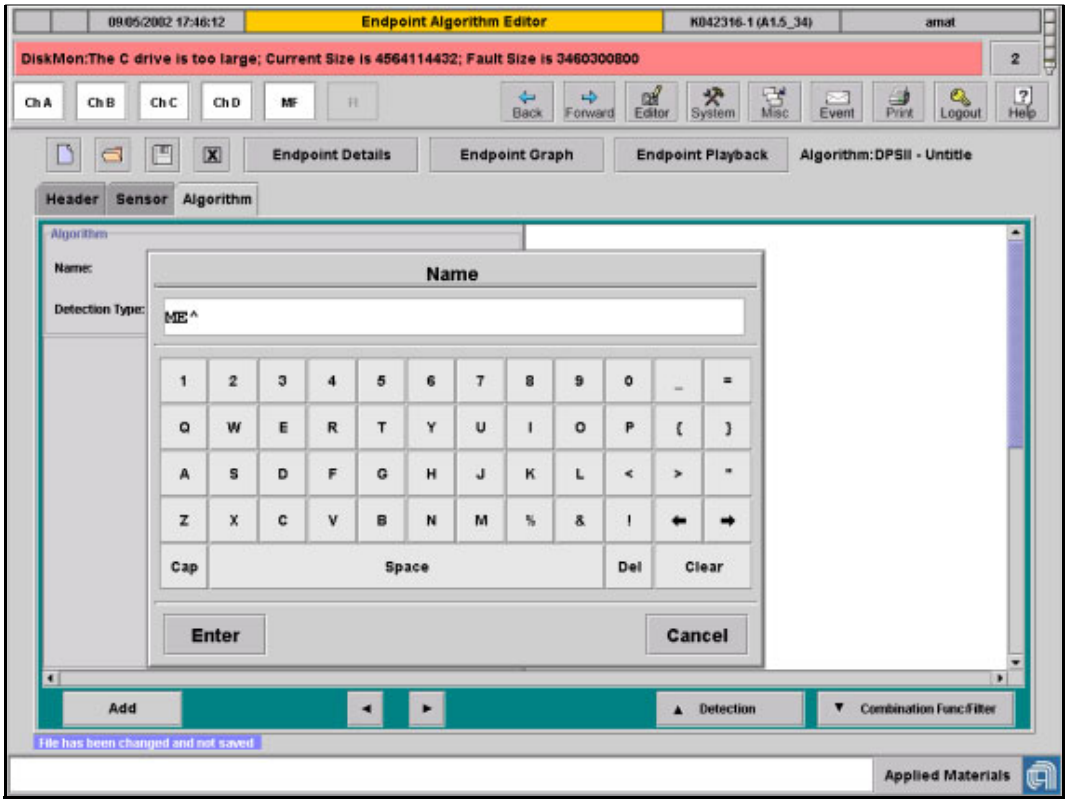


Figure 7-55. Naming the Algorithm

11. Then choose 'EyeD' as the 'Detection Type'.

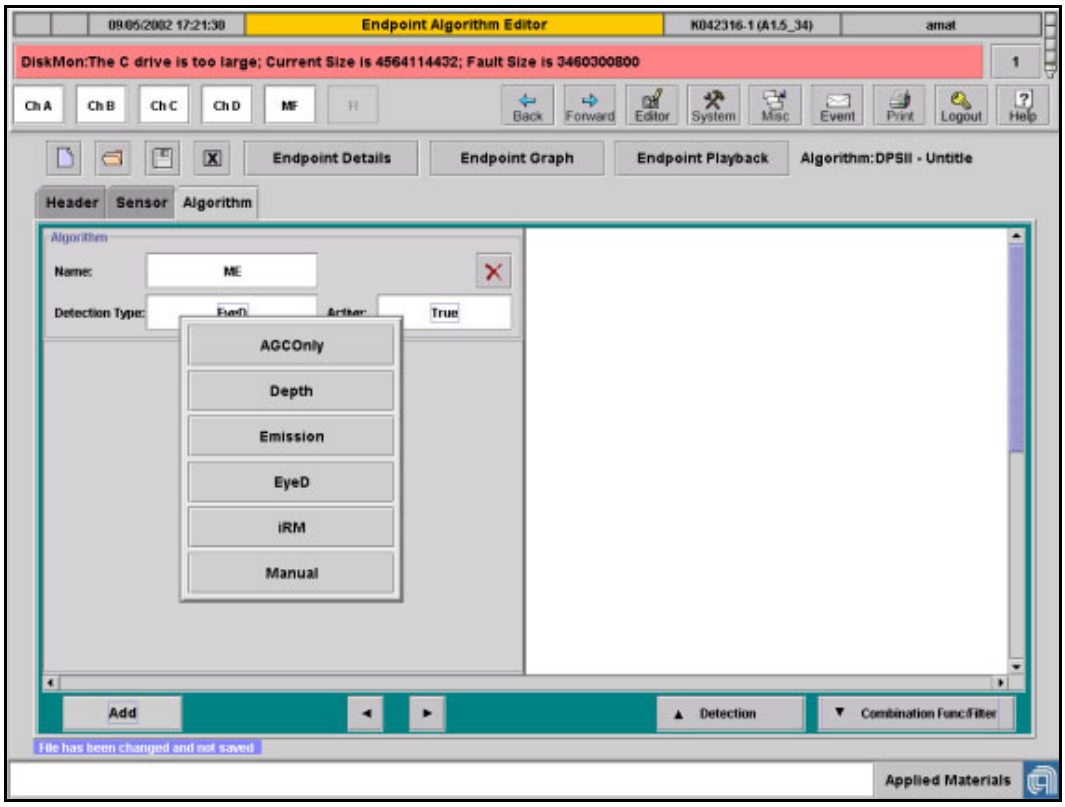


Figure 7-56. Selecting the Detection Type

12. Choose **active** to be *true* if EyeD will be calling endpoint, and *false* otherwise.

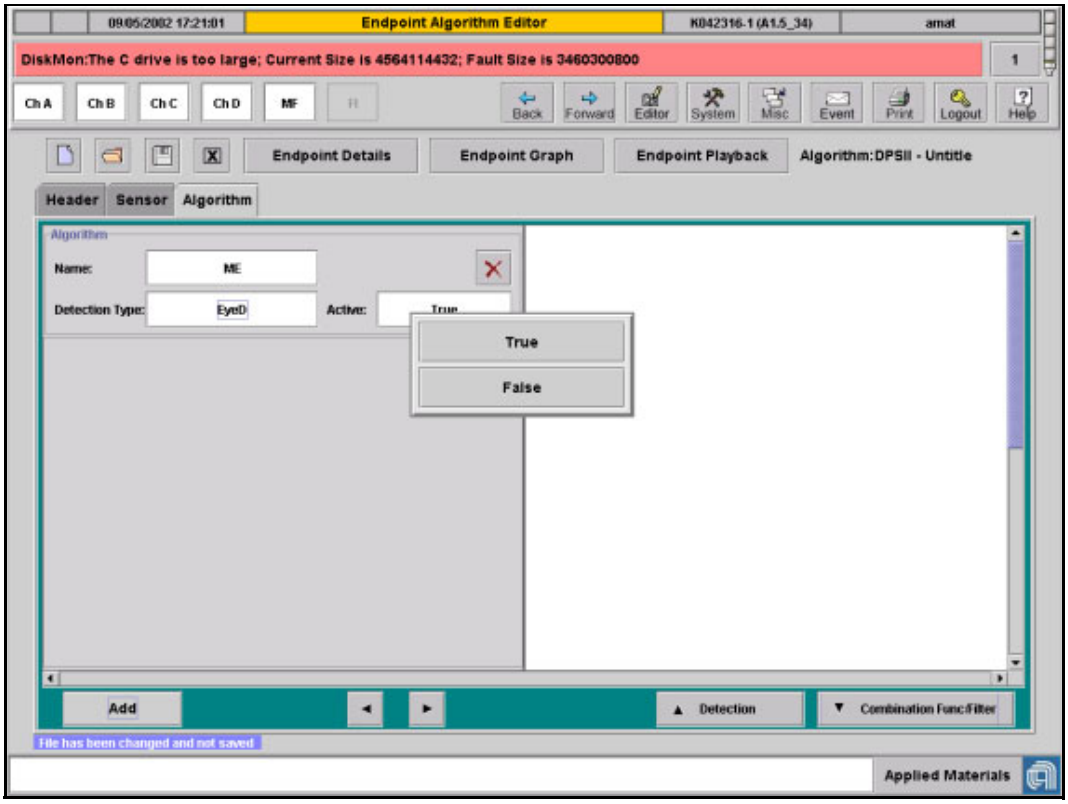


Figure 7-57. Selecting EyeD to Call Endpoint

13. If another endpoint sensor is on the chamber, add another mini-algorithm for it.
14. Click on **Combination Func/Filter**, or scroll down.

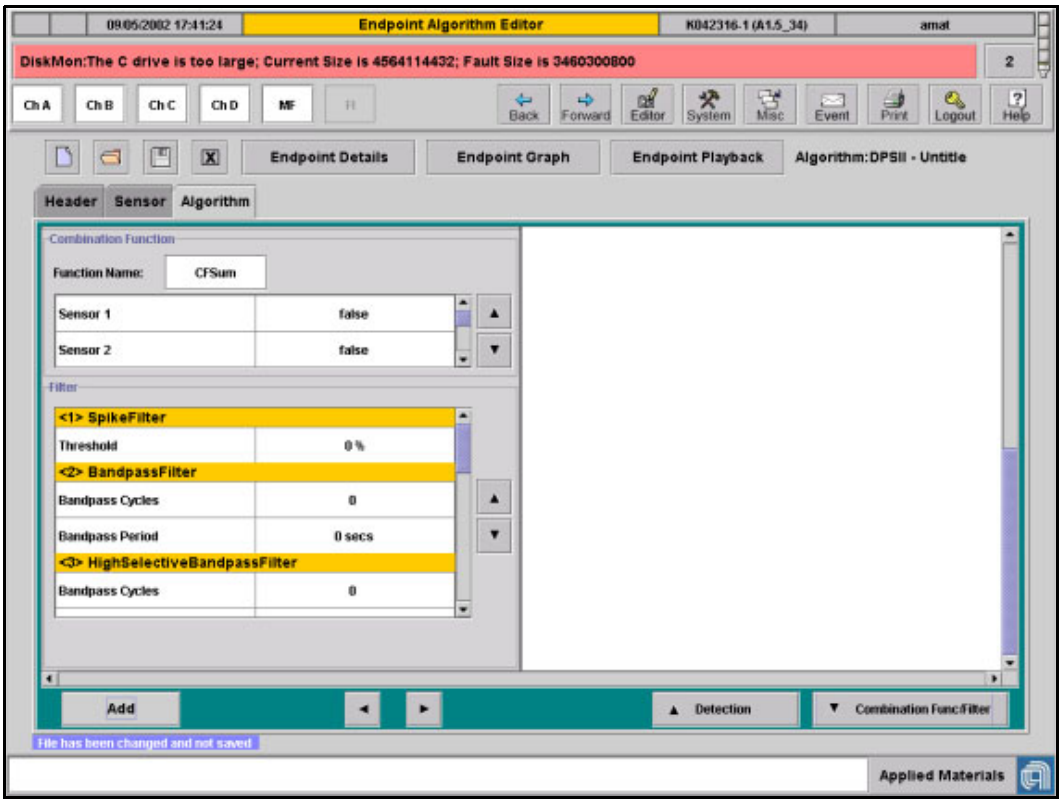


Figure 7-58. Setting the Combination Function

15. The Combination Function selects which sensors are used. Click on the field to the right of Sensor 4 and select **True**.

16. Be sure that Sensors 1,2 and 3 are set to False. See the next section on dual mode if these are used.

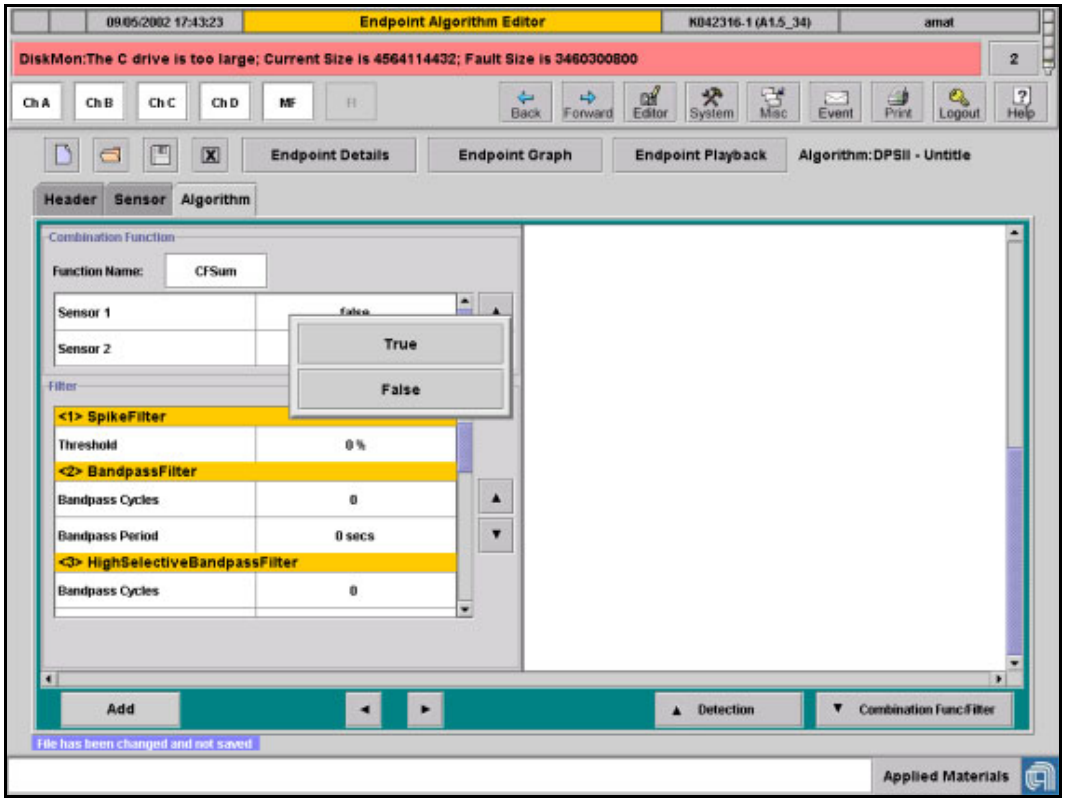


Figure 7-59. Choosing Sensors to Monitor Endpoint

17. Slide the scroll bar on the filter section to view *Magnetic Field Period Averaging*. Set the number of cycles to 0. This will turn the filter off.

18. Save the algorithm with the same name that will be used on Eyed.

7.5.3 Dual-mode Operation

Sometimes it is desirable to enable multiple sensors for simultaneous operation, such as both the monochromator (OES) and EyeD.

This software configuration is set up within the algorithm.

1. Set up Sensors 1 and 4 in the sensor screen as previously described in Section 7.5.2.

2. Click on the algorithm tab **Add** twice (rather than once) to create two mini-algorithms.

3. Each mini-algorithm will be dedicated to a single sensor, and generate a graph on the mainframe screen.

4. For the first mini-algorithm, add a label such as *Eyed*, with the combination function using Sensor4 = True, and the other parameters as described in Section 7.5.2.

5. For the second mini-algorithm, add a label such as *Mono*, with the combination function using Sensor1 = True (Sensor4 = False), Detection type = Emission, and windows and filtering as desired. Two graphs appear when the recipe runs.
6. Select Active = True for the mini-algorithm that is to call endpoint (EyeD or Mono).
7. Select Active = False for the mini-algorithm that is for monitoring.
8. If both are set to True, the earliest occurrence will call endpoint.

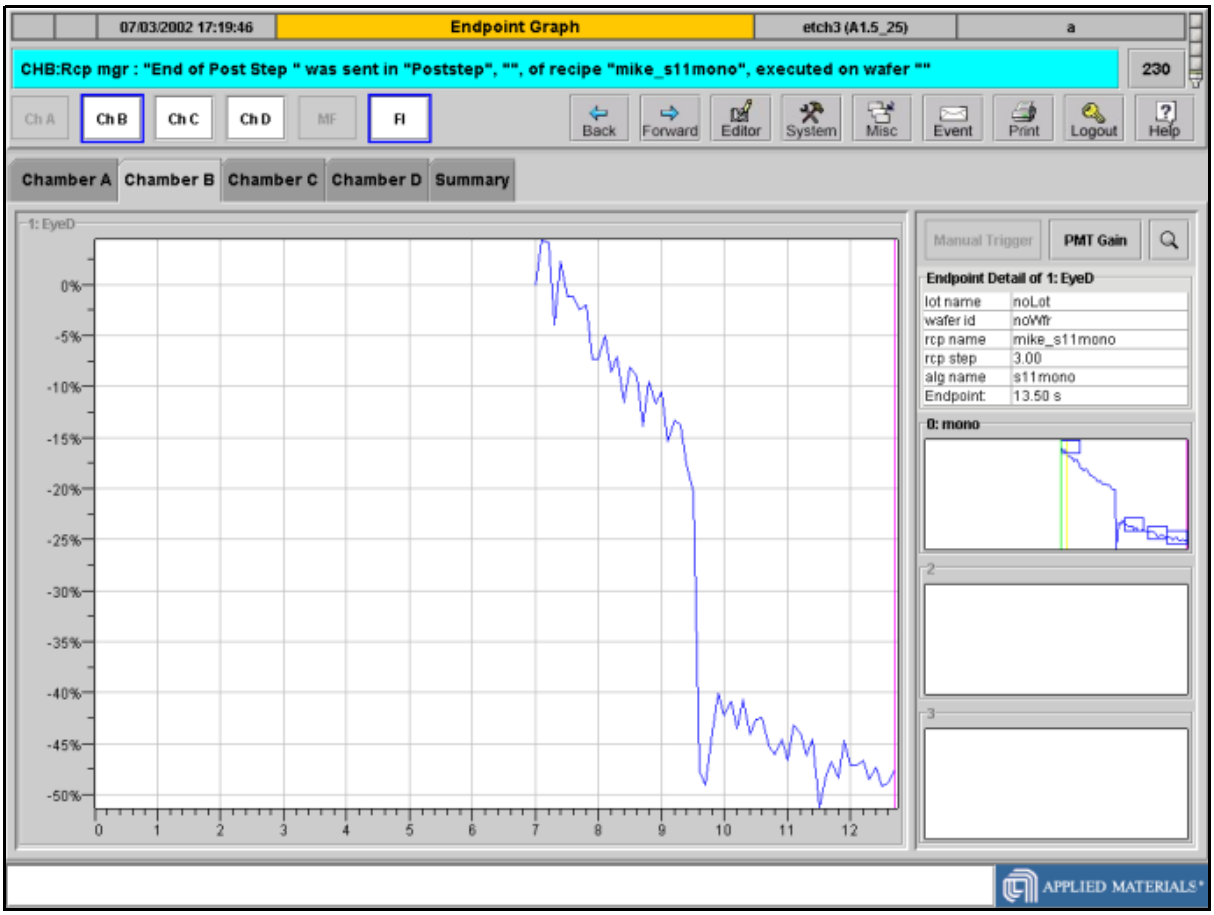


Figure 7-60. Example of Mainframe GUI Showing Eyed and Monochromator Data

Troubleshooting Tips:

1. The recipe faults immediately if the algorithm name is not found on the Eyed computer.
2. The recipe will fault after about 5 seconds if no data is received by the mainframe from Eyed. Be sure that the Eyed algorithm has under *Equations>trends* the *Send to tool controller* box checked for only one of the trends of interest.
3. The mainframe can also be faulted by a marker in the Eyed algorithm which is set to *Severity=Fault*.

7.6 Communication Validation

4. Power up the computer/hub. Login as administrator with no password.
5. Launch EyeD-A icon.
6. Check the communication status between EyeD-A and the Ch A DCS using the Spectra Resource Manager (SRM). Double click on the black spectrometer icon in the system tray (lower right corner of the Windows interface) to launch SRM. Ensure that the EyeD-A application is listed and it is indicated that the Device is Found rather than Missing, and the State is Connected and not Disconnected. If the SRM indicates otherwise, the TCP/IP address expected by the chamber instance of EyeD does not match the actual address. Change the TCP/IP address for that instance of EyeD as described in Section 7.3.1.

NOTE

Whenever a change to physical Ethernet connections is made to the tool LAN (swapping, connecting, disconnecting spectrographs, etc.), be sure to:

a. Cycle the power on the spectrograph

b. Exit and restart the SRM.

This procedure will reestablish the spectrograph-to-hub Ethernet link, and then re-read the communications status in the SRM. The SRM will not necessarily indicate a status change automatically; it must be restarted to obtain the most current communications status. If both of these approaches fail, try cycling the power to the hub (briefly unplug the AC adaptor powering the hub) and restarting Windows and EyeD.

7. Close the EyeD-A instance.
8. Repeat Steps 3-5 for each instance of EyeD.

7.7 Local Area Network (LAN) Setup

See the system management chapter, Chapter 8 EyeD System Management, for network security considerations.

The 300mm EyeD controller is configured with 3network adapters: Spectrograph LAN, tool LAN and actory LAN. When integrating the EyeD controller within Tool and/or Factory Local Area Networks (LANs), a user may need to configure either the Factory or Tool LAN network interface card (NIC) to have specific TCP/IP settings. Each EyeD controller is equipped with multiple network adapters so that a Factory LAN connection will not impose communications traffic on the isolated Spectrograph LAN, thereby reducing its bandwidth.

Note that there 2 network ports are on the main processor board on both 200 and 300mm computers, and that the 300mm computer has a third port on a separate PCI card. The diagram in Figure 7-61 and the following instructions apply regardless of the physical layout.

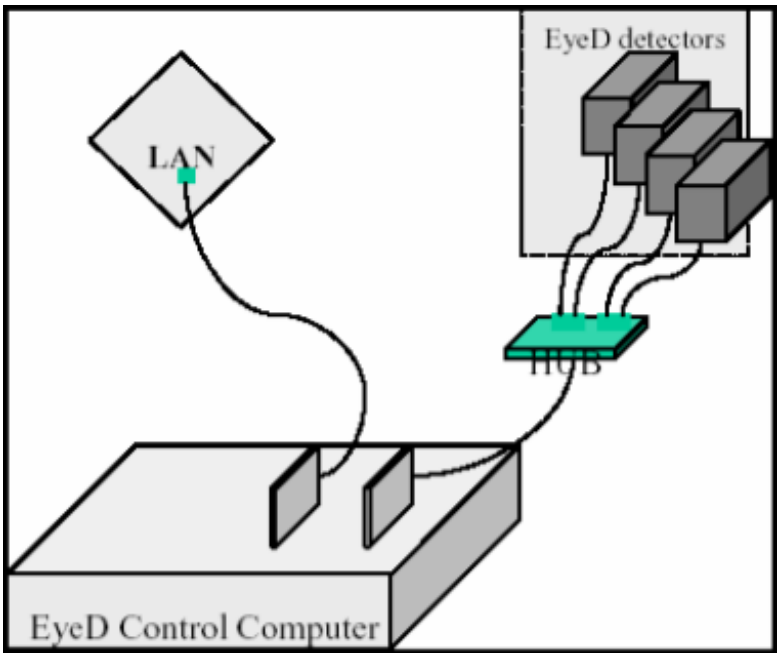


Figure 7-61. Network Diagram

It is recommended that the Spectrograph LAN always be on the "primary" network adapter in order to be the first one polled/detected if several are in use, and the one to get message priority. This will happen automatically if the computer is booted with the spectrographs and the spectrograph hub powered, active, and connected to the Spectrograph LAN port.

Ports are labeled on EyeD controllers. If the EyeD controller is brought up with the Spectrograph LAN disconnected and either of the other NICs connected, then the secondary NIC will be assigned priority.

Again, the possibility of the Spectrograph LAN receiving low priority is eliminated by ensuring that all physical connections are made prior to launching EyeD/Spectra Resource Manager, and ensuring that all spectrographs are powered on prior to booting the controller computer.

If a situation does arise causing the Spectrograph LAN to become disconnected, then one can force the Spectrograph LAN port to have priority by:

1. Disconnecting all Ethernet cables and wait for windows to recognize the disconnection (about 5 sec).
2. Re-connecting the spectrograph LAN only to the correct port; wait ~5 seconds and use SRM to verify the Spectrograph LAN. SRM should indicate that all spectrographs are Found.
3. Re-connect the other LAN cable(s), using Windows Explorer to verify existence of a valid LAN File/Directory.

7.7.1 Configuration of Network Connection Names

1. Navigate (using the Windows "Start" button) to Settings ==>Network and Dialup Connections and double click. Do not select any item from the cascade if present.

   A screen similar to the Figure 7-62 should appear.

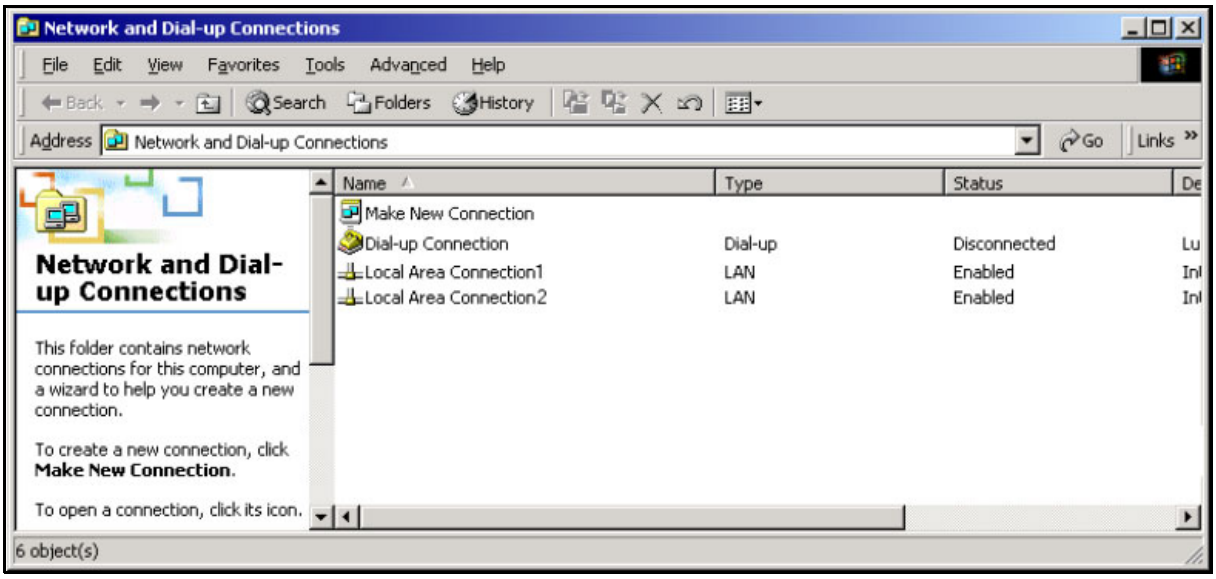


Figure 7-62. Network Dial-up Connections

2. Navigate (using the Windows "Start" button) to Settings ==>Network and Dialup Connections and double click. Do not select any item from the cascade if present.

   A screen similar to the Figure 7-63 should appear.

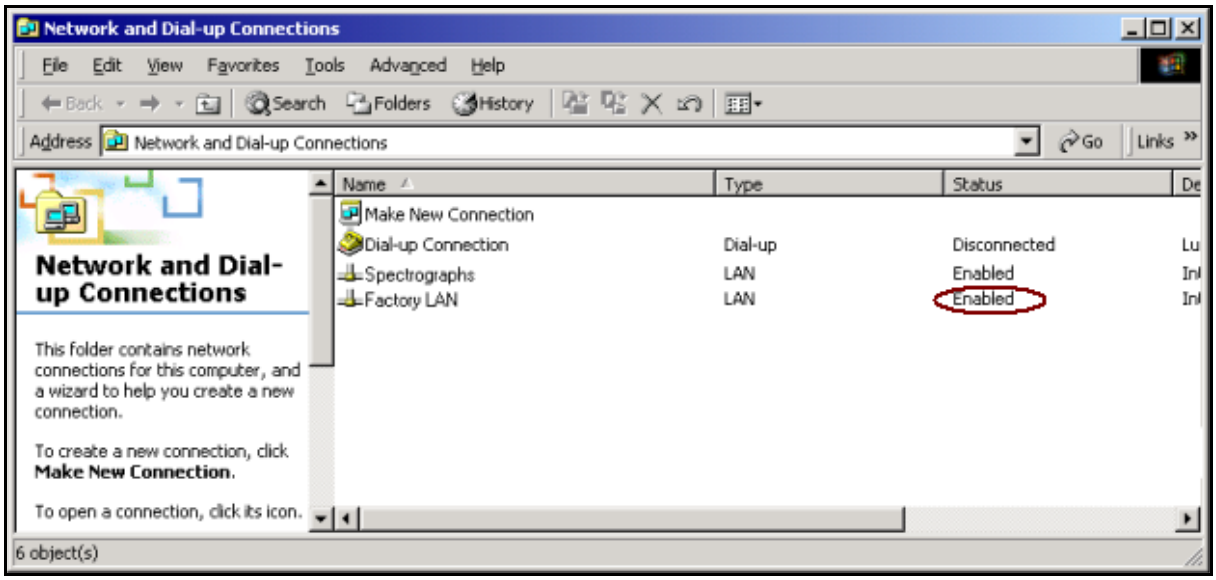


Figure 7-63. Network and Dial-up Connections

3. Ensure that the network cable of the associated card is properly attached to the interface described during the re-name. In windows 2000 this is easy to accomplish simply by disconnecting and re-connecting the cable and watching the "Status" column above.

7.7.2 Configuring the Spectrograph LAN Ethernet Adapter

1. In the Network and Dial-up Connections RIGHT-click the **Spectrographs**. You should be presented with a pop-up menu with the last item being "Properties".

2. Click on **Properties**.

   A dialog similar to the one in Figure 7-64 should appear.

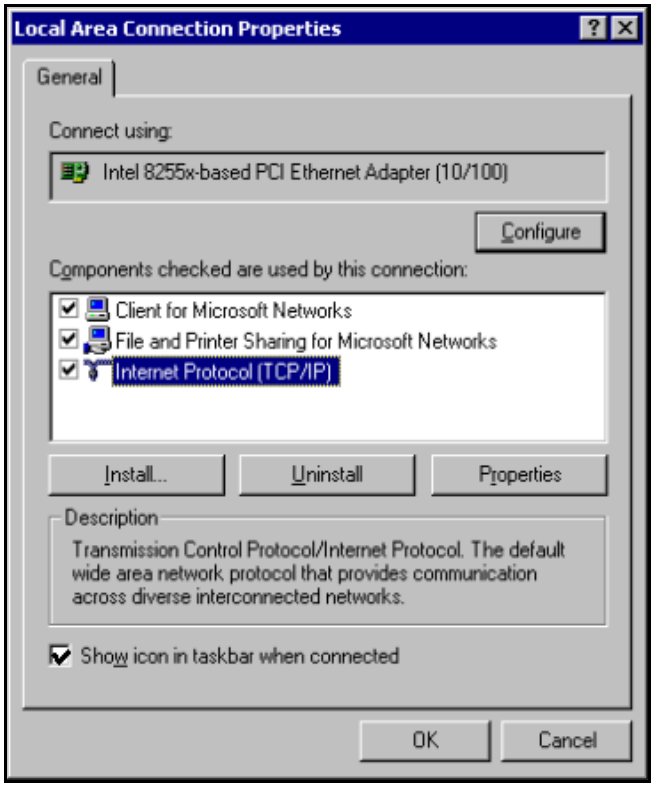


Figure 7-64. Local Area Connection Properties

NOTE

Only TCP/IP settings for the Ethernet card being used for Spectrograp communication should be changed. If there is not a "TCP/IP" protocol entry for the Ethernet card to be used, you will need to press the "Install…" button and define one.

3. Disable the Client for Microsoft Networks entry by clicking on the check mark. There must be no check mark in this entry.

4. Disable File and Print Sharing for Microsoft Networks by ckicking on the check mark There must be no check mark in this entry. The dialog should now resemble Figure 7-65.

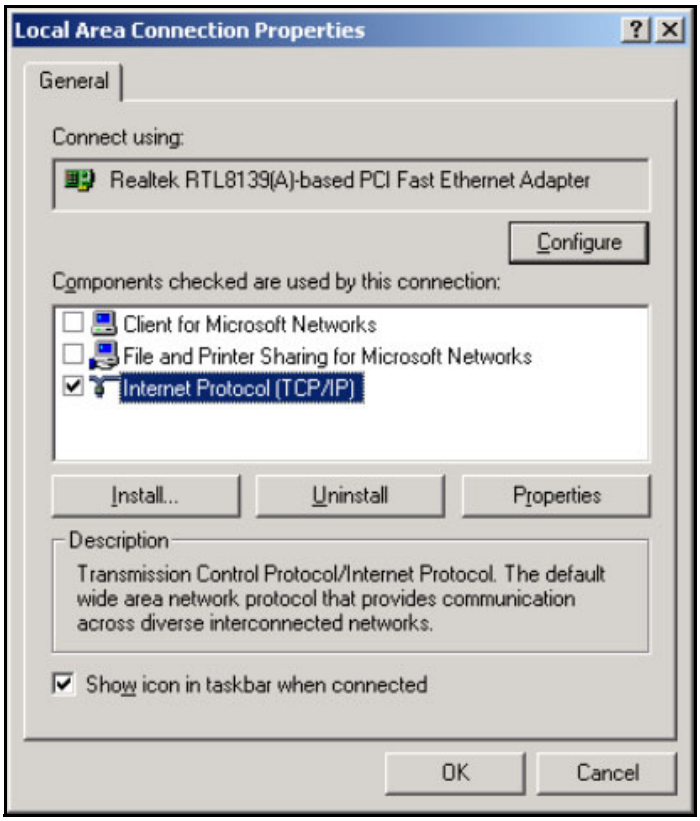


Figure 7-65. Local Area Connection Properties Showing Selection

You may click Properties, with Internet Protocol selected, to view a window as shown in Figure 7-66. Only the IP address and Subnet mask are necessary to communicate with the spectrographs.

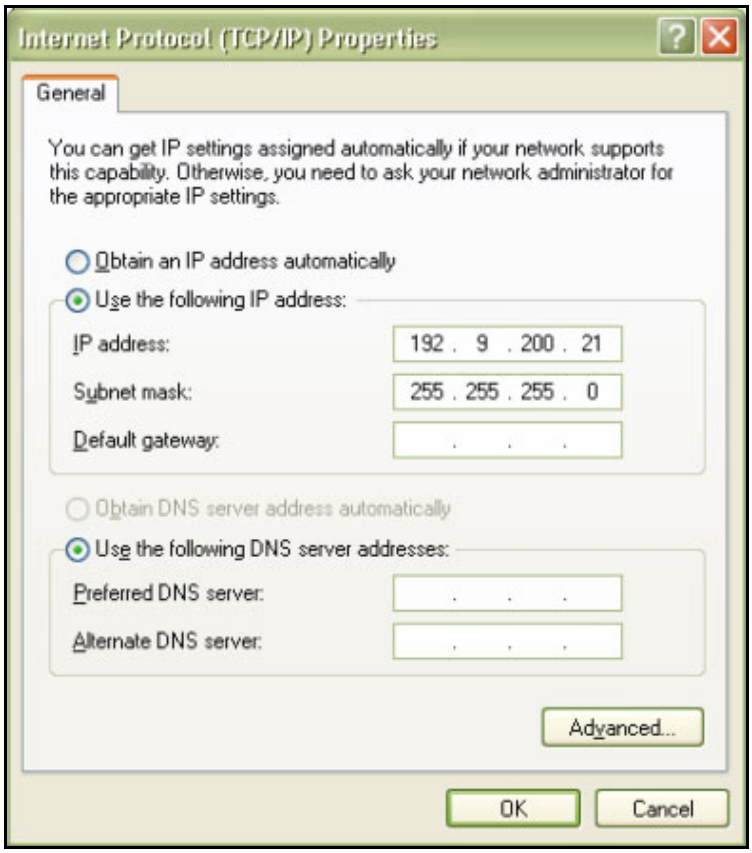


Figure 7-66. TCP/IP Properties

7.7.3 Default NIC TCP/IP Addresses

- Ethernet port PCA-6186 LAN # 1: Spectrograph LAN, IP address 192.9.50.100
- Ethernet port PCA-6186 LAN # 2: Tool LAN, IP address 192.9.200.21
- Ethernet card port: Factory LAN, Obtain an IP address from DHCP server.

7.8 Chamber Performance Validation and Lamp Setup (EyeD-IEP Only)

The EyeD flashlamp is shipped with a factory-preset intensity level and the lamp intensity is computer-controlled. It will be necessary to adjust the light output of the new lamp so that the total light in IEP operations (flashlamp + plasma) does not saturate the CCD detector in the brightest spectral regions with plasma on. This procedure outlines the adjustment to an appropriate level for most processes.

1. Install the source fiber in to the lamp output coupler as shown. Install the IEP probe on to the end of the long fiber optic branch if it was not shipped with a probe (IEP systems only).

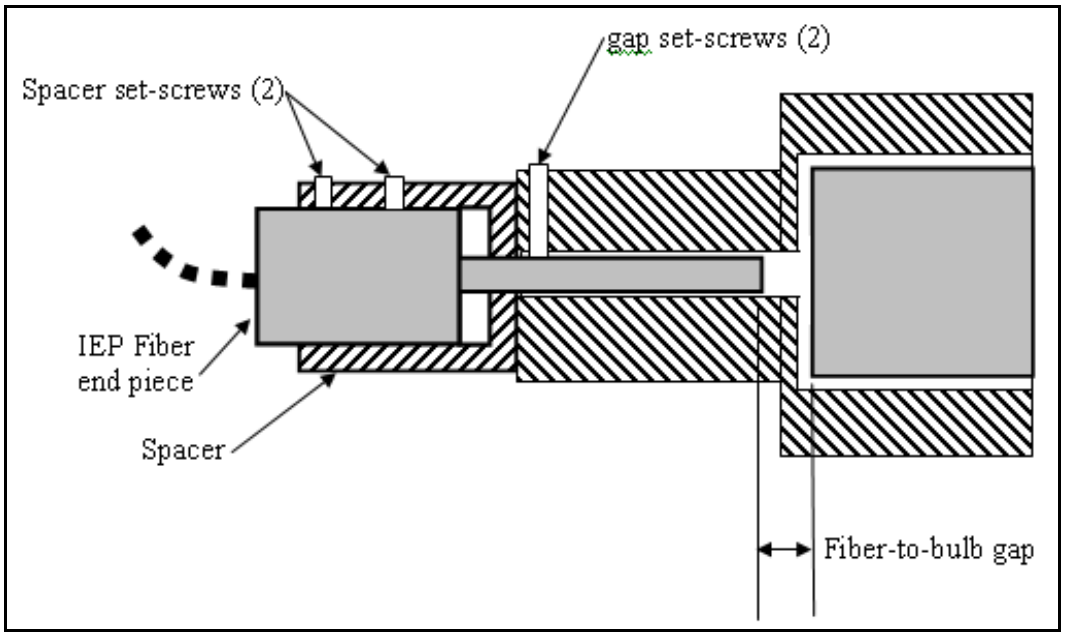


Figure 7-67. Source Fiber Branch IEP Cable Connection Detail

2. Connect the chamber ends of the fiber optic cables.

⚠ CAUTION

The IEP fiber optic probe must be secured by the clamp screws in the DTCU during EyeD endpoint operations. The flashlamp creates short pulses of potentially hazardous levels of ultraviolet light.

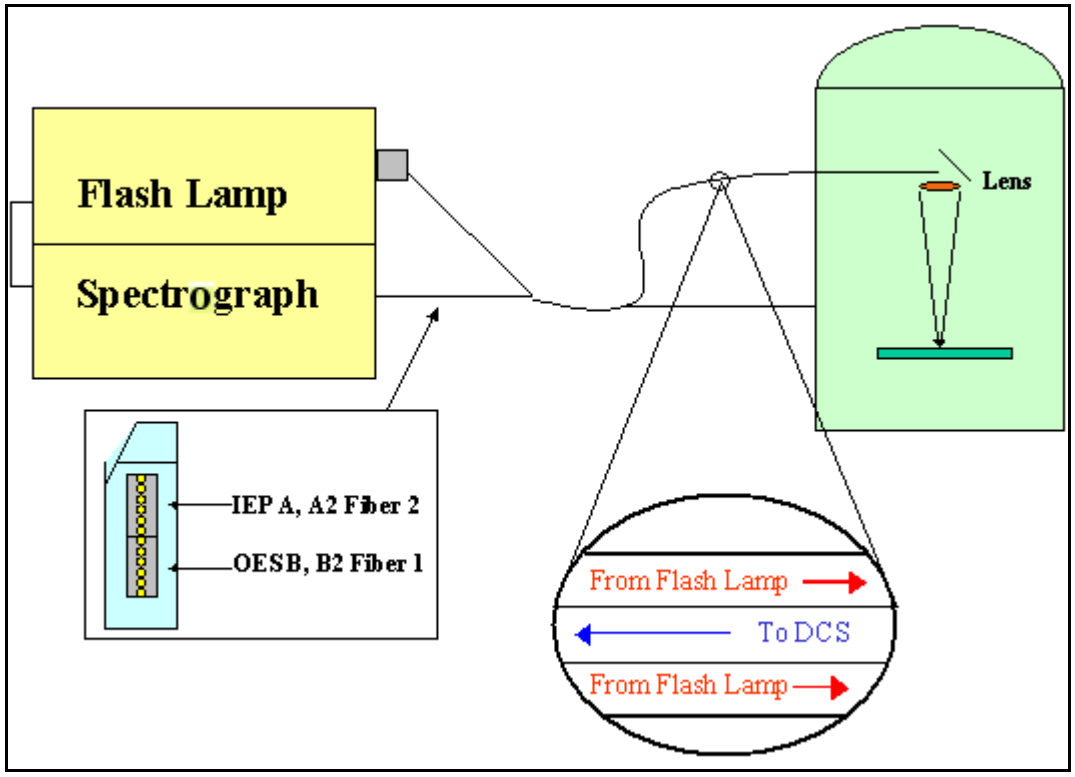


Figure 7-68. IEP Fiber Optic Cable Distribution

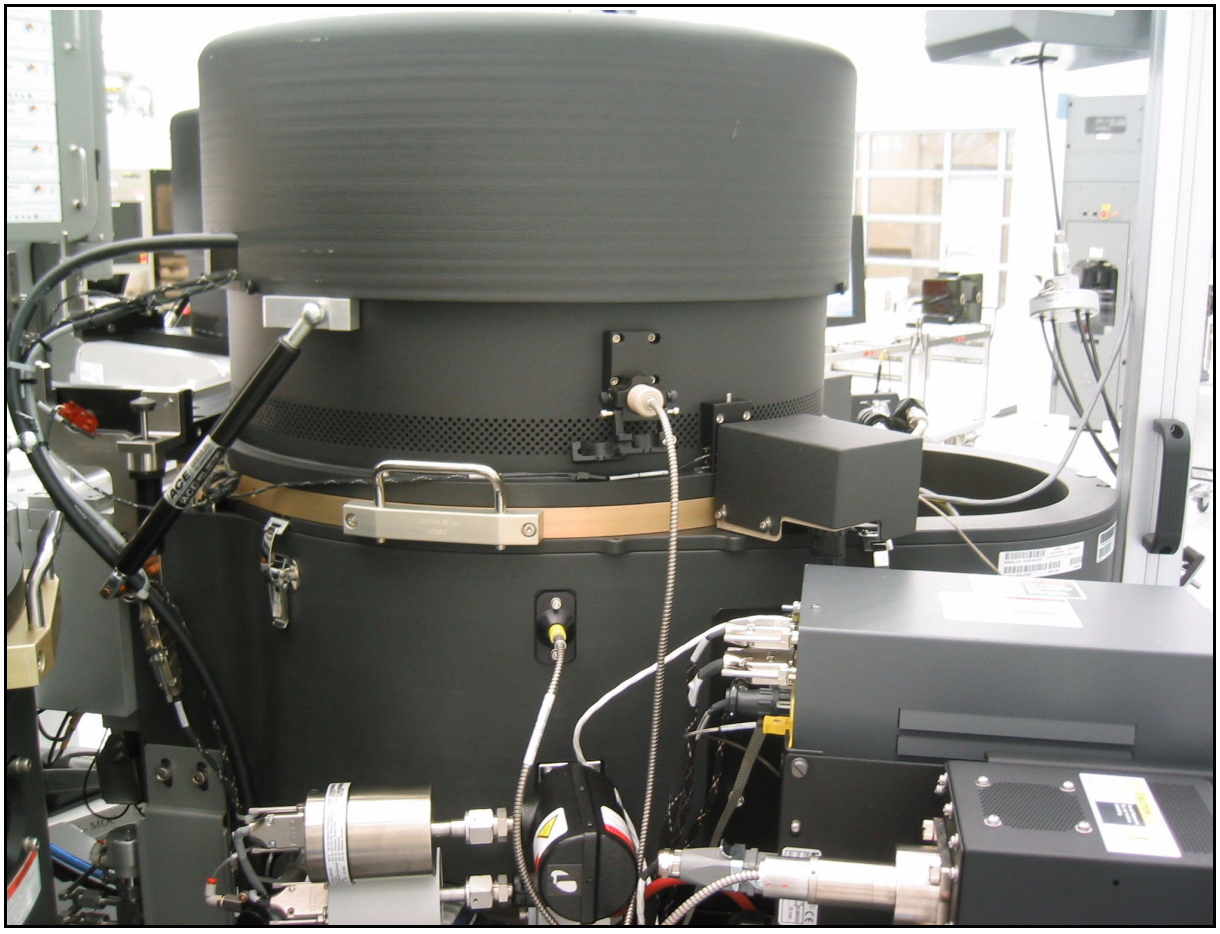


Figure 7-69. Fiber Optic Cable Routed to IEP Access Port on 300mm DPS Chamber

3. Move an unetched blank Si wafer (a particle wafer will work well here) in to the chamber that is to be set up. Put the cathode to process position. This wafer will act as a mirror to reflect the maximum amount of light back up in to the IEP chamber optics.

4. Open the SRM window to adjust the lamp intensity level. Click on **Tools**, then **Adjust Flash Lamp Intensity** to open the window shown in Figure 7-70.

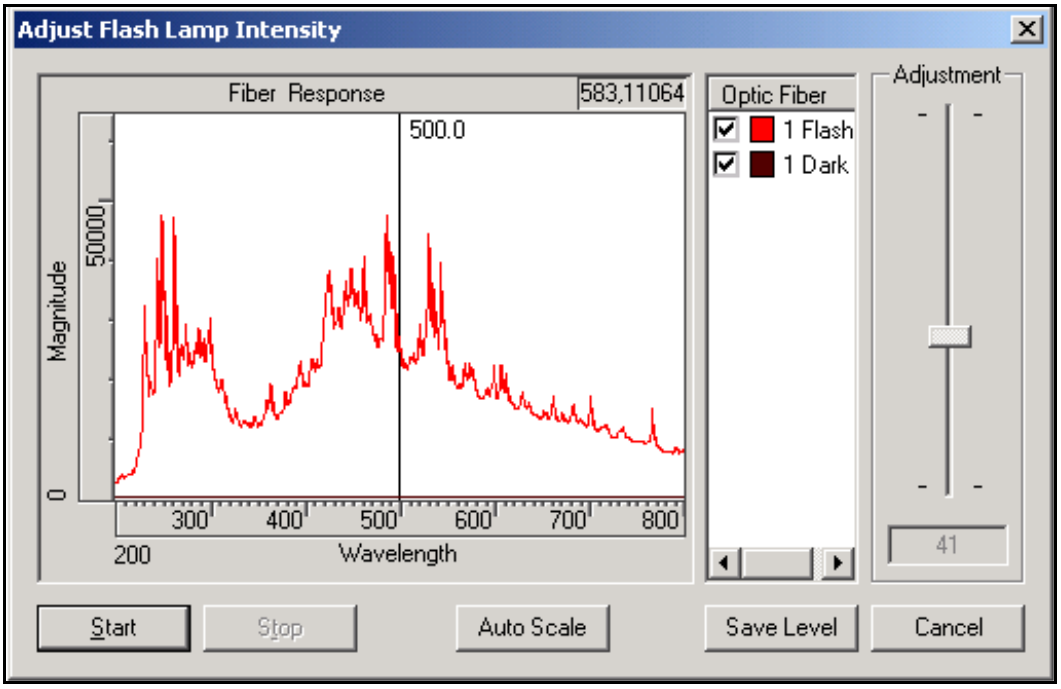


Figure 7-70. Flash Lamp Intensity Adjustment Window

5. Click on **Start** to begin monitoring the intensity. A warning window will pop up asking that the light source be properly contained. Make sure the Fiber optic cable is secured and click on **Yes**.

6. The LCD screen on the DCS will say *Acquire Data*.

7. The default lamp intensity level can be adjusted using the sliding bar at the right side of the window. The level set by this utility will be the one that is automatically used by every algorithm which does not use "lamp intensity override" in its configuration setup. A default lamp intensity of 50,000 +/- 2000 counts usually works well, however for cases where plasma luminance is especially bright, the level should be turned down so as to avoid saturation near wavelengths which are used for endpointing. The lowest lamp level that can be saved is 35%. Although you can see the effect for lower settings using the slider, values below 35% would lead to reduced flash repeatability.

   If a value of 35% does not provide low enough intensity, then a mechanical means of attenuating the lamp signal is provided. Figure 7-67 shows the output coupler of the flashlamp housing in cross section along with the fiber optic end piece. The set screws for *fiber gap* locks the fiber optic end piece in position relative to the flashbulb with a particular gap. Repeatability from insertion to insertion of the fiber end piece is ensured by the spacer.

8. When it is necessary to change this gap, first loosen the fiber gap set screws, and increase the spacing by millimeter increments until the desired reduction in lamp intensity is achieved.

9. Tighten the gap set screws.

10. Use a 0.050" allen key (inserting it through the red laquer that holds the spacer set screws in place) to loosen the spacer set screws.
11. Slide the spacer to its new position and retighten the set screws.
12. Repeat the procedure for each of the other spectrographs.

7.9 Flashlamp Safety Interlock (EyeD-IEP only)

The flashlamp contains internal safety interlocks that prevent operation if the housing is compromised. In addition, the output coupler contains a spring-loaded shutter that prevents any light from escaping if the fiber-optic cable is removed. The lamp interlock circuit is connected to the DCS and monitored for integrity by the internal (embedded) computer. Therefore, if the interlock signal is interrupted, the DCS LED screen will display the following message:

```
STOP

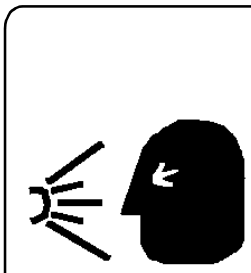
FLASH LAMP DANGER!!
```

A different error message is displayed by the DCS if the unit is started without the interlock signal present:

```
CAN'T START

FLASH LAMP DANGER!!
```

To restart an operation following such a shut down, the interlock signal must be reestablished and a stop signal sent from the control computer running EyeD software. This stop signal clears the shutdown and a subsequent start signal will resume EyeD operation. A start signal can be any one of three commands from the application computer, including monitor, capture or process. In remote operation, the process module must send a digital or packet-based start command.



⚠ WARNING

Ultraviolet Light is present and can hurt your eyes.

Eye Protection is required when working on this device.

The FL2002 produces strong pulses of UV light and can damage vision if improperly configured. Attempting to bypass safety circuitry could result in injury.



Never operate the unit without a leak-proof light seal at the fiber optic port and the distal end of any fiber optic cable connected to the port. Contact Applied Materials technical personnel for process-specific safety procedures.

For the flashlamp to function, the interlock connector BNC Stub on (J4) must be present.

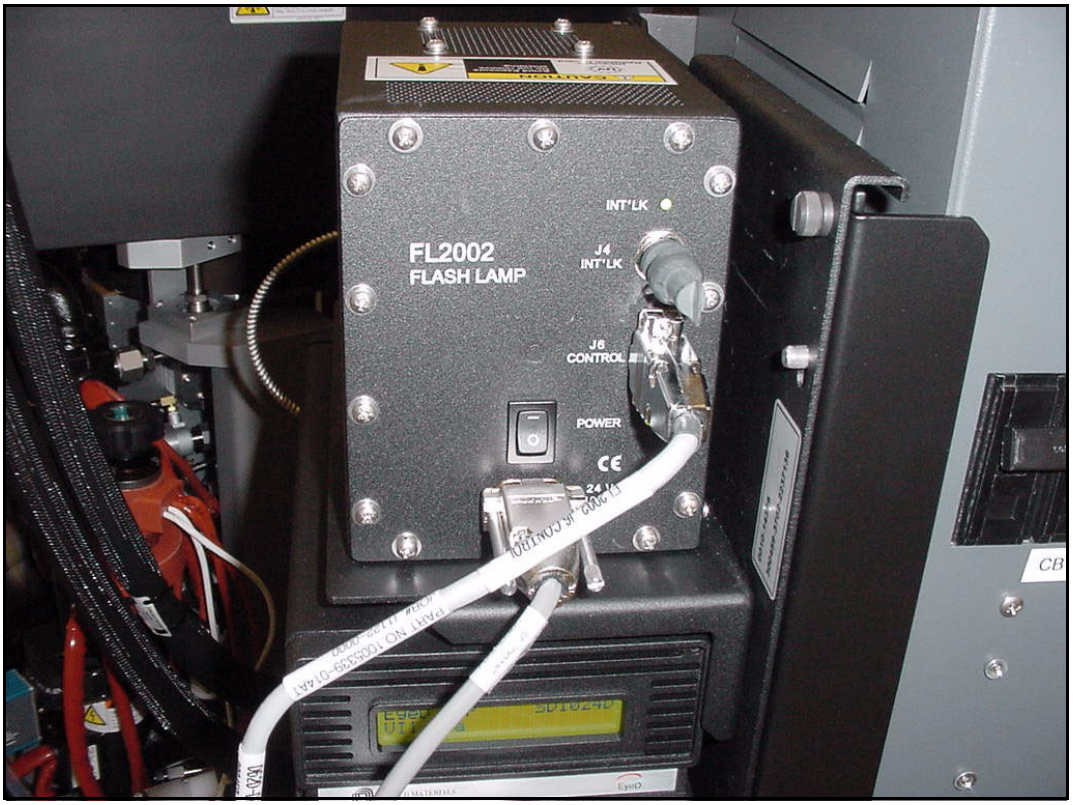


Figure 7-71. SP2000 Interlock Connectors

7.10 Finding the IP Address of a Spectrograph

If the IP Address of the spectrograph is unknown, it may be found by following these steps:

1. Power off the spectrograph.
2. Remove the Ethernet cable from the J2-Com2 Port. Insert a USB cable in its place.
3. Plug the other end of the USB cable into the USB Port on the PC (either USB port is acceptable).
4. Turn on the Power to the spectrograph.
5. Install the USB on the PC:
   a. An install wizard should automatically pop up. Install it under *C:\EyeD\USBDrivers.*
   b. If nothing pops up, go to *Start\Settings\Control Panel\Add/Remove Program*. Install USB.
6. Open the EyeD instance. The IP Address and Serial number can be found under: *Tools\Device Param.*

7.11 Installation Complete

The total installation of the EyeD system is now complete. All hardware installation instructions are found in Chapter 6. Software installation and setup of SRM, URI and the EyeD instances, including setting up DI/O and serial communication, has been explained in this chapter. For further troubleshooting and upgrades, please see Chapter 6.

8 EyeD System Management

The EyeD control computers for both 200 and 300mm mainframes contain an 80 GB hard disc drive (HDD). The number of data files this drive can store depends on settings that are used within algorithms.

8.1 EyeD OES

For systems which use the single channel spectrometer (EyeD OES), if the full spectrum is saved with each 100 mSec data interval, the file size is approximately:

> 1024 wavelengths x 2 Bytes/wavelength x 10 spectra/second = 20 kB/second of process time. For example, a 60 second process run will produce a data file ~1.2 MB in size. The HDD can store about 65,000 of these files.

8.2 EyeD IEP

For systems which use the dual channel spectrometer (EyeD IEP), if the full spectrum is saved with alternating flash mode selected with a 100 mSec data interval, then the file size can be considerable:

> 1024 wavelengths x 2 Bytes/wavelength x 4 spectra x 10 spectra/second = 80 kB/second.
>
> A 60 second process run will produce a data file ~ 4.8 MB in size. The controller HDD can store only 16,250 of these files.

There are a number of approaches for managing the amount of data on the HDD that are detailed in the following sections:

- **Section 8.2.1,** Reducing Data File Size to Minimum**:** reduces the size of each data file to the absolute minimum required for file review purposes (no reprocessing possible)
- **Section 8.2.2,** Reducing Data File Size Proportionately**:** minimizes the file size proportionately by reducing the spectral range stored in the data file (reprocessing possible for wavelengths within the spectral range)
- **Section 8.2.3,** Remote Data Archiving**:** uses the EyeD remote archiving function for relocating data files (large or small) to a location which has much greater storage capacity than the local HDD
- **Section 8.2.4,** Automatic Data File Deletion**:** use of the EyeD auto delete function to maintain sufficient free HDD space

For all HDD data management approaches, it is very important to maintain the HDD such that it does not become overly fragmented. A fragmented HDD has significantly higher access times, which can seriously degrade the runtime performance of EyeD. Section 8.2.5 provides recommendations on defragmentation.

A review of CPU utilization management is in Section 8.2.6. A review of the configurable file naming within EyeD can be found in Section 8.2.9. Section 8.2.10 provides recommendations regarding network security. Recommendations regarding virus protection and eradication is contained in Section 8.3.

8.2.1 Reducing Data File Size to Minimum

Select **Save spectra in the data file** option (as shown below) only for development algorithms, or for troubleshooting purposes, where reprocessing with different wavelength selections will need to be performed. Otherwise, for production (frozen) algorithms, this option should not be selected. Thus, production algorithms will produce data files that are approximately 1/1000 of the size of the examples above, and the HDD will be able to retain vastly more production history.

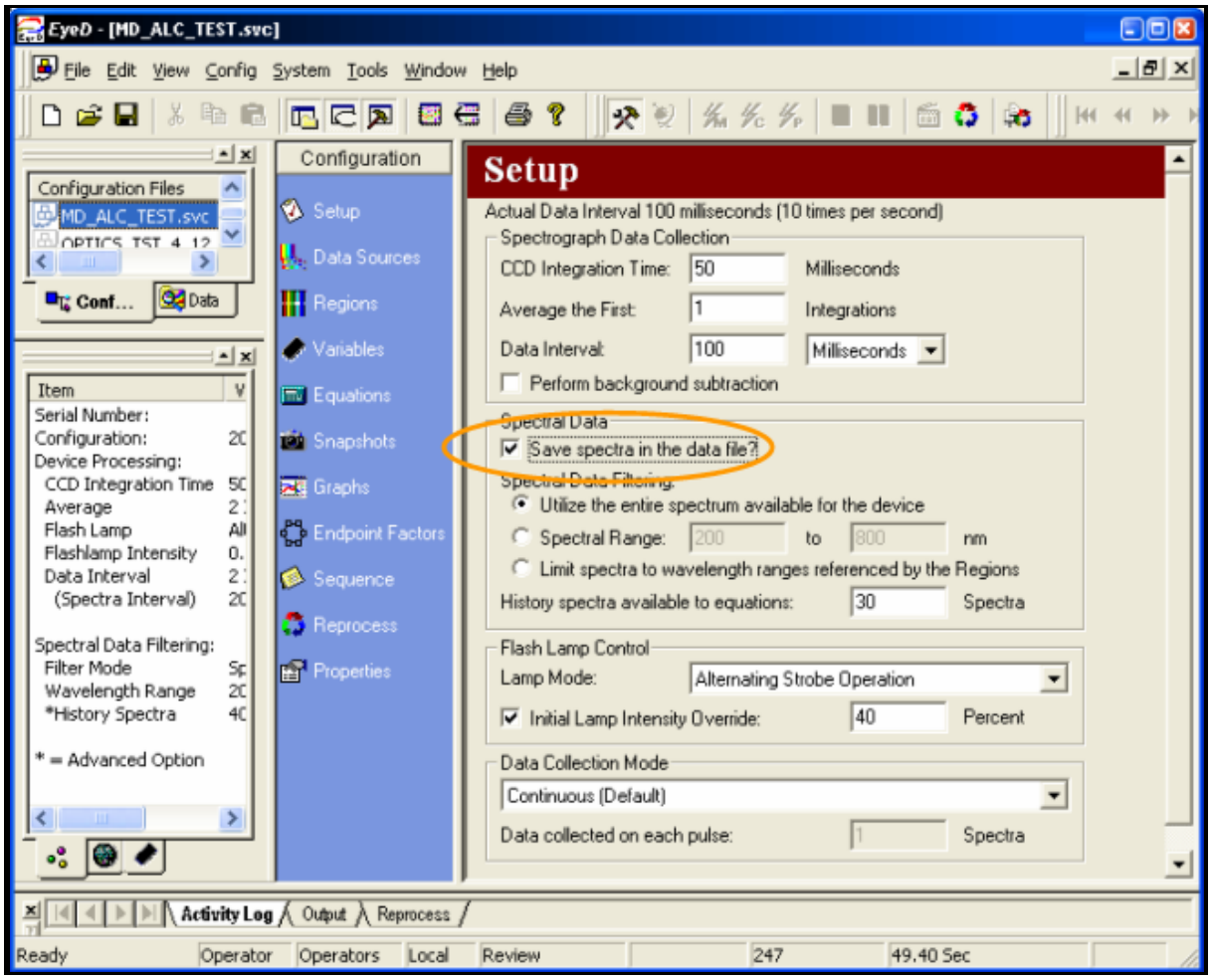


Figure 8-1. Setup Window — Spectral Data Entry

8.2.2 Reducing Data File Size Proportionately

Reduce the *Spectral Range* option (as shown below). If reduced as below, then the data file size reduction factor will be approximately 50nm range / 600nm full spectrum range = 1/12.

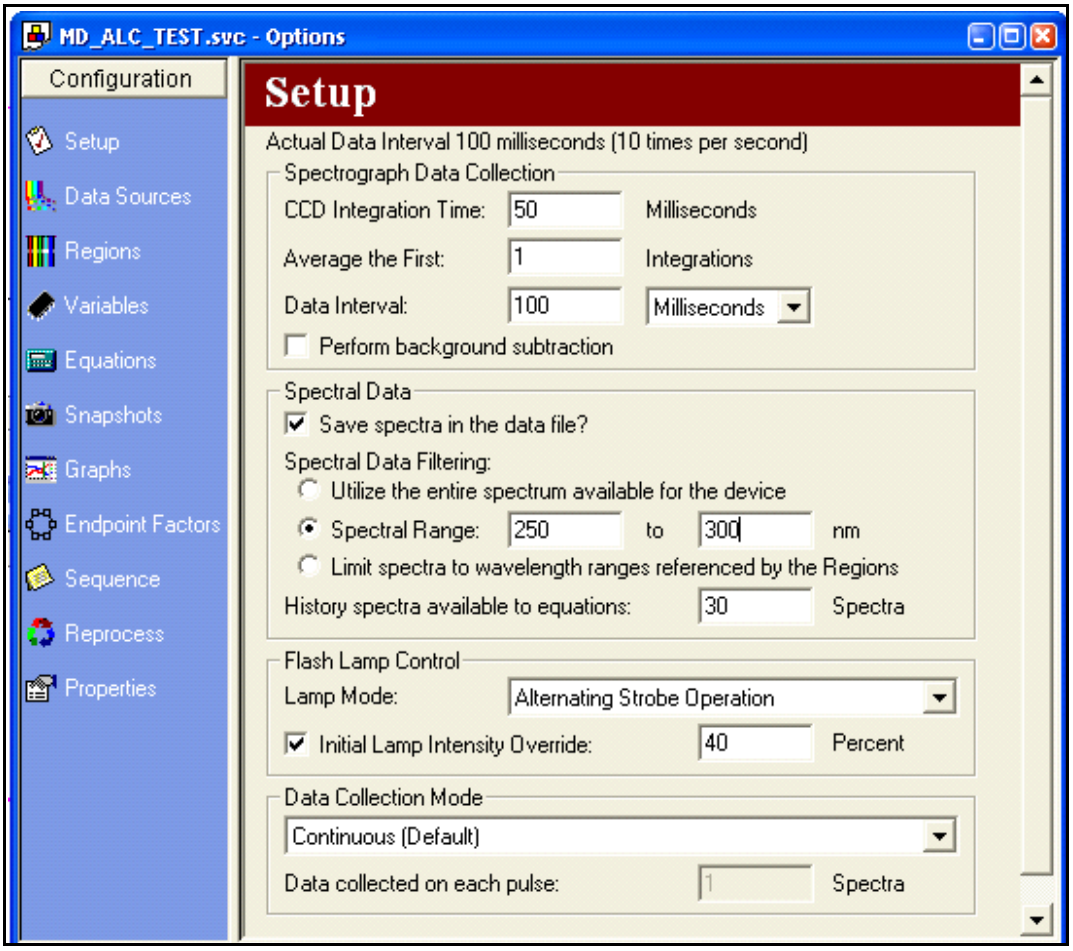


Figure 8-2. Setup Window With Limiting Spectral Range

8.2.3 Remote Data Archiving

Designate a network server for data archiving, and set the EyeD application (fully functional in EyeD 2.51 and later) such that the controller HDD retains data files for a short period of time, for instance one hour, before it archives to the server. As soon as the file is copied to the remote drive, the local file is deleted.

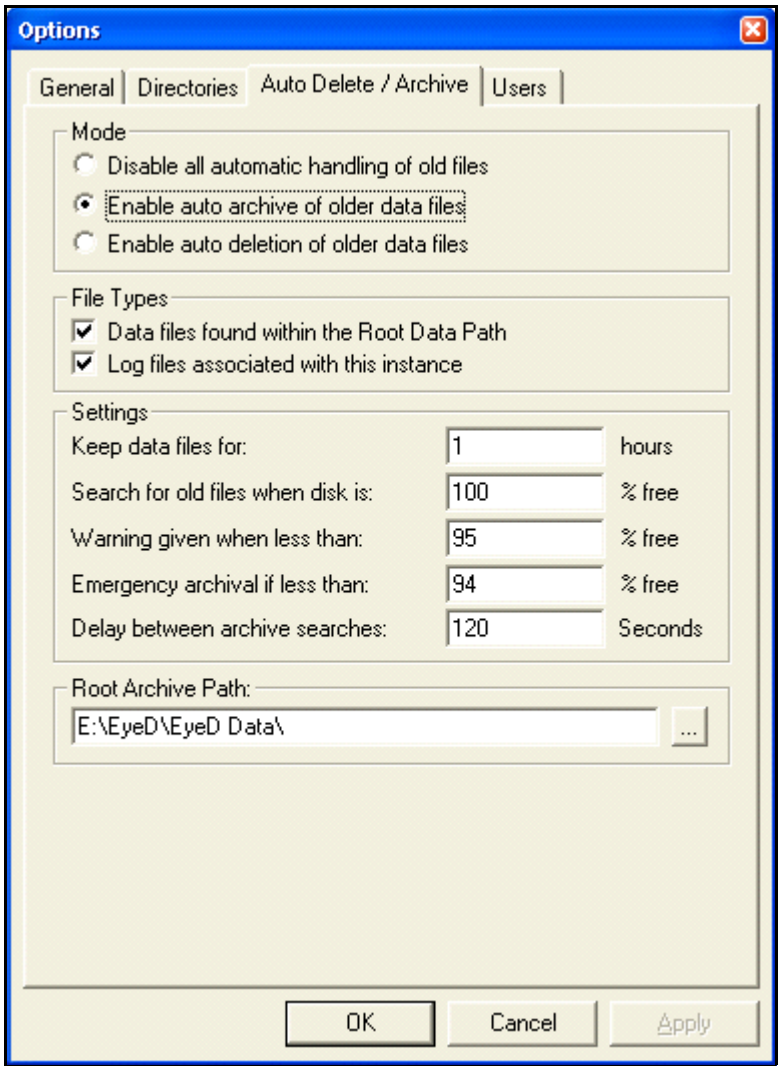


Figure 8-3. Remote Data Archive Window

Figure 8-3 is an example of archiving which maintains the maximum free space on the HDD. Archived data files will appear on the archive server 1-2 hours after processing.

8.2.4 Automatic Data File Deletion

Setting up the auto delete function of EyeD is very similar to that of the auto archiving function. More information on the logic of the auto delete routines controlled by this window can be found in Section 3.3.5.

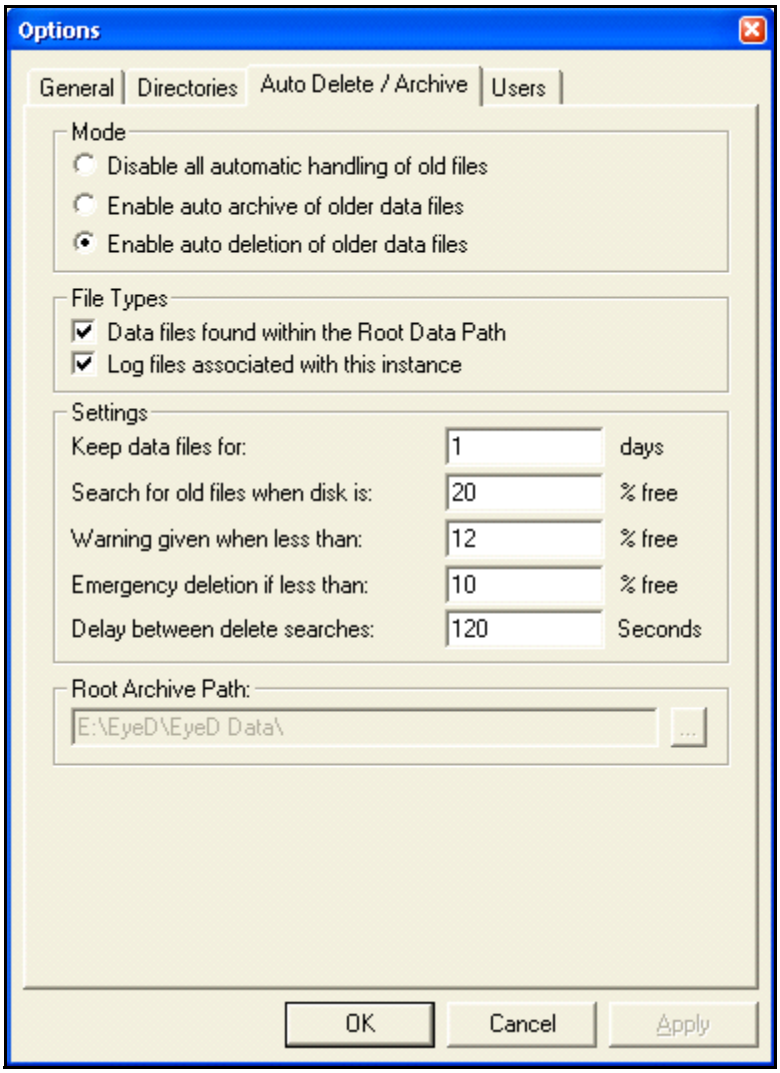


Figure 8-4. Auto Data File Delete Window

Figure 8-4 is an example of Auto Deletion setting which maintains the HDD with ~10% free space; the production history saved on the HDD depends upon selections made for data file size. This setup will maintain a large production history on the local HDD, but still maintains safe free space on the HDD.

8.2.5 Defragmentation.

When the auto delete or auto archive settings are configured to frequently delete large files, the HDD will accumulate file fragments with time. If the settings delete smaller files less frequently, then the fragmentation occurs more slowly. In either case, it is recommended that users take the EyeD controller offline for PM defragmentation whenever file fragmentation exceeds 10%. Fragmentation can be easily determined by right clicking on the **My Computer** desktop icon and drilling down to the windows defragmentation resource.

Note that WindowsNT does not provide an inbuilt defragmentation utility.

It is not recommended to set an automatic defragmentation utility to run on EyeD controllers. Defragmentation is highly HDD intensive and will cause EyeD errors and mis-processing of wafers if it triggers during processing.

Example Disk Defragmenter analysis (30GB drive):

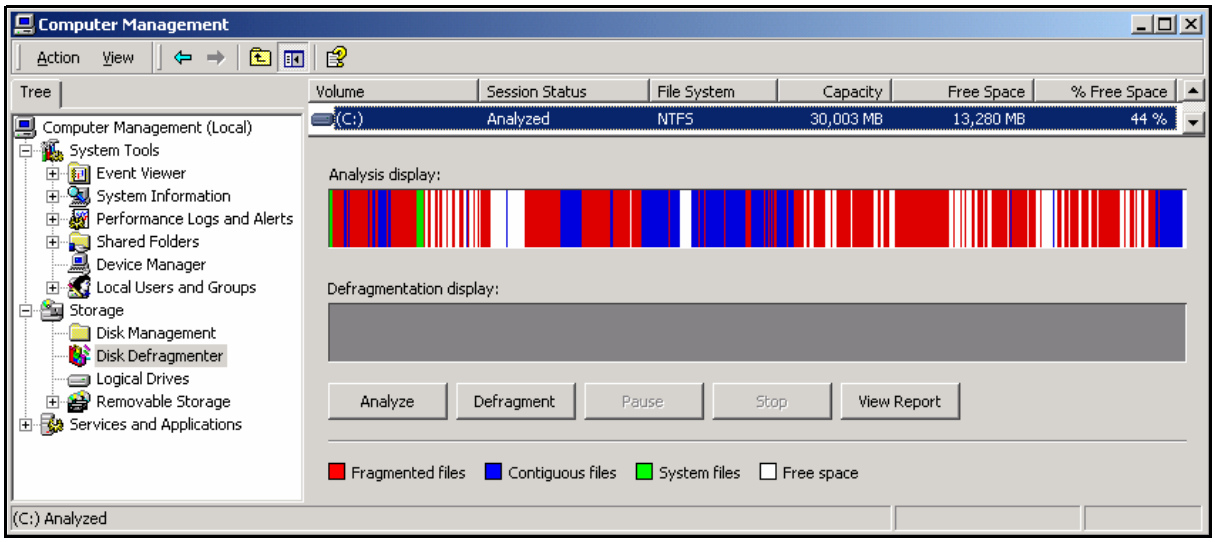


Figure 8-5. Disk Defragmentation Analysis

The View Report / Analysis Report window (Figure 8-6) indicates this drive has 32% file fragmentation and 17% total fragmentation (and should be defragmented):

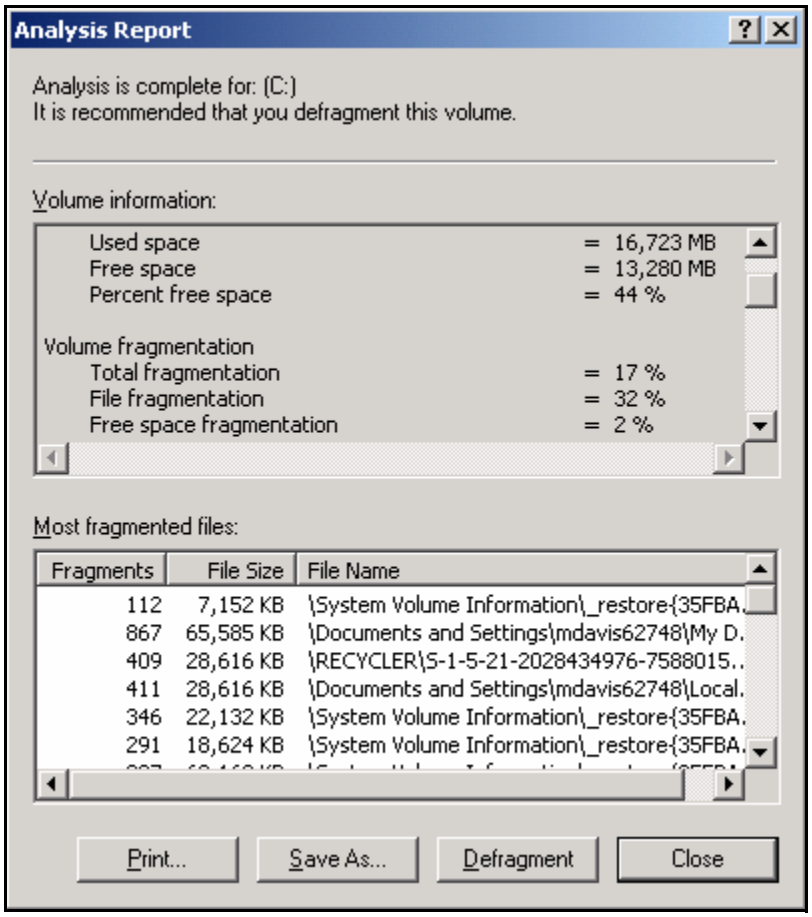


Figure 8-6. Defragmentation Analysis

8.2.6 CPU Utilization.

The EyeD PC is based on a Pentium 4 running at 2 GHz. As with any PC running with a Windows OS, the runtime capability can only be considered *real time* if the system CPU is working at a level such that normal system tasks do not spike the CPU in to saturation. If stressed to 100% utilization, the execution of any application task will be queued, or delayed, until the stress is relieved.

8.2.7 Burning CDs

When burning CDs, do not select the "drag and drop" option ("direct CD" mode), as it leaves a system task active which can trigger high CPU usage when there is a CD is in the drive.

8.2.8 Utilities

Do not install utilities such as "PC Anywhere" to enable remote view of the EyeD GUI. This type of utility will trigger high CPU utilization randomly. For EyeD, there are a number of symptoms of CPU saturation will be that data collection and processing will freeze, and then rapidly catch up when CPU usage drops below saturation.

8.2.9 Data File Naming

EyeD permits great data file name and file structure flexibility in user customization. This is intended to offer users the ability to adjust the data file name to convey the right amount of context information for easy file retrieval. See Section 3.3.2.1 for detailed information. Default file naming and file structure selections are put in place by the EyeD installer; if these are not sufficient and are changed, the installer can be directed so as not to overwrite user selections (see installation chapters).

The default selections are intended to ensure safe operation boundaries within the Windows OS. If a user selects a different file structure, it is important to determine that the selections do not create folders/directories in which the number of elements within the bottom-most path folder approach 500. When there are such large numbers of elements at the bottom level of the directory tree, then Windows will create significant delays and high CPU usage when requested by EyeD to open another uniquely named data file.

8.2.10 Network security

The EyeD controller is delivered with system settings which allow it to be ready for process immediately after boot up, without need for an operator to log in as an administrator and launch each chamber's EyeD application and then put it in to remote mode to make the system ready for production. This auto start/auto ready default requires that the Win2000 system be set to automatically login with administrator level access on boot, allowing the various EyeD application elements access to the Windows registry and other administrative controlled system areas of the system.

⚠ CAUTION

Because of this default functionality, connecting the EyeD controller directly to a customer's network without taking precautions described in the following paragraphs leaves the EyeD system wide open to unauthorized network access and virus attack.

When connection to the customer LAN is required, to enable data archiving, host synchronization of algorithms across many tools, a user/administrator should configure certain user rights in the Windows 2000 Registry (of each EyeD controller) so that any other user of the controller who *DOES NOT* have Administrator Privileges may use the Spectrograph and connect and communicate with a server or other PC via a Local Area Network.

With these user rights changed, then the computer can be set to boot up with user (non-Admin) level access, while still being able to put the system into production-ready mode. *However, the auto start / auto ready feature is not available under user level access. After boot up, users will need to launch all EyeD instances and place them in remote mode to ready the system for process.*

The procedures below allow simultaneous communication between the EyeD controller, one or more EyeD Spectrographs and the customer's LAN without the user needing to be logged in as, or have, Administrator privileges.

The need for the details and instructions below is related to the following two conditions:

a. In normal operations, the Spectra Resource Manager (SRM) utility must be able to write parameters and other information to the Windows Registry under the Key Name: *HKEY_LOCAL_MACHINE\SOFTWARE\Verity\SpectraManager.* The difficulty with this is that this Key (normally) requires Administrator privileges to access. Thus, when an *unauthorized* user tries to access SRM or connect to a Spectrograph, the registry cannot be modified, and spectrograph use is either limited or nonexistent.

b. Some LANs are defined such that any user with Administrator Rights on their local machine automatically receives Administrator privileges on the LAN, and PC's / Drives attached to the LAN.

The procedures below allow modification of the registry entries such that restrictions imposed on the specific Registry Keys are removed for any and all users.

NOTE

1. At present, with Win2000Pro, there is no automated way of making the changes described below.
2. To make the changes defined, the User logged into the Endpoint PC must have Administrator Privileges.

⚠ CAUTION

The capabilities in the following instructions are actually a violation of the intended use of the Upper Level Registry Key HKEY_LOCAL_MACHINE. This Key is defined by Windows defaults to require Administrator Access for changes, or to execute programs that modify registry content. DO NOT modify Key entries other than those listed.

⚠ CAUTION

Use of the Windows Registry editor (as shown in the following instructions) is potentially hazardous to all computer functionality since it allows access to information and data needed by the Operating System and installed applications. Modification of the topic Key specifically, has the potential (if done improperly) of limiting access or disabling the computer from all users including the administrator!

8.2.11 Accessing the Windows 2000 Registry for SRM:

1. Start the Windows Registry Editor REGEDT32. Click **Start**, then click **Run**.
2. Type **regedt32** and click **OK**.

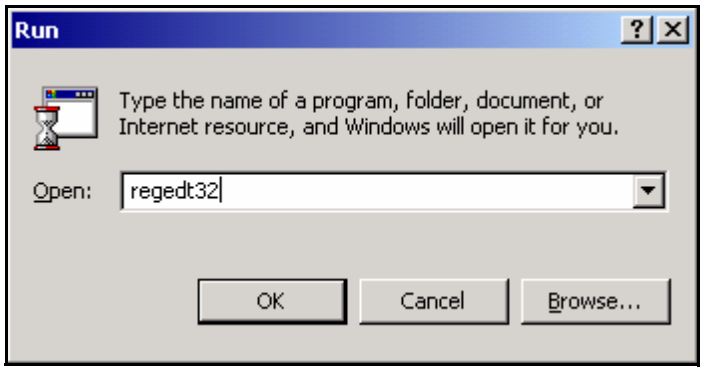


Figure 8-7. Run Command

IMPORTANT: Be sure to use REGEDT32 there is another registry editor, but that editor will not allow these changes

3. Select / Navigate to the HKEY_LOCAL_MACHINE Key Window

   IMPORTANT: Do not select or change any of the other Key name Windows

   Your screen should look like Figure 8-8.

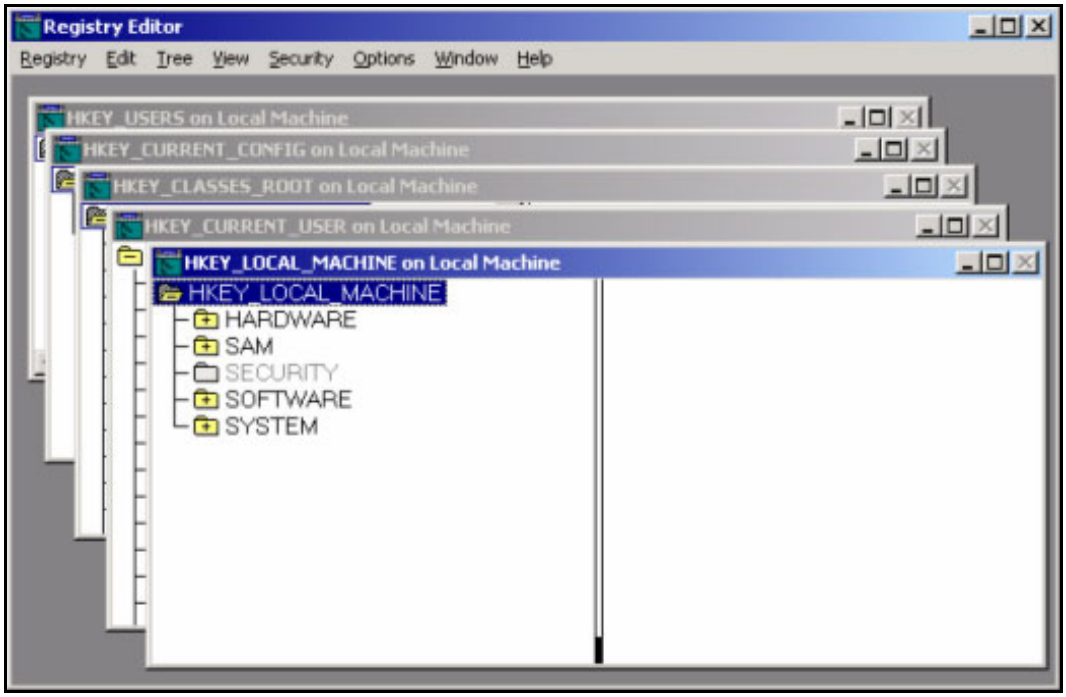


Figure 8-8. Registry Editor

4. Select and Expand **SOFTWARE** and then Select **Verity**.

The screen should resemble Figure 8-9.

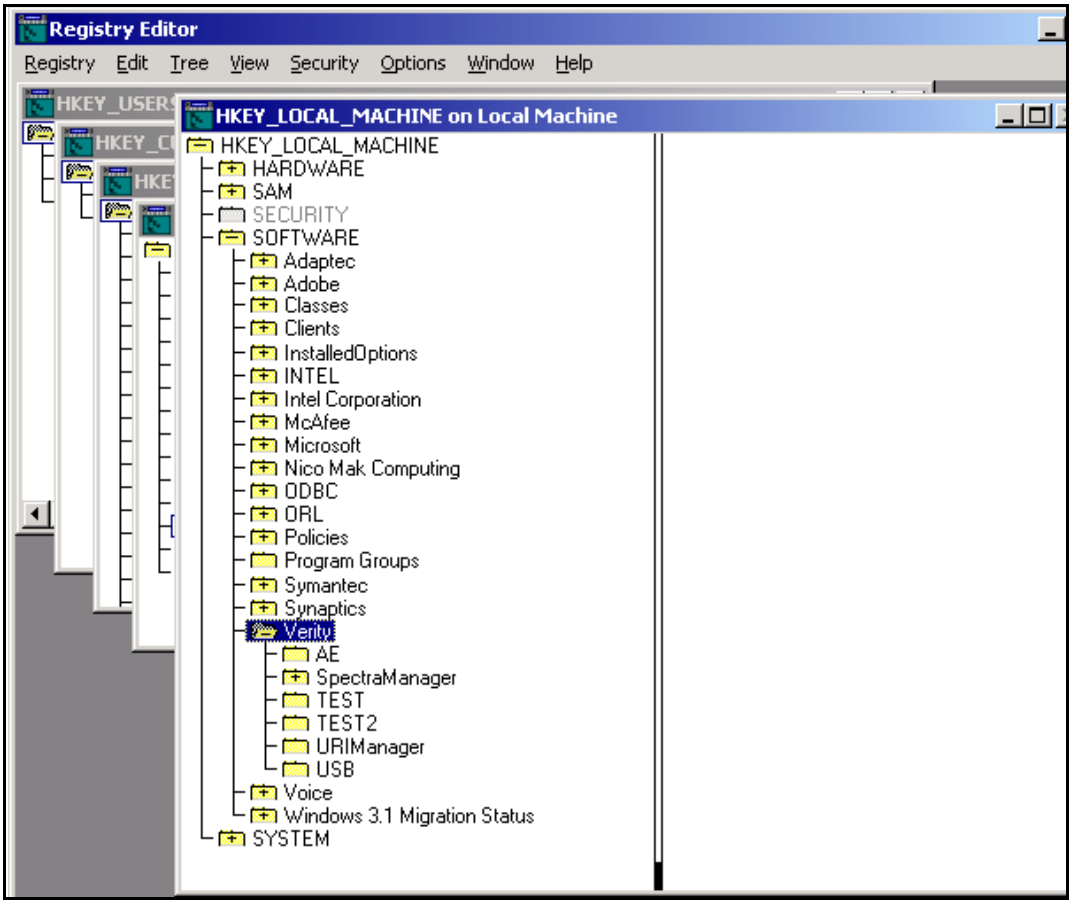


Figure 8-9. Registry Editor Showing Software Level and Verity

8.2.12 Modifying Registry Access Privileges

1. With the display as shown in the prior step (Verity selected), select **Security**'**Permissions…** from the REGEDT32 Menu. The following dialog should be displayed:

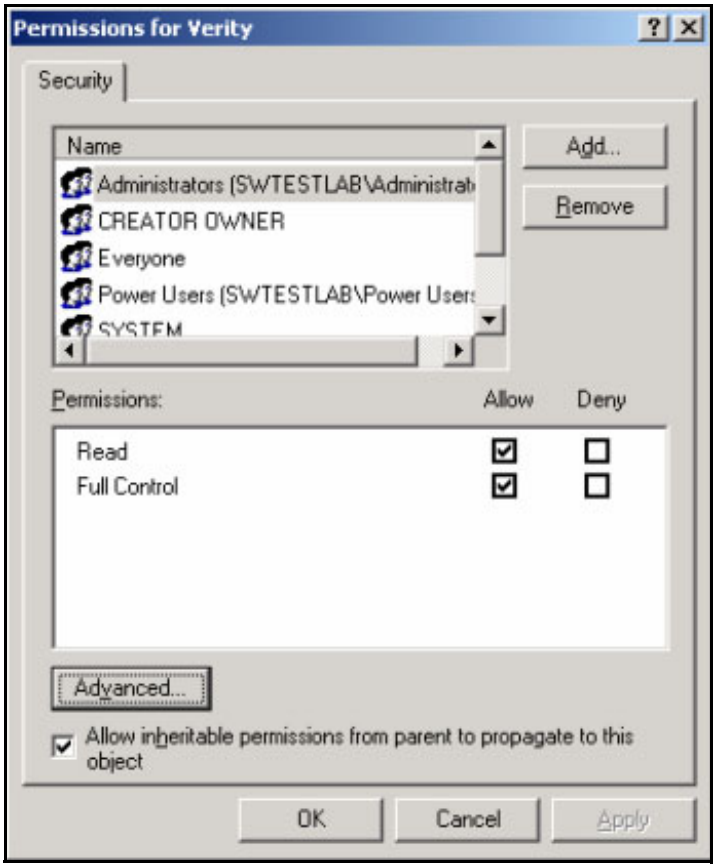


Figure 8-10. Permissions for Verity

2. From the Above Dialog Click on **Advanced…**. A dialog similar to the following should be displayed:

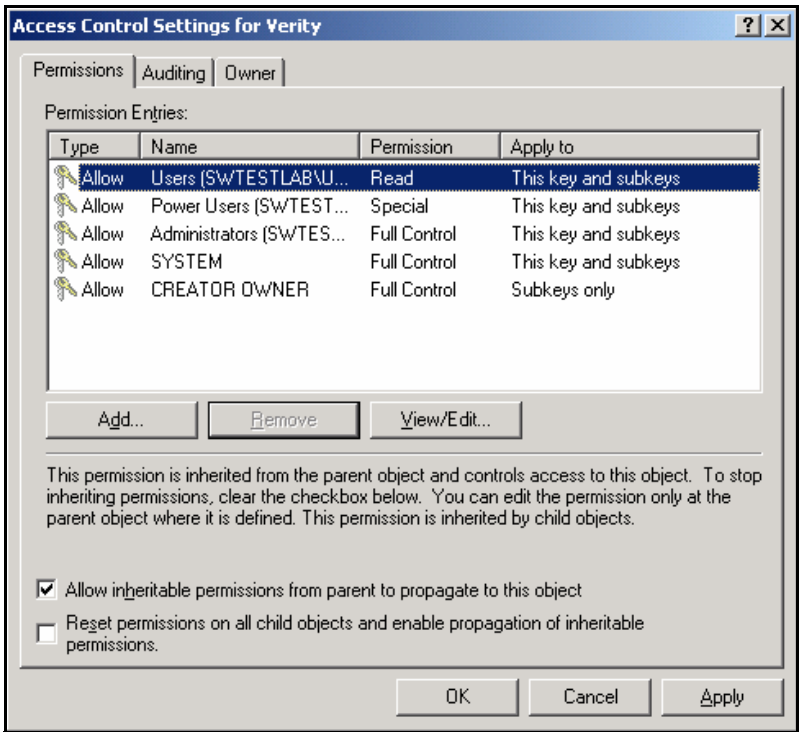


Figure 8-11. Access Control Settings

3. From the above dialog window click the **Add…** button. A dialog similar to that shown in Figure 8-12 should be displayed.

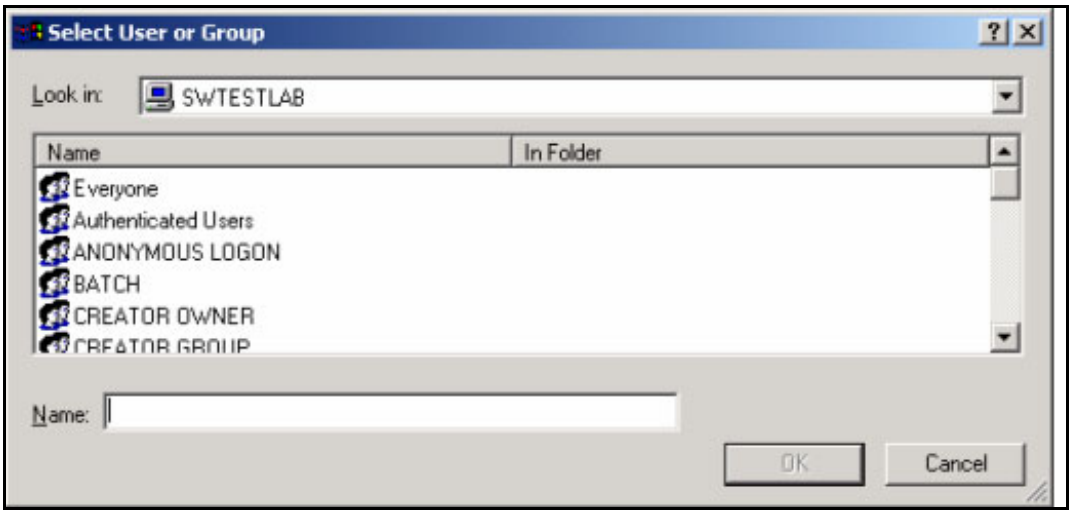


Figure 8-12. Select User or Group

4. From the Above Dialog Click on **Everyone**, and then Click **OK**. A dialogue as shown in Figure 8-13 should be displayed.

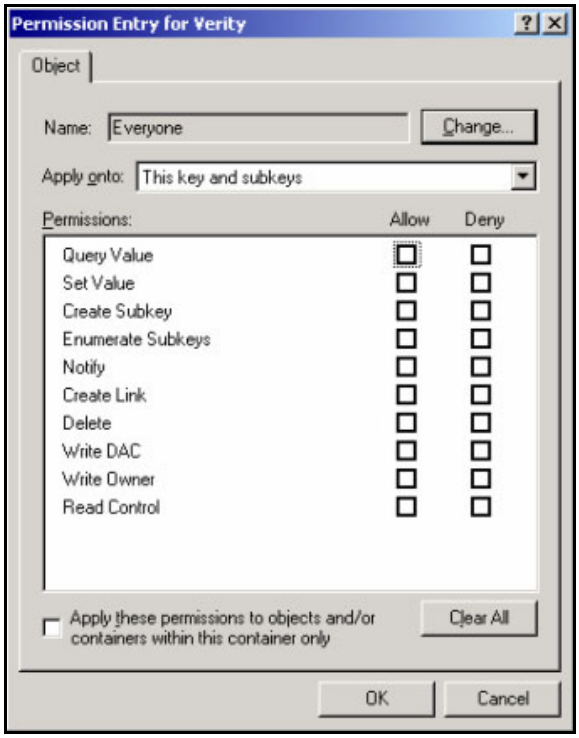


Figure 8-13. Permission Entry

5. From the Permissions entry, ensure **Allow**, is checked for all attributes. The Dialog should look like that in Figure 8-14.

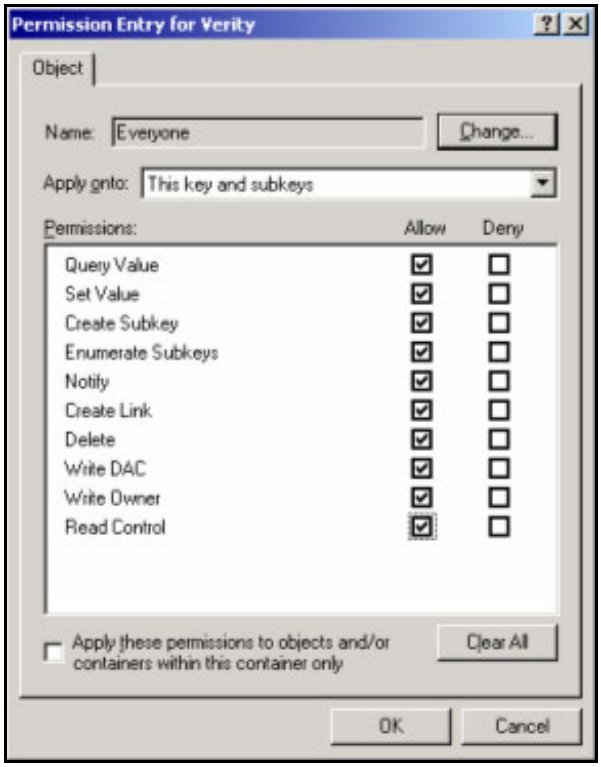


Figure 8-14. Permission Entry Showing Allowed

6. Click **OK** To accept the changes.

7. Click **OK** To accept changes on all the open dialogs until you return to the Main REGEDT32 Screen.

8.2.13 Modify the Current User Key

1. Select / Navigate to the *HKEY_CURRENT_USER Key* window. Select and expand **SOFTWARE,** then select **Verity**.

   Your screen should resemble the contents of Figure 8-15.

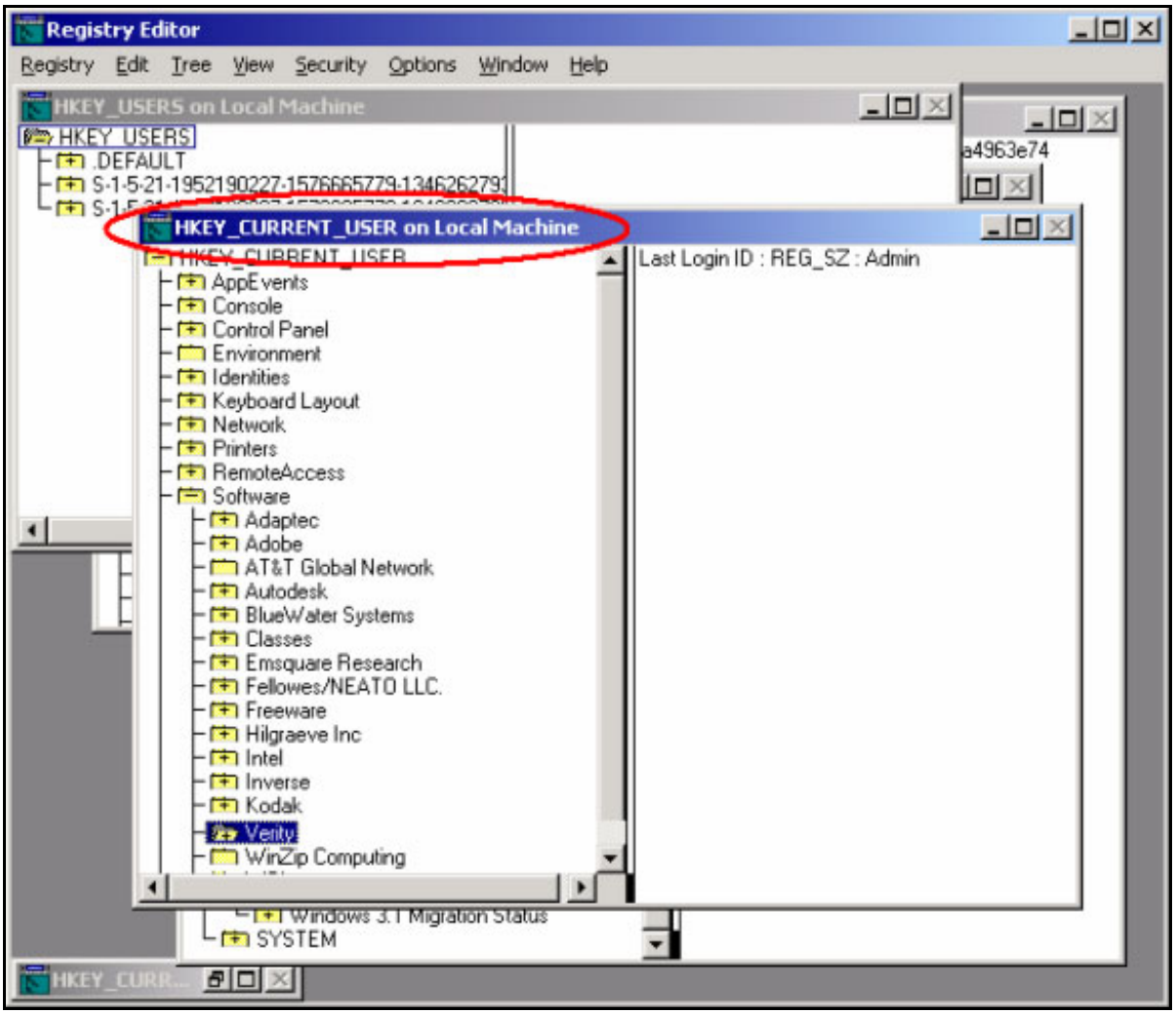


Figure 8-15. Registry Editor

2. With the display as shown in the prior step 3, (Verity Selected) select **Security**'**Permissions…** from the REGEDT32 Menu. The dialog in Figure 8-16 should be displayed.

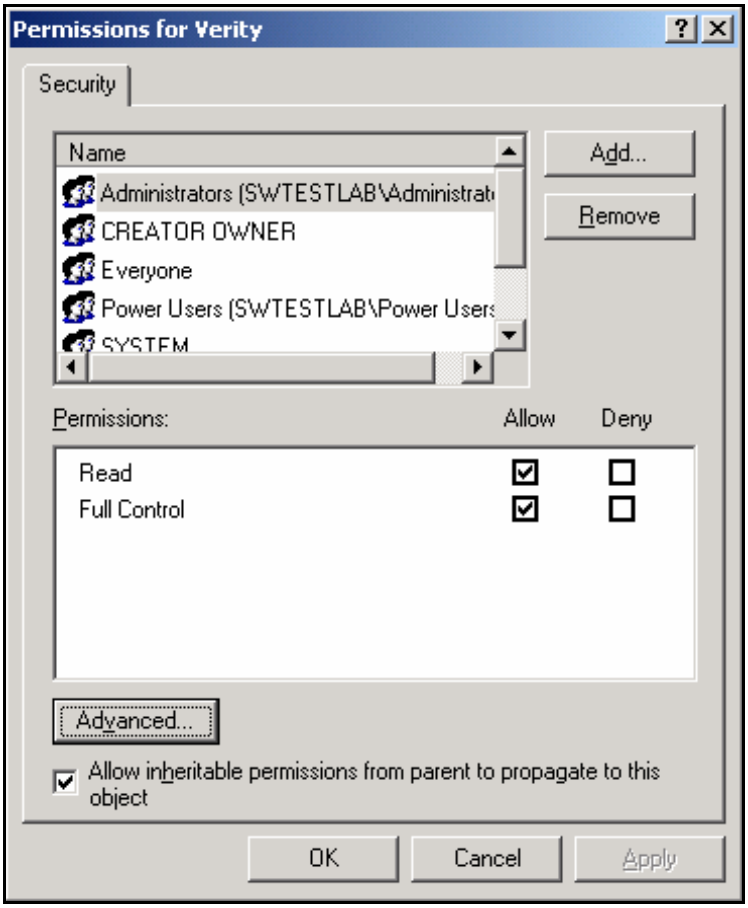


Figure 8-16. Permissions for Verity

3. From the above dialog, click **Advanced…**. A dialog similar to the one shown in Figure 8-17 should be displayed.

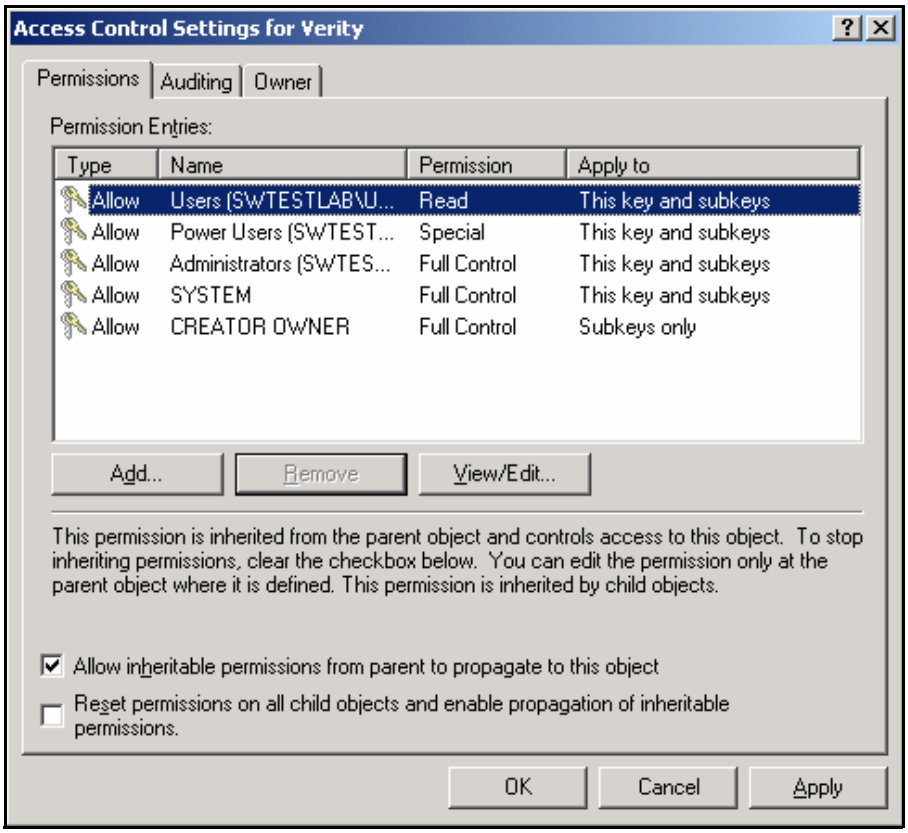


Figure 8-17. Access Control Settings for Verity

4. From the Above Dialog Click **Add…**. A dialog similar to the one shown in Figure 8-18 should be displayed.

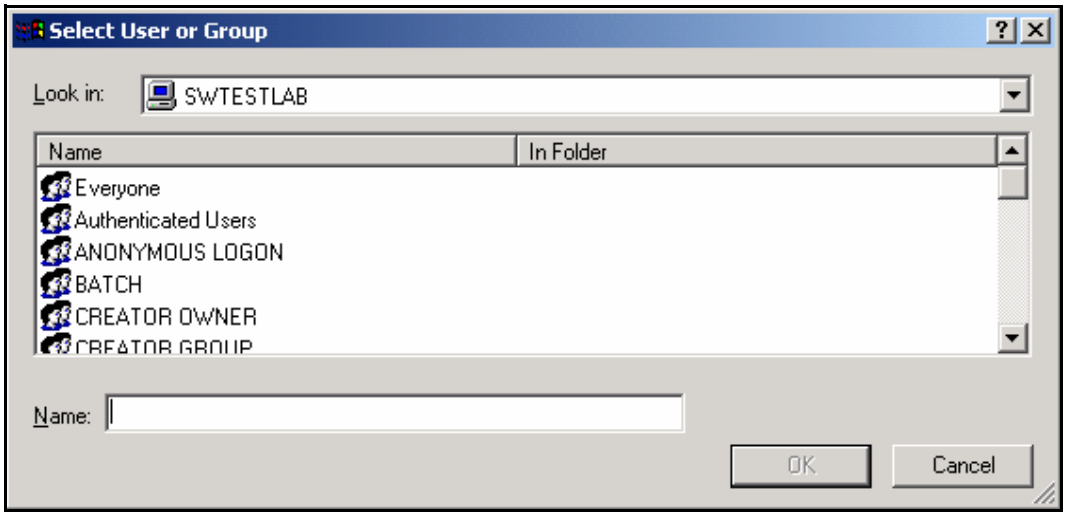


Figure 8-18. Select User or Group

5. From the above dialog, click on **Everyone** then click **OK**. The dialog shown in Figure 8-19 should be displayed

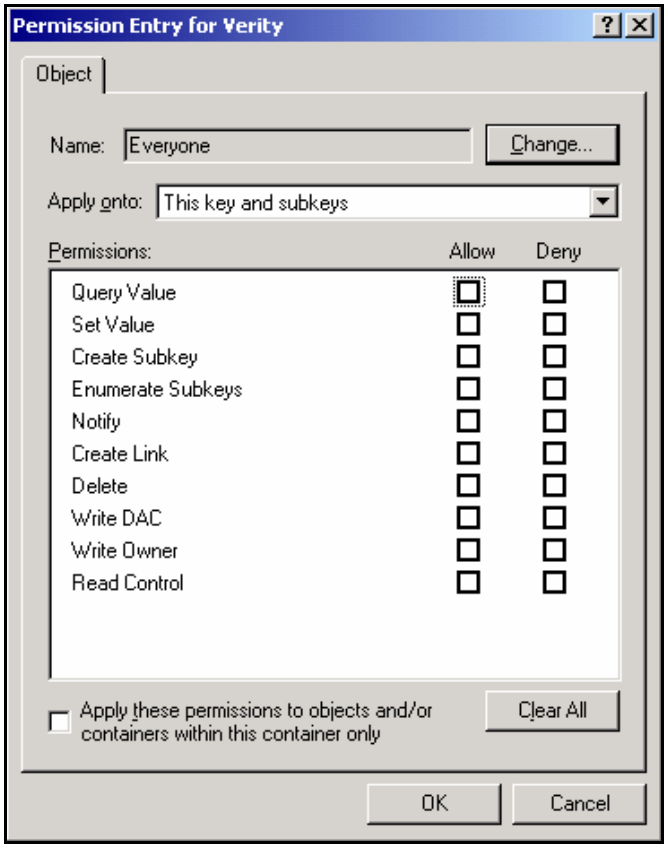


Figure 8-19. Permission Entry for Verity

6. From the Permissions Entry, ensure **Allow**, is checked for all attributes. The Dialog should look like the one displayed in Figure 8-20.

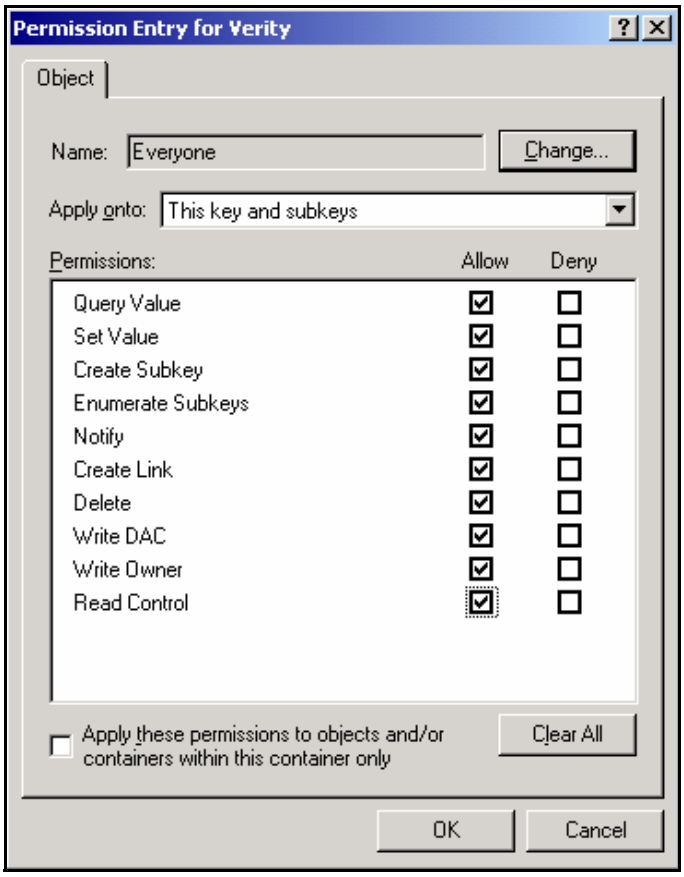


Figure 8-20. Permission Entry for Verity

7. Click **OK** To accept the changes.
8. Click **OK** To accept changes on all open dialogs until you return to the Main REGEDT32 Screen.
9. Select **Registry'Exit…** from the REGEDT32 Menu to close the editor.

The system administrator will now be able to add user accounts, with any desired permission level, that will be able to start EyeD instances which will be able to interact with and control the tool's spectrographs.

8.3 Virus Protection Recommendations

Virus programs can infect the EyeD control computer. Virus infections can have serious consequences to the production performance of EyeD application software. Viruses can infect the endpoint computer through sharing floppy disks, accessing the internet, being connected to a network while logged in as administrator or simply transfering files. The result of this is that the Viruses can take up 100% of the available CPU time. This can result in failing to call endpoint properly, failed communications, or other malfunctions.

Each customer installation will have its own procedures for network security and virus protection of its computer assets. AMAT recommends that virus scanning/eradication software be installed on EyeD controllers, however, *activating automatic background virus*

scanning features is not recommended. Continuous background scanning for viruses can seriously impact runtime performance because these tasks invariably compete for CPU utilization and disc access with the EyeD application.

8.3.1 Determining Total EyeD and Windows Tasks on Win2000Pro OS

1. Close all open EyeD instances.
2. Open Task Manager (alt ctrl and delete keys simultaneously).

   Task Manager Screen should display: 13 Tasks running, 15 including Task Manager and WordPad; note that in this example, WordPad was running to allow capturing of these screen shots. WordPad does not normally run during production with EyeD.

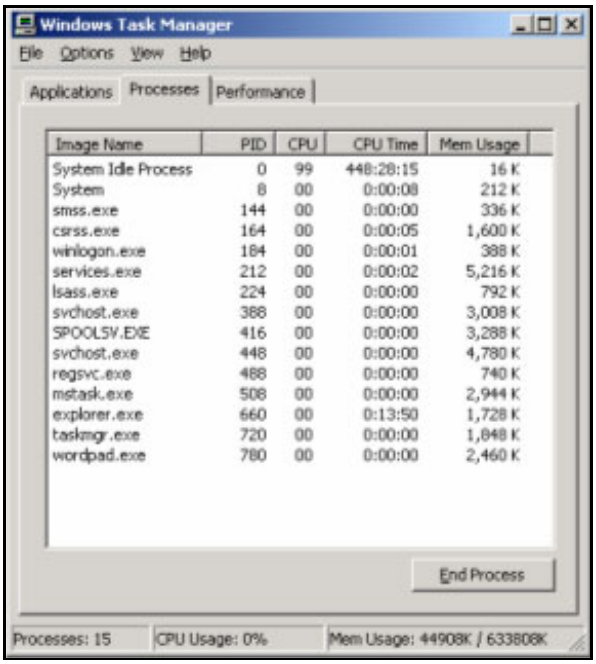


Figure 8-21. Task Manager Screen

3. If more tasks are running than what are shown above, then Verify their source and run anti virus software program.

8.3.2 Verify Windows and EyeD Tasks

1. Open all your EyeD instances.

   The following shows 4 instances. A total of 19 tasks should be seen running: 13 original + 4 EyeD + SRM + URI= 19 Tasks. (WordPad is closed in this example)

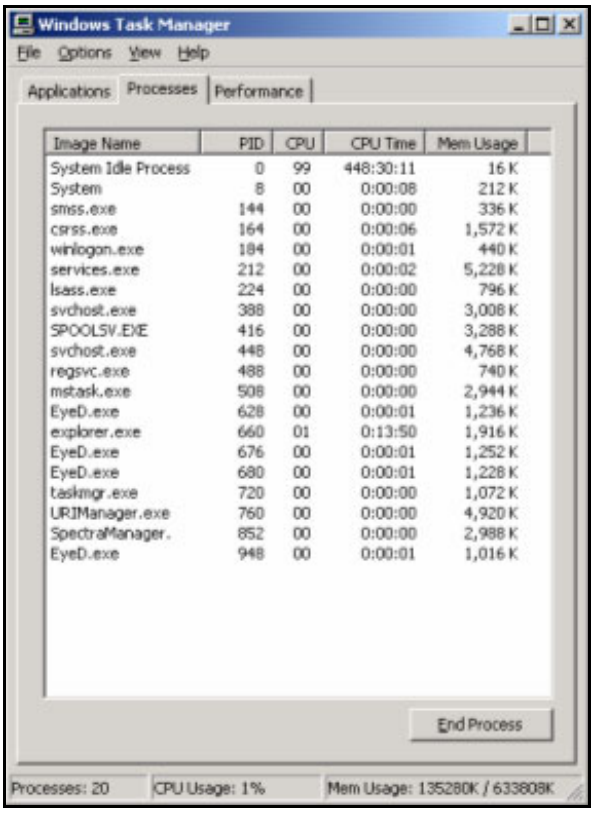


Figure 8-22. Windows Task Manager with 19 Tasks

NOTE

If using the production interface EyeD manager will be an additional task.

2. If more tasks are running, then Verify their source and run anti virus software program.

8.4 Microsoft Performance Monitor for Determining CPU Utilization

(*use this utility as a troubleshooting aid for tracking/logging/identifying CPU utilization if high usage is suspected*)

The following procedure describes how to set up the Microsoft Service Console to track CPU utilization. If the trigger of 75% CPU usage is reached, then a Counter will start and log the system tasks currently running and their individual CPU utilizations. Review of the log will point to the system task or application responsible for the high CPU utilization.

Software Versions: Windows 2000 Pro, Applicable to All EyeD Versions.

8.4.1 Background

High CPU usage may result from a number of factors: excess computation due to non optimal user selections within algorithms; virus scanners which *kick in* at the wrong time; customer added utilities (for instance auto-backup utilities); or be the direct result of Trojan horse or

virus infections. The result of 100% CPU usage is temporary impairment of real time performance of the operating system.

8.4.2 Overview

The Microsoft CPU performance monitor is included as a part of the Win 200 Pro OS and can be configured to run in the background while EyeD applications run in production. When the preset Alert trigger is reached it will start a counter. The counter will log the amount of CPU resources the running applications are consuming. When the log file size of 1Megabytes is reached, a new counter log will be started.

Alert: Triggers the counter to start logging the messages.

Counter: Logs the selected process to a file in the C drive under C:\EyeDCPUTracker

Material Required:

- HTML Counter Setting File; EyeD_CPU_Monitor.htm
- HTML Alert Setting File; 75%CPUTrigger.htm

  These HTML files can be found on the EyeD intranet website (Advanced Modules>EyeD IEP>Software Updates>Tools):

  http://amat.mis.amat.com/sietch/engineering/index.htm

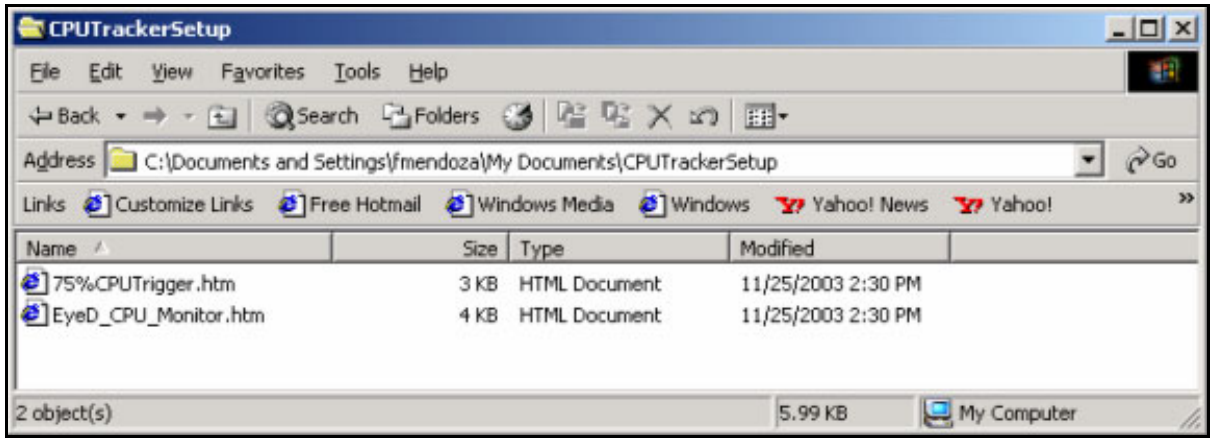


Figure 8-23. CPU Tracker Setup

8.4.3 Procedure

1. It is necessary to have all applications that are to be logged running in the background when setting up the Console. This may include EyeD Basic and EyeD Manager (if production display mode has been selected in the EyeD install), and must include all EyeD instances which are normally used, each set in to remote mode.

2. Performance Console Access:

   a. Select **Start, Settings, Control Panel, Administrative Tools**.

   b. Select **Performance, Performance Log and Alerts**.

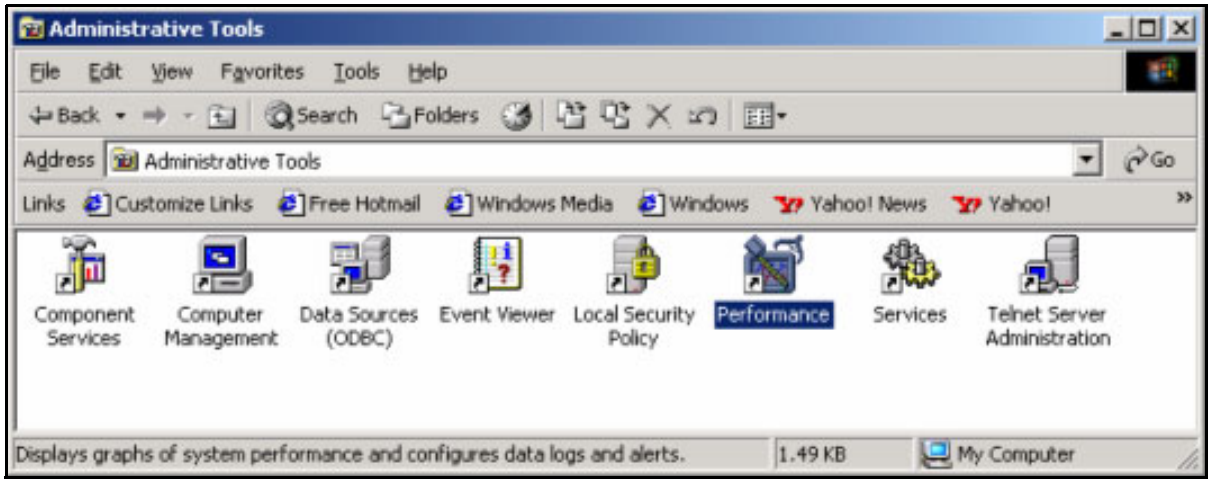


Figure 8-24. Administrative Tools Window

3. Import the HTML Counter Log Setting by:

   a. Highlighting **Counter Log** on left side of screen.

   b. Right Click on **Counter Log**.

   c. Select, **New Log File Settings From...** (From Floppy or other media) and select **EyeD_CPU_Monitor**.

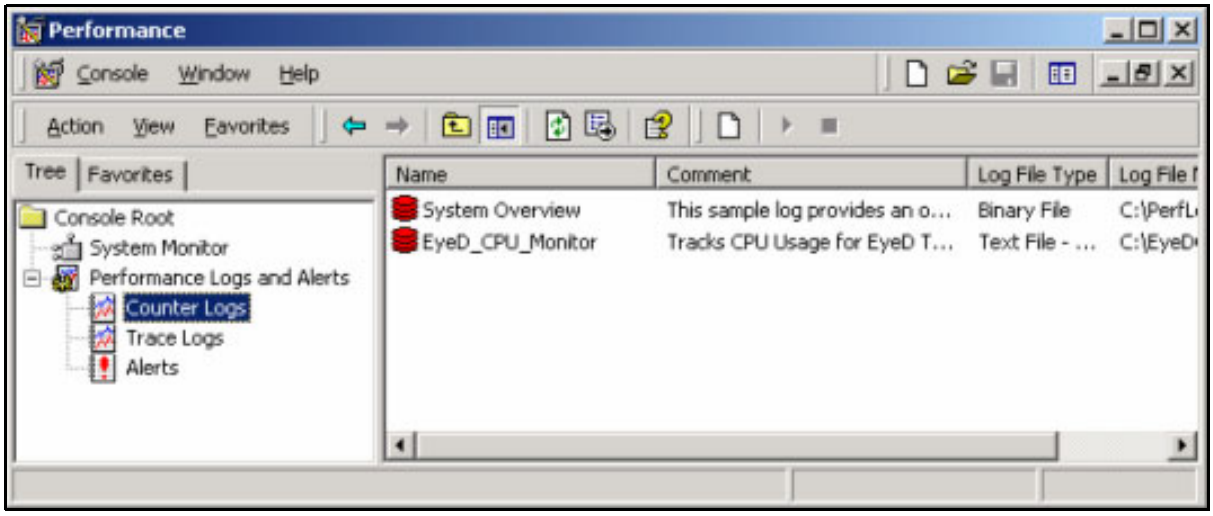


Figure 8-25. Performance Window

4. Import the Alert HTML Log settings by:

   a. Highlight Alerts on left side of screen

   b. Right click on Alerts

   c. Select, **New Log File Settings From…** (From Floppy or other media which contains the HTML files on the EyeD website indicated above) and select **75%CPUTrigger**.

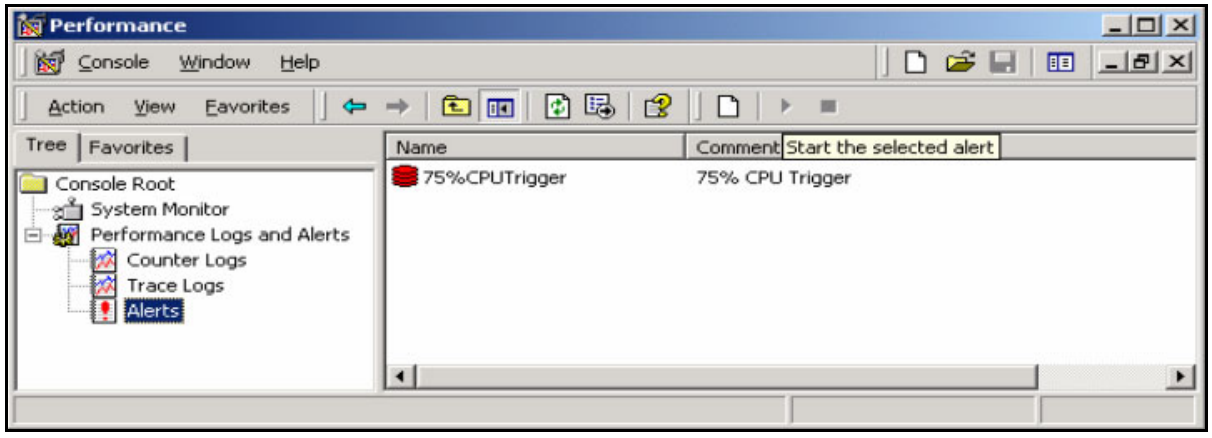


Figure 8-26. Performance Window Showing 75%CPUTrigger

5. Update The Counter Settings by selecting **Counter Logs**. Double click to open settings, as shown in Figure 8-27. This opens the Monitor Process Wiindow shown in Figure 8-28.

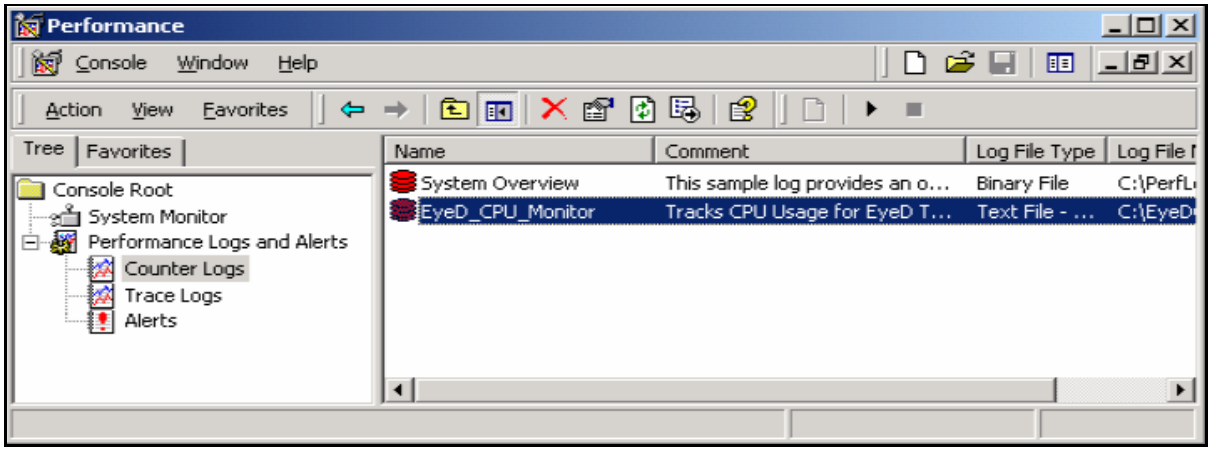


Figure 8-27. Select Counter Logs

6. Select **Process**.

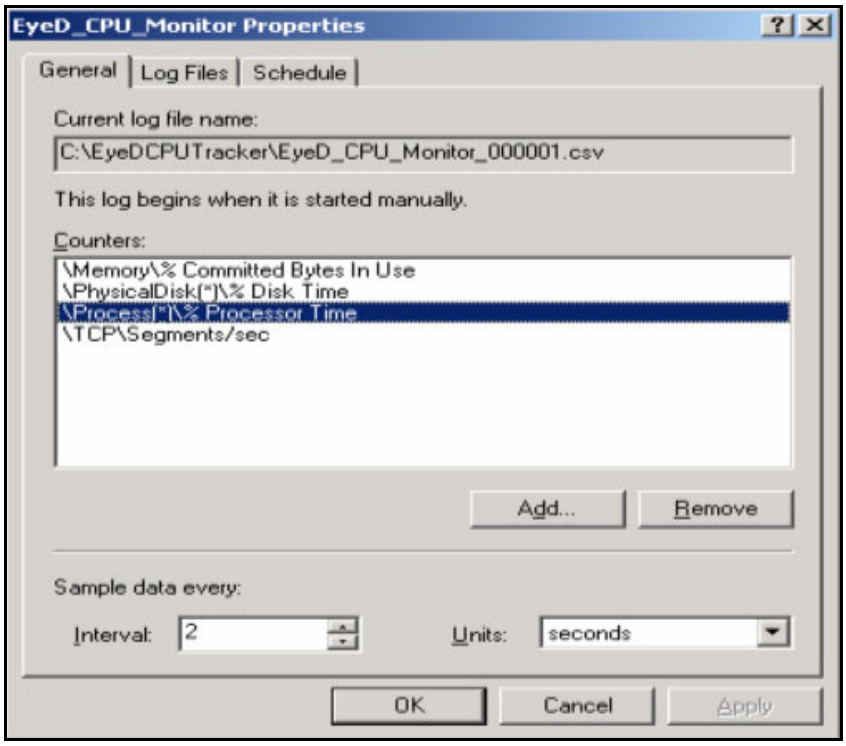


Figure 8-28. Select Process in Monitor Properties Window

7. Select **All Instances** in the Select Counter window, Figure 8-29. This will update all the local computer tasks that will be running in production.

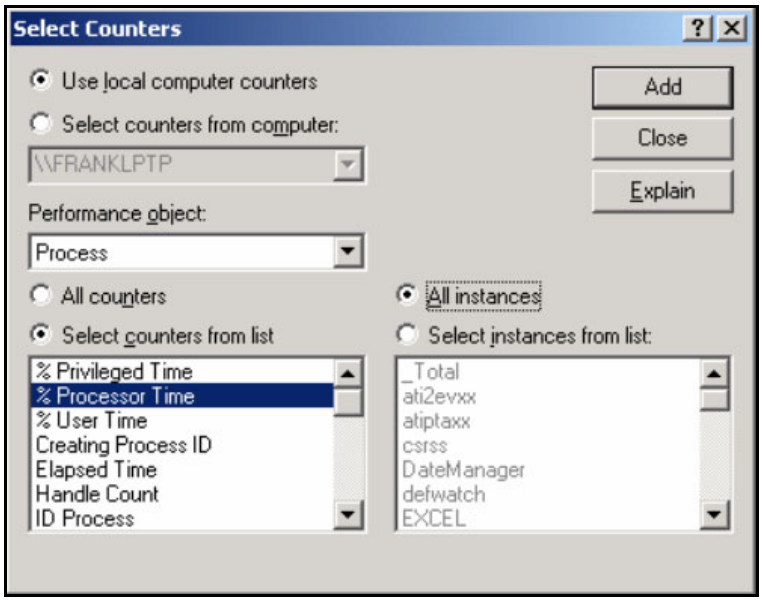


Figure 8-29. Select Counters Window

8. Select **Close** and **OK**.
9. Start the Alert Trigger.

a. Highlight **Alerts**.

b. Right Click.

c. Select **Start**. The Alert will turn green, as in Figure 8-30.

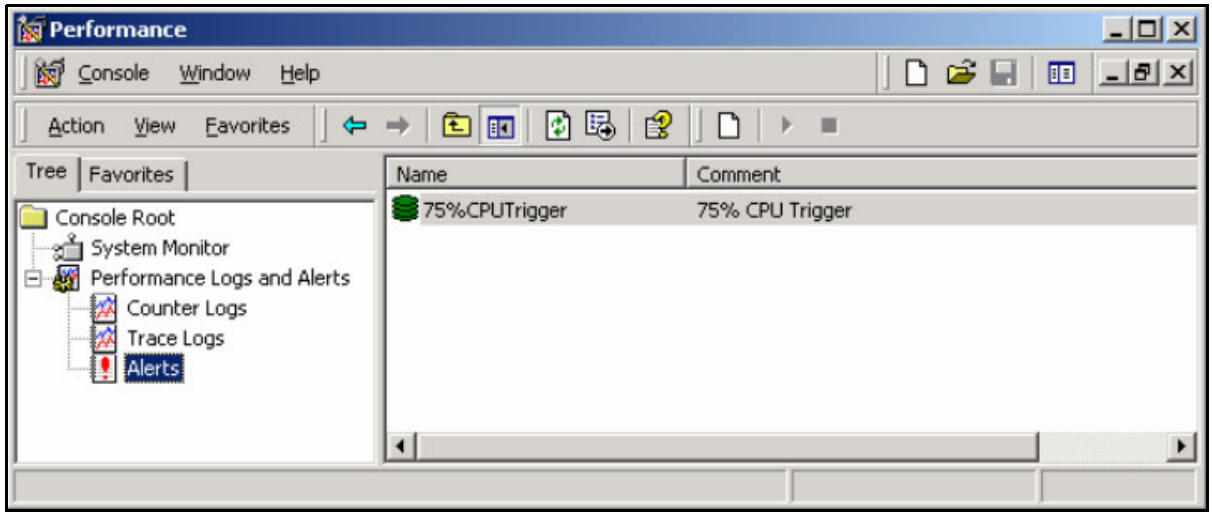


Figure 8-30. Performance Window with Green Trigger

8.4.4 Other

The Alert trigger can be found in the Application Log Event Viewer window. This gives an idea of how many times the CPU trigger was tripped in a particular lab test. See Figure 8-31.

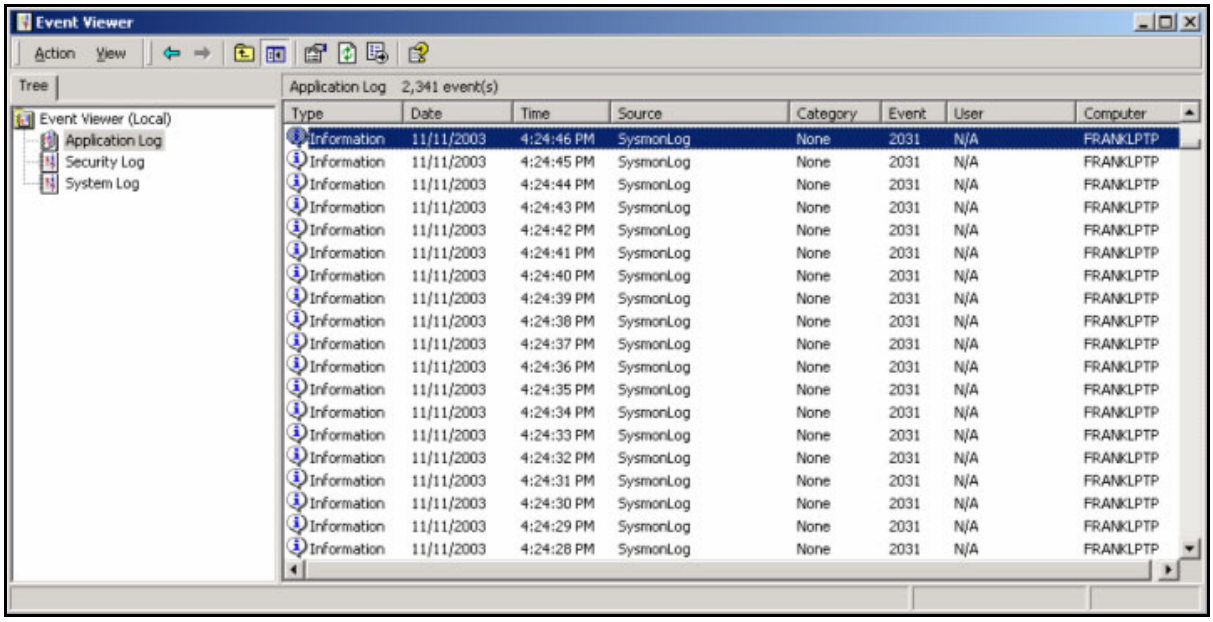


Figure 8-31. Application Log Event Viewer

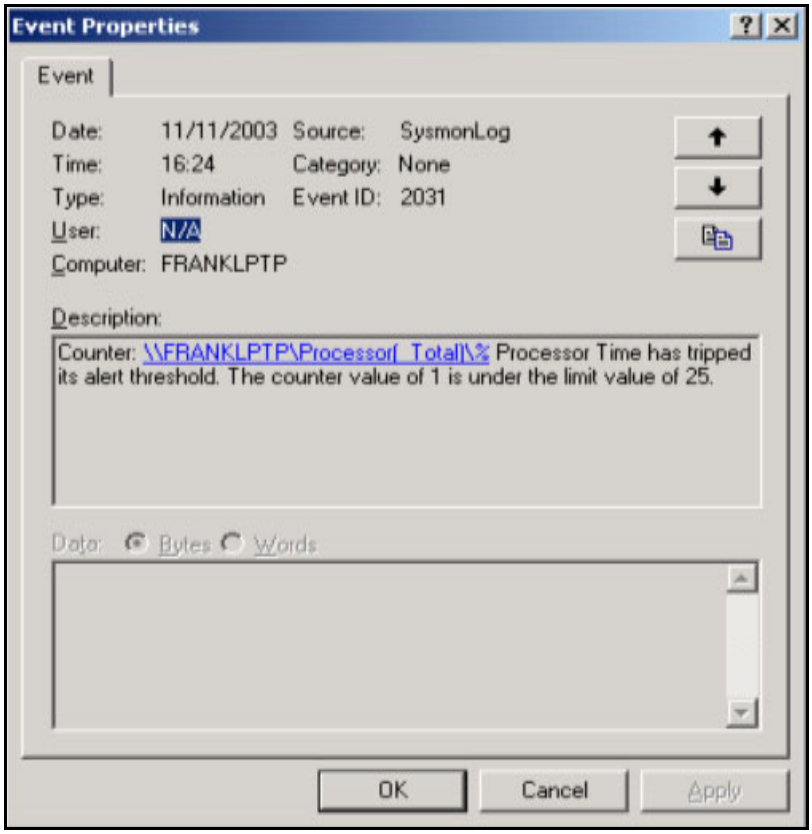


Figure 8-32. Event Properties Window

The CPU Monitor Log file can be opened with Excel. The files can be found at C:\EyeDCPUTracker. When opened within Excel, the system task utilization will appear similar to Figure 8-33.

Z1 \\USER-TEFOHIL7NX\Process(EyeDBasic)\% Processor Time

	F	G	H	Y	Z
1	(Idle)\% Processor Time	(System)\% Processor Time	\\USER-TEF	(EyeDBasic#1)\% Processor Time	(EyeDBasic)\% Processor Time
53	80.46875	4.6875	0	14.0625	0
54	96.09375	0	0	0	0
55	89.84375	0	0	0	0
56	89.84375	0.78125	0	0	3.90625
57	88.28125	1.5625	0	0	8.59375
58	80.46875	0.78125	0	17.96875	0
59	100	0	0	0	0
60	100	0	0	0	0
61	98.4375	0.78125	0	0	0
62	83.59375	1.5625	0	0.78125	12.5
63	79.6875	1.5625	0	17.96875	0
64	97.65625	0.78125	0	0.78125	0
65	100	0	0	0	0
66	98.4375	0	0	0	0
67	85.9375	1.5625	0	0	12.5
68	79.6875	2.34375	0	17.96875	0
69	100	0	0	0	0
70	100	0	0	0	0
71	98.4375	0	0	0	0
72	85.9375	1.5625	0	0	11.71875
73	82.03125	3.125	0	14.84375	0
74	100	0	0	0	0
75	100	0	0	0	0

Figure 8-33. System Task Utilization

Here, the (Idle)\% Processor Time (column F) and the (System)\% Processor Time (column G) indicate CPU Idle percentage, and system utilization percentages, respectively. Columns Y and Z indicate the CPU utilization of the EyeD Basic application at various logged times.

8.5 HDD Backup/Recovery CD Generation

All EyeD computers now ship with a scripted application which launches automatically on boot to enable the end user to easily generate an image of the HDD. It is recommended that an image be generated prior to any significant data file generation so that the entire contents of the HDD will fit on a single CD-R disc. The recovery disc will then allow a user to easily recover the computer back in to its original configuration if there is a system crash, in the event of virus infection, or failure of the HDD. The scripted utility generates the window below after startup; the operations necessary to generate the recovery CD are self explanatory:

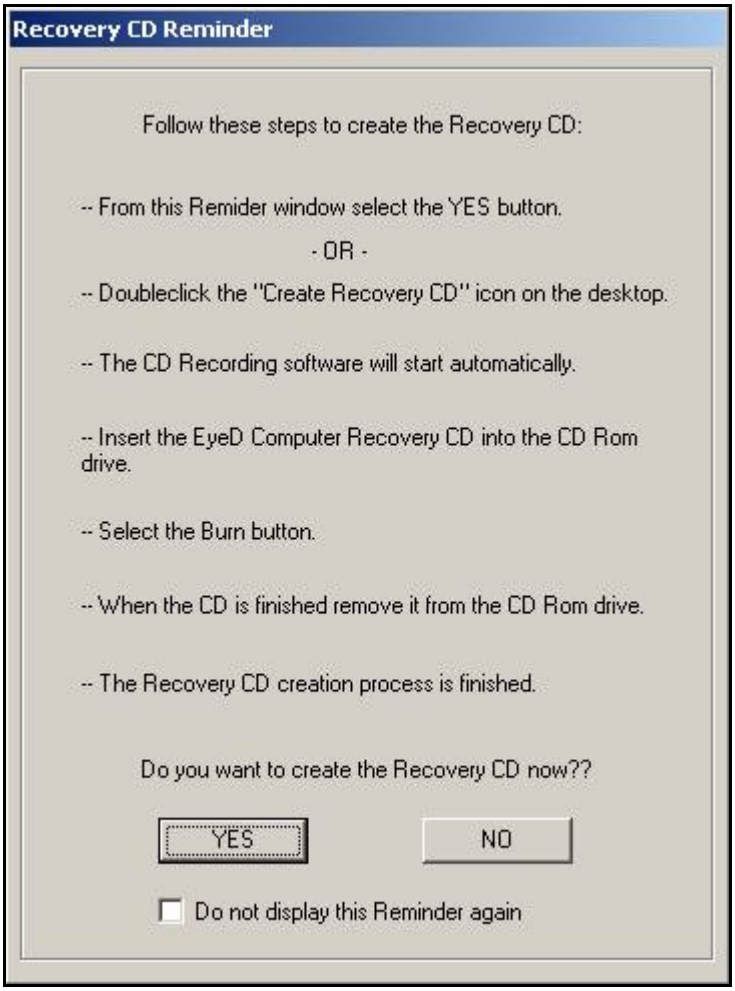


Figure 8-34. Recovery CD Reminder Window

8.6 Efficient Algorithms

CPU usage is a function of the algorithm complexity. It is advisable to remove any unnecessary equations to minimize the CPU usage and to divide up complex algorithms into multiple steps. Some intensive equations include fringe counter and film thickness measurements. It is recommended to keep the CPU usage to under 30% per chamber to avoid excess time delay in measuring endpoint. To monitor the CPU Usage, do the following:

1. Click on **Start**, then **Programs**, then **Command Prompt**
2. Type '**perfmon**' in the Command Prompt window and press '**Enter**'.

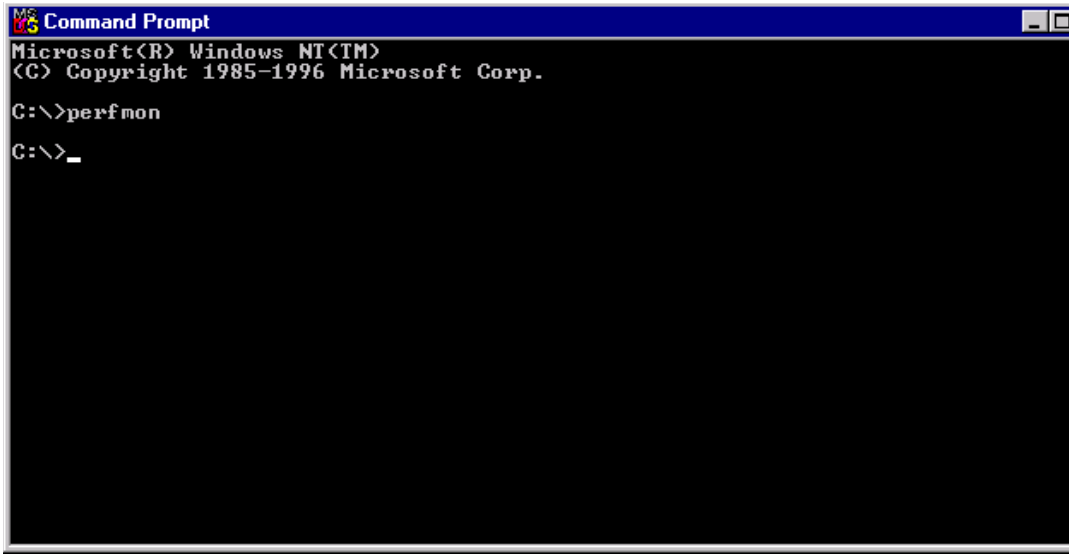


Figure 8-35. Command Prompt Window

3. The **Performance Monitor** window appears.

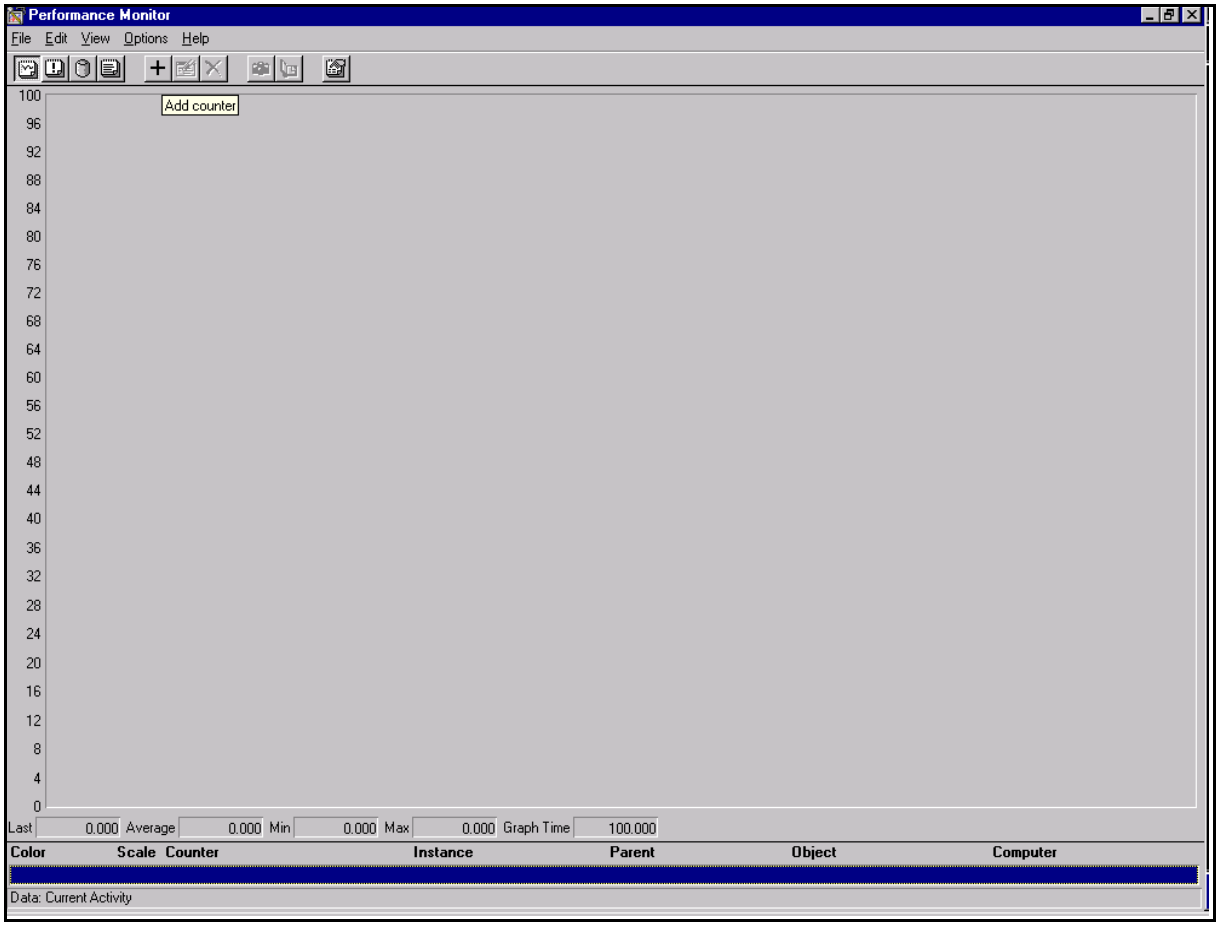


Figure 8-36. Performance Monitor Window

4. Add a counter by clicking on the + on the toolbar.

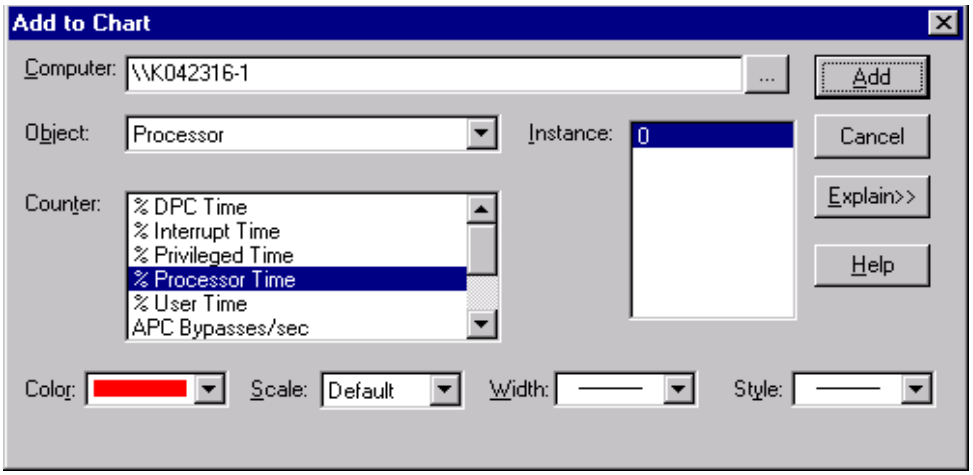


Figure 8-37. Adding a Counter

5. Choose **Object: Processor** and **Counter: % Processor Time.** Choose the color **red**.
6. Click on **Add**.
7. Next choose **Object: Memory** and **Counter: % Committed Bytes In Use**. Choose the color **green**.
8. Click on **Add**, then **Done**.

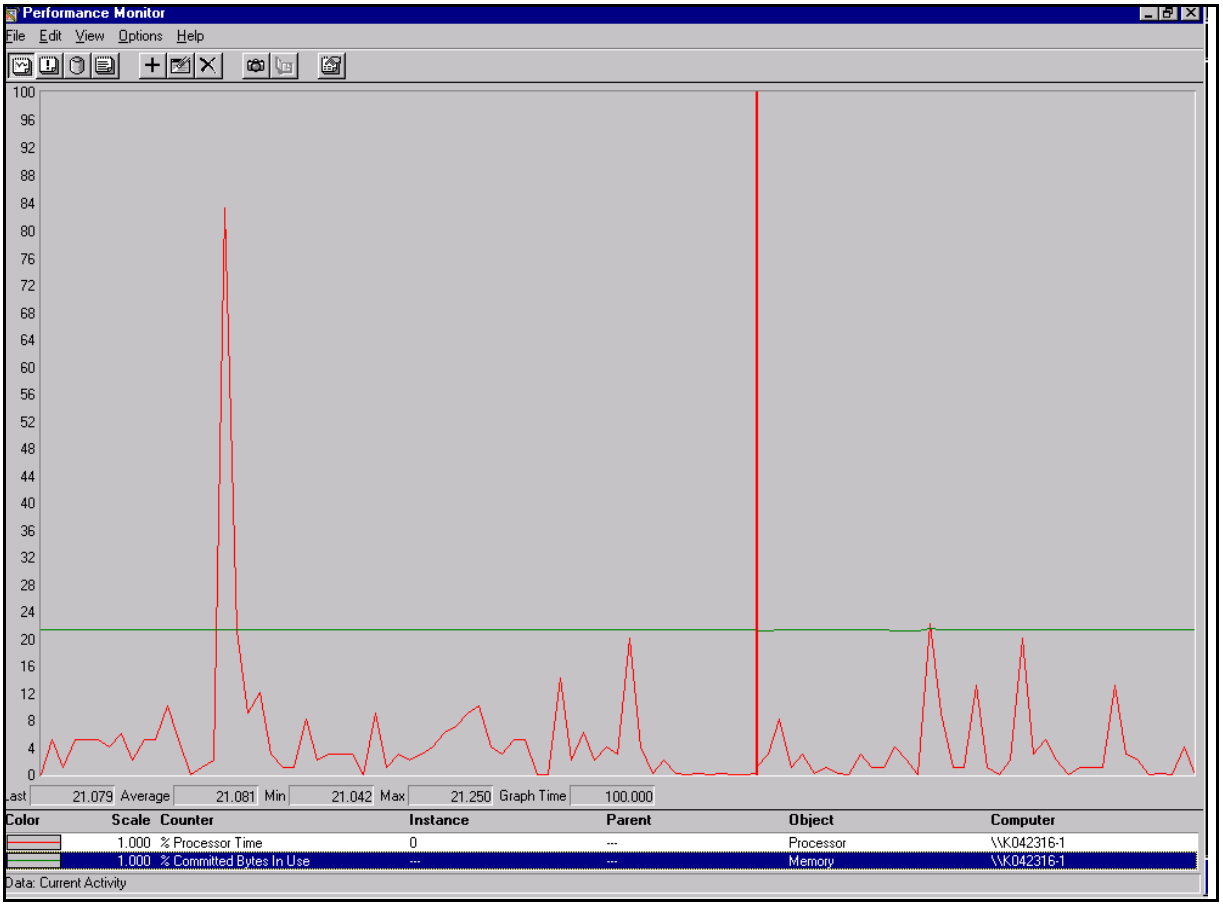


Figure 8-38. Monitoring Processor Time and CPU Usage

9. There should be two lines (red and green) that represent the Processor Time and the CPU Usage (Figure 8-38). Ensure that the latter does not go above 30% per chamber.

8.7 Alternative Hard Drive Backup and Image Installation

Prior to the introduction of EyeD controllers 0190-13923 (300mm) and 0190-14411 (200mm), there was no automatic script application for backing up the hard drive and capturing the images prior to significant file generation. However, Windows has a built-in utility for backing up computer files and settings.

With this utility data files and registry settings can be backed up for use in system recovery later. It is also possible to create an emergency startup disk which can be used to recover the system from a failure that compromises the hard drive. As with the included script application, it is recommended that a backup be taken of the system prior to the generation of large amounts of data, so that the contents easily fit on removable media such as a CD-ROM or flash drive.

Backups can be created using the procedure below.

8.7.1 Backup Process

1. Click on the **Start Menu** and then select **Accessories==>Systems Tools==>Backup** to bring up the Backup utility main Window.

2. Click on the Tab labeled **Backup**.

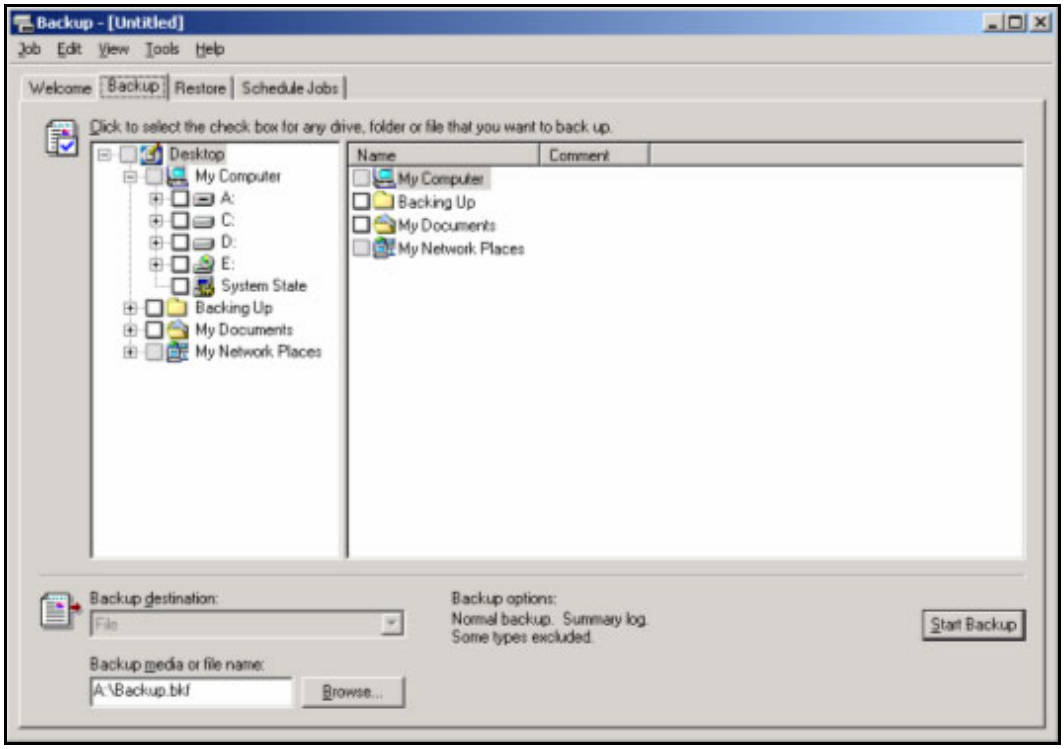


Figure 8-39. Select the Backup tab from the Backup Utility window

3. Use the folder navigator to select the drive and files to backup. For a new system, backup of the entire C: hard drive is recommended. For older systems with a lot of data on them, the user will have to exercise some choice over what to include in a single backup files as these files are typically very large (over 1GB). It is also possible to make generate several different backup files to protect all the data.

   It is important that the system state is backed up in addition to the EyeD data and installation. This allows the computer to be recovered to the state that it was in when the backup was taken.

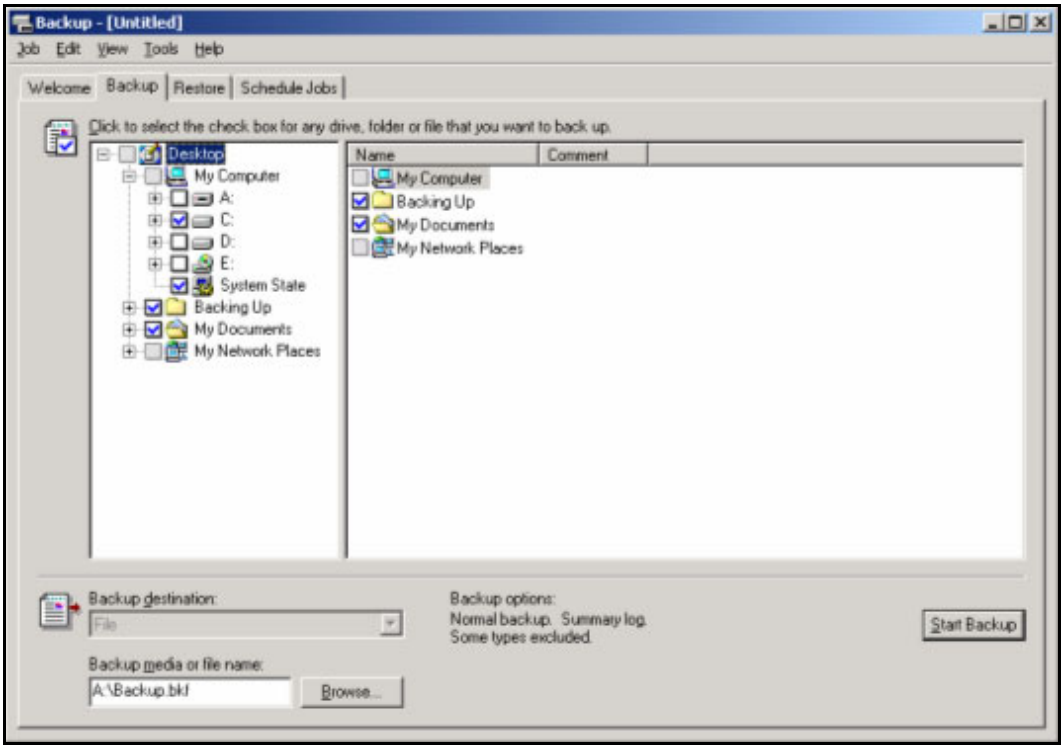


Figure 8-40. Mark Hard Drive and System State Files for Backup

4. Specify the path for the backup file. This may be on another system or some removable media. Adequate space should be allocated for the file: it can grow to over a gigabyte in size.

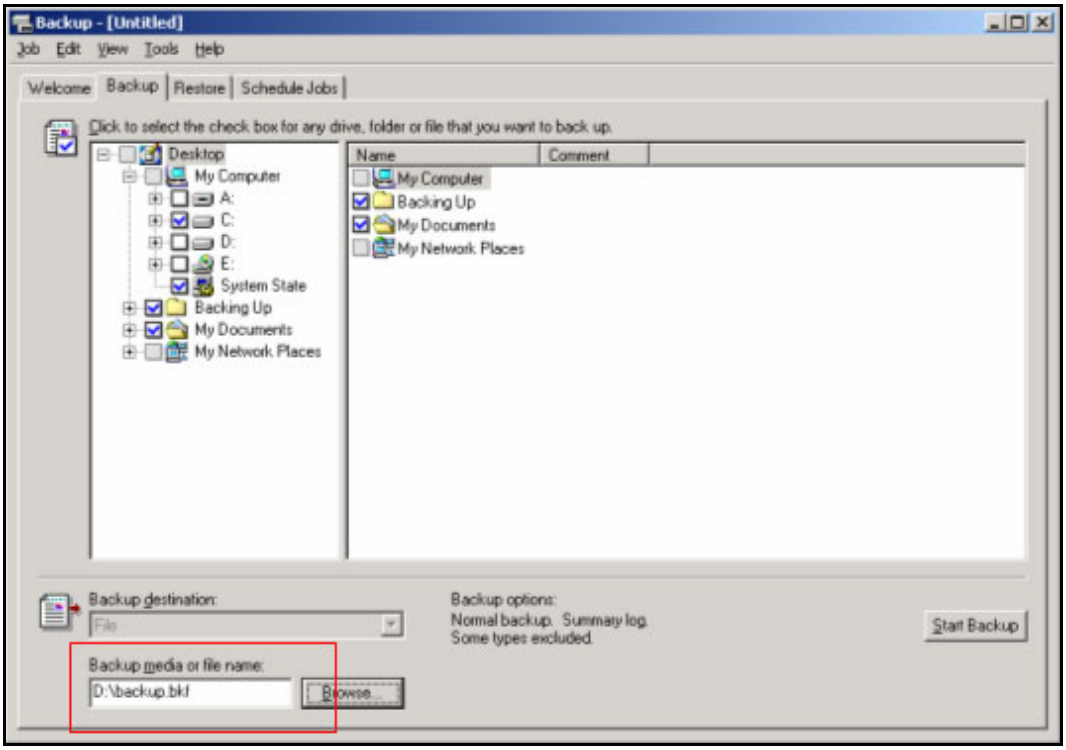


Figure 8-41. Specify Location of Backup File

5. Click on **Start Backup**. A summary of the backup job information is displayed. Review the information for accuracy. For a new backup on media without previous backups, the choices presented have no effect. If backups are already present on the media, select the option to append the new backup to the existing backups, unless older backups are being replaced by a later regular scheduled backup. Descriptive information about the backup can entered in the text fields.

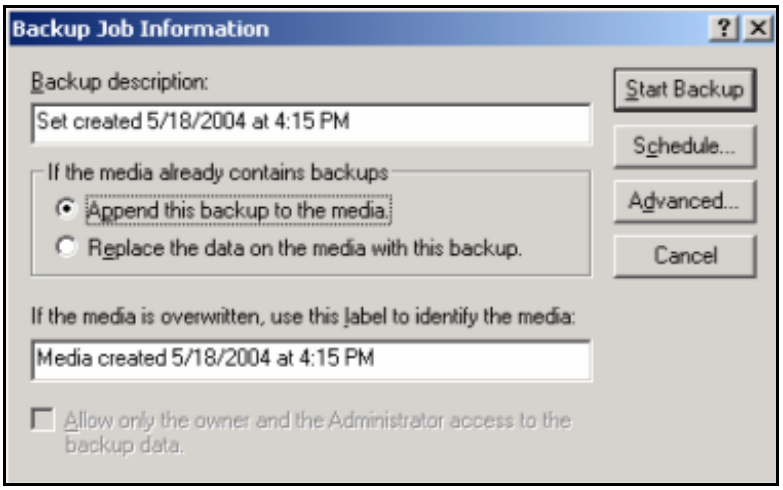


Figure 8-42. Review Backup Information

6. Click Start Backup to begin the backup. The system will verify the files that have been selected, and then begin the tack of backing up. This will take several minutes depending on the size of the job (number of files to backup).



Figure 8-43. System is Preparing to Backup

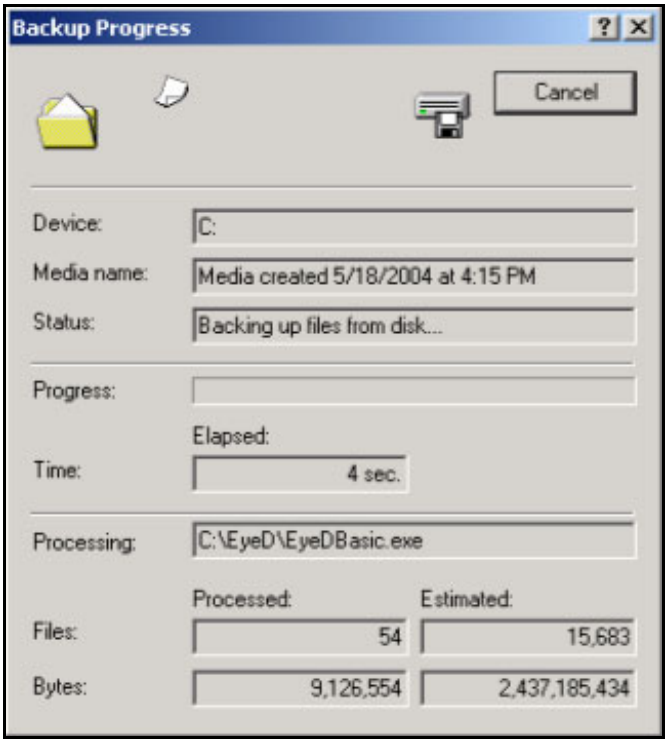


Figure 8-44. Backup Progress

7. If the backup file grows to large for its allocated space, the backup program will fault and display a message shown below. The backup process should be restarted, this time providing adequate storage space.

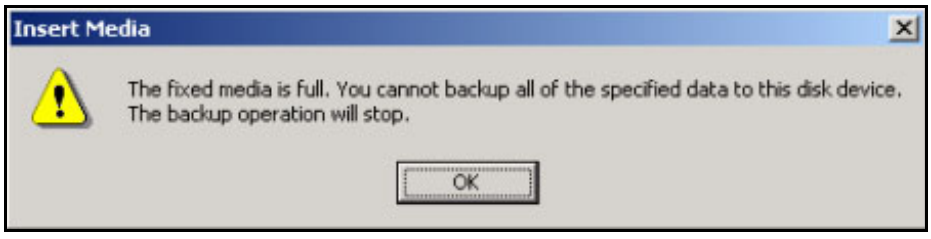


Figure 8-45. Backup Location is Out of Storage Space

8. The backup utility will generate a report once it has completed.

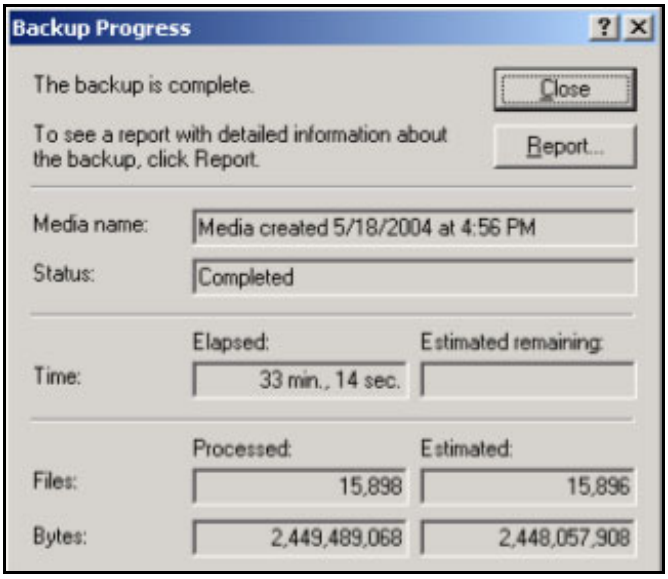


Figure 8-46. Backup Process Complete.

8.7.2 Restoring Backup Files

Use the windows utility to restore data and file settings from a backup.

1. Startup the Backup utility (*Start ==> Program Files ==> Accessories ==> System Tools ==> Backup*). Select the **Restore** tab.

2. Navigate to the location of the backup file and select the files to restore. These should be the files or drives that were originally backed up. Select the option to restore files to the original location.

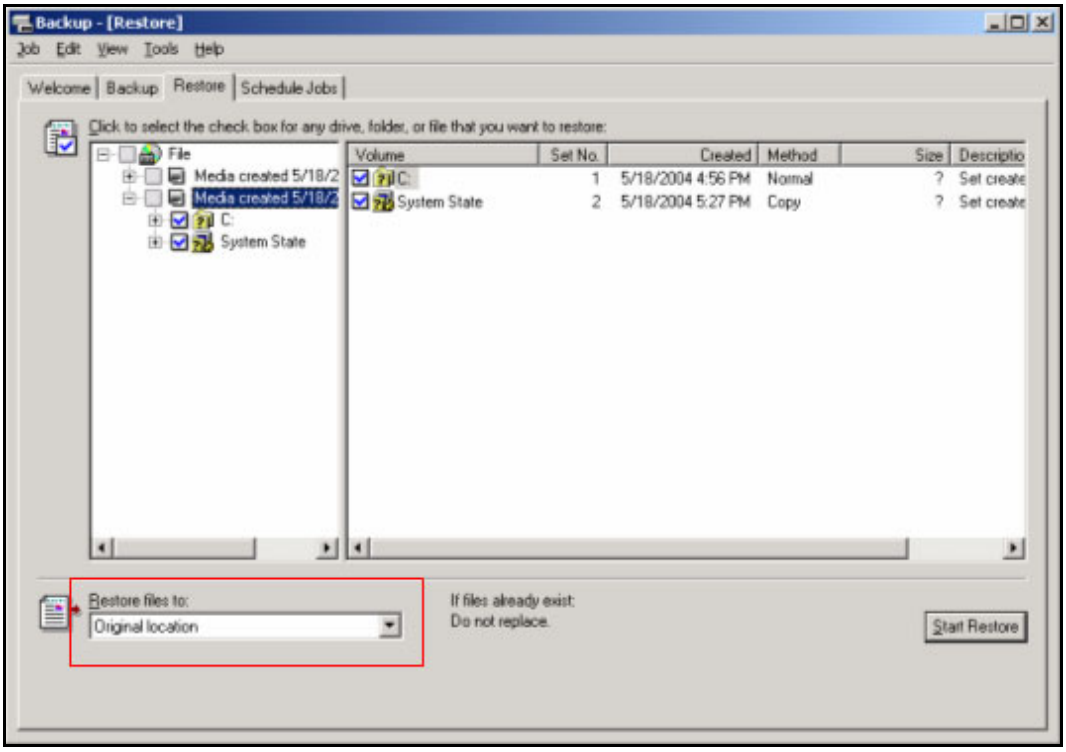


Figure 8-47. Restore Backup Files to Original Location

3. A warning is generated indicating that existing system files in the restore location will be overwritten by the backup files. If the system state has been changed, restoring the backup will return it to its configuration at the time of backup.

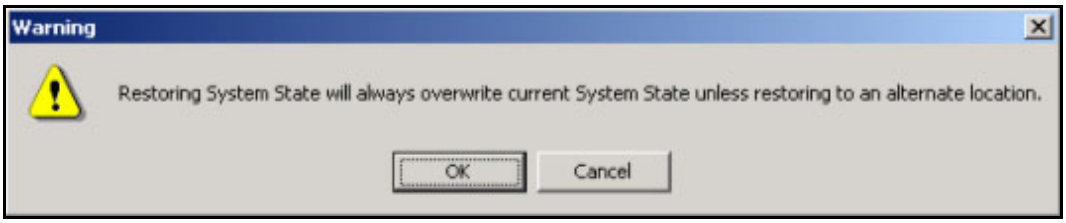


Figure 8-48. Files in Original Location Are Overwritten by Backup Files

4. Click **OK** to proceed. The next dialog box presents the option of selecting advanced options for restoring data.

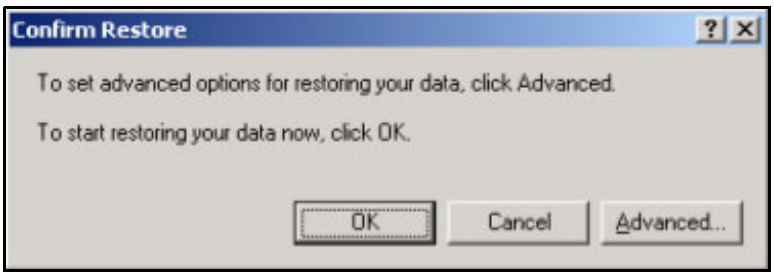


Figure 8-49. Restore Confirmation

The default settings should be fine for most systems.

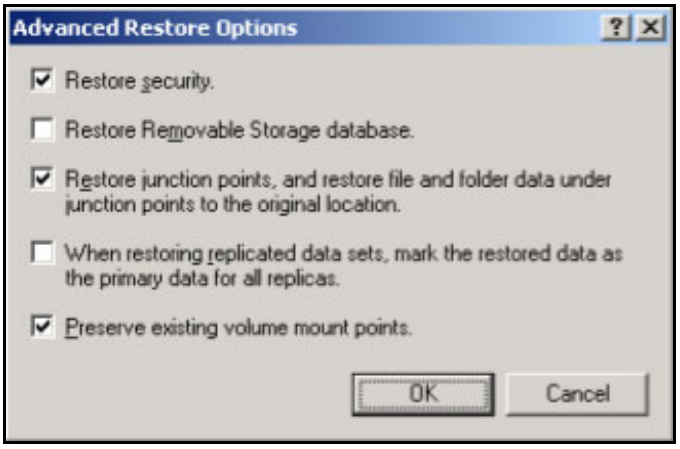


Figure 8-50. Default Advanced Restore Options.

5. Click **OK**. Next select the backup file to restore. This will contain the system state and data files taken at a particular time.

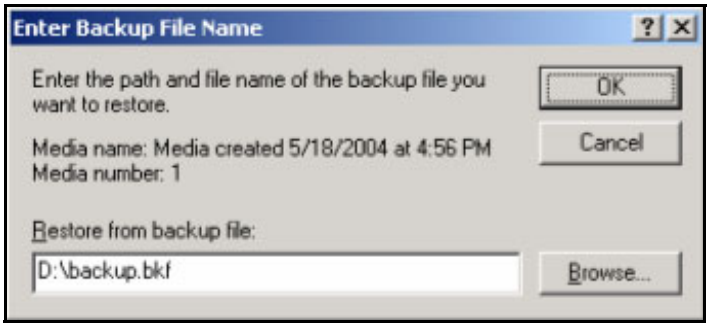


Figure 8-51. Figure 13. Enter Backup File Name

6. Click **OK**. The restore process begins. A progress dialog box indicates the state of the restore, and a report is generated when the restore is complete.

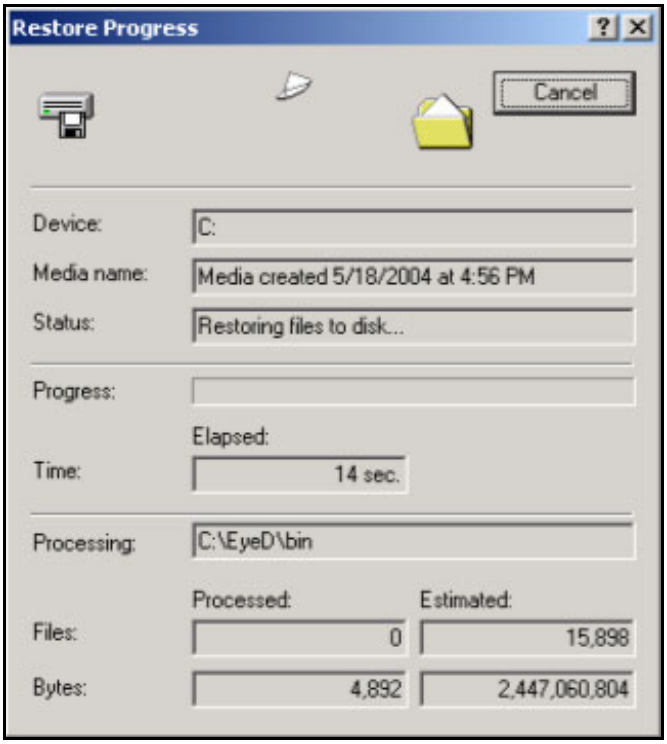


Figure 8-52. Restore Progress

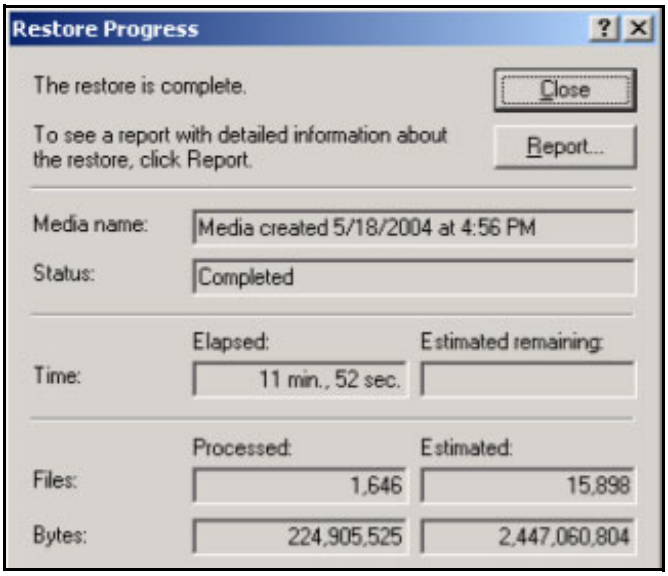


Figure 8-53. Figure 15. Restore Complete Report

7. If system state files are being restored, the computer will have to be restarted to complete the restore.

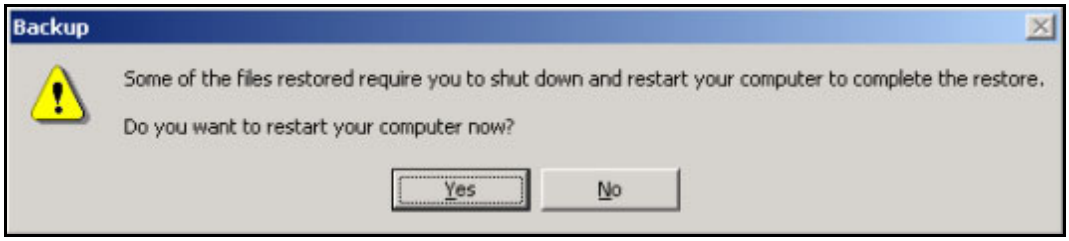


Figure 8-54. Restart Computer to Complete System File Restore

8.7.3 Creating an Emergency Start Disk

Create an emergency start disk in case of hard drive failure.

1. Startup the Backup utility (*Start ==> Program Files ==> Accessories ==> System Tools ==> Backup*). From the Welcome Tab, click on **Emergency Repair Disk**.

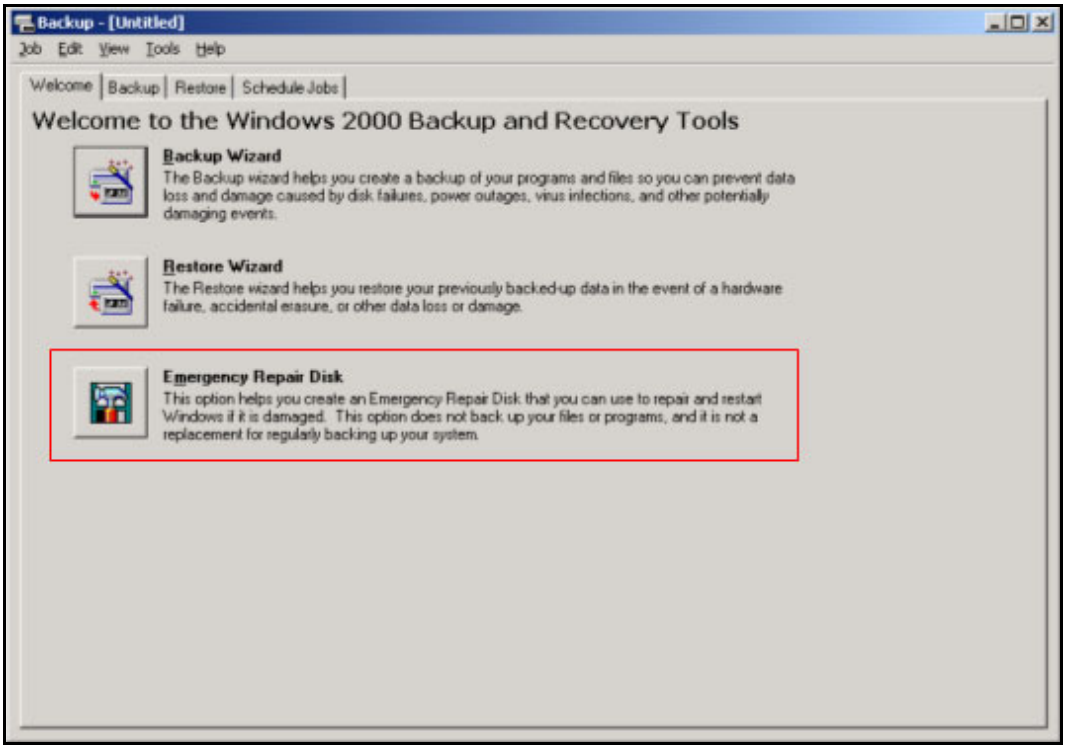


Figure 8-55. Create an Emergency Repair Disk

2. The system will prompt for a blank floppy disk. Insert the disk and click on OK. Click on the checkbox to backup the registry to the repair directory. This will help recover the system from damage to its registry.

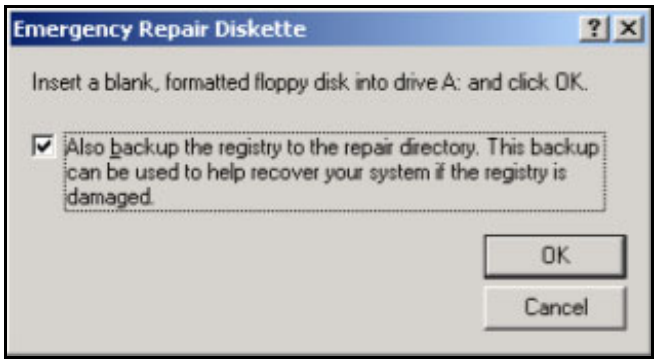


Figure 8-56. Emergency Diskette Dialog with Backup Registry Option

There is also an option to backup the registry.

3. System data is copied to the floppy disk. A dialog will pop up once the process is successfully complete.

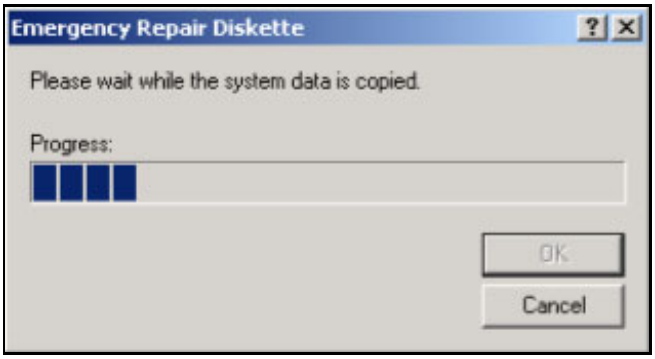


Figure 8-57. Creating Repair Diskette

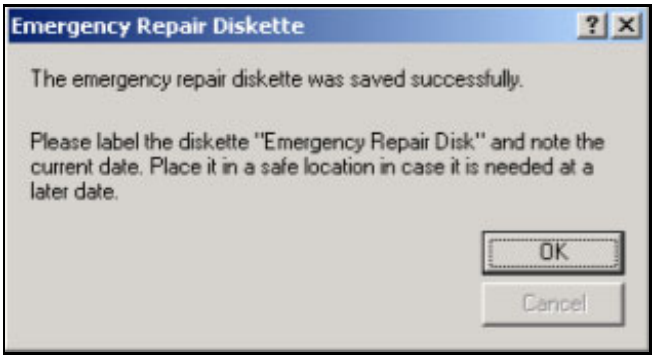


Figure 8-58. Successful Completion of Emergency Repair Diskette

4. The Emergency repair diskette may be used for the following:
   - Repair of the Windows startup environment
   - Checking Windows system files, replacing any that are missing
   - Inspection and repair of the boot sector.

THIS PAGE INTENTIONALLY LEFT BLANK.

9 Maintenance and Upgrades

9.1 Flashlamp Bulb Replacement Procedure

This document provides the process for changing out the bulb inside the Modulated High Intensity Full spectrum (MHIF, or FL2002) lamp housing.

9.1.1 Definitions

MHIF bulb refers to the Applied part number 1010-00142 (mfr. part number 1003284), replacement flashlamp. FL2002 refers to AMAT MHIF lamp controller module, Applied Materials P/N 1010-00168 (mfr. part number 1003525).

9.1.2 Requirements

Before proceeding with the flashlamp bulb change procedure, the FL2002 should be removed from the Centura DPS chamber and placed on a clean, flat surface.

Materials required include:

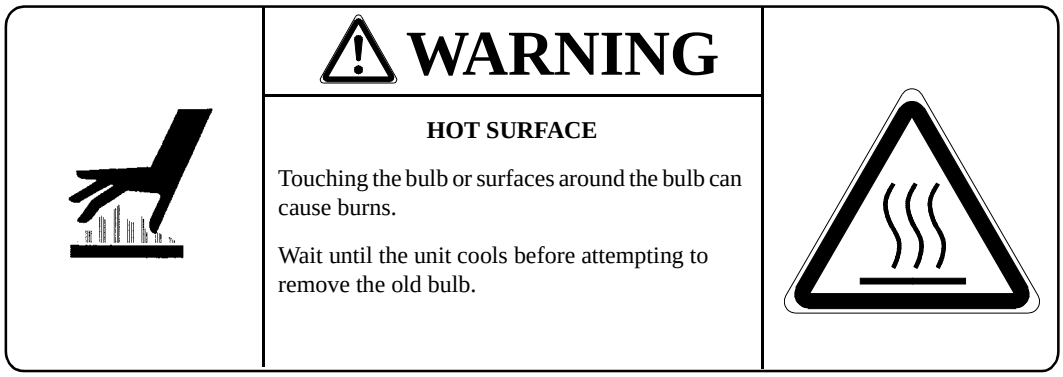
- Replacement bulb
- Open end wrench, 5/16"
- Standard screw driver
- Phillips screwdriver
- 0.050" Allen wrench
- 5/64" Allen wrench

9.1.3 Reflectometer Removal Procedure

1. Disconnect power cords from both the DCS and the MHIF.
2. Disconnect ethernet interface cable.
3. Remove fiber optic source branch from the output coupler of the MHIF lamp module using 0.050" Allen wrench.
4. Remove fiber optic signal branch from the input coupler of the DCS using 5/64" Allen wrench.
5. Loosen four (4) captive quick release thumb screws that attach the reflectometer bracket to the chamber fixed bracket.
6. Lift and remove reflectometer (weight is approximately 16 pounds) using the attached handles, and place reflectometer on a flat work surface.

9.1.4 MHIF Bulb Replacement Procedure

1. Remove the 4 screws on the lamp output fiber optic coupler, located on the rear of the unit (See Figure 8-1).



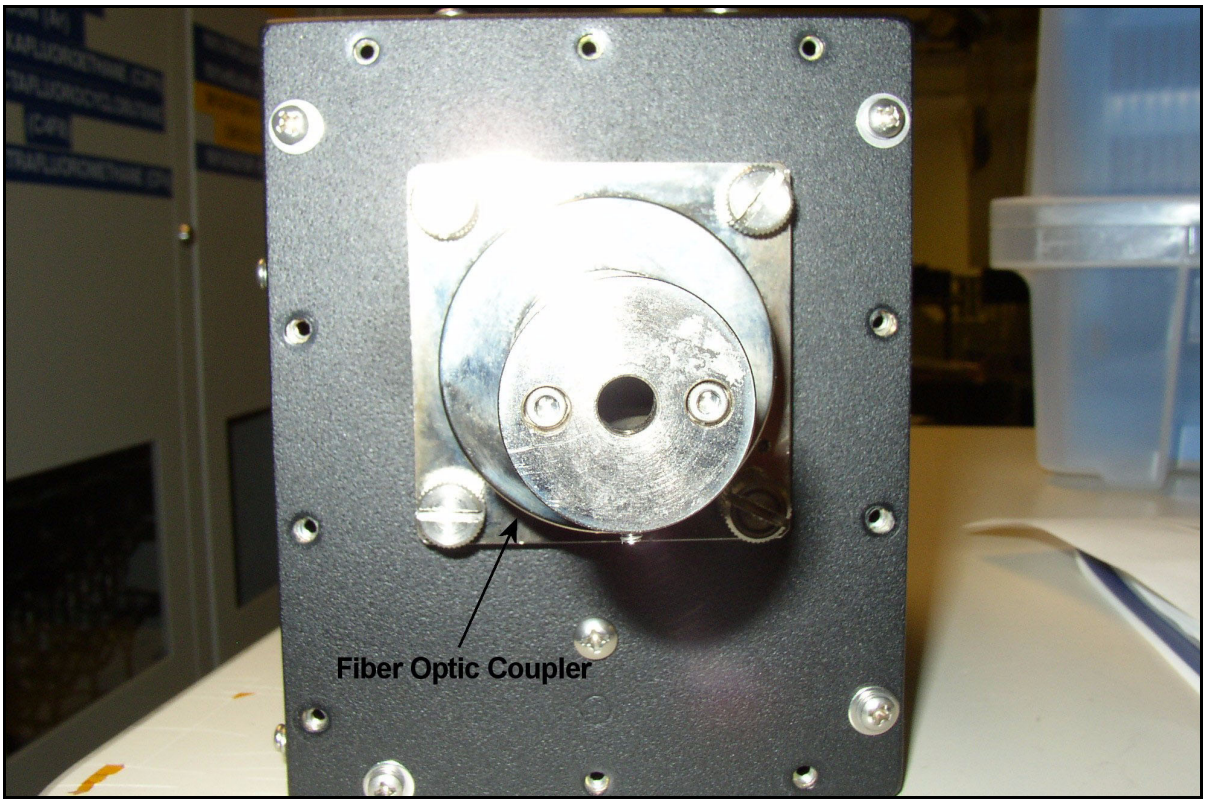


Figure 9-1. Rear of Flashlamp

2. Pull the fiber optic coupler away from the back of the lamp to expose the flashlamp bulb as in Figure 8-2.

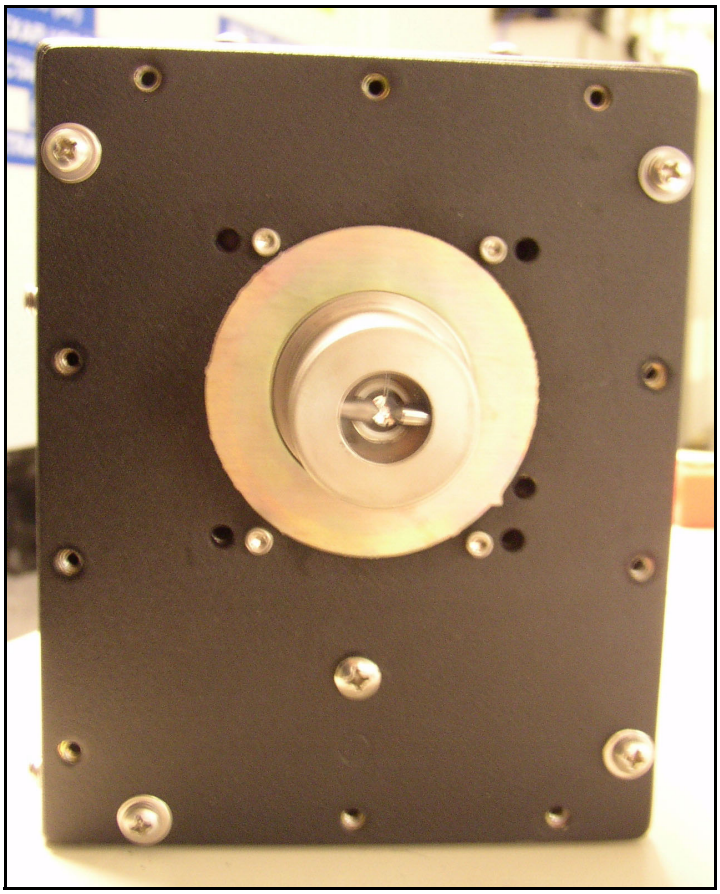


Figure 9-2. Exposed Flashlamp Bulb

3. Use thumb and forefinger to gently pull the flashlamp bulb from its socket.

NOTE

Never touch the lens at the front of the flashlamp bulb.

4. Remove the replacement bulb from its package and align the pins with the socket holes before pressing into place on the flashlamp housing.
5. Replace the fiber optic coupler Note that it is keyed for only one orientation.
6. Replace the four screws holding the coupler to the back of the flashlamp rear panel. The MHIF lamp module is now ready to reinstall on the system.

9.2 Embedded Code Upgrade for the Spectrograph (SD 1024D):

In order to perform this procedure you must already have an Ethernet connection to the spectrograph. You must also know the IP address of the unit. If you do not know the IP address of the unit you can obtain it using a USB cable. See Section 9.3.2.

Installing the Software:

1. Create a directory in the C Drive called 1024D Flash Loader. The path should be *C:\1024D Flash Loader*

2. Copy the flash loader software files (can be obtained from Silicon Etch intranet site) into the 1024D Flash loader directory

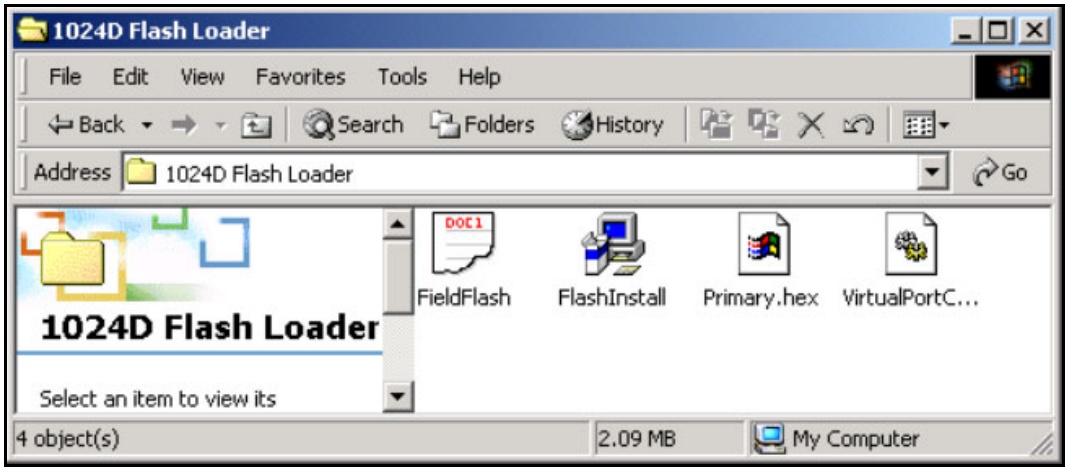


Figure 9-3. Flash Loader Software Saved in C Directory

3. To install the flash loader software, double-click on the Flash Install icon. The window shown in Figure 2 should appear.



Figure 9-4. Flash Loader Installation Wizard

4. Click on Finish. This will install the flash loader program executable on the Desktop with an icon and also a path name in the Start menu.

Flashing the 1024D:

1. Doubleclick on the Verity Field Flash icon on the Desktop.
2. The Communication Options window (see Figure 3) will pop up. Select TCPIP and type the IP Address of the spectrograph you are flashing.

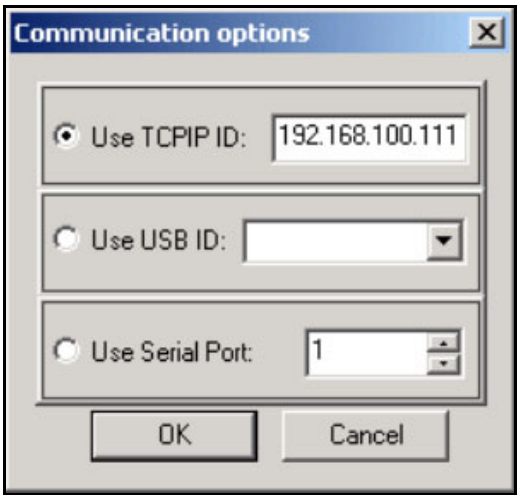


Figure 9-5. Communication Options Window

3. Click on **OK**.
4. The FLDFlash - Flashform1 window opens (Figure 4), where the code and parameters can be output to the spectrograph. In most cases the output will be code.

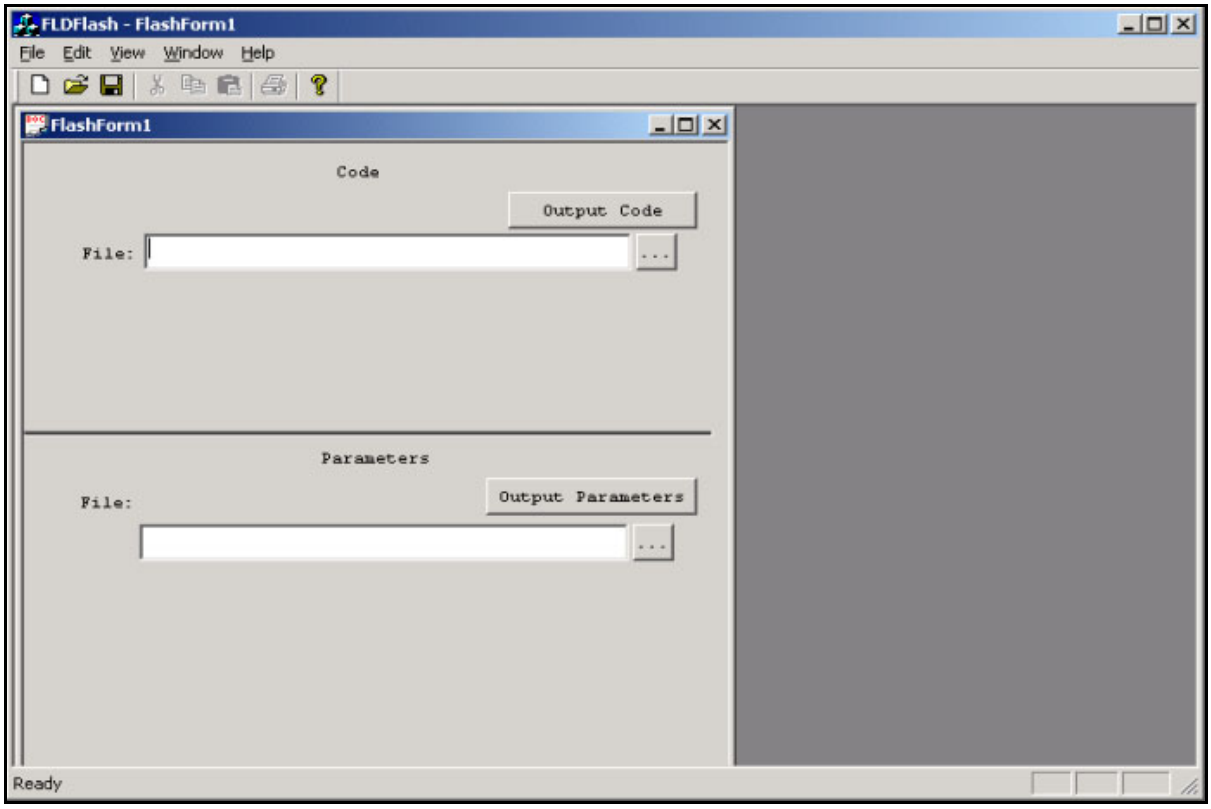


Figure 9-6. FLDFlash - Flashform1 Window

5. Click on the … button to choose a file to output. Open the file with the path *C:\1024D Flash Loader\Primary.hex*.

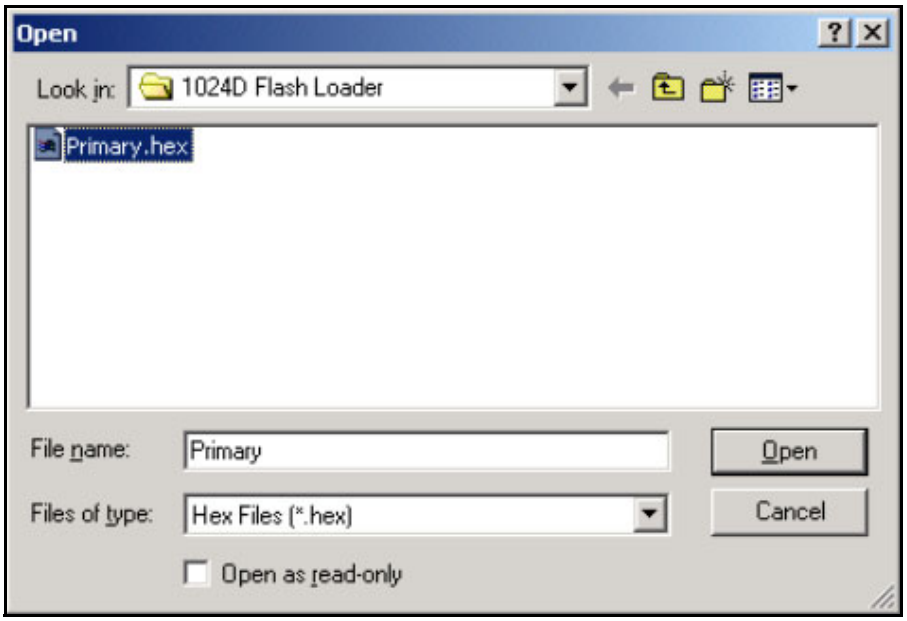


Figure 9-7. Opening Code File Primary.hex for Output to Spectrograph

6. Click on **Open**. The Output window (Figure 6) will pop up; click on Flash to send the file to the spectrograph.



Figure 9-8. Output Window

7. Look at the SD 1024D LCD screen. It will flash with the new code once complete.

NOTE

There is no hourglass on the desktop to show you the progress. You must look at the LCD screen of the SD 1024D to see progress.

9.3 Spectrograph Recovery from Failed Flash Attempt

Problems may occur during the flash process. The spectrograph will respond with an error code once the flash utility has completed if the flash has failed. It is important not to interrupt the flash utility at any point during the flash process, even if it appears that the utility has locked up. There is some variability in the amount of time required to complete the flash process. Flash errors that may occur and procedures for recovering from them are included below.

9.3.1 Flash Error 1

The error code 'Flash Error 1' is displayed on the spectrograph LCD when the flash utility is interrupted and cannot proceed. The user should not reboot the spectrograph when this occurs. Rebooting the spectrograph can corrupt the spectrograph's low level embedded code: when this happens the two row of the LCD will display nothing but black squares. This type of failure cannot be repaired in the field and the unit has to be returned to Applied Materials for repair.

To recover from this error, the user should restart the flash utility to enable it to complete correctly. Restart as often as necessary to finish the flashing.

9.3.2 DUGZ

Unsuccessful attempts to flash EyeD Spectrographs may result in loss of communication with the spectrograph. Symptoms of this situation are as follows:

- The spectrograph LCD displays the code "DUGZ." When the spectrograph is in this condition, its parameter settings have been changed, and its IP address has been changed from the value with which it was previously communicating. The spectrograph will need to be reflashed with its parameter file to restore the IP address to a known value, and also to reset the parameter settings so that it can be brought back up to production state.
- There is no communication between SRM and EyeD computer. When SRM is opened, the EyeD application for the spectrograph in question reads "Missing" under the Device field and "Disconnected" under the State field.

Bring a spectrograph back up after an attempt to flash to fail has failed by following the instructions below. This procedure will need a USB cable (0620-00721).

Note: This procedure applies to all spectrograph models with the "D" designation, ie

- 1400-00204 - Spectrograph, SD1024D-2-S, I/O, 24VDC
- 1400-00205 - Spectrograph, SD1024D-2-S, W/TRIG I/O, 120VAC
- 1400-00206 - Spectrograph SD1024DL, SMA FIBER INPUT, 24VDC POWER
- 1400-00207 - Spectrograph SD1024DLC, SMA FIBER INPUT, 120VAC

1. Each spectrograph has unique parameter file that is matched to its serial number. A spectrograph in the "DUGZ" error sate must be reflashed with its parameter file to return it to production state. Reflashing restores the spectrograph IP address to the default factory setting so that Ethernet communication can be re-established. A USB cable must be used to do the initial reflashing because the IP address is of the spectrograph in the "DUGZ" is unknown. Obtain the parameter file as follows:

    a. Note the serial number of the spectrograph (located at the back of the unit).

    b. Obtain the parameter file that corresponds to the serial number from the EyeD website (Go to http://amat.mis.amat.com/sietch/engineering/index.htm and click on Adv. Modules), under parameter files.

NOTE

The parameter files are password protected, and require authorization before they can be accessed. To obtain authorization, contact the EyeD website administrator (see website).

    c. Download the file and transfer it to the computer that will be sued to flash. Note the location where the file is stored.

NOTE

Be sure to download the appropriate file. Flashing with another spectrograph's parameter file will result in inaccurate operation of the spectrograph.

2. Use a USB cable (0620-00721) to reflash the spectrograph with its parameter file. The IP address is not required when flashing the USB cable.

NOTE

The USB cable cannot be used to flash the spectrograph with its embedded code (which has a hex file extension).

a. Power off the spectrograph

b. Remove the Ethernet cable from the J2-COM2 port. Insert a USB cable in its place. Insert a USB cable (0620-00721) in its place.

c. Connect the other end of the USB cable to a USB port on the PC (any port is acceptable). It may be necessary to physically move the spectrograph closer to the control computer as the USB cable is only 8 feet long. For 200mm, provide power to the spectrograph with any universal AC power cable and one of the convenience outlets on the mainframe. For 300mm, roll the EyeD workstation to within reach of the 8 ft USB communication cable.

d. Power up the spectrograph.

e. If this is the first time the USB cable is being used, install the USB driver on the PC.

   An install wizard should automatically pop up. Install the driver under C:\EyeD\USBDrivers

   If nothing pops up, go to **Start\Settings\Control Panel\Add\Remove Program**. Install USB.

f. Open SRM. Select the SRM application for the down spectrograph by right clicking on it. Choose the option Setup Application. This should open up the Application Setup Dialog.

g. Select USB as the Connection type.

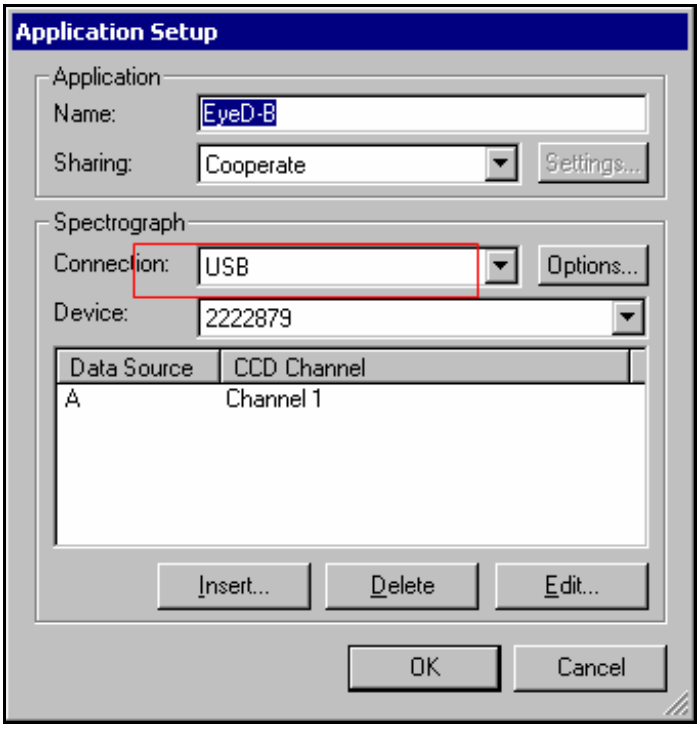


Figure 9-9. Use USB for Spectrograph Communication

h. Click the **OK** button.

i. In the main SRM window the SRM application for the spectrograph should now read **Found** under the Device, along with connection type (USB) and the device ID number, and **Disconnected** under the State field, as shown in Figure 2 below.

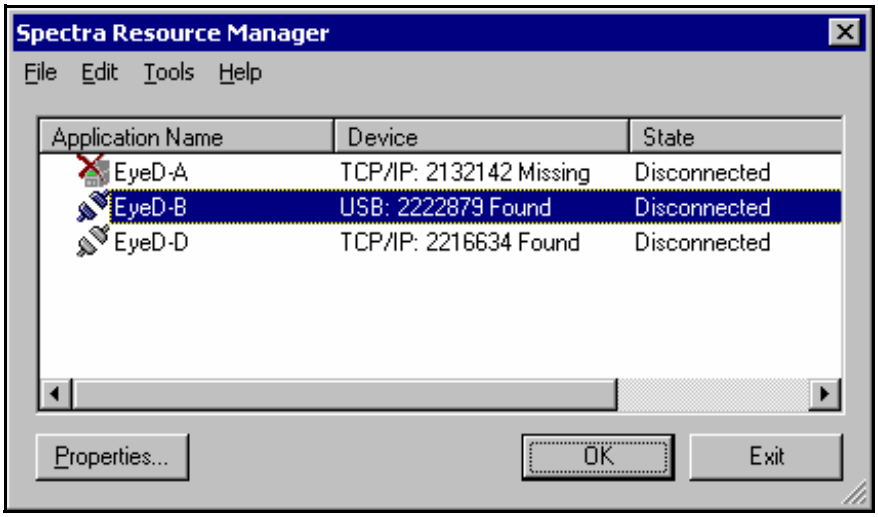


Figure 9-10. SRM Showing USB Connection to Spectrograph

3. The spectrograph must be reflashed with its parameter file once communication has been reestablished between EyeD computer and spectrograph.

NOTE

Reflashing will restore the Spectrograph IP address to its Factory preset IP address. The USB cable can be used to reflash the spectrograph with its parameter code only (not the embedded code).

a. Ensure the spectrograph is on.

b. Close all EyeD instances, SRM and URI.

c. Double-click on the Verity Field Flash Icon, which should be located on the computer desktop. If no icon is on the desktop, the Flash program may need to be installed. This must be done before attempting to flash. If the flash program is already installed, please proceed to step d. For instructions on installing the Flash loader, see Section 9.2 steps 1-4.

d. The Communication Options window will pop up (Figure 4). A Device "ID" should already be Displayed in the "Use USB ID:" pull down. Select the Radio Button next to "Use USB ID:"

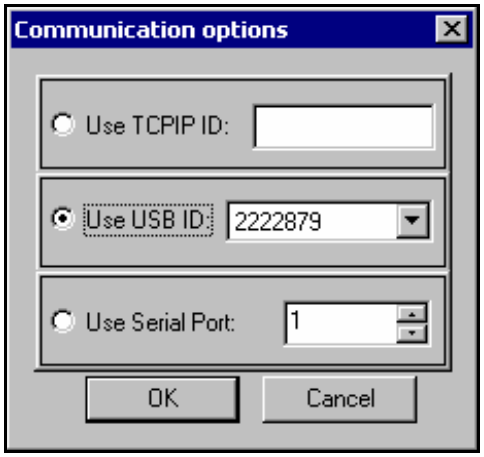


Figure 9-11. Communication Options Window

e. Click on **OK**.

f. The FLDFlash - Flashform 1 opens (Figure 9-12). From here both embedded code and parameters can be output to the spectrograph.

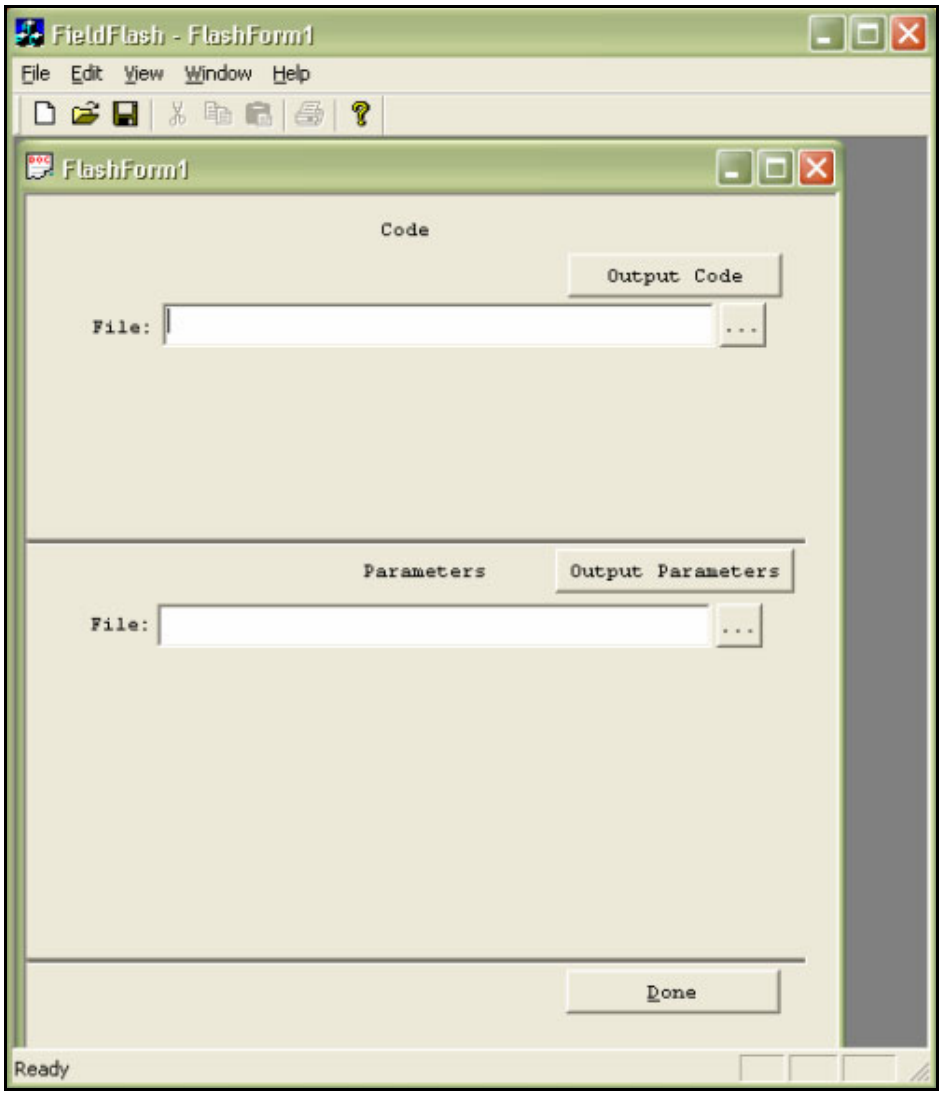


Figure 9-12. FLDFlash - FlashForm 1

g. In the lower text edit box labeled Parameters either enter the full pathname of the Parameter *.BIN* file to be loaded, or press the ellipse […] button to bring up a file browse dialog, and select the file from there. Use the parameter file downloaded previously from the EyeD website.

h. Click on **Output Parameters** button. The dialog in Figure 9-13 is displayed. Click the **Flash** button.



Figure 9-13. Outputs

i. A click will be heard from the spectrograph when the flashing is complete. This indicates the spectrograph has performed an automatic re-boot, and the downloaded parameters are now in-effect. The spectrograph LCD should now display the correct embedded code version and spectrograph model number and type of EyeD unit (EyeD IEP or OES)

   If a click is not heard and the spectrograph LCD displays the message "Reflash Error 1" flashing has not completed successfully. DO NOT cycle power on the spectrograph. This may corrupt the spectrograph boot sector and prevent the spectrograph from being flashed again. Instead, just hit the flash button again, or several times as necessary until the process completes normally.

4. Flashing the parameter code via USB resets the spectragph IP address to its default IP address:

   - 192.168.100.99 for 200mm and
   - 192.9.50.99 for 300mm spectrographs.

   Restore the IP address to the values recommended for installed spectrographs. This should be done using the USB cable.

   a. Open SRM and select the spectrograph application to be updated.

   b. From the Tools menu of SRM select **Device Administration==>Change IP Address**.

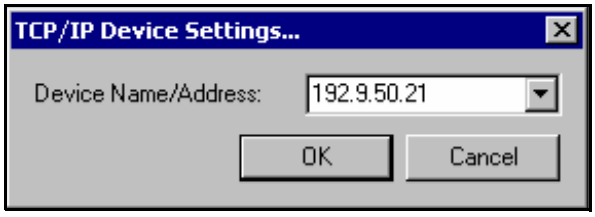


Figure 9-14. Changing Spectrograph IP Address

   c. Enter the IP address corresponding to the chamber and system:

Table 9-1. 200mm Spectrograph IP Addresses		
Chamber	**OES**	**IEP**
A	192.168.100.10	192.168.100.20
B	192.168.100.11	192.168.100.21
C	192.168.100.12	192.168.100.22
D	192.168.100.13	192.168.100.23

Table 9-2. 300mm Spectrograph IP Addresses		
Chamber	**OES**	**IEP**
A	192.9.50.10	192.9.50.20
B	192.9.50.11	192.9.50.21
C	192.9.50.12	192.9.50.22
D	192.9.50.13	192.9.50.23

d. Remove the USB cable and replace it with the original Ethernet cable.

e. Change the communication method for the spectrograph back to TCP/IP. Right click on the EyeD application and select Setup Application.

f. In the Application setup dialog box, select TCP/IP as the Connection type. For the IP address, enter the address that the spectrograph was changed to in step cabove.

g. Click on the OK button and exit the Application Setup dialog. In the main SRM window, the EyeD application device field should now show the connection type as TCP/IP, along with the device ID, and the attribute "Found." The State field should show "Disconnected."

h. This completes recovery of the Spectrograph.

9.4 Spectrograph Changes

Maintenance tasks, in particular changes to SRM, may be complicated by difficulty in communicating with the spectrograph.

Software Versions affected: EyeD 2.3x

9.4.1 Background

When a maintenance item is done with SRM, sometimes it can be difficult to reestablish communication with the spectrograph even though all the settings are correct.

The following describes:

- Section 9.4.2, Change or Swap a Spectrograph

- Section 9.4.3, Changing an IP Address
- Section 9.4.4, Troubleshooting

9.4.2 Change or Swap a Spectrograph

1. Close all EyeD instances including SRM and URI
2. Open the SRM by clicking on icon or going to **Start==>Programs==>EyeD==>SRM**.
3. Disconnect the original spectrograph and connect the replacement spectrograph
4. The window will show the status of the spectrograph. In the example below the instance is setup for the previous spectrograph. The new spectrograph has been connected.

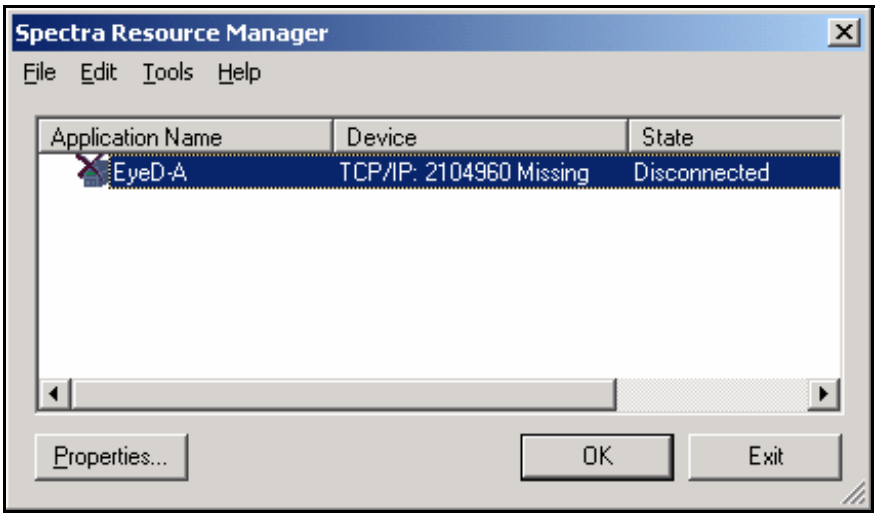


Figure 9-15. Spectra Resource Manager Window

5. Delete the Instance by clicking on **Edit**, **Delete an Application**.
6. Close SRM, by selecting **File**, **OK**, then right click on the **SRM** icon on the desktop tray and select **Exit**.
7. Restart SRM. SRM should be blank.

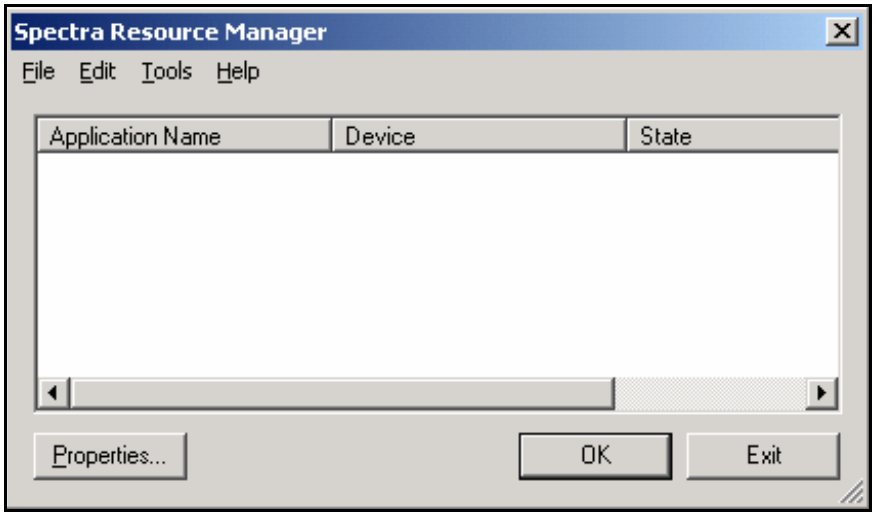


Figure 9-16. Blank SRM

8. Select **Edit==>Insert Application**. Enter the instance name and select **TCP/IP**.

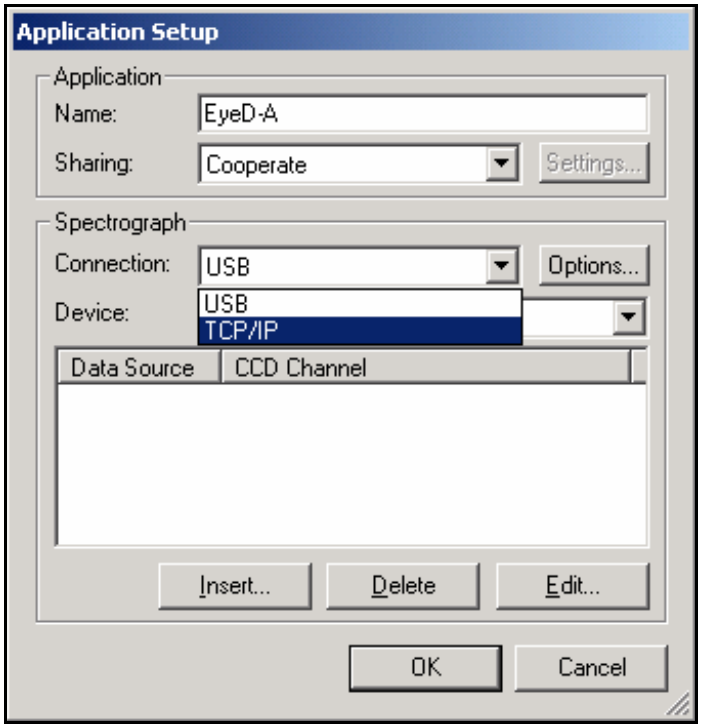


Figure 9-17. Application Setup Window

9. A popup window requesting the IP address of the unit will appear.

   If it is a new unit it will come up with the default IP address of **192.168.100.99** (200mm) or **192.9.50.99** (300mm). If this is a new unit then at this point you must enter a new IP address.

If this unit already has a non-default IP address assigned, then enter that addresss at this time.

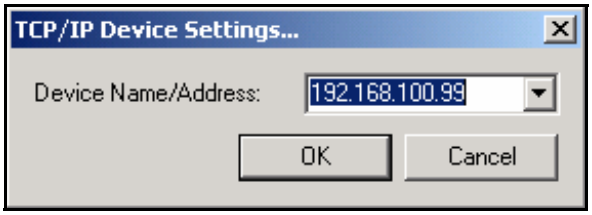


Figure 9-18. Enter Device TCP/IP Address

NOTE

If the SRM entry is found then this procedure is complete. If the IP address detected is different from the assigned spectrograph for that particular EyeD location and instance, the IP address will need to be changed.

9.4.3 Changing an IP Address

Change the IP address of the device to the assigned address of that particular EyeD location and instance.

Select the application, then from the Tools menu select **Change IP Address**.

Enter the appropriate IP address, **192.168.100.xx** or **192.9.50.xx** where **xx** is one of the following pairs of digits, depending on the Chamber and type of EyeD system.

Table 9-3. IP Address Final Digits

	OES	IEP
Chamber A	10	20
Chamber B	11	21
Chamber C	12	22
Chamber D	13	23

9.4.4 Troubleshooting

9.4.4.1 Cannot Connect to Spectrograph

The following message will appear when SRM cannot communicate to the spectrograph.

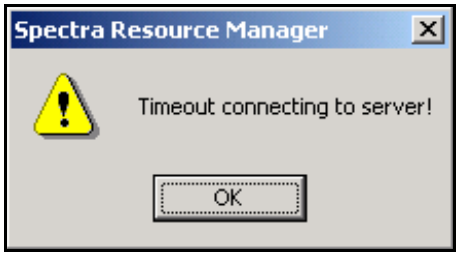


Figure 9-19. Connection Error Message

This could be the result if:

a. Spectrograph is turned off

b. Ethernet connection is broken (or wire disconnected)

c. The Spectrograph LAN port TCP/IP address does not have a matching TCP address scheme (first three prefix numbers must match, and fourth number must differ).

d. Spectrograph IP address conflicts with another spectrograph IP address

e. IP address has been changed on the spectrograph and the spectrograph needs to be rebooted.

f. Windows does not update to the new spectrograph.

g. Ethernet hub needs to be rebooted.

9.4.4.2 Windows Spectrograph LAN Settings do Not Update:

From time to time it may be necessary to RESET the Spectrograph LAN.

This can be done by disabling the LAN connection then re-enabling the LAN connection.

1. Access the Windows Control Panel and select **Network and Dial-Up Connections**.

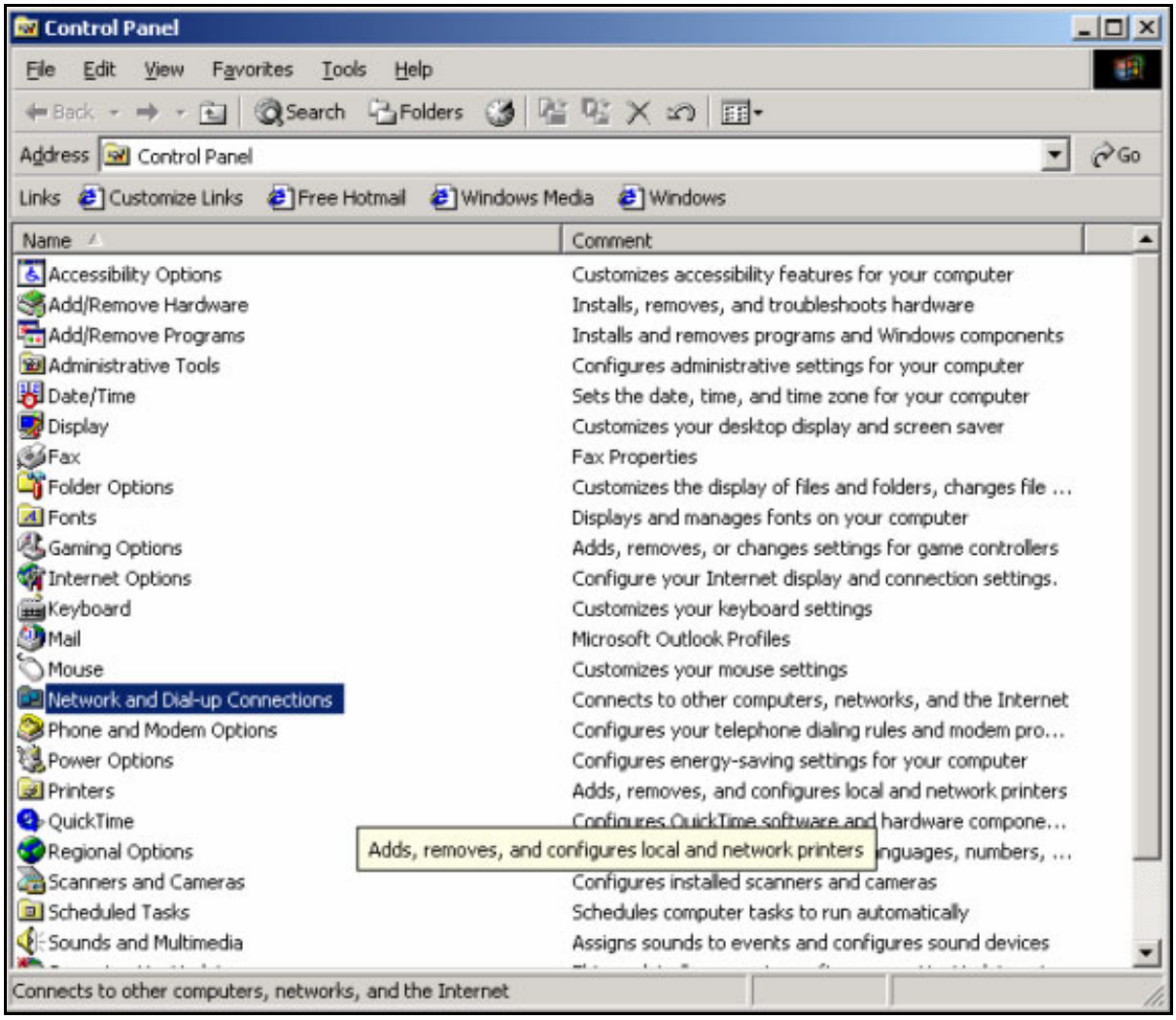

Control Panel
File Edit View Favorites Tools Help
Back Search Folders
Address Control Panel
Go
Links Customize Links Free Hotmail Windows Media Windows
Name
Comment
Accessibility Options
Customizes accessibility features for your computer
Add/Remove Hardware
Installs, removes, and troubleshoots hardware
Add/Remove Programs
Installs and removes programs and Windows components
Administrative Tools
Configures administrative settings for your computer
Date/Time
Sets the date, time, and time zone for your computer
Display
Customizes your desktop display and screen saver
Fax
Fax Properties
Folder Options
Customizes the display of files and folders, changes file ...
Fonts
Displays and manages fonts on your computer
Gaming Options
Adds, removes, or changes settings for game controllers
Internet Options
Configure your Internet display and connection settings.
Keyboard
Customizes your keyboard settings
Mail
Microsoft Outlook Profiles
Mouse
Customizes your mouse settings
Network and Dial-up Connections
Connects to other computers, networks, and the Internet
Phone and Modem Options
Configures your telephone dialing rules and modem pro...
Power Options
Configures energy-saving settings for your computer
Printers
Adds, removes, and configures local and network printers
QuickTime
Configures QuickTime software and hardware compone...
Regional Options
nguages, numbers, ...
Scanners and Cameras
Configures installed scanners and cameras
Scheduled Tasks
Schedules computer tasks to run automatically
Sounds and Multimedia
Assigns sounds to events and configures sound devices
Adds, removes, and configures local and network printers
Connects to other computers, networks, and the Internet

Figure 9-20.

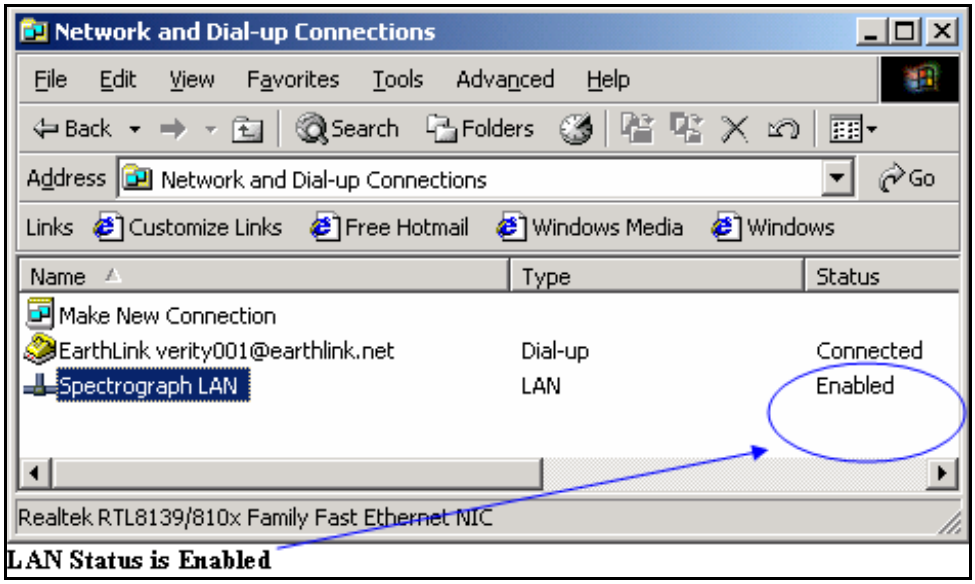


Figure 9-21. Dial-up Connection Showing LAN Enabled

2. Right click on Spectrograph LAN and select Disable

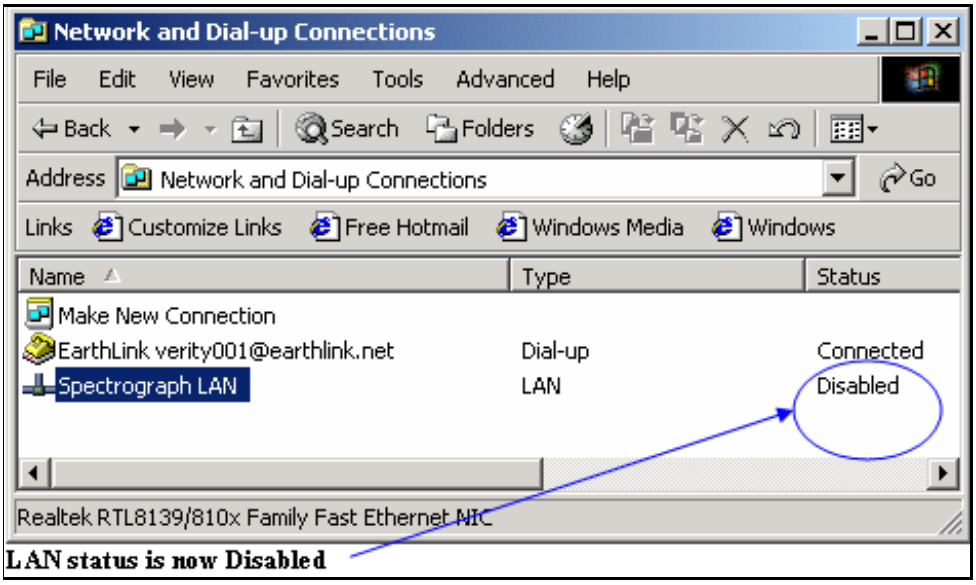


Figure 9-22. Dial-up Connection Showing LAN Disabled

3. Right click on the **Spectrograph LAN** and Re-enable the connection.
4. Close the control panel windows and perform the procedure in Section 9.4.3, Changing an IP Address, following steps 1-8

9.5 Software Upgrades

There are two types of software upgrades:

- Changing the configurations for the existing version of software.
- Installing a new version of software.

9.5.1 Changing Software Configuration

1. Run **Install.exe** as instructed in Section 5.1 for 200mm or Section 7.1 for 300mm.
2. When asked for the installation type, enter **Change** and click **Next**.
3. Choose the desired settings.
4. The system *DOES NOT* need to be rebooted after the change.

9.5.2 Installing a New Version of Software

Follow the instructions given in Section 5.1 or Section 7.1 to install the software. This will automatically transfer all data and active references from the previous version to the new version. If it is preferred to install a new version without transferring any data, simply change the name of the old EyeD file before the installation. Install the new software as described in Section 5.1 or Section 7.1. Any data files may be copied over to the new version through Windows Explorer, however, these data files will not work until the active references have been copied over as well. This is done as follows:

1. Open the desired instance of EyeD.
2. Click on Tools then References.

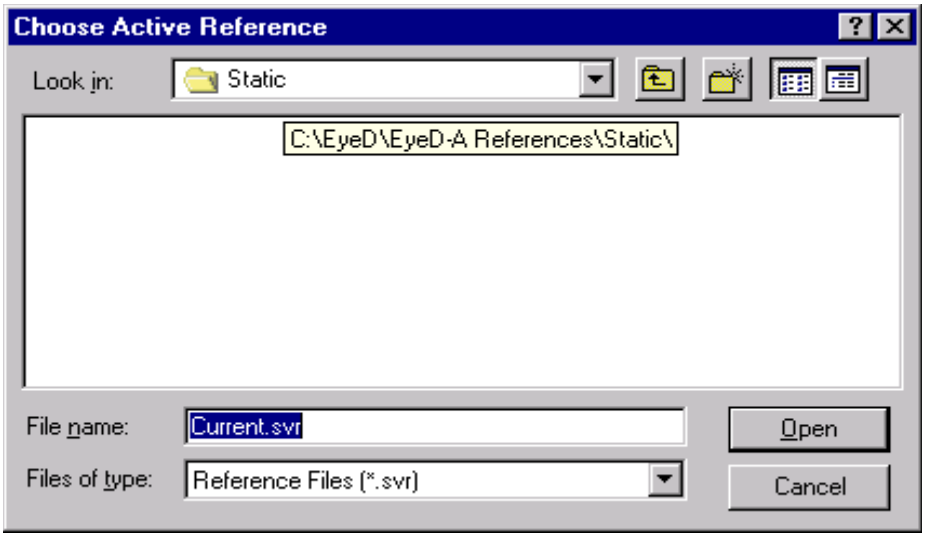


Figure 9-23. Transferring Active References to a New Software Version

3. The Choose Active Reference window will pop up (see Figure 9-23).

4. The references from the previous version of software will be listed and may be transferred by selecting the desired reference and clicking on **Open**.

9.6 Latency

There is a short start delay for EyeD to launch and begin data collection after the start of an endpoint step. This delay is 0.2 and 0.3 seconds. When endpoint is reached, there is a 0.1-0.2 second DIO delay or a 0.2-0.3 second SECS/IDEC serial delay for the Centura to respond and turn off RF power in the chamber. These start and stop times should be considered in the design of the algorithm for high etch rate processes.

9.7 Installing EyeD on Tool with Active Endpoint System

9.7.1 Terminology

Master: The Applied Material Legacy endpoint system, which has control over the chamber and may stop the process.

Slave: The new EyeD system, which may monitor the chamber but may not control the process in the chamber.

9.7.2 Hardware Setup

The EyeD system will be setup as usual, with the following exceptions:

1. The OES fiber optic cable will be attached to A by a bifurcated FO cable that will split the optical signal into two branches, one for each EP system. Note: the IEP fibers can not be bifurcated in this way.

9.8 Configuring URI for Verbose Logging

Prior to EyeD version 2.4, URI was preset to log detailed communication messages. This meant that the log file would grow in size very quickly as it would log every message, making it difficult and inconvenient to read.

In EyeD version 2.4 and higher, the default setting for URI logging is non-verbose, so frequent message, such as PING requests and acknowledgements, are not logged.

Setup URI for Verbose monitoring as follows:

1. Right lick on the URI icon and select Properties:
2. Change target location to the following:

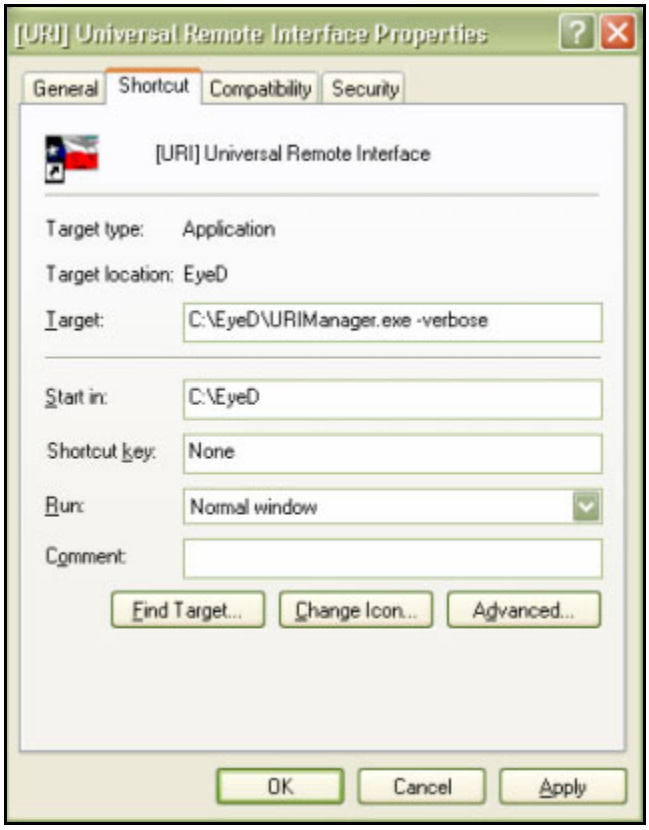


Figure 9-24. URI Properties Window

3. Select **OK**.

9.8.1 Enable Logging URI in URI

1. Open URI and under the tools menu select "Save Communications Log Files".

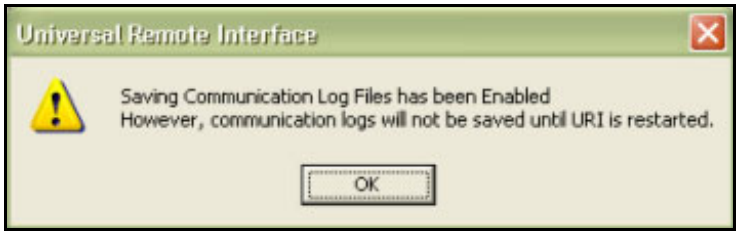


Figure 9-25. Enable Log File Saving

2. Select File and Exit.

9.8.2 Proper Launching of URI/EyeD for Verbose Logging

1. Launch the new URI icon. A Texas flag will appear on the bottom right of the desktop screen.

2. Launch EyeD

THIS PAGE INTENTIONALLY LEFT BLANK

10 Error Tables

10.1 EyeD

10.1.1 EyeD Errors

The following error messages could be encountered in any part of EyeD.

Table 10-1. EyeD Errors

Error message	Error Context	Cause	Corrective action
Clipboard Data is invalid!	Any field where data entry may occur.	A formatting error has occurred.	Retry the operation.
Error copying data to clipboard!	Any field where data entry may occur.	A formatting error has occurred.	Retry the operation.
Device information not returned[1]	During application startup or during device mapping	The application could not communicate with the intended spectrograph.	Make sure that the spectrograph is attached and configured with the correct address if it is an Ethernet connection or that it is plugged in to a USB cable and that the device is turned on.
Dynamic connect is not supported when Spectra Manager is running[1]	During application startup or during device mapping	Only one application at a time may communicate with the USB driver. This disallows concurrent SRM based communications and Dynamic communications.	No correction available.
Dynamic connect is not supported with the basic user-interface. [1]	During application startup or during device mapping	The basic interface only supports SRM connectivity.	Restart application to work with SRM
Multi-instance support not supported if Dynamic instances are running. [1]	During application startup or during device mapping	Only one application at a time may communicate with the USB driver. This disallows concurrent SRM based communications and Dynamic communications.	No correction available.
No Data Sources are mapped for this application! [2]	During application startup or during device mapping	An application communicating with Spectra Resource Manager has no mapped data source.	Shut down this application and bring up the Spectra Resource Manager and assign a data source for this application.

Table 10-1. EyeD Errors

No Spectrographs detected! [1]	During application startup or during device mapping	The application is running in stand-alone Dynamic mode and it cannot detect the presence of a spectrograph on the USB port.	Make sure that there is a spectrograph attached to the USB port.
Notified of the device being available but failed to get Device Parameters from SRM. [1]	During application startup or during device mapping	The application may have lost communications with the intended spectrograph.	Make sure that the spectrograph is attached and configured with the correct address if it is an Ethernet connection or that it is plugged in to a USB cable and that the device is turned on.
Spectra Resource Manager not found. [2]	During application startup or during device mapping	The application could not start the Spectra Resource Manager.	Make sure the system is properly installed and that the Spectra Resource Manager in a path referenced directory.
The device information is corrupted! [1]	During application startup or during device mapping	The application could not communicate with the intended spectrograph properly.	Make sure that the spectrograph is attached and configured with the correct address if it is an Ethernet connection or that it is plugged in to a USB cable and that the device is turned on.
Universal Remote Interface not found	During application startup or during device mapping	The application could not start the Universal Remote Interface.	Make sure the system is properly installed and that the Universal Remote Interface in a path referenced directory.
A packet of data was received from the spectrograph that could not be processed.	During Capturing or Processing	A packet of data was received from the spectrograph that could not be processed.	Retry the operation or contact your manufacturer for more details.
FATAL ERROR: Packet of unexpected size was received!	During Capturing or Processing	A packet of data was received from the spectrograph that could not be processed.	Retry the operation or contact your manufacturer for more details.
Neural Net equation is empty!	During Capturing or Processing	If a Neural Net sequence item was created without an equation.	Remove the Neural Net sequence item or supply an equation for it.
The reprocessed data file is not open	During Capturing or Processing	A file specified for reprocessing could not be opened.	Make sure the file exists and that sufficient rights for reading it exist.

Table 10-1. EyeD Errors

Time out! [3]	During Capturing or Processing	Numerous causes. Most likely cause is the application could not process requested data and equations fast enough to receive spectrograph data.	Reduce the calculations required in the specified processing or buy a faster machine.
Unable to create a directory based on '%s	'During Capturing or Processing	The pattern settings for creating a file may not allow for enough files to be created or the directory specified maybe invalid.	Check the directory or pattern for making files and correct as necessary.
Unable to create a file based on the directory '%s' and the base filename '%s	During Capturing or Processing	The pattern settings for creating a file may not allow for enough files to be created or the directory specified maybe invalid.	Check the directory or pattern for making files and correct as necessary.
Lost connection to Spectral Resource Manager. [1]	Error could occur at any time	The SRM is no longer communicating.	Restart the application and insure that the SRM is running.
Lost connection to Spectrograph. [1]	Error could occur at any time	The connection to the spectrograph has been dropped.	Make sure that all cables are still connected and that the spectrograph and any communications equipment are still working.
Undefined Error! Write a detailed description of the action(s) that resulted in the error message, and contact your vendor.	Error could occur at any time	Unknown/Un-planed for error	Either retry operation or log all pertinent information and contact the vendor.
Failed to save security settings!	Not related to any particular field	There was a fault writing the security settings.	Retry the operation or restart the application.
Spectra Resource Manager: %s [2]	Not related to any particular field	An error occurred in the Spectra Resource Manager.	Consult the error listed with the Spectra Resource Manager error list.

10.1.2 Auto Delete

The following EyeD Errors can be encountered in the path:

Main Menu / Tools Menu / Options / Auto Delete Page

Table 10-2. Auto Delete Page

Error Message	Error Context	Cause	Corrective Action
Please enter a number between 0 and 100	Warning given when less than percentage of disk free	A number was entered in this field that was either less than 0 or greater than 100	Enter a number between 0 and 100 inclusively.
Please enter a number between 0 and 100	Emergency deletion if less than percentage of disk free	A number was entered in this field that was either less than 0 or greater than 100	Enter a number between 1 and 100 inclusively.
Please enter a number between 1 and 100	Search for old files when disk is percentage full	A number was entered in this field that was either less than 1 or greater than 100	Enter a number between 1 and 100 inclusively.
Please enter a positive integer	Delay between delete searches in seconds	A number was entered in this field that was less than 0	Enter a number between 0 and 3600 inclusively.
Please enter an integer between 0 and 3600	Delay between delete searches in seconds	A number was entered in this field that was greater than 3600	Enter a number between 0 and 3600 inclusively.
Please enter an integer between 1 and 365	Keep data files for a number of days	A number was entered in this field that was either less than 1 or greater than 365	Enter a number between 1 and 365 inclusively.
The execution percent must be > the warning percent	*Search for old files* when disk is percentage full & Warning given when less than percentage of disk free	The value of *Search for old files* is less than the value of the Warning given percentage	Either decrease the Search value or increase the Warning value so that its value is greater than the Search value.
The warning percent must be > the error percent	Warning given when less than percentage of disk free & Emergency deletion if less than percentage of disk free	The value of the *Warning given percentage* is less than the value of the Emergency deletion percentage	Either decrease the Warning value or increase the value so that the Emergency value is greater than the Warning value.

10.1.3 Directories

The following EyeD errors can be encountered in the path:

Main Menu / Tools Menu / Options / Directories

Table 10-3. Directories

Error Message	Error Context	Cause	Corrective Action
'!' allowed only out of quotes to represent the instance number	Both 'Filename' and 'Path' templates for both 'Local Capture and Process' and 'Remote Control Processing' sections	One or more special characters are in a quoted text.	Remove the special character from the quoted text.
'&' allowed only out of quotes to represent the configuration name	Both 'Filename' and 'Path' templates for both 'Local Capture and Process' and 'Remote Control Processing' sections	One or more special characters are in a quoted text.	Remove the special character from the quoted text.
'@' allowed only out of quotes to represent the date	Both 'Filename' and 'Path' templates for both 'Local Capture and Process' and 'Remote Control Processing' sections	One or more serial characters are in a quoted text.	Remove the special character from the quoted text.
Cannot begin a template with a back-slash	Both 'Filename' and 'Path' templates for both 'Local Capture and Process' and 'Remote Control Processing' sections	The first character of a template is a black -slash.	Remove the back-slash.
Control characters like tabs and new lines are illegal	Both 'Filename' and 'Path' templates for both 'Local Capture and Process' and 'Remote Control Processing' sections	An illegal character is present.	Remove the character.
Directory breaks must not be in quotes	Both 'Filename' and 'Path' templates for both 'Local Capture and Process' and 'Remote Control Processing' sections	A directory break is in side a quoted text.	Remove the directory break.
Single quotes are not aligned	Both 'Filename' and 'Path' templates for both 'Local Capture and Process' and 'Remote Control Processing' sections	Quotation marks must be added in pairs	Locate the space for the missing quotation mark and add it
Slashes are illegal	Both 'Filename' and 'Path' templates for both 'Local Capture and Process' and 'Remote Control Processing' sections	An illegal character is present.	Remove the character.

Table 10-3. Directories

Error Message	Error Context	Cause	Corrective Action
Spaces are only allowed in single quotes	Both 'Filename' and 'Path' templates for both 'Local Capture and Process' and 'Remote Control Processing' sections	This character is outside of quoted text.	Remove the character.
Text needs to be in single quotes	Both 'Filename' and 'Path' templates for both 'Local Capture and Process and 'Remote Control Processing' sections	There is text outside of quoted text.	Non-symbolic text must be in side a quote range.
Two directory breaks in a row is invalid	Both 'Filename' and 'Path' templates for both 'Local Capture and Process' and 'Remote Control Processing' sections	There are at least two sequential directory breaks.	Remove the extraneous directory breaks.
'#' Step Number only allowed for remote templates	Both 'Filename' and 'Path' templates for the 'Local Capture and Process' section	One or more symbols reserved for 'Remote Control Processing' template has been used in a 'Local Capture and Process' template	Remove the offending Symbol from the affected template.
'$' Wafer Lot name only allowed for remote templates	Both 'Filename' and 'Path' templates for the 'Local Capture and Process' section	One or more symbols reserved for 'Remote Control Processing' template has been used in a 'Local Capture and Process' template	Remove the offending Symbol from the affected template.
'%' Cassette ID only allowed for remote templates	Both 'Filename' and 'Path' templates for the 'Local Capture and Process' section	One or more symbols reserved for 'Remote Control Processing' template has been used in a 'Local Capture and Process' template	Remove the offending Symbol from the affected template.
'*' Wafer ID only allowed for remote templates	Both 'Filename' and 'Path' templates for the 'Local Capture and Process' section	One or more symbols reserved for 'Remote Control Processing' template has been used in a 'Local Capture and Process' template	Remove the offending Symbol from the affected template.
'?' Wafer Recipe only allowed for remote templates	Both 'Filename' and 'Path' templates for the 'Local Capture and Process' section	One or more symbols reserved for 'Remote Control Processing' template has been used in a 'Local Capture and Process' template	Remove the offending Symbol from the affected template.

10.1.4 User Page

The following EyeD Errors can be encountered in the path:

Main Menu / Tools Menu / Options / User Page

Table 10-4. User Page

Error Message	Error Context	Cause	Corrective Action
Please pick an integer between 0 and 100000	Login Time Out Value	The value of this field is not between 0 and 100000 inclusively	Enter a value that is between 0 and 100000 inclusively
Must have at least one user with Administration access	User List Control	No user has Administration rights.	Give at least one-user Administration rights by editing that user profile.

10.1.5 User Page Edit

The following EyeD errors can be encountered in the path:

Main Menu / Tools Menu / Options / User Page Edit

Table 10-5. User Page Edit

Error Message	Error Context	Cause	Corrective Action
The New Password and confirmation do not match	New Password Field & Confirm Password Field	These fields do not contain the same text.	Make sure that the fields contain the same text.
The Old Password is incorrect	Old Password Field	The text in this field does not contain the same password that is associated with the list user.	Make sure the field contains the same text as the established password for this user.

10.1.6 Neural Net

The following EyeD errors can be encountered in the pate:

Setup Dialog / Sequences / Neural Net Properties

Table 10-6. Neural Net

Error Message	Error Context	Cause	Corrective Action
The equation name is not represented by this file	File Name field, the Equation field and the OK button	The File selected does contain the required equation.	Try a different file or select a different equation.
The Neural Net cannot be trained without any training examples	Training Patterns List Control	There are no patterns in the list	Add a pattern-training file.

10.1.7 Configuration Setup Dialog

THE FOLLOWING EyeD ERRORS CAN BE ENCOUNTERED IN THE CONFIGURATION SETUP DIALOG

Table 10-7. Configuration Setup Dialog

Error Message	Error Context	Cause	Corrective Action
The spectrograph sources are not in sync. Enable must be in sync to enable the flash mode.	Apparently a dead error.	Apparently a dead error.	Apparently a dead error.
Turning 'Alternating Strobe Operation' on will add virtual data sources to mirror all spectrograph data sources. Continue?	Flash Lamp Mode list box	There are no virtual data sources and this will create them.	Either answer yes to the message box and alter the configuration or select no and pick a configuration compatible with the desired mode.
Turning off 'Alternating Strobe Operation' will remove the virtual data sources. Continue?	Flash Lamp Mode list box	There are virtual data sources and this will eliminate them.	Either answer yes to the message box and alter the configuration or select no and pick a configuration compatible with the desired mode.
The configuration expects a different spectrum than is available with the current device. Would you like to synchronize the configuration to be compatible with the current device? [4]	Found when trying to load a configuration (*.svc) file	The configuration was created with a different device that the one that is currently attached	Either answer yes to the message box and alter the configuration or select no and pick a configuration compatible with the current device.
The configuration has fewer spectrograph sources than are available to the system. Would you like to synchronize the sources to be compatible with the current system?	Found when trying to load a configuration (*.svc) file	The configuration was created with a different device that the one that is currently attached	Either answer yes to the message box and alter the configuration or select no and pick a configuration compatible with the current device.
The configuration uses more spectrograph sources than are available to the system. Would you like to synchronize the spectrograph sources to be compatible with the current device? [4]	Found when trying to load a configuration (*.svc) file	The configuration was created with a different device that the one that is currently attached	Either answer yes to the message box and alter the configuration or select no and pick a configuration compatible with the current device.

Table 10-7. Configuration Setup Dialog

Error Message	Error Context	Cause	Corrective Action
Derived Data Sources are obsolete	Found when trying to load an outdated data file	Certain very old data files will not be compatible with more recent releases of EyeD, especially those using Synchronous Data Collection settings	Use a different data file
There are errors! Are you sure you want to save the configuration? [4]	Saving a configuration may trigger this.	There are one or more errors in the configuration.	The output log will display any errors produced. Select the error for information and make corrective action as necessary.

10.1.8 Advanced

The following EyeD errors can be encountered in the path:

Configuration Dialog / Advanced

Table 10-8. Advanced

Error Message	Error Context	Cause	Corrective Action
Excessive history may cause the system to fall behind. [5]	History Spectra Available to System for Spectral Equations	A number entered that was greater than 100	Either accept/test the system and determine if will fall behind or pick a smaller number.
Please enter an integer between 0 and 500	History Spectra Available to System for Spectral Equations and number of spectra captured when pulsed	A number was entered that was not between 0 and 500.	Enter a number between 0 and 500

10.1.9 Reprocess Dialog

The following EyeD errors can be encountered in the path:

Configuration Window / Reprocess Dialog / Insert Files

Table 10-9. Reprocess Dialog

Error Message	Error Context	Cause	Corrective Action
Sequence item is not recognized as having an expression	Any time validation occurs	Severe error in Validation testing	Close the application and try again.
Some settings for data file do not match. Use for reprocessing anyway?	File Name	The settings for the current configuration do not match those specified in the data file selected.	Select **Yes** if you know the configuration will work with this data file or select **No** to pick a different file.
Failed to read some spectral data from the original data file!	Trying to save a data file	Saving a file that contained reprocessed data from a separate data file.	None
There is no data to save	When trying to save a data file	Saving a file that contained reprocessed data from a separate data file.	None

10.1.10 Reprocess List

The following EyeD errors can be encountered in the Reprocess List function.

Table 10-10. Reprocess List

Error Message	Error Context	Cause	Corrective Action
Configuration File does not have any files in the reprocess list	When attempting to reprocess	Selecting the Reprocess List button when there are no files in the reprocess list	Select the Reprocess button in the configuration window and files to the Reprocess List

10.1.11 Spectral Graphs

The following EyeD errors can be encountered in the Export function in spectral graphs.

This function is no longer visible once a graph window has lost the focus (i.e. when another unrelated item has been selected or highlighted). Export will invoke varying dialogs based on the type of graph window selected.

Table 10-11. Spectral Graphs

Error Message	Error Context	Cause	Corrective Action
Please enter an integer between 1 and 1000000	Export displayed spectra from sample start and end fields	A number was entered that was not between 1 and 1000000.	Enter a number between 1 and 1000000
Starting sample number must be less than or equal to the ending sample number	Export displayed spectra from sample start and end fields	The start value is greater than the end value.	Make the start value less than the end value.
Please enter an integer between 1 and 800	Export only the wavelengths from start to end.	A number was entered that was not between 1 and 800.	Enter a number between 1 and 800
Starting wavelength must be less than or equal to the ending wavelength	Export only the wavelengths from start to end.	The start value is greater than the end value.	Make the start value less than the end value.

10.1.12 Region Equation

The following EyeD errors can be encountered in the Region Equation Properties Dialog.

Table 10-12. Region Equations

Error Message	Error Context	Cause	Corrective Action
The region is invalid	During validation	The region as defined did not pass validation	Examine the error log for details and correct any validation errors.
This name must be unique	Name Field	The name specified for this region has already been used.	Pick another name not it use for this region.

10.1.13 Snapshot

THE FOLLOWING EyeD ERRORS CAN BE ENCOUNTERED IN THE SNAPSHOT DIALOG

Table 10-13. Snapshot

Error Message	Error Context	Cause	Corrective Action
This name must be unique.	Name Field	The name of the snapshot is not unique.	Supply a name that is unique.
Selection of a spectral input is required	Spectral Input List Control	No item from the list has been selected.	Select one item from the list.

10.2 Spectra Resource Manager (SRM) Errors

10.2.1 SRM

The following errors are encountered in the Spectra Resource Manager (SRM) Utility.

Table 10-14. Spectra Resource Manager Errors

Error Message	Error Context	Cause	Corrective Action
Configure Application: Access denied.	Access Privileges	NSA - Insufficient Access Rights.	If this is a required action then you must use a login with the required access rights, have access rights altered to allow access, or have the administrator login to perform the required task.
Delete Application: Access denied.	Access Privileges	NSA - Insufficient Access Rights.	If this is a required action then you must use a login with the required access rights, have your access rights altered to allow access to these functions, or have someone else log in who's access rights are sufficient to perform the required task.
Insert Application: Access denied.	Access Privileges	NSA - Insufficient Access Rights.	If this is a required action then you must use a login with the required access rights, have your access rights altered to allow access to these functions, or have someone else log in who's access rights are sufficient to perform the required task.

Table 10-14. Spectra Resource Manager Errors

Error Message	Error Context	Cause	Corrective Action
Reset Device: Access denied.	Access Privileges	NSA - Insufficient Access Rights.	If this is a required action then you must use a login with the required access rights, have your access rights altered to allow access to these functions, or have someone else log in who's access rights are sufficient to perform the required task.
Test Dialog: Access denied.	Access Privileges	NSA - Insufficient Access Rights.	If this is a required action then you must use a login with the required access rights, have your access rights altered to allow access to these functions, or have someone else log in who's access rights are sufficient to perform the required task.
A spectrograph must be chosen.	The Device and Connection Fields	No spectrograph was selected.	Select both the connection type and the device.
At least one data source must be mapped for the application.	The Device and Connection Fields	No spectrograph was selected.	Select both the connection type and the device.
Device is busy. [2]	The Device and Connection Fields	A reset command was issued and the device returned that is busy.	Make sure all cables are properly connected and that all required communications devices are enabled and that the spectrograph is powered up. Also, make sure that the Connection and Device parameters match the device access type and address.
Device is unavailable. [1]	The Device and Connection Fields	The specified device could not be reached.	Make sure all cables are properly connected and that all required communications devices are enabled and that the spectrograph is powered up. Also, make sure that the Connection and Device parameters match the device access type and address.

Table 10-14. Spectra Resource Manager Errors

Error Message	Error Context	Cause	Corrective Action
Invalid device parameters returned! [1]	The Device and Connection Fields	The specified device returned unexpected results.	Make sure all cables are properly connected and that all required communications devices are enabled and that the spectrograph is powered up. Also, make sure that the Connection and Device parameters match the device access type and address.
Time out! [6]	The Device and Connection Fields	The specified device could not be reached.	Make sure all cables are properly connected and that all required communications devices are enabled and that the spectrograph is powered up. Also, make sure that the Connection and Device parameters match the device access type and address.
Failed to connect to client application.	The Name Field	The name specified for the application does not match any existing application names.	Make sure the name specified for the application actually matches the name of an application.
You can not delete an application that is connected	When attempting to delete an application	The associated application is currently active.	Shutdown the associated application.
You cannot modify an application that is connected.	When attempting to modify an application	The associated application is currently active.	Shutdown the associated application.
Not all client applications have closed their connections. Close anyway?	When closing SRM	There are active applications.	Select yes to terminate connections anyway (lost data may occur) or no to continue running the SRM.
'%s' is referencing the device, exclusive access denied for device '%s'.	When selecting a device for an application	Another application has access to the specified device.	Select a different device, alter the access of the other application or select non-exclusive access for the device.
Application '%s' has exclusive access to device '%s'.	When selecting a device for an application	Another application has exclusive access to the specified device.	Select a different device or alter the access of the other application.

10.3 Embedded Firmware Errors in the SD1024 series Detector

10.3.1 Embedded Code Errors

The following errors can result from the embedded firmware programmed to the spectrograph's internal chipsets.

Table 10-15. SD1024D Firmware Error Messages

Error No.	Error Message	Explanation	Resolution
0	NO ERROR	No Error has occurred.	
1	UNKNOWN COMMAND	The command received was not a valid text command.	Check the RS-232 communication link and try again.
2		This message indicates that the 2186 DSP is busy. (Not currently used)	N/A
6	BAD DATA	The data received in the storage routine has an incorrect negative message length, or is not correct.	Noise on the serial line is typically the cause of this error message. Make sure a properly grounded cable is being used.
7	DATA OVERFLOW	The data received in the storage routine has too much data to fit in the memory allocated.	N/A
11	HOST BUSY [2]	This error is issued when the host fails to acknowledge an SD1024D message in any communications protocol.	Slow the Data rate down by decreasing the Integration Time.
12	SHARC DATA LOST	The 386 is overloaded and a data message(s) from the DSP has been missed or skipped.	Slow the Data rate down by decreasing the Integration Time.
13	ERROR WRITING SHARC MEMORY	An error occurred writing to the DSP memory (Not currently used).	N/A
14	SHARC BOOT DATA MISMATCH	This error is issued when the flash block that is written to the DSP does not match the actual amount of data transferred.	Re-flash the Sharc DSP code into the spectrograph and try again. If this problem persists, contact Verity Instruments.
15	DATA OVERRUN	This error is issued when a data buffer receives more data than it has space allocated. The Ethernet code and DSP DIO routines use this error code.	Slow the Data rate down by decreasing the Integration Time.

Table 10-15. SD1024D Firmware Error Messages

Error No.	Error Message	Explanation	Resolution
16	DATA TIMEOUT	This error is issued when the 386 attempts to read data from the DSP (which does not send anything) and the time-out period elapses.	Cycle the power to the detector and try again.
17	ALREADY RUNNING	This warning is issued if the 386 has already received a start command.	N/A
18	FLASHLAMP SAFETY SWITCH TRIGGERED	This error occurs when the flashlamp interlock line is not pulled high, AND a command is issued to use the flashlamp.	Check the connections of the Flashlamp unit and try again.
19	19	Status message to signify when an extra Stop command is received (i.e. not running)	N/A
20	COMM ERROR TO HOST ON STOP	This error is issued if the 386 has processed the Stop command, but there is still residual data to the host which receives the Stop command and the data has not been moved out in the time allotted.	Cycle the power to the detector and try again.
21	SPURIOUS SHARC COMMAND	This error is issued when an unknown command is received by the 386 from the DSP's message handler routine.	Ensure that the software versions of the 386 and DSP code are compatible versions. Code updates should be sent in pairs unless specifically instructed by Verity Instruments to use code versions that differ.
22	ETHERNET INITIALIZATION PROBLEM	An error occurred initializing the Ethernet TCP/IP stack.	Cycle the power to the detector and try again. If this problem persists, contact Verity Instruments.
23	ETHERNET OPEN ERROR	An error occurred while trying to open the Ethernet port.	Cycle the power to the detector and try again. If this problem persists, contact Verity Instruments.
24	ETHERNET IP ADDRESS ERROR	An invalid IP address is specified in the unit setup files.	Check the IP address and Subnet mask in the parameter file and re-flash the parameters to the SD1024D detector.
25	SHARC DIDN'T RESPOND TO STOP	A time-out on the 386 occurred waiting for the acknowledgment from the DSP of the Stop command.	Cycle the power to the unit and try again. If this problem persists, contact Verity Instruments.

Table 10-15. SD1024D Firmware Error Messages

Error No.	Error Message	Explanation	Resolution
100	UNASSIGNED SHARC ERROR	Error during DSP boot.	Cycle the power to the unit and try again. If this problem persists, contact Verity Instruments.
101	NO SHARC SETUP	Error by the 386 acquiring the setup pointer from the DSP.	Cycle the power to the unit and try again. If This problem persists, re-flash the Sharc code. If the problem still exists, contact Verity Instruments.
102	NO SHARC DATA	Error acquiring data pointer from the DSP by the 386.	Cycle the power to the unit and try again. If this problem persists, re-flash the Sharc code. If the problem still exists, contact Verity Instruments.
103	SHARC BUS ERROR	Attempt by the 386 to request the DSP bus has failed.	Cycle the power to the unit and try again. If this problem persists, re-flash the Sharc code. If the problem still exists, contact Verity Instruments.
104	DATA UNDERRUN	Not enough data read in the time allotted for reading data.	Increase the Integration Time and try again.
105	SHARC SETUP ERROR	Setup failed verification (Not currently used).	N/A

[1] *This will cause a condition such that a remote command to start processing will fail.*

[2] *This could result in a condition such that a remote command to start processing will fail.*

[3] *This will cause a time-out to be sent to the tool if there is an outstanding message from the PM.*

[4] *This could result in a condition such that a remote command to start processing, if the current configuration is started by the PM.*

[5] *If the current configuration is started by the PM and the system cannot keep up, it could trigger a time out event.*

[6] *This can cascade a time-out condition.*

THIS PAGE INTENTIONALLY LEFT BLANK.

A EyeD Software Operation Tutorial

The purpose of this chapter is to provide an understanding of the EyeD software operations. The chapter is structured as a tutorial for ease in learning the operations. Exercises are used as examples. These exercises teach the steps and techniques required for creating various endpoint algorithms.

A.1 Hardware and Software Requirements

The software can be run on a PC to familiarize operators with the operating processes. To run the exercises, access to a personal computer (PC) running EyeD is required. Ideally, an EyeD spectrograph should be connected to the PC for collecting spectral data in real time. If an EyeD spectrograph is not available, the majority of the exercises can still be completed, as 95% or more of EyeD software capability can be demonstrated using only the PC. Data files are included for use with the exercises.

Some files referred to in this tutorial are included as part of the EyeD software installation. The files are also available on http://amat.mis.amat.com/sietch/engineering/index.htm.

The tutorial data and configuration files are read-only to protect them for future use. Individual operations may be saved under a different file name.

A.2 Different Mathematical Quantities

This section provides an explanation of the different kinds of mathematical quantities that are manipulated to create an endpoint algorithm using the EyeD software. The definition of a simple vector is a point having both direction and magnitude. A point in three-dimensional space is routinely described as a multi-dimensional vector, which is the vector sum of three simple vectors having specific magnitudes in the X, Y, and Z directions. The vector can be written as a three-dimensional row vector (3, 8, 5), where the 3, 8, and 5 indicate magnitudes in the X, Y, and Z directions.

Similarly, a spectrograph-produced spectrum can be described as a vector. The light intensity detected by the spectrograph at one wavelength is a simple vector. This simple vector has a direction (its specific wavelength) and magnitude (intensity measured at that wavelength).

EyeD reports the light intensity at every 0.5 nm wavelength from 200 to 800 nm (1,201 intensity measurements). This instrument also reports the spectrum as a string of 1,201 intensity measurements in wavelength order, viewing the spectrum as a 1,201-dimensional vector known as a spectral vector.

EyeD collects spectral vectors at equal time intervals. By writing each spectral vector as a new row, a spectral matrix can be created that has 1,201 columns (wavelengths) and as many rows as spectra recorded over time. Each row represents the multi-wavelength spectral vector (spectrum) at one instance (integration period) in time. Each matrix column represents the way the intensity of a single wavelength behaved during the time period that spectra were collected.

The design of the EyeD software allows process engineers to perform calculations on each spectral vector immediately after it is reported in real time by the EyeD. EyeD stores each

vector collected (forming the spectral matrix), and stores the instruction set, called the configuration, used during real-time calculations as a header of the data file. With these two pieces of information, the original spectral matrix can be reprocessed to produce the same exact results. Furthermore, by using a different instruction set, reprocessing the data will create the results that would have been produced if the new instruction set had been used. The Reprocessing capability of EyeD makes endpoint algorithm development for semiconductor processing affordable. By collecting a few representative spectral matrices during typical process runs, the process engineer has enough data to perform more than 90% of the work needed to develop an endpoint algorithm.

A.3 Order of Calculations

Equations are calculated in the order in which they are listed in the Equations window. This order of calculations is followed regardless of the equation type. Any Spectral or Trend equation can reference another Spectral or Trend equation. A Region equation can reference any Spectral equation or raw data source that precedes it in the list. Within each class of items listed, items are processed in the order they appear in the configuration file. The schematic on the next page provides a pictorial look at the order of calculation.

A.4 Scenario and Material Organization

This exercise uses the spectrum of room fluorescent lights to simulate a process endpoint and record the “Representative Process Spectra” for the tutorial. By simply placing a hand between the fiber optic and the room light source, one can simulate a pronounced decreasing endpoint signal. Because of the wide availability of fluorescent lighting in office buildings, this light source is used because it contains both background continuum and the spectral lines of the mercury plasma, which is similar to the line spectra of plasma tools. By using the office lights to learn the use of the EyeD Software, process engineers can reduce the need for costly plasma process tool time.

The scenario for the tutorial is that the engineer uses an EyeD to collect two spectra during two typical wafer runs on the plasma process tool. The process engineer develops an endpoint algorithm for the plasma process. From prior knowledge, it is known that the 577 nm peak, one of the mercury doublets in the wavelength, should be used for endpoint. In addition, the fabrication plant manager has requested that the effects of doing background subtraction for the 577 nm peak be shown.

The scenario continues with plans to complete this project according to the following steps:

1. With a minimum of effort, configure the software to collect EyeD spectra from a couple of process runs.
2. Take a quick look at the spectra.
3. Graph the 577 nm region to see the detail in the spectra.
4. Setup the software to do background correction on the 577 nm peak.
5. Compare the background-corrected signal to the uncorrected signal.
6. Select one signal and develop several endpoint detection algorithms.

The presentations of topics in this tutorial appear in the order a project engineer would follow to complete this type of project using the EyeD tools. Each tutorial section logically builds on the previous sections, so it is recommended that the presented order be followed.

To ensure uniform, predictable results throughout the continued use of this tutorial, concepts discussed in each section are captured in a series of read-only configuration files named Tutorial#n.svc. Using these stored configuration files, the tutorial can be started or restarted at any time.

A.5 Tutorial Exercises

- Exercise 1. Starting the EyeD Application, Section A.5.1
- Exercise 2. Configuring the EyeD Applications Window, Section A.5.2
- Exercise 3: Creating a New Configuration File, Section A.5.3
- Exercise 4: Preparing a Configuration File to Collect and Display Spectra, Section A.5.4
- Exercise 5: Collecting and Displaying Spectra, Section B.5.5
- Exercise 6: Reprocessing Previously Collected Spectra, Section B.5.7
- Exercise 7: Becoming Familiar with the Data Navigation Tools, Section B.5.8
- Exercise 8: Examining Reprocessed Spectra, Section B.5.9
- Exercise 9: Tracking Configuration Changes, Section B.5.10
- Exercise 10: Defining Spectral Regions, Section B.5.11
- Exercise 11: Adding a Graph to an Existing Configuration, Section B.5.12
- Exercise 12: Saving and Activating Configurations, Section B.5.13
- Exercise 13: Debugging Errors, Section B.5.14
- Exercise 14: Running (Testing) an Edited Configuration, Section B.5.15
- Exercise 15: Adding Another Trend Equation, Section B.5.16
- Exercise 16: Use Snapshots to Normalize a Data Trend to an Initial Value, Section B.5.17
- Exercise 16: Configure Endpoint Sequence Based on Derivative Trend and Snapshots, Section B.5.18
- Exercise 16: Defining an Endpoint Sequence, Section B.5.19

A.5.1 Starting the EyeD Software

To launch the EyeD software:

Double-click on the EyeD icon (

) on the Windows desktop.

The EyeD main window appears.

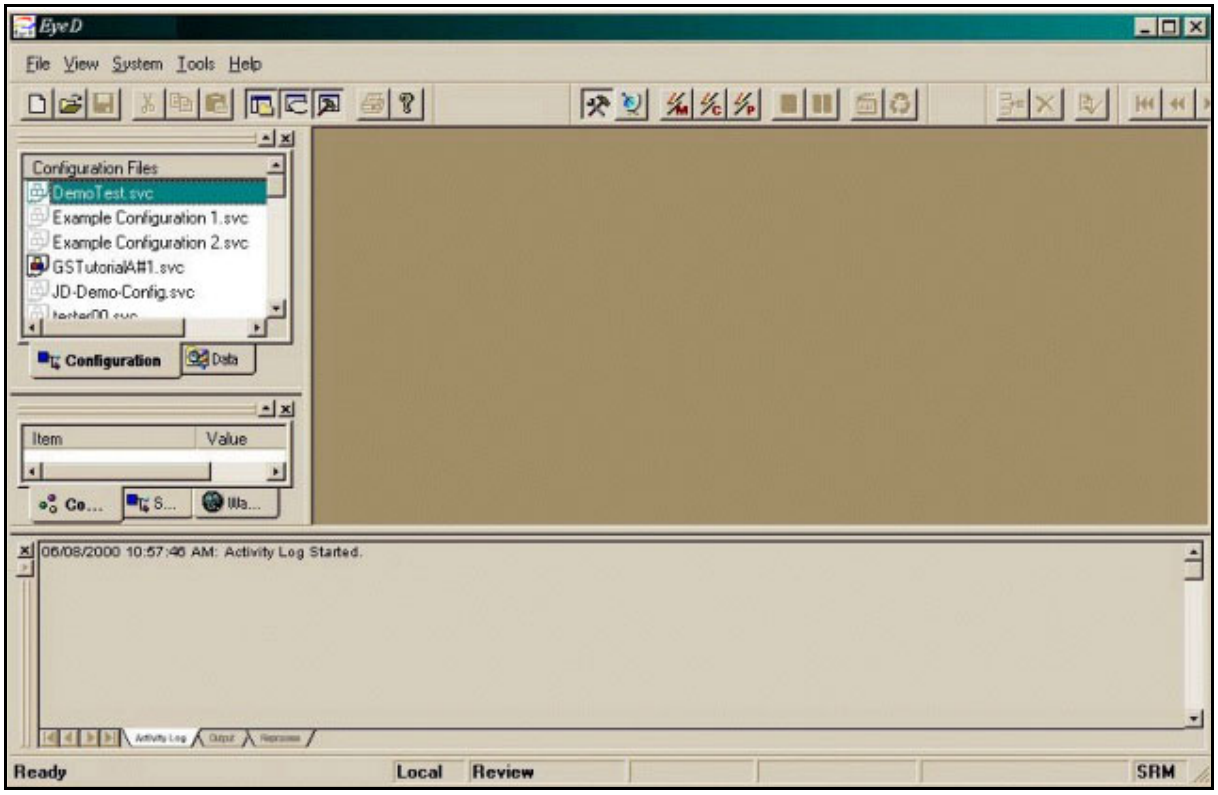


Figure A-1. EyeD Main Window

A.5.2 Configuring the EyeD Screen

This Exercise shows how to configure the EyeD screen for viewing the maximum number of options.

To configure the EyeD screen:

1. Select **View** from the Main Menu Bar.

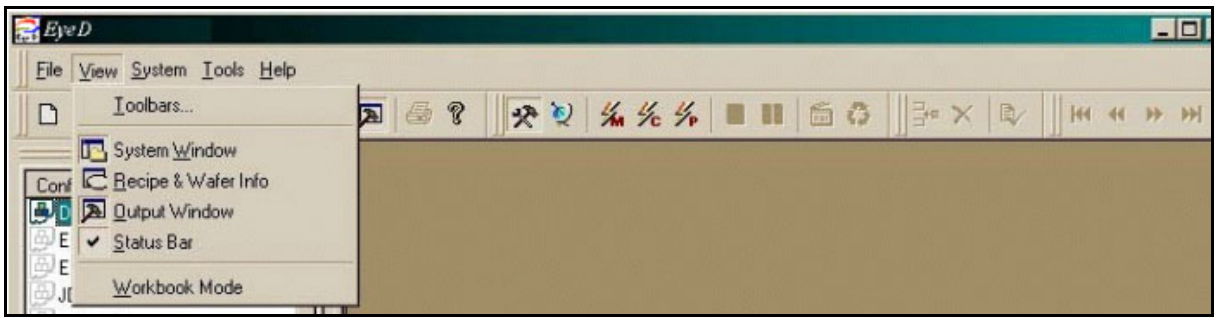


Figure A-2. View Pull-down Menu

2. Select all five screen view options: System Window, Recipe & Wafer Info, Output Window, Status Bar, and Workbook Mode. Select Toolbars from the View pull

down menu and make sure all five toolbars are selected, with associated check boxes marked.

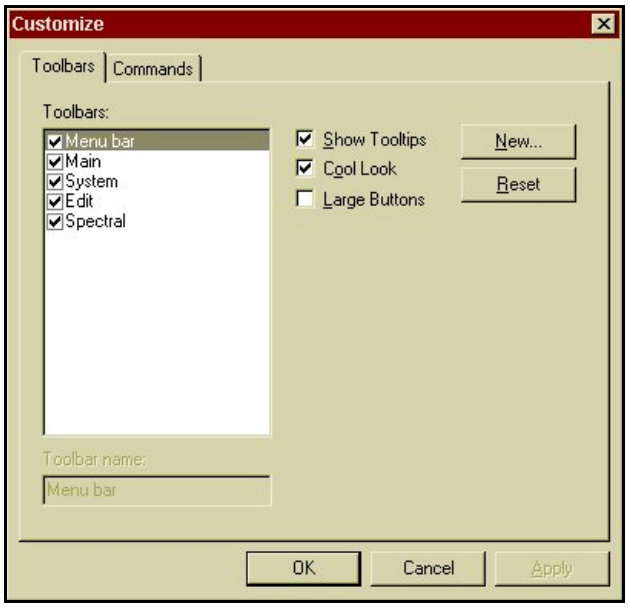


Figure A-3. Toolbar Customizing Window

3. The EyeD Applications Window should appear similar to the following:

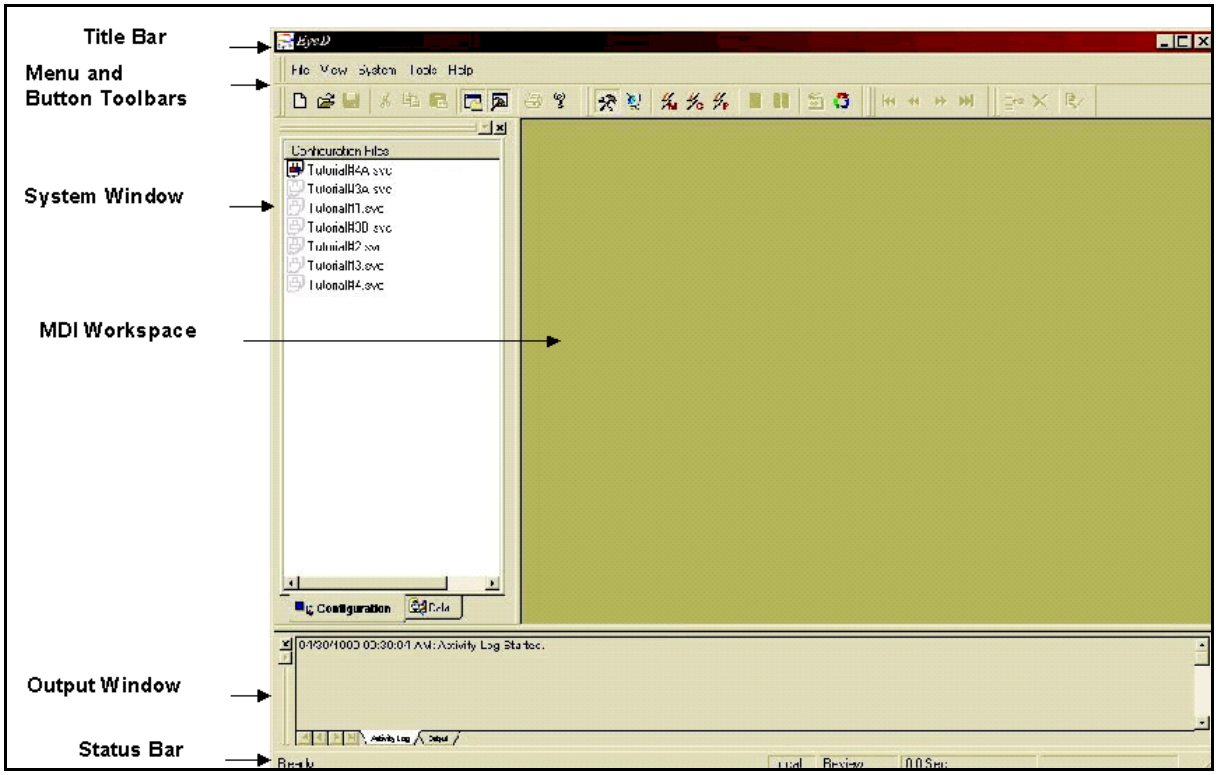


Figure A-4. EyeD Applications Window

A.5.3 Creating a New Configuration File

This Exercise shows how to create a new configuration file to begin data collection.

The process engineer must use an existing configuration file or create a new one that will provide operating parameters for the EyeD's data collection.

To create a new Configuration:

1. Select **New** from the File menu, or click the New icon on the Button toolbar.
2. The Setup Screen, the first item in the Configuration, appears in the Multiple Document Interface (MDI) Workspace.
3. Explore the screen to become familiar with it components.
   a. Note that the Title Bar displays the name of the opened configuration file.
   b. The Configuration Editor window shows the eight sections of a configuration file.
   c. The Setup section is the first displayed configuration section.
   d. Single clicking on any configuration section icon in the Configuration Editor window immediately switches to the window for that section.

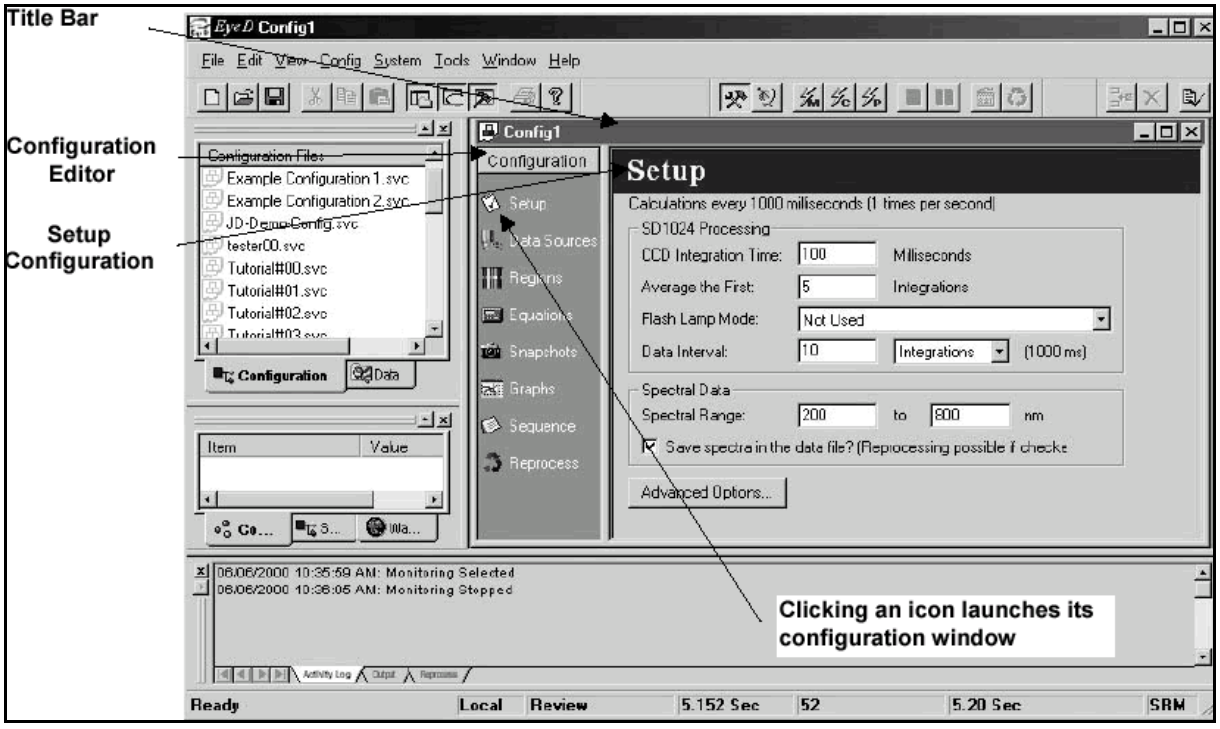


Figure A-5. New Configuration Window

4. Select **Save As...** from the File menu to save the file.
5. Enter **UserInitials-DEMO-CONFIG.SVC** in the file name field of the *Save As* dialog box.

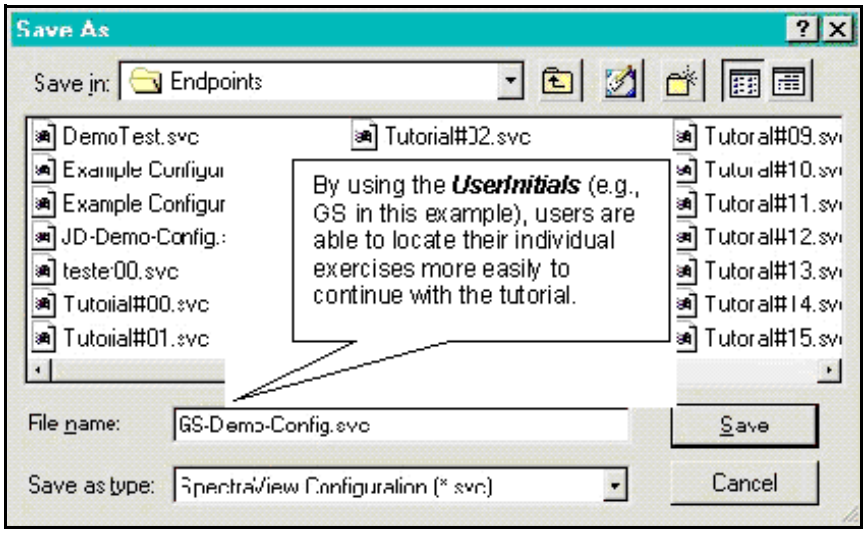


Figure A-6. Saving Files With User Identification

6. Click **OK**.
7. Select **Close** from the File menu or click the **x** icon in the upper right corner of the screen to close the configuration file.

A.5.4 Preparing a Configuration to Collect and Display Spectra

This Exercise shows how to prepare a configuration file for collecting and displaying spectra.

The process engineer will use a configuration previously prepared and stored in a file to ensure predictable examples in this exercise. Click on each icon and review all eight configuration sections (Setup, Data Sources, Regions, Equations, Snapshots, Graphs, Sequence and Reprocess). Preparing a configuration file requires only three of these sections (Setup, Data Sources, and Graphs) to collect and display spectra.

To prepare a configuration to collect and display spectra:

1. Select **New** from the File menu (or click the New icon on the Button toolbar.
2. Click the **Setup** icon in the Configuration Editor if the Setup window is not currently displayed.
3. Enter the EyeD operation parameters located on the Setup configuration window as shown below:

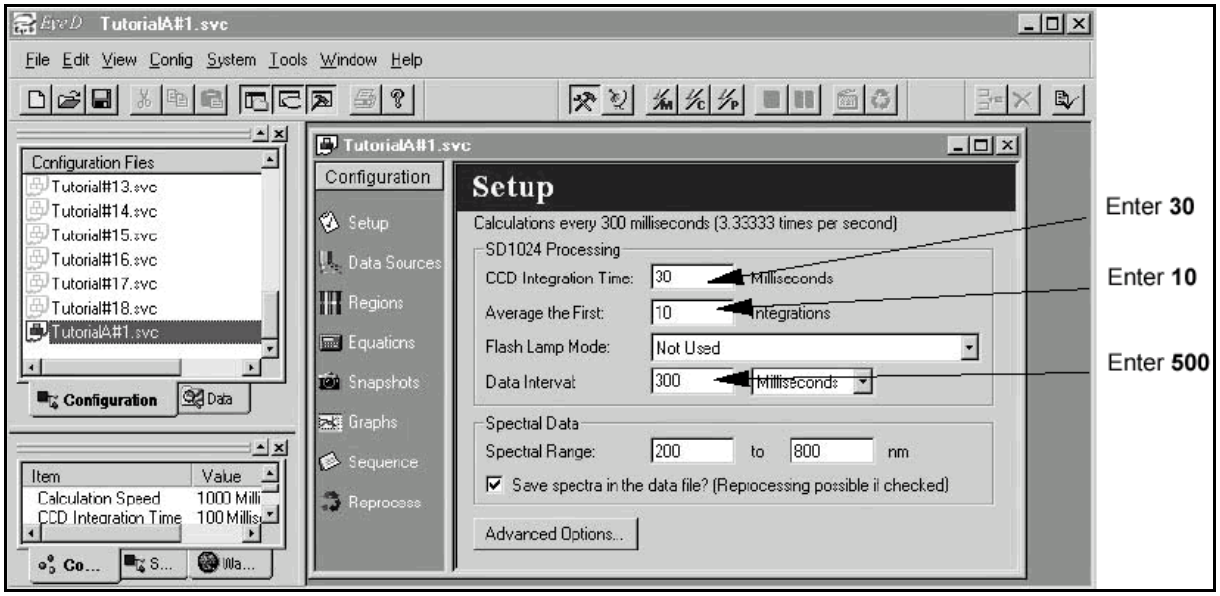


Figure A-7. Configure to Collect and Display Spectra

a. In the Integration Time field, the CCD will operate continuously by integrating the signal for 30 milliseconds, reading out the signal, and restarting the next 30-millisecond integration.

b. In the Average Integrations field, by entering the numeral 70, each spectra will be sent from the spectrograph to EyeD.

c. In the Data Interval field, EyeD will transmit the latest CCD reading to the PC, once every 500 milliseconds. (Currently, only the last CCD reading is sent. In future software enhancements, the EyeD will send average CCD reading and other statistical information about the CCD integrations made between data transmissions).

d. The Spectral Filter is preset for 200 to 800 nm, the minimum and maximum wavelength ranges detected by the EyeD spectrometer.

e. The Flash Lamp defaults to Not Used. (EyeD-IEP units are equipped with an integrated flash lamp. See Section 3.5.4.2 for flash lamp operation).

1. Click the **Data Sources** icon on the Configuration Editor.

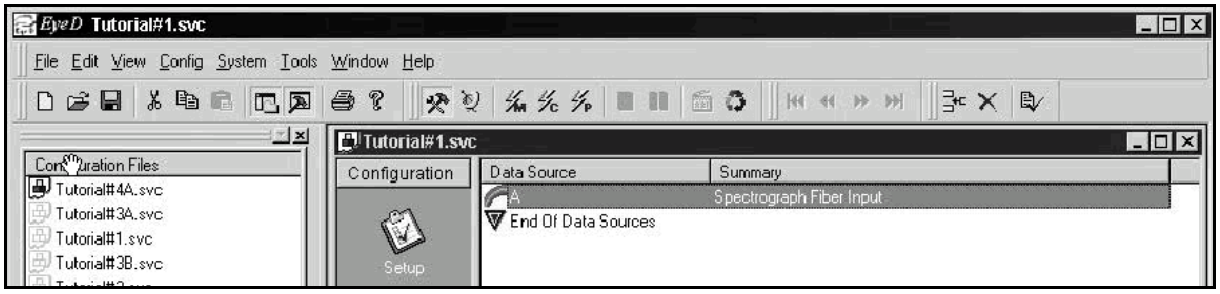


Figure A-8. Data Source Selection

Notice that one fiber optic input channel, A, of the EyeD is listed (by default). A multi-channel EyeD will list all available input channels. (In subsequent sections, this tutorial discusses other possibilities for use in the Data Sources section).

2. Click the **Regions** icon on the Configuration Editor.

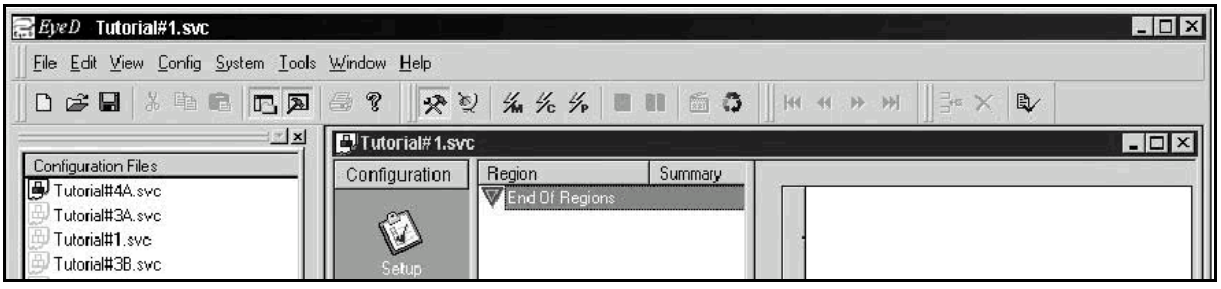


Figure A-9. Select Region in Configuration Editor

Notice that only the End Of Regions marker (shown above) appears in this section. Nothing listed above the End Of Regions marker indicates that the list of Regions is empty (The EyeD reads out light intensities at 0.5 nm intervals: 200.0, 200.5, 201.0, etc.). A Region defines a series of wavelengths that will be similarly treated.

For example, the Region of 576.5 to 577.5 includes the three wavelengths: 576.5, 577.0, and 577.5.

3. Click on the **Equations** icon in the Configuration Editor.

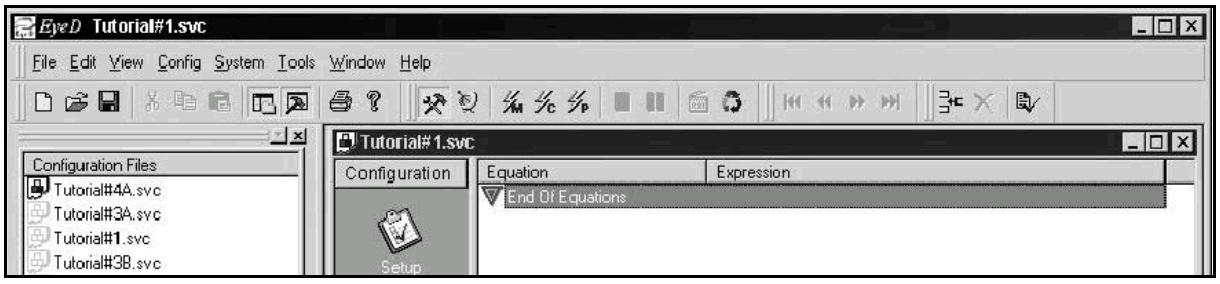


Figure A-10. Select Equations

Similar to the Regions section, the Equations section also only displays the "End Of Equations" marker (shown above), which indicates that the list of Equations is empty. (An Equation performs a calculation on various items).

4. Click on the **Snapshots** icon in the Configuration Editor.

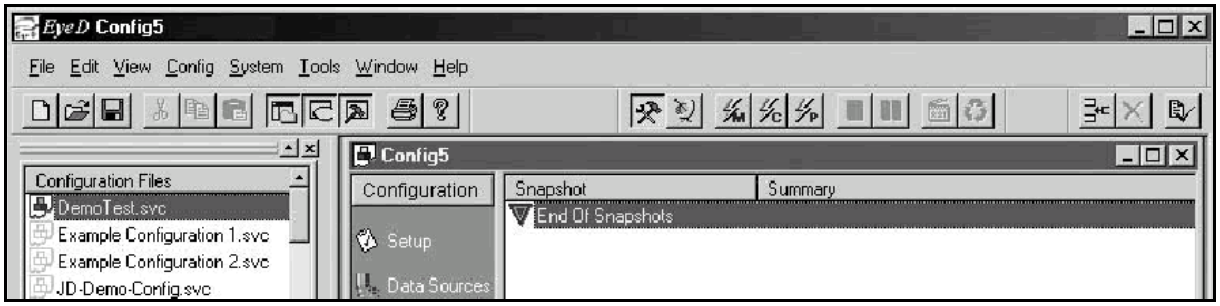


Figure A-11. Set Snapshot and End of Snapshots

The Snapshots section also displays only the "End Of Snapshots" marker (shown above), which indicates that the list of Snapshots is empty. (A Snapshot records sample spectra at a specified time following the start of data collection).

5. Click on the **Graphs** icon in the Configuration Editor.

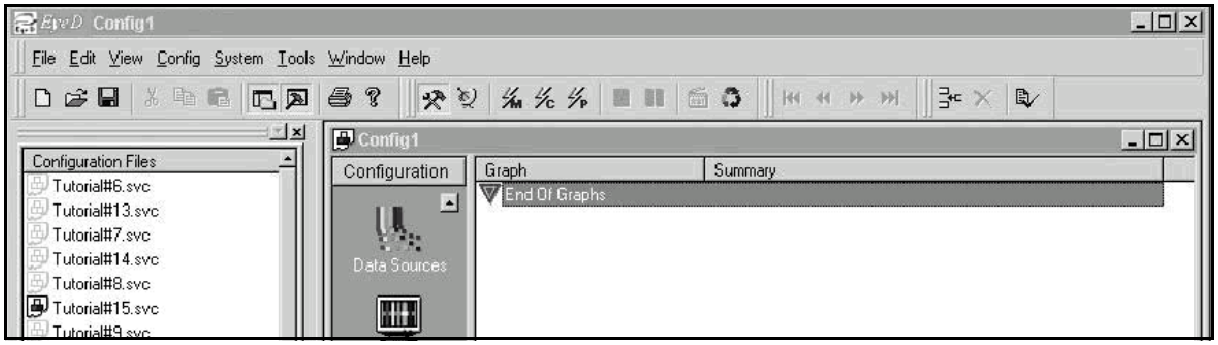


Figure A-12. Graph Selection Window

6. Right-click on the **End Of Graphs** marker.

7. Select **Insert Graph** from the Context Configuration pop-up menu.
8. Select **Spectral Graph** and press the left mouse button. The Spectral Graph Properties window appears.
9. Enter the following:

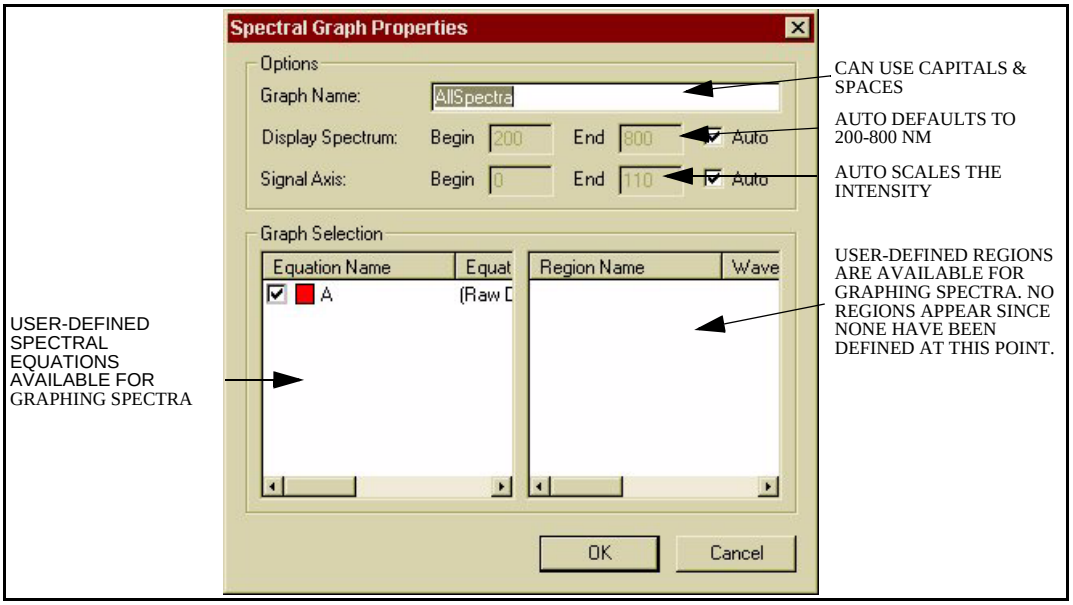


Figure A-13. Spectral Graph Properties Window

a. In the Graph Name field, *AllSpectra*, is the name of this particular graph (Graph titles can include capitals and spaces).

b. In the Display Spectrum field, checking the Auto box allows the EyeD to use its default wavelength ranges of 200 nm (Begin) and 800 nm (End), regardless of what values are grayed out.

c. If the Auto box is not checked, the Begin and End boxes turn white allowing manual entry of a narrower wavelength range.

NOTE

This narrow wavelength range must remain in the 200-800 nm range.

d. In the Signal Axis field, checking the Auto box allows the EyeD to use its intensity values and auto-scale the values to ensure no data ever falls off the graph.

When the Auto box is not checked the Begin and End boxes turn white allowing manual entry for a specific fixed Y-scale.

e. The Graph Selection area includes two sub-areas: Equation Name and Region Name. The Equation Name lists available data sources. Checking the A channel switches to a single EyeD data channel to provide the time-series data

collected from Channel A. Similarly, the Region Name lists all Region Equations that have been user-defined and can be checked for display on the graph (More about Regions next).

10. Click on the **Sequence** icon in the Configuration Editor.

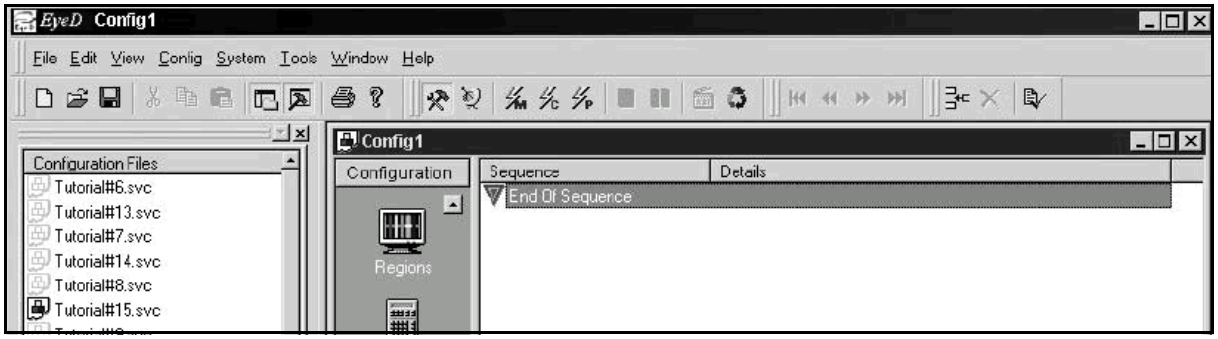


Figure A-14. Sequence List Window

Notice that the End Of Sequence marker appears, indicating that the list of Sequences is empty (A Sequence is a list of procedures that will be sequentially performed as the time-series spectral data is collected).

11. Right click on the **Reprocess** icon. No filenames are listed. The reprocess function allows the user to test the robustness of a configuration. Any files listed here will be reprocessed according to the current configuration when the Reprocess icon is selected.

12. Select **Save As...** from the File menu and name the configuration file appropriately.

    (Refer to step 5 on page 3-7 for exact instructions on saving using a different file name).

13. The above configuration should be saved under the file name TutorialA#1.svc.

A.5.5 Collecting and Displaying Spectra with EyeD

This Exercise provides instruction on the collection and display of spectra using the EyeD spectrograph. If you are working on a computer that is not connected to a spectrograph, proceed to Section A.5.7.

NOTE

If you have an EyeD detector attached to a PC, turn the EyeD on and point the OES fiber optic toward a fluorescent room light.

Data Collection has one optional step and three required steps:

1. (Optional) Clear the MDI Workspace of the EyeD Applications Window.
2. Designate the configuration file to be used as the current configuration.

3. Change to Local mode ( ). In Local mode, the user must manually start and stop data collection.

4. Start the data collection.

Clearing the MDI Workspace (Optional)

Clear the MDI Workspace to reduce the clutter by selecting the x icon in the upper right corner of all open windows that appear in this area. Although this step is not required, it can reduce the confusion of excess data display.

Setting the Current Configuration File

To set the "Current" configuration file for use in data collection:

1. Click once on TutorialA#1.svc file on the Configuration list in the System Window. (TutorialA#1.svc includes all the configuration entries from the first part of the exercise).

2. Right-click on the TutorialA#1.svc file.

3. Select Set as Current from the Configuration Context pop-up menu.

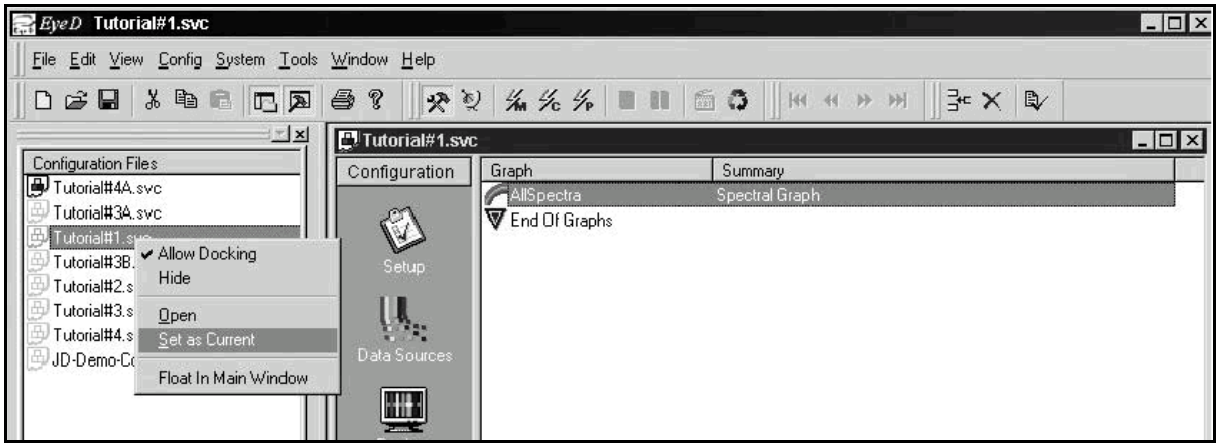


Figure A-15. Set Current Configuration File

Note in Figure A-16 that the icon beside the TutorialA#1.svc file is now colored.

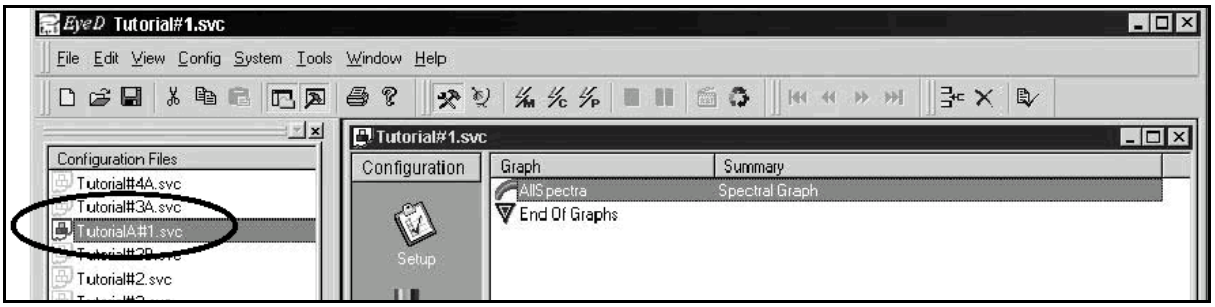


Figure A-16. Selected Configuration File

The remaining configuration file icons stay grayed out. The colored icon indicates that the TutorialA#1.svc configuration file is now set as the current configuration file. At the beginning of each run, EyeD will look to the TutorialA#1.svc configuration file for operating instructions until a different configuration file is selected and made the current configuration file.

It is important to understand the significance of setting a configuration file as the current file. When EyeD first starts collecting data in the local mode only, it goes to the current configuration, makes a copy of the instructions in the current configuration, and executes that copied list of instructions. By setting TutorialA#1.svc as the Current Configuration, the EyeD software now knows how to set up the EyeD, what data sources to use, and what graphs to print when the user requests data acquisition or reprocessing.

In the remote mode, the selection of which configuration is current has no bearing over which configuration will be selected by the Centura D-I/O when in production.

A.5.6 Starting Data Collection

To start collecting data:

1. 1. Click the  (Capture) icon on the Button toolbar, or select Capture from the System menu on the Menu bar.
2. Watch the spectra being collected from the EyeD display on the graph. The spectrum below shows room fluorescent lighting.

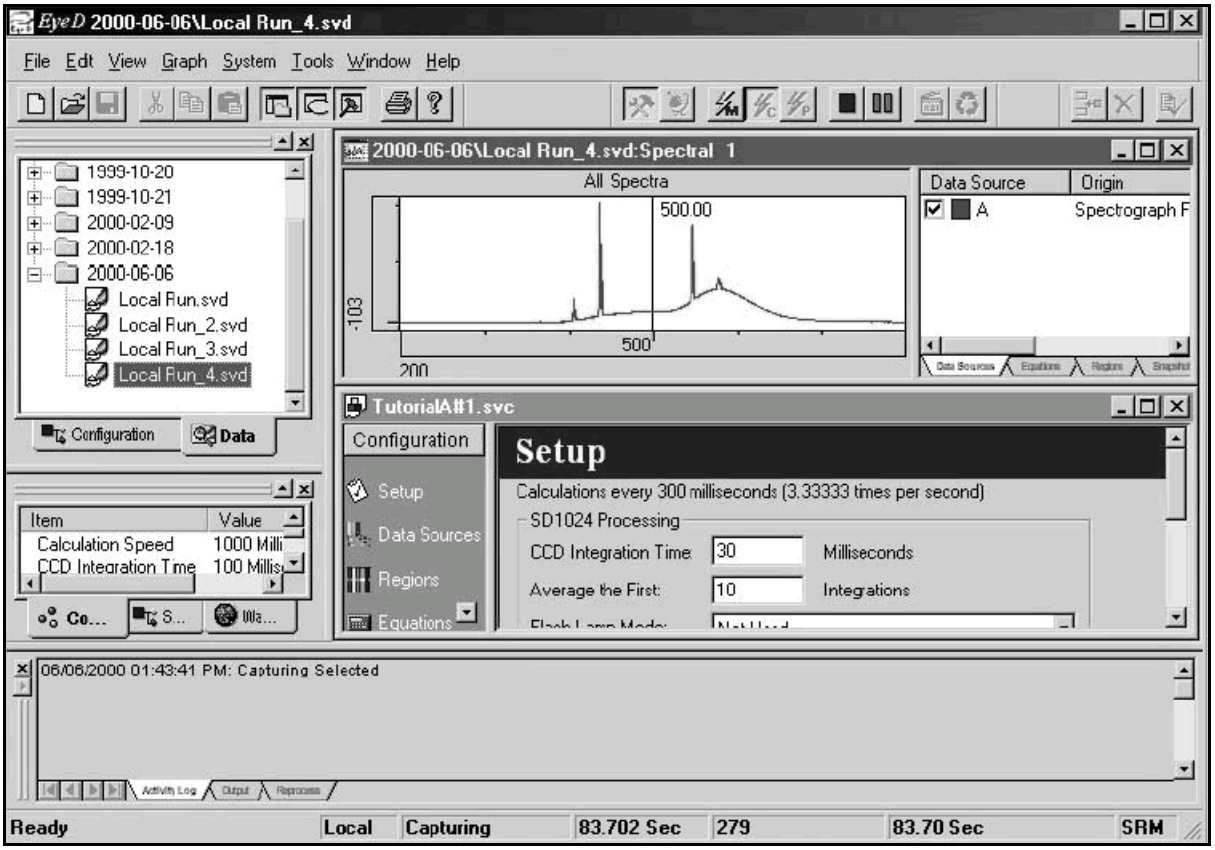


Figure A-17. Capture Data Window

3. Click the (Stop) or the (Pause) buttons on the Button toolbar to stop or pause the data collection.

4. Select the Data tab on the System Window to look at the data file that has automatically been created to store the recently-collected spectra. A new directory named with today's date now appears in the list of data files. Local Run.svd is the first data file collected today. Subsequent files collected on the same day are sequentially numbered (for example, Local Run_2.svd, Local Run_3.svd, etc.).

Three Ways to Start Data Collection

1. The Monitor ( ) function collects the spectra from the EyeD, applies the equations to the data, and displays graphs in real-time. (No data is saved to a file).

2. The Capture ( ) function does everything that the Monitor function does and, at the end of data collection, it automatically stores the collected data and the configuration into a file uniquely named with a date and time stamp.

3. The Process ( ) function does everything that the Capture function does, plus it applies the sequence to the data and produces the outputs in real time.

Three Ways to Stop Data Collection

1. Pressing the Stop button () stops data collection, equation calculation and graphing, and writes the data to a file, if called for. The “Current” Configuration will have to be re-read before performing any other data collection.
2. Pressing the Pause button () interrupts data collection, equation calculations, graphing, and sequence execution. If the Pause button is the next button that is pressed, everything resumes as if nothing had occurred. If any other button or function is pressed, EyeD first executes a Stop command, then proceeds to execute the new command.
3. A Sequence comes to its expected termination and stops data collection.

On Your Own

- Start and stop data collection using each of the methods.
- Check the automatic creation of new data files that result from one of three alternative ways to execute data collection.

A.5.7 Reprocessing Previously Collected Spectra

This exercise walks the user through bringing previously collected data in for reprocessing, within any instance of EyeD where the data is stored. The data file that will be used in this illustration, genericROOM_LIGHT.svd can be downloaded from the Si Etch Engineering intranet web site, if it is not already on the hard drive of the system on which you are working.

EyeD supports reprocessing of a selected data file; the algorithm that is used for reprocessing is the one that is *set as current* in the configurations list. To *set as current*, right-click on any configuration in the list and select appropriately.

This example data should be stored in the file:

C:\EyeD\Ch-X-Data\genericROOM_LIGHT.svd

A.5.7.1 To Reprocess Previously Collected Data

1. If this is the first time a given data file is reprocessed, clear the MDI Workspace to reduce clutter by clicking the x button in the upper right corner of each open screen.
2. Select *genericROOM_LIGHT* from the configuration window, shown below in Figure A-18.

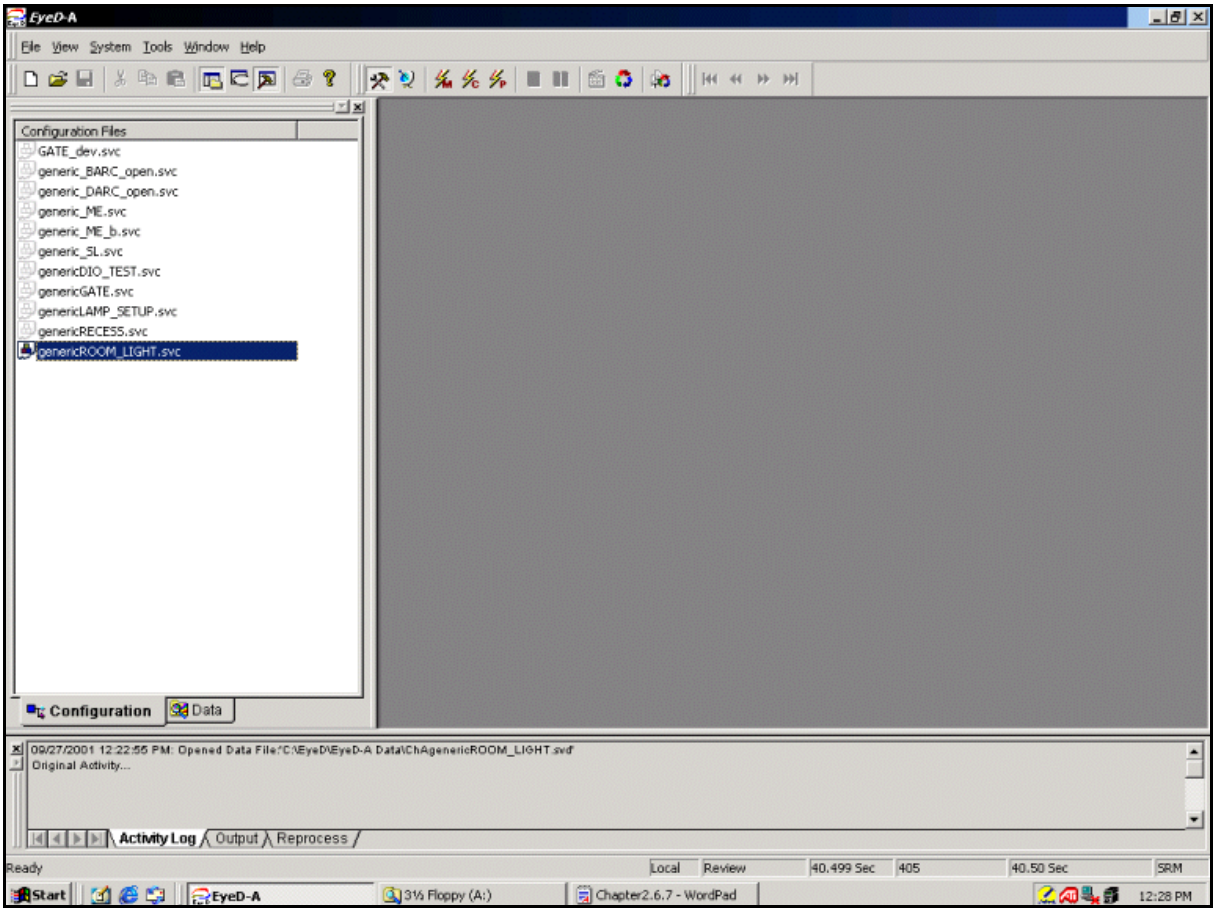


Figure A-18. Configuration Window

3. Right-click on **genericROOM_LIGHT**.
4. Select **set as current** from the pop-up menu.
5. Go to the data window and double click on the data file to be reprocessed. The data file will be displayed just as it was recorded:

   C:\EyeD\Ch-X-Data\genericROOM_LIGHT.svd.

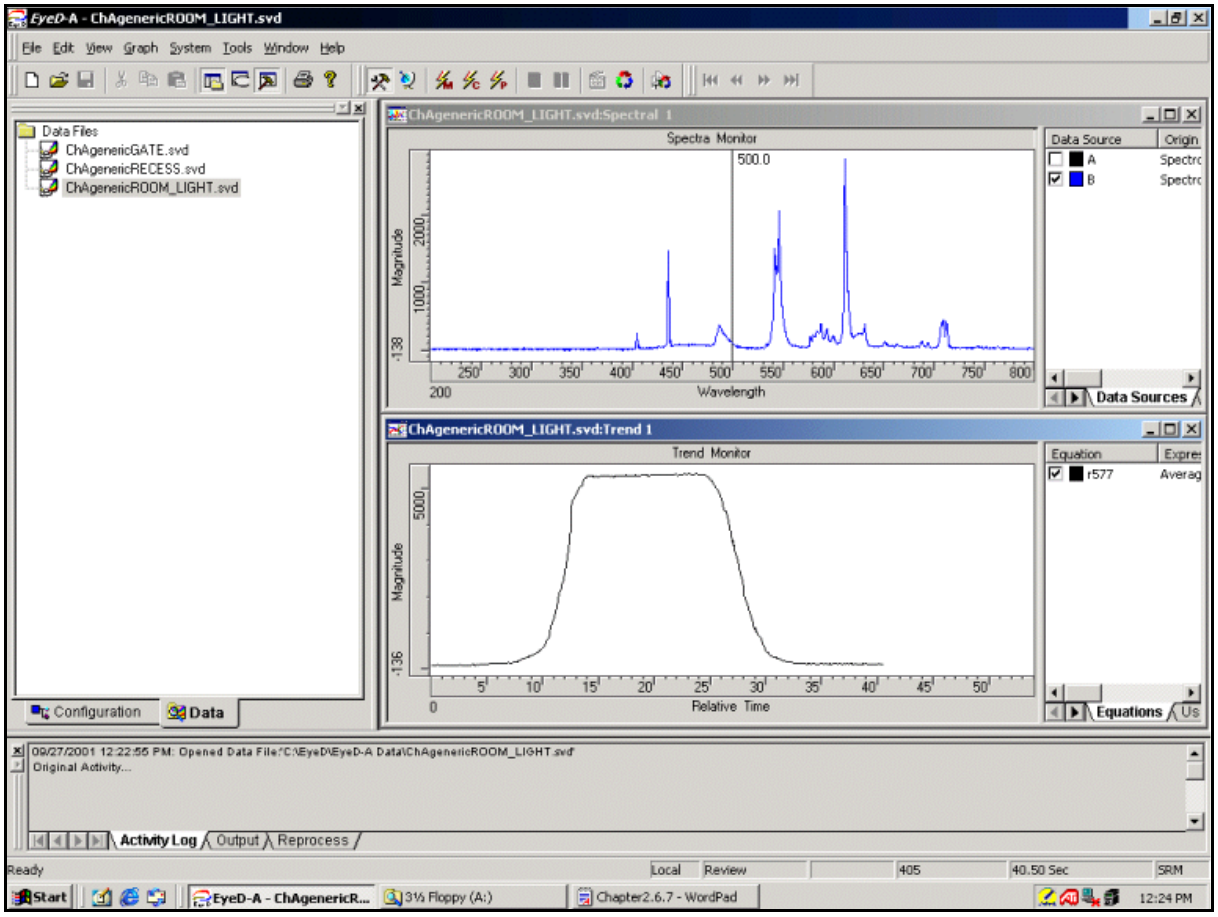


Figure A-19. Data File Window

6. The auto-graphing allows easy verification that the correct data file was selected.

7. Press the left (←) and right (→) arrow keys, or click the arrows (◀◀ ▶▶) on the toolbar to rapidly replay the entire time-series forward or backward in time.

NOTE

The graph of data in the retrieved file reflects the graphing commands recorded in the Configuration that was used at the time of data collection. Typically, the configuration attached to the retrieved file is not the same as the configuration being developed. Therefore, do not be surprised if the data graph format is different from what is shown.

8. Click on the Reprocess button () on the Button toolbar. All the graphs will be generated according to instructions copied from the Current Configuration and the data file will be reprocessed. The data run-time displays in the lower right side of the screen.

9. Select Tile from the Window menu to ensure the visibility of all the graphs.

10. Click the Reprocess button again to see the animated action of each graph.
11. Adjust the graphs as desired.

NOTE

When reprocessing a saved spectral data file, the instructions recorded in the “Current Configuration” are applied to the raw EyeD data recorded in the specified data file. The Configuration file used when the data was collected plays no part in the reprocessing.

Extracting the configuration under which a data file was collected is routine: use the "Save As..."command under “File”, and save the data as a configuration (.svc) in the “endpoints” folder.

A.5.7.2 Reprocess List

The Reprocess List function automatically tests several data files in a list against a configuration to see how each performs. Reprocess List is among the icons listed in the left of the Configuration window. This function uses the configuration selected as Current to operate on each file in the list. The function also can be accessed by the Reprocess button at the tool bar at the top of the screen. While reprocessing the data files, a notation is made in the form of a check mark or an X at the left of the file name. This is to identify whether a detectable endpoint exists in the file when using the selected configuration.

The ability to test the success or failure of an endpoint algorithm is especially useful when fine-tuning a Neural Network or Neural PCA algorithm to detect endpoint reliably on many files that represent the range of variation expected throughout a production run.

To access this feature, select Reprocess List from the bottom of the column of configuration icons. Right-click on the End of Files marker to access the drop-down menu. From that menu, select Insert Data File to insert a single data file or Insert Directory Data Files to insert all of the files listed in a directory.

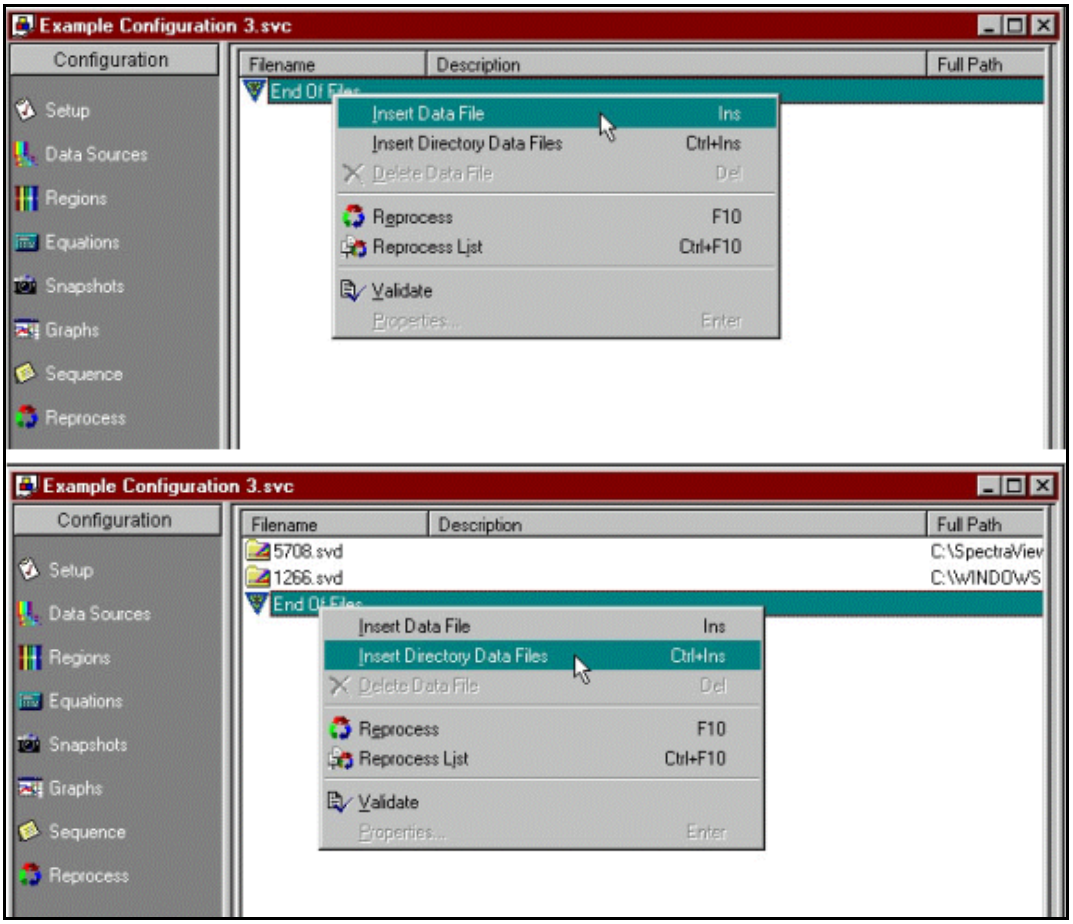


Figure A-20. Insert Data File or Insert Directory

This selection will bring up the associated file or directory browser.

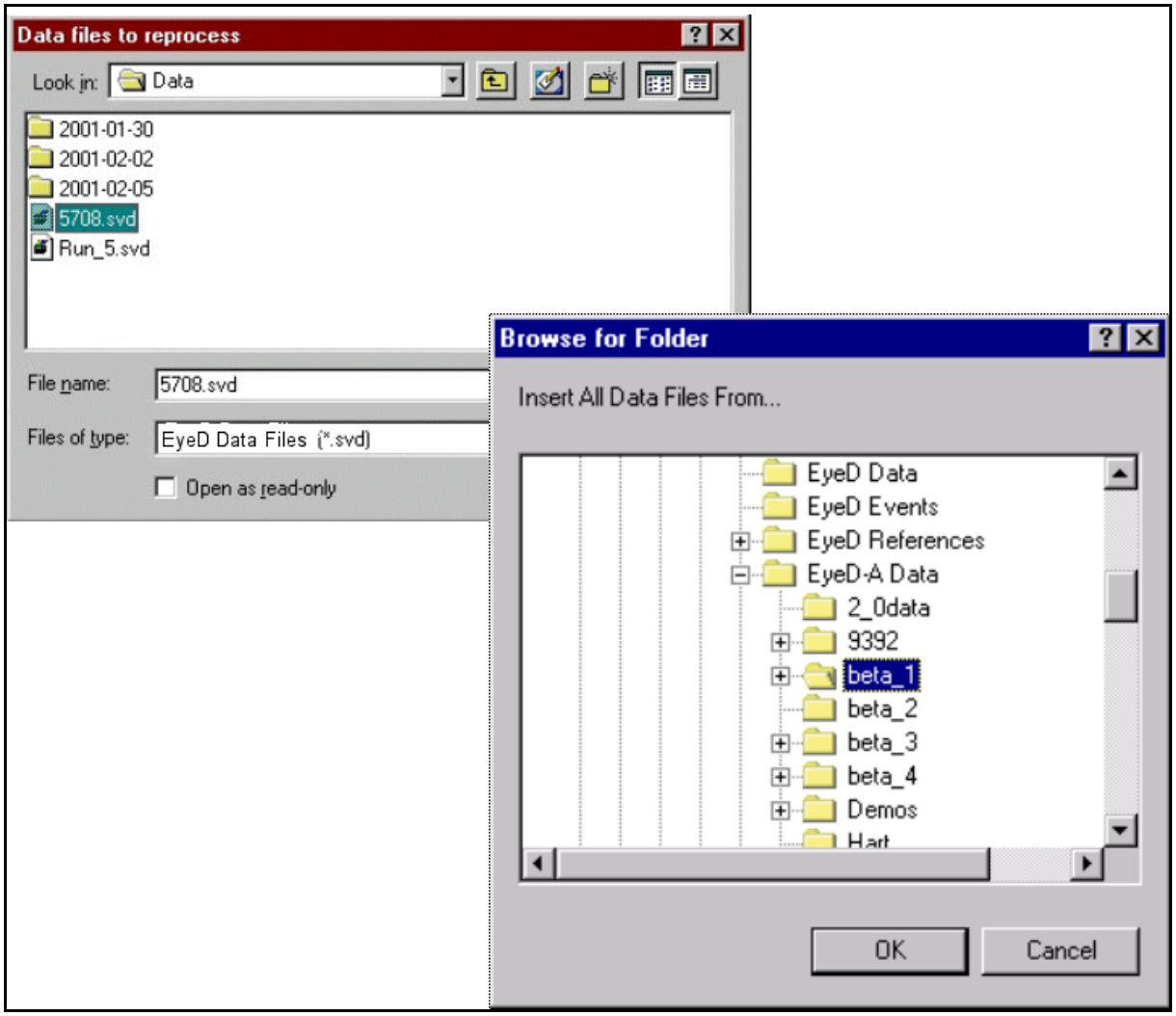


Figure A-21. Browsing Files (left) or Directories (right)

Click **Open** or **OK** to add the highlighted file or directory of files to the reprocess list.

NOTE

Any data files intended for permanent storage should be moved out of the *C:\EyeD\Data\ tree*. Otherwise, the automatic delete utility could remove them to clear drive space.

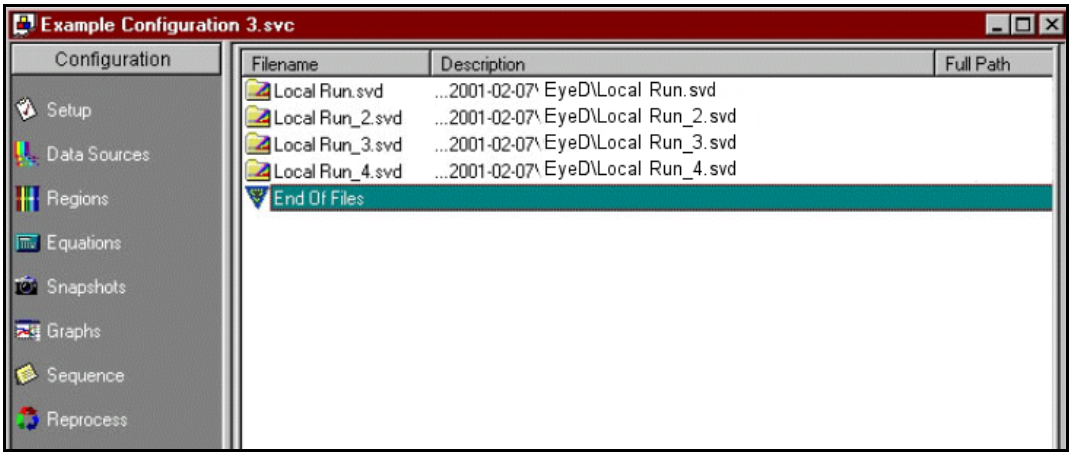


Figure A-22. Listed Files for Reprocessing

There are a number of ways to activate the Reprocess List function. Right click in the reprocess window, select the Reprocess List icon in the toolbar or select Reprocess List from the System pull down menu, Figure A-23.

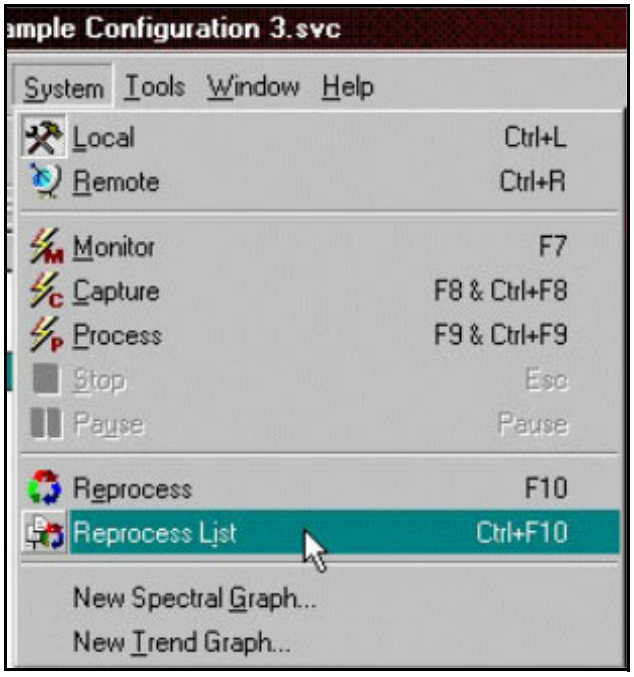


Figure A-23. Select Reprocess List

All data files listed under the current configuration will be reprocessed, and information for each will be displayed in the activity log area in the bottom of the EyeD window.

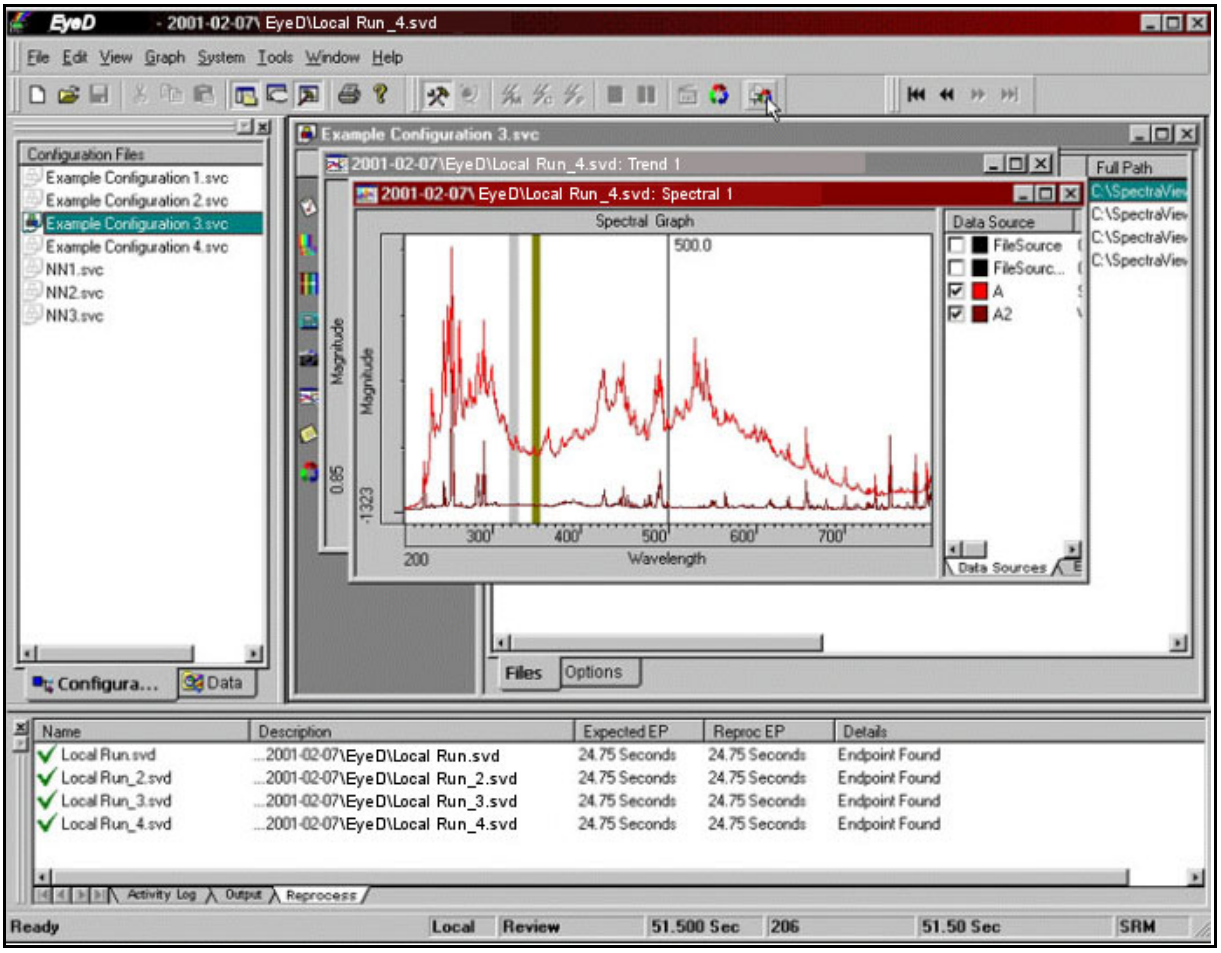


Figure A-24. List Reprocessed and Endpoint Found for all Files

If a pattern recognition algorithm is improperly trained, a given spectral pattern could be mistaken for endpoint. A selection in the file properties window can assist in identifying a case of a mistaken endpoint signature. Click on any file listed in the Reprocess window to view and/or change its properties.

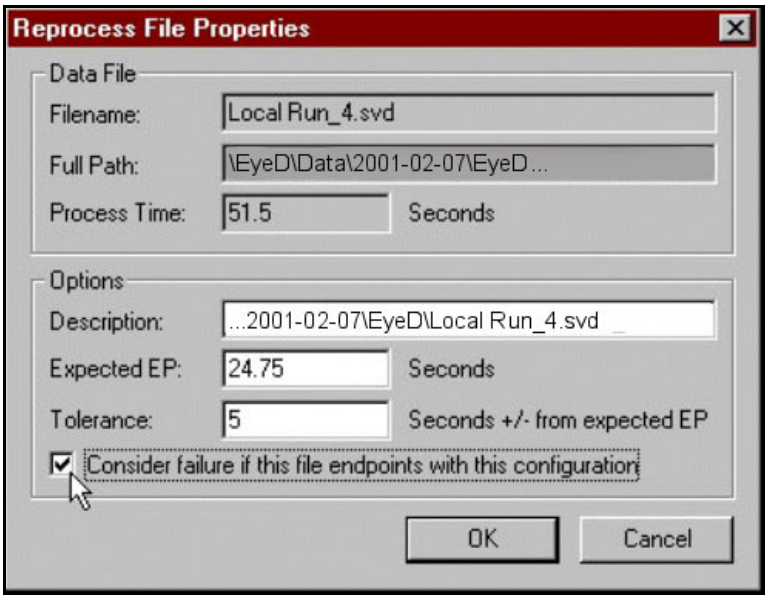


Figure A-25. Reprocess File Properties Window

By default, endpoint is anticipated at some time during the run. In Figure A-25, a file is marked for failure if the endpoint pattern is recognized during its reprocessing. Once the checkbox is selected, the Expected EP and Tolerance fields have no significance.

In the default state, the Description field displays the file path, but this is a user-defined area. Enter any information useful for identifying particulars of the file being reprocessed.

A.5.8 Becoming Familiar With Data Navigation Tools

This exercise acquaints the user with data navigation tools, which view graphically displayed data from a Reprocessed configuration file.

NOTE

Whenever a configuration is opened, the particular hardware configuration under which it was created will be checked against the hardware configuration of the computer or EyeD endpoint system on which you are working.

If you are working with a copy of EyeD on your desk computer, away from the endpoint system, then the hardware configuration will be different, as there will not be any spectrograph detector modules connected. In this case, you will get a message asking whether or not to synchronize the configuration with the present hardware in the following popup window:

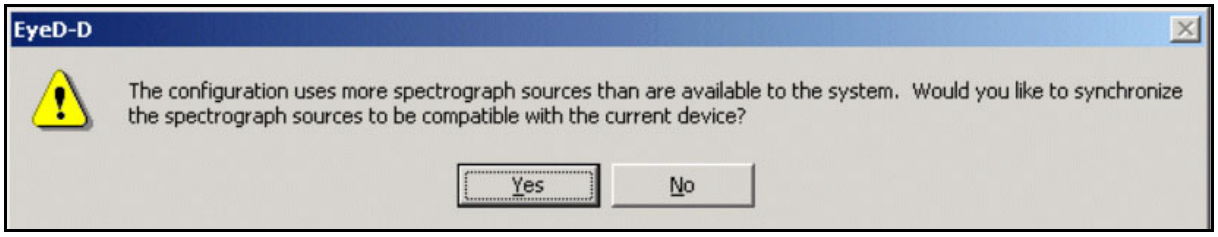


Figure A-26. Synchronize Configuration Message

*It is important to answer **NO** here*. If you answer YES, then the configuration will be re configured, and will not work properly when you try to run it again on an EyeD endpoint system that is connected to spectrographs.

After completing the Reprocessing in Exercise 6, the graph displays the last spectrum of the Reprocessed time-series data.

A.5.8.1 To Become Familiar With the Data Navigation Tools

1. By maximizing and minimizing the graph, notice that the graph scale labels are a function of the graph size.

NOTE

EyeD uses the window-specific features of Microsoft Windows. The process engineer must first click in the window of interest to direct the screen control tools and activate menus for that window. The most likely reason a command does not perform as intended is failure to specify the desired window by clicking inside that window.

2. Arrows located on the Spectral toolbar (Figure A-27) allows the process engineer to adjust the graph display to any specific time increment in the time-series data.



Figure A-27. Spectral Toolbar

⏮ , ⏭ moves to the first and last spectrum in the time-series data

◀◀ , ▶▶ moves backwards and forwards one data interval at a time in the time-series data

3. Use the left (←) and right (→) arrow keys on the keyboard to move backward and forward in the time-series data. Holding down an arrow key will shift to rapid scrolling through the data.

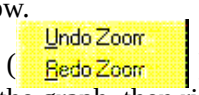
4. A wavelength marker, labeled in nanometers, appears as a black vertical line in the center of the spectral graph. The wavelength marker can be moved with the cursor. When the cursor touches the wavelength marker, it changes from a cross

hair (+) to a double-headed (⇔) arrow, allowing the wavelength marker to be dragged-and-dropped to any feature on the graph.

a. Move the wavelength marker to the peaks at 577 nm.

b. Click on the Reprocess button to see the details in this part of the spectrum.

5. With the cross hair cursor anywhere on the graph, click and drag diagonally to create a rectangle around any feature. When the left-click is released, the graph in the rectangle is zoomed to fill the entire plotting window.

6. Zoom actions, performed through the Zoom pop-up menu (

), can be removed by placing the cross hair cursor anywhere in the graph, then right-click the mouse and select Undo Zoom. When a series of zooms have been performed, Undo Zoom removes one zoom at a time, while Redo Zoom replaces one zoom at a time.

7. Either the horizontal or vertical axis can be modified on a displayed graph. When the cross hair cursor is moved to the axis label bar, it changes into a double-headed arrow.

8. Left-clicking and dragging the double-headed arrow cursor moves the scale through the graph window.

9. Right-clicking and dragging the double-headed cursor expands the scale. The scale is pinned at the axis crossing and the axis scale is stretched or compressed as the cursor is moved.

NOTE

Sometimes dragging the scale will cause the plot to go off the chart. If auto-scale has been specified in the configuration of the graph, simply moving to the next time increment, by clicking the Spectral arrow, will reapply auto-scale and bring the graph back into view.

A.5.9 Examining Reprocessed Spectra

This exercise shows how to use the data navigation tools presented from the previous exercise to examine reprocessed spectra. It also uses the screen displayed after Step 9 of Exercise 6.

To examine reprocessed spectra:

1. Use the data navigation tools to scroll through the data in time.

NOTE

As the spectra are displayed during the reprocessing and reviewed using the arrow keys and buttons, the vertical axis (Intensity) scale changes for every sample. The scale changes are caused by the Auto (auto scaling) option we selected in the Graphs section of the Configuration. Although auto scaling is a useful tool for the first analysis, it is hard to visually interpret auto scaled graphs in real-time.

2. To fix the Y-axis scale, the user must first determine what the Y-maximum should be. Using the data navigation tools, verify that the graph never exceeds a maximum value of 45000 on the vertical intensity axis. In Exercise 12, the user will set Y-max to 45000 to ensure that all the spectra will be shown on a fixed axis.

3. Zoom to make the graph show just the region of the two peaks located at 542 and 546 nm (mercury doublet). Every mercury lamp, including fluorescent lights, emits the familiar mercury doublet. This mercury doublet will be reviewed in more detail later in the tutorial.

   In preparation for that activity, the user will need to identify exactly what wavelengths are of interest. By moving the wavelength marker, verify that the peak wavelengths are 542 and 546 nm.

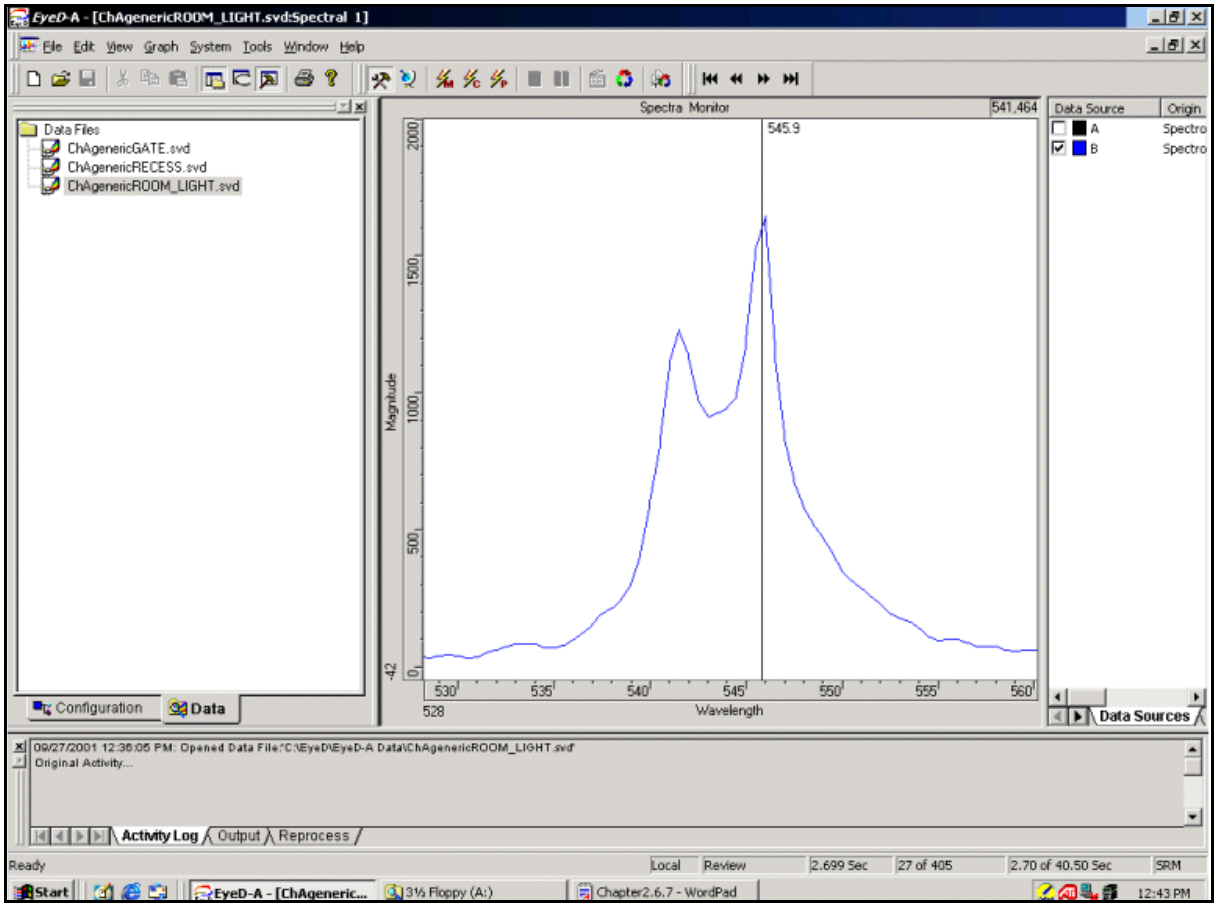


Figure A-28. Data File Wavelength Graph

4. Using the data navigation tools, verify that a minimum value of 0 and a maximum value of 2000 on the vertical intensity axis, which will ensure that all the spectra are being shown in the doublet region on a fixed axis. In Exercise 12, this information will be used to prepare a detailed graph of the mercury doublet region.

A.5.10 Tracking Configuration Changes

This exercise shows how to track configuration changes.

Based on what has been learned by examining the graph of the spectral time-series data, we have developed several ideas about how to change the Configuration. These changes include:

- Define regions around the 542 and 546 nm peak for background correction.
- Provide a graph of the spectra in the region of the mercury doublet at 542 and 546 nm.
- Discontinue auto scaling and establish maximum and minimum Intensity values for the vertical scales on the graphs.

As would be the case in a process line, this tutorial makes continual changes to the configuration file as process spectra are evaluated and endpoint algorithms developed. It is

suggested that each edited configuration file be saved to a new file name to protect the original configuration file.

NOTE

Exercises 10 through 13 make changes to the configuration, *genericROOM_LIGHT.* All four exercises should be worked sequentially in one sitting so that changes are in synchronization with example configurations.

A.5.11 Defining Spectral Regions

This exercise shows how to define spectral regions for a particular graph. The objective of this exercise is to define the three spectral regions needed to perform background subtraction for the 542 nm peak in the mercury doublet.

Because EyeD is operating from a copy of the current configuration, the genericROOM_LIGHT.svc file can be edited at any time, even if EyeD is running and collecting data. With the *AllSpectra* graph from the last reprocessing still on the screen, start defining Regions around the 542 nm peak for background correction.

NOTE

If resuming this tutorial on a different day, the user will need to reprocess the genericROOM_LIGHT.svd data file using the genericROOM_LIGHT.svc configuration.

NOTE

The name of a Region can be anything you wish. The naming convention used in this tutorial is one way to keep track of names when many regions are defined.

To define a spectral region:

1. Double-click **genericROOM_LIGHT.svc** on the Configuration tab of the System Window.
2. Click the **Regions** icon in the Configuration Editor.
3. Select **Tile** from the Windows menu.

   The screen should look like this:

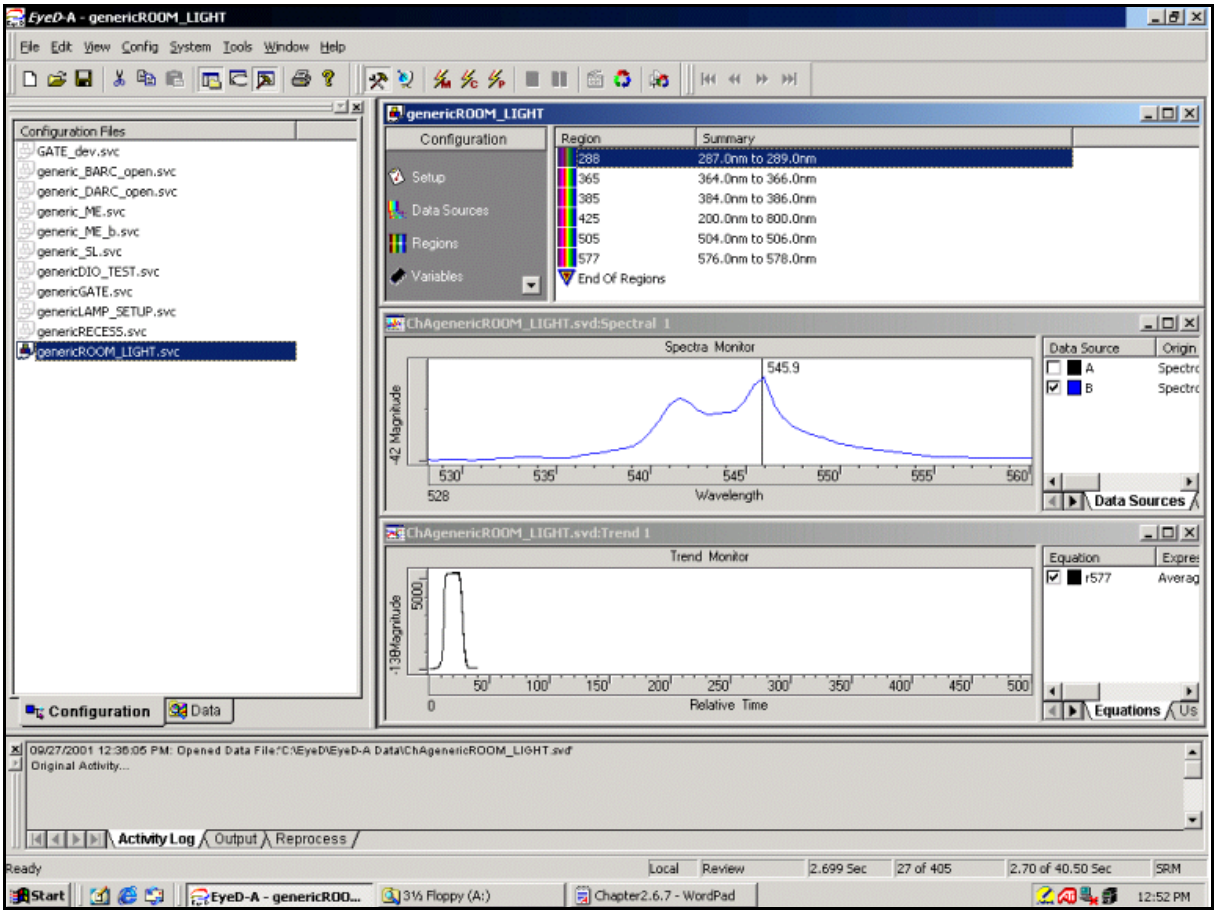


Figure A-29. Spectral Region Definition

NOTE

EyeD software uses Microsoft Windows (r) technology, which allows a number of windows to be displayed at once with only one window being active. Be sure the title bar is highlighted when attempting to change information in a window. Key strokes and mouse clicks apply to the selected, or active window only.

4. Click on **Spectral1** in the genericROOM_LIGHT.svc window (the middle window in Figure A-29).

5. Place the cursor over the upright line running perpendicular to the X axis in the graph window. When the arrows appear, click and drag this wavelength marker to the 542 nm peak.

6. Zoom the 542 nm peak region by moving the cursor near, holding down the left mouse button and dragging to select a rectangular area containing that peak. The Graph will zoom like this:

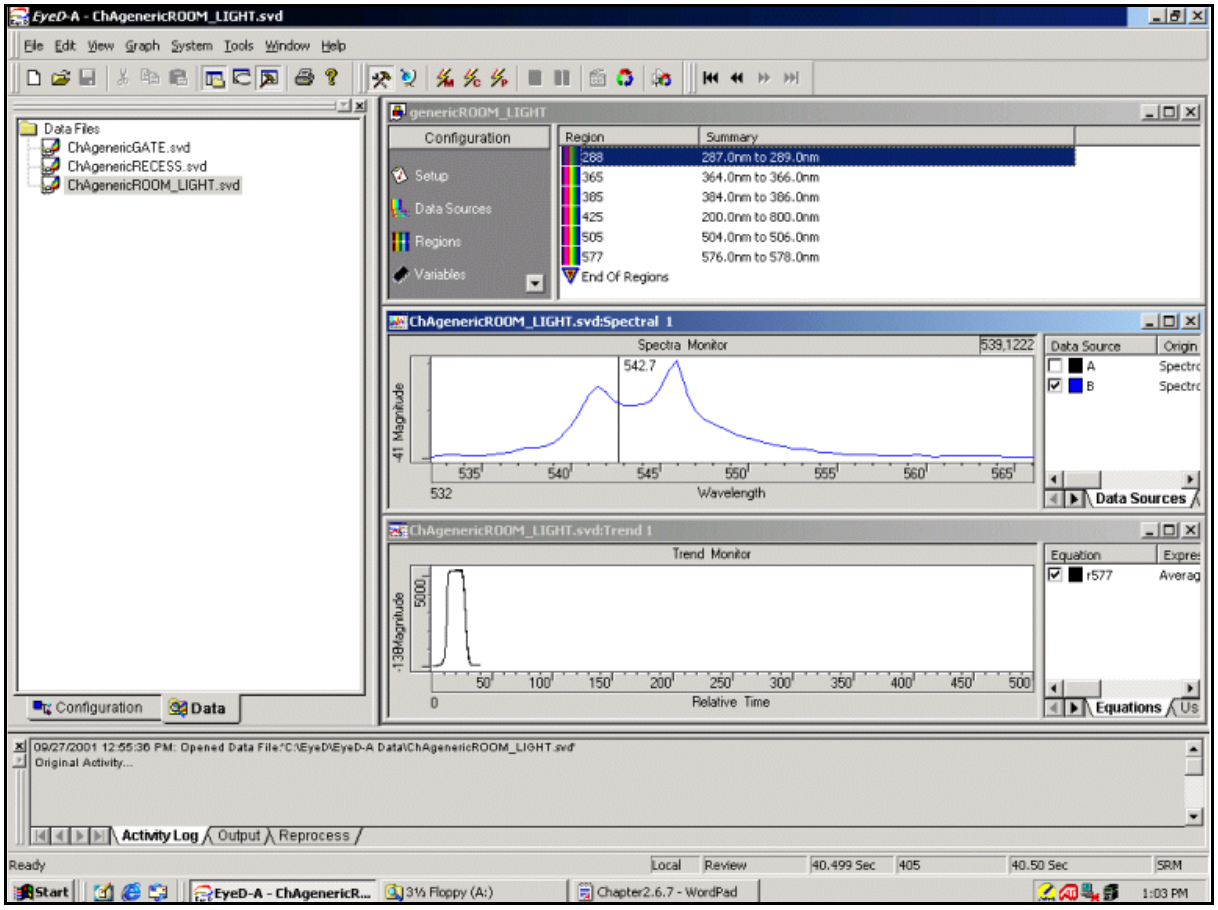


Figure A-30. Select Regional Peak

7. Verify that the regions below are reasonable for performing the background correction task.

Table 1-1. Wavelength (in nanometers)

Starting	Ending	Purpose
537	538	Left background
539	554	Peak
555	556	Right background

8. Click on the **genericROOM_LIGHT.svc** window to make it active.
9. Right-click on the **End Of Regions** marker to begin defining the three regions.
10. Select **Insert Region** and press the left mouse button (or press the Insert key on the keyboard).
11. Enter the following information for the first region.

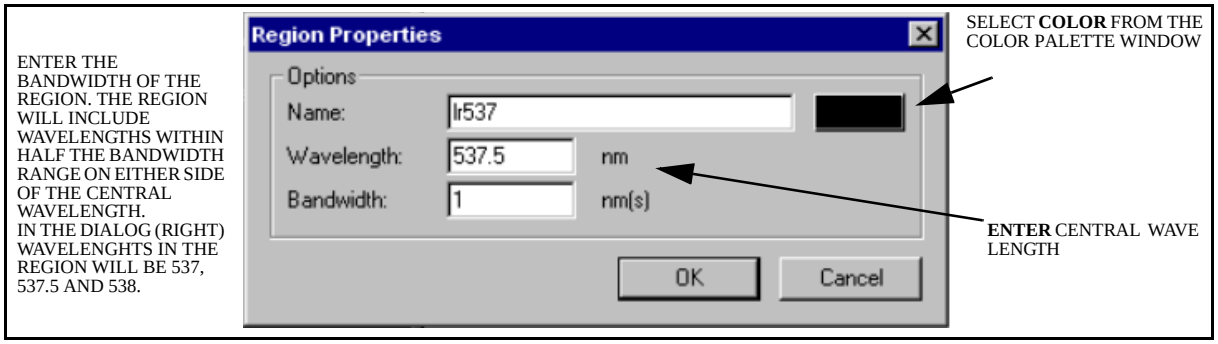


Figure A-31. Region Properties Window

12. Click **OK**.

    The LR537 region marker now appears in the Region edit window.

13. Repeat Steps 8 through 10 for the remaining two regions.

    Region 2:

    - Name: PR539 (Peak Region 539)
    - Green (color button)
    - Range: 539 to 554

    Region 3:

    - Name: RR555 (Right Region 556)
    - Orange (color button)
    - Range: 555 to 556

    Select the three regions for display in Spectra Monitor under the GRAPHS icon, see Figure A-32

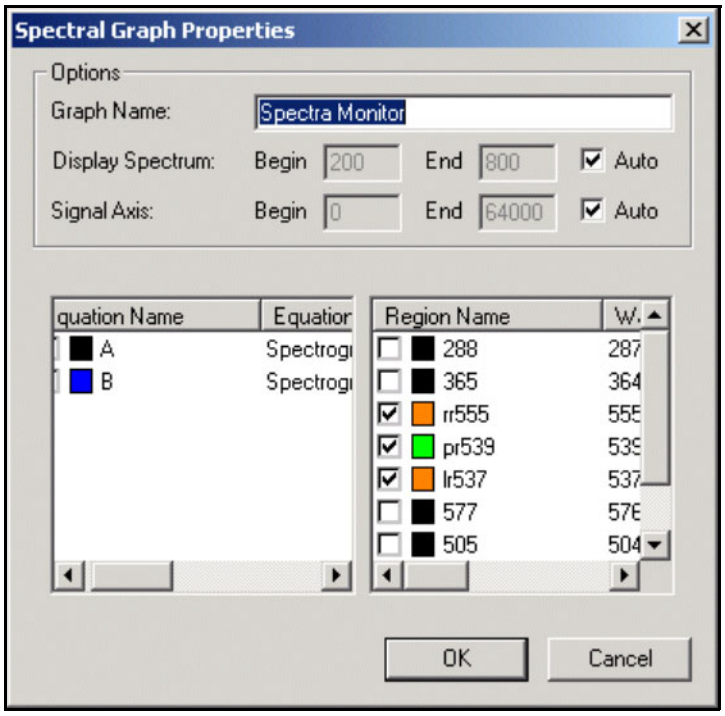


Figure A-32. Spectral Graph Properties Window

Save the new configuration as *genericROOM_LIGHTb* and reprocess the data. See Figure A-33

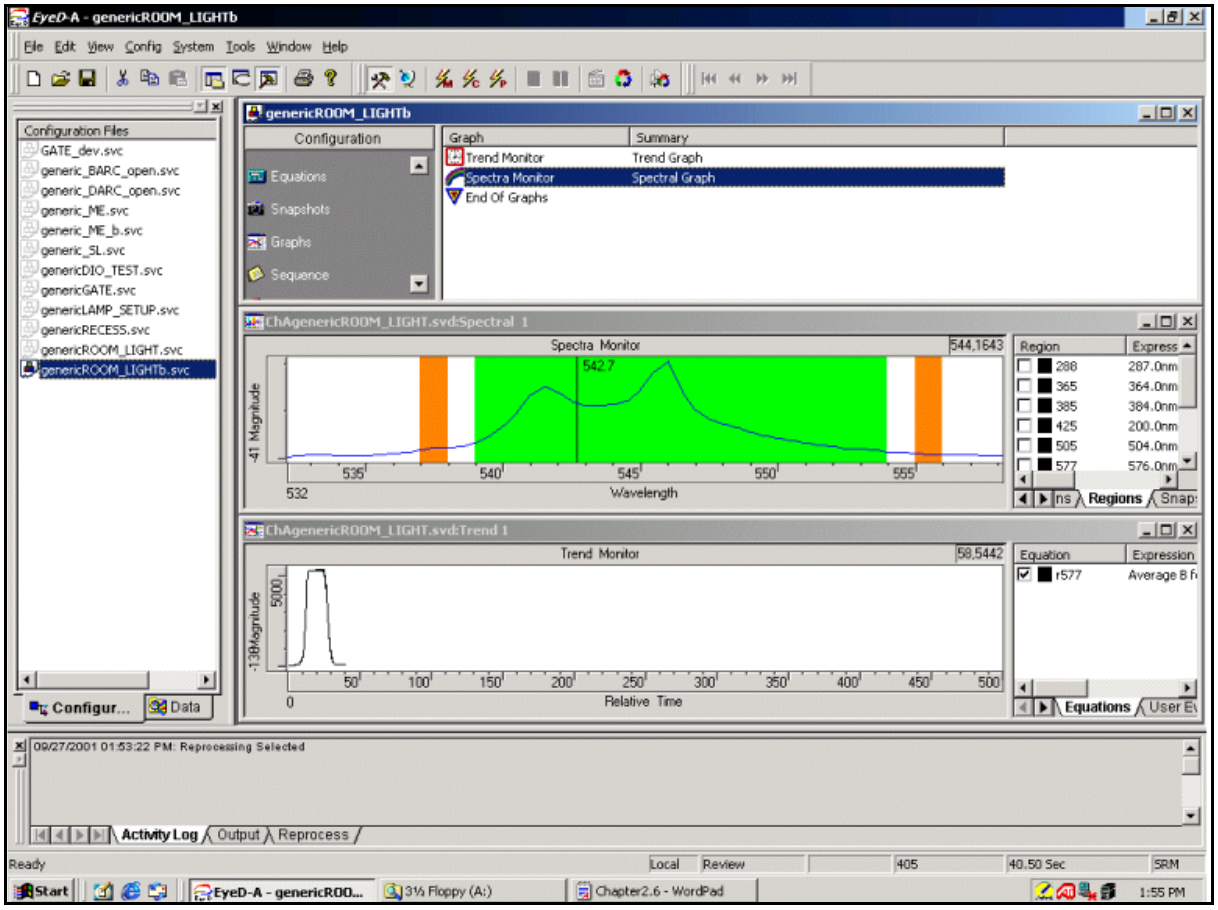


Figure A-33. Spectral Graph of Three Regions

A.5.12 Adding a Graph to the Existing Configuration

This exercise shows how to add a graph to an existing configuration file and continues with the edits to genericROOM_LIGHT.svc configuration started in Section A.5.6.

To add a graph to an existing configuration file:

This exercise should be done immediately after Section A.5.11. The objective is to add a new graph that will show spectral details of the mercury doublet and the three regions defined for background subtraction.

1. Click the Graphs icon in the Configuration Editor.
2. Right click the End Of Graph line.
3. Select Insert Graph (or press the Insert key on the keyboard).

NOTE

By convention, items are inserted above the line that is highlighted in blue or has a gray-dotted box around it. Graphs will be generated in the order listed in the Graphs Configuration Window. By listing the new Mercury Doublet Graph last, it will appear last (i.e., on the top of the cascaded plots generated) when the data is Reprocessed.

4. Select Spectral Graph from the Context Configuration pop-up menu and press the left mouse button.
5. In the Spectral Graph Properties window, enter the following information:

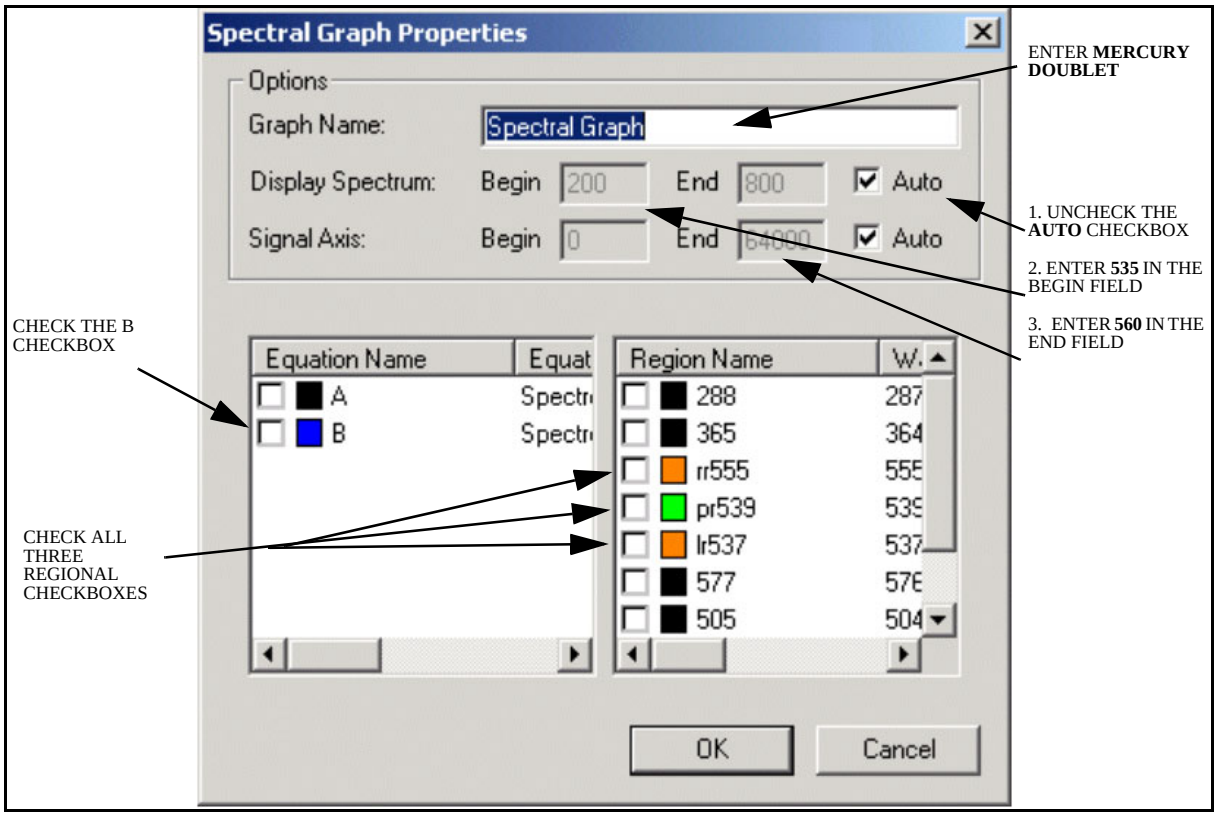


Figure A-34. Spectral Graph Properties Window

The screen should look like this:

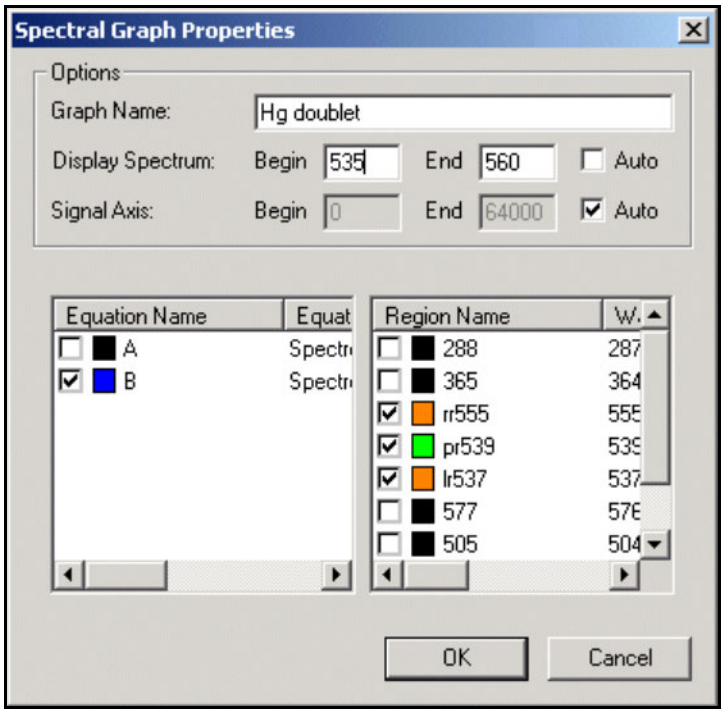


Figure A-35. Completed Spectral Graph Properties Window

After clicking OK, the user should have three graphs in the Graphs Edit window, as shown in Figure A-36.

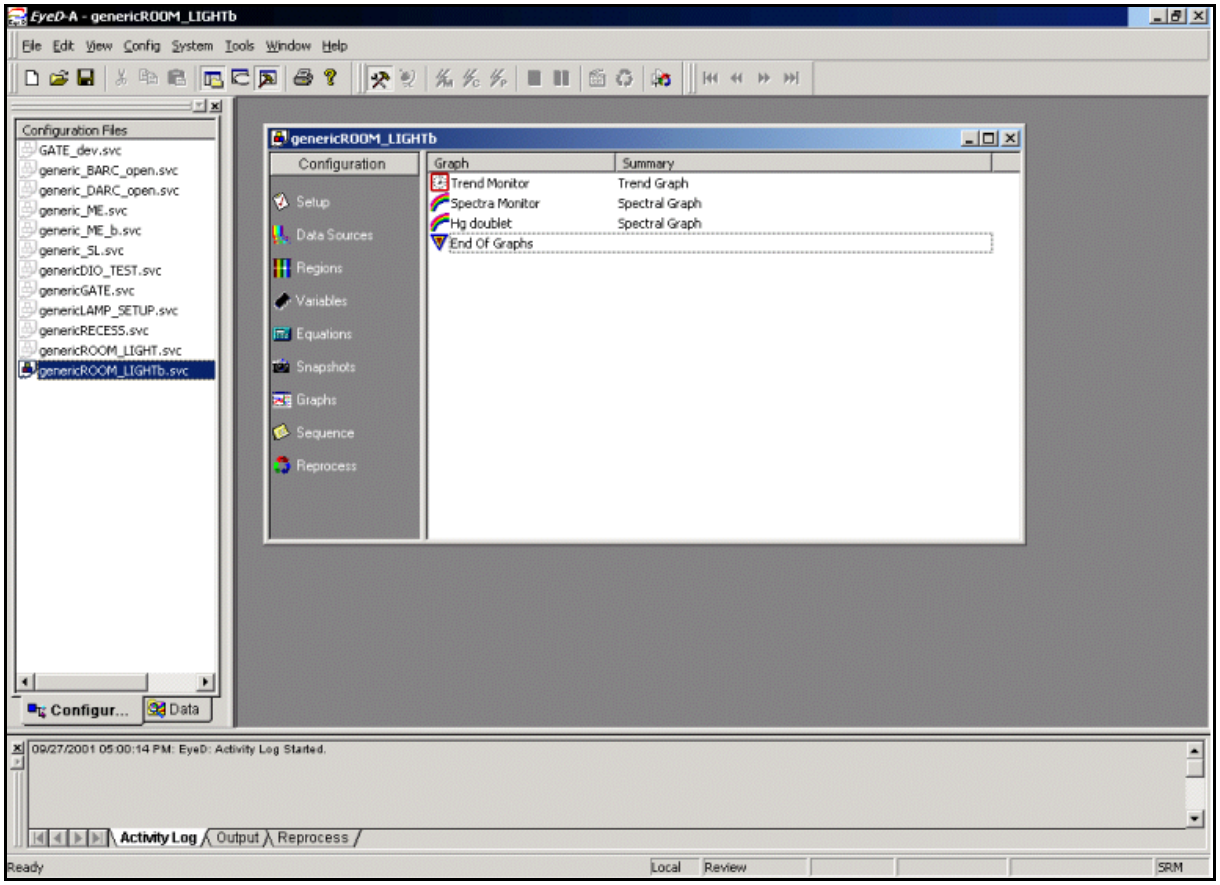


Figure A-36. Graph Edit Window

A.5.13 Saving and Activating Configuration File Changes for Endpoint Algorithms

Click **File > Save** to save the configuration as the *genereicROOM_LIGHTb*. Make sure that you save the configurations with different file names using *File > Save As...* whenever you want to preserve the original file without edits

NOTE

If the user chooses not to save the edited configuration file, EyeD will prompt if the changes are to be saved before allowing the configuration file to be closed.

When all edits are complete, to make the configuration an active endpoint algorithm on the EyeD system, use *File > Save As...* to make the final configuration have a numerical name with the form XX.svc (XX being the integer between 1-62). XX is the algorithm number selected for the Centura recipe step.

A.5.14 Debugging Errors

This exercise acquaints the user with automated error checking features of the EyeD software.

EyeD software is, in essence, a high-level programming language for creating unique algorithms applying to spectrograph data. As a debugging aide, EyeD provides an error-checking feature, called validation that runs constantly. As soon as Validation detects an error, it alerts the process engineer by displaying an error message in the Activity Log of the Output Window.

Below are examples of Range definition errors that the Validation feature will detect and report.

Example #1:

1. Enter 100 in the starting Range field of the LR537 Region Properties window.
2. Click **OK**.

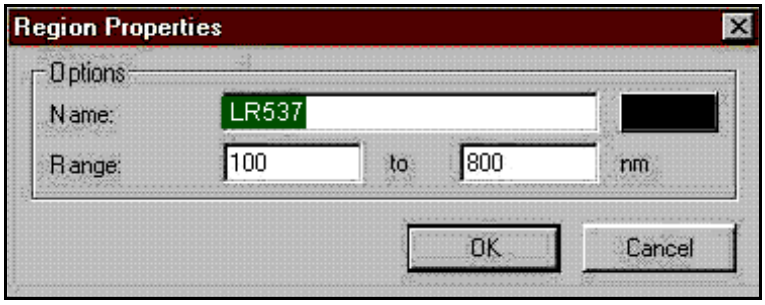


Figure A-37. Region Properties Window

3. Click the Validate icon ( ) on the Button toolbar or select **Validate** from the Edit menu.

   After validating, the following error appears in the Activity Log of the Output Window.

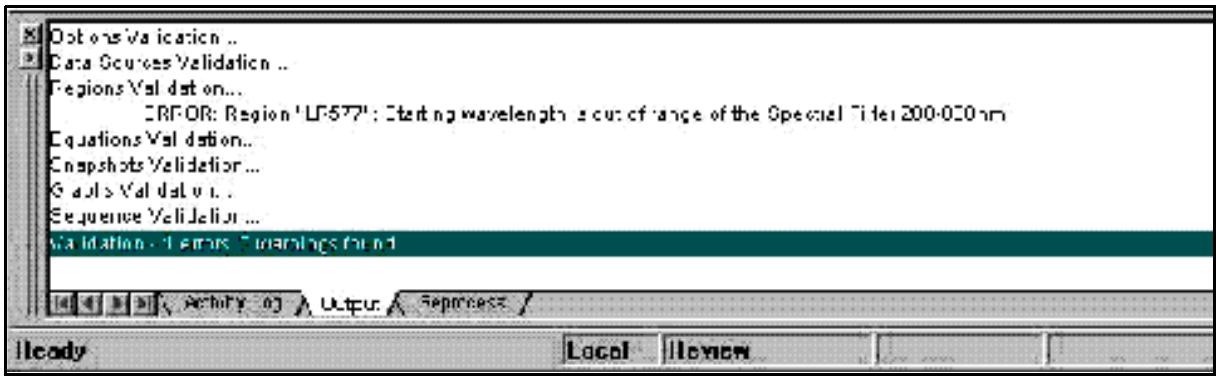


Figure A-38. Output Window Activity Log Validation Message

As soon as the configuration file is reprocessed, saved, or validated using the Validation icon, the validation debugger checks to see if any errors exist in the configuration file. If an error exists in the Regions edit window, for example, an “X” prints over the Region icon on the Regions list to alert the process engineer where the problem exists. See Figure A-39. The process engineer must correct the error before running the configuration file.

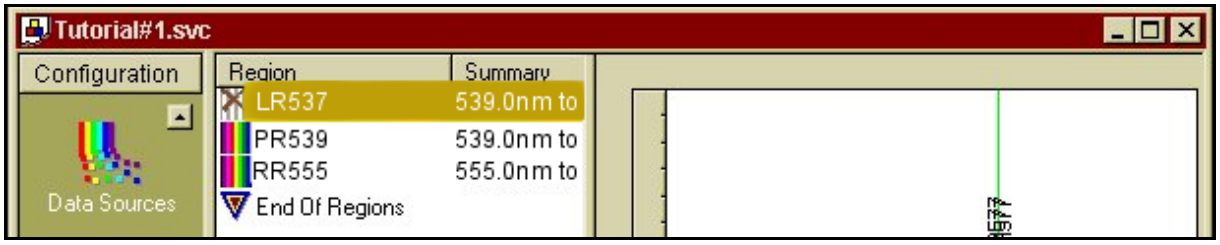


Figure A-39. Validation Error Icon

When saving a configuration, if Validation finds an error, the process engineer can choose to:

- Continue with the Save without correcting the error (i.e., saving the configuration file in its present error state). Note, however, that the process engineer must correct the error before running the configuration file.
- Not save the configuration file
- Correct the configuration file and validate again by clicking the Validate icon on the Button toolbar or selecting Validate from the Edit menu.

A.5.15 Running (Testing) an Edited Configuration File

This exercise shows how to run (or test) a previously edited configuration file.

Follow the same reprocessing steps outlined in Section A.5.7. Reprocess the data genericROOM_LIGHT.svd using the configuration genericROOM_LIGHT.svc, and then with genericROOM_LIGHTb.svc. You will notice how the changes appear on the screen, first the original configuration screen, Figure A-40

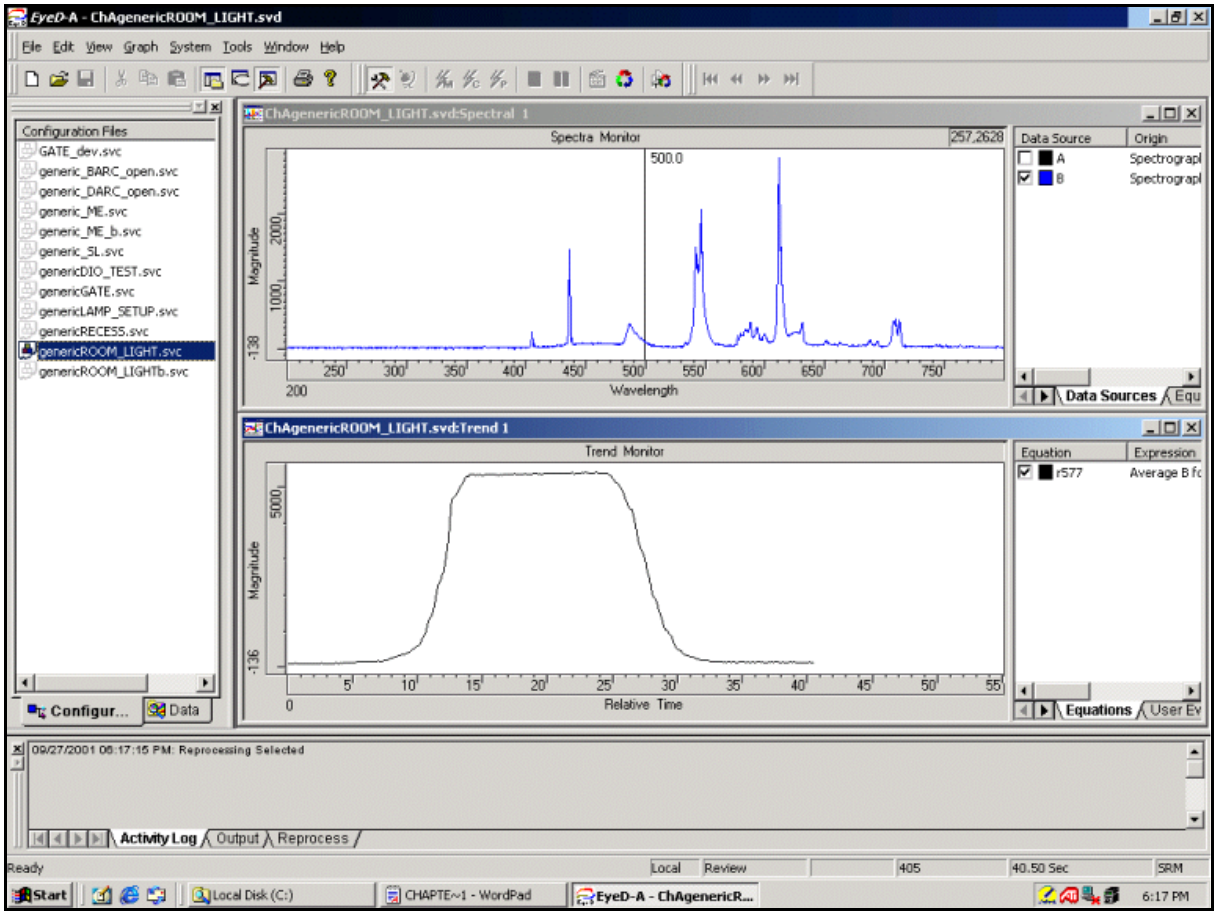


Figure A-40. Original Configuration

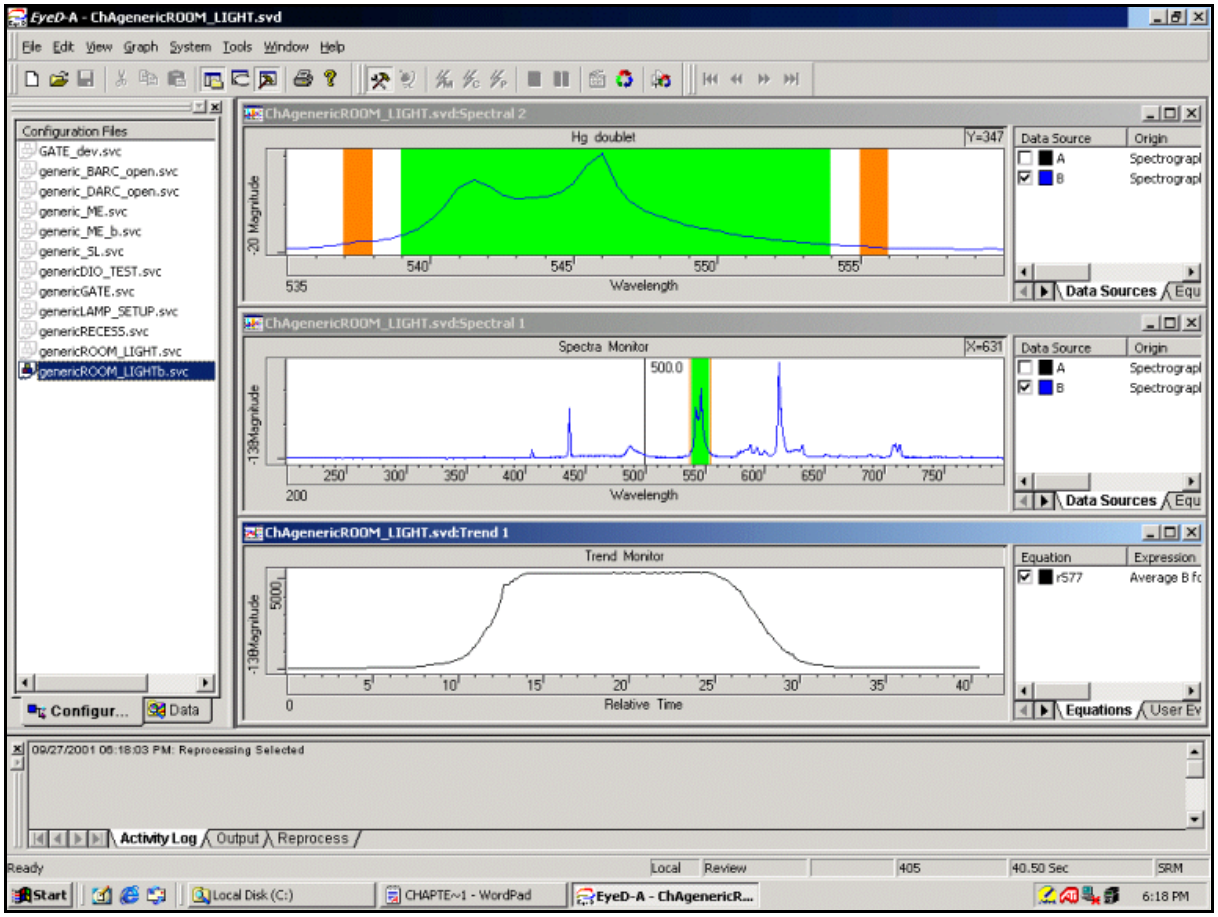


Figure A-41. Revised Configuration

In summary, to run (or test) an edited configuration file:

1. After tiling the graphs, click the Reprocess button again and watch the reprocessing sequence of the selected data file(s).
2. Use each of the Data Navigation Tools, previously described, to change the display in real time while the data is reprocessing.
3. Watch the changes that occur in the graph window when clicking on the Data Sources, Equations, and Regions tabs in the window that appears to the right of the graphs.
4. With the Data Sources tab selected, the user can remove or place a check mark in the check box, marked A. While reprocessing, this check box controls the display of the spectra on the graph in real-time, as well as the static display.
5. With the Equations tab selected, notice that no information appears in this window. This window will be discussed in a later tutorial exercise.
6. With the Regions tab selected, the new regions, defined in the genericROOM_LIGHT.svc configuration file, are available to be graphed. Placing

or removing a check mark in a Region box controls the display of the Region on the graph in real time while reprocessing and on the static graph after reprocessing.

7. Each time the data is reprocessed, the graphs are re-configured as prescribed by the “Current” configuration. Therefore, all changes manually made to the graphs during or after Reprocessing will be lost when the data is subsequently Reprocessed.

A.5.16 Adding Another Trend Equation

Open the *genericROOM_LIGHTb.svc* configuration, and go to the equations section:

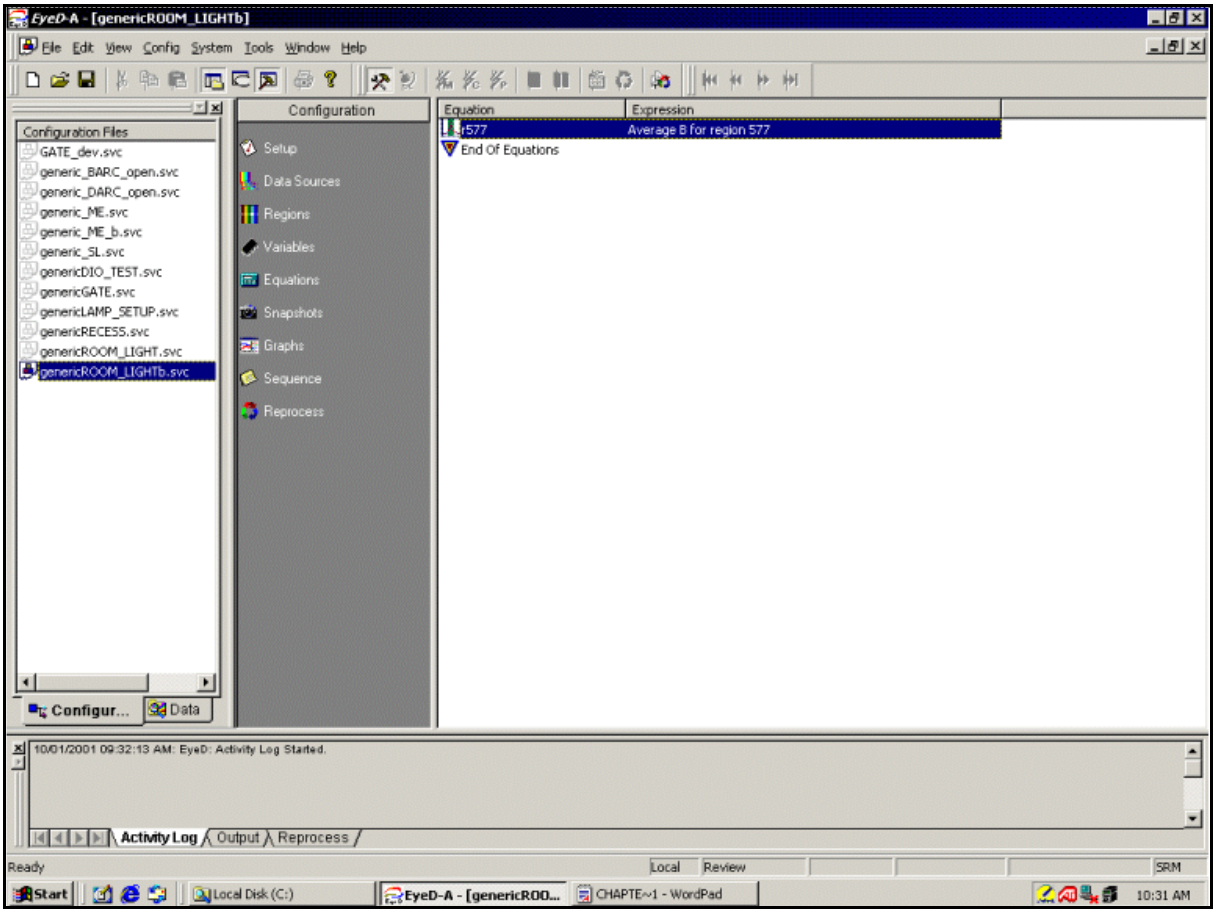


Figure A-42. Configuration Window

Right-click the **End of Equations** icon and make the selection to insert a trend.

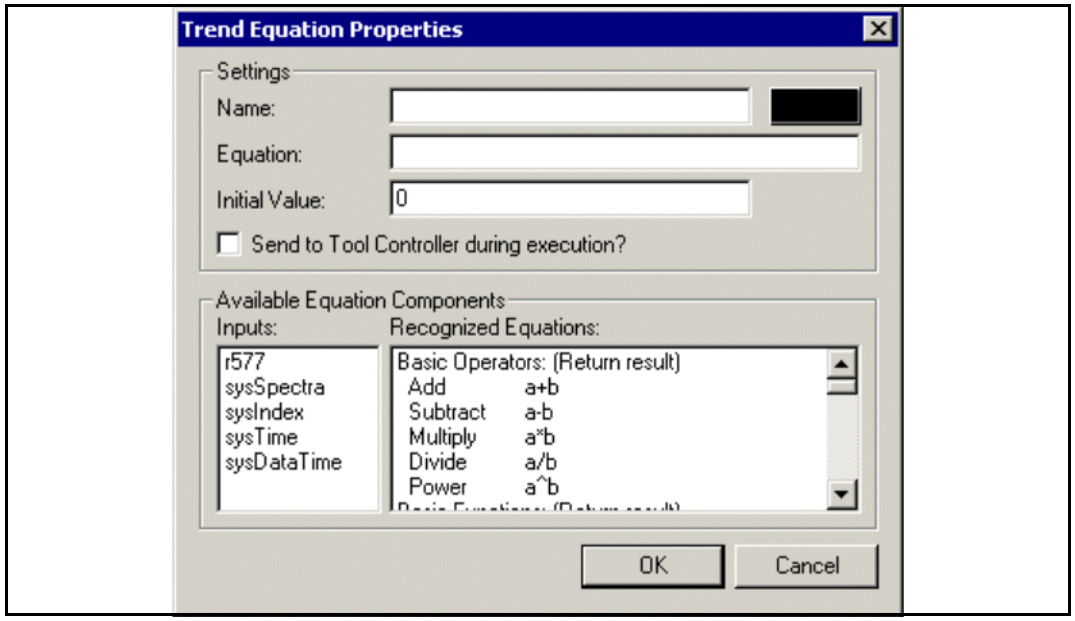


Figure A-43. Trend Equation Properties

Enter the following: trend equation name (here tavg577 is selected to readily identify the trend as a *time average*), color, and equation expression.

Entering an equation expression is quickest if you first select the desired *Recognized Equation* by double clicking on it, then entering the argument for **a**, and the number of data points **n** to perform the time average on (it is not necessary to type out the entire expression).

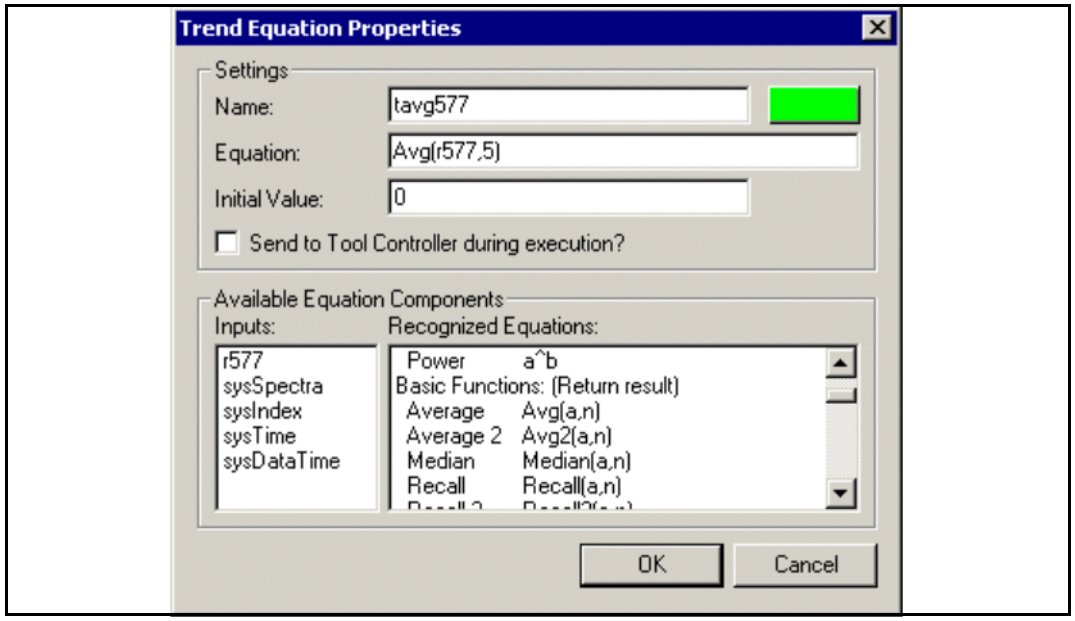


Figure A-44. Completed Trend Equation Properties Window

In Figure A-44 the selected number of data points to average was 5 (five), which implies an averaging window of 0.5 seconds based on the number of data points (5) times the data

interval (100ms). The data interval and integration period for configurations is selectable, and is defined in the Setup portion of the configuration.

The Equations screen will look like:

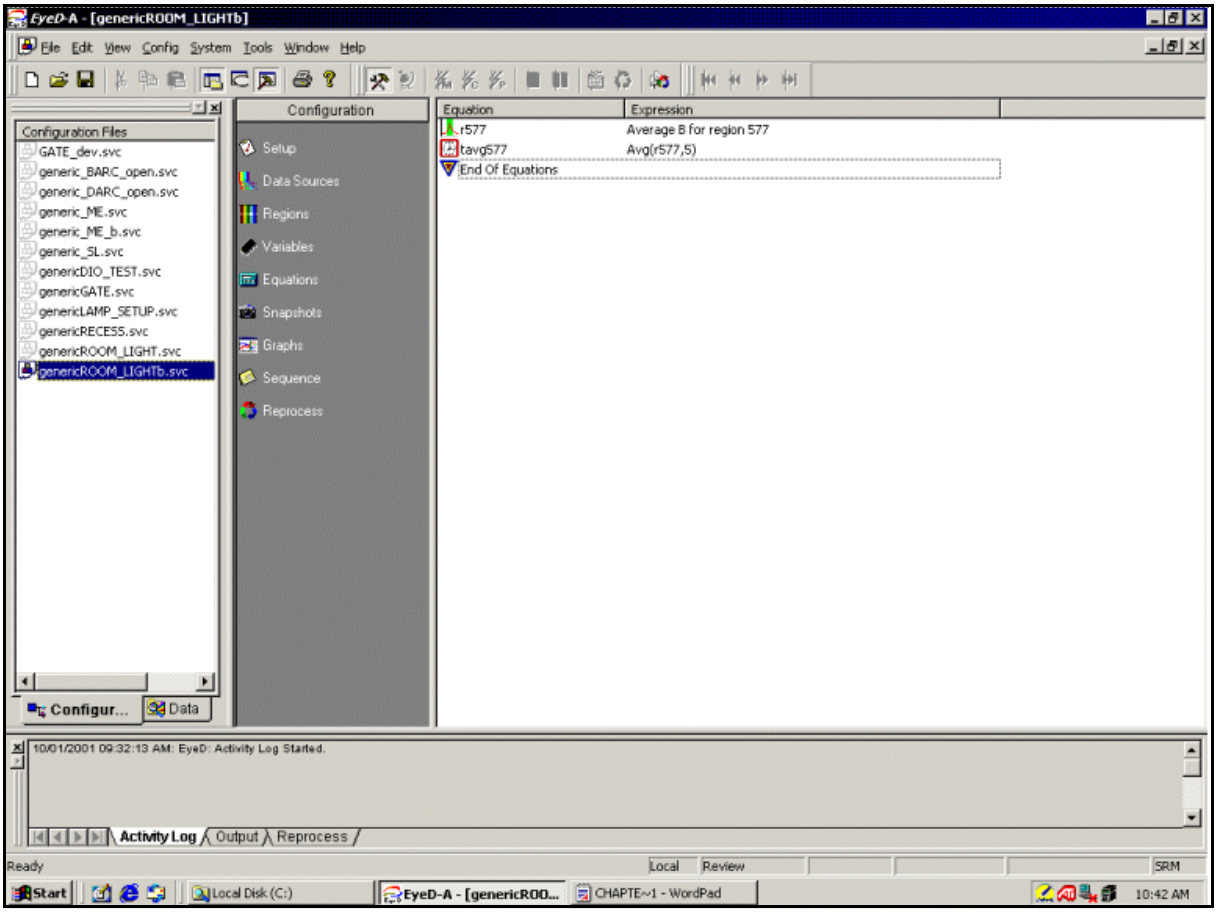


Figure A-45. Resulting Equations Window

Now go to the graphs section of the algorithm and double click on the **Trend Monitor** icon, and select **tavg577** for display.

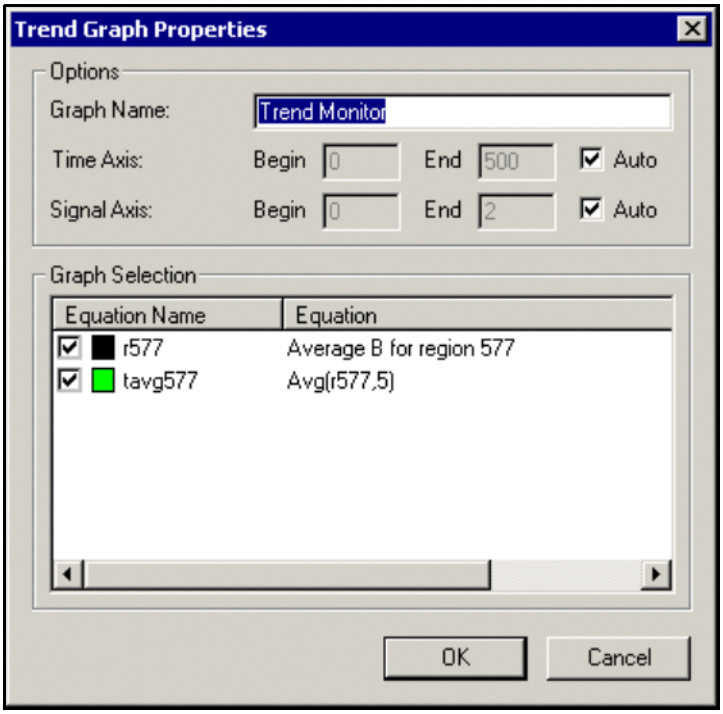


Figure A-46. Trend Graph Properties

Save and close the configuration.

Next, reprocess the data file genericROOM_LIGHT.scd with the updated genericROOMb.svc. Maximize the Trend Monitor graph; the output will look like that in Figure A-47.

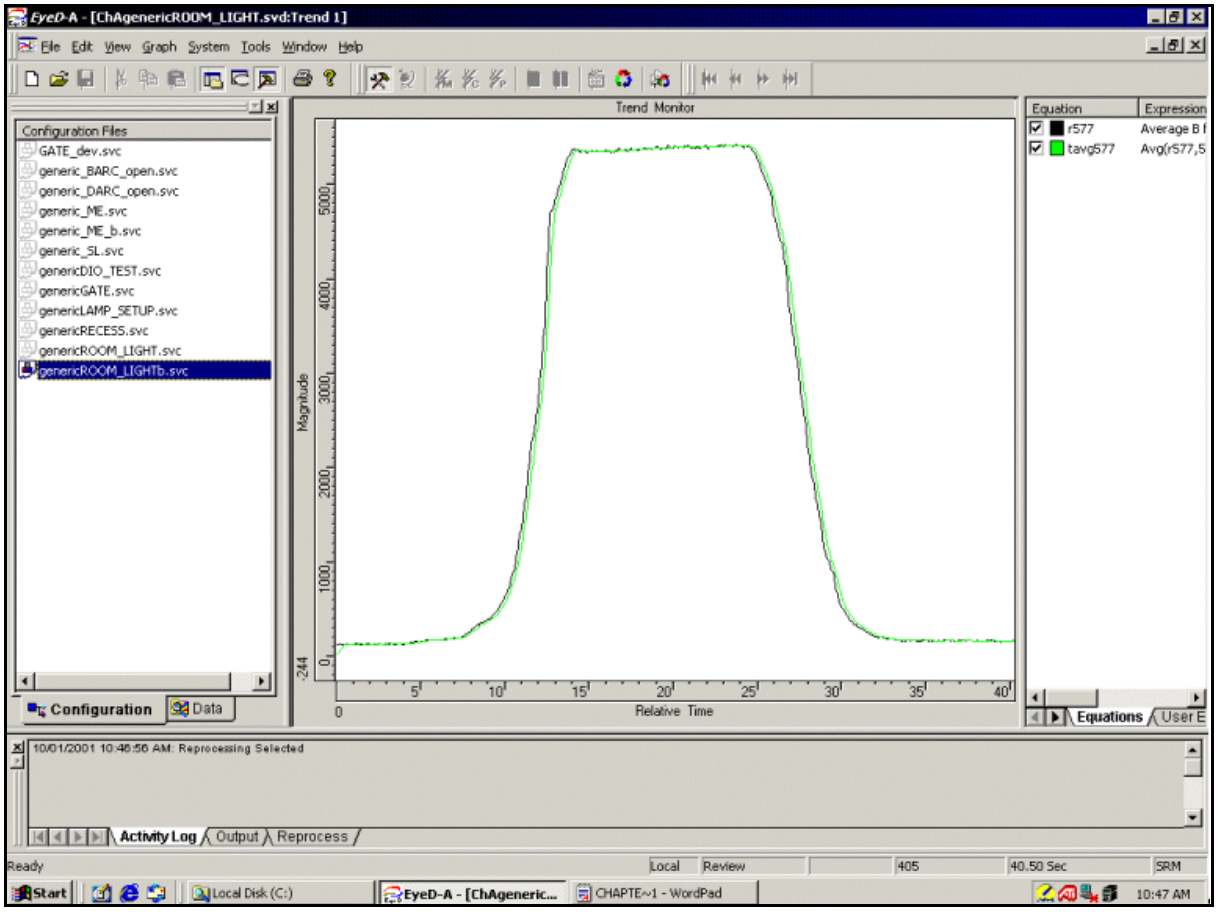


Figure A-47. Maximized Trend Monitor Graph

You will see two trends, the original raw data stream for 557nm (black) and the smoother line of tavg577 (green). There is a small time lag between the raw and time averaged trends, an unavoidable consequence of using a running average. The lag can be minimized by selecting fewer data points in the time averaging function (for instance 5 rather than 10). More data points make the output smoother.

A.5.17 Use Snapshots to Normalize a Data Trend to an Initial Value

A snapshot creates a spectral data file at a defined instant in time. The values of this spectrum can be used to normalize data that comes after the snapshot instant. Generally, a snapshot should be taken as soon as possible in to the endpoint algorithm, with enough time given for the plasma in the chamber to stabilize after the initial RF transient and match tuning are complete.

A.5.17.1 Snapshots

Just as the name implies, the Snapshot captures a stop-action picture of a spectrum from a stream of real-time spectra. This spectrum is captured by setting the parameters on the Spectral Snapshot Properties screen. See Section 3.5.13 for details.

A.5.18 Configure Endpoint Sequence Based on Derivative Trend and Snapshots

Derivative trends are very useful for setting up endpoint configurations. These replace the boxes that have been used in previous AMAT endpoint software. Keep in mind that the previous box height divided by the box time is equivalent to the idea of derivative used here. Previously, the box height value in use was in percent of full scale. In EyeD software, this is easily configured in one of three ways: the intensity value can be in terms of CCD counts, in terms of percent variance from the initial value using a snapshot to normalize the data to the initial value as shown above, or in terms of percent of full scale (by creating a trend equal to the result of dividing the data trend tavg577 by the full scale range of the CCD, which is 64,000 counts).

To create a derivative trend, in the equations portion of the configuration, right-click on *End of Equations*, select **delta**, and enter values for the name, color, equation **a** (tavg577) and **n** (the derivative time segment, or *window time* in previous AMAT endpoint terminology); the initial value should be left at zero. See Figure A-48.

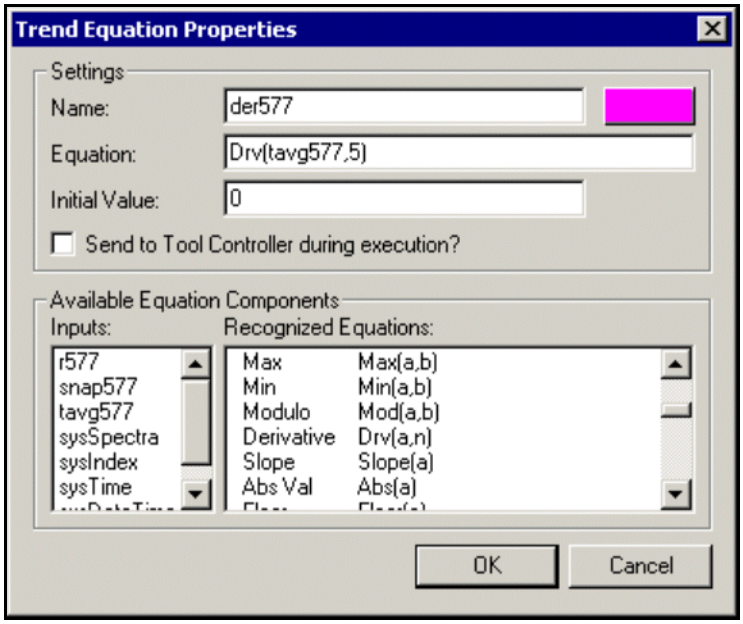


Figure A-48. Trend Equation Properties Window

It is good practice to smooth the raw data using a time average in order for the noise of the derivative of the data to be minimized. The degree of smoothing must be balanced with the need to introduce as little time lag as possible.

Further smoothing of the derivative trend is realized by choosing larger values of n in the definition of the derivative equation; use as little smoothing as possible when it is necessary to have the fastest time response, for instance, for a gate etch emission endpoint step. In practice, our tests have shown that 5 data points of smoothing with the time average, followed by a selection of 5 data points for dt in the derivative equation provides good results with minimal time lag.

Modify the Trend Monitor graph to only display *tavg577* and *der577*. See Figure A-49.

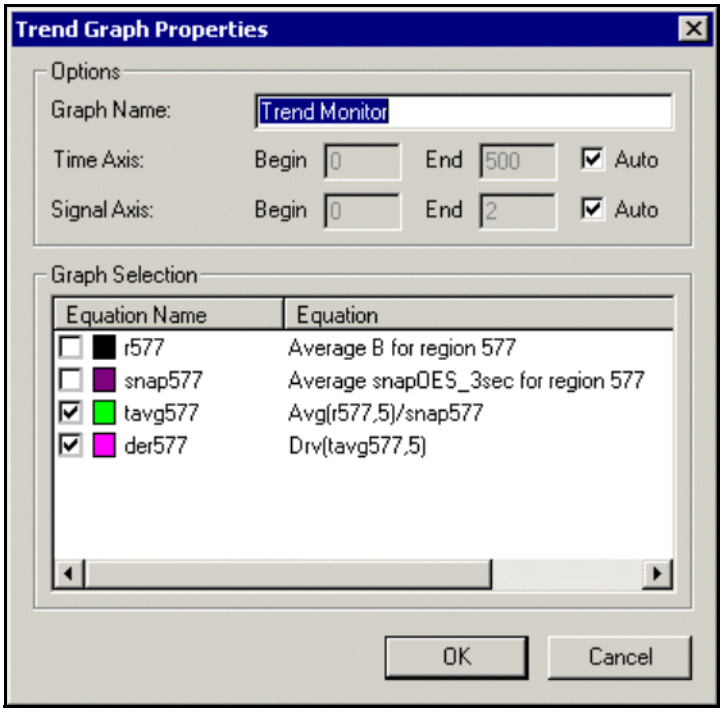


Figure A-49. Trend Graph Properties

Save the configuration and reprocess. The time average and derivative trends will look like Figure A-50.

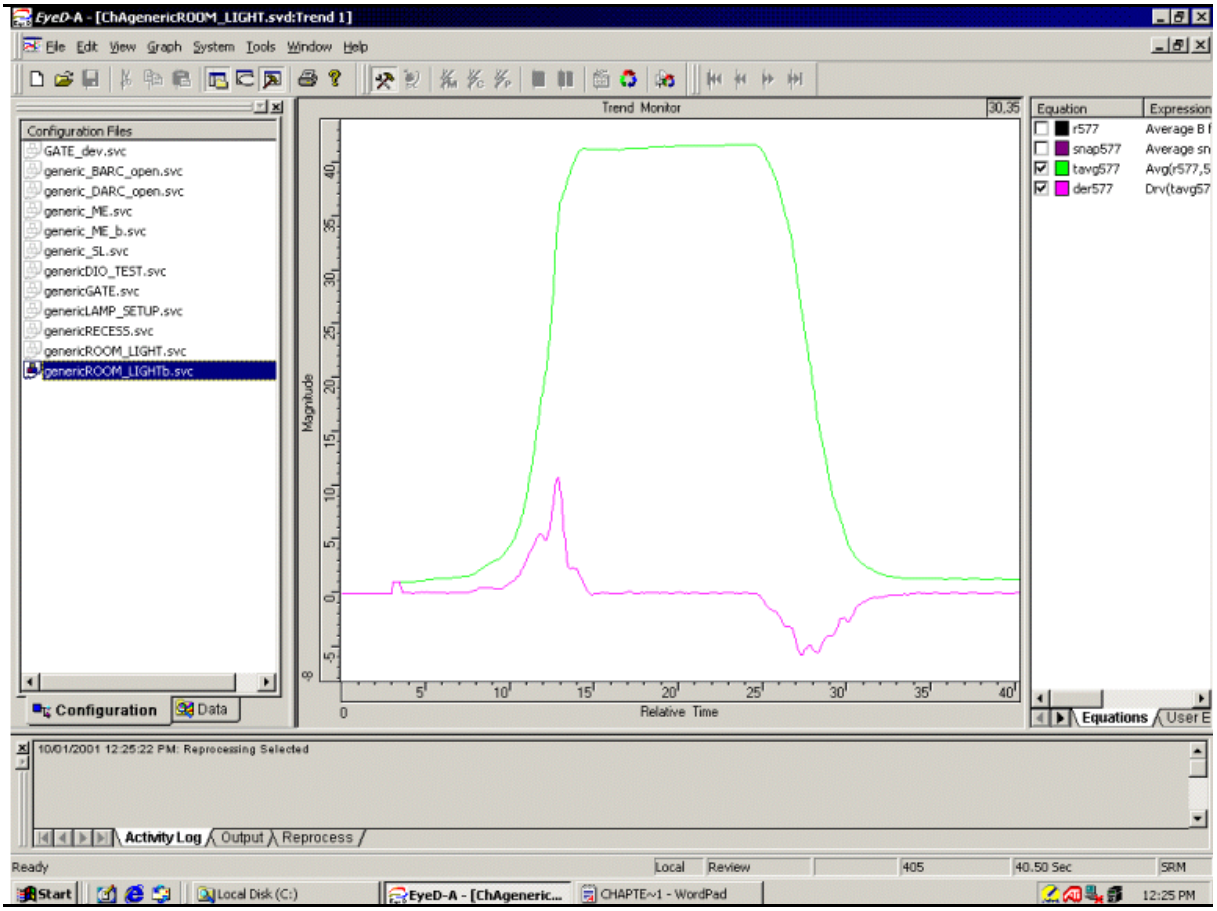


Figure A-50. Time Average and Derivative Trends

The derivative function will be used to develop the endpoint sequence outlined in the next section.

A.5.19 Defining an Endpoint Sequence

An endpoint sequence defines the logical order which events must occur for the EyeD system to issue an endpoint command back to the Centura to halt processing of a recipe step. There are many elements which can make up a sequence. For many applications, a time delay followed by the detection of a threshold are all that will be required to make a robust endpoint algorithm. In this example, a time delay to get past the transient of the RF on sequence and the snapshot will be used. Then, a threshold test of the value of *der577* will be used to detect endpoint at the onset of the falling trace that occurs at about 25 seconds into the process.

Open the configuration sequence icon, then right-click on *End of Sequence* to access the possible sequence items. See Figure A-51.

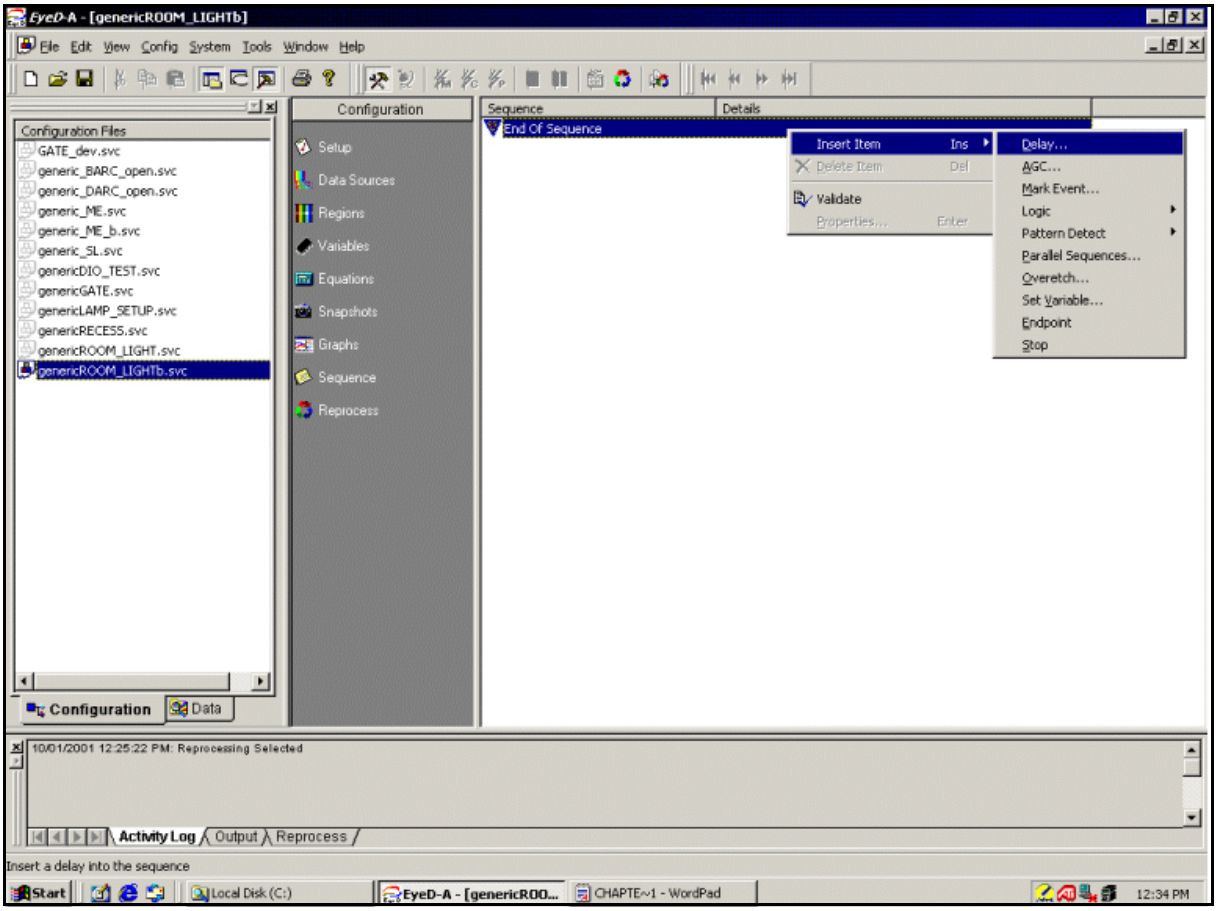


Figure A-51. Insert Items Menu

Now enter values for the time delay. See Figure A-52.

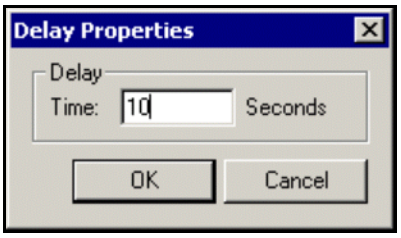


Figure A-52. Time Delay Properties

It is good to put in markers in order to validate the progress of sequence steps. After entering the time delay above, select and insert a *Mark Event*. See Figure A-53.

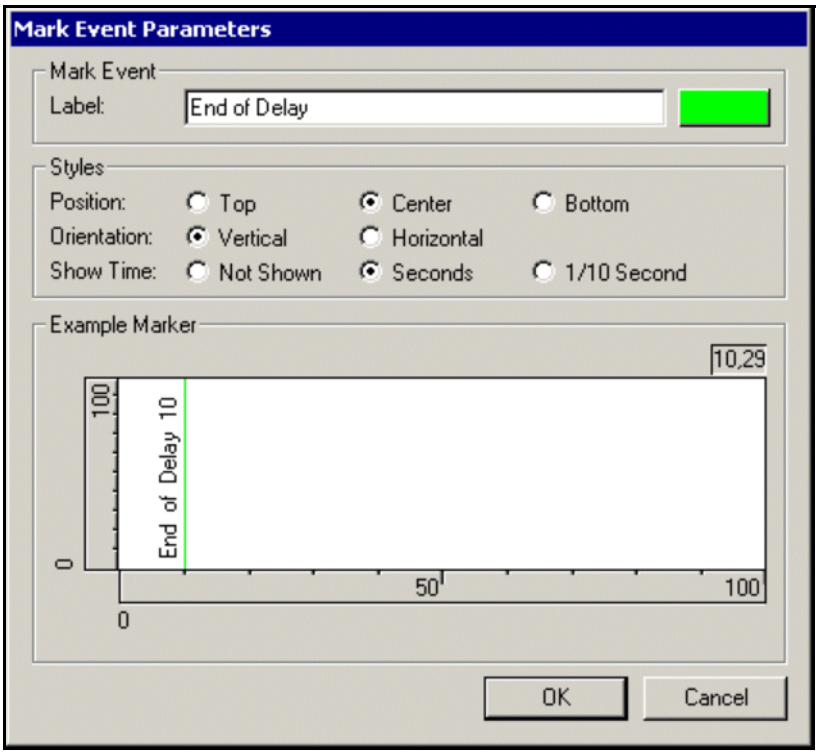


Figure A-53. Mark Event Parameter Window

At the end of the time delay, the sequence can be configured to detect almost any conceivable change in a trend. There are resources to perform Neural Network pattern detection, threshold tests, Fourier analyses, and many other detection schemes built in to EyeD. This example will use a simple threshold pattern detection, operating on *der577*. To set this up go to **Pattern Detect > Threshold...** See Figure A-54.

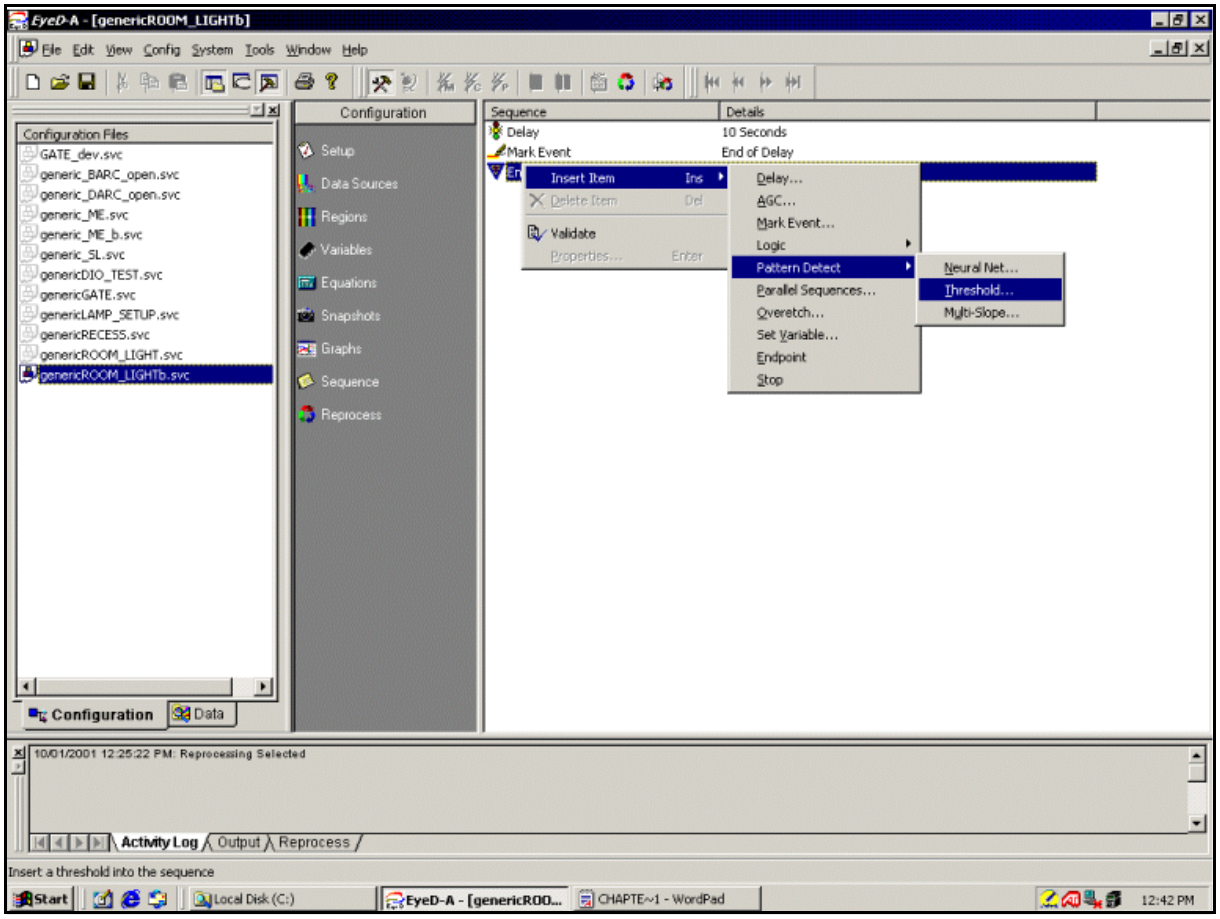


Figure A-54. Pattern Detect / Threshold

The following window appears. See

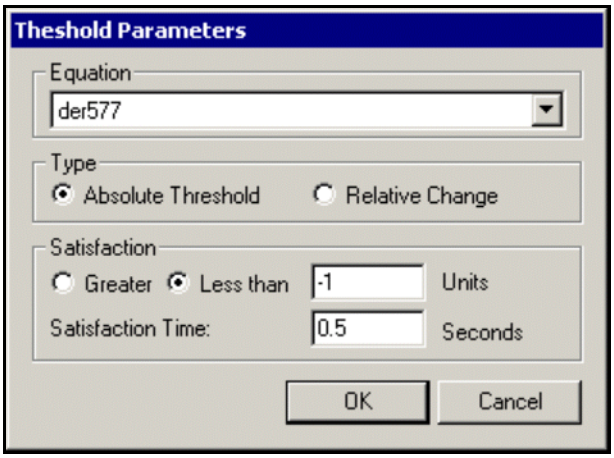


Figure A-55. Threshold Parameters

Selections are made here to detect a negative slope of a value less than (more negative than) -1 unit for a time of at least 0.5 seconds. Next, insert another *Mark Event* called *ENDPOINT*, and insert the command endpoint. The final sequence will look like Figure A-56.

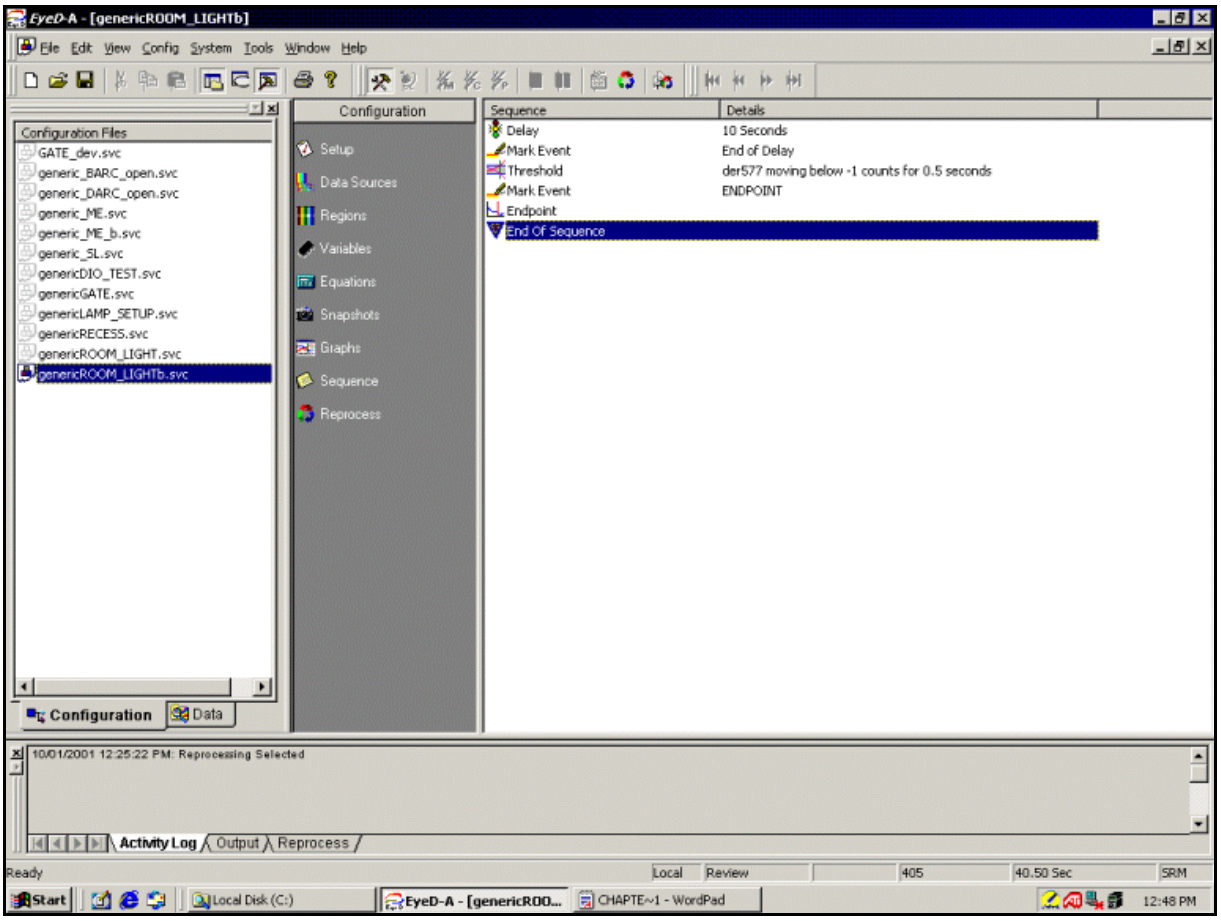


Figure A-56. Building Endpoint Equation

Now save the configuration and reprocess to see the result. See Figure A-57.

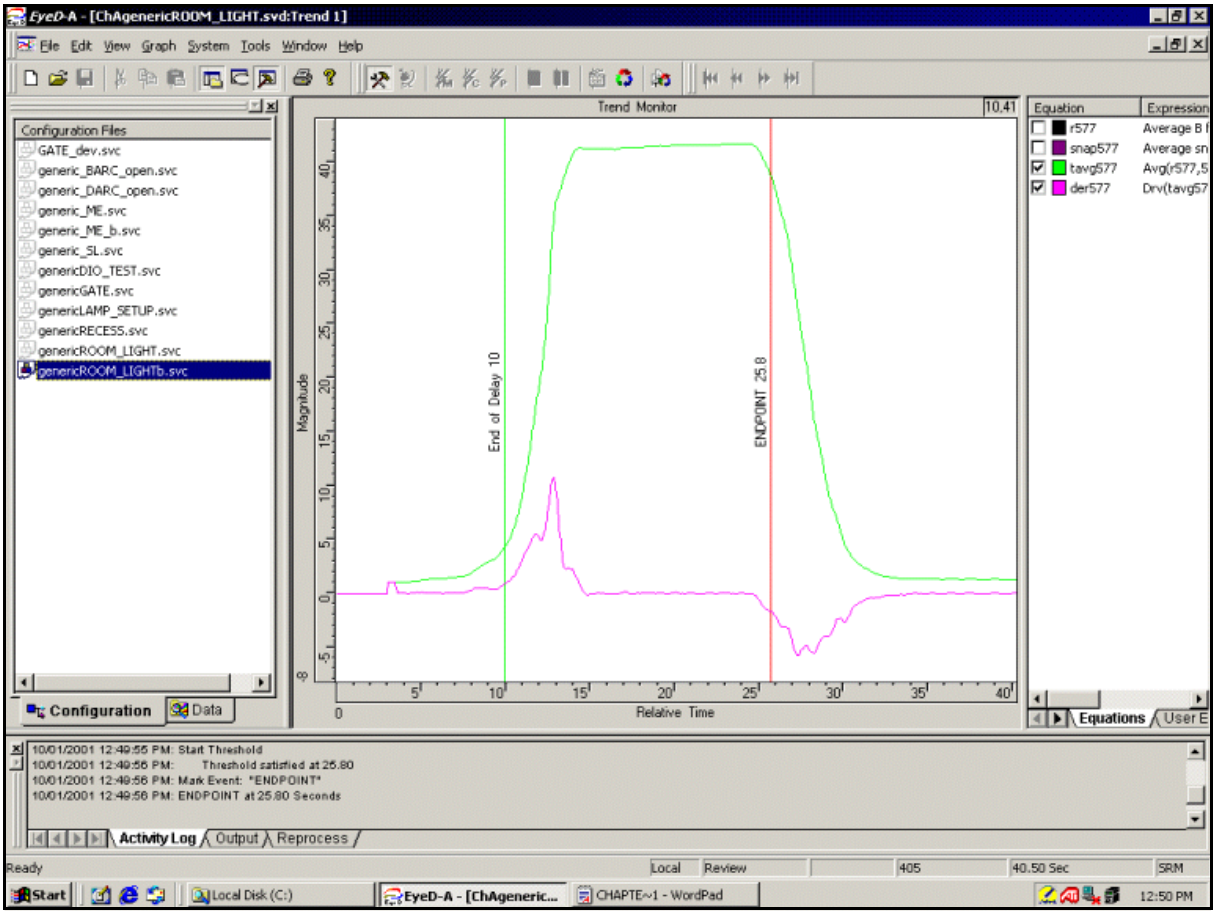


Figure A-57. Endpoint Graph

The configuration now detects endpoint for a falling trace having a slope greater than -1unit per 0.5 second of slope, and satisfied for 0.5 seconds. Adjustments to the detection parameters are straightforward should faster response or more noise immunity be required for particular situations.

This tutorial is now completed with the user having been stepped through the steps of creating a basic endpoint configuration using OES data. Other generic data files are available for practicing the steps of building configurations for IEP-gate or IEP-recess applications. Please refer to the Silicon Etch Engineering intranet web site to download these files.

THIS PAGE INTENTIONALLY LEFT BLANK.

B Wavelengths by Emission Species

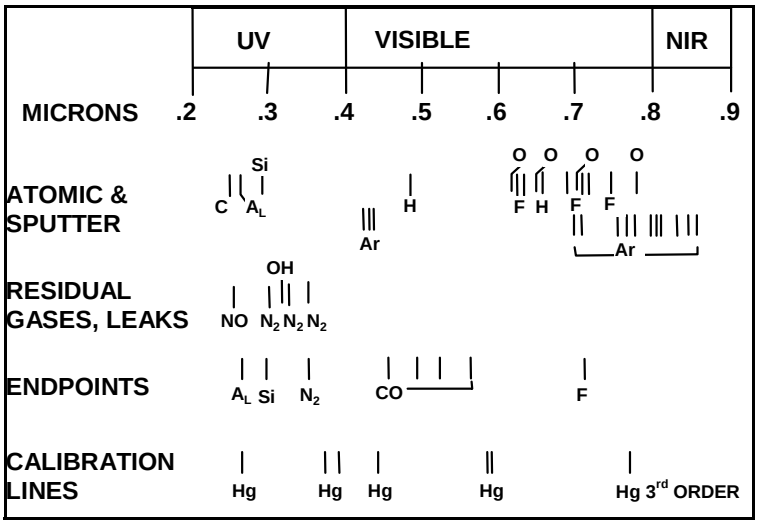


Figure B-1. Spectra of Common Species

B.1 Representative Emission Lines Used in Endpoint Detection of Plasma Etching

Use the table below when considering wavelengths to monitor. This table is an abbreviated list of the wavelength information that appears presented on pages 11 and 12 and has been developed from Verity research and Herman[1].

Table B-1. Representative Emission Lines

Monitored Species	Wavelength (nm)
Al	308.2, 309.3, 396.1
AlCl	261.4
As	235.0
C2	516.5
CF2	251.9
Cl	741.4
CN	289.8, 304.2, 387.0
CO	292.5, 302.8, 313.8, 325.3, 482.5, 483.5, 519.8
F	703.7, 712.8
Ga	417.2
H	486.1, 656.5
In	325.6
N	674.0

Table B-1. Representative Emission Lines

Monitored Species	Wavelength (nm)
N2	315.9, 337.1
NO	247.9, 288.5, 289.3, 303.5, 304.3, 319.8, 320.7, 337.7, 338.6
O	777.2, 844.7
OH	281.1, 306.4, 308.9
S	469.5
Si	288.2
SiCl	287.1
SiF	440.1, 777.0

[1] *From Herman, Irving, P. (1996), "Optics Diagnostics for Thin Film Processing," Academic Press, p. 177. Ref. From Singer (1988), Selwyn (1993) and other sources cited in the text.*

Table B-2. Common Spectral Lines in Etching Applications (by Wavelength)

200nm	201.2 - Au 202.1 - Au 205.5 - Cr 206.8 - Ge 221.6 - Ni 228.8 - Cd 229.9 - SiO 232.0 - Ni 234.4 - SiO 235.0 - As 237.0 - NO 238.9 - CO	240.0 - CF 241.4 - SiO 242.8 - Au 247.4 - CF 247.9 - NO 248.3 - Fe 248.7 - SiO 248.8 - CF_2 249.8 - B 251.9 - CF_2 253.6 - P 253.7 - Hg	254.4 - Cl2 255.1 - W 255.3 - P 255.8 - CF 256.1 - Cl2 257.8 - He 258.0 - CCl 259.5 - CF_2 259.6 - NO 261.4 - AlCl 262.8 - Pt 262.9 - CF2	264.8 - AlCl 264.7 - Ta 265.1 - Ge 265.9 - Pt 266.5 - BCl 266.9 - SiO 267.6 - Au 268.0 - NO 268.3 - AlCl 269.4 - SiO 269.8 - CO 270.2 - Pt	271.1 - CF_2 271.5 - Ta 272.2 - BCl 272.2 - NO 272.4 - W 274.8 - Au 275.0 - CF_2 277.8 - CCl 278.8 - CCl 280.0 - CF_2 280.2 - Pb 280.7 - SiCl	281.0 - SiCl 281.1 - OH 281.4 - N_2 282.0 - N_2 282.4 - SiCl 283.3 - CO 283.3 - Pb 283.7 - C 286.0 - BCl 286.0 - NO 287.1 - SiCl 288.0 - CO_2	288.2 - Si 288.5 - NO 289.3 - NO 289.8 - CN 290.0 - CO_2 292.1 - CF_2 292.5 - CO 293.0 - Pt 295.3 - N_2 296.2 - N_2 297.7 - N_2
300nm	301.2 - Ni 301.2 - Ta 302.1 - OH 302.8 - CO 303.5 - NO 304.2 - CN 304.3 - NO 306.4 - OH 306.5 - Pt 306.7 - OH 307.0 - CCl 307.8 - OH 308.2 - Al 308.9 - OH 309.3 - Al 310.4 - N2	311.7 - N_2 312.3 - Au 313.2 - Mo 313.4 - CO 313.6 - N_2 313.8 - CO 315.9 - N_2 317.0 - Mo 319.3 - Mo 319.8 - NO 320.7 - NO 321.4 - CF_2 324.7 - Cu 325.3 - CO 325.6 - In 326.8 - N_2	327.4 - Cu 328.1 - Ag 328.5 - N2 330.6 - CO 330.9 - N2 331.1 - Ta 333.9 - N2 334.6 - SiF 335.0 - Gd 335.0 - N2 335.0 - Ti 336.0 - NH 336.3 - SiF 337.0 - CO2 337.1 - N2 337.7 - NO	338.3 - Ag 338.6 - NO 339.2- Zr 340.5 - Pd 341.5 - Ni 343.8 - Zr 346.2 - Ni 346.6 - Cd 349.3 - CO 349.6 - Zr 350.0 - N2 352.5 - Ni 353.7 - N2 357.2 - NO 357.7 - N2 357.9 - Cr	358.1 - Fe 358.4 - NO 358.6 - CN 359.0 - CN 359.3 - Cr 360.1 - Zr 360.5 - Cr 361.0 - Pd 361.1 - Cd 363.5 - Pd 363.5 - Ti 364.2 - N2 365.0 - Hg 365.3 - Ti 367.2 - N2 368.3 - Pb	371.1 - N2 372.0 - Fe 373.7 - Fe 375.5 - N_2 376.8 - Gd 379.8 - Mo 380.5 - N2 382.0 - He 385.8 - N2 386.2 - CN 386.4 - Mo 387.0 - CN 387.1 - CN 388.3 - CN 388.9 - He 389.5 - N2	389.0 - Zr 390.2 - SiCl 390.3 - Mo 391.2 - O 394.3 - N2 394.4 - Al 395.5 - SiF2 396.0 - Al 396.5 - He 397.3 - O 399.8 - N2 399.9 - Ti
400nm	400.0 - Ti 400.9 - W 402.6 - He 404.7 - Hg 405.1 - SiN 405.8 - Pb 405.9 - N_2 407.2 - W 407.4 - W 407.6 - O	407.7 - TiF 408.1 - Zr 408.7 - SiN 409.5 - N_2 410.2 - In 411.6 - SiN 412.7 - SiN 414.2 - N_2 417.2 - Ga 418.1 - CN	418.3 - TiCl 419.0 - O 419.3 - TiCl 419.7 - CN 420.0 - N_2 420.4 - SiN 421.6 - CN 423.9 - SiN 424.1 - AlH 425.4 - Cr	425.9 - AlH 426.7 - C 427.0 - N_2 427.5 - Cr 429.5 - W 431.4 - CH 434.0 - H 434.5 - N_2 434.8 - Ar 435.8 - Hg	436.8 - SiF 438.8 - He 440.1 - SiF 440.7 - SiN 444.3 - SiN 447.1 - He 451.1 - In 451.1 - CO 460.0 - CO 460.2 - P	464.9 - O 468.8 - Zr 469.0 - Zr 469.5 - S 471.3 - He 473.7 - C_2 474.2 - Ge 476.5 - Ar 479.4 - Cl 482.5 - CO	483.5 - CO 486.1 - H 488.0 - Ar 489.7 - Cl 492.2 - He

Table B-2. Common Spectral Lines in Etching Applications (by Wavelength)

500nm	501.6 - He 504.1 - Si 504.8 - He 505.5 - Si	508.6 - Cd 516.5 - C2 519.8 - CO 520.8 - Cr	520.9 - Ag 521.8 - Cl 542.3 - Cl 546.6 - Ag	546.0 - Hg 561.0 - CO 575.5 - N2 580.4 - N2	585.8 - Cn 585.4 - N2 587.6 - He 589.3 - Ge	590.6 - N2 595.9 - N2	
600nm	601.4 - N_2 607.0 - N_2 608.0 - CO 615.6 - O 615.7 - O 615.8 - O	623.9 - F 632.3 - N_2 634.7 - Si 634.8 - F 637.1 - Si 639.5 - N_2	639.7 - Ga 641.3 - Ga 641.4 - F 643.8 - Cd 645.6 - O 646.0 - P	646.9 - N_2 647.8 - CN 654.5 - N_2 656.3 - H 656.5 - H 662.0 - CO	662.4 - N_2 667.8 - He 670.5 - N_2 674.0 - N 677.4 - F 678.9 - N_2	683.4 - F 685.4 - F 685.6 - F 687.0 - F 690.2 - F 691.0 - F	696.5 - Ar 696.6 - F
700nm	703.7 - F 706.5 - He 706.7 - Ar 712.8 - F 716.5 - N2	720.2 - F 725.4 - O 725.6 - Cl 727.3 - N2 728.1 - He	732.6 - C 733.2 - F 738.4 - Ar 738.7 - N2 739.9 - F	741.4 - Cl 742.6 - F 750.4 - Ar 750.4 - N2 751.5 - Ar	751.5 - F 755.2 - F 757.3 - F 760.7 - F 762.6 - N2	763.5 - Ar 772.4 - Ar 775.3 - N2 775.5 - F 777.0 - SiF	777.2 - O 780.0 - F 787.3 - CN 789.6 - N2 794.8 - Ar
800nm	844.7 - O						

[1]*This table is based on Verity research; Herman, Irving P. (1996), "Optics Diagnostics for Thin Film Processing," Academic Press, p. 177 (from Singer (1988), Selwyn (1993), and other sources cited in the text "CRC Handbook of Chemistry and Physics," CRC Press, Inc. (1978); and Pearse, R. W. B. and Gaydon, A. G. (1976), "Identification of Molecular Spectra", Chapman and Hall.*

B.2 Common Spectral Lines in Etching Applications (by Species)

Table B-3. Common Spectral Lines by Species

	Species	Spectral Lines
A	Ag	328.1, 338.3, 520.9, 546.6
	Al	308.2, 309.3, 394.4, 396.1
	AlCl	261.4, 264.8, 268.3
	AlH	424.1, 425.9
	Ar	434.8, 476.5, 488.0, 696.5, 706.7, 738.4, 750.4, 751.5, 763.5, 772.4, 794.8
	As	235.0
	Au	201.2, 202.1, 242.8, 267.6, 274.8, 312.3
B	B	249.8
	BCl	266.5, 272.2, 286.0

Table B-3. Common Spectral Lines by Species

	Species	Spectral Lines
C	C	283.7, 426.7, 732.6
	C2	473.7, 516.5
	CCl	258.0, 277.8, 278.8, 307.0, 460.0
	Cd	228.8, 346.6, 361.1, 508.6, 643.8
	CF	240.0, 247.4, 255.8
	CF2	248.8, 251.9, 259.5, 262.9, 271.1, 275.0, 280.0, 292.1, 321.4
	CH	431.4
	Cl	479.4, 489.7, 521.8, 542.3, 725.6, 741.4
	Cl2	254.4, 256.1
	CN	289.8, 304.2, 358.6, 359.0, 386.2, 387.0, 387.1, 388.3, 418.1, 419.7, 421.6, 585.8, 647.8, 787.3
	CO	238.9, 269.8, 283.3, 292.5, 302.8, 313.4, 313.8, 325.3, 330.6, 349.3, 451.1, 482.5, 483.5, 519.8, 561.0, 608.0, 662.0
	CO2+	337.0
	Cr	205.5, 357.9, 359.3, 360.5, 425.4, 427.5, 520.8
	Cu	324.7, 327.4
F	F	623.9, 634.8, 641.4, 677.4, 683.4, 685.4, 685.6, 687.0, 690.2, 691.0, 696.6, 703.7, 712.8, 720.2, 733.2, 739.9, 742.6, 755.2, 757.3, 760.7, 775.5, 780.0
	Fe	248.3, 358.1, 372.0, 373.7
G	Ga	417.2, 639.7, 641.3
	Gd	335.0, 376.8
	Ge	206.8, 265.1, 474.2, 589.3
H	H	434.0, 486.1, 656.3, 656.5
	He	257.8, 382.0, 388.9, 396.5, 402.6, 438.8, 447.1, 471.3, 492.2, 501.6, 504.8, 587.6, 667.8, 706.5, 728.1
	Hg	253.7, 365.0, 404.7, 435.8, 546.1
I	In	325.6, 410.2, 451.1
M	Mo	313.2, 317.0, 319.3, 379.8, 386.4, 390.3

Table B-3. Common Spectral Lines by Species

	Species	Spectral Lines
N	N	674.0
	N2	281.4, 282.0, 295.3, 296.2, 297.7, 310.4, 311.7, 313.6, 315.9, 326.8, 328.5, 330.9, 333.9, 335.0, 337.1, 350.0, 353.7, 357.7, 364.2, 367.2, 371.1, 375.5, 380.5, 385.8, 389.5, 394.3, 399.8, 405.9, 409.5, 414.2, 420.0, 427.0, 434.5, 575.5, 580.4, 585.4, 590.6, 595.9, 601.4, 607.0, 632.3, 639.5, 646.9, 654.5, 662.4, 670.5, 678.9, 716.5, 727.3, 738.7, 750.4, 762.6, 775.3, 789.6
	NH	336.0
	Ni	221.6, 232.0, 301.2, 341.5, 346.2, 352.5
	NO	237.0, 247.9, 259.6, 268.0, 272.2, 286.0, 288.5, 289.3, 303.5, 304.3, 319.8, 320.7, 337.7, 338.6, 357.2, 358.4
O	O	391.2, 397.3, 407.6, 419.0, 464.9, 615.6, 615.7, 615.8, 645.6, 725.4, 777.2, 844.7
	OH	281.1, 302.1, 306.4, 306.7, 307.8, 308.9
P	P	253.6, 255.3, 460.2, 646.0
	Pb	280.2, 283.3, 368.3, 405.8
	Pd	340.5, 361.0, 363.5
	Pt	262.8, 265.9, 270.2, 293.0, 306.5
S	S	469.5
	Si	288.2, 504.1, 505.5, 634.7, 637.1
	SiCl	280.7, 281.0, 282.4, 287.1
	SiF	334.6, 336.3, 436.8, 440.1, 777.0
	SiF2	390.2, 395.5
	SiN	405.1, 408.7, 411.6, 412.7, 420.4, 423.9, 440.7, 444.3
	SiO	229.9, 234.4, 241.4, 248.7, 266.9, 269.4
T	Ta	264.7, 271.5, 301.2, 331.1
	Ti	335.0, 363.5, 365.3, 399.9
	TiCl	418.3, 419.3
	TiF	407.7
W	W	255.1, 272.4, 400.9, 407.4, 429.5
Z	Zn	339.2, 343.8, 349.6, 360.1, 389.0, 407.3, 408.1, 468.8

Table B-4. Element Wavelengths by Wavelength

201.1	BF	201.2	Au	201.2	CO
201.6	BF	202.1	Au	202.6	CO
203.3	AlH	204.6	CO	205.5	Cr
206.8	CO	206.8	Ge	207.6	ZnCl
207.8	ZnCl	208.9	Si	209.0	B
209.0	CO	210.7	CO	211.2	CO+
211.3	CO	212.4	Si	212.8	CO
213.6	P	213.8	CO+	213.9	Zn
214.9	P	215.0	CO	215.5	NO
217.3	CO	217.4	AlH	219.0	CO+
219.7	CO	221.6	Ni	222.2	CO
222.9	AlH	223.6	NO	223.8	CO
224.7	CO	225.9	SiCl	226.2	CO
226.9	NO	227.5	AlF	227.5	AlF
227.5	AlF	227.6	AlF	227.8	AlF
227.8	AlF	228.6	CO	228.8	As
228.8	Cd	229.9	SiO	230.0	CO+
231.1	Ni	231.2	CO	231.3	C2
231.6	AlF	231.6	AlF	231.8	AlF
231.8	AlF	232.0	Ni	232.5	CO+
232.8	CF	233.1	BO	233.8	CO
234.4	SiO	235.0	As	235.1	N2
235.3	AsF	235.3	CO+	236.5	BO
236.6	SiO	236.8	CCl	237.0	NO
238.2	CO	238.3	SiF3	238.4	CCl
238.6	SiCl	238.8	SiO	238.9	CO
239.9	AsF	239.9	BO	240.0	CF
240.2	SiF3	240.7	SiF3	240.8	CO
240.9	CO+	241.4	SiO	241.9	CO+
242.2	SiF3	242.5	As2	242.7	SiF3
242.8	As	242.8	Au	243.3	NO
243.4	CO	243.6	W	243.7	BO
243.8	CO+	243.9	As2	243.9	AsF
244.6	CO+	244.7	SiF3	244.8	N2

Table B-4. Element Wavelengths by Wavelength

245.3	SiF3	245.6	SiCl	245.8	CF2
246.3	CO	247.4	CF	247.4	CO+
247.4	CO+	247.5	Ta	247.9	C
247.9	NO	248.0	AsF	248.1	W
248.3	Fe	248.3	GaCl	248.7	SiO
248.8	CF2	248.8	O2+	248.8	SiCl
248.9	Ta	249.1	GaCl	249.3	CO
249.3	NO	249.7	B	249.8	B
250.4	Ta	250.5	CO+	250.7	Si
250.7	Ta	251.0	CO	251.3	GaCl
251.4	Si	251.6	Si	251.9	CF2
251.9	Si	252.4	Si	252.6	Ta
252.6	Ta	252.9	Si	253.0	CO+
253.0	NH	253.3	O2+	253.4	P
253.6	P	253.7	GaCl	253.7	Hg
253.9	SiF	254.4	Cl2	255.0	CO+
255.1	BO	255.1	CF2	255.1	N2
255.1	W	255.3	P	255.4	As2
255.5	P	255.8	CF	255.8	NO
255.9	Ta	256.1	Cl2	256.4	SiO
257.0	Cl2	257.7	Ta	257.8	CO+
257.8	He	258.0	CCl	258.1	O2+
258.7	SiO	258.8	BO	259.5	CF2
259.5	SiF	259.5	Ta	259.6	NO
260.7	CO+	260.8	NO	260.9	Ta
261.0	AlCl	261.4	AlCl	262.4	AlCl
262.7	NO	262.8	Pt	262.9	CF2
263.0	CO	263.1	BF	263.3	O2+
263.7	Ta	263.9	As2	263.9	CO+
264.6	Ta	264.6	Ta	264.7	Ta
264.8	AlCl	265.1	Ge	265.2	CF4
265.3	Ta	265.7	Ta	265.7	W
265.9	Pt	266.0	BCl	266.1	N2
266.1	Ta	266.5	BCl	266.5	CO
266.5	SO	266.9	SiO	266.9	Ta

Table B-4. Element Wavelengths by Wavelength

267.0	BCl	267.2	CO+	267.5	BO
267.6	As	267.6	Au	267.6	CF4
268.0	NO	268.1	AlCl	268.1	W
268.3	AlCl	268.6	AlCl	269.3	AlCl
269.4	SiO	269.8	CO	269.8	Ta
270.2	Pt	270.5	O2+	271.0	Ta
271.1	CF2	271.4	BCl	271.4	BO
271.5	Ta	271.9	W	272.0	BCl
272.2	BCl	272.2	BCl	272.2	CO+
272.2	NO	272.4	BCl	272.4	W
272.7	BCl	272.7	BCl	272.8	BCl
273.3	BCl	274.3	CO	274.4	SO
274.8	Au	274.9	CF2	274.9	Ta
275.0	Ta	275.3	BO	275.4	NO
275.5	SiO	275.8	Ta	276.2	O2+
276.9	SiCl	277.6	Ta	277.8	CCl
277.9	CCl	278.0	As	278.1	SiO
278.2	CCl	278.4	BCl	278.5	CO
278.7	BCl	278.8	CCl	279.2	BCl
279.3	BCl	279.4	BO	279.6	BCl
279.6	Ta	280.0	CF2	280.0	CO
280.2	Pb	280.6	SiO	280.7	SiCl
280.7	Ta	281.0	BO	281.0	NO
281.0	SiCl	281.1	OH	281.4	N2
281.6	OH	281.9	OH	282.0	N2
282.3	SiCl	282.4	O2+	282.4	SiCl
282.6	SiCl	282.7	SO	282.9	OH
282.9	SiCl	283.1	W	283.3	CO
283.3	Pb	283.7	C	284.4	Ta
284.8	BCl	285.0	Ta	285.1	BO
285.1	Ta	285.3	CF4	285.5	C2
285.6	As2	285.7	BCl	285.9	BCl
286.0	As	286.0	BCl	286.0	NO
286.6	CF2	286.7	BCl	287.1	SiCl
288.2	CO2+	288.2	Si	288.3	SiCl

Table B-4. Element Wavelengths by Wavelength

288.4	CO2+	288.5	NO	288.9	As2
289.0	O2+	289.2	BO	289.3	NO
289.4	CF2	289.4	SiF	289.5	CO2+
289.6	W	289.8	CN	289.8	CO2+
290.2	O2+	290.2	Ta	291.0	ZnCl
292.1	CF2	292.5	CO	293.0	Pt
293.4	Ta	293.5	BO	294.0	Ta
294.2	SiCl	294.3	ZnCl	294.4	W
294.7	W	294.8	Ti	295.2	Ta
295.3	N2	295.6	Ti	295.8	AlO
296.2	N2	296.3	Ta	296.6	Ta
296.7	Hg	296.7	SiF	296.9	SO
297.0	O2+	297.6	ZnCl	297.7	CO
297.7	N2	298.7	C2	298.9	SiCl
299.8	As2	300.0	BO	300.2	Ni
300.4	Ni	301.2	Ni	301.3	Ta
302.1	OH	302.1	SiCl	302.2	AlO
302.2	Hg	302.8	CO	303.5	NO
303.8	Ni	304.2	CN	304.3	NO
304.4	BO	304.4	O2+	305.1	Ni
305.4	Ni	305.8	Ni	306.4	OH
306.4	SO	306.5	Pt	306.7	OH
306.9	Ta	307.0	CCl	307.0	Cl2
307.8	OH	308.2	Al	308.9	BO
308.9	OH	309.3	Al	310.2	Ni
310.2	Ni	310.3	Ta	310.4	N2
310.5	As2	311.3	AlO	311.7	N2
311.8	BF	312.0	BF	312.1	BF
312.2	BF	312.3	Au	312.6	Hg
312.9	C2	313.2	Hg	313.2	Hg
313.2	Mo	313.4	CO	313.4	Ni
313.6	N2	313.8	CO	314.2	As2
315.9	N2	316.5	SO	317.1	Mo
318.1	Ta	318.6	Ti	319.2	Ti
319.3	Mo	319.8	NO	320.0	Ti

Table B-4. Element Wavelengths by Wavelength

320.7	NO	320.9	BO	321.1	O2+
321.4	CF2	324.2	CO	324.7	CO2+
324.8	Cu	325.0	N2+	325.3	CO
325.3	NH	325.6	In	325.7	BO
326.1	Cd	326.3	N2+	326.8	N2
327.1	SO	327.3	B2	327.4	Cu
328.1	Ag	328.3	B2	328.3	C2
328.5	N2	329.3	N2+	329.9	N2+
330.0	O2+	330.2	Na	330.3	Na
330.5	BO	330.6	CO	330.8	N2+
330.9	N2	331.1	Ta	331.9	Ta
333.5	BO+	333.9	N2	334.2	N2+
334.5	Zn	334.6	N2+	334.6	SiF
334.7	GaCl	335.0	Gd	335.0	N2
335.0	N2+	335.5	Ti	336.0	NH
336.1	Ti	336.3	SiF	337.0	CO2+
337.0	Ne	337.0	NH	337.0	Ni
337.1	N2	337.1	Ti	337.2	Ta
337.7	NO	337.7	Ti	338.1	Ni
338.3	Ag	338.3	SO	338.4	GaCl
338.5	AlH	338.6	NO	338.6	Ti
338.8	BO	339.1	Ni	339.2	Zn
339.3	Ni	339.8	O2+	339.8	SiF
340.4	Cd	340.5	Pd	340.7	Ta
341.5	Ni	343.4	Ni	343.8	Zn
344.0	BN	344.6	Ni	345.3	Ni
345.8	Ni	346.2	Ni	346.6	Cd
347.3	Ni	349.3	CO	349.3	Ni
349.4	O2+	349.6	Zn	350.0	N2
351.0	Ni	351.1	Ta	351.2	CO+
351.5	Ni	352.5	Ni	352.6	BO
352.7	BO	353.3	N2+	353.7	N2
353.8	N2+	354.9	N2+	354.9	SO
356.4	N2+	356.5	OH+	356.6	Ni
356.7	BO+	357.2	NO	357.7	N2

Table B-4. Element Wavelengths by Wavelength

357.9	Cr	358.1	Fe	358.2	N2+
358.3	AlH+	358.4	CN	358.4	NO
358.6	CN	359.0	CN	359.3	AlH+
359.3	Cr	359.8	Ni	359.9	BN
360.1	AlH+	360.1	CO+	360.1	Zn
360.2	AlH+	360.4	O2+	360.5	Cr
360.7	Ar	360.7	Ta	361.0	Ni
361.0	Pd	361.1	Cd	361.2	AlH+
361.8	W	361.9	Ni	362.6	BN
362.7	Ta	363.0	AlH+	363.0	O2+
363.2	AlH+	363.5	Pd	363.5	Ti
364.2	N2	364.2	Ta	364.3	Ti
365.0	Hg	365.4	Ti	365.5	Hg
366.3	Hg	367.2	N2	367.6	SO
367.8	BO	367.9	BO	368.3	Pb
370.7	O2+	371.1	CO+	371.1	N2
372.0	Fe	372.1	SiF2	372.5	CO+
373.0	Ti	373.7	Fe	374.1	Ti
375.3	Ti	375.5	N2	376.2	N2+
376.8	Gd	378.3	N2+	379.6	CO+
379.8	Mo	380.1	NO	380.3	BN
380.5	N2	380.9	SiF2	381.1	BO+
381.3	AlH	381.4	SiN	381.7	W
382.0	He	382.3	Cl2+	383.0	BO
383.1	O2+	383.5	AsF	384.7	BO
384.9	BO	385.0	SiF2	385.5	CN
385.8	N2	385.8	Ni	386.2	CN
386.4	Mo	386.8	W	387.1	CH
387.1	CN	388.1	NO	388.3	CN
388.9	CH	388.9	He	389.0	Zn
389.3	CO	389.5	N2	389.7	CuCl
390.2	SiF2	390.3	Mo	390.5	Ti
391.0	CN	391.2	O	391.4	N2+
392.4	Ga	393.5	ZnH	394.3	N2
394.4	Al	394.5	CN	394.8	Ar

Table B-4. Element Wavelengths by Wavelength

394.9	Ar	394.9	Ti	395.4	CH+
395.4	CO+	395.5	SiF2	395.6	CuCl
395.6	Ti	395.7	CO+	395.8	SiN
395.8	Ti	396.1	Al	396.2	CH+
396.5	He	397.0	H	397.3	O
397.4	CO+	398.2	Ti	398.5	CN
398.6	SiN	398.9	ZnH	399.0	Ti
399.8	N2	399.9	Ti	400.9	SiF2
400.9	W	400.9	W	401.4	Ar+
401.7	SiN	401.8	CO+	402.6	He
403.3	Ga	403.6	BO	403.7	BO
404.2	NO	404.4	Ar	404.7	Hg
405.1	SiN	405.6	AlCl	405.8	Pb
405.9	N2	406.1	AlCl	406.1	NiCl
406.3	AlCl	406.4	Cl2+	406.5	SiF2
406.6	AlH	407.2	Ar+	407.3	AlH
407.3	Zn	407.4	AlCl	407.4	W
407.4	W	407.6	O	407.7	TiF
408.2	O2+	408.7	SiN	408.9	CuCl
409.4	NiCl	409.5	N2	409.7	N
410.0	N	410.2	H	410.2	In
410.4	Ar+	411.0	N	411.3	Cl2+
411.6	SiN	412.4	CO	412.5	CO
412.7	SiN	412.8	SiH	413.2	Ar+
414.1	Cl2+	414.2	N2	414.2	SiH
414.2	SiN	414.6	BO	414.6	NiCl
415.9	Ar	416.4	Ar	416.8	CN
417.0	SiN	417.2	Ga	417.9	Cl2+
418.1	CN	418.2	Ar	418.2	AsF
418.3	TiCl	418.9	CuCl	419.0	O
419.1	Ar	419.3	TiCl	419.4	Cl2+
419.7	CN	419.8	Ar	419.9	CN
419.9	N2+	420.1	Ar	420.1	N2
420.4	SiN	420.9	CO+	421.3	CO+
421.6	CN	422.5	CH+	422.8	CN

Table B-4. Element Wavelengths by Wavelength

423.2	CO+	423.7	N2+	423.8	CH+
423.9	CN	423.9	SiN	424.0	ZnH
424.1	AlH	424.1	SiF	425.4	Cr
425.9	AlH	425.9	Ar	425.9	CuCl
426.0	ZnH	426.6	Ar	426.7	C
426.7	C+	426.9	W	427.0	N2
427.0	SiF	427.2	Ar	427.2	CO+
427.4	Kr	427.5	Cr	427.7	SiN
427.8	N2+	428.1	CuCl	429.5	W
429.5	W	429.9	Ti	430.0	Ar
430.1	SiF	430.1	Ti	430.1	Ti
430.1	ZnH	430.2	Ti	430.5	NiCl
430.6	Ti	431.4	CH	431.6	Cl2+
431.8	SiN	431.9	Kr	432.0	Kr
432.4	CH	432.6	ZnH	433.0	Ar+
433.2	BH	433.3	CuCl	433.4	Ar
433.4	SiF	433.9	BO	434.0	H
434.2	BO	434.3	BO	434.5	Ar
434.5	N2	434.8	Ar	434.8	Ar+
435.3	AlH	435.3	CuCl	435.8	Hg
436.1	AlH	436.6	BO	436.7	BH
436.8	SiF	436.9	C2	438.0	CO
438.8	He	439.3	CO	439.7	NiCl
440.1	Ar+	440.1	SiF	440.5	Cl2+
440.7	SiN	441.2	CuCl	442.6	Ar+
443.0	SiF	443.0	SiF	443.4	BH
443.4	CuCl	444.3	SiN	444.7	N
446.2	SiF	447.1	He	448.2	Ar+
448.2	SiN	448.7	Cl2+	449.6	SiF
451.1	Ar	451.1	CO	451.1	In
451.5	NiF	451.9	NiF	452.3	NH
452.4	NiF	452.4	SiN	453.2	SiF
453.3	Ti	453.5	Ti	453.6	NiF
453.6	SiF	453.6	Ti	453.8	Ne
454.5	Ar+	454.7	AlH	454.9	Cl2+

Table B-4. Element Wavelengths by Wavelength

456.3	NiCl	456.6	CO+	457.0	SiF
457.6	AlH	458.6	BO	458.6	CO
458.9	BO	459.0	Ar+	459.6	Ar
459.7	NiCl	460.0	CCl	460.2	P
461.0	Ar+	461.3	BO	461.4	Cl2+
461.5	BO	462.3	NiCl	462.6	NiCl
462.8	Ar	463.7	Ar+	464.8	AlO
464.9	O	465.2	N2+	465.5	Cl2+
465.8	Ar+	466.4	SiN	466.9	NiF
467.2	AlO	467.3	NiF	467.9	NiF
468.0	Zn	468.3	Cl2+	468.8	He
468.9	C2	469.4	AlO	469.4	S
469.5	NiF	469.8	C2	470.0	NiF
470.2	Ar	470.4	Ne	470.9	N2+
470.9	Ne	471.0	Ne	471.2	Ne
471.3	He	471.5	C2	471.5	Ne
472.2	Zn	472.7	Ar+	473.2	AlH
473.6	Ar+	473.7	C2	474.2	Ge
474.4	BO	474.7	BO	475.1	Cl2+
475.3	Ne	476.5	Ar	476.5	Ar+
478.5	SiCl	479.3	Au	479.5	Cl
479.5	Cl2+	480.0	Cd	480.6	Ar+
480.7	CO	481.0	Cl	481.1	Zn
482.0	Cl	482.7	Ne	483.2	SiCl
483.5	CO	484.2	AlO	484.7	CuCl
484.8	Ar+	485.1	N2+	486.0	NiF
486.1	H	486.6	AlO	488.0	Ar
488.0	Ar+	488.2	CuCl	488.5	Ne
489.7	Cl	490.5	SiCl	492.2	He
493.3	Ar+	493.5	N	495.6	SiCl
495.7	Ne	496.5	Ar+	497.9	CO
498.2	Ti	499.1	Ti	500.0	Ti
500.7	Ti	500.9	Ar+	501.4	Ti
501.6	He	503.1	SiCl	504.0	BO
504.1	Si	504.8	He	505.3	CO

Table B-4. Element Wavelengths by Wavelength

505.5	Si	506.2	Ar+	506.5	Ti
508.1	Cl2+	508.4	SiCl	508.6	Cd
510.2	AlO	510.6	Cu	512.3	AlO
513.6	N2+	514.2	Ar+	515.3	Cu
516.2	SiCl	516.5	C2	519.3	Ti
519.8	CO	520.8	Cr	520.9	Ag
521.0	Ti	521.8	Cl	521.8	Cu
521.8	SiCl	522.0	Cu	523.4	O2+
524.1	O2+	525.1	O2+	525.9	O2+
526.8	AlCl	527.5	O2+	528.4	AlCl
528.6	AlCl	529.6	O2+	530.0	SiCl
530.4	AlCl	534.1	Ne	535.8	SiCl
540.1	Ne	541.6	AlCl	542.3	Cl
543.3	AlCl	543.5	AlCl	545.2	AlCl
545.4	AlCl	546.1	Hg	546.6	Ag
547.8	P	549.6	Ar	550.0	CO+
550.6	Ar	554.8	BO	555.2	BO
555.9	Ar	556.7	O2+	557.0	Kr
557.3	Ar	558.6	C2	558.9	Ar
559.7	Ar	559.8	O2+	560.7	Ar
561.0	CO	563.2	O2+	563.6	C2
564.8	CO	565.1	Ar	565.9	Ar
566.7	N+	567.6	N+	568.0	N+
568.2	Ar	573.0	CN	574.0	Ar
574.9	CO	575.5	N2	576.4	Ne
577.0	Hg	579.1	Hg	580.4	N2
585.2	Ne	585.4	N2	585.8	CN
586.1	CO	587.1	Kr	587.6	He
588.2	Ne	588.3	O2+	589.0	Na
589.3	Ge	589.6	Na	589.9	C2
590.6	N2	591.2	Ar	592.6	O2+
595.9	N2	597.3	O2+	599.3	CN
601.1	CO	601.4	N2	602.6	O2+
603.0	Ne	605.3	S	607.0	N2
607.4	Ne	608.0	CO	611.5	Ar+

Table B-4. Element Wavelengths by Wavelength

614.3	Ne	615.6	O	615.7	O
615.8	O	616.4	Ne	617.2	Ar+
621.7	Ne	623.9	CO+	624.0	F
626.6	Ne	632.3	N2	633.2	CN
633.4	Ne	634.7	Si	634.9	F
635.1	O2+	636.2	Zn	637.1	Si
638.3	Ne	639.5	N2	639.7	Ga
639.7	SiF	640.2	Ne	641.3	Ga
641.4	F	641.6	SiF	641.9	O2+
643.3	CO	643.3	CO+	643.8	Cd
644.2	C2	645.4	O	645.4	O
645.6	O	646.0	P	646.9	N2
647.9	CN	649.2	SiF	650.7	Ne
651.4	CO	651.4	CO+	654.5	N2
656.3	H	656.3	H	656.5	H
659.9	Ne	662.0	CO	662.0	CO+
662.4	N2	663.1	CN	664.0	Ar+
667.8	He	668.4	Ar+	668.5	CO
668.5	CO+	670.5	N2	673.8	NiCl
674.0	N	675.7	S	677.4	F
678.9	N2	680.4	CO	680.4	CO+
683.4	F	685.4	F	685.6	F
685.6	O2+	687.0	F	690.2	F
691.0	F	692.6	NiCl	692.9	Ne
696.5	Ar	696.6	F	700.2	O
700.2	O	703.2	Ne	703.7	F
706.5	He	706.7	Ar	708.9	CN
712.8	F	716.5	N2	717.4	Ne
720.2	F	724.5	Ne	725.4	O
725.4	O	725.5	O	725.7	Cl
725.9	CN	727.3	Ar	727.3	N2
727.5	NiCl	728.1	He	731.1	F
732.6	C	733.2	F	733.5	O
733.5	O2+	738.4	Ar	738.4	AsF
738.7	N2	739.1	AsF	739.7	AsF

Table B-4. Element Wavelengths by Wavelength

739.9	F	741.4	Cl	742.5	F
743.7	CN	748.7	NiCl	750.4	Ar
750.4	Ar	750.4	N2	751.5	Ar
754.7	Cl	755.2	F	757.3	F
758.7	Kr	760.2	Kr	760.7	F
762.6	N2	763.5	Ar	763.5	Ar
768.5	Kr	769.5	Kr	769.7	S
771.3	NiCl	771.8	Cl	772.4	Ar
772.4	Ar	774.5	Cl	775.3	N2
775.5	F	777.0	SiF	777.2	O
777.4	O	777.5	O	780.0	F
787.3	CN	788.0	NiCl	789.6	N2
791.5	SO	792.4	S	793.2	S
794.8	Ar	794.8	Ar		

C Hardware Specifications

C.1 Recommended Application Computer Requirements

If more demands are placed on the host system, as in the case of multiple spectrograph configurations, then greater computing resources will be required.

Table C-1. Computer Requirements

Attribute	Multiple Spectrograph or Multi-Fiber Optic Input
Platform	Windows 2000
Processor	Intel Pentium IV @ 2.0Ghz
Memory	1.0 GB (2 X 512 MB)
Hard Drive	80GB UDMA 1000 Interface
CD ROM	48X24X48 Read/Write CD ROM Drive
Graphics	Minimal PCI or AGP Video
Communication Port to Spectrograph	Ethernet
Communication Port to Tool	RS232, Digital I/O, USB or Ethernet

Table C-2. Detector Specifications

Model Number	SD1024D	SD1024DL
Type	High Performance	General Purpose
Performance/Optics		
Range	200-800nm	200-800nm
Resolution	1.7nm	2-4nm
CCD	1024 x 128 pixels, TE cooled Backthinned (for enhanced UV sensitivity)	2048 pixels Phosphor coated for UV sensitivity
Mechanical		
Slit Width	25 microns	25 microns
Dimensions [inches (mm)]	10.25 (260.0) x 5. 4 (137.2) x 6. 05 (153.5) [See Outline Drawing for details]	10.25 (260.0) x 5. 4 (137.2) x 6. 05 (153.5) [See Outline Drawing for details]
Weight	7 lbs (3.2 kg)	6 lbs (2.7 kg)
Software		

Table C-2. Detector Specifications

Model Number	**SD1024D**	**SD1024DL**
Application Software	EyeD	
Application Software Platform	Windows 98/NT/2000	
Communication to Application	USB or Ethernet (preferred)	
Integration		
Communication Protocol for Embedded Operation	For ease of integration, an ActiveX interface is provided for Windows-32 applications. RS232, USB or Ethernet	For ease of integration, an ActiveX interface is provided for Windows-32 applications. RS232, USB or Ethernet
Hardware Communication	Digital I/O	Digital I/O
Fiber Optic Connection	Custom Design	SMA905
Power	95-250VAC, 50/60Hz 35W typical - 50W Max.	95-250VAC, 50/60Hz 35W typical - 50W Max.
Standards		
Compliance	CE, Semi S2-93	CE, Semi S2-93
Environmental		
Operating Temperature Range		32 (0°C) - 104 (40°C)
Storage Temperature Range		-4 (-20°C) - 140 (60°C)
Max. Humidity (Operation and Storage)		85% Non condensing

D Neural PCA Equation Worksheet

Table D-1.Settings (All of these user-selected parameters are applied in real-time to modify the incoming data)					
Name	-				
Spectrum	-				
Calibrate Selection	-				
Calibrate Method	-				

Table D-2.Setup Calibration (These parameters are used only once during the calibration of the Neural PCA algorithm).					
Calibration file	-				
Data source	-				
Total Samples	-				
Samples per Period	-				
Total Periods	-				
Min Period (sec)	-				
Max. Period (sec)	-				
Period Error (%)	-				
TIME PARAMETERS					
Startup Transient (periods)	-				
Shutdown Transients (periods)	-				
Least squares polynomial smoothing?	-				
Degree of Fit	-				
Number of samples to fit	-				
Select sample numbers within a period?	-				
Sample numbers	-				
WAVELENGTH PARAMETERS					
Least squares polynomial smoothing?	-				

Table D-2.Setup Calibration
(These parameters are used only once during the calibration of the Neural PCA algorithm).

Degree of fit	-				
Number of wavelengths to fit	-				
Remove saturated wavelengths?	-				
# of wavelengths in saturated window	-				
Normalize spectra?	-				
Select wavelengths (nm)	-				

Table D-3.Calibrate
(These parameters are used only once during the calibration of the Neural PCA algorithm)

Automatically calculate endpoint regions?	-				
T1 Start Pre-Endpoint Region (periods)	-				
T2 Stop Pre-Endpoint Region (periods)	-				
T3 Start Post-Endpoint Region (periods)	-				
T4 Stop Post-Endpoint Region (periods)	-				
Select wavelengths that change AFTER endpoint	-				
Select wavelengths that change AT endpoint	-				
Select wavelengths that change RAPIDLY at endpoint	-				
Select wavelengths that use single samples only	-				
Manually select wavelengths to omit?	-				

Table D-3.Calibrate (These parameters are used only once during the calibration of the Neural PCA algorithm)					
Percent Change at Endpoint	-				
Combine Wavelengths Method (I, II or III)	-				

D.1 NPCA Equation Properties Definitions

Table D-4.Equation Properties Definitions

Run Time	
Name	User assigned name for the Neural PCA (Advanced) Equation inserted into the EyeD Sequence.
Spectrum	User selected (from the drop-down list) name of the Spectral Source or Equation on which the Neural PCA algorithm will be applied.
Calibrate selection	This information reflects the selection that was made the last time the NPCA was calibrated. It is displayed here for convenience.
Calibrate Method	This information reflects the selection that was made the last time the NPCA was calibrated. It is displayed here for convenience.
Setup Calibration	
Calibration file	The filename of the pre-recorded spectrum used for calibration (If the window is empty, you must request to browse for the file twice to get access to the directory structure).
Data Source:	The user selected (from a drop-down list) spectrograph channel used in the calibration.
Total Samples	The number of spectra in the calibration data file.
Samples per period	The number of periods in the calibration data file
Total Periods	The number of periods in the calibration data file
Min. Period (sec)	
Max. Period (sec)	
Period Error (sec)	
Period Error (%)	The number of full rotations in the Calibration data file.
TIME PARAMETERS:	
Startup Transients (periods)	For rotating magnet applications, enter the number of full rotations (noisy startup transients) to omit from the PCA modeling. For other applications, enter the number of spectra to omit (see graph).

Table D-4.Equation Properties Definitions

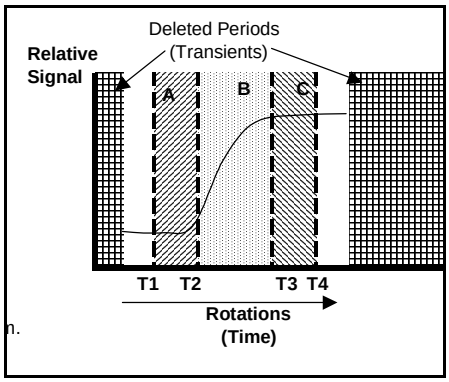


Figure D-1. Transient Periods

Shutdown Transients (periods)	For rotating magnet applications, enter the number of full rotations (noisy shutdown transients) to omit from the PCA modeling. For other applications, enter the number of spectra to omit (see graph).
Least squares polynomial smoothing?	Checking this box means yes, use polynomial smoothing in the time dimension (recommended).
Degree of fit	Enter the exponential order of the polynomial to be used for smoothing the data along the time axis (recommended degree of fit = 1- simple moving average).
Number of Samples to fit:	Enter the number of data points to use in the polynomial smoothing fit along the time or rotations axis (recommend 3 minimum. For Continuous data collection, averaging several seconds is recommended).
Select sample numbers within a period?	Not checking this box uses every spectrum in the magnet rotation for calibration. All spectra will be used in run-time since this parameter only applies to calibration. If the box is checked, only the spectra from the magnet positions listed will be used for calibration. For example, the list [2-4, 28] will calibrate using only the spectra collected in magnet positions 2,3,4,and 28.
WAVELENGTH PARAMETERS:	
Least squares Polynomial smoothing?	Check this box to select smoothing in the wavelength axis (not recommended for plasma spectroscopy).
Degree of fit	The exponential order of the polynomial to be used for smoothing the data along the wavelength axis.
Number of wavelengths to fit	The number of 0.5 nm data points to use in the polynomial smoothing fit along the wavelength axis.
Remove saturated wavelengths?	The exponential order of the polynomial to be used for smoothing the data along the wavelength axis. (Caution! The detector reports a seriously saturated wavelength as zero intensity. If an important wavelength is seen to be zero during the startup of the plasma, this routine will identify it as saturated and it will be omitted throughout the run, thus loosing that important endpoint information.)

Table D-4.Equation Properties Definitions	
# of wavelengths in the sat. window	The number of wavelengths to delete on either side of any wavelength that saturates anytime during the run.
Normalize spectra	Not checking this box allows intense wavelengths to have more influence on the endpoint than less wavelengths. Checking this box will normalize the intensity of each wavelength to unit length. Normalizing is recommended because it looks at the % change of each wavelength at endpoint instead of the magnitude of its change at endpoint.
Select wavelengths?	Not checking this box uses all wavelengths from 200 to 800 nm. Checking this box uses the wavelength listed in the Wavelengths box. For example, the list [200-300, 652. 5] will include the 201 intensities at every 0.5 nm increment from 200.0 though 300.0 nm and the single intensity at 652. 5 nm.
Calibrate ENDPOINT REGION SETTINGS	
Automatically calculate endpoint Regions?	Checking this box will invoke a subroutine to calculate the T1 to T4 values. For the first calibration, it is faster to guess values you know will be inside the data set (see the examples above). Use the graphs that are generated by calibration and then drag-and-drop the T-markers on the graph. The T-marker values will be updated automatically.
T1 to T4 Endpoint Regions:	Period (or rotation) markers that define the three contiguous time periods shown in the graph above (the time periods are: A = before endpoint; B = during endpoint; C= after endpoint).
Select wavelengths that …	Change after endpoint = wavelengths that have a large change from region A to region C are more heavily weighted. Change rapidly at endpoint = wavelengths with the highest slope in region B are more heavily weighted. Use single samples only: This box is checked if the data was collected using continuous data collection mode.
Manually select wavelengths to omit:	Checking this box allows the user to set a threshold for retaining wavelengths in the endpoint selections. (Not recommended)
Combine wavelengths using: Method I, II, or III.	These are three different proprietary methods of using the selected wavelengths to generate a trend chart for endpoint detection. All three methods should be tried for each of the two-wavelength selection method.

D.2 Example NPCA Parameters

Table D-5.Settings
(All of these user-selected parameters are applied in real-time to modify the incoming data)

Name	-	NPCA B & A3	A-2	A-1	A-4
Spectrum	-	Avg. Spectrum	✔	✔	✔
Calibrate Selection	-		✔		
Calibrate Method	-		✔		

Table D-6. Setup Calibration
(These parameters are used only once during the calibration of the Neural PCA algorithm).

Calibration file	-	LocalRun_2	✔	✔	✔
Data source	-	A	✔	✔	✔
Total Samples	-	2017	✔	✔	✔
Samples per Period	-	1000	✔	✔	✔
Total Periods	-	2017	✔	✔	✔
Min Period (sec)	-	0.100	✔	✔	✔
Max. Period (sec)	-	0.100	✔	✔	✔
Period Error (%)	-	0.000	✔	✔	✔
TIME PARAMETERS					
Startup Transient (periods)	-	150	✔	✔	✔
Shutdown Transients (periods)	-	150	✔	✔	✔
Least squares polynomial smoothing?	-	Y	✔	✔	✔
Degree of Fit	-	1	✔	✔	✔
Number of samples to fit	-	10	✔	✔	✔
Select sample numbers within a period?	-	-			
Sample numbers	-	-			
WAVELENGTH PARAMETERS					
Least squares polynomial smoothing?	-	-			

Table D-6. Setup Calibration
(These parameters are used only once during the calibration of the Neural PCA algorithm).

Degree of fit	-	-			
Number of wavelengths to fit	-	-			
Remove saturated wavelengths?	-	-			
# of wavelengths in saturated window	-	-			
Normalize spectra?	-	Y	✔	✔	✔
Select wavelengths (nm)	-	-			

Table D-7.Calibrate
(These parameters are used only once during the calibration of the Neural PCA algorithm)

Automatically calculate endpoint regions?	-	-			-
T1 Start Pre-Endpoint Region (periods)	-	670	670	670	670
T2 Stop Pre-Endpoint Region (periods)	-	770	770	770	770
T3 Start Post-Endpoint Region (periods)	-	906	1302	1302	1302
T4 Stop Post-Endpoint Region (periods)	-	1006	1402	1402	1402
Select wavelengths that change AFTER endpoint	-	-	Y	Y	-
Select wavelengths that change RAPIDLY at endpoint	-	Y	-	-	Y
Select wavelengths that use single samples only	-	Y	✔	✔	✔
Manually select wavelengths to omit?	-	-	-	-	-
Percent Change at Endpoint	-	-	-	-	-
Combine Wavelengths Method (I, II or III)	-	I	I	I	I

E CCD Integration Process

The CCD surface is comprised of many pixels, each of which detects photons and stores the information as charges. At intervals, the charge at each of these pixels is read during the integration of the CCD.

Before light reaches the CCD, it enters the spectrograph through the entrance slit and strikes the diffraction grating where it is diffracted at an angle that is a function of wavelength. All of the light is collected by the optics, and light of a single wavelength is projected as a high-resolution, point-to-point image of the entrance slit onto the CCD.

There will be as many horizontally spaced images of the entrance slit on the face of the CCD as there are distinct wavelengths passing through the entrance slit. In a continuum light source, these overlapping slit images would create a single continuous region of light on the face of the CCD. Light emitted from atomic and molecular sources is typically dominated by a few discrete wavelengths, which results in a series of bright lines in the image on the CCD.

The intensity of light in each point in the diffracted spectrum is determined by how much light of that wavelength passed through that point of the entrance slit. The CCD is a two dimensional array of pixels, with each pixel being a solid-state light detector. The slit image forms a line parallel to the columns of pixels in the CCD. Each pixel in a column integrates the number of photons of a given wavelength that pass through a corresponding point along the length of the entrance slit. As light reaches each pixel, photons are converted to electrons and these electrons are stored on each pixel as an electrical charge. The charge is proportional to the sum of the light received at that pixel.

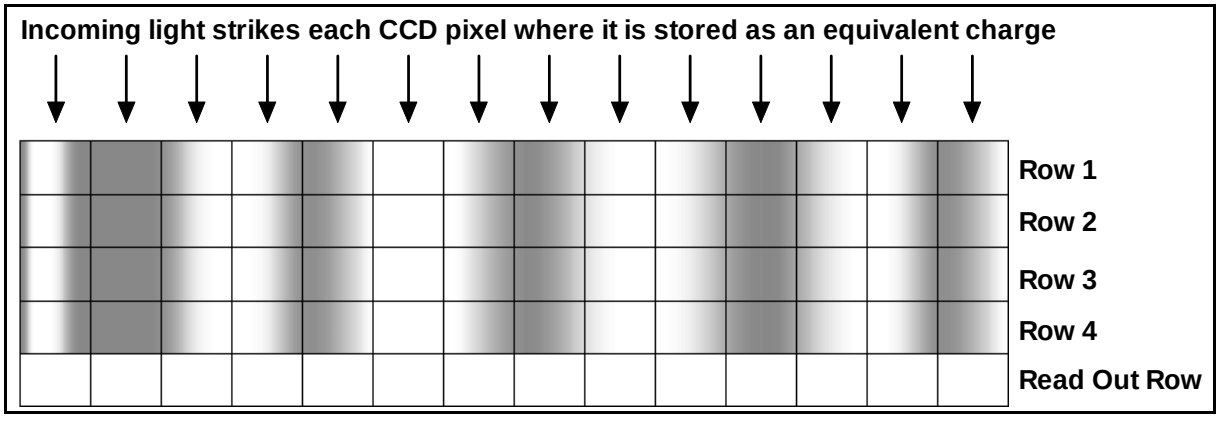


Figure E-1. Read-Out Row is Empty of Charge Following the Last Read Out

At the end of the integration time, the charge on each pixel is shifted down the number of rows assigned to a channel (one row per channel in this diagram). Immediately after each charge shift, all pixels in the top row hold zero charge.

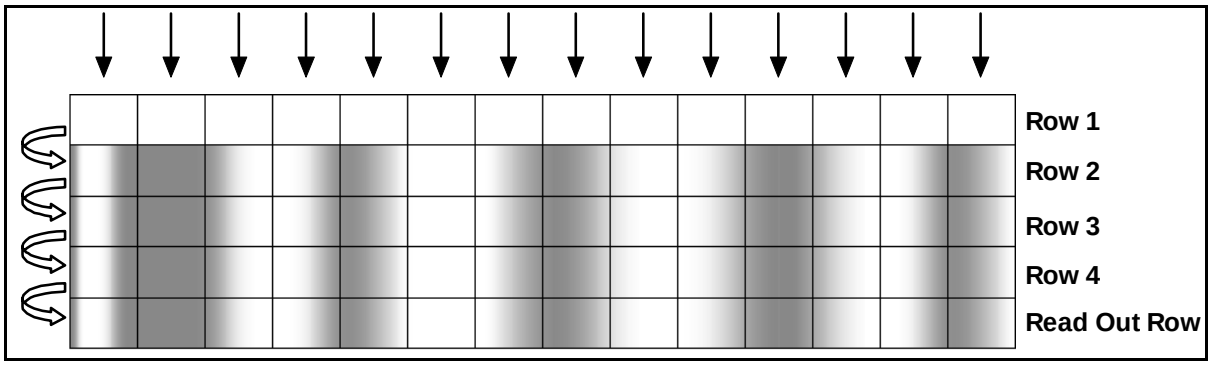


Figure E-2. Rows of charges are shifted down leaving first row empty

The Read-Out Row accumulates the charges from each row assigned to the channel being read. Once the charge accumulation in the Read-Out Row is complete, the values in the Read-Out Row are serially read and the electrons (charges) removed, leaving the Read-out Row empty for receiving the next channel of pixel charges. All during the charge shifting and read-out process, light continues to strike all the pixels. The charge on every pixel increases as it is shifted down the column. Integration is uninterrupted during the read-out process. Because the shift and readout is highly reproducible, each pixel gets the same total exposure to light during one integration period.

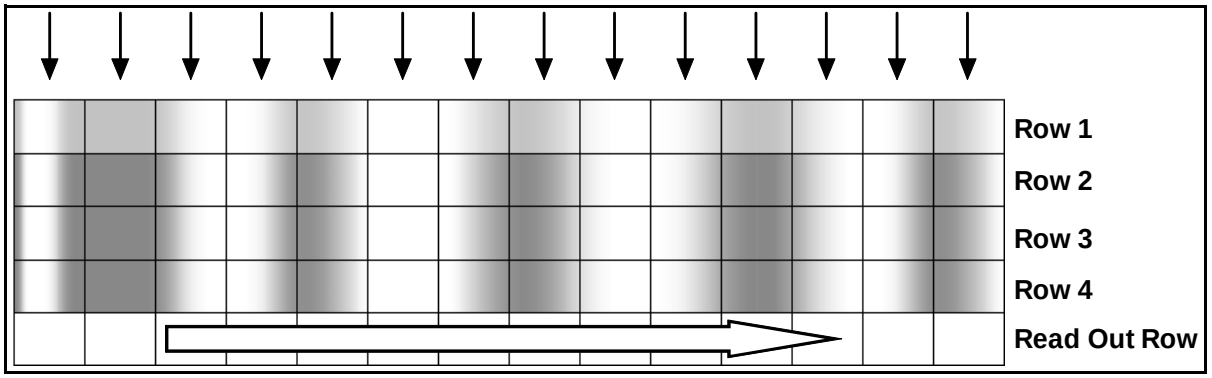


Figure E-3. Charges Accumulate on First Row as a New Read Out Occurs and the Read-Out Row is Emptied of Charge

Very rapidly in succession, each grouping of rows assigned to each channel are similarly shifted down, accumulated and read out on the Read-Out Row. As it is read, the Read-Out Row is emptied of all charge in anticipation of receiving the next row of charges for a subsequent read out. For a single channel SD1024D, the pixel charges in all 128 rows are accumulated in the Read-Out Row and read out at one time.

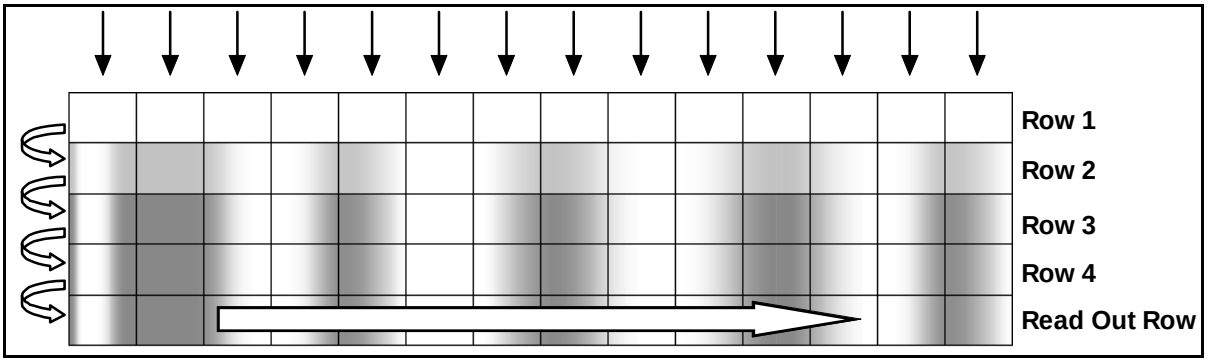


Figure E-4. Charges Continue to Accumulate on all Rows as They are Shifted Down

THIS PAGE INTENTIONALLY LEFT BLANK.

Index

A
AC Box Showing Location F3 4-6
Add Data Source 3-107
Adding a Counter 8-32
Adding a Graph to the Existing Configuration A-36
Adding Another Trend Equation A-45
Adjusting the Grid Resolution 3-175
Advanced Equation List 3-103, 3-118
Advanced Equations 2-10
Advanced Equations List 3-112
Advanced Neural Net Parameters Window 3-173
Appendix A, EyeD Elements B-1, C-1, D-1, E-1
Application Features 3-199
Application Setup Window, 200mm URI 5-37
Application Setup Window, 300mm SECS 7-35
Application Window 2-5
Applied Materials Emergency Contact 1-6
Archive Options 5-62, 7-38
Assign Film Thickness Value to Global Variable 3-121
Association Between Centura DI/O and URI DI/O, 200mm 5-42
Auto Delete Options 5-62, 7-38
Automated Reference Generation 3-103
Automation Window 3-104
Average Trend Equation Properties for 577nm Spectral Line 6-24
B
Basic Functionality Check of DCS using Room Light 4-32
Becoming Familiar With Data Navigation Tools A-26
Browsing Files (left) or Directories (right) A-23
Building Endpoint Equation A-56
C
Cable Connections to Spectrograph 4-19, 6-16
Cable Installation, 300mm Mainframe 6-17
Calibration Wafer Properties 3-101
Calibration Wafer Properties Window 3-99
Calibration Window 3-101
Capture Data Window A-16
Capture State 2-8
Capture Window 3-102
Captured Reference Spectrum 3-102
Cautions 3-110
Chamber Performance Validation and Lamp Setup (EyeD-IEP Only) 5-65, 7-59
Changing EyeD Instance Target to EyeD.bat File 5-23, 7-23
Changing Software Configuration 9-21
Chapter 1 1-1
Choose Active Reference Window 3-106
Choose References 3-105
Collecting and Displaying Spectra with EyeD A-13
Com Port Settings for RS232 Communications, 300mm 7-36
Com Port Settings for SECS and RS232 Communications, 200mm 5-39
Command Prompt Window 8-31
Commands Recognized by EyeD, 200mm 5-45
Common Neural Network Problems 3-178
Communications Log for Active Chamber A, 300mm 7-37
Communications Log Window with Serial Cable Problem, 200mm 5-58
Communications Log Window with Serial Cble Problem, 300mm 7-38
Communications Lot for Active Chamber A, 200mm 5-57
Comparing Auto Reference with Initial Reference After P/M 3-107
Comparison of Reference Spectrum 3-108
Completed Spectral Graph Properties Window A-38
Completed Trend Equation Properties Window A-46
Compliance with SEMI S2 1-5
Computer and Ethernet Hub Attached to

Mainframe 4-10
Computer Assembly, 300mm 6-14
Configuration Tab 3-11
Configuration Window A-19, A-45
Configure Endpoint Sequence Based on Derivative Trend and Snapshots A-50
Configure to Collect and Display Spectra A-8
Configuring Multiple Spectrographs, 300mm 7-23
Configuring the EyeD Screen A-4
Connecting Cables 4-16
Connecting Cables, 300mm 6-14
Creating a New Configuration File A-6
D
Data File Wavelength Graph A-30
Data File Window A-20
Data Files Tab 3-11
Data Source Selection A-10
DCS Functionality Check using Room Light, 300mm 6-22
Debugging Errors A-39
Define Global Variable in Etch Control Algorithm 3-121
Defining an Endpoint Sequence A-52
Defining Spectral Regions A-31
Definitions 9-1
Different Mathematical Quantities A-1
Distribution of the 32 DI/O Channels 5-44
DI/O Hardware Configuration Window, 200mm 5-41
E
Edit Neural Nte Tag Window 3-171
Efficient Algorithms 8-30
Electrical Hazards 1-3
Endpoint 3-193
Endpoint Communications Channel Setup, Table, 200mm 5-64
Endpoint Detection Software 2-8
Endpoint Graph A-57
Equation Types 2-9
Equations Menu for genericRoom_Light, Functionality Check 6-24
Ergonomic Requirements of SEMI S8-95A 1-6
Event History Window Legend 3-24
Event Plot Tool Bar 3-22
Events for Mapping, 200mm 5-44
Examining Reprocessed Spectra A-28
Examples of Marker Placement 3-178
External Hardware Components 2-1
EyeD Applications Window A-5
EyeD Computer and Monitor Installation for 200mm DPS and eMAX 4-5
EyeD Main Window A-4
EyeD Operating States 2-7
EyeD Software Installation, 300mm 7-1
EyeD Software Operation Tutorial A-1
EyeD Usage, 200mm 5-7
EyeD Usage, 300mm Software Installation 7-7
EyeD Window Components 2-5
EyeD-IEP Assembly with DCS and Flashlamp on 300mm DPS II 6-2
EyeD-IEP Detector and Lamp on 300mm DPS II 6-7
EyeD-IEP Fiber Optic Cable Diagram 4-33, 6-22
EyeD-IEP Hardware Overview, 300mm 6-3
EyeD-IEP Interconnect Diagram 4-21, 4-22, 4-23
EyeD-IEP Interconnect Diagram, 300mm 6-18
EyeD-IEP 200mm Computer Installation 4-9
EyeD-IEP, 300mm 6-1
EyeD-OES Hardware Overview, 300mm 6-2
EyeD-OES Installation of SCS Remotely from 200mm eMAX Chamber 4-16
EyeD-OES Interconnect Diagram 4-23
EyeD-OES Interconnect Diagram, 300mm 6-20
EyeD-OES SCS Installation on 300mm eMAX 6-10
EyeD-OES 300mm eMAX Chamber Assembly with SCS 6-1
EyeD-OES, 300mm 6-1
F
Fiber Optic Cable Bracket on 300mm DPS

II 6-9
Fiber Optic Cable Installation of DCS - Rear Bezel 4-34
Fiber Optic Cable Installed on DCS Rear Bezel 6-23
Fiber Optic Cable Routed to IEP Access Port on 200mm DPS Chamber 5-68, 7-62
Film Stack Model 3-113, 3-116, 3-117
Film Thickness Equation Properties 3-112
Film Thickness Measurement Capability 3-96
Film Thickness Measurement Capability Overview 3-96
Final DI/O Check, 200mm 5-54
Flash Lamp Intensity Adjustment Window 5-69, 7-63
Flashlamp Bulb Replacement Procedure 9-1
Flashlamp Safety Interlock (EyeD-IEP only) 5-70, 7-64
Fringe Counter 3-74
Front View of DCS Shelf on 200mm DPS, DPS+ Chamber 4-12
Front View of Installed Detector Module on 300mm eMAX 6-12
F3 Front Fuse Panel 4-7
G
General Options 3-19
genericROOM_LIGHT Equations Menu of the Configuration Editor 4-35
Ghost Pattern 3-171
Global Variables 3-109
Graph Edit Window A-39
Graph Selection Window A-11
Graph Types 2-11
H
Hardware and Software Requirements A-1
Hardware Configurations 2-2
Hardware Introduction 2-1
Hardware Setup 9-22
Hardware Specification Table 2-3
Hardware Specifications 2-3
Hazardous Voltage 1-4
Hazardous Waste 1-5
I
IEP Fiber Optic Cable Distribution 5-67, 7-61
IEP Mirror Assembly on 300mm DPS II 6-10
Initial Communications Log for Chamber A, 200mm 5-56
Initial Communications Log for Chamber A, 300mm 7-37
Insert Data File or Insert Directory A-22
Insert Items Menu A-53
Install EyeD-IEP Flashlamp and DCS on 300mm DPS II 6-6
Install Fundamentals 5-6
Install Fundamentals, 300mm Software Installation 7-6
Install Magnet Synchronous Detection Module Hardware 4-16
Install SCS Assembly, 200mm 4-16
Installaing EyeD Software onto Computer Used in Production 5-2
Installation Complete 4-36
Installation of Ergotron and Computer on 300mm DPS II and eMAX 6-5
Installation Type, 200mm 5-8
Installed EyeD-IEP Detector and Lamp on 200mm DPS Chamber 4-14
Installing a New Version of Software 9-21
Installing EyeD on Tool with Active Endpoint System 9-22
Installing EyeD on Tool with Active Endpoint System, Terminology 9-22
Installing EyeD Software on AMAT K-Station 5-22, 7-22
Installing EyeD Software, 300mm 7-3
L
Laser and X-ray 1-5
Latency 9-22
Layer Properties 3-100
Layer Properties Window 3-100, 3-114
L-Clamp on Support Shelf 4-9
List of Available Material in the Database 3-116
List of Equation Window 3-98
List Reprocessed and Endpoint Found for all Files A-25
Listed Files for Reprocessing A-24

Location for Bracket Installation, 300mm 6-11
Location of DCS Shelf on 200mm DPS, DPS+ Chamber 4-12
Log Event 3-150
Logic Expressions 3-151
Logical Progression of Equation Types 2-10
M
Mainframe 4-19
Mainframe Setup 5-62
Maintenance and Upgrades 8-1, 9-1
Map Digital Input Signal Dialogue Box, 200mm 5-45
Map Digital Signals Window, 200mm 5-43
Mapping Digital Signals, 200mm 5-43
Mark Event Parameter Window A-54
Marker Positioning 3-179
Material Optical Properties File 3-111
Material Palette Builder Window 3-115
Maximized Trend Monitor Graph A-49
Menu and Button Toolbars 2-5
MHIF Bulb Replacement Procedure 9-1
Monitor State 2-8
Monitor (Video Display Terminal) 1-4
Monitoring Processor Time and CPU Usage 8-33
Multiple Document Interface (MDI) Workspace 2-6
Multiple Fiber Optic Inputs 2-2
Multiple Steps Per Column 3-24
N
Neural Net Activity Log Entries 3-177
Neural Net Marker Color Definitions 3-176
Neural Net Progress Markers 3-177
Neural Net Properties Window 3-170
Neural Net Stages 3-166, 3-176
Neural Network Graph 3-165
Neural Network Software 2-9
New Configuration Window A-6
O
OES and IEP Time Average Trend Equation Properties of the 577nm Spectral Line 4-35
One Step Per Column 3-24
Operation Modes 2-7
Operator Notification Window 3-149
Optical Properties Database 3-111
Order of Calculations A-2
Original Configuration Window A-42
Output of Film Thickness Equation 3-119
Output Window Activity Log Validation Message A-40
Overetch 3-189
Overetch Properties Window 3-190
P
Parallel Sequence 3-186
Parameter Settings for SECS Communication, 200mm 5-38
Passing Thickness Result to Etch Control Algorithm 3-119
Pattern Detect/Threshold A-55
Performance Monitor Window 8-31
Port 4/Com1 under 300mm DPS II Chamber 6-17
Power Saving Scheme, 300mm 7-2
Power Up System 4-32
Powering Up System, 300mm 6-20
Preparing a Configuration to Collect and Display Spectra A-7
Principal Components Analysis 2-9
Process State 2-8
Properties for ‘Start’ Command, 200mm 5-46
R
Radiation Hazards 1-4
Reference Properties Calibration Window 3-99
Reference Properties Window 3-98, 3-104
Reflectometer Removal Procedure 9-1
Region Equations 2-10
Region Properties Window A-34, A-40
Reprocess File Properties Window A-26
Reprocess List 3-193, A-21
Reprocess State 2-7
Reprocessing Previously Collected Spectra A-18
Requirements 9-1
Response to Motion Graph for OES Cable 4-36
Resulting Equations Window A-47

Retrofitted Dual Manometer on 300mm DPS II 6-8
Retrofitted Tray and Lid Heater PID of 300mm DPS II 6-6
Review State 2-7
Revised Configuration A-44
Run States 2-7
Running (Testing) an Edited Configuration File A-41
S
Safety References 1-1
Save Reference File 3-103
Saving Files With User Identification A-7
Saving Power Scheme 5-2, 7-2
Saving, Activating Configuration File changes for Endpoint Algorithms A-39
Scenario and Material Organization A-2
Select Equations A-11
Select Region in Configuration Editor A-10
Select Regional Peak A-33
Select Reprocess List A-24
Selected Configuration File A-14
Selecting Wavelength Range and Number of Data Analysis Points 3-111
Sequence List Window A-13
Serial Communication Setup (IDEC), 200mm 5-36
Set Current Configuration File A-14
Set Delay Time in Seconds 3-139
Set File Management, 200mm 5-62, 7-38
Set Overetch Type 3-190
Set Snapshot and End of Snapshots A-11
Set Variable 3-190
Set Variable in Sequence 3-120
Set Variable Properties 3-120
Setting up the Film Stack Model 3-113
Setup Window 3-109
Side View of DCS Shelf Mounting Bracket with Arm 4-13
Single Fiber Optic Input 2-2
Snapshots A-49
Software Upgrades 9-21
Sound 1-5
Source Fiber Branch IEP Cable Connection Detail 5-66, 7-60
Spade Lugs F3-1 and F3-2 4-7
Specify Material Window 3-115
Specifying Reference to be Used 3-117
Spectral Equation Properties Window 3-118
Spectral Equations 2-9
Spectral Graph of Three Regions A-36
Spectral Graph Properties Window A-12, A-37
Spectral Graph Prpoerties Window A-35
Spectral Graphs 2-11
Spectral Region Definition A-32
Spectral Toolbar A-27
Spectrograph Assembly 4-18, 6-16
SP2000 Interlock Connectors 5-71, 7-65
Start Neural Net Marker Placement 3-172
Starting Data Collection A-15
Starting the EyeD Software A-3
Status Bar 2-6, 3-15
Stop 3-193
Synchronize Configuration Message A-27
System Window 3-11
System Window a 3-11
T
Tend Equation Properties Window 3-122
Threshold Parameters A-55
Threshold-Based Software 2-8
Time Average and Derivative Trends A-52
Time Delay Properties A-53
To Become Familiar With the Data Navigation Tools A-27
To Reprocess Previously Collected Data A-18
Tool Interface Settings 5-14
Tool Interface Settings, 300mm Software Installation 7-14
Toolbar Customizing Window A-5
Tracking Configuration Changes A-30
Transferring Active References to a New Software Version 9-21
Transpose Data Matrices 3-207
Trend Equation Properties A-46
Trend Equation Properties Window A-50
Trend Equations 2-10
Trend Graph 3-146
Trend Graph Properties A-48, A-51

Trend Graphs 2-11
Tutorial Exercises A-3
U
Universal Remote Interface (URI) Setup, 200mm 5-36
Universal Remote Interface (URI) Setup, 300mm 7-34
Upgrading the Centura I AC Box 4-6
URI Application Setup Window, 200mm Digital Setup 5-40
URI Diagnostics Window, 200mm 5-42
URI Setup for Digital Communication, 200mm 5-39
URI Window for SECS Communication, 300mm 7-34
Use Snapshots to Normalize a Data Trend to an Initial Value A-49
Using the Film Thickness Measurement Resource 3-110
V
Validation Error Icon A-41
Variable Properties Window 3-110
Variables List 3-110
View Event History 3-21
View Pull-down Menu A-4
W
Wafer Information 2-6
Warning of Large Reflection Spectrum Variation 3-108
Wavelength (in nanometers) A-33
Symbols
_Toc14853889 5-2
Numerics
200mm Computer Assembly 4-16
200mm Control Computer Connections 4-17
200mm Ergotron Cart Installation 4-10
200mm Ergotron Cart with Mounted Monitor and Keyboard 4-11
200mm Ethernet Hub 4-18
200mm Hardware Installation Introduction 4-1
200mm IEP Fiber Optic Cable Support Conduit 4-15
200mm Mainframe Side View Showing Computer Shelf 4-9
200mm Port VP6/Com1 in the System Controller 4-20
200mm Software Installation and Set-Up 5-1
300mm Control Computer Connections 6-15
300mm Ergotron Integrated Monitor/ Computer Assembly 6-3
300mm Ethernet Hub 6-16
300mm EyeD-IEP Software and Hardware Communication Diagram 6-4
300mm EyeD-OES Software and Hardware Communication Diagram 6-3
300mm Hardware Installation 6-1
300mm Hardware Installation Introduction 6-1
300mm Software Installation & Set-Up 7-1

Applied Materials, Inc.
3050 Bowers Avenue
Santa Clara, CA 95054-3299

Address correspondence to:
Applied Materials, Inc.
P.O. Box 58039
Santa Clara, CA 95052-8039
Tel: (408) 727-5555
Telex: 6719476 AMTUW
Fax: (408) 748-9943
Web Site: http://www.AppliedMaterials.com

To order copies of this manual or other manuals, call 1-800-HOT-TTTT option 3

APPLIED MATERIALS

Applied Materials, Inc. 2003. All rights reserved. Printed in U.S.A. 2/10/2003 CPS