Clarus 500 GC
Service Manual

PerkinElmer Private

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Table of Contents

Chapter 1 Introduction
ABOUT THE MANUAL 1-3
MANUAL SUMMARY 1-4
Related User Documentation 1-4
CONVENTIONS USED IN THIS MANUAL 1-5
Notes, cautions and warnings 1-5
ELECTROMAGNETIC COMPATIBILITY (EMC) 1-6
United States (FCC) 1-6
European Union 1-6
Susceptibility to RF Interference 1-6
WARNING SIGNS ON THE INSTRUMENT 1-7
Label locations on instrument 1-8
SAFETY PRACTICE 1-9
Generic Warnings 1-9
Heated Zones 1-9
Precautions 1-10
Environmental Conditions 1-10
Storage Conditions 1-12
General Laboratory Safety 1-12
Electrical Safety 1-12
Moving the Clarus 500 GC 1-14
ECD Radioactive Hazards 1-14
Safe Handling of Gases 1-17
Hazardous Chemicals 1-20

CHAPTER 2 INSTALLATION
PREPARING YOUR LAB 2-3
Preparing the Laboratory 2-3
Clarus 500 GC Requirements 2-5
Pre-Installation Checklist 2-9
INSTALL THE AUTOSAMPLER 2-10
CONNECTING THE GASES AND ELECTRICAL SUPPLY 2-18
Gas Cylinder Connections 2-18
Clarus 500 GC Gas Connections 2-21
Common Injector/Detector Gas Connections 2-23
Connecting the Gas for Subambient Operation 2-32
Connect the Electrical Supply 2-34
CONNECT THE ACCESSORIES 2-38
Connect the EICD 2-38
Connect the ElCD Control Unit to the ElCD Components 2-39
Connect the ElCD Solvent System 2-41
Make the ElCD/PID Series Connection 2-42
Check the Calibration 2-45
Install the NPD Bead Assembly 2-45
Connect a Printer 2-49
RESTRICTOR INFORMATION 2-50
Available Restrictors 2-50
Restrictors for Carrier Gas Control 2-50

Restrictors for Detector Gas Control ... 2-51

CHAPTER 3 MAINTENANCE
CHAPTER OVERVIEW ... 3-1
AUTOSAMPLER MAINTENANCE ... 3-2
Changing a Syringe ... 3-2
Removing a Syringe ... 3-3
Installing a Syringe ... 3-4
REPLACING THE VIAL-LOCATOR MECHANISM ... 3-5
SYRINGE MAINTENANCE ... 3-6
Cleaning the 5-µL and 50-µL Syringe Plungers ... 3-6
Servicing Idle Syringes ... 3-6
INJECTOR MAINTENANCE ... 3-7
Changing Septa ... 3-7
Changing and Repacking Packed Column Injector Liners ... 3-8
Changing the Hourglass Needle Guide on the Programmed On-Column (POC) Injector ... 3-10
CHANGING AND REPACKING CAPILLARY SPLIT/SPLITLESS (CAP) AND PROGRAMMED SPLIT/SPLITLESS (PSS) INJECTOR LINERS ... 3-12
Removing a CAP or PSS Injector Liner ... 3-12
About O-Rings ... 3-15
Selecting an Appropriate CAP Injector Liner ... 3-16
Packing the CAP Injector Liner with Quartz Wool ... 3-17
Packing a CAP Injector Liner for Split Operation ... 3-17
Packing a CAP Injector Liner for Splitless Operation ... 3-17
CHANGING THE CHARCOAL TRAP OR REPLACING CHARCOAL ON THE SPLIT/SPLITLESS CAP AND PSS INJECTORS ... 3-23
Removing a Charcoal Trap ... 3-23
Installing a New Charcoal Trap ... 3-24
ECD MAINTENANCE ... 3-26
Baking the ECD ... 3-27
Changing the Charcoal Traps ... 3-27
Cleaning the ECD Anode ... 3-27
Wipe Testing an ECD Cell ... 3-28
FID MAINTENANCE ... 3-33
Replacing a FID Jet ... 3-33
Cleaning a FID Jet ... 3-36
PID MAINTENANCE ... 3-38
Changing a PID Lamp ... 3-38
Cleaning PID Lamp Windows ... 3-39
Changing PID Lamp Window Seals and Positioning Disks ... 3-41
ELCD MAINTENANCE ... 3-42
Replacing the ElCD Reactor Tube ... 3-42
Replacing the Sealing Ring ... 3-43
NPD MAINTENANCE ... 3-46
Changing the NPD Bead ... 3-46
Replacing an NPD Jet ... 3-53
FPD MAINTENANCE ... 3-56
Cleaning/Replacing an Optical Filter Assembly ... 3-56
Cleaning/Replacing the Detector Liner ... 3-58
Cleaning/Replacing the Detector Window ... 3-60

Replacing the Photomultiplier Tube 3-62
Cleaning/Replacing the FPD Jet 3-65
PPC MAINTENANCE 3-68
Replacing a Restrictor 3-68
PRACTICAL HINTS 3-71

CHAPTER 4 FIRMWARE
SETTING UP HYPERTERMINAL 4-3
CREATING A SHORTCUT TO THE FIRMWARE 4-8
To Create a Shortcut 4-8
DOWNLOADING FIRMWARE TO THE CLARUS 500 GC INSTRUMENTS 4-9
To Download Firmware 4-10

Chapter 5 Performance Test
CLARUS 500 GC TEST SPECIFICATIONS 5-3
FID PACKED COLUMN 5-4
FID Capillary Column 5-6
TCD PACKED COLUMN 5-9
NPD PACKED COLUMN 5-11
NPD CAPILLARY COLUMN 5-14
ECD PACKED COLUMN 5-17
ECD CAPILLARY COLUMN 5-21
FPD PACKED COLUMN (SULFUR MODE) 5-25
CALIBRATING THE OVEN TEMPERATURE 5-46
Calibrate the Reference Thermometer 5-46
Place the Thermometer Probe in the Oven 5-46
Equilibrate the Oven Temperature 5-48
Enter the Required Offset Value 5-50
Remove the Thermometer Probe 5-50

CHAPTER 6 AUTOSAMPLER
ABOUT THIS CHAPTER 6-3
OVERVIEW OF THE AUTOSAMPLER 6-4
Tower Interface PC Board 6-5
Replacing a Syringe 6-6
Servicing Idle Syringes 6-8
Cleaning the 5-µl and 50-µl Syringe Plungers 6-8
Accessing the Autosampler Diagnostics 6-9
Carousel Service Procedures 6-10
Replacing the Carousel Motor 6-15
TOWER SEVICE PROCEDURES 6-20
Replacing and Aligning the Tower Sensor 6-20
Replacing the Plunger Sensor 6-24
Replacing the Vial Locator Sensor 6-32
Replacing the Vial-Locator Mechanism 6-35
Replacing the Door Sensor 6-36
Replacing the Tower Motor 6-38
Replacing the Elevator Motor 6-40
Disassembling and Reassembling the Tower 6-42
Replacing the Elevator Leadscrew /Supernut Assembly 6-46

Replacing the Plunger Motor 6-48
Replacing the Plunger Leadscrew /Supernut Assembly 6-50
Replacing the Plunger Flag Assembly 6-52
Replacing the Needle Guide 6-54
Replacing the Vial Locator 6-55
Replacing the Tower Disk Assembly 6-56

CHAPTER 7 DIAGNOSTICS
INSTRUMENT START UP 7-3
Power on Diagnostics 7-3
Power Failure Recovery 7-5
Diagnostics Mode 7-5
Autosampler 7-11
CHROMATOGRAPH MODE 7-14
Splash Screen 7-14
Chromatograph Mode 7-18

CHAPTER 8 TROUBLE SHOOTING
CHAPTER OVERVIEW 8-3
Solving GC Problems 8-3
In the Event the Customer Forgets Their Password 8-5
Trouble shooting General Instrument Problems 8-5
Error Messages 8-5

CHAPTER 9 ELECTRICAL SYSTEM
LEGO INTERFACE P. C. BOARD OVERVIEW 9-5
CPU and Memory (Sheets 1 and 4 on the LEGO Interface Board Schematic) 9-5
LCD Display and Touch Screen Interface (Sheet 2 on the LEGO Interface Board Schematic) 9-6
RS232 Interface (Sheet 3 on the LEGO Interface Board Schematic) 9-10
OVERVIEW OF THE ELECTRICAL SYSTEM 9-13
Power Supply 9-15
OUTPUT RIPPLE 9-15
OUTPUT HOLD-UP TIME 9-15
POWER LINE SURGE 9-15
POWER LINE SAG 9-15
AC Distribution PC Board 9-15
Heater, Solenoid, and Fan Control 9-16
Interrupt Generation 9-16
Main PC Board 9-16
CPU 9-17
Solenoid and Motor Control 9-17
RS232 Interface 9-18
Slave Interface 9-19
Analog Section 9-19
Connector Description List 9-20
Power On Diagnostics Bits 9-21
Interrupts 9-21
Main Board Memory Map 9-22
Autosampler PC Board 9-23

Signal Name Notation....9-23
Microprocessor 9-23
Memory....9-24
Main Board Interface....9-24
Input/Output 9-24
System Operation....9-24
Motor Control....9-25
Current Control....9-25
Carousel Encoder Interface....9-27
Tower Ilnterface PC Board....9-27
Design Specification....9-28
Block Diagram/Overview 9-29
Microprocessor 9-29
Main Board Interface....9-29
Memory....9-30
Xilinx Field Programmable Gate Array PWM Control....9-30
Analog Input / Analog to Digital Conversion....9-30
On Board Ambient Pressure Transducer....9-32
Voltage References....9-33
Pressure Modules Interface....9-34
Switching Power Supply 9-34
FID Amplifier PC Board....9-35
Polarizing Voltage....9-35
Electrometer 9-35
A/D Converter Front End Stages....9-36
Analog Signal Output 9-37
Voltage Reference....9-37
Electrometer Balance Adjustment....9-37
ECD Amplifier PC Board....9-37
Standing Current Feedback Control Loop 9-37
Frequency-to- Voltage Converter 9-38
A/D Converter Front End Stage....9-38
Analog Signal Output 9-39
Voltage Reference....9-40
TCD Amplifier PC Board....9-40
Command Decoding....9-40
Bridge Ground System....9-41
Bridge Current Range Select....9-41
Bridge Current Control....9-41
Bridge Output Circuits....9-41
Safety Circuits 9-41
A/D Converter Front End Stage....9-42
Analog Signal Output 9-43
Voltage Reference....9-43
TCD Range Values....9-44
FPD Amplifier PC Board....9-45
High Voltage Section....9-45
Electrometer 9-45
A/D Converter Front End Stage....9-45
Analog Signal Output 9-46

Voltage Reference....9-47
NPD Amplifier PC Board....9-47
Polarizing Voltage....9-47
Electrometer....9-48
A/D Converter Front End Stages....9-48
Analog Signal Output....9-49
Voltage Reference....9-49
Bead Voltage Conversion (RMS-to-DC)....9-49
Pulse Width Modulation Control....9-50
NPD Transformer....9-50
PID Amplifier PC Board....9-51
Polarizing Voltage....9-51
Electrometer....9-51
A/D Converter Front End Stage....9-52
Analog Signal Output....9-53
Voltage Reference....9-53
Electrometer Balance Adjustment....9-53
External Amplifier PC Board....9-53
Differential Analog Input....9-54
A/D Converter Front End Stage....9-54
Analog Signal Output....9-55
Voltage Reference....9-55
Pressure Transducer PC Board....9-55
Touch Screen Display....9-56
I/O PC Board....9-56
Timed Event Drivers....9-56
Position Gas Sampling Valve Interface....9-57
Analog Inputs....9-58
D / A & Communications....9-58
Power....9-59
Servicing the Electrical System....9-59
Accessing the PC Boards....9-59
Pressure Transducer Zero Adjustment....9-60
Pressure Transducer Span Adjustment....9-60
Removing the Pressure Transducer Board....9-61
Replacing the Gate Array on the Autosampler Control PC Board....9-61
Replacing Fuse....9-61
AC Distribution Board Fuses....9-62
TCD Power Supply Board Fuses....9-62
Autosampler Transformer Fuses....9-62
Check Resistance Values....9-63
Schematics Diagrams....9-64

CHAPTER 10 SCHEMATICS

SCHEMATIC DIAGRAMS....10-3

Chapter 11 Hardware System

ABOUT THIS CHAPTER....11-2
DETECTORS....11-3
Flame lonization Detector (FID)....11-3

Electron Capture Detector (ECD)....11-4
Thermal Conductivity Detector (TCD)....11-5
Flame Photometric Detector (FPD)....11-6
Nitrogen Phosphorus Detector (NPD)....11-7
Photoionization Detector (PID)....11-8
Electrolytic Conductivity Detector (ELCD)....11-9
INJECTORS 11-12
Packed Column Injector....11-12
Capillary (Split/Splitless) Injector....11-13
Programmable Split/Splitless (PSS)....11-15
Programmable On-Column (POC)....11-18
PNEUMATIC CONTROLS....11-19
Manual Pneumatic Controls 11-19
Programmable Pneumatic Control....11-19
Oven....11-27

CHAPTER 12 PNEUMATICS

PNEUMATICS.... 12-3
Auxiliary Pneumatics 12-3

Chapter 13 Service Data Bulletins

Clarus 500 GC Technical SDB: CLRS001A.SBS 13-4
Clarus 500 GC Technical SDB: CLRS002A.SBS 13-10
Clarus 500 GC Technical SDB: CLRS004A.SBS 13-12

Introduction 1

ABOUT THE MANUAL 1-3
MANUAL SUMMARY 1-4
Related User Documentation 1-4
CONVENTIONS USED IN THIS MANUAL 1-5
Notes, cautions and warnings 1-5
ELECTROMAGNETIC COMPATIBILITY (EMC) 1-6
United States (FCC) 1-6
European Union 1-6
Susceptibility to RF Interference 1-6
WARNING SIGNS ON THE INSTRUMENT 1-7
Label locations on instrument 1-8
SAFETY PRACTICE 1-9
Generic Warnings 1-9
Heated Zones 1-9
Precautions 1-10
Environmental Conditions 1-10
Storage Conditions 1-12
General Laboratory Safety 1-12
Electrical Safety 1-12
Moving the Clarus 500 GC 1-14
ECD Radioactive Hazards 1-14
Safe Handling of Gases 1-17
Hazardous Chemicals 1-20

About the Manual

This manual is designed to be used by PerkinElmer Field Service Engineers. It is a complete reference guide for servicing Clarus 500 GC, including calibration procedures, troubleshooting and replacement procedures. The manual also includes a functional description of the Clarus 500 GC and complete details about the mechanical and electrical construction.

How to Use this Manual

This manual includes all the information you will need to install, test, and service the Clarus 500 Gas Chromatograph as efficiently as possible.

How the Manual is Organized

This service manual is divided into 10 chapters. Color-coded tabs have been included to help you quickly locate Chapters. In addition, important service aids such as the Pre-Installation and Installation Checklists are included in the Installation Chapter of this service manual.

Conventions Used in This Manual

The following conventions are used throughout this manual:

Conventions in the Text

Bold type is used for:

- commands. For example, **Open Data**.
- a button that you touch. For example, "Touch **Method Used**." the name of an icon that you touch.
- An asterisk "*" is used to indicate a one-step procedure.

Underlining is used for clarification or emphasis. In the case of the Help file, it is used to show jumps, popups and hotspots.

Turn the page for a summary of the contents of this manual.

Manual Summary

Chapter 1. Introduction
This chapter includes an overview of the manual and safety information.

Chapter 2. Installation
This chapter describes the hazards and recommended safety practices you should observe when servicing or operating the Clarus 500 GC.

Chapter 3. Maintenance
This chapter describes how to install the Clarus 500 GC. The Pre-Installation and Installation Checklist are included in this chapter, as is the Customer Orientation Script.

Chapter 4. Firmware
This chapter describes how to download the firmware on to the Clarus 500 GC.

Chapter 5. Performance Test
This chapter describes how to test the instrument using different detector/ injector configurations.

Chapter 6. Autosampler
This chaper includes descriptions of and service procedures for all autosampler mechanical and electrical components. Schematics for autosampler electrical components are included in this chapter.

Chapter 7. Diagnostics
This chapter describes how to run the Clarus 500 GC software diagnostics.

Chapter 8. Troubleshooting
This chapter describes how to troubleshoot general instrument problems.

Chapter 9. Electrical System
This chapter includes circuit descriptions of and service procedures for all electrical system components. Schematics are included in this chapter.

Chapter 10. Hardware System
This chapter describes the components of the Clarus 500 GC mechanical system, which includes detectors, injectors, pneumatic controls, and the oven.

Chapter 11. Pneumatics
This chapter includes a full range of pneumatics options provides optimum performances with all types of columns and detectors.

Chapter 12. Service Data Bulletins
This chapter allows you to store your upcoming service data bulletins.

Related User Documentation

For detailed operating instructions beyond what is included in this manual, refer to the *Clarus 500 GC User's Guide*, Part No. 0993-6625A.

Conventions Used in this Manual

Normal text is used to provide information and instructions.

Bold text refers to text that is displayed on the screen.

UPPERCASE text, for example ENTER or ALT, refers to keys on the PC keyboard. '+' is used to show that you have to press two keys at the same time, for example, ALT+F.

All eight digit numbers are PerkinElmer part numbers unless stated otherwise.

Notes, cautions and warnings

Three terms, in the following standard formats, are also used to highlight special circumstances and warnings.

NOTE: *A note indicates additional, significant information that is provided with some procedures.*

CAUTION	*We use the term CAUTION to inform you about situations that could result in* ***serious damage to the instrument*** *or other equipment. Details about these circumstances are in a box like this one.*

 **WARNING**	*We use the term WARNING to inform you about situations that could result in* ***personal injury*** *to yourself or other persons. Details about these circumstances are in a box like this one.*

Electromagnetic Compatibility (EMC)

United States (FCC)

This product is classified as a digital device used exclusively as industrial, commercial, or medical test equipment. It is exempt from the technical standards specified in Part 15 of the FCC Rules and Regulations, based on Section 15.103 (c).

European Union

All information concerning EMC standards will be in the Declaration of Conformity and these standards will change as the European Union adds new requirements.

European Union Industrial Environment

The 230 V/50 Hz. Clarus GC has been manufactured for use in the European Union and is intended for the industrial environment. The instrument is to be connected to a mains power network supplied from a high or medium-voltage transformer dedicated for the supply of an installation feeding a manufacturing or similar plant.

Industrial environments are characterized by the existence of one or more of the following conditions:

-industrial, scientific and medical (ISM) apparatus are present

-heavy inductive or capacitive loads are frequently switched

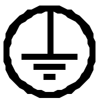
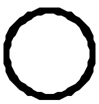
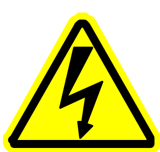
-currents and associated magnetic fields are high

These are the major contributors to the industrial electromagnetic environment and as such distinguish the industrial from other environments. The instrument is not intended for connection to a public mains network supplying residential, commercial and light-industrial locations.

Susceptibility to RF Interference

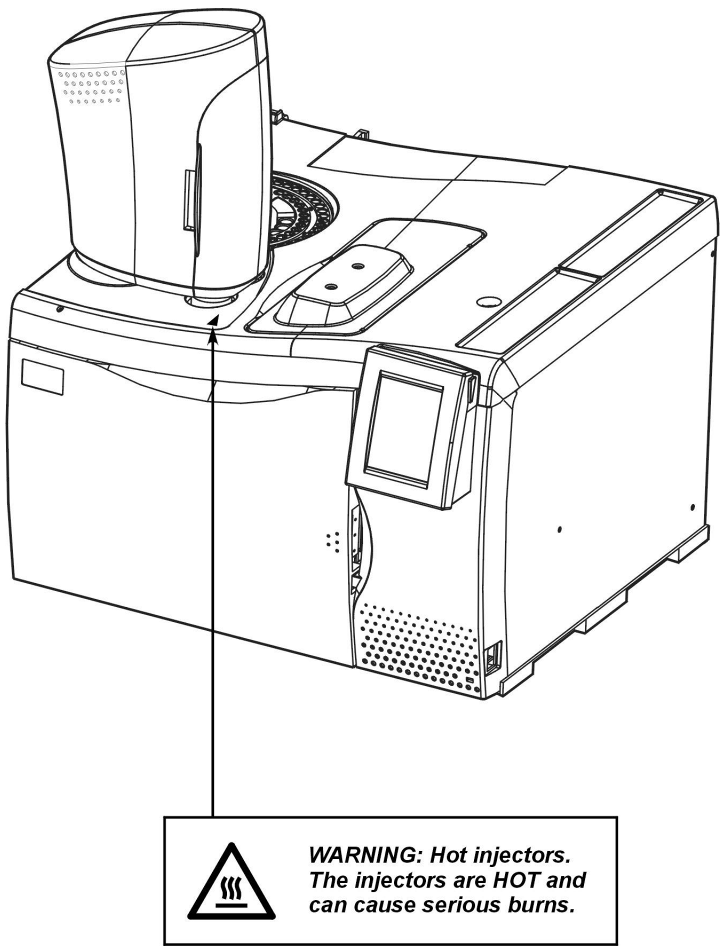
With the exception of the Flame Ionization Detector (FID), an RF field strength of 10 V/m between 80 MHz. and 1000 MHz. with 80% modulation at 1 kHz. may cause a deflection on the chromatographic detector baseline that exceeds its normal pattern. This implies that if a transmitting device, such as a walkie-talkie carried by a security guard, is use near the detector, a spike or peak on the chromatographic baseline may occur. If you are concerned that such an event may occur, PerkinElmer recommends that walkie-talkie restriction notices be posted in the vicinity. Cell phones, beepers, and other similar devices operate in a much higher frequency range and do not cause interference.

Warning Signs on the Instrument

	*Alternating current.*
	*Protective conductor terminal.*
	*Off position of the main power source.*
	*On position of the main power source.*
	*Warning, hot surface*
	*Warning, risk of electric shock.*

Warning (refer to accompanying documents).

Label locations on instrument



Safety Practice

This chapter describes the general safety practices and precautions that must be observed when operating the Clarus 500 GC.

This advice is intended to supplement, not supersede, the normal safety codes in the user's country. It is also a supplement to the PerkinElmer standard Safety and Health Policy. The information provided does not cover every safety procedure that should be practiced. Ultimately, maintenance of a safe laboratory environment is the responsibility of the analyst and the analyst's organization.

Please consult all manuals supplied with the Clarus 500 GC and accessories before you start working with the instrument. Carefully read the safety information in this chapter and in the other manuals supplied. When setting up the instrument or performing analyses or maintenance procedures, strictly follow the instructions provided. The Clarus 500 GC should be used in accordance with the instructions provided in this manual. If used otherwise, the protection provided by the instrument may be impaired.

Generic Warnings

Before installing or operating the Clarus 500 GC, read the following information concerning hazards and potential hazards. You should ensure that anyone involved with installation and/or operation of the Clarus 500 XL GC is knowledgeable in both general safety practices for the laboratory and safety practices for the Clarus 500 GC. Get advice from your safety engineer, industrial hygienist, environmental engineer, or safety manager before you install or use this instrument.

Heated Zones

Heated zones should be treated with caution, for example, injector caps and detectors. Avoid physical contact with the injector caps. The detector cover may get hot, especially if flame ionization detectors are operated at high temperatures. As a general rule, allow heated zones to cool before attempting to work in the oven, injector, or detector areas.

CAUTION

THERMAL RUNAWAY PROTECTION: *The Clarus 500 GC software shuts down the instrument if any heated zone exceeds 470 °C. Should this occur, the following error message is displayed:*

INSTRUMENT SHUTDOWN
xxx THERM RUNAWAY where xxx is the heated zone

Call your PerkinElmer Representative.

Instrument shutdown also occurs if there is a PRT (Platinum Resistance Thermometer) or MPU (Micro Processor Unit) failure. In these cases the following error message is displayed:

INSTRUMENT SHUTDOWN
xxx PRT ERROR where xxx is the failed zone.

Call your PerkinElmer Representative.

Precautions

WARNING ***Be sure that all instrument operators read and understand the precautions listed below. It is advisable to post a copy of the precautions near or on the instrument shelf.***

The following precautions must be observed when using the Clarus 500 GC:

- Be sure that the power line voltage of the Clarus 500 GC corresponds to the voltage used in your laboratory.
- Never remove the side panels of the Clarus 500 GC without shutting down the instrument and disconnecting the instrument power cord from line power.
- Do not immerse the purge gas exit line in a liquid, as the liquid may be drawn back into the sample holder.
- Only high quality purge gases should be used with the Clarus 500 GC. Minimum purity of 99.995 % is recommended. A high quality filter-dryer accessory is recommended for the removal of any moisture from the purge gases.
- Always encapsulate indium, tin, lead, and zinc standards in aluminum or graphite pans, as these metals will alloy with gold, copper or platinum pans.
- It is very important that nothing fall down into the cavity surrounding the sample holders. If anything does fall down, IMMEDIATELY turn off the power switch of the Clarus 500 GC and call your PerkinElmer Service Representative.

Environmental Conditions

Operating Conditions

CAUTION *The Clarus 500 GC is designed for indoor use only.*

CAUTION	*Do not operate in a Cold Room or a refrigerated area. The Clarus 500 GC operates most efficiently under the following conditions:* • *Ambient temperature is 10 °C to 35 °C (50 °F to 95 °F). The GC will operate safely between 5 °C and 40 °C (41 °F and 104 °F).* • *Ambient relative humidity is 20% to 80% non-condensing.* • *Operating altitude is in the range of 0 to 2 000 m.*

WARNING	*The Clarus 500 GC is not designed for operation in an explosive environment.*

Installation Category

The Clarus 500 GC is able to withstand transient overvoltage according to Installation Category II as defined in IEC 1010-1.

Pollution Degree

The Clarus 500 GC will operate safely in environments that contain nonconductive foreign matter up to Pollution Degree 2 in IEC 1010-1.

Storage Conditions

The Clarus 500 GC may be stored under the following conditions:

- ambient temperature is -20 °C to +60 °C (-4 to 140 °F)
- ambient relative humidity is 20 to 80%, non-condensing
- altitude is in the range 0 to 12 000 m.

General Laboratory Safety

Your laboratory should have all equipment ordinarily required for the safety of individuals working with chemicals (fire extinguishers, first-aid equipment, safety shower and eye-wash fountain, spill cleanup equipment, etc.).

Electrical Safety

The Clarus 500 GC contains high voltage. To prevent the risk of shock, unplug the line cord from the AC outlet and wait at least one minute before opening or removing any instrument panels.

The instrument has been designed to protect the operator from potential electrical hazards. This section describes some recommended electrical safety practices.

CAUTION	*This unit contains protective circuitry. Contact PerkinElmer Service before performing any AC line tests.*

WARNING	*Connect the GC to an AC line power outlet that has a protective ground connection. To ensure satisfactory and safe operation of the GC, it is essential that the protective ground conductor (the green/yellow lead) of the line power cord is connected to a true electrical ground. Any interruption of the protective ground conductor, inside or outside the GC, or disconnection of the protective ground terminal may impair the protection provided by the GC.*

WARNING

Do not operate the GC with any covers or parts removed.

WARNING

To avoid electrical shock, disconnect the power cord from the AC outlet before servicing. Servicing on the GC is to be performed only by a PerkinElmer service representative or similarly trained and authorized person.

WARNING

Do not attempt to make adjustments, replacements or repairs to this GC except as described in the user documentation.

WARNING

For protection against fire hazard, only replace fuses with the same type and rating. Servicing on the GC is to be performed only by a PerkinElmer service representative or similarly trained and authorized person.

Ensure that the power cord is correctly wired and that the ground leads of all electrical units (for example, recorders, integrators) are connected together via the circuit ground to earth. Use only three-prong outlets with common earth ground connections.

Servicing of incoming AC line components in your laboratory should be performed only by a licensed electrician.

WARNING

Lethal voltages are present at certain areas within the instrument. Installation and internal maintenance of the instrument should only be performed by a PerkinElmer service engineer or similarly authorized and trained person. *When the instrument is connected to line power, opening the instrument covers is likely to expose live parts. Even when the power switch is off, high voltages can still be present. Capacitors inside the instrument may still be charged even if the instrument has been disconnected from all voltage sources.*

The instrument must be correctly connected to a suitable electrical supply. The supply must have a correctly installed protective conductor (earth ground) and must be installed or checked by a qualified electrician before connecting the instrument.

WARNING *Any interruption of the protective conductor (earth ground) inside or outside the instrument or disconnection of the protective conductor terminal is likely to make the instrument dangerous. Intentional interruption is prohibited.*

When working with the instrument:

- Disconnect the instrument from all voltage sources before opening it for any adjustment, replacement, maintenance, or repair. If afterwards, the opened instrument must be operated for further adjustment, maintenance, or repair, this must only be done by a PerkinElmer Service engineer.
- Whenever it is possible that the instrument is no longer electrically safe for use, make the instrument inoperative and secure it against any unauthorized or unintentional operation. The electrical safety of the instrument is likely to be impaired if, for example, the instrument shows visible damage, has been subjected to prolonged storage under unfavorable conditions, or has been subjected to severe stress during transportation.

Moving the Clarus 500 GC

The Clarus 500 GC weighs 53.5 kg (118 lb). Improper lifting can cause injury to the back. If the instrument must be moved, we recommend that at least two people carefully lift the instrument in order to move it.

ECD Radioactive Hazards

WARNING *To assure that removable radioactive contamination on the external parts of the ECD remains at a safe level, the United States Nuclear Regulatory Commission requires that:*

- *The ECD be Wipe Tested at least once every six months.*
- *A record of the results be maintained for NRC inspection.*

United States Government Regulations for ECDs

NOTE: *To repair an Electron Capture Detector cell requires a specific license issued by the U.S. Nuclear Regulatory Commission (NRC) and/or in some states by the equivalent state agency. For further information on obtaining a license, contact the Customer Service Department at PerkinElmer, Shelton, Connecticut, or the NRC Material Branch, Office of Nuclear Materials, Safety and Safeguards, Washington, DC 20555.*

Special Instructions for ECD Cell Purchasers

NOTE: *These instructions are for ECD cell purchasers who are not specifically licensed to handle radioactive materials*.

The Clarus 500 GC Electron Capture Detector model (P/N N610-0063) contains a maximum of 15 mCi of Nickel 63 (Ni 63), a radioactive material. Your possession and use of this detector is governed by 10 C.F.R. Section 31.5 which is reproduced in Appendix I. Under the provisions of that regulation you are deemed a "General Licensee."

Your possession and use of the detector cell may also be regulated by the state where you are located. The requirements of state regulatory agencies are substantially similar to those contained in NRC regulation 10 C.F.R. Section 31.5, but they may differ in some respects. It is suggested that you procure a copy of the regulations of your particular state. (Supplement 2 in Appendix I contains a list of the "Agreement States" which have been granted authority by the U.S. Nuclear Regulatory Commission to regulate the possession and use of radioactive material.)

It is required that you be familiar with regulation 10 C.F.R. Section 31.5 (Appendix 1 in the Hardware Guide 0993-6590). Following are summaries of its requirements.

Labels

Do not remove any of the labels attached to the ECD cell or any of the labels attached to your Clarus 500 Gas Chromatograph that refer to the ECD cell. Follow all instructions and abide by all precautions provided by the labels and in user instruction manuals referred to by the labels.

Leak Testing

You are obligated under U.S. federal and state regulations to make certain that the ECD cell is wipe-tested for leakage of radioactive materials at intervals of no longer than six months, and that the analysis of these wipe tests is conducted by a person specifically licensed to do so, either by the U.S. Nuclear Regulatory Commission or by an Agreement State. The analyses can be performed by the firm listed below:

National Leak Test Center
P.O. Box 486
North Tonawanda, New York 14120

ECD Cell Failure or Damage

If a leak test detects more than 0.005 µCi (microcurie) of removable radioactive material on the surface of an ECD cell, or if the cell itself is damaged in such a way as to indicate that it may no longer adequately shield the radioactive material inside, you must immediately suspend operation of your chromatograph until the cell has been repaired or disposed of by ***a person specifically licensed to do so***. Any such incident must be reported by you to the Regional Office, Inspection and Enforcement, U.S. Nuclear Regulatory Commission.

Reporting Radiation Incidents, Theft or Loss

Please read Regulation 10 C.F.R. Section 20.402 and 20.403 (Appendix I). These describe your duties should the radioactive material (Ni 63) in the ECD cell be lost, stolen, or released, or should any person be exposed to radiation.

Other ECD Requirements

Regulation 10 C.F.R. Section 31.5 (see Appendix I) does not permit you to abandon the ECD cell or export it. It may not be transferred except to a person specifically licensed to receive it. Within thirty days of such a transfer, you must report to the Director of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, the name and address of the transferee.

You may transfer the ECD cell to another general licensee, like yourself, only when it remains at the same location to which it was shipped by PerkinElmer. Give the transferee a copy of these instructions and the regulations in Appendix I, and report to the commission as required in Regulation C.F.R. Section 31.5.

WARNING

NEVER DISMANTLE THE ECD CELL!!
However, if a specific license has been obtained, you can remove the ECD cell from the GC for repair.

United Kingdom Regulations

In the U.K., registration is required under the Radioactive Substances Act of 1960, for anyone keeping or using radioactive materials. Application should be made to any one of the following governing bodies:

ENGLAND	Department of the Environment Queen Anne's Chambers Tothill Street London, SW1H 9J4
SCOTLAND	Scottish Development Department 21 Hill Street Edinburgh, EH2 3J4
WALES	Welsh Office Cathay's Park Cardiff, CF1 3NG
NORTHERN	Ministry of Development
IRELAND	Parliament Building Storemont Belfast, Northern Ireland

Safe Handling of Gases

When using hydrogen, either as the combustion gas for a flame ionization detector or as a carrier gas, special care must be taken to avoid buildup of explosive hydrogen/air mixtures. Ensure that all hydrogen line couplings are leak-free and do not allow hydrogen to vent within the oven.

Ventilation

Adequate ventilation must be provided, particularly if a liquid nitrogen or carbon dioxide subambient accessory is in constant use. When analyzing hazardous compounds, such as pesticides, it may be necessary to arrange for venting of detector effluent into a fume hood.

Using Hydrogen

WARNING

Flame Ionization Detectors (FID) and Flame Photometric Detectors (FPD) use hydrogen as fuel. If the hydrogen is turned on without a column attached to the injector and detector fittings inside the oven, hydrogen could diffuse into the oven creating the possibility of an explosion. To avoid possible injury, ***DO NOT TURN ON THE HYDROGEN UNLESS A COLUMN IS ATTACHED AND ALL JOINTS HAVE BEEN LEAK TESTED.***

Before disconnecting a column, make certain that the hydrogen has been turned ***OFF.***

If two FIDs or FPDs are installed and only one has a column attached to it, make certain that you cap off the unused detector inlet fitting with a 1/8-inch stainless steel plug (P/N N930-0061).

WARNING

Contact the gas supplier for a material safety data sheet (MSDS) containing detailed information on the potential hazards associated with the gas. *Carefully use, store, and handle compressed gases in cylinders. Gas cylinders can be hazardous if they are mishandled.*

NOTE: *The permanent installation of gas supplies is the responsibility of the user and should conform to local safety and building codes.*

If liquid nitrogen is used, the gas cylinder must be fitted with an over-pressure regulator which will vent the cylinder as necessary to prevent it from becoming a safety hazard.

Consult the following references for more detailed information and additional guidelines about gas cyclinders.

- Compressed Gas Association (USA), "Safe Handling of Compressed Gases in Containers," pamphlet no. P-1, 1984.
- Compressed Gas Association (USA), "The Inert Gases – Argon, Nitrogen and Helium," pamphlet no. P-9, 1992.

Identification of Gas Cylinders

- Legibly mark cylinders to identify their contents. Use the chemical name or commercially accepted name for the gas.

Storing Gas Cylinders

Review the following precautions with the customer to ensure the safe use and storage of gas cylinders.

- Cylinders should be stored in accordance with the regulations and standards applicable to the customer's locality, state, and country.

- When cylinders are stored indoors in storage rooms, the storage room should be well ventilated and dry. Ensure that the ventilation is adequate to prevent the formation of dangerous accumulations of gas. This is particularly important in small or confined areas.

- Do not store cylinders near elevators, gangways, or in locations where heavy moving objects may strike or fall against them.

- Use and store cylinders away from exits and exit routes.

- Locate cylinders away from heat sources, including heat lamps. Compressed gas cylinders should not be subjected to temperatures above 52 °C (126 °F).

- It is recommended that gas cylinders be stored and placed outside the laboratory and connected to the instrument through copper lines.

Handling of Gas Cylinders

CAUTION	*To ensure adequate cooling of the instrument electronics, do not obstruct the gap at the base of the GC, and leave at least a 6-inch clearance between instruments.*

- Do not allow ignition sources in the storage area and keep cylinders away from readily ignitable substances such as gasoline or waste, or combustibles in bulk, including oil.

- Store cylinders standing upright, fastened securely to an immovable bulkhead or permanent wall.

- When storing cylinders outdoors, they should be stored above ground on a suitable floor and protected against temperature extremes (including the direct rays of the sun).

- Arrange gas lines where they will not be damaged or stepped on and where things will not be dropped on them.

- Take care not to kink or stress the gas lines. For safety, cylinders should be firmly clamped in position.
- If it becomes necessary to move the cylinders, do so with a suitable hand truck after insuring that the container cap is secured and the cylinder is properly fastened to the hand truck.
- Use only regulators, tubing and hose connectors approved by an appropriate regulatory agency.
- Do not refill cylinders.
- Check the condition of pipes, lines and connectors regularly. Perform gas leak tests at all joints and seals of the gas system regularly, using an approved gas leak detection system.
- When the equipment is turned off, close all gas cylinder valves tightly at the cylinder. Bleed the remainder of the line before turning the exhaust vent off.

Hazardous Chemicals

Before using samples, you should be thoroughly familiar with all hazards and safe handling practices. Observe the manufacturer's recommendations for use, storage and disposal. These recommendations are normally provided in the Material Safety Data Sheets (MSDS) supplied with the solvents.

Be aware that the chemicals that you use in conjunction with the GC may be hazardous. **DO NOT** store, handle, or work with any chemicals or hazardous materials unless you have received appropriate safety training and have read and understood all related Material Safety Data Sheets (MSDS). MSDSs provide information on physical characteristics, precautions, first aid, spill clean up and disposal procedures. Familiarize yourself with the information and precautions contained in these documents before attempting to store, use or dispose of the reagents. Comply with all federal, state, and local laws related to chemical storage, handling, and disposal.

You must work under a suitable hood when handling and mixing certain chemicals. The room in which you work must have proper ventilation and a waste collection system. Always wear appropriate safety attire (full-length laboratory coat, protective glasses, gloves, etc.), as indicated on Material Safety Data Sheets.

WARNING

Some chemicals used with this GC may be hazardous or may become hazardous after completion of an analysis. The responsible body (for example, the Lab Manager) must take the necessary precautions to ensure that the GC operators and the surrounding workplace are not exposed to hazardous levels of toxic substances (chemical or biological) as defined in the applicable Material Safety Data Sheets (MSDS) or OSHA, ACGIH, or COSHH documents. Venting for fumes and disposal of waste must be in accordance with all national, state and local health and safety regulations and laws.

Definitions in Warning for Hazardous Chemicals

Responsible body. "Individual or group responsible for the use and maintenance of equipment, and for ensuring that operators are adequately trained." [per IEC 1010-1].

Operator. "Person operating equipment for its intended purpose." [per IEC 1010-1].

OSHA: Occupational Safety and Health Administration (United States)

ACGIH: American Conference of Governmental Industrial Hygienists

COSHH: Control of Substances Hazardous to Health (United Kingdom)

Installation 2

Preparing Your Lab **2-3**
Preparing the Laboratory 2-3
Environmental Conditions 2-3
Exhaust Vent Requirements 2-4
Clarus 500 GC Requirements 2-5
Laboratory Space Requirements: 2-5
Environmental Requirements: 2-6
Electrical Power Requirements: 2-6
Safety Requirements: 2-7
Gas Requirements: 2-7
Sample Preparation Requirements 2-8
Pre-Installation Checklist 2-9
Install the Autosampler **2-10**
Remove the Encoder Protector Block 2-10
Install the Autosampler Tower 2-10
Install the Autosampler Tower Cover 2-13
Install the Syringe Cover 2-16
Connecting the Gases and Electrical Supply **2-18**
Gas Cylinder Connections 2-18
Clarus 500 GC Gas Connections 2-21
Leak Test the Gas Connections 2-22
Common Injector/Detector Gas Connections 2-23
Connecting the Gas for Subambient Operation 2-32
Connect the LN_2 Supply Tubing 2-33
Connect the CO_2 Supply Tubing 2-33
Connect the Electrical Supply 2-34

Connecting the Clarus 500 GC to Line Power in the U.S. 2-35
Connecting the Clarus 500 GC to Line Power Outside the U.S. 2-35
In Countries with 230V Single-Phase Power 2-35
In Countries with 230V Two-Phase Power 2-36
Connect the Accessories.. 2-38
Connect the EICD.. 2-38
Connect the ElCD Control Unit to the ElCD Components.............................. 2-39
Connect the ElCD Solvent System 2-41
Make the ElCD/PID Series Connection 2-42
Check the Calibration.. 2-45
Install the NPD Bead Assembly 2-45
Connect a Recorder or Integrator 2-47
Connect a Printer 2-49
Restrictor Information.. 2-50
Available Restrictors.. 2-50
Restrictors for Carrier Gas Control.. 2-50
Restrictors for Detector Gas Control.. 2-51

Preparing Your Lab

The items shown in the following checklist need to be considered when preparing the laboratory for the instrument.

- Environmental Conditions
- Exhaust Vent Requirements (if required)
- Laboratory Space Requirements
- Cooling Water Requirements (if required)
- Electrical Requirements
- Pneumatic Requirements (if required)

Preparing the Laboratory

The following sections describe the laboratory requirements in detail for the Clarus 500 GC.

Environmental Conditions

The laboratory in which the Clarus 500 GC is located must meet the following conditions:

- A corrosive-free environment.
- The instrument will operate with a laboratory temperature between 10 and 35 °C (50- 95 °F). For optimum instrument preformance, the room temperature should be controlled at 20° ± 2 °C.
- Dust levels above 36,000,000 particles, 0.5 microns or larger, per cubic meter of air. The environment should be relatively dust-free to avoid sample and instrument contamination problems.
- Free of excessive vibration.

The Clarus 500 GC has been designed for indoor use. Do not use the instrument in an area where explosion hazards may exist.

Exhaust Vent Requirements

Exhaust venting is important for the following reasons.

- It protects laboratory personnel from toxic vapors that may be produced by some samples.
- It helps to protect the instrument from corrosive vapors that may originate from the sample(s).
- It removes dissipated heat produced by the instrument and power supply.

WARNING

The use of Clarus 500 GC without adequate ventilation to outside air may constitute a health hazard.

NOTE: *Local electrical codes do not allow PerkinElmer Service Engineers to install the blower and vent assembly.*

The blower capacity depends on the duct length and number of elbows or bends used to install the system. If an excessively long duct system or a system with many bends is used, a stronger blower may be necessary to provide sufficient exhaust volume at the instrument.

Alternatively, smooth stainless-steel tubing should be used instead of flexible stainless steel tubing where flexibility is not required to reduce system friction loss or "drag." If smooth stainless steel is used, there must be a way to move the vent hood out of the way for servicing. A length of smooth stainless steel ducting has 20-30% less friction loss than a comparable length of flexible ducting. When smooth stainless steel tubing is used, elbows must be used to turn corners. These elbows should turn at a centerline radius of 150mm with a maximum bend angle of 45 degrees to reduce friction losses, and the number of elbows should be minimized.

Additional recommendations on the venting system include the following items.

- Make sure the duct casting is installed using fireproof construction. Route ducts away from sprinkler heads.
- The duct casing and venting system should be made of materials suitable for temperatures greater than 70 °C (158 °F). It should be installed to meet local building code requirements.
- Locate the blower as close to the discharge outlet as possible. All joints on the discharge side should be airtight, especially if toxic vapors are being carried.

- Equip the outlet end of the system with a back draft damper and take the necessary precautions to keep the exhaust outlet away from open windows or inlet vents. In addition, extend it above the roof of the building for proper dispersal of the exhaust.

- Equip the exhaust end of the system with an exhaust stack to improve the overall efficiency of the system.

- Make sure the length of the duct that enters into the blower is a straight length at least ten times the duct diameter. An elbow entrance into the blower inlet causes a loss in efficiency.

- Provide make-up air in the same quantity as is exhausted by the system. An "airtight" lab will cause an efficiency loss in the exhaust system.

- Ensure that the system is drawing properly by using an air flow meter.

- Equip the blower with a pilot light located near the instrument to indicate to the operator when the blower is on.

Clarus 500 GC Requirements

Laboratory Space Requirements:

Size	
GC:	66 cm (26 in.) wide x 40 cm (19 in.) high x 64 cm (25 in.) deep
Autosampler:	13 cm (5 in.) wide x 36 cm (14 in.) high x 24 cm (9.5 in.) deep
Weight	
GC:	49 kg (108 lb)
Autosampler:	4.5 kg (10 lb)
Physical Configuration:	Single unit for use on standard laboratory bench which can be interfaced to a computer and/or printer.
Bench Space:	The laboratory bench should be sturdy enough to support the full weight of the GC as well as additional equipment (i.e., computer and/or printer). Expect the total weight of the GC and accessory equipment to be at least 91 kg (200 lb). Allow a minimum clearance of 10.2 cm (4 in.) on each side, 15.2 cm (6 in.) at the rear of the GC, and

	137.2 cm (54 in.) at the top of the GC. If this is not possible, install the GC on a bench that has wheels.
Peripherals, Printers, etc.	Allow at least 61 cm (24 in.) on either side of the GC to accommodate additional equipment.

Environmental Requirements:

Pollution Degree:	This instrument will operate safely in environments that contain nonconductive foreign matter up to Pollution Degree 2 as defined in IEC 1010-1.
Laboratory Environment:	Install the GC in an indoor laboratory environment that is clean and is free of drafts, direct sunlight and vibration. The laboratory should be free of flammable, explosive, toxic, caustic, or corrosive vapors or gases and should be relatively free of dust. The ambient laboratory temperature should be between 10 °C and 35 °C (50 °F and 95 °F) with a relative humidity between 20% and 80% with no condensation. The GC will operate safely between 5 °C and 40 °C (41 °F and 104 °F).

Electrical Power Requirements:

Installation Category Statement:	This instrument is able to withstand transient over-voltage according to Installation Category II as defined in IEC 1010-1.
Power Consumption:	2 400 VA (volt-amps) for the GC. Add 100 VA for the computer and 108 VA for the printer.
Power Specification:	All electrical supplies must be smooth, clean, and free of line transients greater than 40 V peak to peak and must meet and remain within the following tolerances: 120 VAC ±10% @ 50/60 Hz ±1% 230 VAC ±10% @ 50/60 Hz ±1%

	Instruments and peripherals should not be connected to circuits with large inductive or large and frequent loads (i.e., large motors, discharge lamps, photocopy systems, radio transmitters, etc.).
Power Outlets:	A minimum of one dedicated 120 VAC outlet at 20 A or one 230 VAC outlet at 10 A (minimum) is required for the GC. Additional equipment, such as computers and printers, should be connected per their specifications.

Safety Requirements:

Gas Cylinders and Gas Delivery Lines:	All gas cylinders should be firmly clamped to a suitable surface. Care must be taken not to kink or overstress the gas delivery lines.
Hydrogen:	Ensure that all hydrogen lines and connections are leak-free. When using a hydrogen tank, install an in-line hydrogen snubber (P/N 0009-0038) between the tank regulator and the delivery tubing.
Ventilation:	Always provide adequate ventilation. When analyzing hazardous compounds, such as pesticides, it may be necessary to arrange for venting the detector effluent into a fume hood.

Gas Requirements:

All gases must have a minimum purity of 99.995%. Gases used with the mass spectrometer and ElCD detectors require a minimum purity of 99.999%. Gas cylinders should be located outside of the laboratory whenever possible and should always be stored and operated in the vertical position. Always use copper tubing that is free of grease, oil, and organic material for all gases delivered to the Clarus 500 GC.

Helium, Nitrogen, 8.5% H_2/91.5% Helium 95% Argon/5% Methane:	A number 1A (200 ft^3) gas cylinder should be used for all carrier gases. Filter all gases (except methane) through a moisture filter and/or hydrocarbon trap and de-oxo filter. Argon/methane should be filtered through a moisture filter and a de-oxo filter. Gas delivery pressure to the GC should be 60 – 90 psig (414-621 kPa).
Air:	A number 1A (200 ft^3) gas cylinder of compressed air or an air compressor can be used. All air should be filtered through a moisture filter. Do ***NOT*** use "Breathing Air." When using manual pneumatics, gas delivery pressure to the GC must not exceed 30 psi (207 kPa). If this is not possible, secondary regulation will be required. With PPC pneumatics, a delivery pressure range of 70 – 90 psig (483 - 621 kPa) is acceptable.
Hydrogen:	A number 2 (62 ft^3) gas cylinder or a hydrogen generator can be used. All hydrogen should be filtered through a moisture filter. When using manual pneumatics, gas delivery pressure to the GC must not exceed 30 psi (207 kPa). If this is not possible, secondary regulation will be required. With PPC pneumatics, a delivery pressure range of 60 – 90 (414-621 kPa) psig is acceptable.

Sample Preparation Requirements

Customer Responsibility

Pre-Installation Checklist

Model: ______________________________________ Date: ______________

Customer: ___________________________________

SPO# ____

Installation Requirements	**OK**	**Needs Prior to Installation**
Lab Space Requirements Instrument		
Lab Space Requirements Peripherals		
Environmental Requirements		
Power Requirements		
Safety Requirements		
Gas Requirements		
Sample Preparation (Customer Responsibility)		
Computer Configuration		
Miscellaneous		

Install the Autosampler

This section describes how to install the autosampler tower, the autosampler tower cover, and the autosampler syringe. The autosampler tower and the tower cover are shipped together in one box. The autosampler tray is installed in the Clarus 500 GC at the factory.

Remove the Encoder Protector Block

The Clarus 500 GC autosampler has been shipped with an encoder protector block. This is a piece of antistatic polyethylene foam that protects the tower disk during shipment. Before you install the autosampler tower onto your Clarus 500 GC, you *must* remove the encoder protector block from the tower disk assembly.

To remove the encoder protector block:

1. Carefully remove the autosampler tower from the shipping box.

2. The piece of foam on top of the tower is the encoder protector block. Carefully slide the block straight out from the tower disk.

CAUTION *Do not twist the block off. This will damage the tower disk.*

Install the Autosampler Tower

Perform the following procedure to install the autosampler tower:

1. The autosampler tower mounting hardware is shipped already secured to the Clarus 500 GC top. Remove the three screws and flat washers securing the mounting hardware and use them to secure the tower base to the Clarus 500 GC.

2. Position the tower interface harness through the autosampler stop, which is part of the tower base. The harness should be fitted carefully into the hole in the autosampler base assembly (see Note below).

NOTE: *You may find it easier to feed the wires a few at a time. The two yellow tie wraps on this harness indicate the portion of the harness that needs to be fed to the tower. Only one yellow tie wrap should be visible at the autosampler stop.*

3. Install the autosampler tower on the top of the Clarus 500 GC as shown in Figure 2-1. The locating pin on the Clarus 500 GC fits into the slotted hole in the autosampler tower base.

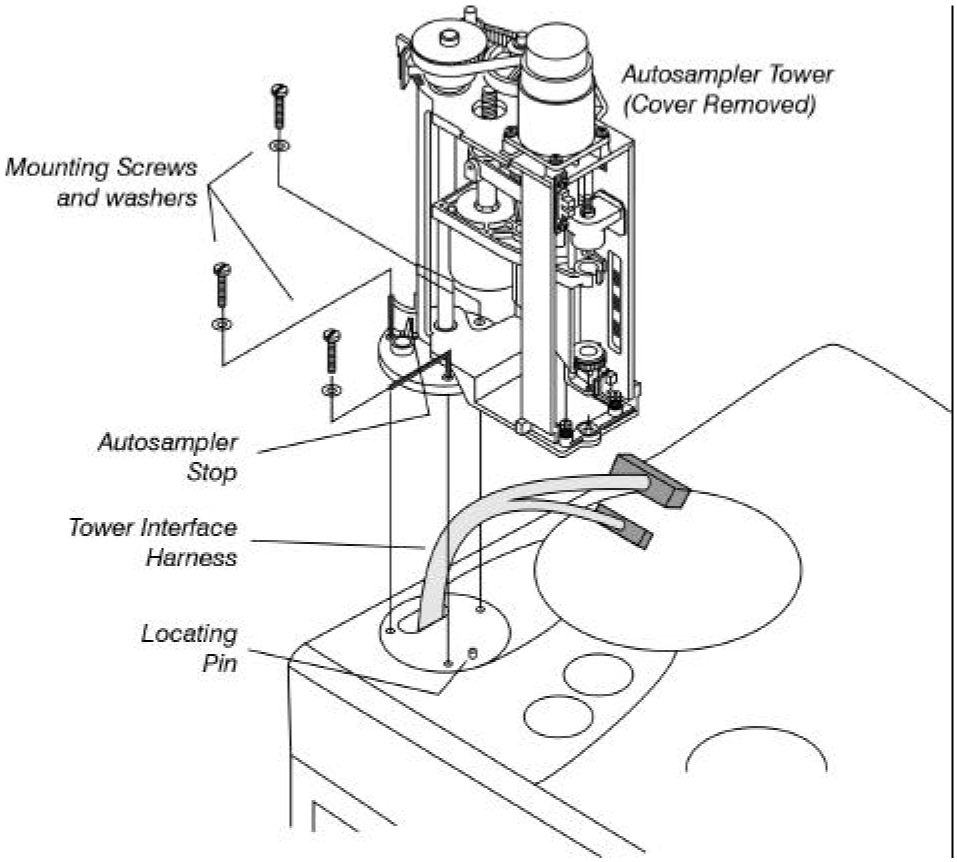


Figure 2- 1 Installing the autosampler tower.

4. Connect the two harness connectors to the tower interface P.C. board. Plug the large connector into J2 and the small connector into J1 (see Figure 2- 2).

These connectors are keyed and connect only one way.

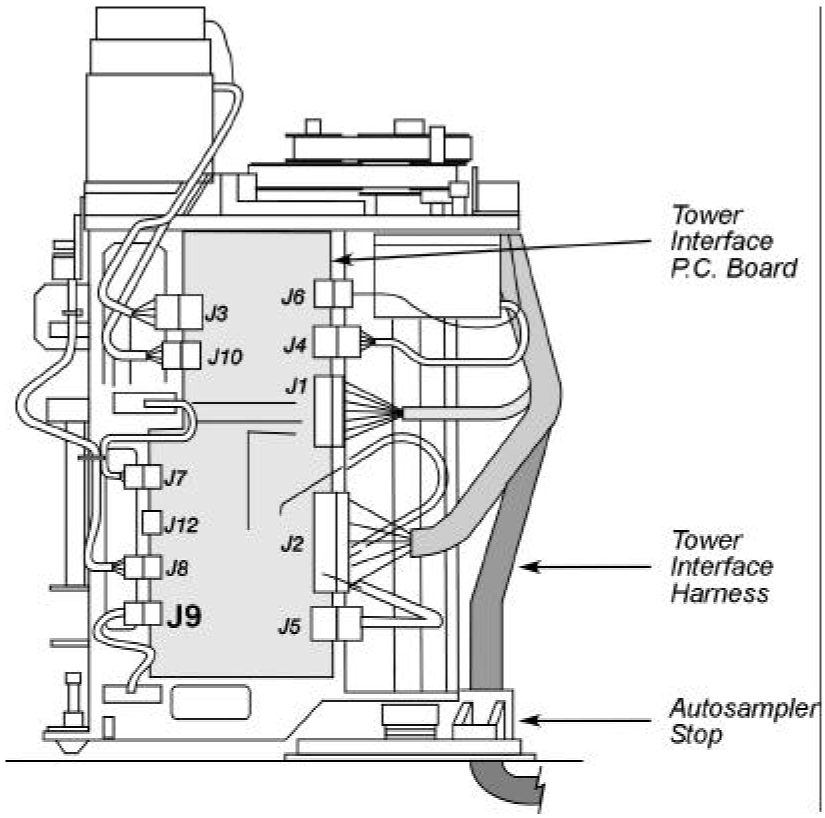


Figure 2- 2 Connecting the tower interface harness to the tower interface p.c. board.

5. Manually rotate the autosampler tower so that the front of the tower (this is where the syringe will be installed) faces the rear of the Clarus 500 GC.

6. Secure the harness to the autosampler tower frame using the cable clamp attached to the harness. Attach the cable clamp and the harness ground wire to the underside of the casting as shown in Figure 3, using the screw provided. Make sure the harness is routed correctly before you tighten the screw, or you may have difficulty installing the autosampler tower cover.

NOTE: *There are two holes in the autosampler tower frame casting in the area to which the cable clamp should be secured. Secure the harness cable clamp and ground wire to the inner-most hole.*

7. The screw is already attached to the casting. Use a long Phillips screwdriver to remove the screw, then attach the cable clamp.

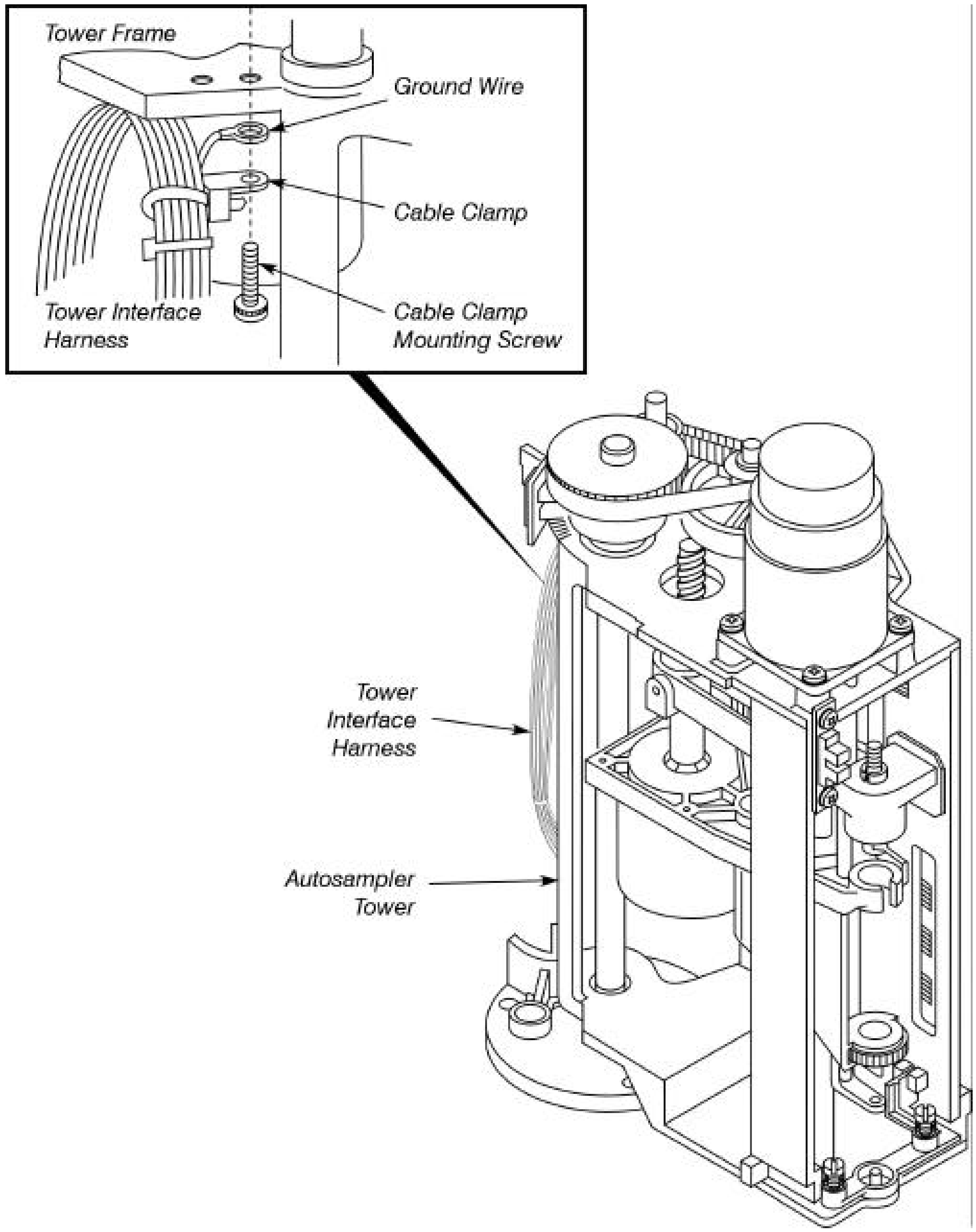


Figure 2- 3 Securing the harness to the tower.

Install the Autosampler Tower Cover

Install the autosampler tower cover by referring to Figures 2-4 and 2-5 as you follow this procedure:

1. The tower is shipped with two 3/8-in. long screws installed on the bottom of the tower frame. Loosen but do not remove these screws.
2. Open the cover door and carefully lower the cover onto the tower, aligning the two guides inside the cover with the sides of the tower (see Figure 2-5).

3. Pull the sides of the cover away from the tower frame just enough to slide the cover tabs onto the two screws.
4. Tighten the two screws. Verify that the cover door opens and closes freely and that it locks when closed. If not, realign the cover until the door locks when closed.

NOTE: *If the door is hitting the door sensor, loosen the two screws that secure the door sensor bracket to the tower, then adjust the sensor up or down until the door no longer hits the sensor (see Figure 2-4).*

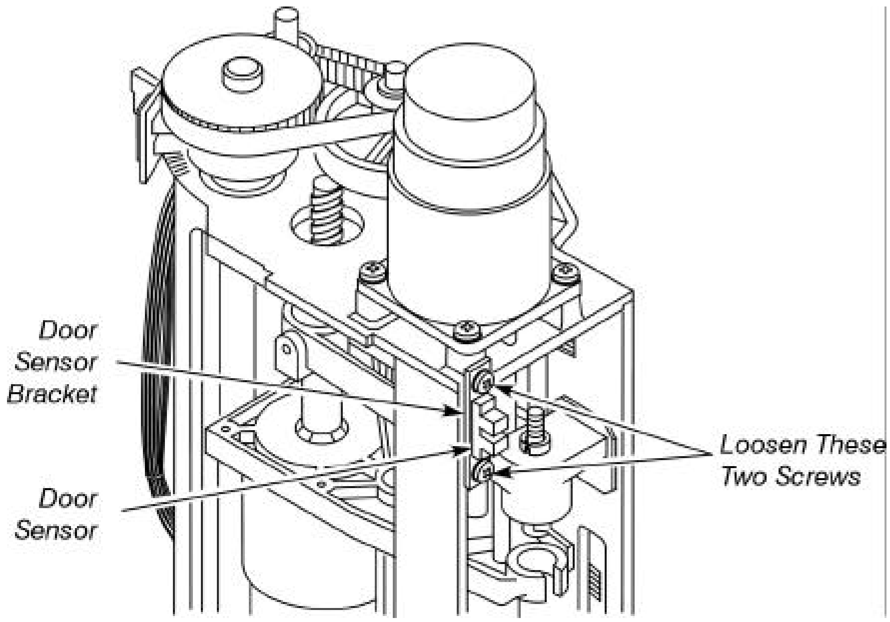


Figure 2- 4 Adjusting the position of the tower door sensor.

Figure 2- 5, on the following page, shows how to install the autosampler tower cover onto the tower.

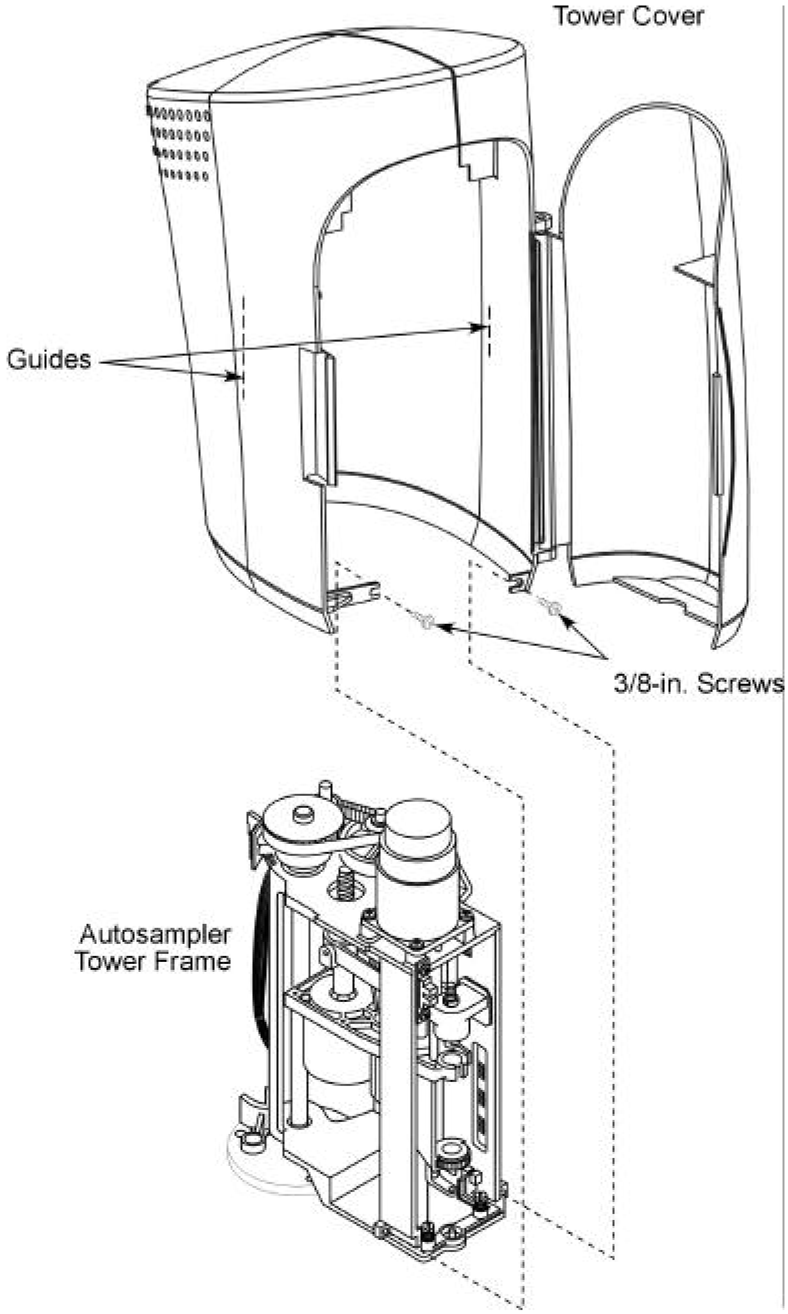


Figure 2- 5 Installing the autosampler tower cover.

Install the Syringe Cover

To install the syringe, proceed as follows:

1. Before you install the syringe, move the autosampler tower so it faces the front of the instrument; by selecting the “Park" position from the autosampler menu (see Figure 2-6).

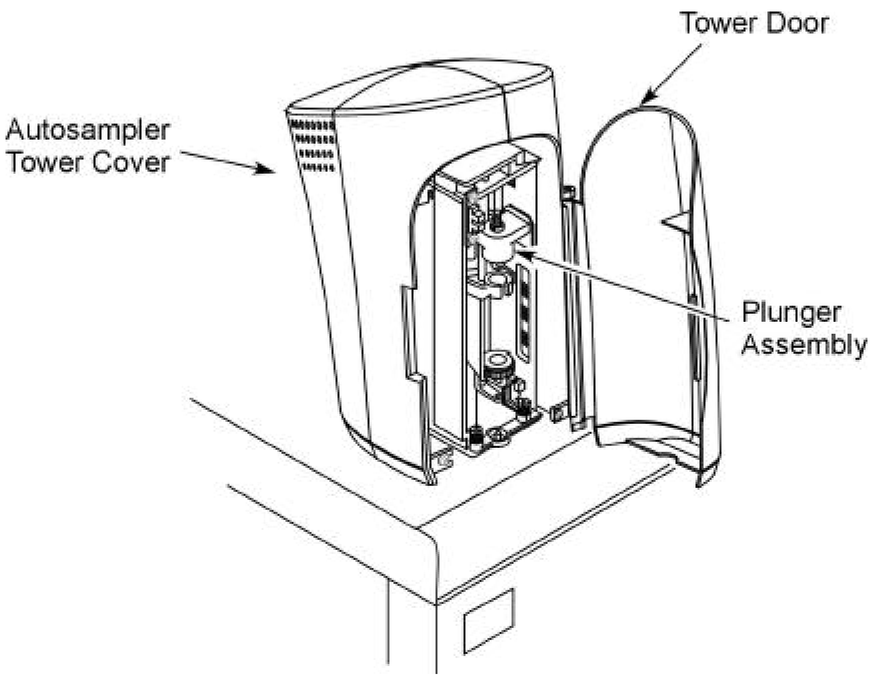


Figure 2- 6 The autosampler tower in the “Park” position.

CAUTION	*Always handle the syringe with extreme care. Be careful not to bend the needle. Before installing the syringe, pull some solvent up into the barrel to moisten the mechanism.*

NOTE: *Use only syringes sold by PerkinElmer for the Clarus 500 GC. Syringe plungers are not interchangeable from one syringe to another.*

2. Lift and turn the plunger cap handle (located on top of the plunger assembly) until the pin locks it in the up position as shown in Figure 2- 7.

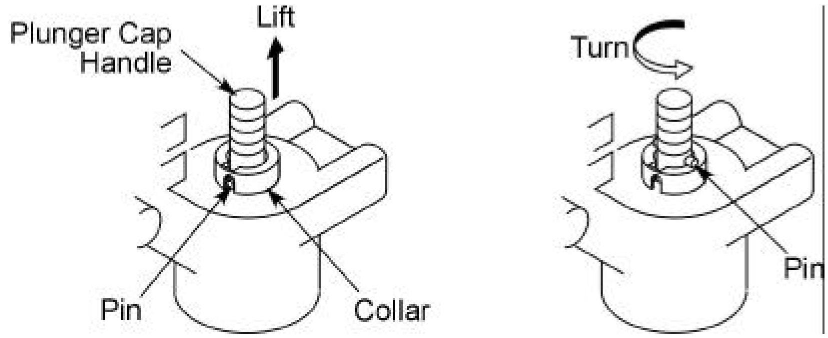


Figure 2- 7 Lifting and turning the plunger cap handle.

3. Insert the syringe needle through the bottom of the carriage assembly and use your finger to carefully guide the needle through the hole in the needle guide (see Figure 2-8).

CAUTION	*Be careful not to bend the needle when inserting it into the hole in the needle guide.*

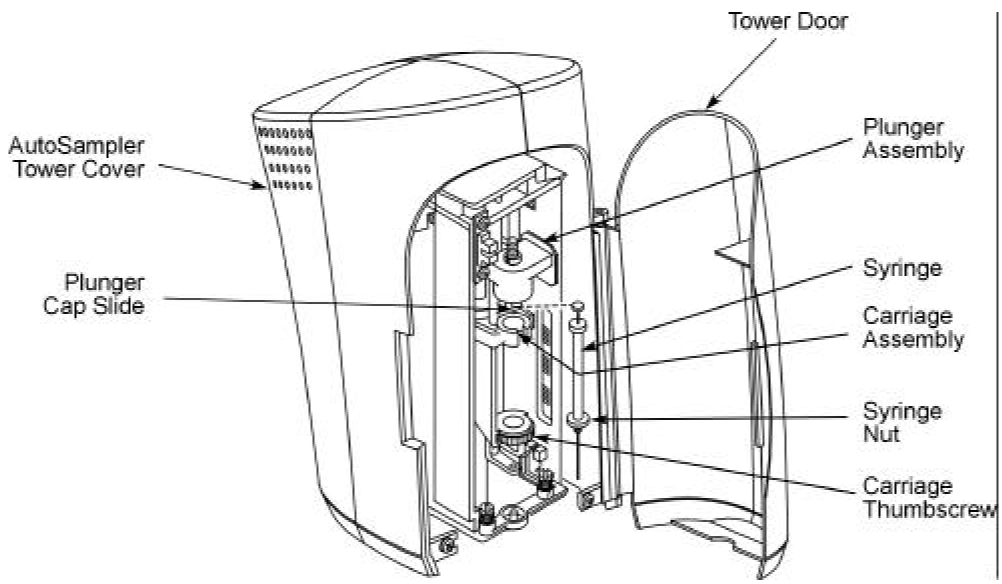


Figure 2- 8 Installing the syringe.

4. Slide the top of the syringe plunger into the plunger cap slide, then lift and turn the plunger cap handle so the pin drops down into place. This will lock the syringe plunger into place.
5. Hold the syringe nut with one thumb and, with your other thumb, turn the carriage thumbscrew counterclockwise to tighten it (see Figure 2- 8). ***DO NOT OVERTIGHTEN THE THUMBSCREW***.
6. Carefully guide the needle into the needle locator in the center of the vial locator as you tighten the thumbscrew (see Figure 2- 1).

Your autosampler is now installed.

Connecting the Gases and Electrical Supply

The following sections describe how to connect the gas cylinders to the Clarus 500 GC and how to check the connections for leaks. Use the fittings and copper tubing supplied in the installation kit (P/N 0332-8000).

Gas Cylinder Connections

Use the following procedure to make the gas cylinder connections:

1. Using a large adjustable wrench (at least 1¼ in.), attach a dual-stage regulator, or two single-stage regulators in series, to each gas cylinder. The regulator outlet fitting must be a 1/8-in. Swagelok type.

CAUTION	*The following applies to MANUAL PNEUMATICS configurations ONLY:* 1. *Dual-stage regulation is required with the Clarus 500 GC. It permits steady gas delivery at high or low flows and provides precise control of gas pressure throughout the discharge of virtually the entire contents of a compressed gas cylinder. (It is not necessary for PPC units.)* 2. *If your Clarus 500 GC is equipped with a TCD and you are operating more than one GC from the same carrier gas tank, and/or operating the TCD at high sensitivity, install an additional single-stage regulator (0 – 90 psig) before you install the gas to the TCD.* 3. *If your Clarus 500 GC is equipped with an ECD, you can control the flow of make-up gas by installing an additional 30-psig single-stage regulator before the ECD needle valve.(See Note)* 4. *If your Clarus 500 GC is equipped with a NPD, we recommend installing a toggle valve in the hydrogen line that enters the Clarus 500 GC. This allows you to turn off the hydrogen when the NPD is not in use without changing the regulator setting on the Clarus 500 GC.* *If your Clarus 500 GC is equipped with a FPD, we recommend installing a toggle valve in the air line that enters the Clarus 500 GC. This allows you to turn off the air when the FPD is not in use without changing the regulator setting on the Clarus 500 GC.*

2. Connect a 1/4-in. to 1/8-in. adapter to the regulator outlet fitting on all your gas cylinders except the hydrogen cylinder.
3. Insert a hydrogen snubber (P/N 0009-0038) in the hydrogen cylinder regulator outlet fitting as shown in Figure 2- 9. Use a 1/4-in. to 1/8-in. reducer (P/N 0990-3212) between the snubber and the regulator.

NOTE: *PerkinElmer offers a fixed 30-psig stainless steel diaphragm regulator (P/N N610-1473) for use with manual pneumatics configurations. This provides a second stage of regulation between the tank and the needle valves on the manual pneumatics version Clarus 500 GC.*

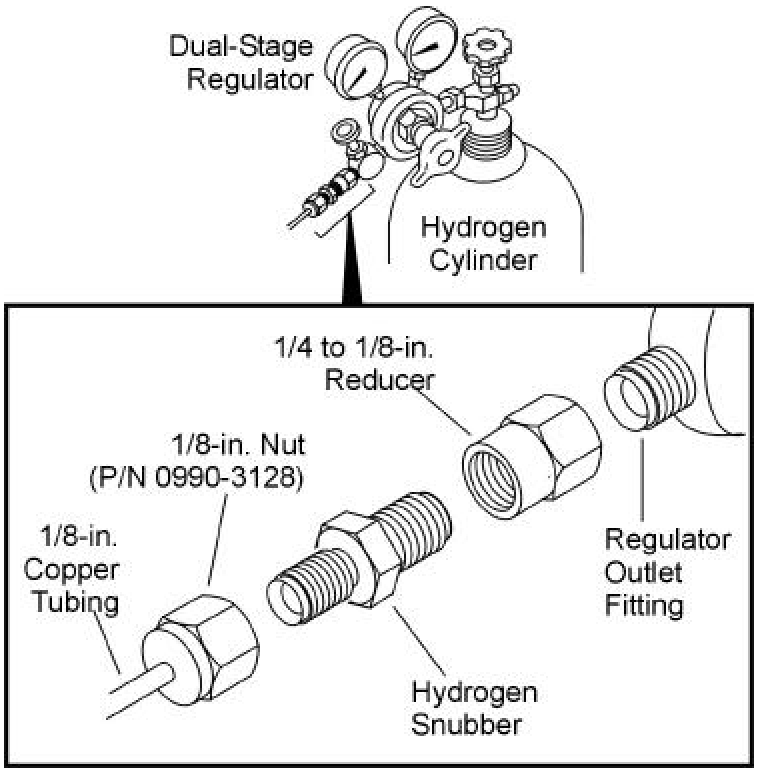


Figure 2- 9 Connecting a hydrogen snubber.

4. Cut a length of 1/8-in. copper tubing long enough to connect a line filter to each gas supply line or gas cylinder.
5. Place a 1/8-in. nut, a 1/8-in. rear ferrule, and a 1/8-in. front ferrule over each end of the copper tubing as shown in Figure 2-10.

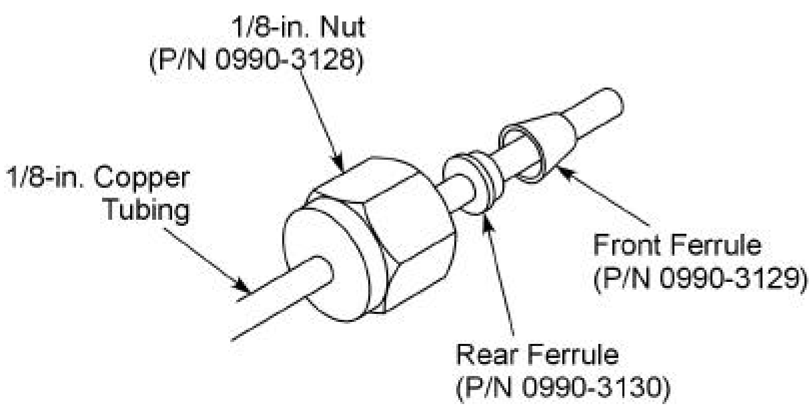


Figure 2- 10 Components of a 1/8-in. tubing connection.

6. Insert one end of the tubing with the nut and ferrules into the end fitting of a suitable line filter (see Table 2- 1), and insert the other end into the regulator outlet fitting or the end fitting of the hydrogen snubber.

7. Insert the tubing into the fitting so that the tubing bottoms firmly, then tighten the nut ½-turn past finger-tight.
8. Cut a piece of 1/8-in. copper tubing long enough to connect the filter to the Clarus 500 GC. To allow for future instrument movement, cut the tubing 2 – 3 ft longer than necessary.

Table 2- 1 Recommended Filters*

Detectors	**Carrier Gas**	**Combustion Gas** H_2	**Air**
FID NPD FPD	Hydrocarbon Trap (N930-1192) + Oxygen Filter (N930-1179) if capillary column is used	Moisture Filter (i.e., Molecular Sieve) (N930-1193)	Moisture Filter (i.e., Molecular Sieve) (N930-1193)
TCD**	Hydrocarbon Trap (N930-1192) + Oxygen Filter (N930-1179) if capillary column is used		
ECD**	Moisture Filter (i.e., Molecular Sieve) (N930-1193) + Oxygen Filter (N930-1179)		
PID	Hydrocarbon Trap (N930-1192) + Oxygen Filter (N930-1179) if capillary column is used		
ElCD#	Hydrocarbon Trap (N930-1192) + Oxygen Filter (N930-1179) if capillary column is used	Molecular Sieve (N930-1193) + Charcoal (N930-1192)	

* There is a combination filter system that contains an Oxygen Filter, Oxygen Indicator, and a Moisture Trap. Its Part No. is N930-6002.

** Install a tee fitting on the carrier gas line for the TCD reference line or for the make-up line for the ECD.

99.999%-purity helium and hydrogen must be used with the ElCD.
Stainless-steel diaphragm regulators must be used with the ElCD (hydrogen regulator P/N 0990-7128, helium regulator P/N 0990-7127).

Clarus 500 GC Gas Connections

Perform the following procedure to connect the gases to the Clarus 500 GC:

CAUTION	*Do **NOT** connect any gases to the manual pneumatics bulkhead if there is a PPC module installed for any channel. In this case, the manual pneumatics bulkhead is NOT connected on the inside of the Clarus 500 GC. Therefore, if a gas line is connected to the manual pneumatics bulkhead, the gas would flow into the Clarus 500 GC itself. This must especially be avoided with the hydrogen gas.*

1. Make a tubing strain relief by forming an approximate 3-in. diameter loop in the tubing so that it is approximately 3 in. from the end of the tubing closest to the Clarus 500 GC as shown in Figure 2-11. Make this strain relief on all gas lines.

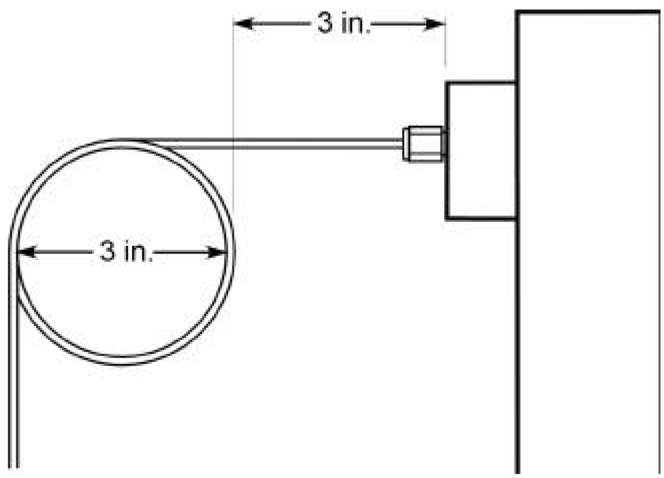


Figure 2- 11 Tubing strain-relief loop.

2. Insert a 1/8-in. nut, a 1/8-in. rear ferrule, and a 1/8-in. front ferrule over the end of each piece of copper tubing as shown in Figure 2-10.

3. Insert the tubing into the proper fitting on the Clarus 500 GC bulkhead for the gas that you are connecting. Be sure the tubing bottoms out firmly in the fitting, then tighten the nut ½-turn past finger-tight.

Figure 2- 12 shows the manual pneumatics bulkhead and PPC bulkheads on the back of the Clarus 500 GC. M/U = make-up gas, CARR. = carrier gas, and HYD and H2 = hydrogen gas.

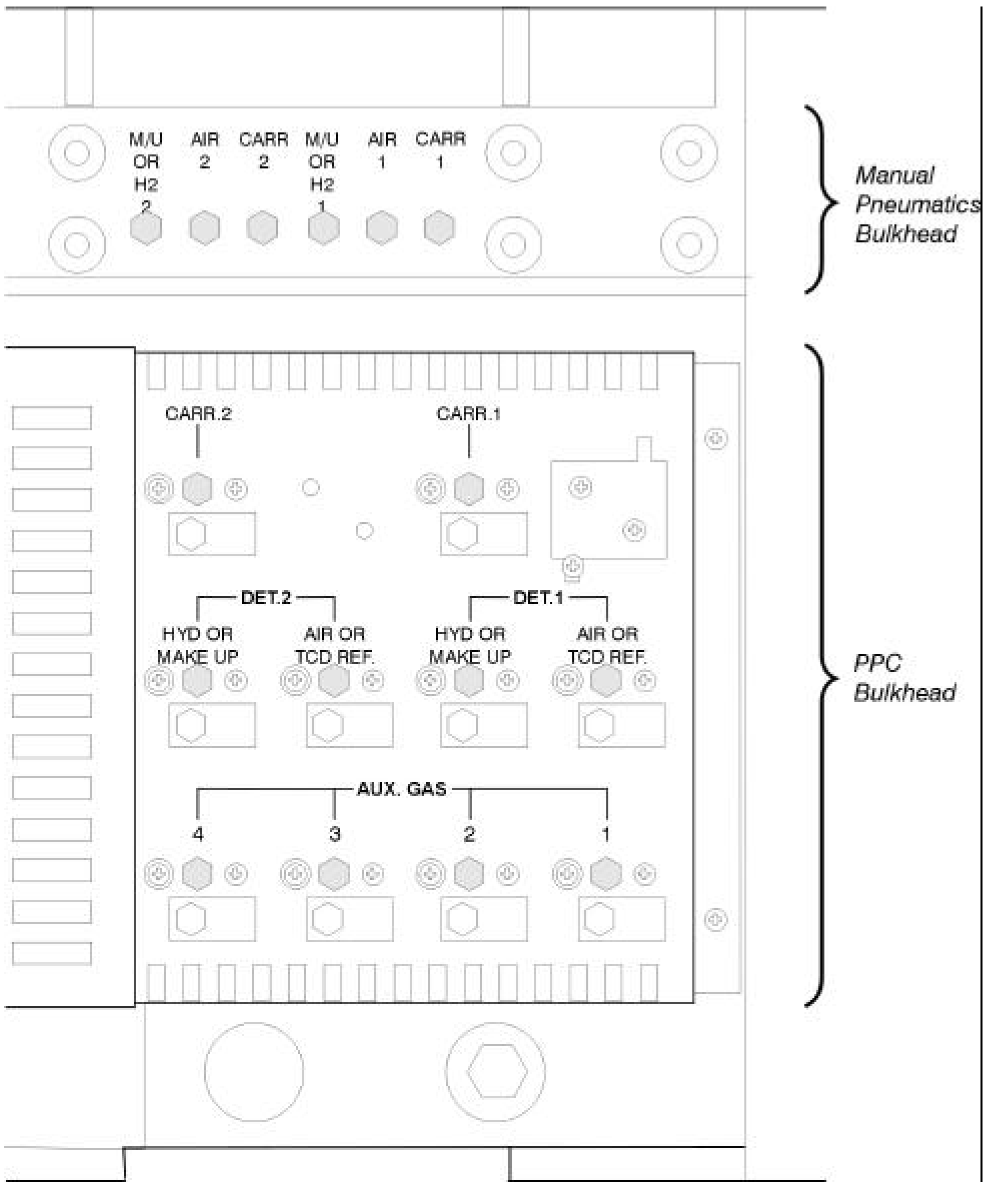


Figure 2- 12 Location of the Clarus 500 GC bulkheads on the rear panel.

Leak Test the Gas Connections

After connecting the gases to the Clarus 500 GC, check all connections for possible leaks by following this procedure:

1. Set the regulator on the carrier gas cylinder between 60 and 90 psig.

2. Test the carrier gas connections by using either a gas leak-check solution of 50% isopropyl alcohol in water or an electronic leak detector. Check for leaks (indicated by bubbles) at each connection.

CAUTION *Do **not** use a soap solution to check for gas leaks. It could contaminate the system.*

3. To check a hydrogen or air cylinder for leaks, set the regulator to 30 psig for manual pneumatics and for PPC systems between 60 and 90 psig for H_2 and between 70 and 90 psig for air; test the connections in the same manner that you tested the carrier gas connections.

Common Injector/Detector Gas Connections

Figures 13 through 21 shows how gases are connected to the Clarus 500 GC in several common injector/detector configurations. Note that the strain relief, which is required on all gas lines, is not shown in these figures.

WARNING *Position incoming gas lines away from the oven exhaust duct so that the hot exhaust will not blow directly on the gas lines.*

CAUTION *Thoroughly purge the incoming gas lines before measuring and adjusting the gases. This is especially important when using hydrogen gas.*

NOTE: *For Clarus 500 GC's that have a combination of both PPC and manual pneumatics, set the detector gas delivery pressure between 60 and 90 psig and install the fixed 30-psig stainless steel diaphragm regulator (P/N N610-1473), behind the Clarus 500 GC for the manual pneumatics detector gases.*

The manual pneumatics bulkhead always contains Swagelok nuts in all six locations whether or not there is an injector or a detector connected to this bulkhead. The PPC modules will be installed only if your Clarus 500 GC has been configured with PPC for an injector and/or detector.

The Clarus 500 GC can be configured as any of the following:

- All zones (injector/detector) as PPC.
- All zones as manual pneumatics.

- A combination of PPC and manual pneumatics.
  For example, the injectors could be controlled by PPC and the detectors could be controlled by manual pneumatics.

The following nine figures show the connections for the injectors and detectors to either the PPC or the manual pneumatics bulkheads. The connections for a PPC system are indicated by solid lines and the connections for manual pneumatics are indicated by dashed lines.

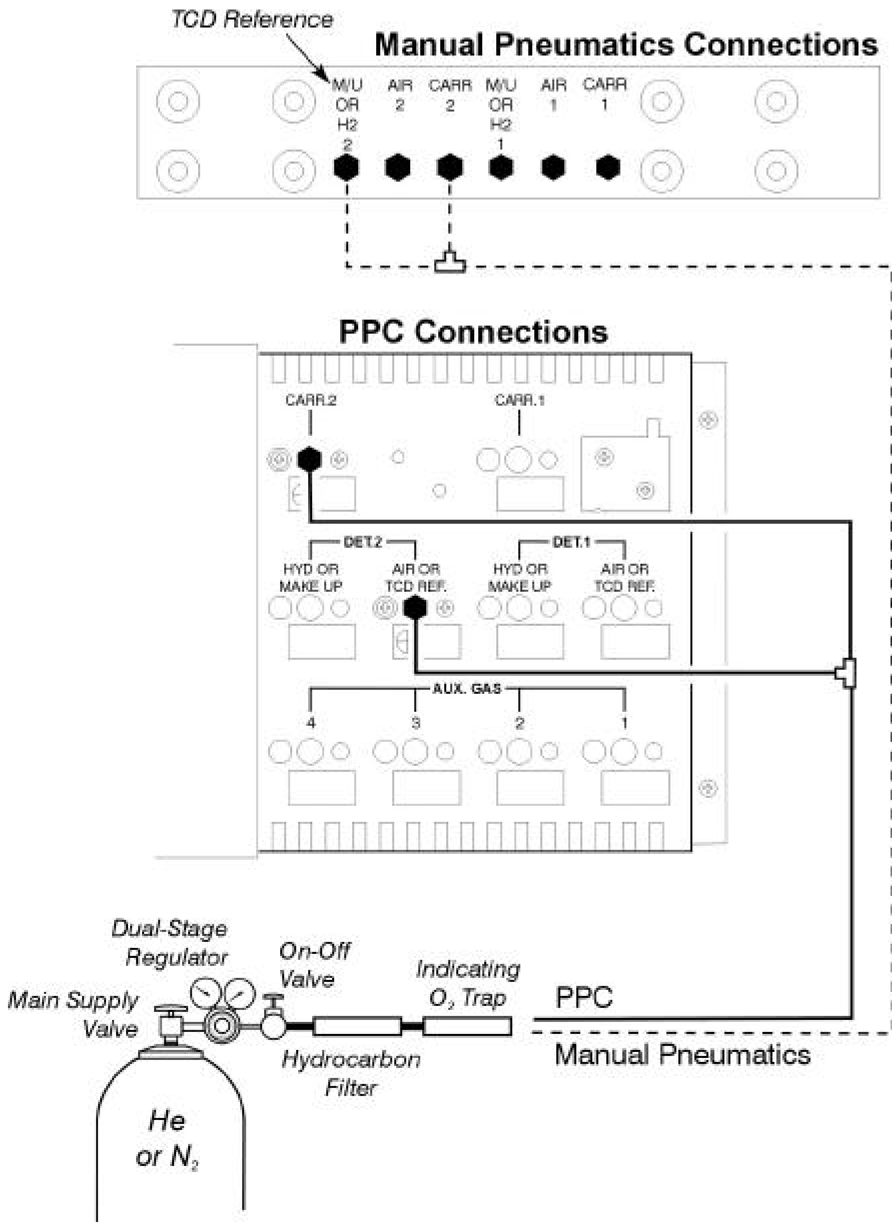


Figure 2- 13 TCD in Channel 2 (rear channel) with one packed injector.

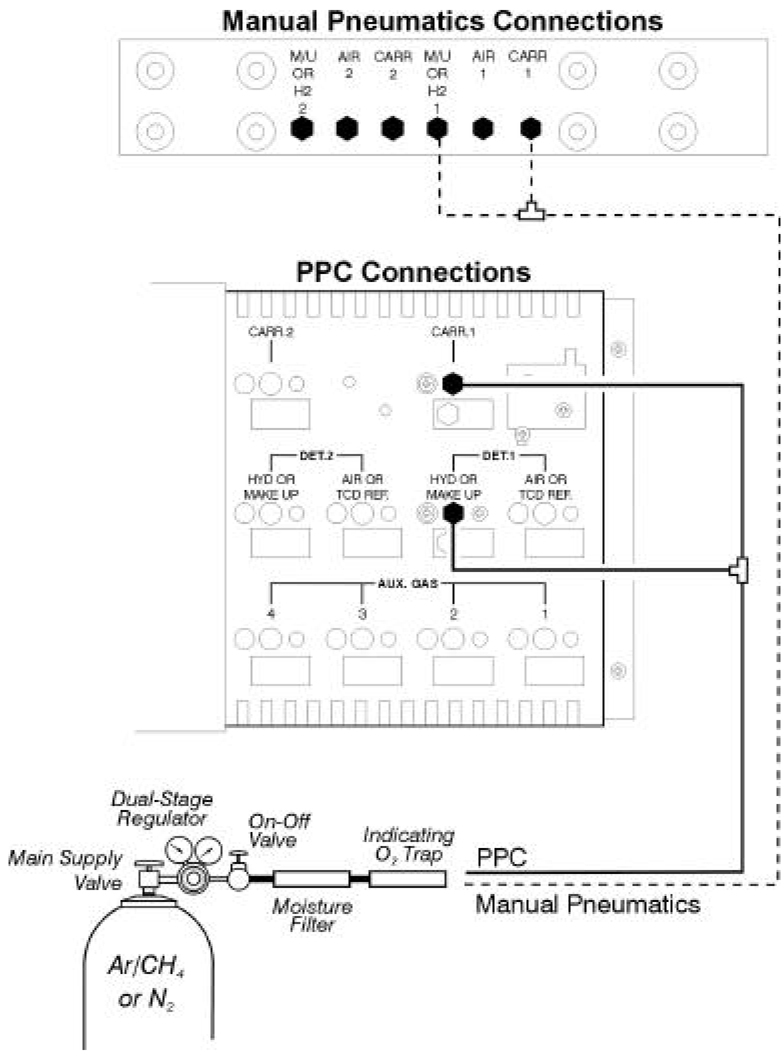


Figure 2- 14 ECD in Channel 1 (front channel) using argon/methane or nitrogen as the carrier gas, with one injector.

NOTE: *If you are using the ECD with a capillary column at low flows (5 mL/min or less), you can plumb the injector with helium and the make-up line with argon/methane or nitrogen. Helium is the preferred carrier for capillary columns.*

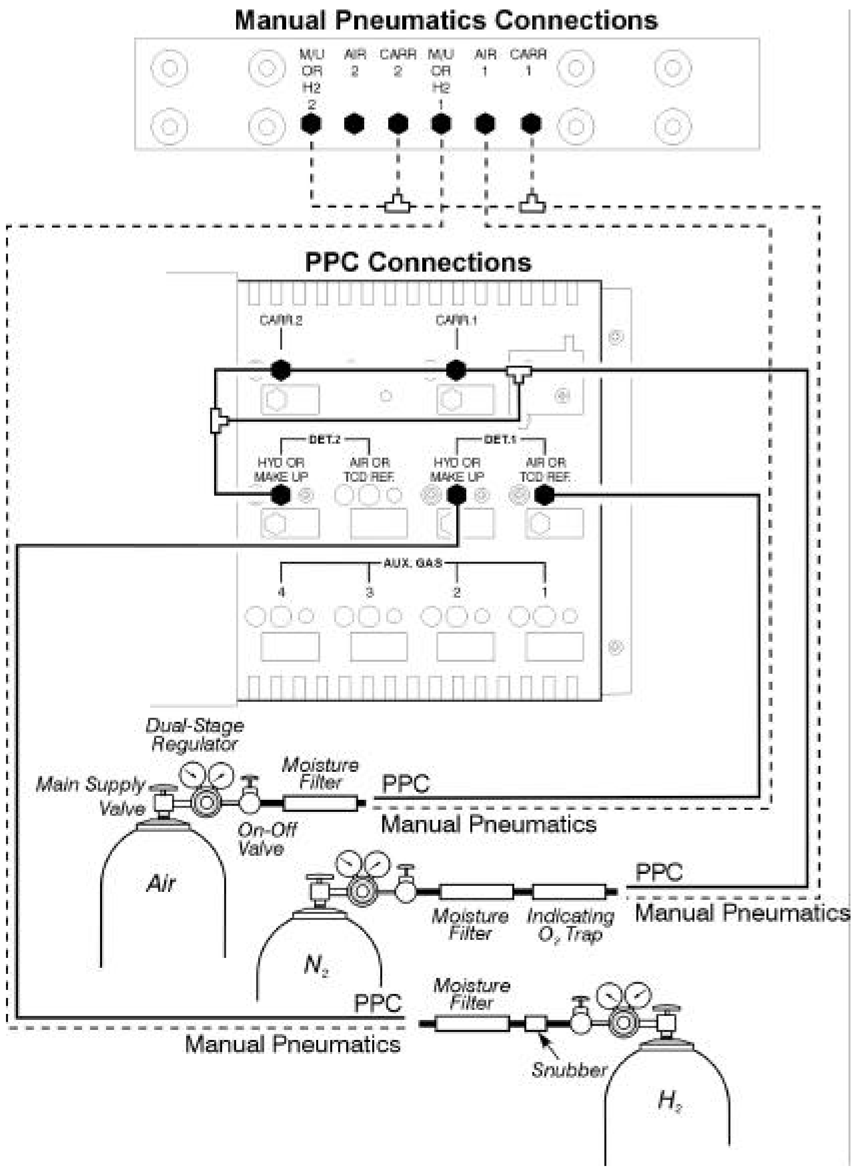


Figure 2- 15 FID, NPD, or FPD in Channel 1 and ECD in Channel 2 using nitrogen as the carrier gas, with two injectors.

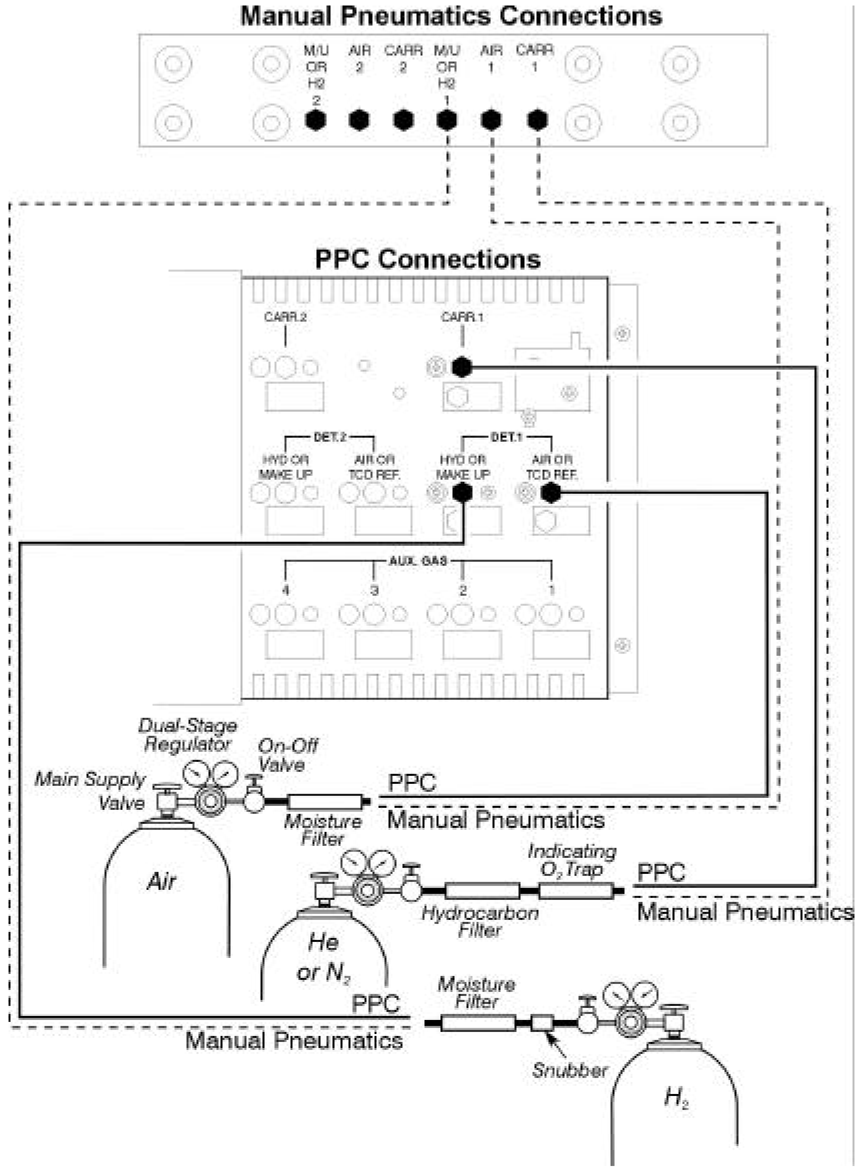


Figure 2- 16 FID, NPD, or FPD in Channel 1 using helium or nitrogen as the carrier gas, with one injector.

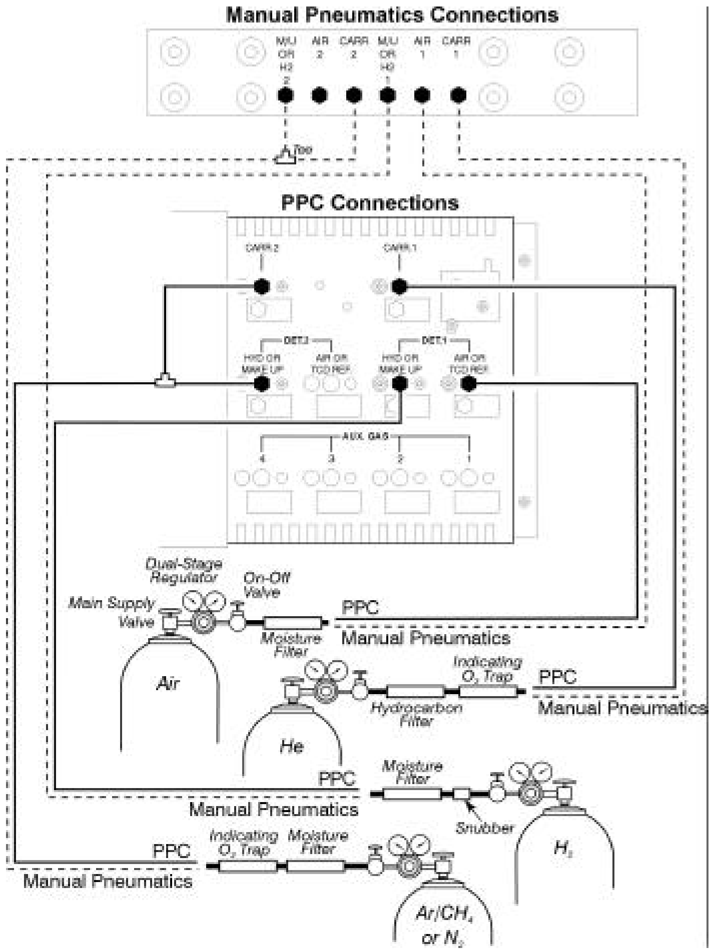


Figure 2- 17 FID, NPD, or FPD in Channel 1 using helium carrier gas, ECD in Channel 2 using argon/methane or nitrogen carrier gas, with two injectors.

NOTE: *If you are using the ECD with a capillary column at low flows (5 mL/min or less), you can plumb the injector with helium and the make-up line with argon/methane or nitrogen. Helium is the preferred carrier gas for capillary columns. The FID, NPD, and FPD do not require make-up gas.*

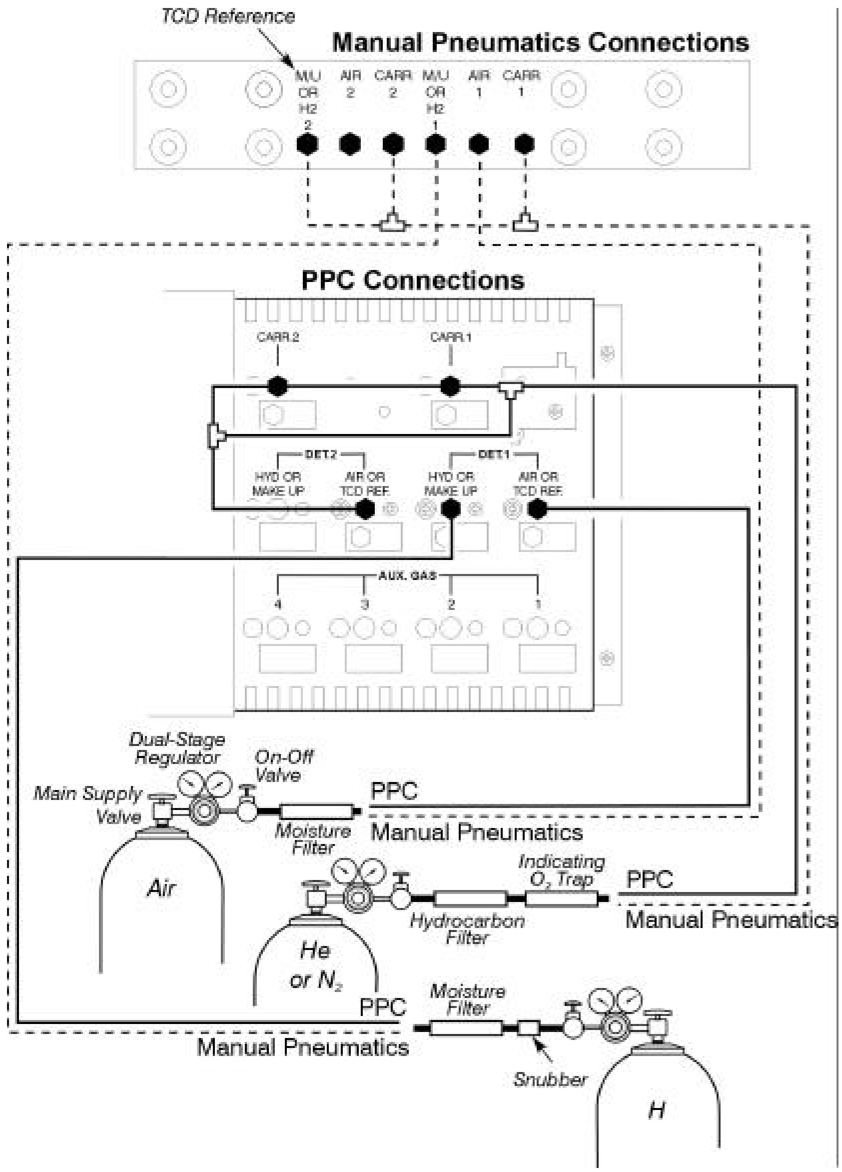


Figure 2- 18 FID, NPD, or FPD in Channel 1, TCD in Channel 2, with two packed injectors.

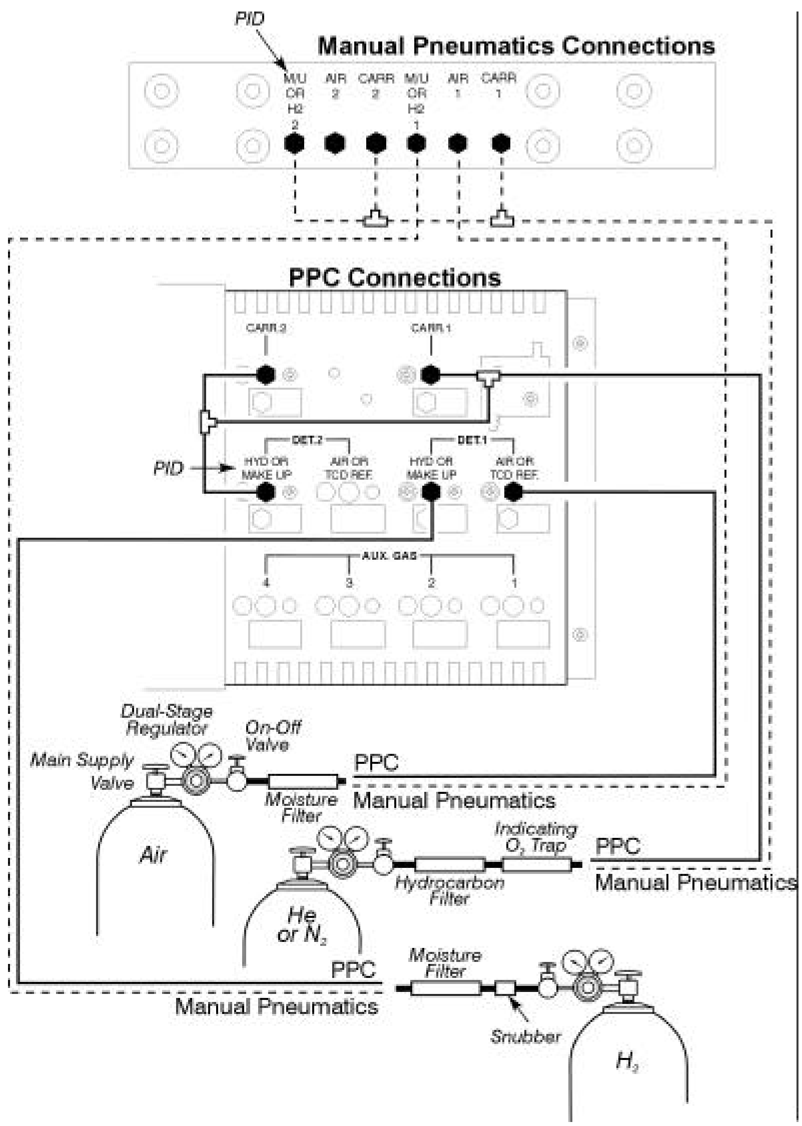


Figure 2- 19 FID, NPD, or FPD in Channel 1, PID in Channel 2, with two packed injectors.

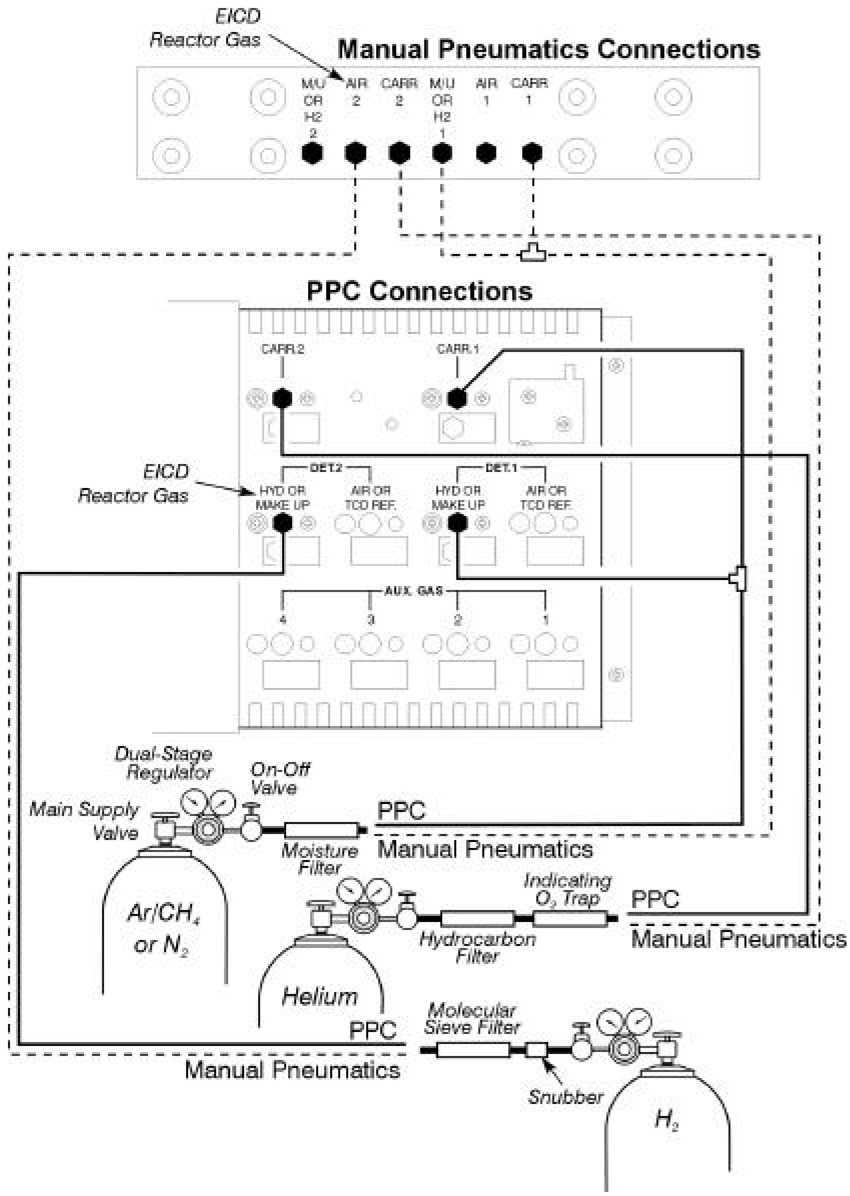


Figure 2- 20 ECD in Channel 1, ElCD in Channel 2, with two packed injectors.

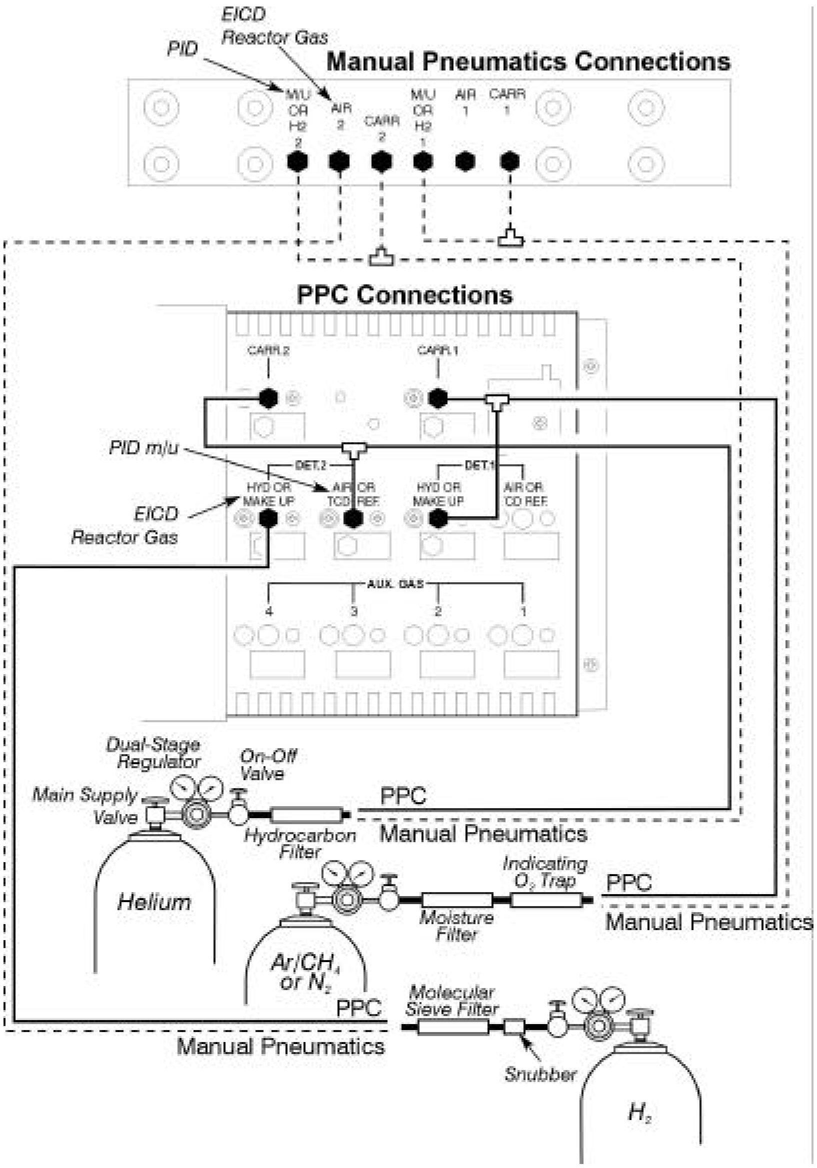


Figure 2- 21 ECD in Channel 1, PID/ElCD in Channel 2, with two packed injectors.

Connecting the Gas for Subambient Operation

This section describes how to connect a liquid nitrogen or liquid carbon dioxide supply to your Clarus 500 GC for subambient operation.

For liquid nitrogen, use a supply with a liquid delivery pressure of 20 – 30 psig. For liquid carbon dioxide, use a size 1A cylinder equipped with a fitting containing a full-length dip (eductor) tube and approximately 27.3 kg (60 lb) of carbon dioxide.

The LN_2 or CO_2 supply tubing connects the supply tank to the 1/4-in. union on the rear of the Clarus 500 GC. To install the supply tubing, select the procedure that corresponds to the subambient kit you are installing and refer to Figure 2- 22.

Connect the LN_2 Supply Tubing

1. Locate the LN_2 tank. Make sure the tank provides a liquid delivery pressure of 20 – 30 psig.

2. Connect the large nut on one end of the LN_2 supply tubing (P/N N600-0403) to the 1/2-in. pipe to 1/4-in. Swagelok reducer labeled "LIQUID"
on the LN_2 tank by turning the nut clockwise until it is finger-tight. To provide a leak-free connection, tighten the nut an additional half-turn with a large adjustable wrench.

3. Connect the 1/4-in. nut on the other end of the tubing to the 1/4-in. union (see Figure 2- 22) on the rear of the Clarus 500 GC by turning the nut clockwise until it is finger-tight. To provide a leak-free connection, place a 9/16-in. wrench on the nut and a 1/2-in. wrench on the union, then tighten the nut an additional half-turn.

4. Turn on the valve and check for leaks.

Connect the CO_2 Supply Tubing

WARNING

Protect the CO_2 supply from undue heating. CO_2 is a gas above 31°C (87.8°F) at a pressure of 1069 psig. The pressure increases rapidly at temperatures above 31°C (87.8°F).

1. Locate a size 1A CO_2 cylinder equipped with a fitting containing a full-length dip (eductor) tube and approximately 27.3 kg (60 lb) of carbon dioxide.

2. Connected to the CO_2 supply tubing (P/N N600-0404) is an envelope containing a Teflon gasket. This goes inside the nut on the tubing before attaching it to the tank. Connect the large nut on one end of the CO_2 supply tubing to the CO_2 tank fitting by turning the nut clockwise until it is finger-tight. To provide a leak-free connection, tighten the nut an additional half-turn with a large adjustable wrench.

3. Connect the 1/4-in. nut on the other end of the tubing to the 1/4-in. union on the rear of the Clarus 500 GC by turning the nut clockwise until it is finger-tight. To provide a leak-free connection, place a 9/16-in. wrench on the nut and a 1/2-in. wrench on the bulkhead fitting, then tighten the nut an addition half-turn.

WARNING

The CO_2 supply system contains liquid CO_2 pressurized at 6000 kPa (870 psig) at 20°C (68°F). Before breaking connections to change cylinders, shut off the liquid CO_2 cylinder valve, then bleed the supply tubing by closing the oven door and adjusting the oven temperature below 60°C (140°F). This opens the coolant solenoid valve and allows the CO_2 supply tubing to bleed.

4. Turn on the valve and check for leaks.

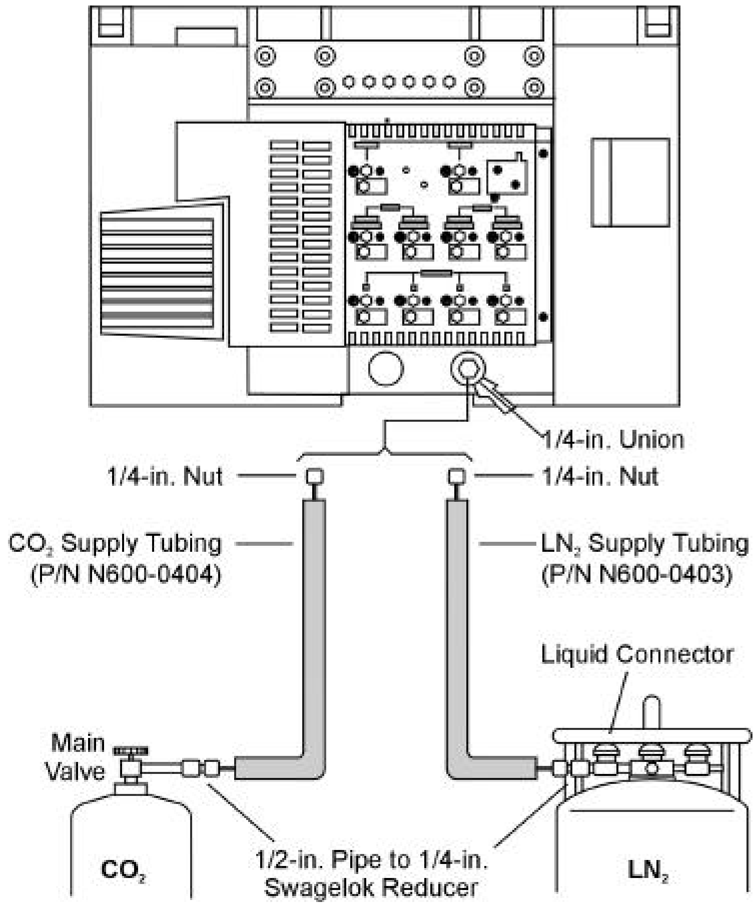


Figure 2- 22 Connecting the CO_2 or LN_2 supply.

Connect the Electrical Supply

This section describes how to connect the Clarus 500 GC to AC line power both in and outside the U.S.

WARNING

Only a PerkinElmer Service representative or similarly trained and authorized personnel should ever change or replace the plug for the Clarus 500 GC.

Connecting the Clarus 500 GC to Line Power in the U.S.

To connect the Clarus 500 GC to line power in the U.S., simply plug the power cord into the proper AC outlet (see the following table).

Connecting the Clarus 500 GC to Line Power Outside the U.S.

To connect the Clarus 500 GC to line power outside the U.S., connect a properly grounded plug to the power cord and change the wiring on the AC Distribution P.C. board as described in the following procedures.

Table 2-2 shows the available plugs, their electrical power, and the countries where they are used.

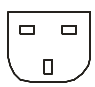
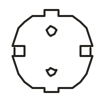
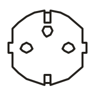
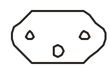
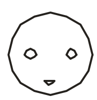
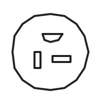
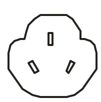
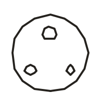
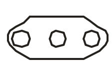
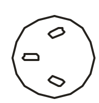
 13A, 250V Two-Pole with Earth Contact for use in Great Britain, Ireland, and Hong Kong	 10/16A, 250V Two-Pole with Earth Contact for use in Austria, Germany, Netherlands, Norway, Portugal, and Sweden
 10/16A, 250V Two-Pole with Dual Earth Contacts for use in Austria, Belgium, France, Germany, Netherlands, Norway, Portugal, Spain, Sweden, and Finland	 10A, 250V Two-Pole with Earth Contact for use in Switzerland
 10A, 250V Two-Pole with Earth Contact for use in Denmark	 20A, 120V for use in the United States
 10A, 250V Two-Pole with Earth Contact for use in Australia, New Zealand, New Guinea, and China	 10A, 250V Single Phase for use in South Africa, India, and Hong Kong
 10A, 250V/AC for use in Italy and North Africa	 10A, 250V for use in Israel

Table 2-2 Plugs Used in Different Countries

In Countries with 230V Single-Phase Power

WARNING

Only a PerkinElmer Service representative or similarly trained and authorized personnel should ever change or replace the plug for the Clarus 500 GC.

1. Select the appropriate plug and connect it to the three power cord wires as follows:

- Connect the brown wire to line (AC).
- Connect the blue wire to neutral (ACC).
- Connect the green/yellow wire to chassis ground.

2. Remove the three screws that secure the right side panel to the Clarus 500 GC. Then remove the panel.
3. Verify that the brown wire from the line filter is connected to E1, that the blue wire from the line filter is connected to E2, and that the yellow/green wire is connected to E3 on the AC Distribution P.C. board (see Figure 23).
4. Make sure that a 10-A Slow-Blow fuse is installed in the F3 fuse holder and a wire is soldered across the contacts of the F3 fuse holder to short this connection.
5. Replace the right side panel and connect the power cord to a suitable electrical outlet.

In Countries with 230V Two-Phase Power

> **WARNING**
>
> ***Only a PerkinElmer Service representative or similarly trained and authorized personnel should ever change or replace the plug for the Clarus 500 GC.***

1. Select the appropriate plug and connect it to the three power cord wires as follows:
   - Connect the brown wire to line (AC Hot).
   - Connect the blue wire to line (AC Hot).
   - Connect the green/yellow wire to chassis ground.
2. Remove the three screws that secure the right side panel to the Clarus 500 GC and remove the panel.
3. Verify that the brown wire from the line filter is connected to E1, that the blue wire from the line filter is connected to E2, and that the green/yellow wire is connected to E3 on the AC Distribution P.C. board (see Figure 2- 23).
4. Cut and remove the wire that is used as a jumper across the F3 fuse holder. Make sure that the 10-A Slow-Blow fuse remains installed in the F3 fuse holder.
5. Replace the right side panel and connect the power cord to a suitable electrical outlet.

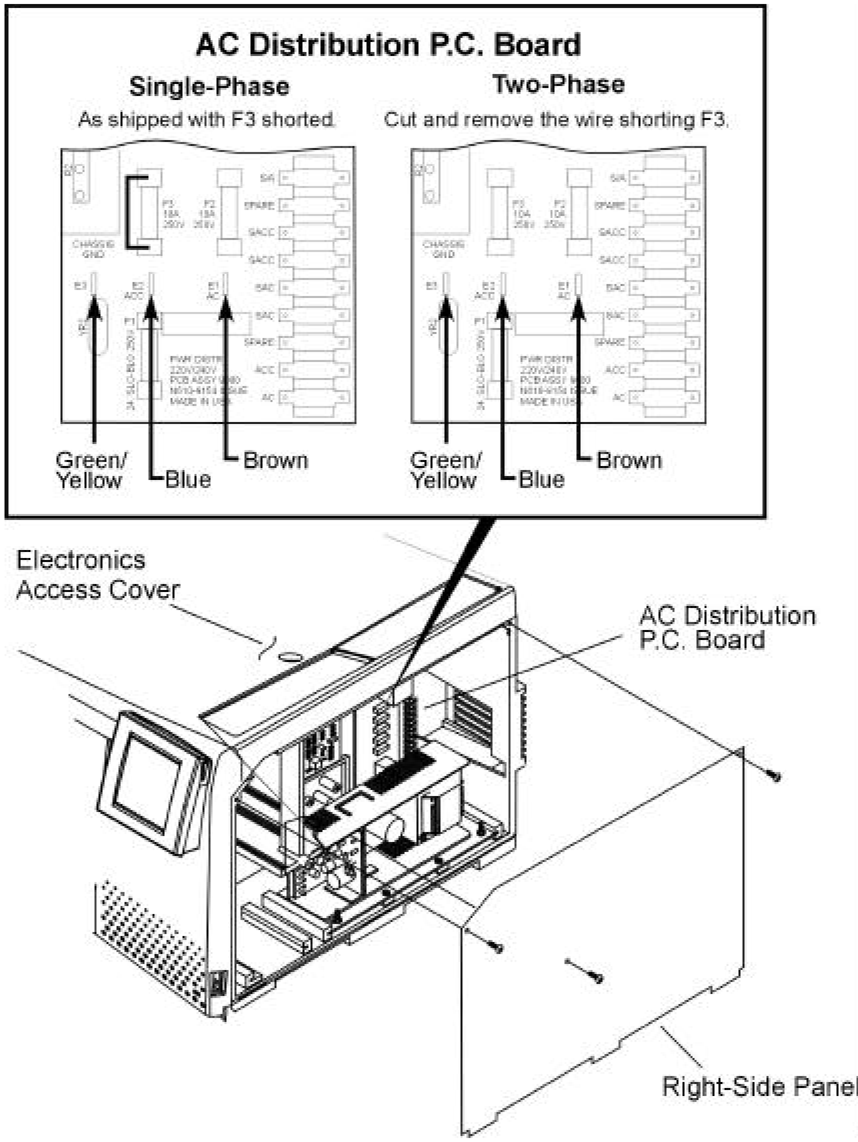


Figure 2- 23 AC Distribution P.C. board connections for countries that use single-phase or two-phase power.

Connect the Accessories

Connect the EICD

If you ordered your Clarus 500 GC with either an EICD (also called a Hall detector) or an EICD in series with a photoionization detector (PID), you must perform the following procedures:

- Connect the EICD Control Unit to the EICD Components
- Connect the EICD solvent system
- Make the EICD/PID series connection
- Check the calibration
- If necessary, convert the EICD Control Unit line voltage setting to 230-V operation. Refer to the procedure described in the *Tremetrics Instruction Manual* that is shipped with the Control Unit.

WARNING	*Never operate the Control Unit at an incorrect voltage setting.*

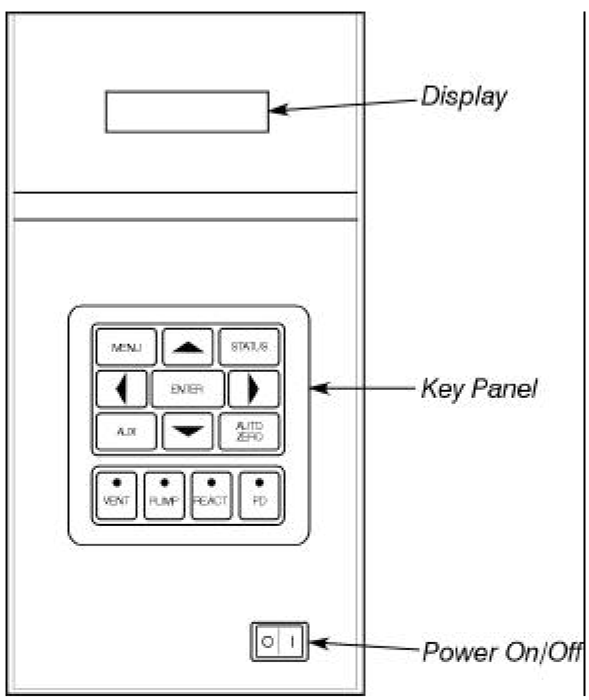


Figure 2- 24 ElCD Control Unit front panel.

Connect the ElCD Control Unit to the ElCD Components

To connect the ElCD Control Unit to the ElCD components, refer to Figure 2- 25 and follow this procedure:

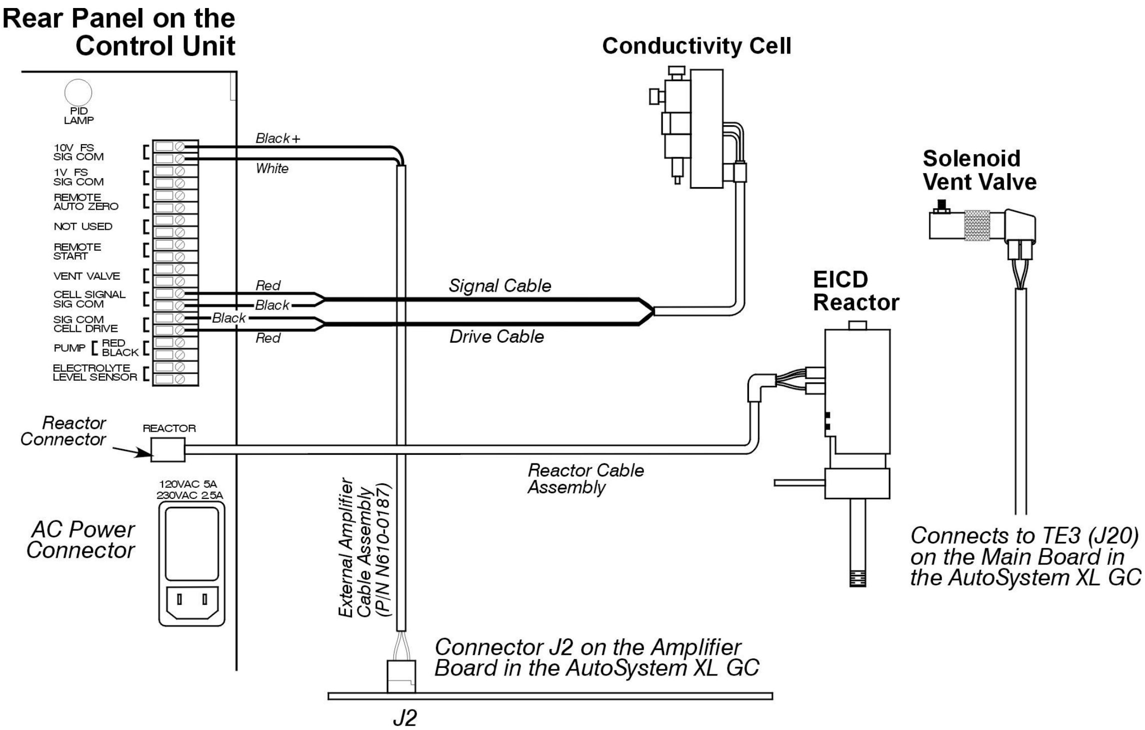


Figure 2- 25 Connection diagram of the ElCD Control Unit to ElCD components.

1. Plug the connector on the end of the Reactor Cable Assembly into the ElCD's Reactor Connector on the rear panel of the Control Unit.
2. Connect the Conductivity Cell Drive Cable and the Signal Cable to the following connectors on the Control Unit rear panel:
   - Connect the Drive Cable red lead to CELL DRIVE and the black lead to SIG COM.
   - Connect the Signal Cable red lead to CELL SIGNAL and the black lead to SIG COM.
3. If you are installing an ElCD amplifier board (P/N N612-0060) in the Clarus 500 GC, locate the External Amplifier Cable Assembly
   (P/N N610-0187) supplied with the amplifier kit.
4. Connect one end of the External Amplifier Cable Assembly to connector J2 on the ElCD amplifier board that is installed in the Clarus 500 GC, and at the other end of the cable connect the red lead to 10V FS and the black lead to SIG COM on the Control Unit rear panel (top two connectors).
5. Connect the solenoid vent valve cable to TE3 (J20) on the main board in the Clarus 500 GC electronics compartment behind the right side panel.
6. Secure all cables in the existing cable clamps.

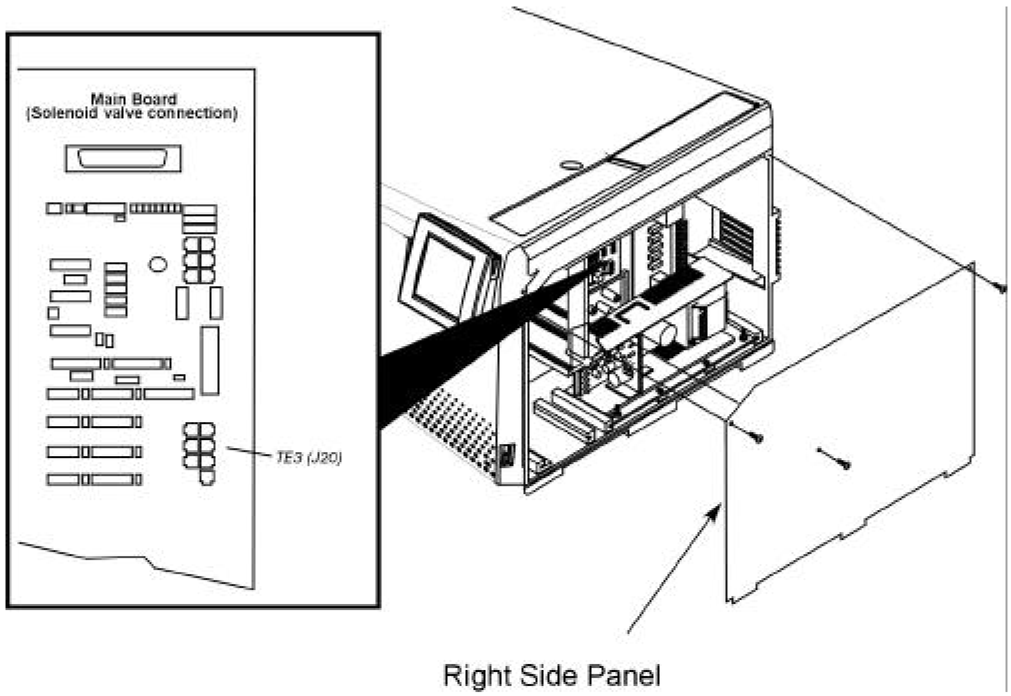


Figure 2- 26. ElCD solenoid valve connection to TE3 on the Main Board in the Clarus 500 GC.

Connect the ElCD Solvent System

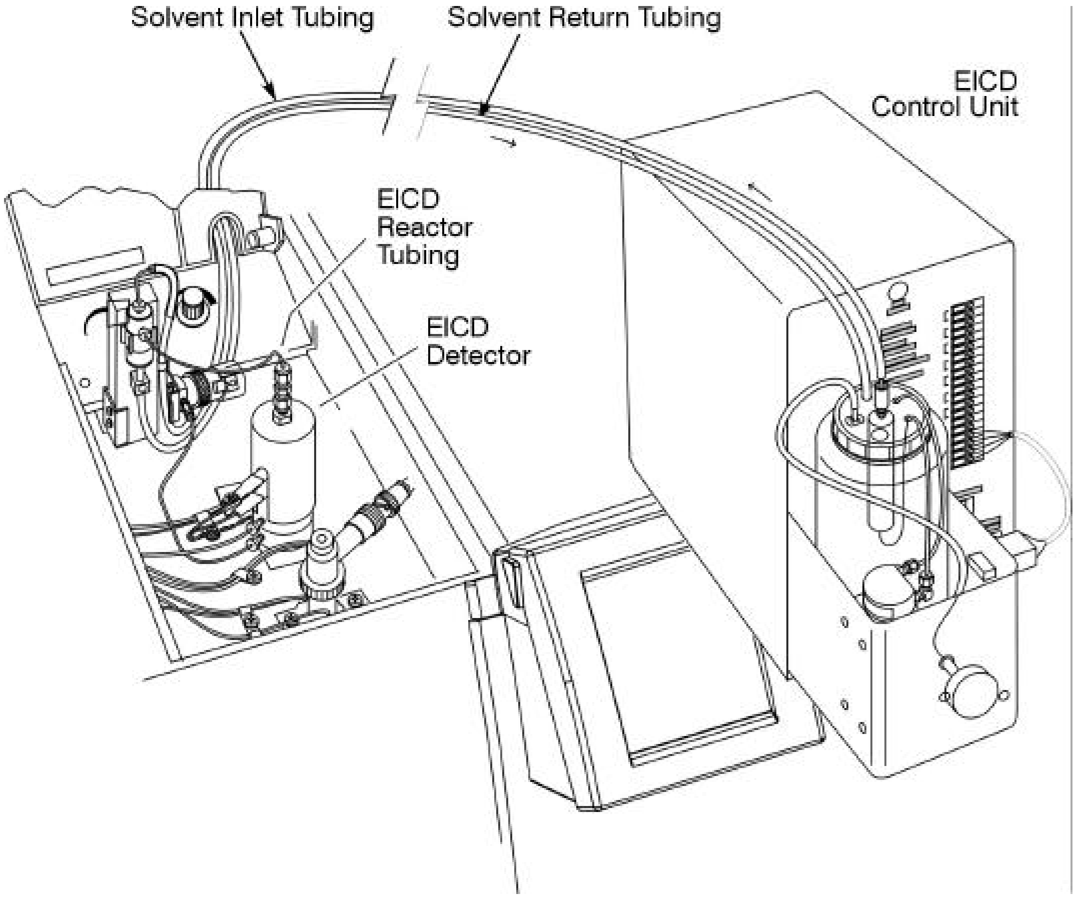


Figure 2- 27 Connecting the ElCD solvent system.

To connect the ElCD solvent system, refer to Figure 2- 27 and Figure 2- 28 then follow the procedure below. The lines have been connected to the detector assembly at the Clarus 500 in the factory. These lines have been dressed to the back of the unit.

1. At the back of the ElCD Control Unit, connect the output of the pump (the elbow fitting on the left side of the pump) to the top of the ion exchange tube. The ion exchange tube is inside the solvent reservoir.

2. Connect the solvent reservoir to the fitting on the right side of the pump.

3. Connect the top of the ElCD reactor tube to the Conductivity Cell.

4. Place the drain tubing from the bottom of the Conductivity Cell into the solvent reservoir.

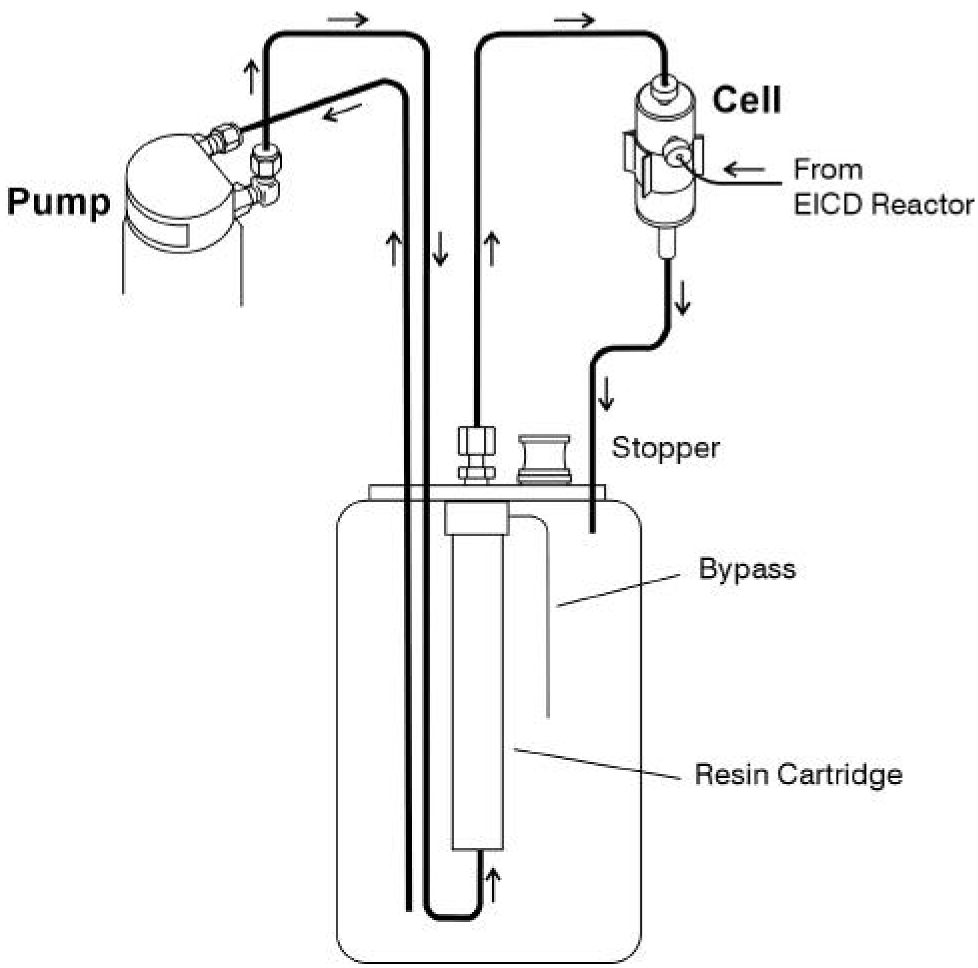


Figure 2- 28 Solvent Delivery System Connections

Make the ElCD/PID Series Connection

Use the following procedure to make the ElCD/PID series connection. After you make this connection, you can operate either the ElCD or the PID without any loss of sensitivity.

NOTE: *Always connect the analytical column to the PID, and the PID exit tube to the ElCD.*

1. Cut a length of the supplied deactivated 0.53-mm. I.D. fused silica tubing (P/N N930-1358) long enough to connect the PID exit line to the ElCD. Try to use the shortest possible length (approximately 12 inches).

2. Insert a 1/16-in. column nut and a 1/16-in. graphite/Vespel ferrule (P/N 0992-0301) over one end of the cut fused-silica tubing. Make sure the tapered end of the ferrule faces the nut as shown below.

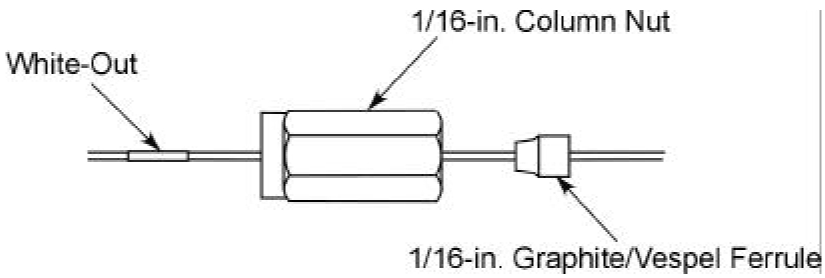


Figure 2- 29 Placing a 1/16-in. nut and graphite ferrule over the fused silica line.

3. Cut about 1 cm (3/8 inch) from the end of the fused-silica tubing using a wafer scribe (P/N N930-1386, pkg. of 10 scribes) or other column cutting tool. Break off the tubing at the score mark and make sure that the break is clean and square. Examine the cut with a magnifying glass and compare it to the examples below.

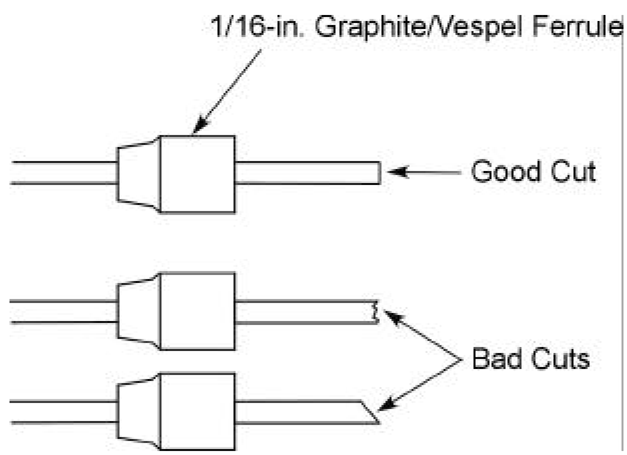


Figure 2- 30 Examples of a good tubing cut and bad cuts.

4. Position the nut on the fused-silica tubing so that the back of the nut is 8.8 cm (3 1/2 inches) from the end of the fused-silica tubing. This positions the fused-silica tubing inside the EICD receiver.

5. Using typewriter "white-out" or a felt-tipped pen, make a mark on the fused-silica tubing just beyond the back edge of the nut.

CAUTION	*To avoid contaminating the system, make sure the nut does not come into contact with the mark on the fused-silica tubing.*

6. Connect the fused-silica tubing to the ElCD fitting inside the oven as follows:

   a) Insert this end of the fused-silica tubing into the ElCD fitting. Slide the nut up to the ElCD and turn it until it is fingertight.

b) Push the fused-silica tubing into the ElCD fitting until the mark on the tubing is aligned with the back of the nut.

c) Using two 1/4-inch wrenches, tighten the nut only until the fused-silica tubing cannot be pulled out of the ElCD fitting. ***Do not overtighten the nut!***

7. Connect the other end of the fused-silica tubing to the PID exit tubing as follows:

   a) Insert the nut on one end of the 1/16 to 1/16-in. union (P/N 0990-3075) over the PID exit tube until it bottoms. Using two wrenches, tighten the nut 1/4 turn past fingertight.

   b) Remove the nut and metal ferrule from the other end of the 1/16 to 1/16-in. union. Put the metal ferrule aside; you will not need it.

   c) Insert the nut and a 1/16-inch graphite/Vespel ferrule (P/N 0992-0301) over the free end of the fused-silica tubing.

   d) Insert the end of the fused-silica tubing into the union until it bottoms. Slide the nut up to the union and tighten it fingertight.

   e) Using two 1/4-in. wrenches, tighten the nut only until the fused-silica tubing cannot be pulled out of the ElCD fitting. ***Do not overtighten the nut!***

You can operate the ElCD and the PID in series or operate either detector independently. Always connect your analytical column to the PID.

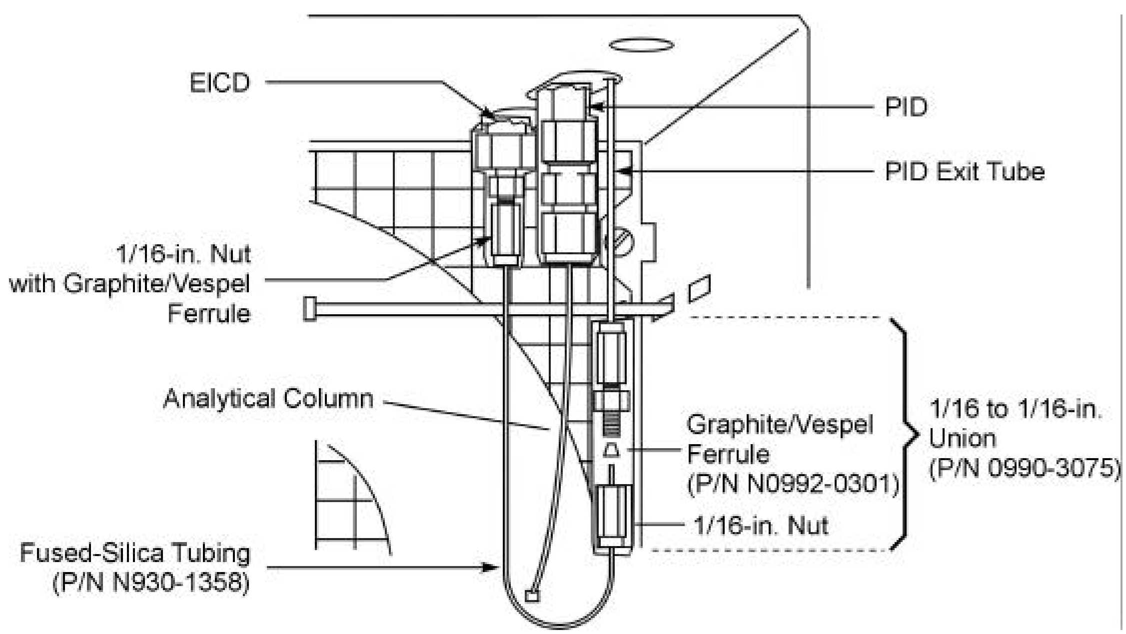


Figure 2- 31 Connecting the fused silica line to the ElCD and the PID.

Check the Calibration

After you have made all the proper connections, check the calibration by following this procedure:

1. Connect the Control Unit to the AC line power.

2. Select SOLVENT FLOW. Then set the SOLVENT FLOW to 0.8 mL/min. You can set the solvent flow to 0.8 mL/min by turning the knob to the right of SOLVENT FLOW until 60 appears.

3. Start the flow by setting the switch to the right of SOLVENT FLOW to the On position.

4. Measure the solvent flow at the exit of the Conductivity Cell and adjust the SOLVENT FLOW until you get 0.8 mL/min.

5. Allow the ElCD to equilibrate at 0.8 mL/min for 4 to 5 hours.

6. Check the CALIBRATE display. It should indicate 2000 $\pm$ 20.

7. If the CALIBRATE display does not indicate 2000 $\pm$ 20, refer to Diagnostic Display in the Operation Section of the *ElCD Operator's Manual* that is supplied with the ElCD.

Install the NPD Bead Assembly

If you purchased your Clarus 500 GC equipped with a Nitrogen Phosphorus Detector (NPD), the NPD bead assembly is packaged separately and shipped inside the Clarus 500 GC oven. To install the NPD bead assembly, use the following procedure and refer to Figure 2- 32.

CAUTION	*After installing a NPD bead, you must set up the NPD and condition a new bead before you can use it. Refer to Setting Up a NPD in Chapter 8 of the Clarus 500 GC User's Manual (P/N 0993-6073).*

1. Open the detector cover.

2. Remove the bead assembly package from the Clarus 500 GC oven.

3. Loosen the knurled ring on the NPD collector assembly. Then remove the collector assembly.

CAUTION	*You may find it easier to first remove the coaxial cable from the collector assembly before you remove the collector assembly.*

4. Remove the screw that secures the bead transformer assembly to the top of the Clarus 500 GC oven.

5. Plug the bead assembly (P/N N612-0092) into the connector on the bead transformer. The connector is keyed so that the bead assembly can only be inserted one way.
6. Carefully insert the bead portion of the bead assembly in the detector body as shown in Figure 2-32.
7. Secure the bead transformer to the top of the oven with the screw removed in step 4.
8. Replace the collector assembly on the detector body and secure it by tightening the knurled ring. If the coaxial cable was removed, connect it to the collector assembly.

CAUTION	*Ensure that the polarizing wire is still connected to the polarizing pin on the detector body before you set up and run the NPD.*

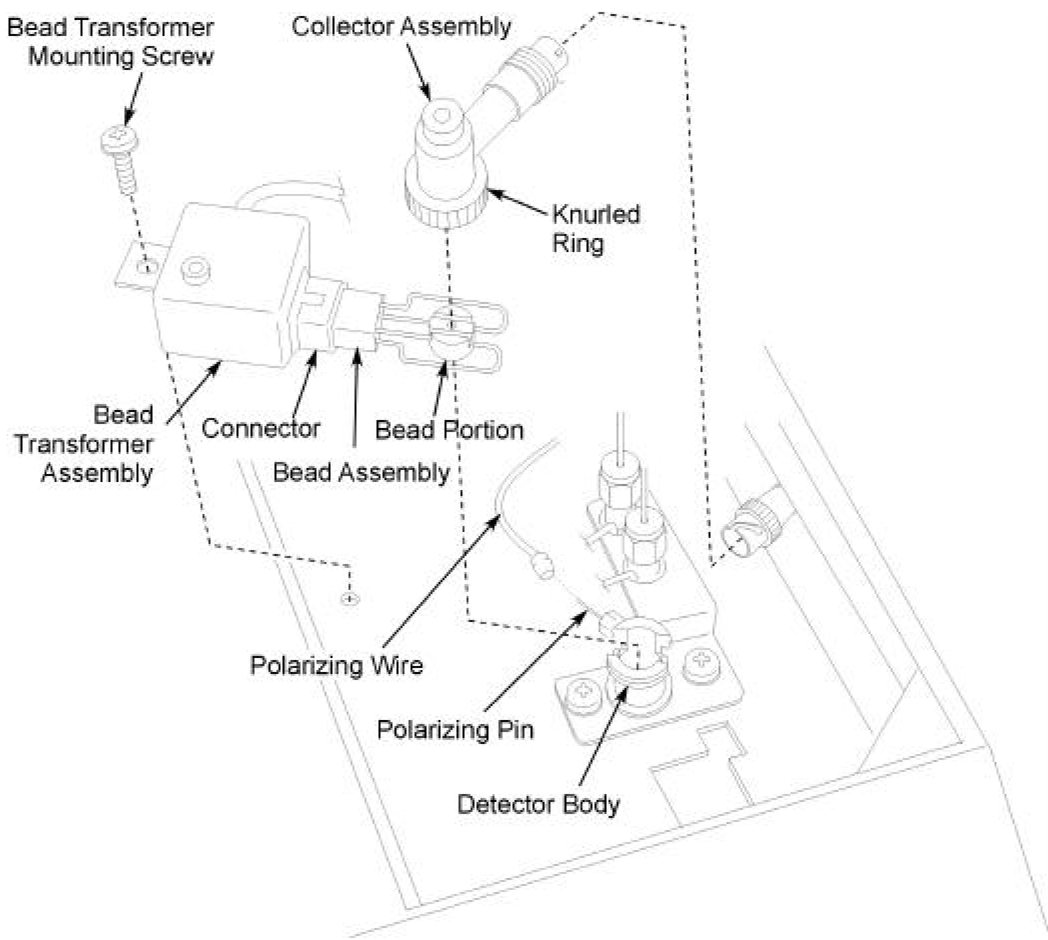


Figure 2- 32 Exploded view of the Nitrogen Phosphorus Detector.

Connect a Recorder or Integrator

This section describes how to connect an optional recorder or integrator to the Clarus 500 GC. To connect either one of these devices, use the following procedure.

1. To connect a device to amplifier Channel A or B, first configure output 1 or 2 for a recorder or integrator as described in Chapter 3, Initial Setup Procedures, in the *Clarus 500 GC User's Manual*.

2. Lift the top deck cover (see Figure 2-23) to gain access to TB1 (see Figure 2-33). This is where you will connect the recorder or integrator leads.

3. To connect a recorder or integrator to Channel A, connect the ground lead of the device to TB1-13 and the positive lead of the device to TB1-14. Make sure you route the wires around the strain relief posts as shown in Figure 2-34.

4. To connect a recorder or integrator to Channel B, connect the ground lead to TB1-15 and the positive lead to TB1-16.

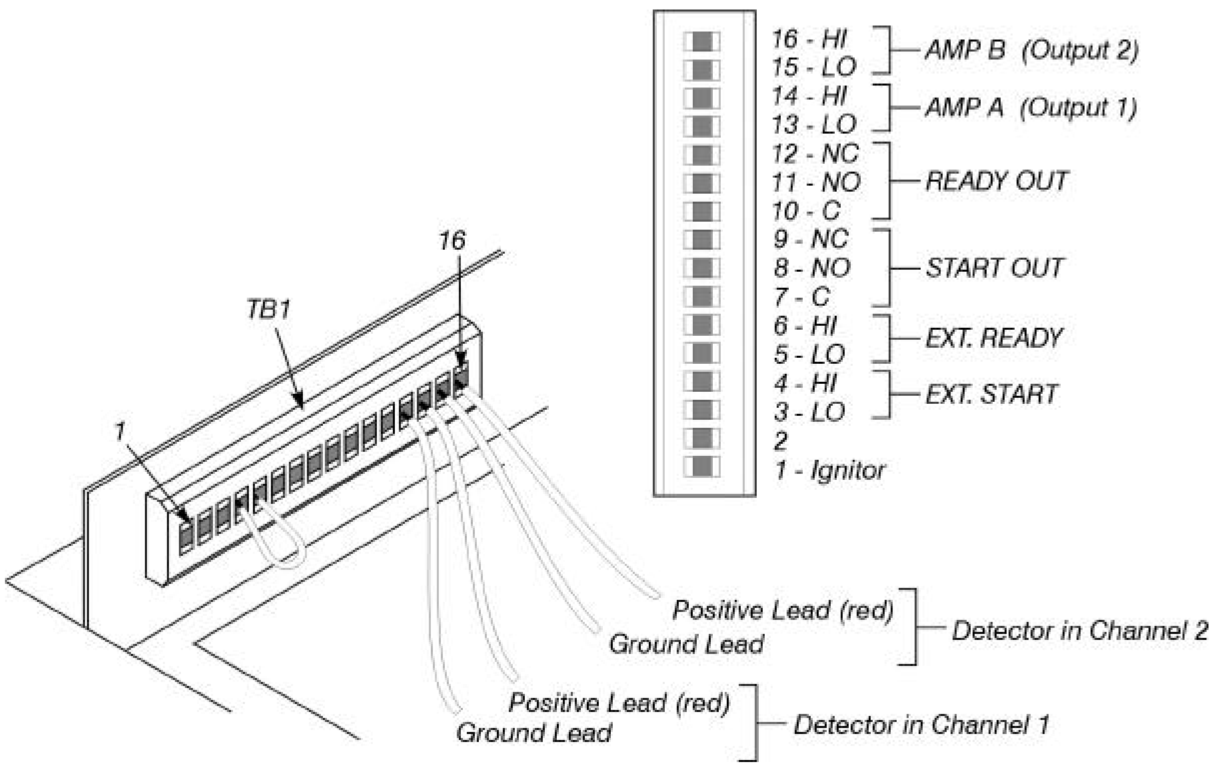


Figure 2-33 Recorder and integrator connections at TB1.

In addition to the amplifier Channel A and B contacts, TB1 has READY and START contacts. Table 2-3 describes the functions of these contacts.

Table 2- 3 READY and START Connections at TB1

Connection	**Function**
READY OUT TB1-10 (C), 11 (NO), 12 (NC)	*Instrument READY OUT Relay:* These contacts are used to tell an external device that the Clarus 500 GC is ready. The normally open contact (NO) is closed in the Ready state.
START OUT TB1-7 (C), 8 (NO), 9 (NC)	*Instrument START OUT Relay:* These contacts are used to start an external device, such as an integrator, when the Clarus 500 GC starts a chromatographic run. The normally open contact is closed for 1 sec when a run is started.
EXT. READY (TB1-5, 6) TB1-6 is signal TB1-5 is ground	*External Ready In:* The Clarus 500 GC requires that these contacts be shorted together to become ready and is shipped with a link across them. When using an external device, such as an integrator, remove the link and wire the device to provide a contact closure indicating the Ready state. This will prevent the instrument from becoming ready before the external device is ready.
EXT. START (TB1-3, 4) TB1-4 is signal TB1-3 is ground	*External Start In:* Shorting these contacts will cause the Clarus 500 GC to start a chromatographic run. It is equivalent to pressing the RUN key.

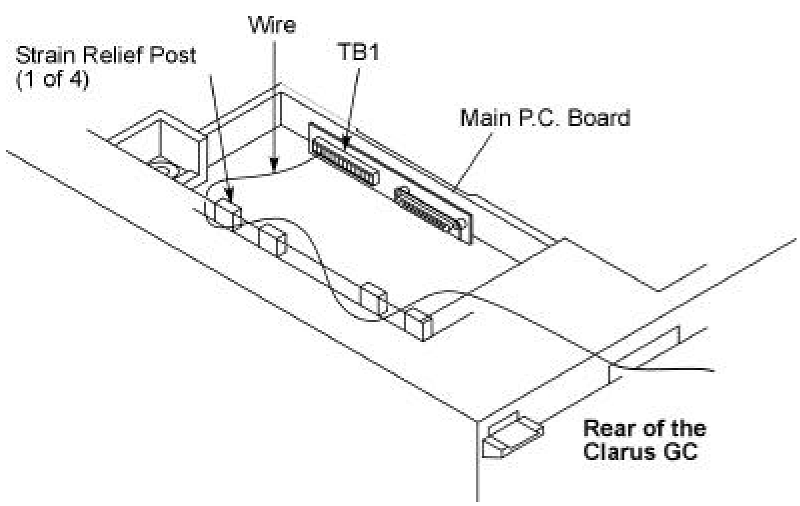


Figure 2- 34 Routing recorder/integrator wires around the strain relief posts.

Connect a Printer

To connect a printer to the Clarus 500 GC, connect an RS-232 cable from the printer to the Clarus 500 GC .

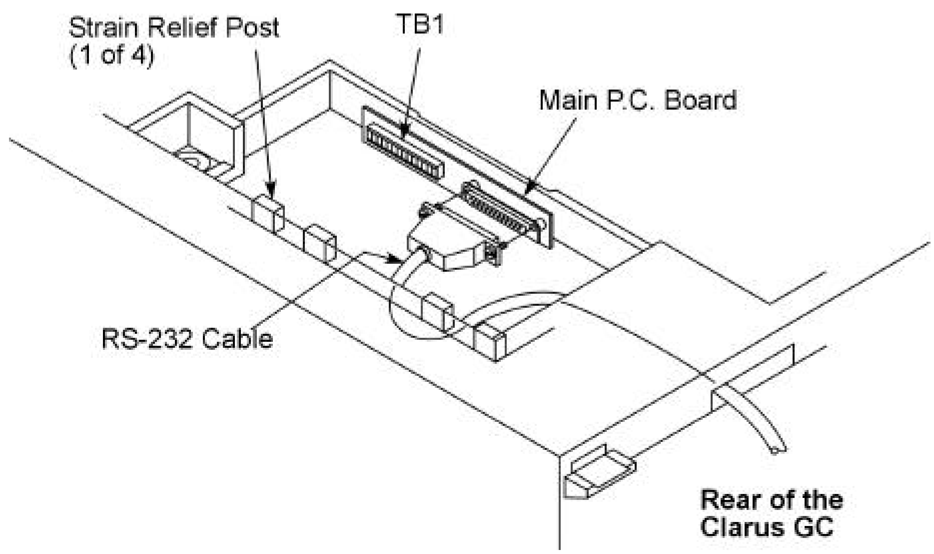


Figure 2- 35 Connecting an RS-232 cable to the Clarus 500 GC.

The printer port is configured as a DTE port. The following table describes the individual pins of the Clarus 500 GC printer port.

Table 4. Printer Port Pin Functions

Pin	Signal	Function
1	CHSGND	Chassis ground
2	TXD	Transmitted data (from GC)
3	RXD	Received data (to GC)
4	RTS	Ready to send (from GC)
5	CTS	Clear to send (to GC)
6	DSR	Data set ready (to GC, ignored)
7	GND	Signal ground
8	DCD	Data carrier detect (to GC, ignore)
20	DTR	Data terminal ready (from GC)

Restrictor Information

Available Restrictors

Restrictor Number	**Color**	**Helium Flow at 30 PSIG, vent to atmosphere**
1	Silver	1 mL/min
2	Red	3 mL/min
3	Yellow	10 mL/min
4	Black	30 mL/min
5	Green	100 mL/min
6	Blue	300 mL/min

Restrictors for Carrier Gas Control

Injector	**Restrictor Number and Color**	**Helium Flow (mL/min)** (**with a 90 psig inlet pressure and a 10 psig drop across the restrictor**)
Packed	4 (std) Black	30
Split/Splitless or PSS	6 (std) Blue	300
Split/Splitless or PSS	4 (acc) Black	30
POC	3 (std) Yellow	10
POC	2 (acc) Red	3

Restrictors for Detector Gas Control

NOTE: *Maintain an inlet pressure between 60 and 90 psig.*

Detector	**Gas**	**Restrictor Number and Color**	**Nominal Flow Required (mL/min)**
FID	Air	6 Blue	450
FID	Hydrogen	4 Black	45
NPD	Air	5 Green	100
NPD	Hydrogen	1 Siler	2
FPD	Air	5 Green	90
FPD	Hydrogen	4 Black	75
ECD	Argon/Methane	4 Black	30
ECD	Nitrogen	4 Black	30
TCD	Helium	4 Black	30
TCD	Hydrogen	3 Yellow	30
ElCD	Hydrogen	3 Yellow	25

Maintenance 3

Chapter Overview 3-1
Autosampler Maintenance 3-2
Changing a Syringe 3-2
Removing a Syringe 3-3
Installing a Syringe 3-4
Replacing the Vial-Locator Mechanism 3-5
Syringe Maintenance 3-6
Cleaning the 5-µL and 50-µL Syringe Plungers 3-6
Servicing Idle Syringes 3-6
Injector Maintenance 3-7
Changing Septa 3-7
Changing and Repacking Packed Column Injector Liners 3-8
Changing the Hourglass Needle
Guide on the Programmed On-Column (POC) Injector 3-10
Changing and Repacking Capillary Split/Splitless (CAP)
and Programmed Split/Splitless (PSS) Injector Liners 3-12
Removing a CAP or PSS Injector Liner 3-12
About O-Rings 3-15
Selecting an Appropriate CAP Injector Liner 3-16
Packing the CAP Injector Liner with Quartz Wool 3-17
Packing a CAP Injector Liner for Split Operation 3-17
Packing a CAP Injector Liner for Splitless Operation 3-17
Changing the Charcoal Trap

or Replacing Charcoal on the Split/Splitless CAP and PSS Injectors 3-23
Removing a Charcoal Trap............ 3-23
Installing a New Charcoal Trap............ 3-24
ECD Maintenance............ 3-26
Baking the ECD............ 3-27
Changing the Charcoal Traps 3-27
Cleaning the ECD Anode............ 3-27
Wipe Testing an ECD Cell............ 3-28
FID Maintenance 3-33
Replacing a FID Jet............ 3-33
Cleaning a FID Jet............ 3-36
PID Maintenance 3-38
Changing a PID Lamp............ 3-38
Cleaning PID Lamp Windows............ 3-39
Changing PID Lamp Window Seals and Positioning Disks 3-41
ElCD Maintenance............ 3-42
Replacing the ElCD Reactor Tube 3-42
Replacing the Sealing Ring 3-43
NPD Maintenance............ 3-46
Changing the NPD Bead............ 3-46
Replacing an NPD Jet............ 3-53
FPD Maintenance 3-56
Cleaning/Replacing an Optical Filter Assembly............ 3-56
Cleaning/Replacing the Detector Liner 3-58
Cleaning/Replacing the Detector Window............ 3-60
Replacing the Photomultiplier Tube............ 3-62
Cleaning/Replacing the FPD Jet............ 3-65
PPC Maintenance 3-68
Replacing a Restrictor............ 3-68
Practical Hints 3-71

Chapter Overview

This chapter contains procedures for:

- Autosampler Maintenance — changing a syringe and replacing a vial-locator mechanism.
- Syringe Maintenance — cleaning the 5-µL and 50-µL syringe plungers.
- Injector Maintenance — changing septa, changing and repacking packed-injector liners, changing and repacking injector liners on the capillary (CAP), programmed split/splitless (PSS), and programmed on-column (POC) injectors, and changing the charcoal trap on the split/splitless injector.
- ECD Maintenance — baking out ECD cells, cleaning the ECD anode, and wipe testing an ECD cell.
- FID Maintenance — replacing the FID jet, cleaning the FID jet, replacing an O-ring in the FID collector, and cleaning the FID collector and cap.
- PID Maintenance — changing PID lamps, cleaning PID lamp windows, changing PID lamp window seals, and positioning disks.
- ElCD Maintenance — replacing the ElCD reaction tube and cleaning ElCD cells.
- NPD Maintenance — changing and conditioning the NPD bead and replacing an NPD jet.
- FPD Maintenance — cleaning or replacing an FPD optical filter assembly, cleaning the detector liner, cleaning/replacing the detector window, replacing the photomultiplier tube, and cleaning and replacing the FPD jet.
- PPC Maintenance — replacing PPC module restrictors.

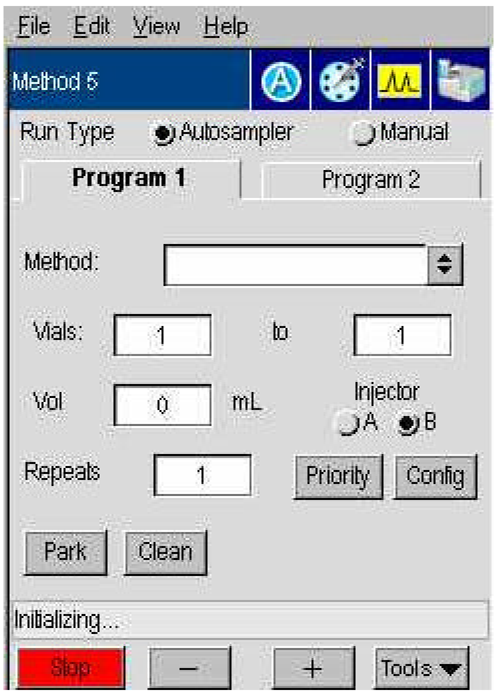
Autosampler Maintenance

Autosampler maintenance consists of changing a syringe and replacing a vial locator mechanism.

Changing a Syringe

1. From the main status screen select the run tab.

2. On the run tab page select the Autosampler radio button. The following page will appear.



Screen 3- 1 Run Tab Page

3. Select the Park button and the autosampler tower moves to the park position (facing the front of the Clarus 500 GC).

4. Open the tower door on the autosampler tower cover.

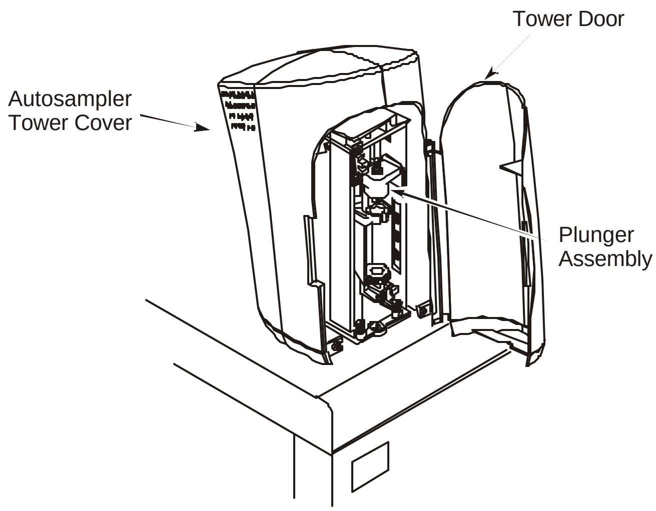


Figure 3- 1 Autosampler tower in the park position

Removing a Syringe

1. Locate the plunger assembly shown in the previous illustration.

Then, refer to the following figure, as you lift up the plunger cap handle and rotate it until it rests on the collar. Then release the plunger cap handle.

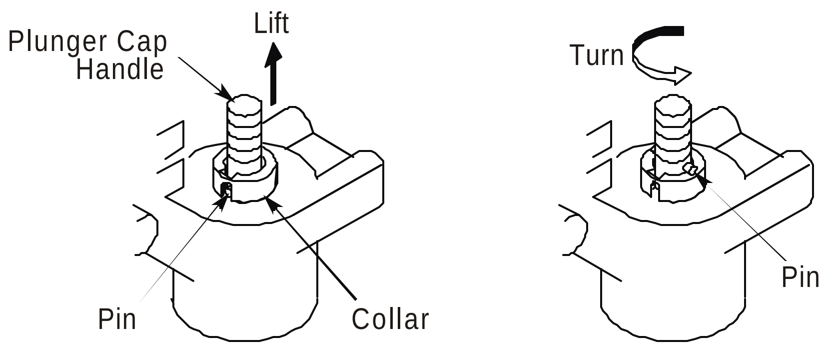


Figure 3- 2 Plunger assembly

2. Hold the syringe by the barrel or syringe nut (see the following figure) and turn the carriage thumbscrew clockwise until the syringe is free.
3. Gently pull the top of the syringe forward until it just clears the carriage assembly.
4. Gently lift the syringe out of the carriage assembly.

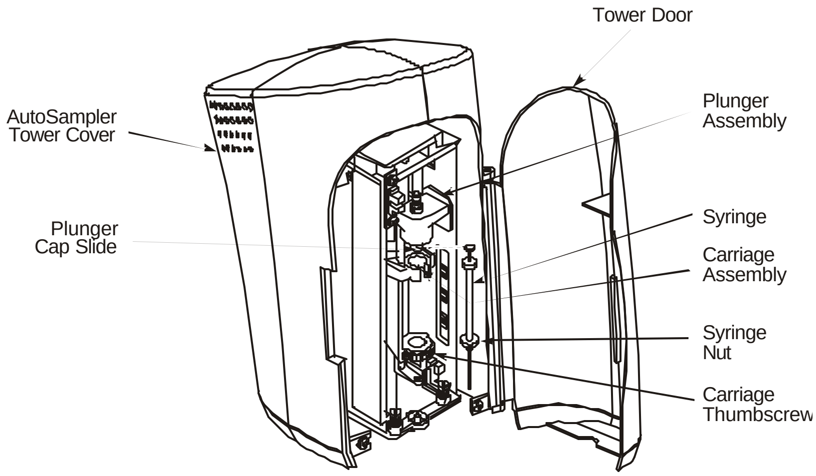


Figure 3- 3 Removing a syringe

Installing a Syringe

Please refer to Figures 3-2 through 3-4 as you follow these steps.

1. Guide the needle through the hole in the carriage thumbscrew, then thread the needle through the needle guide. Use your fingers as a guide.

2. Rest the top of the plunger on the plunger cap slide, which is a shelf located on the underside of the plunger assembly.

3. While holding the syringe nut, engage the carriage thumbscrew on the threaded part of the syringe by turning the carriage thumbscrew counterclockwise.

4. Continue turning the thumbscrew counterclockwise. This slowly lowers the needle. Carefully guide the needle through the needle guide into the vial locator.

5. Tighten the carriage thumbscrew.

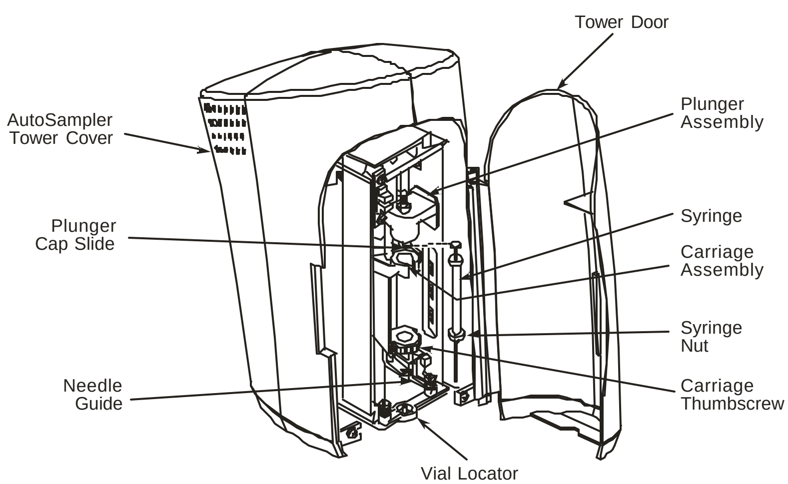


Figure 3- 4 Installing a syringe

Replacing the Vial-Locator Mechanism

The vial-locator mechanism will wear out with extended use and require replacement. If the autosampler begins missing vials, or if the hole for the syringe needle begins to plug, it is an indication that you should replace the vial-locator mechanism.

To replace a vial-locator mechanism:

1. Remove the two shoulder screws that secure the locator to the autosampler tower frame. Remove the two springs, then remove the vial locator. Discard the vial locator.

2. Mount the new vial locator (P/N N610-1182) on the autosampler tower frame.

3. Install the two shoulder screws through the two springs and into the vial locator. This secures the vial locator to the autosampler tower frame.

WARNING

When securing the vial-locator molding, be sure that the flag is centered (not touching either side) in the sensor. If it touches a side, adjust the flag by loosening and then tightening the screws. ***DO NOT ADJUST THE SENSOR****.*

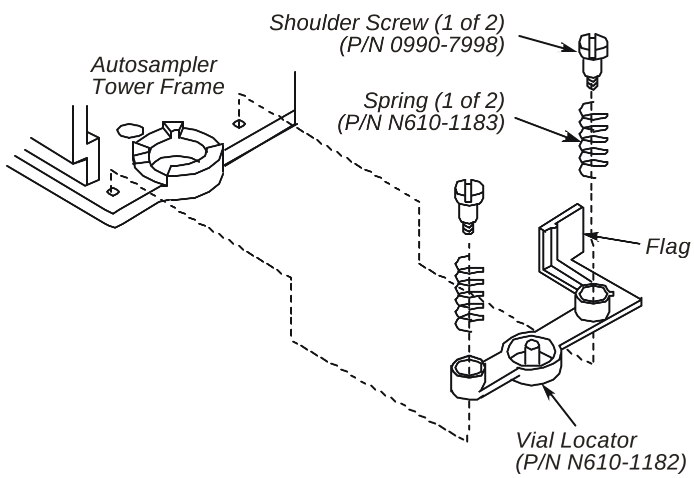


Figure 3-5 Exploded view of the vial locator

Syringe Maintenance

Syringe maintenance consists of cleaning the 5-µL and 50-µL syringe plungers and servicing idle syringes.

Cleaning the 5-mL and 50-mL Syringe Plungers

The 5-µL and 50-µL syringe plungers should be cleaned regularly, after approximately 500 injections, since insolubles can build up and cause friction.

To clean the syringe plunger:

1. Remove the syringe using the procedure described in the preceding section.
2. Remove the plunger from the syringe barrel.
3. Wipe the plunger with a tissue soaked in an appropriate solvent.
4. Replace the plunger.
5. Pull and expel the same solvent through the barrel several times.
6. Replace the syringe using the procedure descried in the preceding section.

NOTE: *Only syringes distributed by PerkinElmer should be used with the Clarus 500 GC. Plungers are not interchangeable from syringe to syringe.*

Servicing Idle Syringes

Syringes that are not used for several hours could "freeze," i.e., the syringe plunger will not move. To avoid this condition, **PARK** the tower, then remove and clean the syringe plunger as described above.

NOTE: *If you notice the Clarus 500 GC precision degrading, replace the syringe. The Clarus 500 GC syringe is a consumable part. After extended use, you will need to replace it.*

Injector Maintenance

CAUTION	*If you are analyzing reactive compounds, you should use deactivated liners and wool which are appropriate for your sample type.*

Injector maintenance consists of changing septa, changing and repacking injector liners, changing the hourglass needle guide on the POC injector, changing and repacking CAP and PSS injector liners, removing a broken liner from the PSS injector body, changing the charcoal trap or replacing charcoal on the split/splitless CAP and PSS injectors.

Changing Septa

Septa should be replaced on a regular basis. How often depends on the type of septa used, the temperature of the injection port, and the number of injections made.

The septum shipped with your instrument is a Thermogreen LB-2 Septa (P/N N662-1028, package of 50). This septum can handle over 200 injections at moderate temperatures.

To change a septum:

1. Turn off the injector heater and allow the injector to cool.
2. Remove the septum cap.
3. Pry the old septum from the septum cap with a screwdriver.
4. Insert a new septum in the septum cap.
5. Replace the septum cap.

NOTE: *To minimize the possibility of contamination, avoid unnecessary handling of septa.*

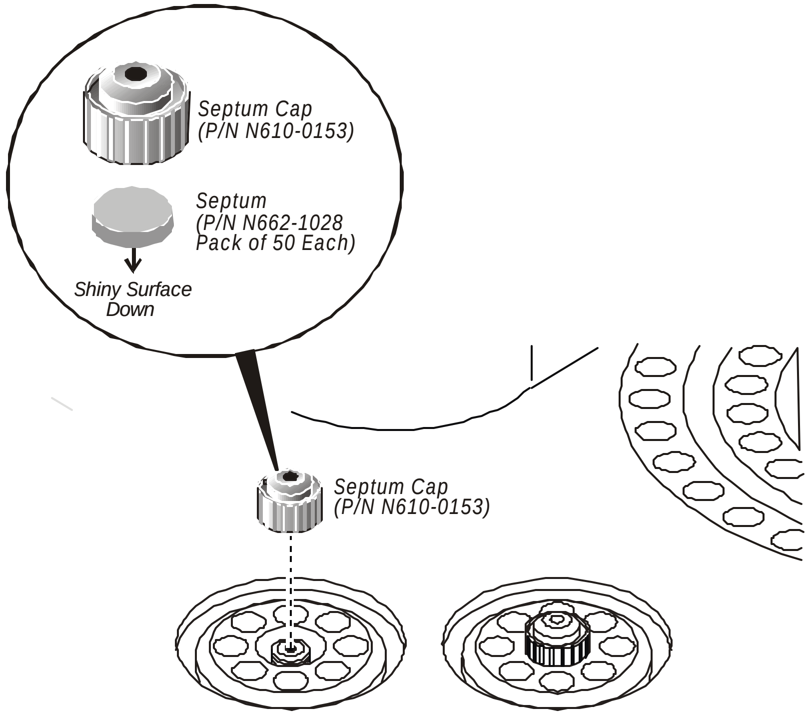


Figure 3- 6 Changing a septum

Changing and Repacking Packed Column Injector Liners

To improve the performance of the injector used with packed columns, insert a small amount of quartz wool (P/N N610-2354) into the top portion of the injector liner (P/N N610-1048). The quartz wool accomplishes two things: (1) it wipes the end of the syringe needle to insure that reproducible sample volumes are injected, and (2) it retains any nonvolatile components present in your sample, making cleaning the liner easier.

The injector liner should be removed and the wool packing replaced on a regular basis, particularly if your samples contain nonvolatile components that could build up on the wool. This could cause adsorption of peaks of interest, tailing, and loss of sensitivity.

You can remove the wool with a small hook on the end of a thin wire, or blow it out using compressed air.

To remove a packed injector liner and install new wool:

1. Turn off the injector heater.

   Allow the injector to cool until it is slightly warm to the touch. Cooling the injector to a temperature that is too low (<100 °C) will make it difficult to remove the injector liner.

2. Remove the septum cap.

3. Remove the septum shield (P/N N610-1050) with the large end of the liner-removal tool (P/N N610-0102).

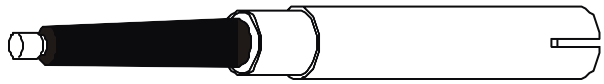


Figure 3- 7 Liner-Removal Tool (P/N N610-0102)

4. Press the small end of the liner-removal tool into the injector liner, then pull the injector liner out.

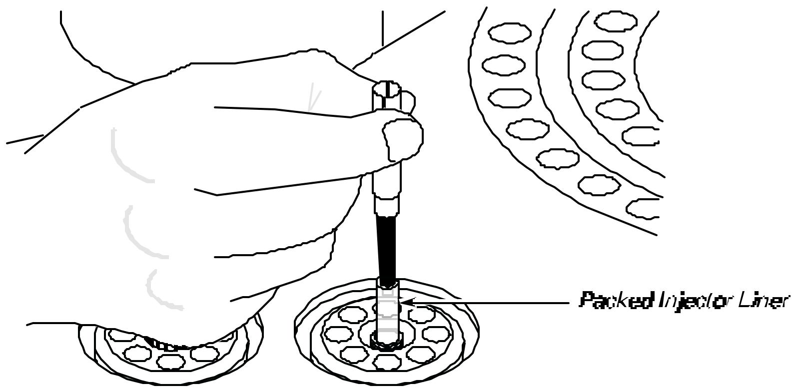


Figure 3- 8 Removing the packed column injector liner

NOTE: *To avoid contaminating the quartz wool when packing the injector liner, wear vinyl, powder-free, disposable gloves (for example, the same type of gloves used to perform maintenance on the Mass spectrometer).*

5. Take a small piece of quartz wool and twist it into an elongated shape so that you can insert it into the injector liner. Then, using the supplied 1/16-inch rod (P/N N610-T100), push the quartz wool into the injector liner. *Loosely* pack a 1-inch (2.5 cm) piece of quartz wool into the top portion of the liner (see the following figure).

6. Replace the injector liner, septum shield, and septum cap.

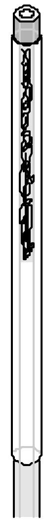


Figure 3-9 Packed column injector liner (P/N N610-1048) packed with wool

Changing the Hourglass Needle Guide on the Programmed On-Column (POC) Injector

To change the hourglass needle guide:

1. Turn off the injector heater. Allow the injector to cool until it is slightly warm to the touch.

2. Remove the septum cap.

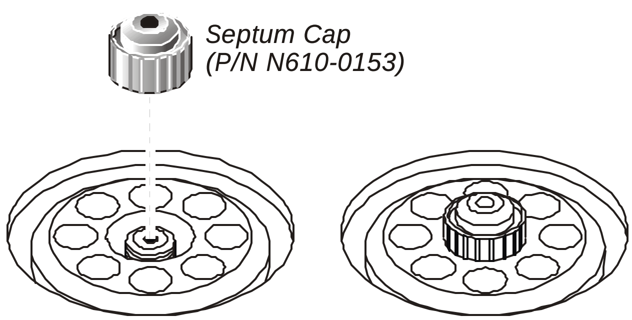


Figure 3-10 Removing a septum cap

3. Remove the septum shield (P/N N610-1702) with the large end of the liner-removal tool (P/N N610-0102).

4. Remove the hourglass needle guide (see the following figure) with a pair of tweezers or small pliers.

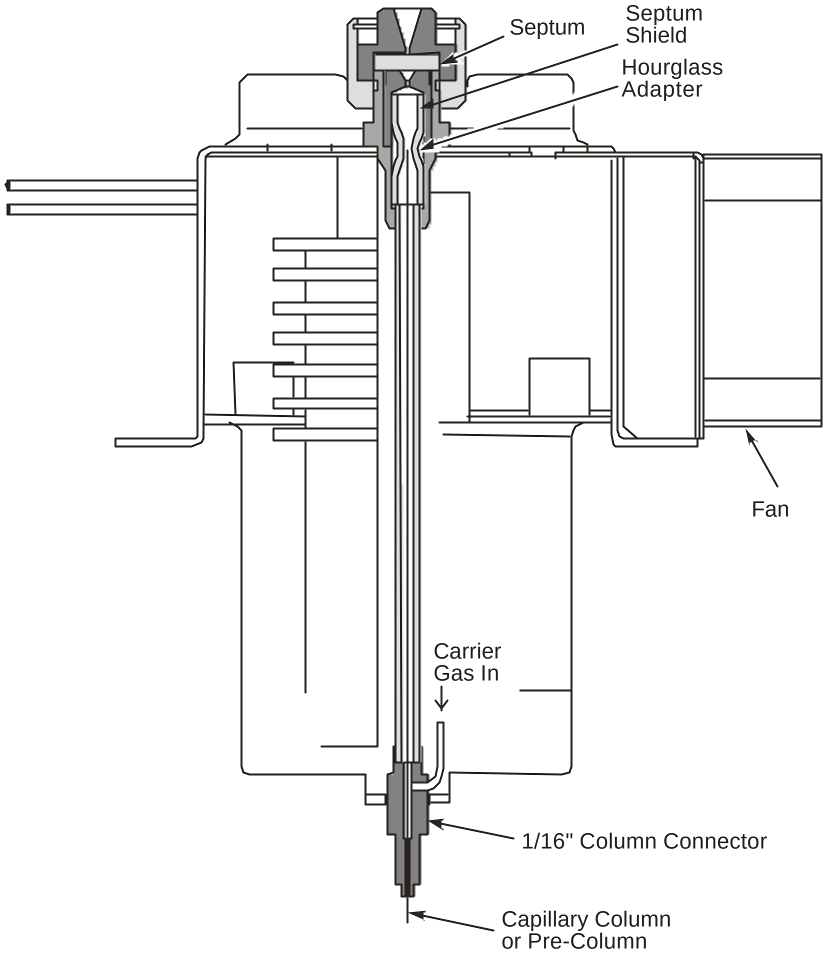


Figure 3- 11 Cutaway view of the POC injector showing the location of the hourglass needle guide

5. Install the new hourglass needle guide (P/N N610-1703).
6. Replace the septum shield.
7. Replace the septum cap.
8. Reinstall your column.

Changing and Repacking Capillary Split/Splitless (CAP) and Programmed Split/Splitless (PSS) Injector Liners

The procedure below is applicable to the following injector liners:

Injector Liner	Size	Part Number
CAP wide-bore liner	4.0-mm i.d. and a 6.0-mm o.d.	N612-1001
CAP narrow-bore liner	2.0-mm i.d. and a 6.0-mm o.d.	N612-1002
PSS wide-bore liner	2.0-mm i.d. and a 4.0-mm o.d.	N612-1004
PSS narrow-bore liner	1.0-mm i.d. and a 4.0-mm o.d.	N612-1006
PSS on-column liner	--	N610-1539

Removing a CAP or PSS Injector Liner

The liner-removal procedure is similar for CAP and PSS wide-bore and narrow-bore liners. To remove the liners, you need a CAP liner-removal tool (P/N 0250-6534) or a PSS liner-removal tool (P/N 0250-6247) as shown below.

Figure 3- 12 CAP and PSS liner-removal tools

To remove a capillary injector liner:

1. Turn off the injector heater.

   Allow the injector to cool until it is slightly warm to the touch. **Cooling the injector to a temperature that is too low (<100 °C) will make it difficult to remove the injector liner.**

2. Remove the septum cap.

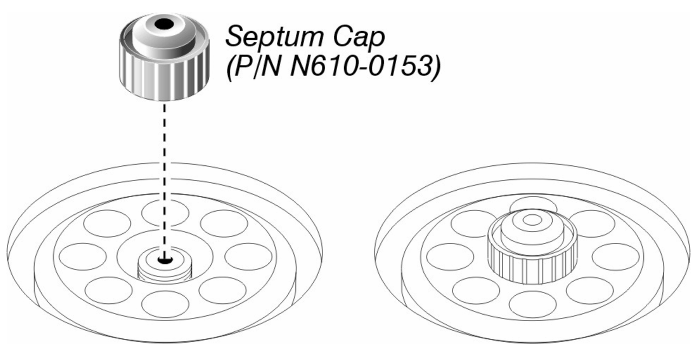


Figure 3- 13 Removing the septum cap

3. Remove the injector cover.

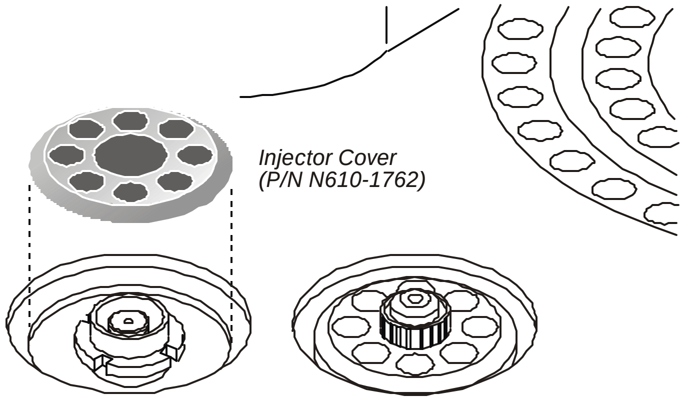


Figure 3- 14 Removing the injector cover

4. Loosen the threaded collar using the spanner (P/N N610-1359) provided, then remove the threaded collar.

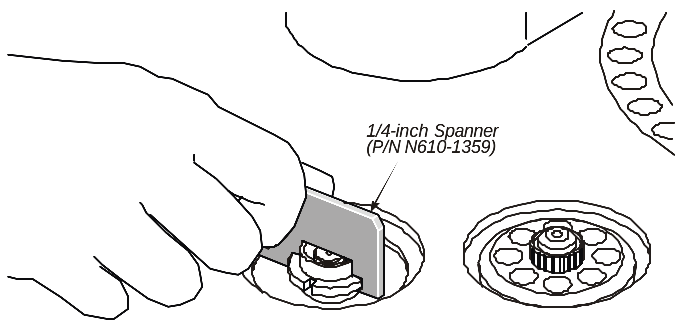


Figure 3- 15 Loosening the threaded collar

5. Replace the septum cap on the injector.

6. Pull the septum cap upwards to remove the septum purge assembly.

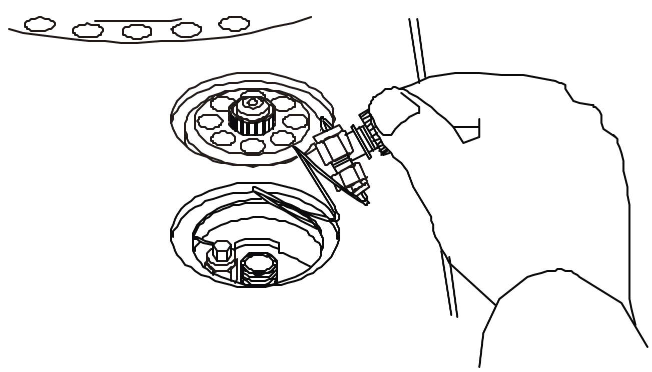


Figure 3- 16 Removing the septum purge assembly

The carrier gas inlet line is coiled. This allows you to pull the septum purge assembly over to the side and gain access to the injector liner.

NOTE: *The inlet line used in PPC capillary injectors (CAP and PSS) is coiled but the septum purge assembly does not terminate in a snubber as shown. Instead it is connected to a PPC module. The coil of the inlet line is long enough so that you can pull the septum purge assembly out of the opening in the top cover and gain access to the injector liner.*

7. Insert the CAP liner-removal tool (P/N 0250-6534) over the end of the CAP liner and lift the liner out of the injector.

OR

Insert the PSS liner-removal tool (P/N 0250-6247) over the end of the PSS liner and lift liner out of the injector.

CAUTION	*The liner must be cool (no hotter than 100 °C) or the liner-removal tool will melt! The end of the liner-removal tool may flare out with use. If this happens,*

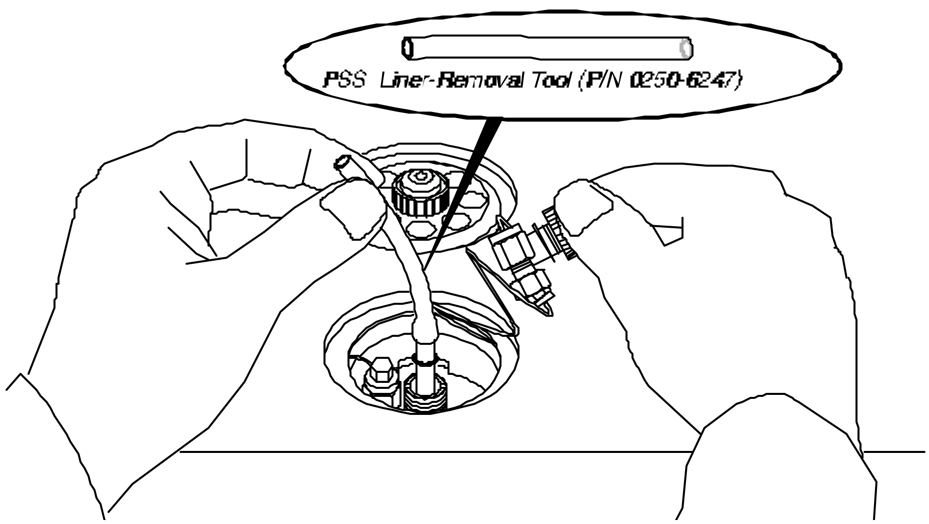


Figure 3- 17 Removing an injector liner

NOTE: *If the quartz liner breaks inside the CAP injector, it can be removed by first removing the column, then removing with a 9/16-inch wrench the 1/4-inch injector fitting that is inside the oven. The liner should fall out of the injector with the fitting. If the liner is stuck, you can push it out from the top or bottom of the injector.*

CAUTION	*The PSS injector liner does not have a 1/4-inch fitting like the CAP injector. Be very careful when removing this liner to prevent breaking it.* *Do not cool the injector below 80 °C. This will make it easier to remove the liner and O-ring. As the injector cools, the O-ring adheres to the metal base.*

NOTE: *Each capillary liner has an O-ring installed on the frosted portion of the CAP liner and on the part furthest away from the dimple on the PSS injector. If the O-ring has adhered to the injector, you may not be able to easily remove the liner (step 7 above). If this is the case, use a small screwdriver to dislodge the O-ring before removing the liner and O-ring.*

About O-Rings

If your results produce background contamination when a new O-ring is first installed, condition the injector at the maximum temperature of the O-ring (listed below). Depending on the type of column used, you may first want to remove the column before baking it out at a high temperature.

NOTE: *High-temperature seals should be used at temperatures of 300 °C or higher. These seals are available in Kalrez or graphite from PerkinElmer's catalog service (in the U.S. dial: 1-800-762-4000). Viton maximum temperature of 250 °C is recommended for the mass spectrometer.*

Injector O-Rings	Recommended Maximum Temperature
CAP Injector	
N610-1374 Silicone (pkg .of 10)	250 °C
N610-1378 Graphite (pkg. of 5)	450 °C
N930-2782 Kalrez (pkg. of 1)	450 °C
N930-2783 Viton (pkg. of 1)	250 °C (not recommended for use with ECD)
PSS Injector	
N610-1751 Graphite (pkg. of 5)	450 °C
0992-1004 Kalrez (pkg. of 1)	450 °C
N610-1747 Viton (pkg. of 10)	250 °C (not recommended for use with ECD)

Selecting an Appropriate CAP Injector Liner

Select the correct CAP liner for your application and pack it with quartz wool. The CAP injector uses the following two liners:

- CAP wide-bore liner (P/N N612-1001); 4.0-mm i.d. and 6.0-mm o.d.
- CAP narrow-bore liner (P/N N612-1002); 2.0-mm i.d. and 6.0-mm o.d.

The narrow-bore liner is generally used for a splitless injection, and the wide-bore liner is generally used for a split injection. Due to the small internal volume (0.3 mL) of the narrow-bore liner, prevent overfilling the liner with vapor (caused by solvent expansion upon injection) by limiting the amount of sample injected to 0.5 µL. The wide-bore liner is used for splitless injection volumes over 0.5 µL, since its internal volume is 1.25 mL. The sample size should be limited to a maximum of 2 µL for hydrocarbon solvents, and less than that for high-expansion solvents such as water or CH_2Cl_2.

If the wide-bore liner is used for splitless injection, the splitless sampling time (the vent-on time) should be more than one minute. Also, lower initial oven temperatures may be required to give good resolution in the first few minutes after the solvent peak elutes. The wide-bore liner should be used with columns having an i.d. of 0.32 mm or greater.

Packing the CAP Injector Liner with Quartz Wool

We recommend packing a small amount of quartz wool in the top portion of the liner to wipe the syringe needle regardless of the liner type or injector mode (for example, split or splitless). This packing assures that reproducible volumes are injected by wiping the syringe needle every time it is inserted.

Remove the liner and replace the quartz wool packing on a regular basis, particularly if your samples contain nonvolatile components that could build up on the wool. This buildup could cause adsorption of peaks of interest, tailing, and loss of sensitivity.

Remove the wool by making a small hook on the end of a thin wire and using that to pull it out, or blow it out using compressed air.

NOTE: *To avoid contaminating the quartz wool when packing the injection liner, wear vinyl, powder-free, disposable gloves (for example, the same type of gloves used to perform maintenance on a mass spectrometer).*

Packing a CAP Injector Liner for Split Operation

Take a small piece of quartz wool and twist it into an elongated shape so that you can insert it into the liner. Then using the supplied 1/16-inch rod (P/N N610-T100), push the quartz wool into the liner. Pack the wool tightly* from the dimple upwards [about 1 in. (2.5 cm)]. Loosely pack quartz wool in the top portion of the liner to wipe the syringe needle upon injection.

Packing a CAP Injector Liner for Splitless Operation

Take a small piece of quartz wool and twist it into an elongated shape so that you can insert it into the liner. Then using the supplied 1/16-inch rod (P/N N610-T100), push the quartz wool into the liner. Pack a 1-inch (2.5 cm) piece of quartz wool *loosely* below the top ground portion of the liner (see the following figure). The sample is then injected into the wool, thereby preventing the delivery of sample beyond the column. The wool also wipes the syringe needle upon injection.

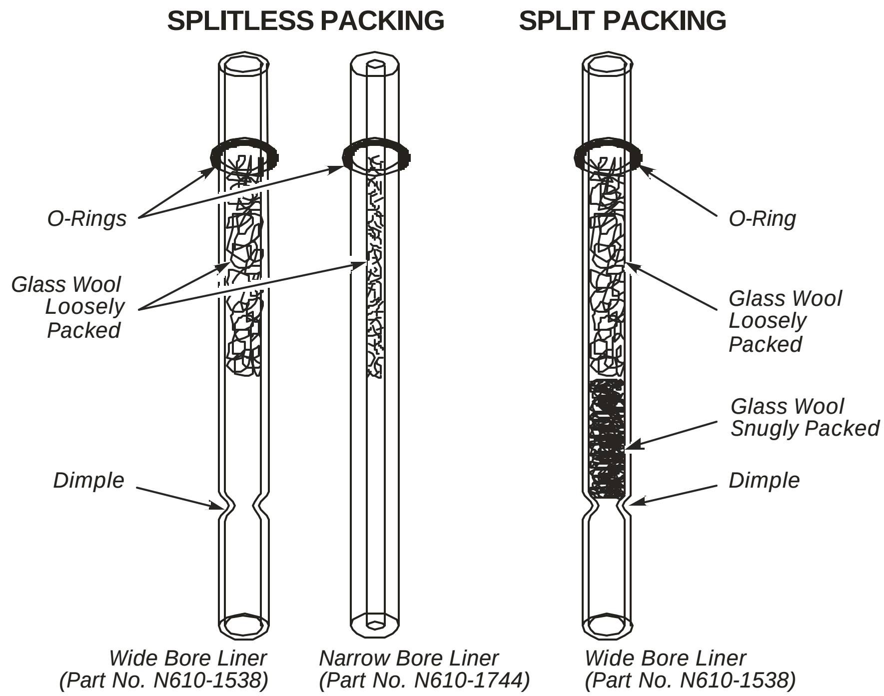


Figure 3- 18 CAP injector liners packed with quartz wool

NOTE: *As you can see in Figure 3-18, each CAP injector liner has an O-ring installed on the ground portion. If the O-ring has adhered to the liner, it may not be easy to remove the liner. (If this is the case, use a small screwdriver to dislodge the O-ring before removing the liner and O-ring).*

Reinstalling the Liner in the CAP Injector

1. Install a new O-ring near the ground portion of the liner.
2. Insert the liner in the injector body.
3. Place the septum purge assembly over the liner.
4. Press the septum purge assembly down to correctly position the liner in the injector.

Selecting an Appropriate PSS Injector Liner

Select the correct PSS liner for your application and pack it with quartz wool. The PSS injector uses the following three liners:

- PSS injector wide-bore liner (P/N N612-1004); 2.0-mm i.d.
- PSS injector narrow-bore liner (P/N N612-1006); 1.0-mm i.d.
- PSS injector on-column (hourglass) liner (P/N N610-1539)

In general, operate the PSS in the inlet-programmed mode with the 2-mm or 1-mm-i.d. liner for PSS split or splitless injection. For PSS on-column operation, use the hourglass liner and the oven-program mode.

The 2-mm-i.d. PSS liner that is used for either split or splitless operation should be packed with quartz wool as described in this chapter. The 1-mm-i.d. PSS liner may give better early-eluting peak resolution in the split or splitless mode. It should be used for samples with early-eluting peaks for which additional solute trapping/focusing cannot be obtained by lowering the initial oven temperature or by using a column with thicker stationary-phase film.

Packing the PSS Injector Liner with Quartz Wool

CAUTION	***Never*** *pack the hourglass liner with quartz wool.*

Pack a small amount of quartz wool in the top portion of the liner to wipe the syringe needle regardless of the liner type or injector mode (for example, split or splitless). Packing assures that reproducible volumes are injected by wiping the syringe needle every time it is inserted.

Remove the liner and replace the quartz wool packing on a regular basis, particularly if your samples contain nonvolatile components that could build up on the wool. This could cause adsorption of peaks of interest, tailing, and loss of sensitivity. You can remove the wool by making a small hook on the end of a thin wire and using that to pull it out, or blow it out using compressed air.

NOTE: *To avoid contaminating the quartz wool when packing the injection liner, wear vinyl, powder-free, disposable gloves (for example, the same type of gloves worn when performing maintenance on a mass spectrometer).*

Packing a CAP Injector Liner for Split Operation

Take a small piece of quartz wool and twist it into an elongated shape so that you can insert it into the liner. Then, using the supplied 1/16-inch rod (P/N N610-T100), push the quartz wool into the liner. Pack the wool ***tightly***[*] from the dimple upwards [about 1 in. (2.5 cm)]. ***Loosely*** pack quartz wool in the top portion of the liner to wipe the syringe needle upon injection.

Packing a CAP Injector Liner for Splitless Operation

Take a small piece of quartz wool and twist it into an elongated shape so that you can insert it into the liner. Then, using the supplied 1/16-inch rod (P/N N610-T100), push the quartz wool into the liner. Pack a 1-inch (2.5 cm) piece of quartz wool ***loosely*** below the top ground portion of the liner (see the following figure). The sample is then injected into the wool, thereby preventing the delivery of sample beyond the column. The wool also wipes the syringe needle upon injection.

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* The recovery of high-molecular-weight components (e.g., C_{40} and higher) may be improved if the liner is packed loosely.

NOTE: *The narrow-bore liner is more difficult to pack because of its small inner diameter. However, there is a dimple in the middle of the liner to hold the wool in place.* ***Do not pack the wool too tightly!***

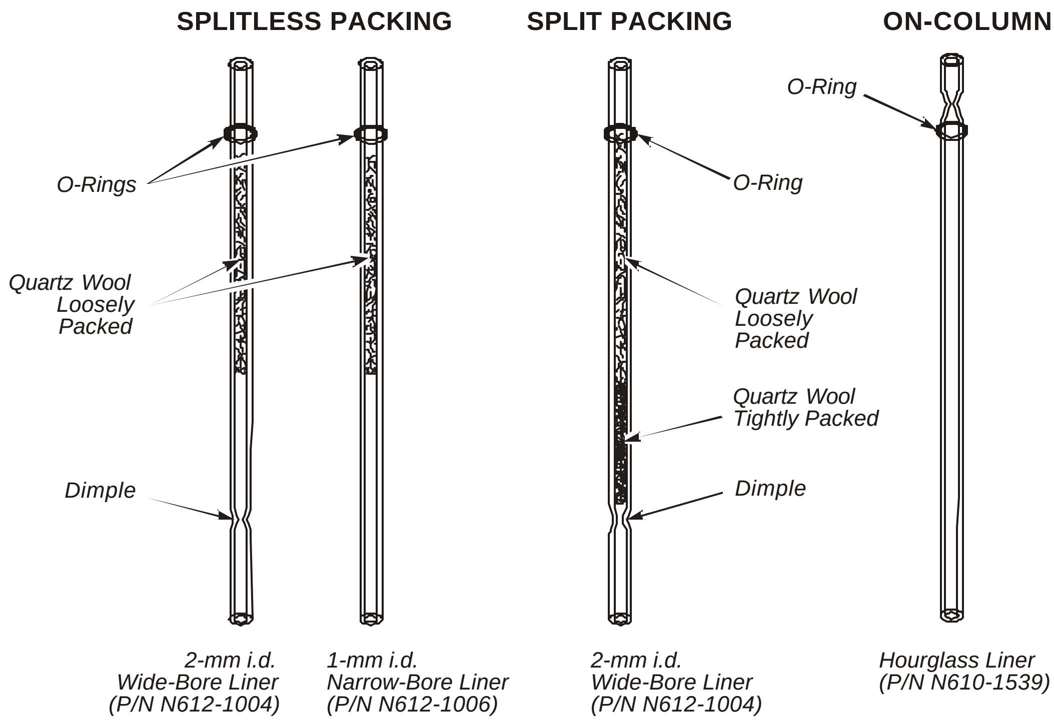


Figure 3- 19 PSS injector liners packed with quartz wool

NOTE: *As you can see in the preceding figure, each PSS injector liner has an O-ring installed near the end furthest away from the dimple. If the O-ring has adhered to the liner, it may not be easy to remove the liner. If this is the case, use a small screwdriver to dislodge the O-ring before removing the liner and O-ring.*

Reinstalling the Liner in the PSS Injector

1. Install a new O-ring on the top portion of the liner.
2. Insert the liner in the injector body.
3. Place the septum purge assembly over the liner.
4. Press the septum purge assembly down to correctly position the liner in the injector.

Make sure that you **secure** the septum purge assembly ***tightly*** to the injector base with the 1/4-inch spanner.

Removing a Broken Liner from the PSS Injector Body

If a liner breaks in the PSS injector body, the best way to remove all pieces of quartz is to remove the injector from the Clarus 500 GC.

To remove a broken PSS liner from the injector:

1. Turn off the Clarus 500 GC. Allow the injector to cool until it is slightly warm to the touch.
2. Disconnect and remove the column from the injector.
3. Loosen the two screws the secure the Clarus 500 GC top cover and raise the top cover until it locks in the raised position.
4. Remove the top cover from the PSS injector. Mark the position of the injector on the metal deck with a pencil.
5. Remove the screw that secures the fan assembly to the PSS injector, then remove the fan assembly (see the following figure).
6. Remove the two screws that secure the PSS injector to the metal deck.
7. Remove the cable clamps that hold the heater and sensor wires and the gas tubing (see the following figure).
8. Carefully lift the PSS injector out of the Clarus 500 GC. Invert the PSS injector and remove all of the broken quartz liner from it.
9. Reinstall the PSS injector to the AutoSystem and reinstall the fan assembly.
10. Lower the Clarus 500 GC top cover and properly align the PSS injector with the top cover before you completely tighten the PSS injector mounting screws.

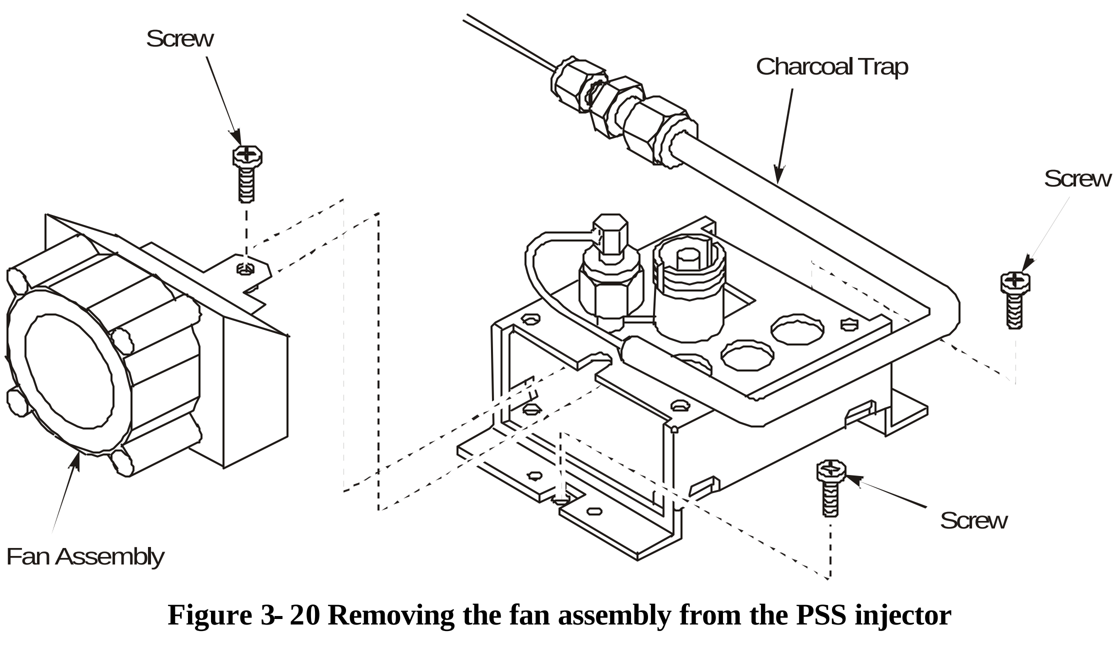


Figure 3- 20 Removing the fan assembly from the PSS injector

CAUTION	**To prevent autosampler needle damage after the Clarus 500 GC top cover has been opened and closed, verify that the autosampler tower is aligned with both injectors.** *Do this by manually rotating the autosampler tower and stopping over injector 1 and injector 2 to check that the vial locator is in the center of the septum cap. If the vial locator does not align with the center of the septum cap, loosen the two hold-down screws that secure the top cover (see Figure 15-22). Then move the top cover so that the vial locator is aligned with the center of the septum cap. Secure the Clarus 500 GC top cover in this position by tightening the two screws.*

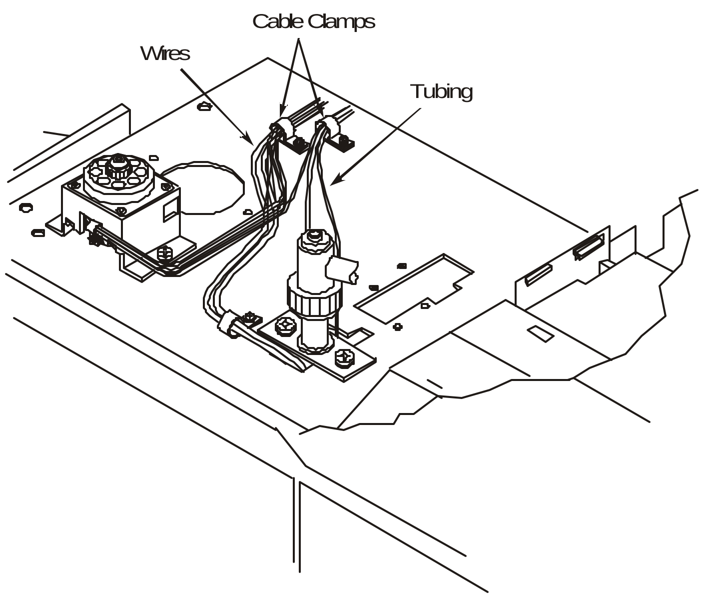


Figure 3-21 Location of the cable clamps that secure the wires and tubing

Changing the Charcoal Trap or Replacing Charcoal on the Split/Splitless CAP and PSS Injectors

The charcoal trap will eventually become saturated. When this occurs, ghost peaks and changes in split ratio will be observed.

Removing a Charcoal Trap

1. Turn off the Clarus 500 GC. ***Allow the injectors/detectors to become cool to the touch.***

2. Loosen the two hold-down screws on the top cover of the Clarus 500 GC (see following figure) and raise the top cover until the cover locks in the raised position.

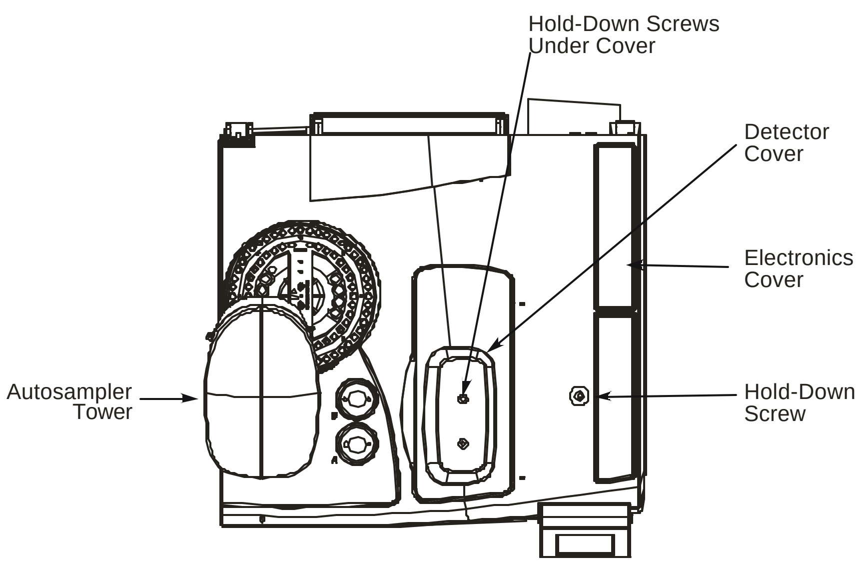


Figure 3- 22 Location of the top cover hold-down screws

3. Remove the septum cap, then remove the top cover from the injector.

4. Loosen the threaded collar using the 1/4-inch spanner (P/N N610-1359) provided, then remove the threaded collar.

5. Replace the septum cap on the injector.

6. Pull the septum cap upwards to remove the septum purge assembly.

7. Using an 1/8-inch wrench, loosen the fittings that are connected to the charcoal trap and remove the charcoal trap (see the following figure). If you have a PPC charcoal trap, use a 1/4-inch wrench to loosen the fitting that connects the trap to the transducer.

Installing a New Charcoal Trap

1. Install a new PPC version charcoal trap (P/N N610-0331) or the manual pneumatics version charcoal trap (P/N N610-0275), or just replace the charcoal in your current trap.

For Manual Pneumatics (P/N N610-0275)

Replace the charcoal by removing the glass wool plug from the 1/4-inch tubing end of the charcoal filter. Empty the old charcoal from the charcoal filter. Repack the charcoal filter with activated charcoal (30-60 mesh, P/N 0330-0904). Plug the end of the charcoal filter with a small piece of silanized glass wool. Reinstall the charcoal trap.

For PPC Pneumatics (P/N N610-0331)

Replace the charcoal by removing the glass wool plug from the 1/4-inch tubing end. Empty the old charcoal and the glass wool plug at the 1/8-inch end. Push a small glass wool plug from the 1/4-inch end to the end of the 1/4-inch tube (near the 1/8-inch end) then fill with charcoal (P/N 0330-0904) and plug the end with a small piece of silanized glass wool.

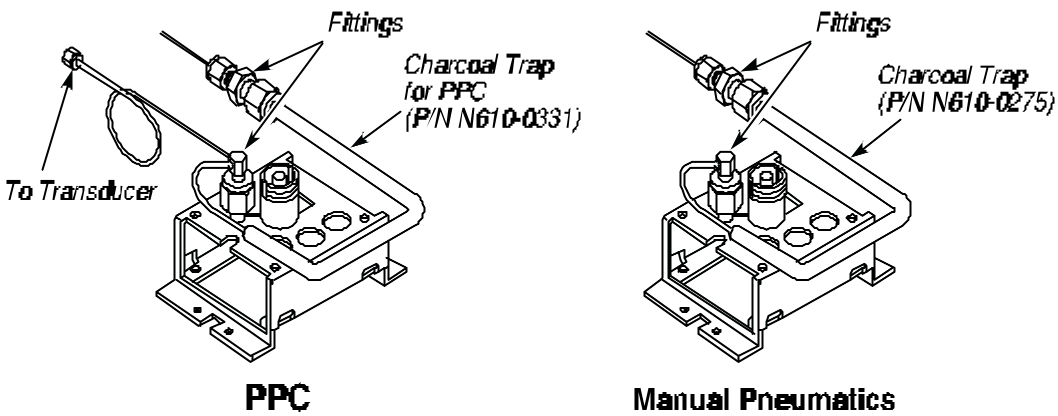


Figure 3- 23 Charcoal Trap on an injector controlled by PPC (left) or manual pneumatics (right)

2. Replace the septum purge assembly and remove the septum cap.

3. Replace the threaded collar and tighten it using the spanner.

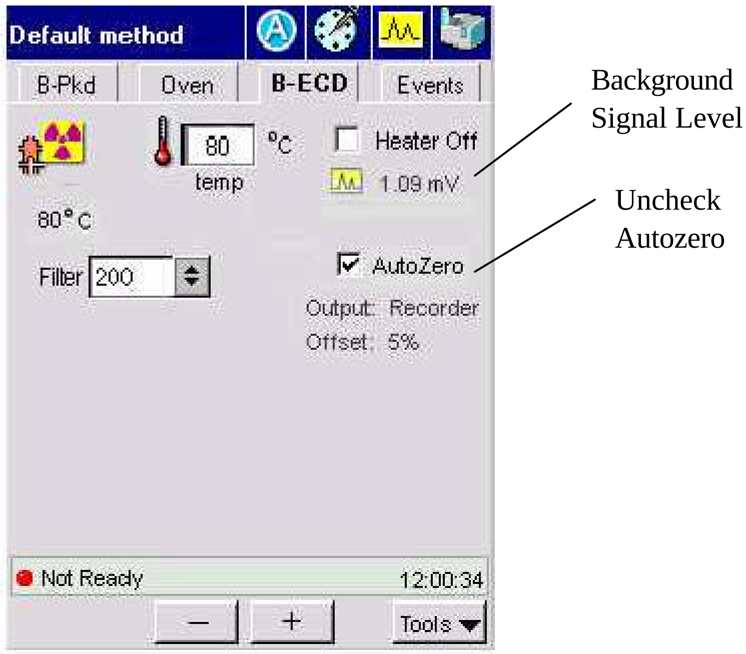
4. Replace the injector cover then replace the septum cap.

5. Lower the Clarus 500 GC top cover and tighten the two hold-down screws.

CAUTION	**To prevent autosampler needle damage after the Clarus 500 GC top cover has been opened and closed, verify that the autosampler tower is aligned with both injectors.** *Do this by manually rotating the autosampler tower and stopping over injector 1 and injector 2 to check that the vial locator is in the center of the septum cap. If the vial locator does not align with the center of the septum cap, loosen the two hold-down screws that secure the top cover (see Figure 3-22). Then move the top cover so that the vial locator is aligned with the center of the septum cap. Secure the Clarus 500 GC top cover in this position by tightening the two screws.*

ECD Maintenance

If you observe that the ECD background is higher than normal for your operating conditions, the cell could be contaminated. You can view the ECD background reading from the Clarus 500 GC touch screen by selecting the signal tab in the ECD tab. Make sure the **Autozero** box is checked off. .Under normal operating conditions, the ECD background will be up to 7 mV.



Screen 3- 2 B-ECD Tab

If you suspect cell contamination, first eliminate column bleed by lowering the oven temperature to ambient. If bleed is not the problem and the high background coincided with changing the carrier gas tank, the carrier gas may be contaminated. To check for this condition:

1. Cool the ECD to < 100° C.

2. Remove the column from the ECD, then cap the ECD with a 1/8” Stainless Steel plug (P/N 0990-3098).

3. Increase the make-up flow. If the background remains the same as the make-up flow increases, the carrier gas could be contaminated. (The ECD is a concentration-sensitive detector. Increasing the make-up gas flow would normally dilute the contamination and cause a decrease in the background.) If bleed or carrier gas contamination is not the problem, bake the ECD using the following procedure.

Baking the ECD

1. Remove the column, then cap the ECD with a plug (P/N 0990-3098).

2. Increase the flow of make-up gas to 60 mL/min and raise the detector temperature to 450 °C.

3. Bake the system until the background returns to normal levels. This could take from hours to several days.

NOTE: *It may also help to remove the column and increase the oven temperature to 450 °C to bake out the lower portion of the ECD body.*

Changing the Charcoal Traps

The ECD is shipped with charcoal traps (P/N N660-0037) installed in the make-up and injector pneumatics lines to remove contamination from the needle valve, flow controller, or pressure regulator. The traps should be replaced periodically.

To change charcoal traps:

1. Turn off the Clarus 500 GC and allow the injectors/detectors to cool.

2. Loosen the two hold-down screws on the Clarus 500 GC top cover (see Figure 22) and raise the top cover until it locks in the raised position.

3. Disconnect the charcoal traps from the make-up gas and injector lines.

4. Install new charcoal traps.

Cleaning the ECD Anode

WARNING

THE FOLLOWING PROCEDURE MUST BE PERFORMED ONLY AT LABS THAT HOLD A SPECIFIC NRC LICENSE, NOT A GENERAL LICENSE. ALL OF THE MATERIALS USED TO CLEAN THE ANODE MUST BE DISPOSED OF IN ACCORDANCE WITH THE NRC REGULATIONS REGARDING RADIOACTIVE MATERIAL.

NOTE: *If a dirty or contaminated ECD is suspected, try baking out the detector before using this procedure.*

NOTE: *Wear plastic or rubber gloves when cleaning the ECD anode.*

To clean the ECD anode:

1. Turn off the ECD heater and allow the system to cool to room temperature.
2. Unscrew the knurled ring and lift out the anode assembly (see the following figure).
3. Place the collector assembly on top of a beaker of hexane with the anode tube submerged and soak for several minutes. **DO NOT** submerge the side arm in the hexane; submerge only the anode.
4. Remove the anode assembly and wipe it dry with a tissue.
5. Replace the anode assembly, then tighten the knurled ring.
6. Turn on the detector temperature and observe that the background signal has returned down to a normal level.

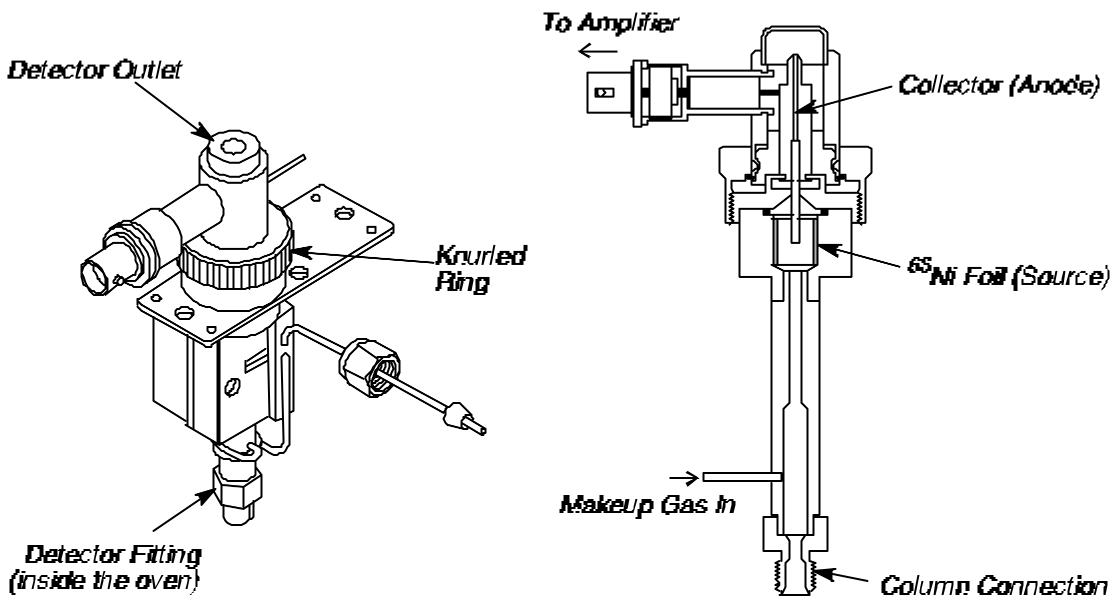


Figure 3- 24 Isometric view and cross section view of the ECD

Wipe Testing an ECD Cell

CAUTION	*Until the results of the wipe test are known, use caution and suitable protection when handling the cell and equipment in contact with it. Wear disposable plastic or rubber gloves when performing this test.*

It is strongly recommended that you become familiar with the NRC regulation covering the use of Nickel-63, as well as any other national, state, or local requirements.

To perform the wipe test:

1. Turn the instrument off and allow the detector to become cool to the touch.

2. Gain access to the detector by lifting the detector cover (see the following figure).

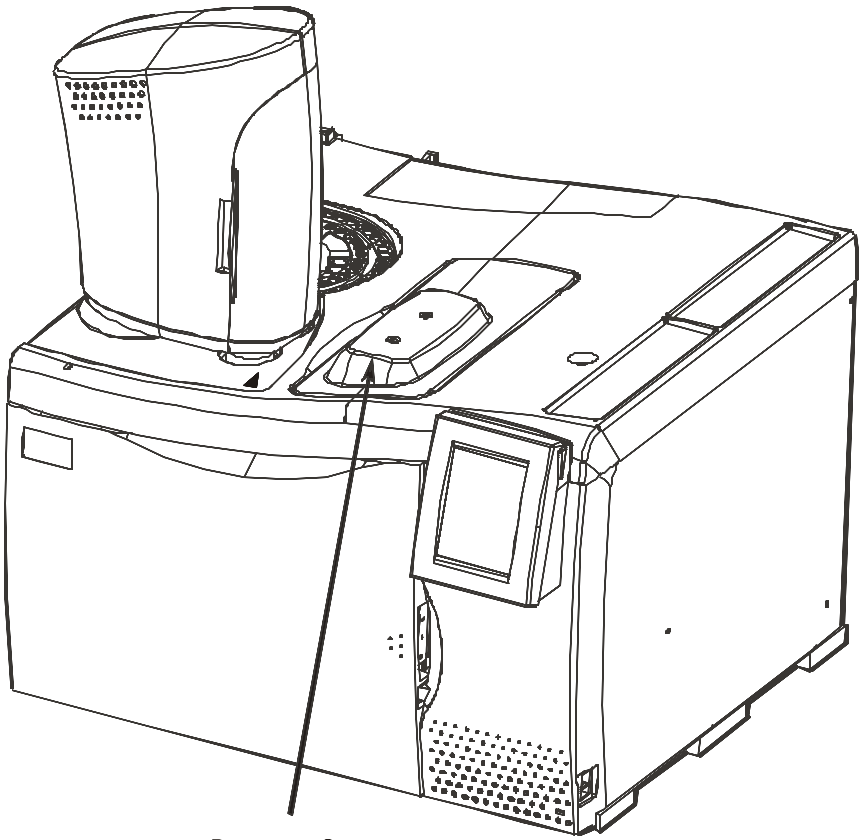


Figure 3- 25 The detector cover

3. Remove the two screws holding down the ECD insulating cover, then remove the insulating cover (see the following figure). (Removing the insulating cover exposes the knurled ring and detector outlet.)

WARNING

DO NOT DISMANTLE THE ECD CELL!

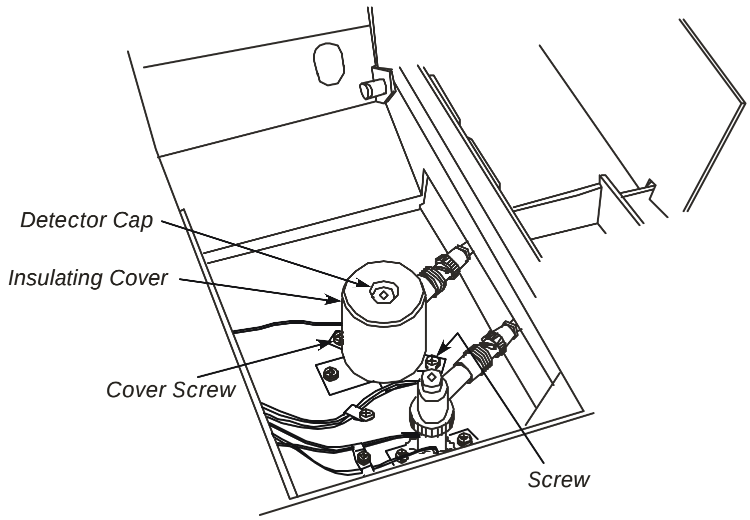


Figure 3- 26 ECD insulating cover

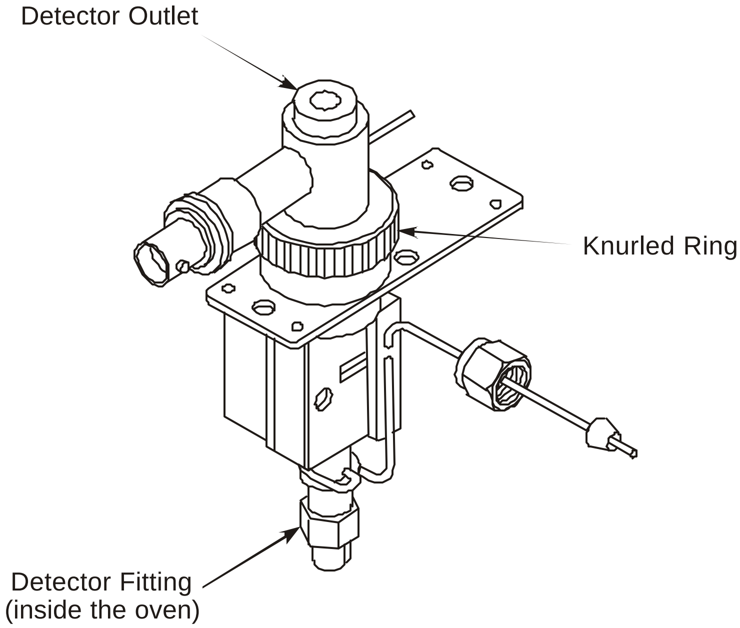


Figure 3- 27 ECD surfaces to wipe

4. Using the instructions included with the wipe-test kit (P/N 0009-1667) supplied with the detector, wipe the external surfaces of the items shown in the previous figure with the "low Activity Source" filter papers or stick swabs:
   - Detector outlet
   - Knurled ring
   - Detector fitting

CAUTION	*Do not remoisten the wipe-test paper once it has been moistened or any part of the ECD has been wiped.* ***Do not allow any of the wipe-test solution to enter the cell.***

5. Place the wipe-test paper in the container provided in the wipe-test kit. Include a data sheet stating that the wipe test was performed on a PerkinElmer electron capture detector cell (P/N N610-0063) and the date of the test.

6. Request a new wipe-test kit to be sent with the test results.

7. Return the envelope to:

National Leak Test Center
P.O. Box 486
North Tonawanda, New York 14120
Tel: 716-693-0550

NOTE: *The sensitivity of the wipe test is 0.0001 mCi.*

Disposal and Refurbish/Refoil of an ECD Cell

If it is necessary to dispose of an ECD cell, contact:

Nuclear Radiation Development Corp.
2937 Alt. Blvd. North
Grand Island, NY 14072
Tel: (716) 773-7634
Fax: (716) 773-7744

for disposal instructions and current fees.

In addition, report the ECD cell disposal to:

PerkinElmer Instruments LLC
Radiation Safety Officer
710 Bridgeport Ave.
Shelton CT 06484

and

Nuclear Material Safety and Safeguard
U.S. Nuclear Regulatory Commission
Washington, DC 20251

and/or

your state and local agency, if applicable.

FID Maintenance

FID maintenance consists of replacing the FID jet, cleaning the FID jet, replacing an o-ring in the collector, and cleaning the FID collector and cap.

Replacing a FID Jet

NOTE: *The FID jet rarely becomes plugged. However, if plugging occurs, it is usually sample dependent. It is recommended that you replace a plugged jet rather than clean it.*

To replace the FID jet:

WARNING

Before you begin, extinguish the flame via the keyboard by setting the hydrogen flow to "0" or if you have manual pneumatics, turn the outer knob on the hydrogen needle valve completely clockwise.

1. Turn off the Clarus 500 GC power.

WARNING

The FID is hot and can cause serious burns! *To prevent injury, allow the detector to become cool to the touch.*

2. Open the detector cover.

3. Remove the polarizing cable from the pin on the polarizing filter assembly.

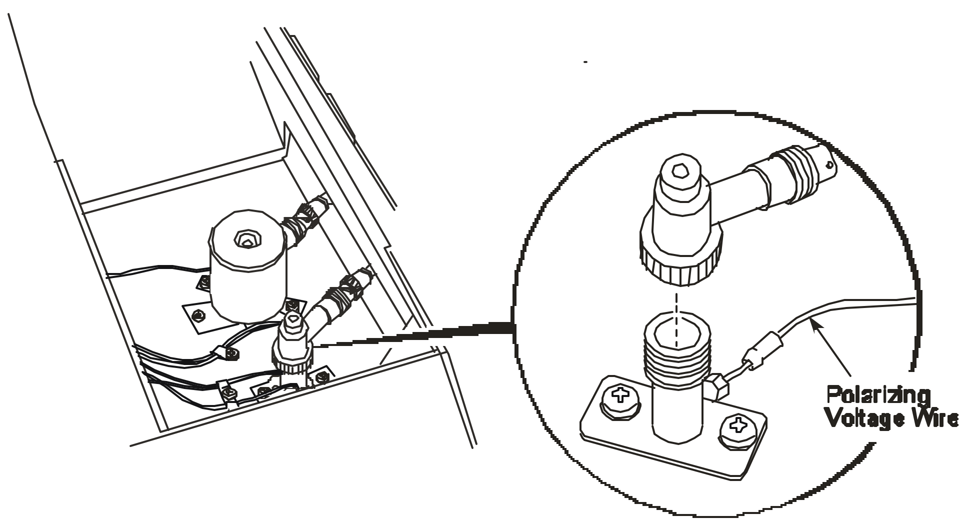


Figure 3- 28 FID polarizing voltage wire

4. Loosen the knurled ring, then lift the FID collector off of the FID base and put it out of the way.

5. Insert the nozzle removal tool (P/N N610-3188) into the FID base and lift the nozzle out of the FID base. Do not unscrew it.

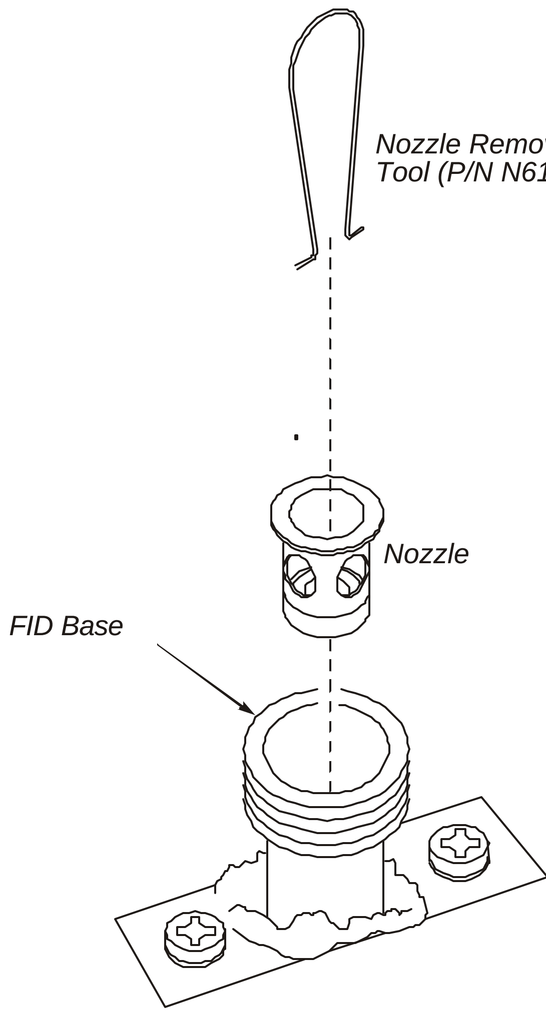


Figure 3- 29 Removing the nozzle assembly from the FID base

6. Insert a 1/4-inch nutdriver into the FID base to engage the 1/4-inch nut on the FID jet assembly.

7. Loosen the FID jet assembly (turn the 1/4-inch nut counterclockwise) and pull it out of the FID. You should be able to pull out the FID jet assembly with the nutdriver. If not, then pull out the FID jet assembly with a pair of forceps or needle nose pliers.

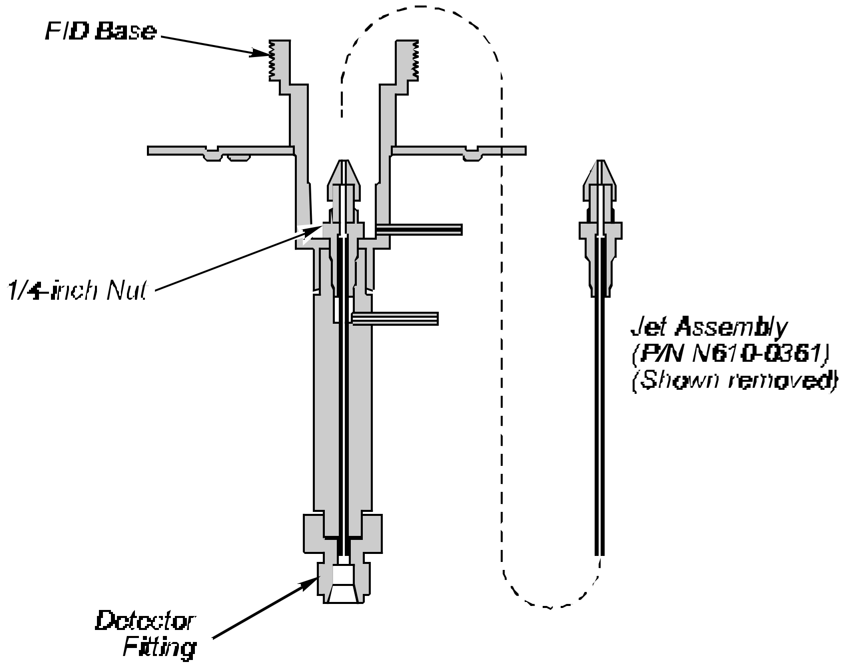


Figure 3- 30 Cross section view of the FID

8. Insert a new FID jet assembly (P/N N610-0361) and secure it in place with the 1/4-inch nut driver.

9. Insert the nozzle assembly into the FID base until you feel it bottom.

10. Insert the FID collector back on the FID base and tighten the knurled ring.

11. Reconnect the polarizing wire to the polarizing pin on the FID collector.

12. Turn on the FID heater and allow it to return to the temperature setting.

13. Re-ignite the flame.

Cleaning a FID Jet

Although it is not recommended, you may try to clean the FID jet as a last resort. Use one or both of the following techniques:

- Based on your analytical application, wash the jet with an appropriate solvent.
- Dislodge the plug with a fine wire such as a syringe needle, then blow out loosened debris using compressed air.

Replacing the O-Ring in the FID Collector

Since the O-ring in the FID collector is in contact with the heated surface of the FID base, you will notice over time that it has become brittle or broken and must be replaced.

WARNING

The FID is hot and can cause serious burns! *To prevent injury, extinguish the FID flame, turn off the FID heater, and allow the detector to become cool to the touch.*

To replace the O-ring in the FID collector:

1. Remove the polarizing voltage wire from the polarizing pin (Figure 28).
2. Loosen the knurled ring, then lift the FID collector off of the FID base.
3. Remove the old O-ring (see the following figure) from the FID collector and insert a new O-ring (P/N 0990-2143).
4. Insert the FID collector back on the FID base and tighten the knurled ring.
5. Connect the polarizing wire to the polarizing pin on the FID collector.
6. Turn on the FID heater and allow it to return to the temperature setting.
7. Re-ignite the flame.

Cleaning the FID Collector and Cap

Occasionally clean the collector and cap if you are running samples that may generate soot, for example, carbon disulfide.

WARNING

The FID is hot and can cause serious burns! *To prevent injury, extinguish the FID flame, turn off the FID heater, and allow the detector to become cool to the touch.*

To clean the FID collector:

1. If necessary, disconnect the amplifier coaxial cable, and other wires from the FID collector.
2. Loosen the knurled ring on the collector and remove the collector from the FID base.
3. Using a pipe cleaner, wipe the inside of the collector and then the outside of the collector near the top.
4. Wash the collector with a laboratory soap such as Alconox. Try to keep the side-arm dry.
5. Air dry the collector, replace it on the FID base, and tighten the knurled ring to secure the collector in place.
6. If you disconnected the amplifier coaxial cable and any wires from the FID collector, reconnect them to the FID collector.

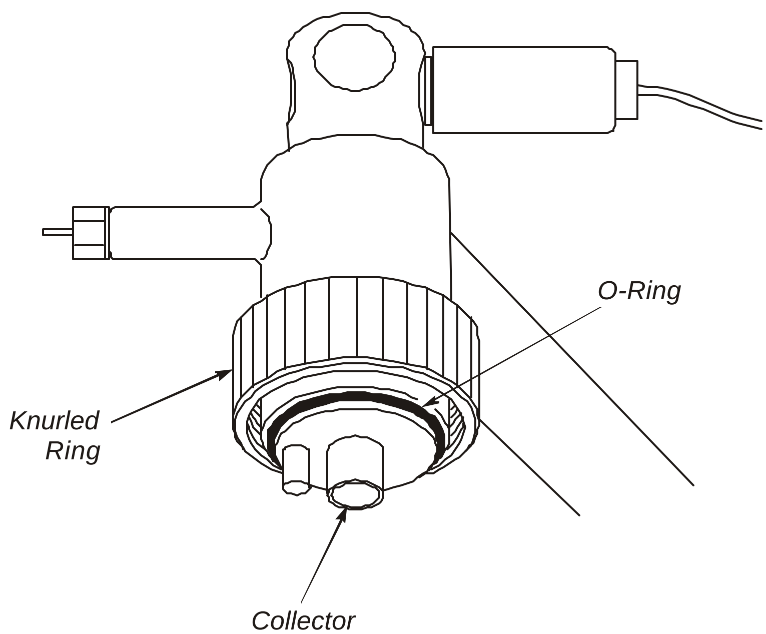


Figure 3-31 View of the FID collector and O-ring

PID Maintenance

Routine PID maintenance consists of the following:

- Changing PID lamps
- Cleaning PID lamp windows
- Changing PID lamp window seals and positioning disks

Procedures for performing these tasks follow.

WARNING	***The PID operates at a high temperature and voltage.*** *To avoid injury, before attempting maintenance procedures, disconnect the PID from line power and allow it to cool to room temperature.*

CAUTION	*To avoid contamination, wear rubber gloves or use tweezers when disassembling the PID.*

Changing a PID Lamp

To change a PID lamp:

1. Disconnect the instrument from line power.

2. Allow the system to cool to room temperature.

3. Place a piece of paper towel to the right of the detector area (see shaded area in the following figure) to cover the space between the oven skin and the electronics compartment of the Clarus 500 GC. This will prevent the lamp housing fasteners (see next step) from falling into the instrument when they are loosened.

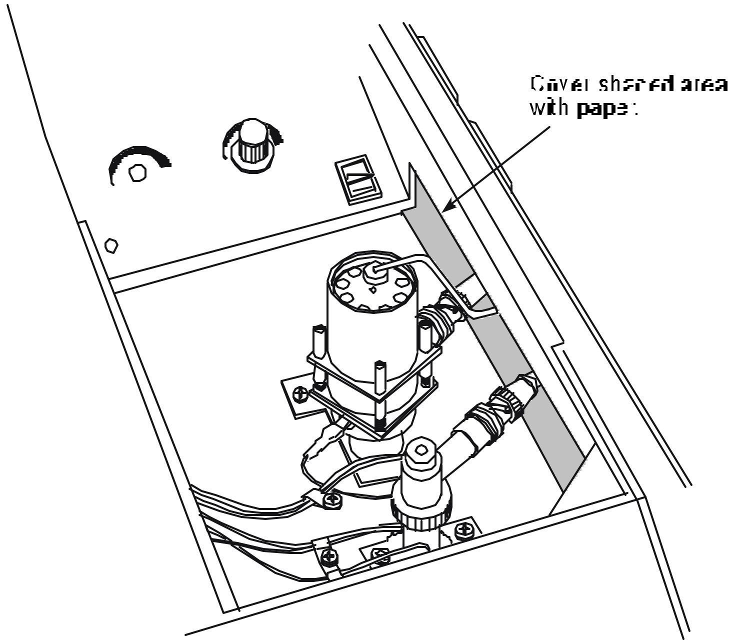


Figure 3-32 Placing a towel in the space between detector and electronics compartment

4. Please examine the previous figure. While pressing down on the top of the PID (lamp housing), remove the four fasteners securing the lamp housing to the detector and place them in a safe place.

5. Slowly ease up on the lamp housing. As you do, the spring inside the housing (see the following figure) will push the housing up. Pull off the lamp housing and reveal the spring. The spring is quite powerful and may shoot off if the lamp housing is removed too quickly.

6. Remove the spring.

7. Replace the worn out or damaged lamp, window seal, and positioning disk.

8. Replace the spring and housing.

9. While holding the lamp housing down tightly, replace the four fasteners previously removed.

10. Remove the paper inserted in step 3.

Cleaning PID Lamp Windows

CAUTION	*Wear rubber gloves to avoid contaminating the lamp window.*

To clean PID lamp windows:

1. Remove the lamp using steps 1 through 7 in the previous procedure.

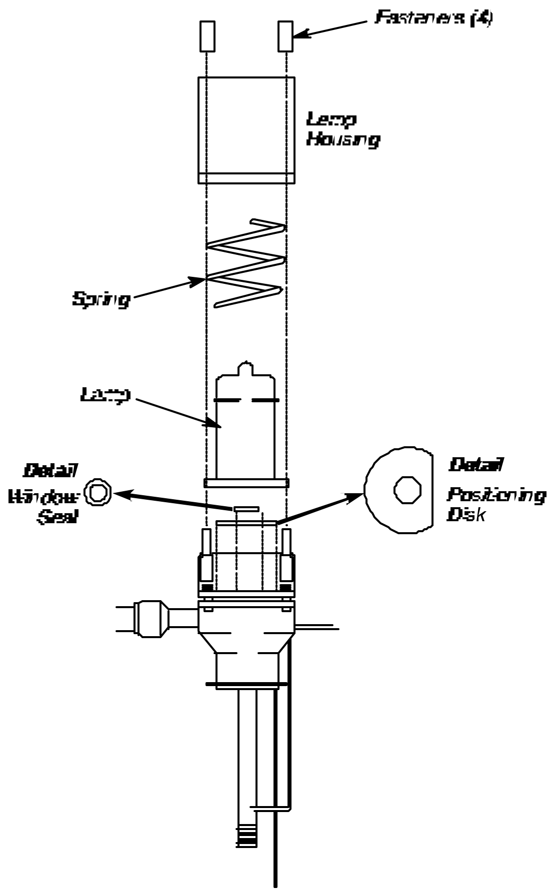


Figure 3- 33 Exploded view of the PID

2. First clean the window with a moist, clean Kimwipe or other lint-free tissue. Use a gentle, circular motion.

3. Complete the cleaning by using a tissue moistened with cleaning compound supplied (P/N 0330-2775).

4. Rinse the window using a warm (80 °C) solution of a mild dishwashing detergent in water.

5. Rinse with warm (80 °C) distilled water.

6. Dry with air or a lint-free tissue.

7. Ensure that a new lamp window seal and a new positioning disk are in place (see Figure 3- 33). Then position the lamp over the window seal, place the spring over the lamp, and place the housing over the lamp and spring.

8. While holding the lamp housing down tightly, replace the four fasteners previously removed.

Changing PID Lamp Window Seals and Positioning Disks

CAUTION	*New seals and positioning disks must be baked (preferably in a vacuum oven) before use for one to two hours at 240 °C.*

To change PID lamp window seals and positioning disks, refer to the previous figure and follow this procedure:

1. Wearing rubber gloves to avoid contaminating the lamp window, remove the lamp using the appropriate steps in the previous procedure.
2. The lamp window seal will either be in the center of the positioning disk or stuck to the lamp window. Using a pair of tweezers, remove the lamp window seal.
3. Lift out the positioning disk.
4. Replace the positioning disk with a new one, making certain that you do not crease or bend it.
5. Place a new lamp window seal in the center of the positioning disk. Viewing the detector from the end, make certain that the opening in the seal is lined up with the ion chamber opening. The whole window seal must rest on the gold-plated ceramic portion of the ionization chamber.
6. Position the lamp over the seal, place the spring over the lamp, and place the housing over the lamp and spring.
7. Secure the lamp housing with the four fasteners.

Leak-Test

You can check for leaks by turning on the make-up gas and checking the flow rates at the detector inlet and outlet to make certain they are equal.

ElCD Maintenance

ElCD maintenance consists of replacing the ElCD reaction tube and cleaning ElCD cells. It is good practice to periodically replace solvent to avoid possible contamination due to increasing concentrations of ionic and other materials. Discard the first 50 – 100 mL of solvent (when replacing the solvent or resin tube) before cycling solvent through the cell.

Replacing the ElCD Reactor Tube

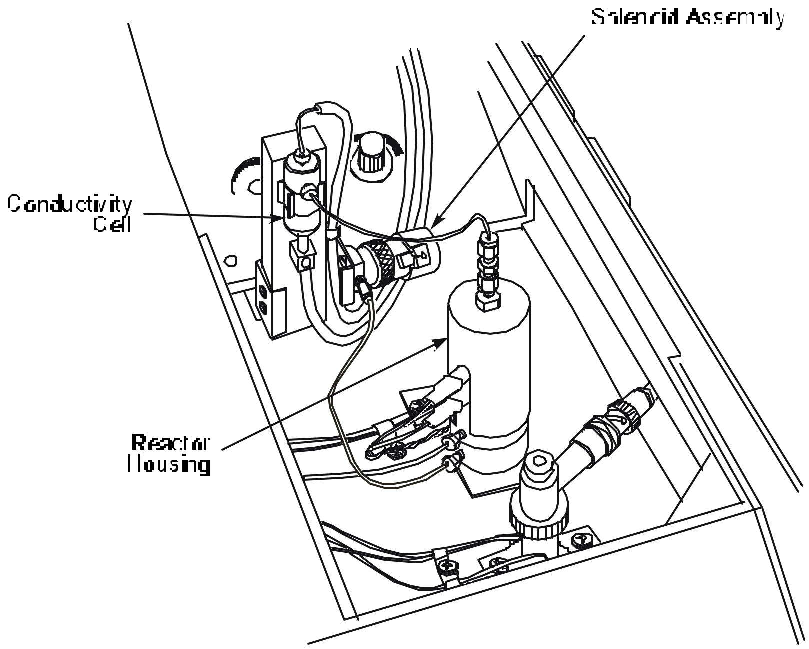


Figure 3- 34 Reactor tube location on the ElCD

1. Turn off the controller and reactor. Allow the reactor to cool to room temperature.

2. Referring to the previous figure, locate the upper hex nut on top of the reactor. This nut is attached to a Teflon tube by means of a union. While holding the upper hex nut with one wrench, loosen the union hex nut with another wrench. You will then be able to remove the union and Teflon tube as one piece, exposing the reactor tube.

3. Loosen and remove the screw on the side of the reactor housing. Gently turn the reactor housing counterclockwise as far as possible. Then gently pull the reactor tube out, twisting it back and forth if necessary.

4. Locate the end of the new reactor tube that has a cross-drilled hole. Gently insert this end through the seal until it bottoms, then turn the reactor housing clockwise as far as possible. Secure the reactor housing by replacing the screw on the side.

5. Reattach the Teflon tube union and tighten the hex nut loosened in step 2.

6. Set the carrier gas and check for leaks using the procedures in “Setting up the ElCD,” in the *Clarus 500 GC Users Guide.*

Replacing the Sealing Ring

The sealing ring should be replaced if you have difficulty either removing or replacing a reactor tube (see previous page).

To replace sealing rings:

1. Turn off the controller and reactor. Allow the reactor to cool to room temperature.

2. Refer to previous figure and locate the upper hex nut on top of the reactor. This nut is attached to a Teflon tube by means of a union. While holding the upper hex nut with one wrench, loosen the union hex nut with another wrench. You will then be able to remove the union and Teflon tube in one piece, exposing the reactor tube.

3. Loosen and remove the screw on the side of the reactor housing. Gently turn the reactor housing counterclockwise. Then lift the reactor housing from the assembly and place it to one side.

4. Using a hollow spin-tight wrench, remove the swaging screw and lift out the reactor tube with the graphite/Vespel ferrule and metal ring.

5. Insert the new graphite/Vespel ferrule (P/N N660-1084) and metal ring (P/N N660-1085).

6. Locate the end of the new reactor tube that has a cross-drilled hole. Gently insert this end through the seal until it bottoms, then replace the swaging screw and tighten it. Replace the reactor housing, turning it clockwise as far as possible. Secure the reactor housing by replacing the screw on the side.

7. Reattach the Teflon tube union and tighten the hex nut loosened in step 3.

8. Set the carrier gas and check for leaks using the procedures in “Setting up the ElCD,” in the *Clarus 500 GC Users Guide.*

9. Cleaning the Conductivity Cell

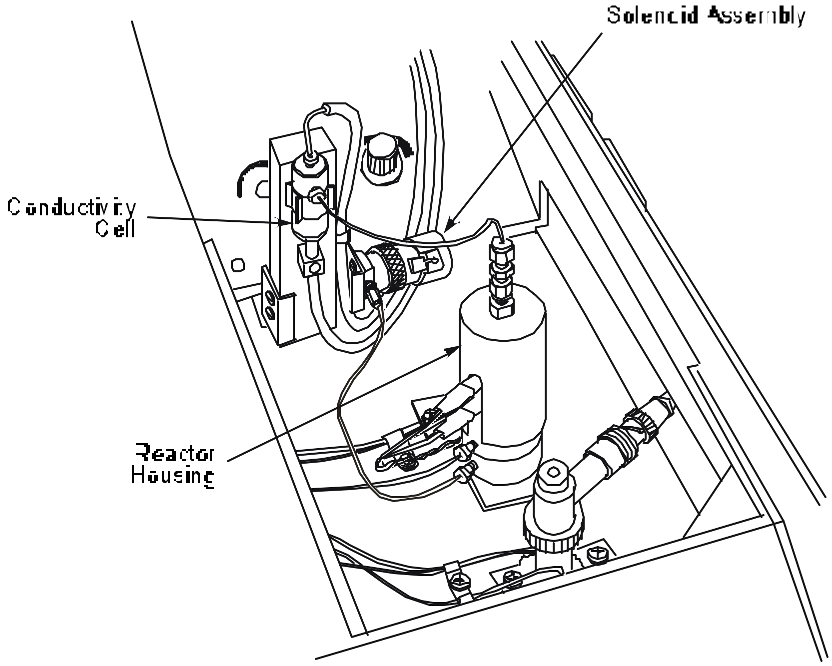


Figure 3- 35 Location of the ElCD conductivity cell

To clean the conductivity cell, refer to the following figure and follow this procedure:

1. Turn off the controller and the hydrogen.
2. Disconnect the solvent inlet line from the top of the cell and insert it into the solvent reservoir.
3. Disconnect the gas inlet line from the side of the cell.
4. Pull the cell body away from the cell mounting bracket and slip off the solvent return line from the bottom of the cell.
5. Remove the screws from the bottom of the cell.
6. Pull out the electrode assembly.

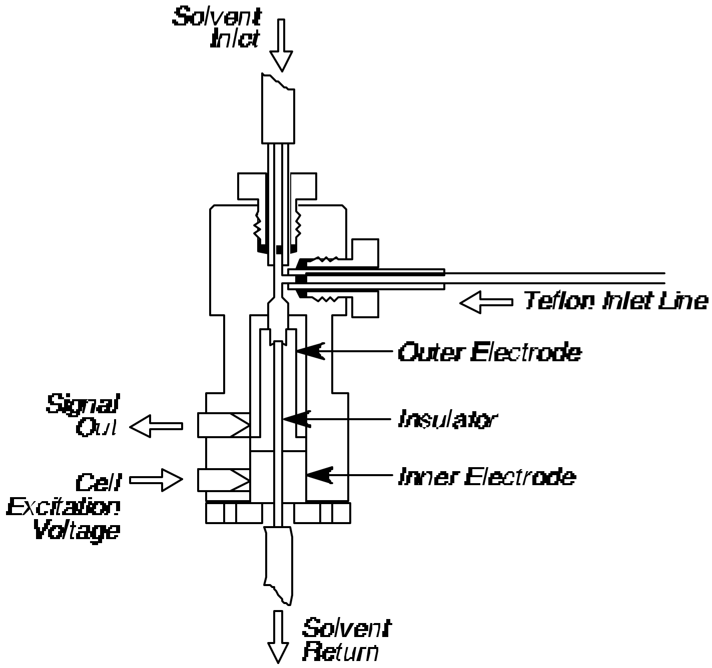


Figure 3- 36 Cross section view of the ElCD conductivity cell

7. Pull out the inner electrode and place it in a 100-mL beaker.
8. Cover the inner electrode with distilled water and sonicate for 10 minutes. Discard the water.
9. Repeat steps 7 and 8 using n-propanol.
10. Reassemble and install the cell, following steps 7 back to 1.

NPD Maintenance

NPD maintenance consists of changing and conditioning the NPD bead and replacing a NPD jet.

Changing the NPD Bead

The Nitrogen Phosphorus Detector utilizes a glass bead containing alkali metal (single bead P/N N612-0092 or package of five P/N N612-0093) to detect organically bound nitrogen and phosphorus compounds. In time, the bead will not respond, or the wire on which the bead is placed may break. The bead is considered a consumable part.

If you cannot achieve a response at your normal operating background (0.25 mV or greater with the detector range set to x1), increase the potentiometer setting (try higher settings). If you cannot achieve a response at higher settings, the bead must be replaced.

NOTE: *An indication of a broken bead wire is that the bead does not glow when you increase the bead potentiometer setting (by turning it clockwise).*

To change the NPD bead:

1. Lift open the detector cover.

2. Locate the bead potentiometer.

   If the NPD is installed in the front detector position, the bead potentiometer is located on the left side of the detector panel. If the NPD is installed in the rear detector position, the bead potentiometer is located on the right side of the detector panel.

3. Turn the NPD bead off by turning the potentiometer counterclockwise**.**

NOTE: *If two NPDs are installed, turn both beads off, even if you are only replacing one bead.*

4. Turn off the Clarus 500 GC.

WARNING

The gases can remain on during this procedure, but the detector should be cool to the touch to protect you from getting burned.

5. Remove the NPD collector assembly (see the following figure) by loosening its knurled ring and lifting the collector assembly upward.

CAUTION	*Lift the collector assembly straight up so that it does not chip the ceramic header of the bead assembly. You may find it easier to remove the coaxial cable from the collector assembly before you remove the collector assembly from the detector body (see the following figure).*

6. Remove the screw that secures the bead transformer assembly to the top of the Clarus 500 GC oven.

7. Carefully remove the bead portion from the detector body by lifting the bead transformer assembly straight up and out of the detector body.

8. Remove the bead assembly from the transformer assembly by unplugging it from the connector (see the following figure).

9. Plug a new bead assembly (P/N N612-0092) into the connector on the bead transformer. The connector is keyed so that the bead assembly can only be inserted one way.

10. Carefully insert the bead portion of the bead assembly in the detector body as shown in (see the following figure).

11. Secure the bead transformer to the top of the oven with the screw removed in step 6 of this procedure.

12. Replace the collector assembly on the detector body, and secure it by tightening the knurled ring. If the coaxial cable was removed, connect it to the collector assembly.

NOTE: *Check that the polarizing wire has not fallen off the detector. If it has, replace it (Figure 3-37).*

13. Turn on the Clarus 500 GC.

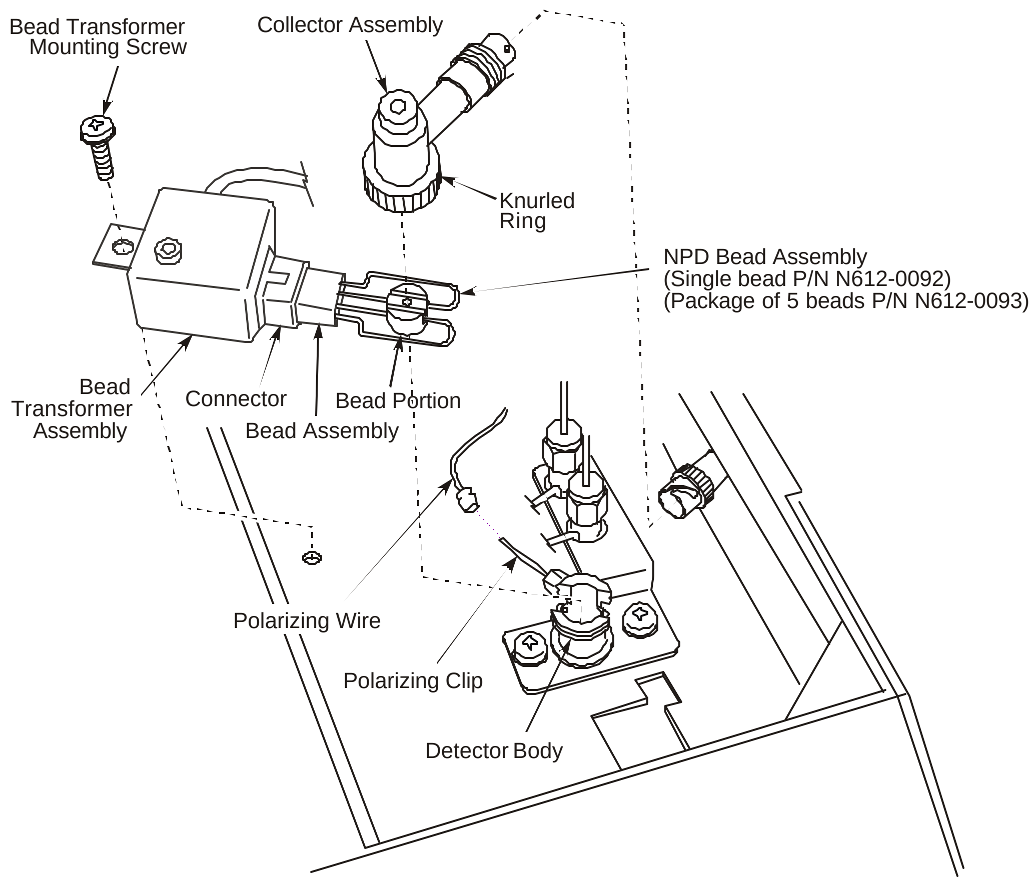


Figure 3- 37 Exploded view of the NPD bead assembly

Conditioning a New NPD Bead for Use with a Packed Column

CAUTION	*Never condition a NPD bead when a column is connected to the detector fitting. To properly condition the NPD bead, the column must be removed from the detector fitting and the detector fitting must be capped.*

1. Open the oven door and allow the oven to cool.

2. Loosen and remove the column nut from the detector fitting using a 7/16-inch wrench. Remove the column from the detector fitting.

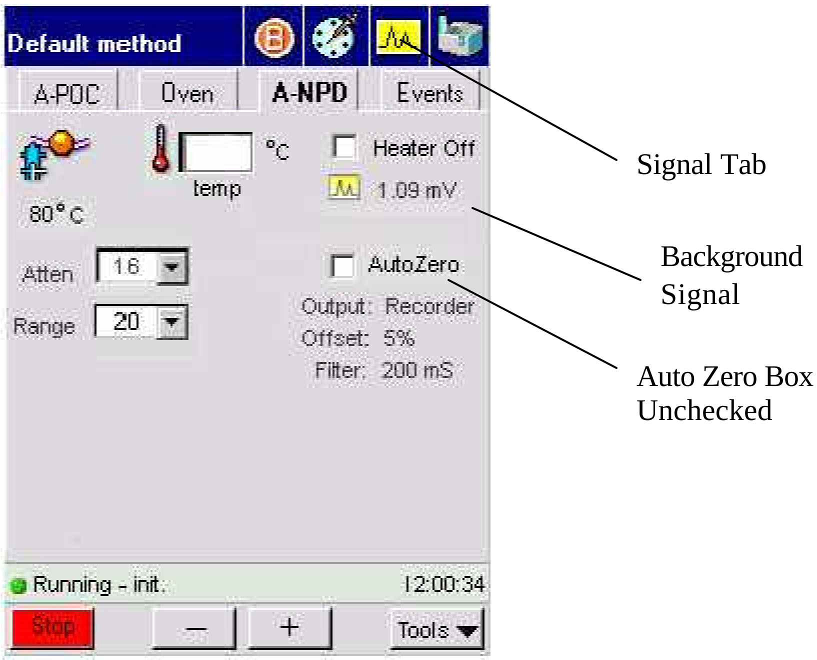
3. Install a 1/8-inch Swagelok plug (P/N N930-0061) on the detector fitting. Provide a leak-free seal by tightening the plug with a 7/16-inch wrench.

4. Close the oven door and continue to flow carrier gas through the column.

5. Set the hydrogen flow, air flow, and all temperatures to operating conditions.

6. Set the detector range to x1.

7. Check off the **AutoZero** box and select the signal tab to display the detector background.



Screen 3- 3 A-NPD Screen

When the bead is turned off, the background value should be 0 ±0.25 mV. Write down the background value with the bead off.

8. Open the detector cover and locate the bead potentiometer dial (see Figure 3-33).

   If the NPD is detector 1 (front position), the potentiometer is located on the left side of the panel. If the NPD is detector 2 (rear position), the potentiometer is located on the right side of the panel.

9. Turn the bead potentiometer dial clockwise to apply current to the bead. Slowly increase the setting to 700 on the dial.

   The millivolt reading on the autozero display will begin to increase. A maximum reading of 997.61 mV at a range setting of x1 is required to condition the bead.

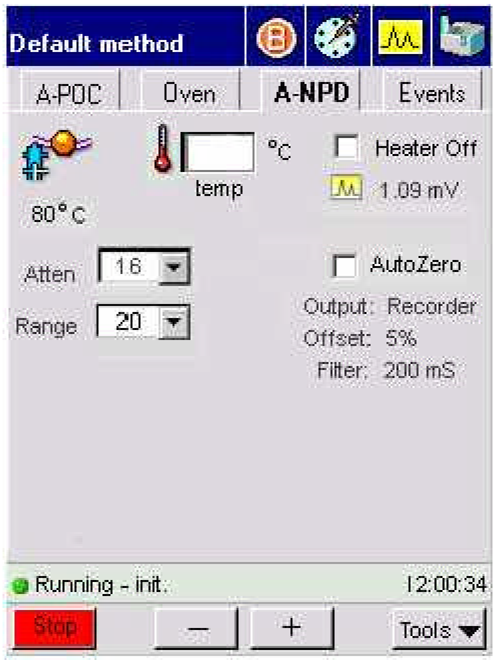
10. Monitor the display for about one minute at this setting. If the millivolt reading is less than 997.61, increase the bead potentiometer setting by an increment of 10 (to 710) and wait about one minute.

    Repeat this process until the bead potentiometer setting produces a maximum signal of 997.61 mV.

11. Allow the bead to "condition" at this setting for one hour. The background readout will drift downward during the process.

12. After conditioning the bead, lower the bead potentiometer dial setting to 600. Remove the Swagelok plug from the detector fitting and reinstall the packed column.

13. Make sure the column flow is properly set, check off the **AutoZero** box and select the signal tab to display the detector background produced by carrier gas flow. The bead background will be less due to cooling effects.



Screen 3- 4 A-NPD Screen

14. Turn the bead potentiometer dial clockwise until you achieve a reading of 0.25 mV above the "off" reading, with the detector range set to x1 as noted in step 7 of this procedure.

15. Once the system has stabilized, it is ready for operation.

If you are unable to achieve adequate sensitivity for your standard, increase the background of the NPD. Increasing intervals of 0.25 mV are recommended.

NOTE: ***1***. *The bead will be stable for several hours of operation but will drift in time. At the start of each day, adjust the background reading to the setting you are using and allow a few minutes for it to stabilize.*
2. *Due to the loss of alkali metal with use, the nature of the bead is to drift over time. We strongly recommend using an internal standard for quantitative analysis.*
3. *The bead can operate at higher background settings. The higher the setting the greater the signal and noise. Therefore, the signal to noise ratio will not increase dramatically. Operate at the lowest possible setting to achieve the required sensitivity. This will also prolong the life of the bead.*

CAUTION	*The bead should be turned off by turning the bead potentiometer dial fully counterclockwise before you turn off the Clarus 500 GC. Remember that the bead has a finite life. You can extend the bead life by turning the bead off when it is not in use for an extended period of time (for example, over the weekend).*

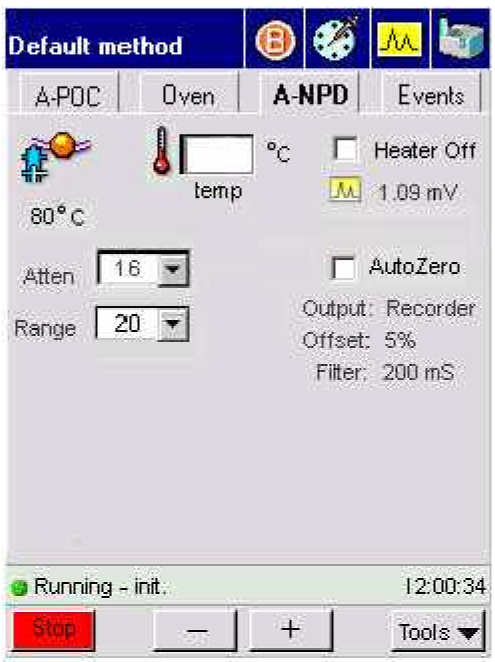
Conditioning a New NPD Bead for Use with a Capillary Column (0.53 mm i.d. and smaller)

1. Make sure the capillary column is installed in the detector and the carrier gas is flowing through the column. If the column is a wide-bore column, lower the column flow to 1.0 mL/min or less.

2. Set the hydrogen flow, air flow, and all temperatures to operating conditions.

3. Set the detector range to x1.

4. Check off the **AutoZero** box and select the signal tab to display the detector background.



Screen 3- 5 A-NPD Screen

When the bead is off, the background value should be 0 ±0.25 mV. Write down the background value with the bead off.

5. Open the detector cover and locate the bead potentiometer dial.

   If the NPD is detector 1 (front position), the potentiometer is located on the left side of the panel. If the NPD is detector 2 (rear position), the potentiometer is located on the right side of the panel.

6. Turn the bead potentiometer dial clockwise to apply current to the bead. Slowly increase the setting to 700 on the dial.

   The millivolt reading on the autozero display will begin to increase. A maximum reading of 997.61 mV at a range setting of x1 is required to condition the bead.

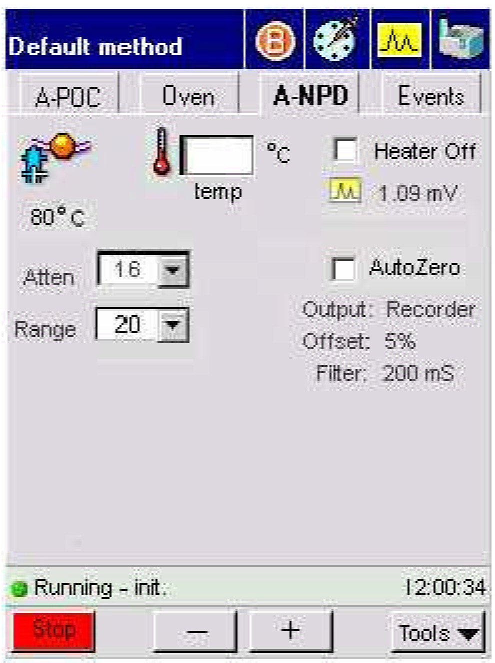
7. Monitor the display for about one minute at this setting. If the millivolt reading is less than 997.61, increase the bead potentiometer setting by an increment of 10 (to 710), and wait about one minute.

   Repeat this process until the bead potentiometer setting produces a maximum signal of 997.61 mV.

8. Allow the bead to "condition" at this setting for one hour. The background readout will drift downward during this process.

9. After conditioning the bead, readjust the column flow if necessary.

10. Check off the **AutoZero** box and select the signal tab to display the detector background.



Screen 3- 6 A-NPD Screen

11. Turn the bead potentiometer dial clockwise or counterclockwise until you achieve a reading of 0.25 mV above the "off" reading with the detector range set to x1 (see step 4 of this procedure).

12. Once the system has stabilized, it is ready for operation.

If you are unable to achieve adequate sensitivity for your standard, increase the background of the NPD. Increasing the background in intervals of 0.25 mV is recommended.

NOTE: ***1***. *The bead will be stable for several hours of operation but will drift in time. At the start of each day, adjust the background reading to the setting you are using and allow a few minutes for it to stabilize.*
2. *Due to the loss of alkali metal with use, the nature of the bead is to drift over time. We strongly recommend using an internal standard for quantitative analysis.*
3. *The bead can operate at higher background settings. The higher the setting the greater the signal and noise. Therefore, the signal to noise ratio will not increase dramatically. Operate at the lowest possible setting to achieve the required sensitivity. This will also prolong the life of the bead.*

CAUTION	*Before you turn off the Clarus 500 GC, turn off the bead by turning the bead potentiometer dial fully counterclockwise. Remember that the bead has a finite life. You can extend the bead life by turning the bead off when it is not in use for long periods of time (for example, over the weekend).*

Replacing an NPD Jet

NOTE: *The NPD jet rarely becomes plugged. However, if the jet does become plugged, it is usually because of the type of sample used. We recommend replacing a plugged NPD jet.*

To replace an NPD jet:

1. Turn off the bead by turning the potentiometer dial fully counterclockwise.
2. Turn off the Clarus 500 GC.
3. Turn off the hydrogen and air flows.
4. Open the detector cover.

WARNING	*Wait until the detector is cool to the touch to protect you from getting burned.*

5. Loosen the knurled ring on the collector assembly, then remove the collector assembly (see the following figure).

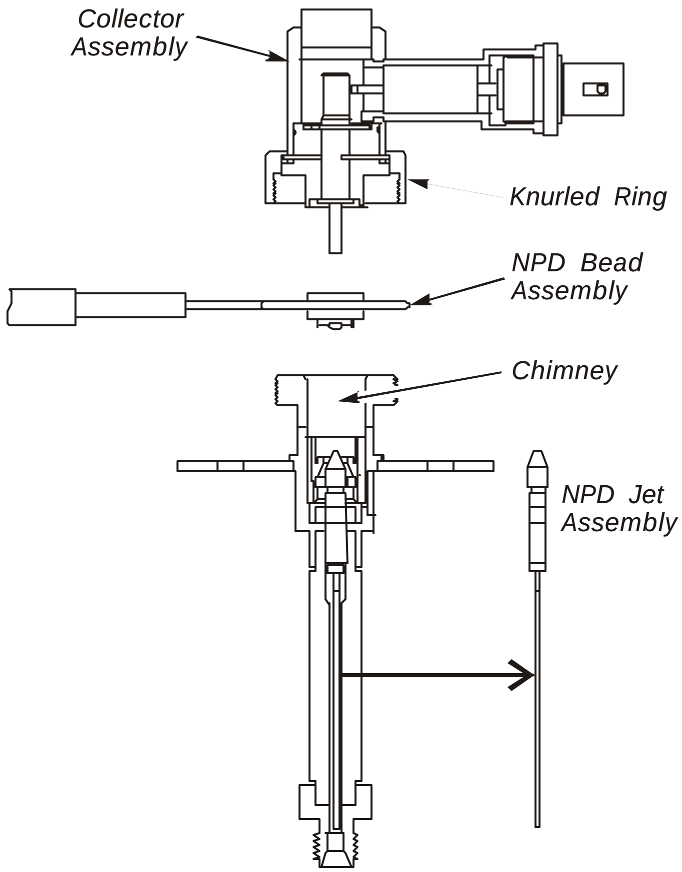


Figure 3-38 Location of the NPD jet assembly

CAUTION	*Lift the collector straight up so that it does not chip the ceramic header of the bead assembly. You may find it easier to remove the coaxial cable from the collector before you remove the collector (see the previous figure).*

6. Remove the screw that secures the bead transformer assembly to the top of the Clarus 500 GC oven.

7. Remove the bead assembly from the detector body by lifting the entire bead transformer assembly straight up and out of the detector body.

NOTE: *Carefully place the bead transformer assembly out of the way so that the bead is not damaged. You may want to remove (unplug) the bead assembly from the transformer in order to protect the bead.*

8. Remove the polarizing wire. This exposes a spring-loaded polarizing pin, which is a piece of wire about 3/8-inch long (see the following figure).

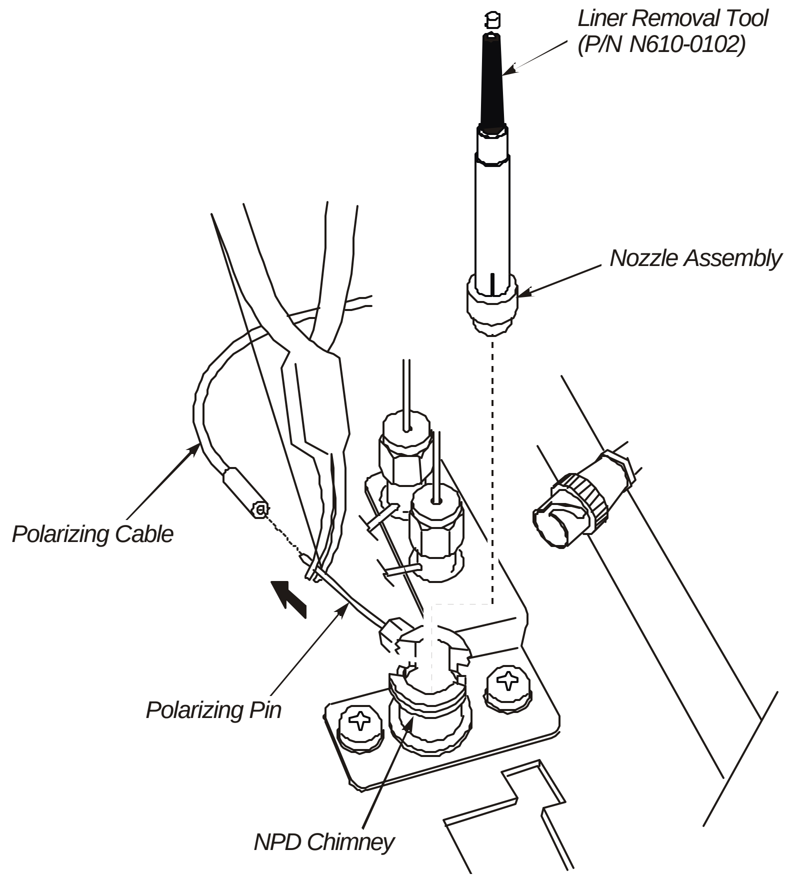


Figure 3- 39 Removing the NPD nozzle assembly and polarizing wire

9. Grasp and pull the spring-loaded polarizing pin using a pair of needle nose pliers with your left hand. Maintain a steady pull on the spring-loaded pin.

10. With your right hand, insert the large end of the liner removal tool (P/N N610-0102) into the NPD chimney so that it engages the nozzle assembly. Then remove the nozzle assembly by lifting it out.

11. Still maintaining a steady pull on the spring-loaded polarizing pin, use your right hand to hold a pair of curved pliers or forceps and remove the ceramic insulator (not shown) from the detector body.

12. Still maintaining a steady pull on the spring-loaded polarizing pin, use your right hand to insert a 1/4-inch nutdriver (P/N N610-1297 provided in shipping kit) into the NPD chimney and engage the nut on top of the NPD jet assembly.

13. Loosen the NPD jet assembly by turning the nut counterclockwise. Then pull the jet assembly out of the NPD with the nutdriver.

    If you cannot pull the jet assembly out with the nutdriver, use a pair of forceps or pliers.

14. Install a new jet assembly (P/N N610-0038) by reversing steps 5 through 13.

FPD Maintenance

The most common causes of FPD performance deterioration which results in a decrease of the signal-to-noise ratio are as follows:

- Dirty optical filter
- Dirty detector liner
- Dirty window
- Defective photomultiplier tube
- Dirty jet

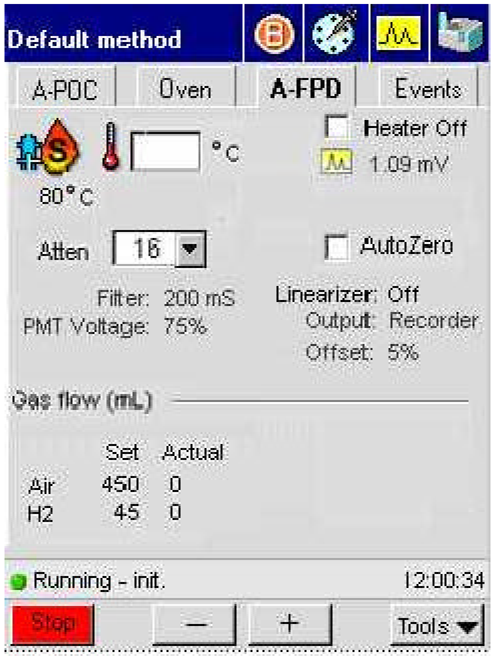
Cleaning/Replacing an Optical Filter Assembly

Obtain one of the following filters before you begin:

- Sulfur Filter Assembly, P/N N600-0637 (standard shipping filter) (Purple)
- Phosphorus Filter Assembly, P/N N600-0981 (Yellow)
- Tin Filter Assembly, P/N L413-5472 (Orange)

To clean or replace an optical filter assembly:

1. Turn off the photomultiplier voltage by selecting the following screen. Locate **PMT Voltage** on the screen and select **OFF**.



Screen 3- 7 A-FPD Screen

2. Extinguish the flame by turning off the hydrogen needle valve. (Turn the outer knob fully clockwise.)

CAUTION	*The photomultiplier tube can be damaged if exposed to light while voltage is ON. Never remove the detector cap or Photomultiplier tube WITH the voltage on.*

3. Turn off the Clarus 500 GC and allow the detector to cool.

4. Loosen the knurled nut that secures the photomultiplier tube assembly to the detector body.

5. Slide the photomultiplier tube assembly away from the detector. If the FPD is detector 1 (front position), slide the photomultiplier tube assembly to the left. If the FPD is detector 2 (rear position), slide the photomultiplier tube assembly back.

6. Remove the filter assembly by pulling it out of the photomultiplier tube assembly. Clean the filter assembly with lens paper.

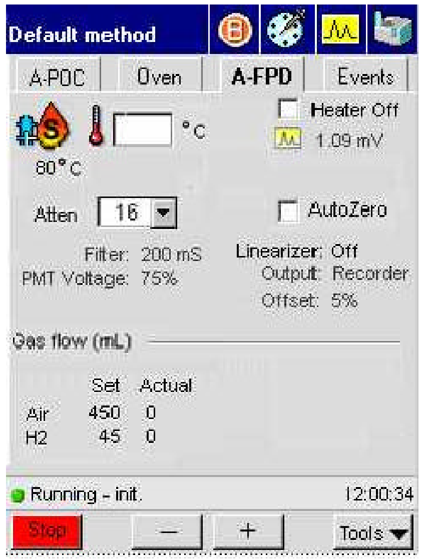
7. Insert the cleaned filter or a replacement filter with the colored side facing the photomultiplier tube assembly. The sulfur filter is purple, the phosphorus filter is yellow, the tin filter is orange.

8. Insert the filter end of the photomultiplier tube assembly into the detector body and secure it with the knurled nut.

Cleaning/Replacing the Detector Liner

To clean or replace the detector liner:

1. Turn off the photomultiplier voltage by selecting the following screen. Locate **PMT Voltage** on the screen and select **OFF**.



Screen 3- 8 A-FPD Screen

2. Extinguish the flame by turning off the hydrogen needle valve. (Turn the outer knob fully clockwise.)

CAUTION	*The photomultiplier tube can be damaged if exposed to light while voltage is ON. Never remove the detector cap or Photomultiplier tube WITH the voltage on.*

3. Turn off the Clarus 500 GC and allow the detector to cool.

4. Remove the cap (see the following figure).

5. Lift out the glass liner and O-ring. Clean the liner by washing it in a soap solution and/or solvent.

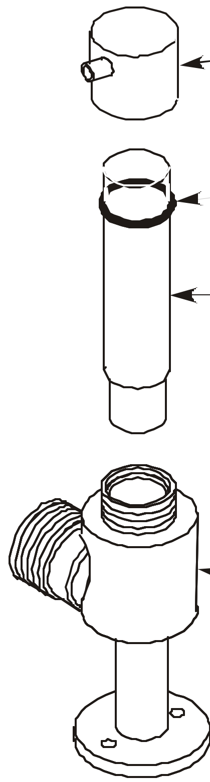


Figure 3- 40 Removing a glass liner from the FPD

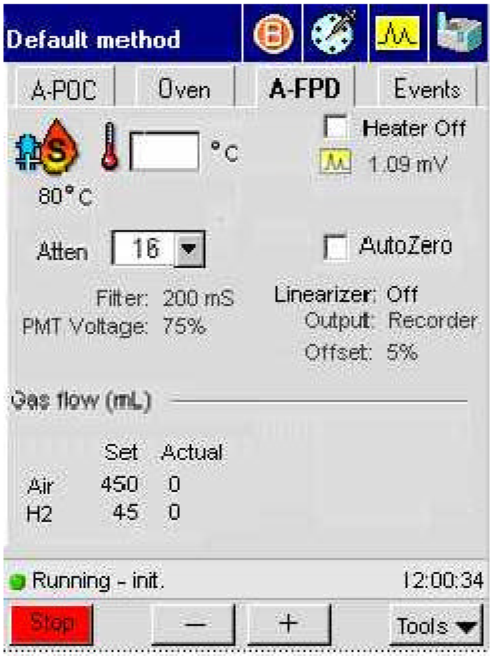
6. Insert the glass liner and O-ring into the detector body, then replace the cap.

NOTE: *Replace the glass liner (P/N N600-3057) if it is chipped or if it cannot be cleaned. Replace a worn O-ring (P/N 0990-2247).*

Cleaning/Replacing the Detector Window

To clean or replace the detector window:

1. Turn off the photomultiplier voltage by selecting the following screen. Locate **Range** on the screen and lower the value to **[0]**.



Screen 3- 9 A-F-D Screen

2. Extinguish the flame by turning off the hydrogen needle valve. (Turn the outer knob fully clockwise.)

CAUTION	*The photomultiplier tube can be damaged if exposed to light while voltage is ON.* ***Never remove the detector cap or Photomultiplier tube WITH the voltage on.***

3. Turn off the Clarus 500 GC and allow the detector to cool.

Removing the Window

1. Loosen the knurled nut that secures the photomultiplier tube assembly to the detector body.

2. Slide the photomultiplier tube assembly away from the detector body. If the FPD is detector 1 (front position), slide it to the left. If the FPD is detector 2 (rear position), slide it back.

3. Remove the cap (see the following figure).

4. Lift out the glass liner and O-ring from the detector body.

5. Remove the two hex head screws from the base of the FPD by using a 3/32-inch hex wrench. Then lift the detector body off the base.

6. Remove the spacer from the light pipe on the detector body.

7. Push the detector window out of the light pipe on the detector body (see the following figure). You can do this by inserting the end of a small pair of curved pliers into the top opening on the detector body. Then push the window out of the light pipe.

8. Remove the seal from the window.

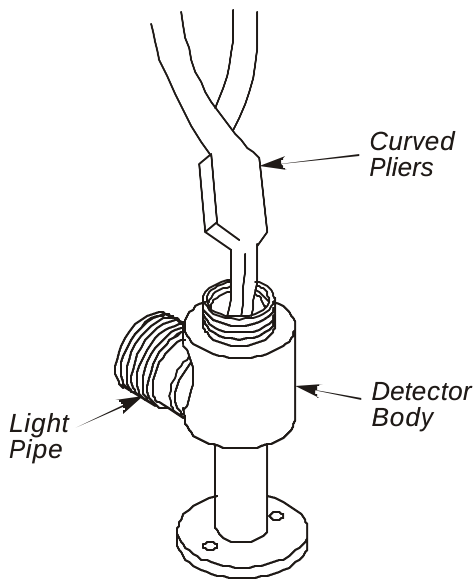


Figure 3- 41 Removing a FPD detector window

Cleaning and Replacing the Window

1. Clean the window with soap and water. If necessary, replace the window and seal (P/N N930-0096).

2. Install the seal on the clean window.

3. Place the detector window on the window holder so that the spring portion of the seal faces the beveled edge in the window holder (see the following figure).

4. Use the spacer to insert the window into the light pipe on the detector body. Push the window and holder completely into the light pipe.

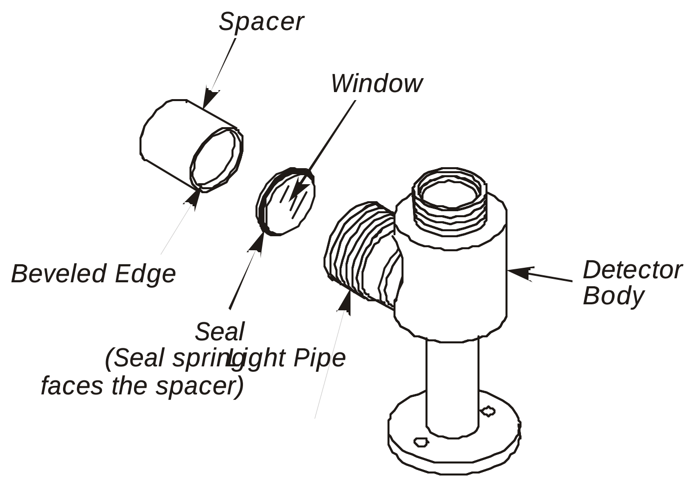


Figure 3- 42 Inserting a seal and window assembly into the FPD body

5. Insert the detector body on the detector base. Secure the detector body with the hex screws.

6. Replace the detector liner, O-ring, and detector cap on the detector body.

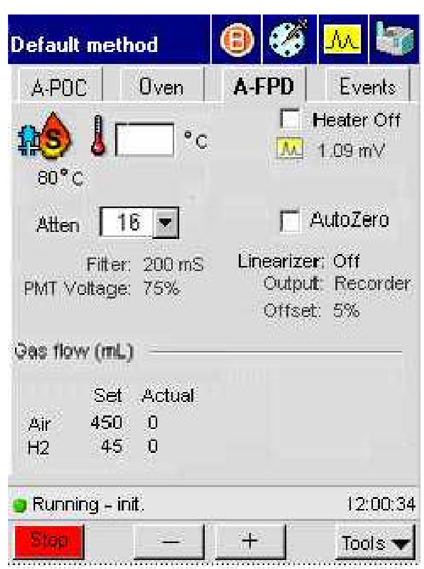
7. Connect the photomultiplier tube assembly to the light pipe on the detector body.

8. Turn on the detector heater. Then turn on the photomultiplier tube and light the flame.

Replacing the Photomultiplier Tube

To replace the photomultiplier tube:

1. Turn off the photomultiplier voltage by selecting the following screen. Locate **PMT Voltage** on the screen and select **OFF**.



Screen 3- 10 A-FPD Screen

2. Extinguish the flame by turning off the hydrogen needle valve. (Turn the outer knob fully clockwise.)

CAUTION	*The photomultiplier tube can be damaged if exposed to light while voltage is ON.* ***Never remove the detector cap or Photomultiplier tube WITH the voltage on.***

3. Turn off the Clarus 500 GC and allow the detector to cool.

4. Remove the two screws from the base of the photomultiplier assembly using a 7/64-inch hex wrench (see the following figure).

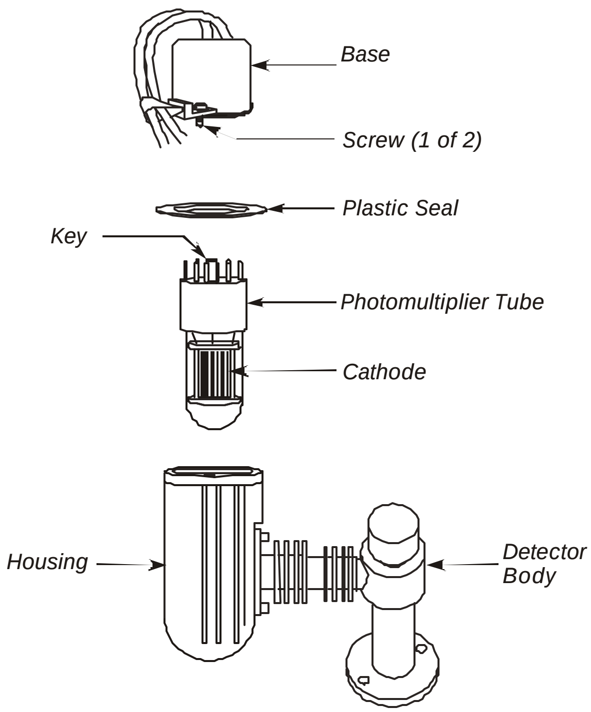


Figure 3- 43 Exploded view of a FPD photomultiplier tube

5. Pull the photomultiplier tube and base out of the housing.

6. Carefully unplug the photomultiplier tube from the base. Be careful not to dislodge the O-ring and plastic seal.

7. Align the key in the new photomultiplier tube with the key hole in the socket.

8. Plug the new photomultiplier tube (P/N 0997-2321) into the socket in the base.

CAUTION	***Do not force the key into an incorrect position. Do not touch the glass. Do not expose the photomultiplier tube to any bright, direct light***

9. Position the photomultiplier tube in the housing so that the cathode (the horizontal filament grating; not visible in Figure 3- 42) faces the detector body. Align the holes in the plastic seal with the holes in the base.

CAUTION	*Make certain that the photomultiplier tube cathode is facing the detector body*

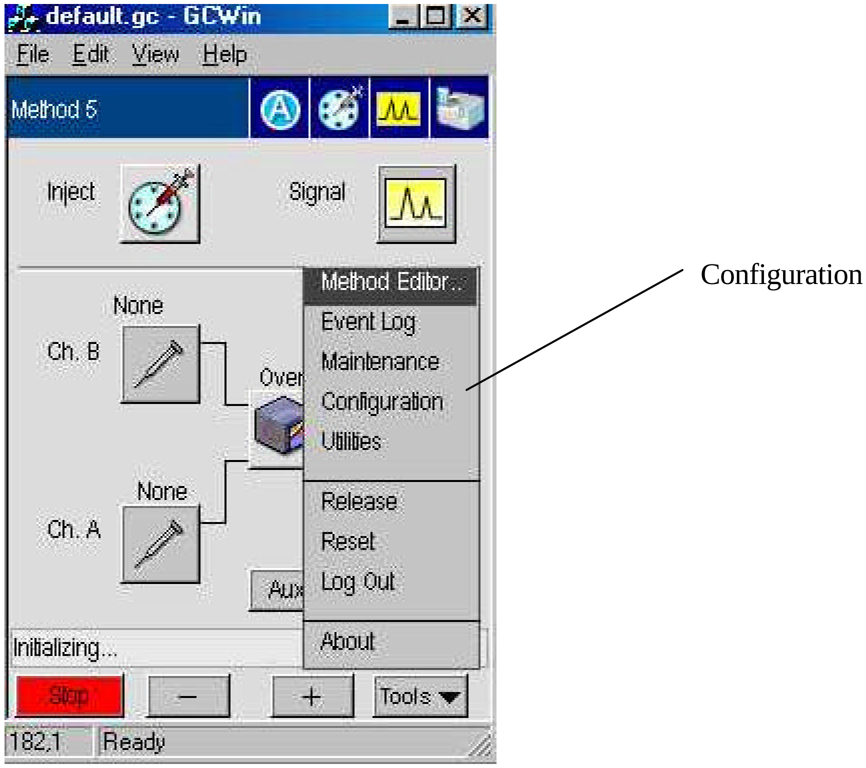
10. Secure the base to the photomultiplier housing with the two screws removed in step 4 of this procedure.

11. Turn on the Clarus 500 GC. Then turn on the hydrogen flow and the photomultiplier tube, and light the flame.

NOTE: *A new photomultiplier tube may require several hours to stabilize*

CAUTION	*When a replacement tube is installed, the noise should be about 2% at attenuation 8 with the linearizer off. If it is not, modify the voltage setting until this level of noise is achieved. Adjust the voltage as follows:*

a. In the main status screen select Tools for the configuration menu.



Screen 3- 11 Main Status Screen

b. In the Configuration screen select the FPD photomultiplier screen to view the voltage.

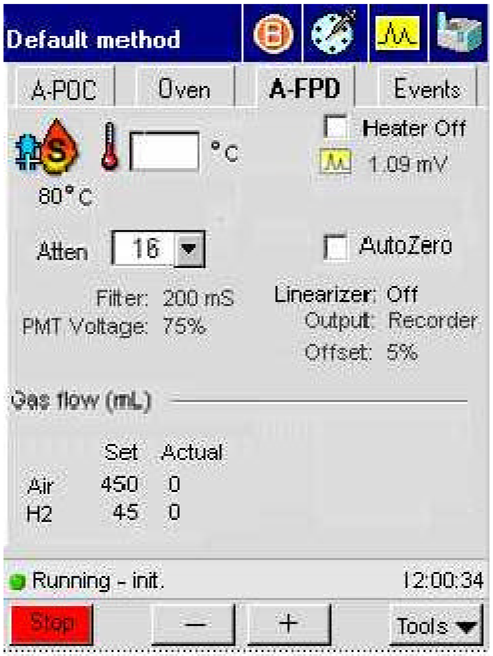
c. Using the touch pad increase the percent (%) value or to increase the voltage in 0.1% increments or decrease the voltage in 0.1% increments, by using the up or down arrows.

NOTE: *The millivolt setting is displayed in the upper-right corner. This number will be close to zero and will only change slightly as the photomultiplier tube voltage is modified.*

Cleaning/Replacing the FPD Jet

To clean or replace the FPD jet:

1. Turn off the photomultiplier voltage by selecting the following screen. Locate **PMT Voltage** on the screen and select **OFF**.



Screen 3- 12 A-FPD Screen

2. Extinguish the flame by turning off the hydrogen needle valve. (Turn the outer knob fully clockwise.)

CAUTION	*The photomultiplier tube can be damaged if exposed to light while voltage is ON. Never remove the detector cap or Photomultiplier tube WITH the voltage on.*

3. Turn off the Clarus 500 GC and allow the detector to cool.

4. Remove the two screws from the base of the FPD by using a 3/32-inch hex wrench. Lift the detector body and the attached photomultiplier tube assembly off the detector base. This exposes the FPD jet (see the following figure).

5. Insert a 1/4-inch nutdriver (P/N N610-1297) over the FPD jet.

6. Turn the nutdriver counterclockwise until the jet assembly is completely loosened. Then remove the jet assembly from the detector base.

7. Clean the jet in a suitable solvent (such as methanol or acetone) and scrape off any deposits with a cotton swab on a piece of soft wood. DO NOT INSERT WIRE OR HARD TOOLS INTO THE JET. Replacement jets are available from PerkinElmer (see the last page in this manual) by ordering P/N N610-0245.

8. Insert the jet in the detector base and secure it with the 1/4-inch nutdriver.

9. Replace the detector body and the attached photomultiplier tube assembly.

10. Turn on the Clarus 500 GC. Then turn on the hydrogen flow and the photomultiplier voltage, and light the flame.

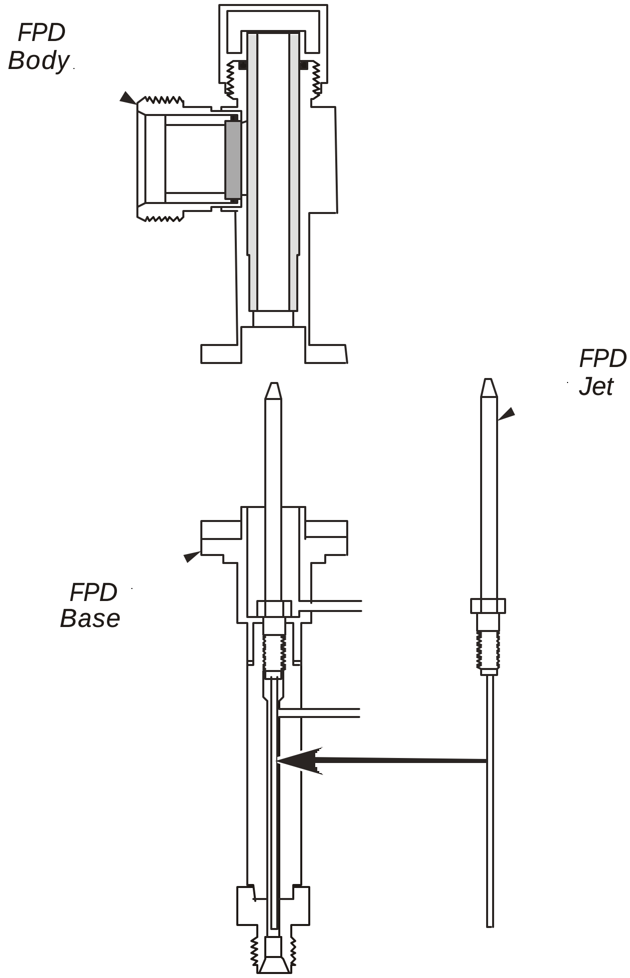


Figure 3- 44 Cutaway view of a FPD showing the jet assembly

PPC Maintenance

PPC maintenance consists of replacing a plugged or restricted PPC module restrictor.

Replacing a Restrictor

To replace a restrictor:

1. Locate the PPC module on the rear of the Clarus 500 GC.

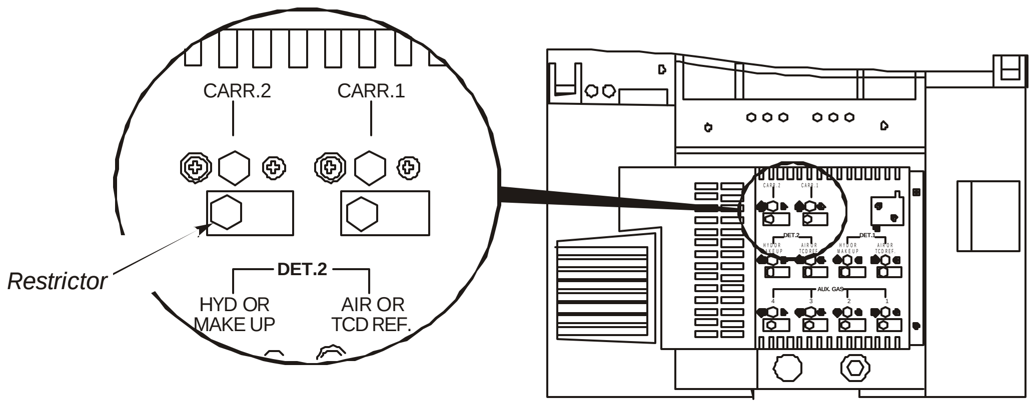


Figure 3-45 Location of a PPC module restrictor

2. Turn off all gases to the module on which you are replacing the restrictor.

3. Using a 1/2-inch socket or open-end wrench, loosen and remove the restrictor and install a new restrictor.

4. Turn on the gas and check for leaks.

5. Calibrate the PPC module.

Zeroing the Pressure

The Clarus 500 GC PPC modules are zeroed at the factory, prior to shipping, but it should be periodically checked to identify any change. This is particularly important if there have been large changes in the ambient temperature from 22 °C. For information about zeroing the pressure, refer to the "Clarus 500 Users Guide."

PPC Restrictor Information

Available Restrictors

Restrictor Number	Color	Helium Flow at 30 PSIG, vent to atmosphere
1	Silver	1 mL/min
2	Red	3 mL/min
3	Yellow	10 mL/min
4	Black	30 mL/min
5	Green	100 mL/min
6	Blue	300 mL/min

Restrictors for Carrier Gas Control

Injector	Restrictor Number	Helium Flow (mL/min) (with a 90 psig inlet pressure and a 10 psig drop across the restrictor)
Packed	4 (std)	30
Split/Splitless or PSS	6 (std)	300
Split/Splitless or PSS	4 (acc)	30
POC	3 (std)	10
POC	2 (acc)	3

Restrictors for Detector Gas Control

NOTE: *Maintain an inlet pressure between 60 and 90 psig.*

Detector	Gas	Restrictor Number	Nominal Flow Required (mL/min)
FID	Air	6	450
FID	Hydrogen	4	45
NPD	Air	5	100
NPD	Hydrogen	1	2
FPD	Air	5	90
FPD	Hydrogen	4	75
ECD	Argon/Methane	4	30
ECD	Nitrogen	4	30
TCD	Helium	4	30
TCD	Hydrogen	3	30
ElCD	Hydrogen	3	25

Practical Hints

Reversing TCD Polarity

The following examples indicate when you may want to change the TCD polarity.

- When one of the components being analyzed has a higher thermal conductivity than the carrier gas.
- For example, if hydrogen is a sample component and helium the carrier gas, set up a timed event to reverse the polarity of the TCD prior to elution of the hydrogen (to generate a positive peak for the hydrogen). Then change the polarity back for the remaining components.
- If negative peaks are produced when two packed injectors are installed, each has a different column attached, and you are running two different analyses. Change the polarity to produce positive peaks.
- When two packed injectors are installed with two identical columns and the TCD is being operated at maximum sensitivity. In this case, alternate the column into which the sample is being injected in order to expose both sets of filaments (reference and sample) to sample, thus keeping the filaments more electrically balanced.
- To change the TCD polarity, enter a negative detector range. For example, TCD ranges of +2 and –2 have opposite polarities.

Optimizing FID Performance

FID sensitivity is affected primarily by the hydrogen flow. The optimum hydrogen flow varies slightly if the column flow changes dramatically. For example, if you go from a packed column with a flow rate of 30 mL/min or higher to a capillary column with flows of 2 mL/min or less, the optimum hydrogen flow will be a different value.

The hydrogen flows recommended in this manual assume packed column flow rates. If you switch from a packed to a capillary column, re-optimizing the hydrogen flow will help to improve the FID sensitivity.

The following is the suggested FID optimization procedure after you have switched from a packed to a capillary column.

1. Prepare a one component standard.
2. Set up the carrier gas flow.
3. Set up the hydrogen and air flows, then ignite the flame.
4. Make 2 to 3 injections at varying hydrogen flows.

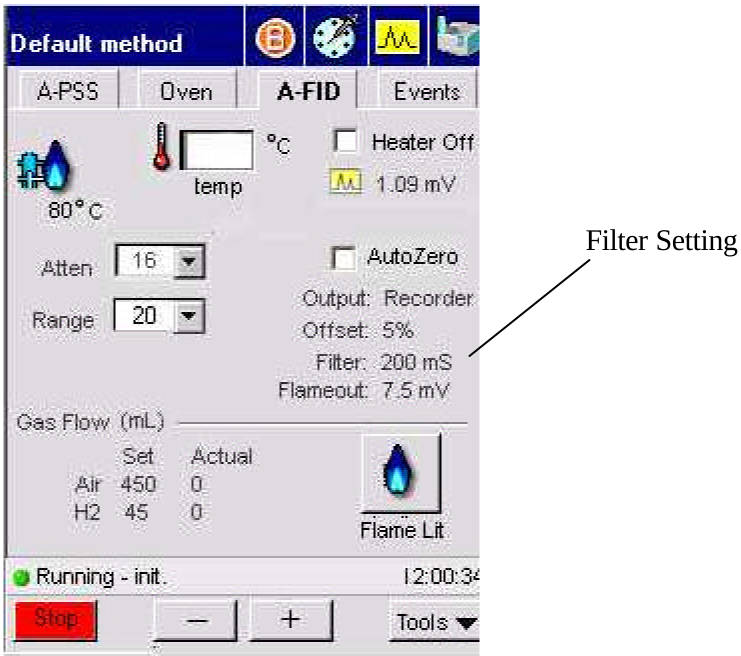
The optimum hydrogen flow is that which produces the maximum area counts.

Optimizing ElCD Performance

You may improve the response on the ElCD by setting a slightly lower hydrogen flow. When using a standard injector at several different hydrogen flows (from 25 mL/min to 10 mL/min), select the hydrogen flow setting that provides the best signal.

Filtering Detector Output

You can select one of three software filters from the Filter Menu. See the screen below for one of the filters:



Screen 3- 13 A-FID Screen

If your column delivers a peak width at half height of ≥1 s, select 200. If your column delivers a peak width at half height of <1 s, select 50.

A value of 800 should be used only with caution to minimize the signal-to-noise ratio. Try 800 with your application. If the peak height and area are not affected but the noise is decreased, then 800 will improve the signal-to-noise ratio.

NOTE: *The ECD has values of 200 and 800 only.*

Autozero Display Sensitivity

The maximum detector signals for various detectors that produce a 1-V reading on the Autozero Display are as follows:

FID, NPD, or PID (nA, Range 1) – 21.3

FID, NPD, or PID (nA, Range 20) – 426

TCD (mV) – 510

ECD (KHz) – 150

ElCD (V) (10-V input selected) – 10

[*] ElCD (V) (1-V input selected) – 1

[*] Install the ElCD by connecting the 10-V output from the ElCD control box to the 10-V input on the ElCD Clarus 500 GC amplifier.

Attenuation vs. Detector Output

The following table lists attenuation vs. the maximum detector signal producing 100% deflection on a 1-mV recorder.

Atten	NPD, PID and FID (fA) Range 1	NPD, PID and FID (fA) Range 20	TCD (V)	ECD (Hz)	ElCD (V) 10-V input	ElCD (V) 1-V input
1	$3.3x10^2$	$6.7x10^3$	8.0	2.3	$1.7x10^2$	$1.7x10^1$
2	$6.7x10^2$	$1.3x10^4$	1.6x10	4.7	$3.4x10^2$	$3.4x10^1$
4	$1.3x10^3$	$2.7x10^4$	3.2x10	9.4	$6.3x10^2$	$6.3x10^1$
8	$2.7x10^3$	$5.3x10^4$	6.4x10	19.0	$1.3x10^3$	$1.3x10^2$
16	$5.3x10^3$	$1.1x10^5$	$1.3x10^2$	38.0	$2.5x10^3$	$2.5x10^2$
32	$1.1x10^4$	$2.1x10^5$	$2.6x10^2$	75.0	$5.0x10^3$	$5.0x10^2$
64	$2.1x10^4$	$4.3x10^5$	$5.1x10^2$	150.0	$1.0x10^4$	$1.0x10^3$
128	$4.3x10^4$	$8.5x10^5$	$1x10^3$	$3.0x10^2$	$2.0x10^4$	$2.0x10^3$
256	$8.5x10^4$	$1.7x10^6$	$2x10^3$	$6.0x10^2$	$4.0x10^4$	$4.0x10^3$
512	$1.7x10^5$	$3.4x10^6$	$4.1x10^3$	$1.2x10^3$	$8.0x10^4$	$8.0x10^3$
1024	$3.4x10^5$	$6.8x10^6$	$8.2x10^3$	$2.4x10^3$	$1.6x10^5$	$1.6x10^4$
2048	$6.8x10^5$	$1.4x10^7$	$1.6x10^4$	$4.8x10^3$	$3.2x10^5$	$3.2x10^4$
4096	$1.4x10^6$	$2.7x10^7$	$3.3x10^4$	$9.6x10^3$	$6.4x10^5$	$6.4x10^4$
8192	$2.7x10^6$	$5.5x10^7$	$6.6x10^4$	$1.9x10^4$	$1.3x10^6$	$1.3x10^5$
16384	$5.4x10^6$	$1.1x10^8$	$1.3x10^5$	$3.8x10^4$	$2.6x10^6$	$2.6x10^5$
32768	$1.1x10^7$	$2.2x10^8$	$2.6x10^5$	$7.7x10^4$	$5.1x10^6$	$5.1x10^5$
65536	$2.2x10^7$	$4.4x10^8$	$5.2x10^5$	$1.5x10^5$	$1.0x10^7$	$1.0x10^6$

The following table lists attenuation vs. the maximum detector signal producing a 1-V output to an integrator.

Atten	NPD, PID and FID (pA) Range 1	NPD, PID and FID (pA) Range 20	TCD (mV)	ECD (kHz)	ElCD (mV) 10-V input	ElCD (mV) 1-V input
1	$3.3x10^2$	$6.7x10^3$	8.0	2.3	$1.7x10^2$	$1.7x10^1$
2	$6.7x10^2$	$1.3x10^4$	1.6x10	4.7	$3.4x10^2$	$3.4x10^1$
4	$1.3x10^3$	$2.7x10^4$	3.2x10	9.4	$6.3x10^2$	$6.3x10^1$
8	$2.7x10^3$	$5.3x10^4$	6.4x10	19.0	$1.3x10^3$	$1.3x10^2$
16	$5.3x10^3$	$1.1x10^5$	$1.3x10^2$	38.0	$2.5x10^3$	$2.5x10^2$
32	$1.1x10^4$	$2.1x10^5$	$2.6x10^2$	75.0	$5.0x10^3$	$5.0x10^2$
64	$2.1x10^4$	$4.3x10^5$	$5.1x10^2$	150.0	$1.0x10^4$	$1.0x10^3$

Prolonging the Life of a PID UV Lamp

Lamp life decreases at elevated temperatures. (For example, when conditioning the detector above 250 °C.) To increase lamp life, substitute a disc (P/N N0330-2989) for the UV lamp during such procedures.

Optimizing ECD Performance

ECDs are extremely sensitive. Therefore, care should be taken to avoid contamination from any part of the system (for example, pneumatics, injector, column, gases, etc.). To help assure a clean system: condition the column, bake out the injector and detector, use clean tubing, and use pure filtered gases.

CAUTION	*To minimize detector contamination, run the ECD hot, at a temperature of at least 375 °C.*

Optimizing FPD Performance

About Ionization Gas Flows

FPD sensitivity is affected by both the hydrogen flow and the air flow. Hydrogen has a true optimum flow; that is, above or below a certain flow there is less response. Air, on the other hand, is more critical. That is, below a certain flow there is no response at all. The flows provided in the *Clarus 500 Users Guide* are in the optimum range, but there may be slight variation from detector to detector.

Optimizing FPD Gas Flows

To optimize gas flows:

1. Set the hydrogen flow to 65 mL/min.
2. Set the air flow to 90 mL/min.
3. Set the detector temperature to 250 °C, and wait for the detector to reach that temperature.
4. Light the flame.
5. Prepare a one-component standard (sulfur, phosphorus, or tin, depending on the filter installed).
6. Make two or three injections.
7. Increase the hydrogen flow by 5 mL/min and repeat the injections.
8. Continue increasing the hydrogen, and running the sample, until a maximum signal is obtained. Set the hydrogen at that flow.
9. Repeat the above procedure, varying the air flow by 5 mL/min (both below and above 90 mL/min).
10. Set the air flow to at least 10 mL/min above the flow that previously produced no response.

Quenching

When hydrocarbons co-elute with the sulfur compound (or phosphorus or tin compound depending on which filter is being used), they will "quench" the flame, thereby causing a diminished response, or no response at all, to the peak of interest. To avoid this problem, complete separation and elution of all peaks is necessary. Because the FPD is a selective detector, hydrocarbons may not show as significant peaks. We recommend that you first profile your sample by using the same column with either an FID or TCD. All peaks will then be seen and you can determine the necessary conditions to completely separate and elute all compounds.

PSS and POC Operating Hints

Both of the Programmed Split/Splitless (PSS) and Programmed On-Column (POC) injectors can be operated in either the oven programming mode or the inlet programming mode. For specific operation, refer to the *Clarus 500 Users Guide*.

Oven Programming Mode

This is the default mode for both the POC and the PSS injectors. This mode is the easiest to use, since only the oven temperature program needs to be entered into the method. In this mode, the injector will follow the oven temperature profile plus 5 °C. In this mode, the sample should be introduced into the injector when the temperature of the inlet is at the boiling point of the solvent. Then temperature program the injector and oven.

If the initial temperature of the oven is above the boiling point of the solvent you are using, then it would be better to modify the oven program to start at a lower temperature or to configure the injector for the Inlet mode and set a temperature for the injector separate from the oven temperature.

Inlet Programming Mode

This mode permits the use of independent injector temperatures and rates that you define in the method. The injector will be programmed for injector temperature 1, injector time 1, injector rate 1, injector temperature 2, injector time 2, etc. You can program up to three temperatures and two ramps for each PSS or POC configured in the inlet mode.

It is important to set the initial injector temperature to about the boiling point of the solvent you are using.

CAUTION	*The PSS injector can be used in the "hot" split or splitless mode. However, this is not recommended due to liner size and could cause solvent flashback in the injector. This mode should be used with caution, depending upon the solvent and temperatures you choose.*

CAUTION	*When using the PSS injector in the on-column mode or the POC injector with the autosampler, you* must use *a special syringe that has a needle o.d. of 0.47 mm (P/N N610-1253 or N610-1380). Refer to the Clarus 500 Users Guide for more detail. You must use only the "Norm" injection speed with this syringe in the on-column mode. The "Fast" injection speed will bend this thin needle and the "Slow" injection speed may produce peak breakup or distorted peaks. You can achieve better precision in the on-column mode when sample volumes of 1.0 L or greater are injected.*

CAUTION	*If you have the subambient option, the POC and PSS injectors are linked to the oven subambient option; therefore, you cannot operate the injectors below the oven subambient temperature.*

If a column is used extensively at high temperatures (350 °C or greater), the polyimide may become very brittle. This brittleness will cause the column to fracture when you try to seal it in the universal adapter. If you wish to continue to use the brittle column, a low dead volume union may be a helpful alternative.

PPC Restrictor Information

Available Restrictors

Restrictor Number	Color	Helium Flow at 30 PSIG, vent to atmosphere
1	Silver	1 mL/min
2	Red	3 mL/min
3	Yellow	10 mL/min
4	Black	30 mL/min
5	Green	100 mL/min
6	Blue	300 mL/min

Restrictors for Carrier Gas Control

Injector	Restrictor Number/ Color	Helium Flow (mL/min) (with a 90 psig inlet pressure and a 10 psig drop across the restrictor)
Packed	4 (std)/ Black	30
Split/Splitless or PSS	6 (std)/ Blue	300
Split/Splitless or PSS	4 (acc)/ Black	30
POC	3 (std)/ Yellow	10
POC	2 (acc)/ Red	3

Restrictors for Detector Gas Control

NOTE: *Maintain an inlet pressure between 60 and 90 psig.*

Detector	Gas	Restrictor Number/Color	Nominal Flow Required (mL/min)
FID	Air	6/ Blue	450
FID	Hydrogen	4/ Black	45
NPD	Air	5/ Green	100
NPD	Hydrogen	1/ Silver	2
FPD	Air	5/Green	90
FPD	Hydrogen	4/ Black	75
ECD	Argon/Methane	4/ Black	30
ECD	Nitrogen	4/ Black	30
TCD	Helium	4/ Black	30
TCD	Hydrogen	3/ Yellow	30
ElCD	Hydrogen	3/ Yellow	25

Firmware Update 4

Setting Up Hyperterminal.. 4-3
Creating a Shortcut to the Firmware.. 4-8
To Create a Shortcut.. 4-8
Downloading Firmware to the Clarus 500 GC instruments 4-9
To Download Firmware...4-10

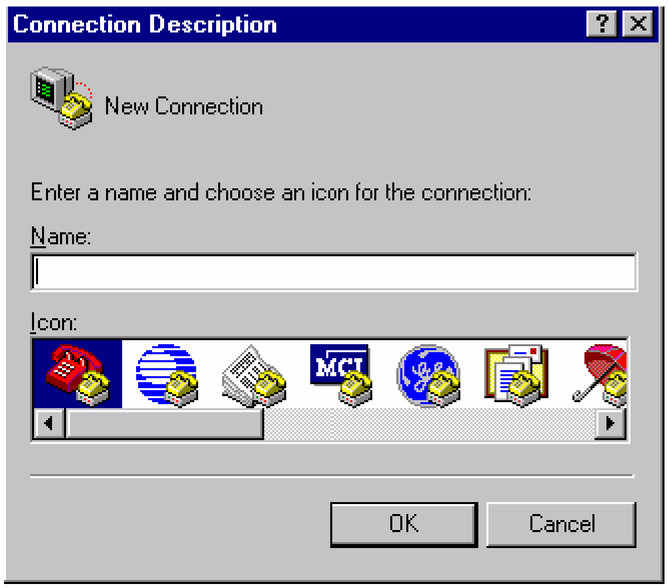
Setting Up Hyperterminal

Use the following instructions to set up Hyperterminal for the downloading of firmware to the HS and TD instruments.

1. Start Hyperterminal.

   Hyperterminal is typically found through Start/Programs/Accessories/Hyperterminal but this may not always be the case.

2. After starting Hyperterminal, the following should appear:



Screen 4- 1 Connection Screen

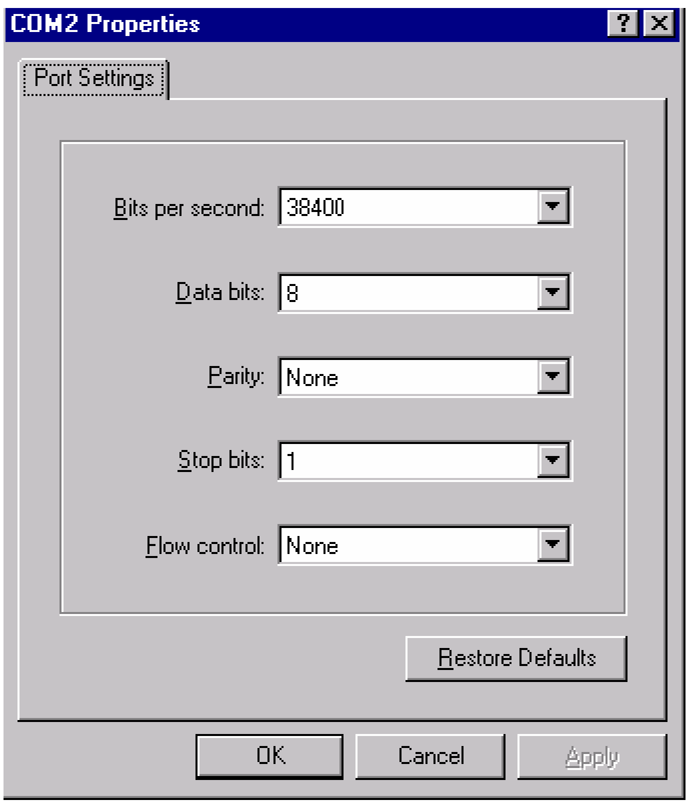
3. Enter the name of the connection **Firmware** then touch **OK**.

   The following dialog box appears.

Screen 4- 2 The connection Description Dialog Box

4. The selection under **Connect using** should be the **COM** port that you will use on the back of the PC. Touch **OK**.

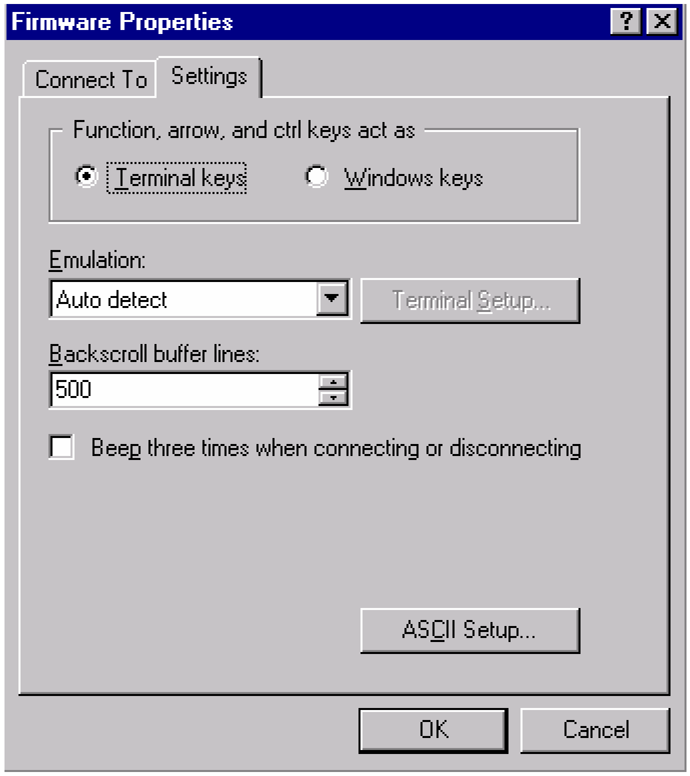
   The following appears:



Screen 4- 3 The COM2 Properties Dialog Box

5. Ensure that the settings on the PC match those above then touch **OK**.

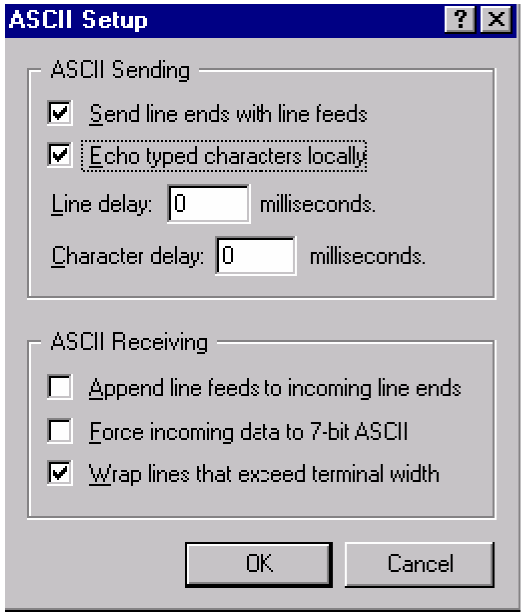
6. From the Hyperterminal window, open the File menu then select **Properties**. In the dialog box that appears, select the Settings tab.



Screen 4- 4 Firmware Properties Settings

7. Ensure that the settings on the PC match those above then touch **ASCII Setup**.

The following dialog box appears:



Screen 4- 5 The ASCII Setup Dialog Box

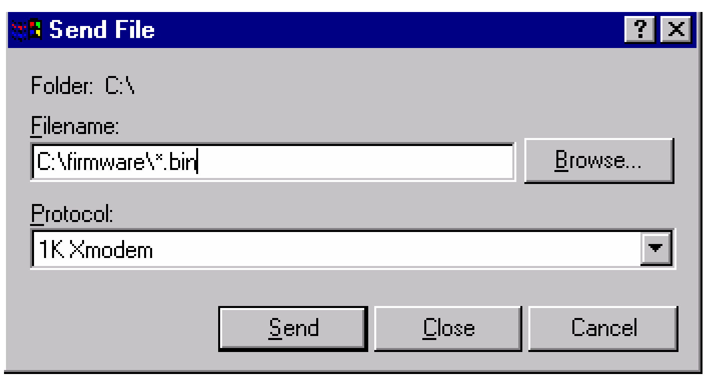
8. Ensure that the settings on the PC match those above then touch **OK**.

9. Touch **OK** again.

   The main Hyperterminal window should appear.

10. From the **Transfer** menu, select **Send File**.

The following dialog box appears:



Screen 4- 6 The Send File Dialog Box

11. The filename is not important at this point but ensure that the **Protocol** selected is **1KXmodem** then touch **Close**.

12. You may now exit Hyperterminal.

13. When prompted whether to save the session, touch **Yes**.

    Hyperterminal is now setup for downloading firmware.

Creating a Shortcut to the Firmware

It is handy to have a shortcut to these settings.

To Create a Shortcut

1. Navigate through **Start/Programs/Accessories/Hyperterminal** and you should see an entry for **Firmware.ht** along with the Hyperterminal program.
2. Select **Firmware.ht** then drag and drop the cursor over the desktop.
3. A menu will appear. Select the option **Create Shortcut(s) here**. An icon named **Shortcut to Firmware.ht** will appear on the desktop.

   Double clicking on this icon will start Hyperterminal with the correct settings.

Downloading Firmware to the Clarus 500 GC instruments

1. Connect the PC to the instrument using the service firmware download cable (N650-0131). Plug into the location circle below removing the link cable. This connector is keyed.

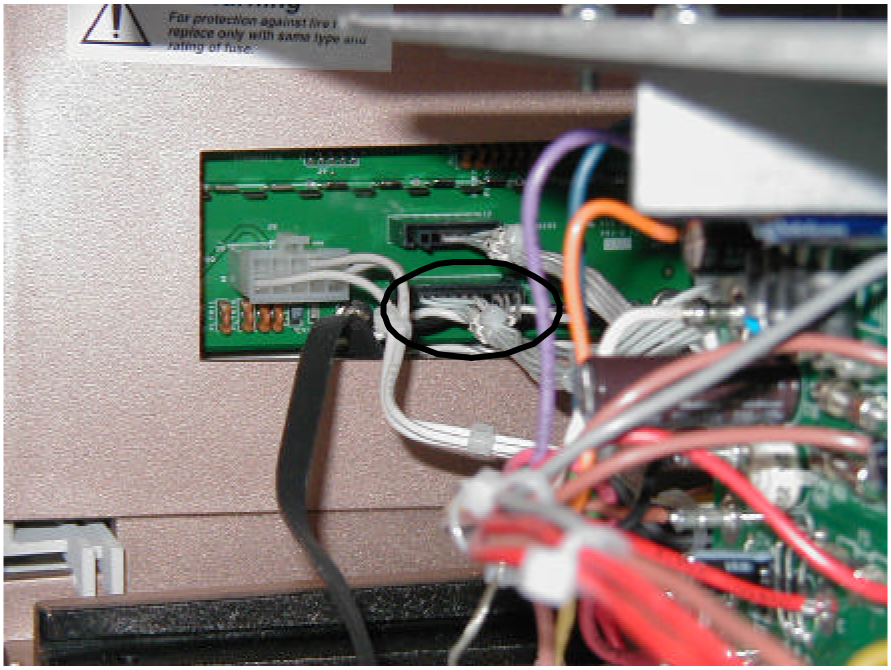
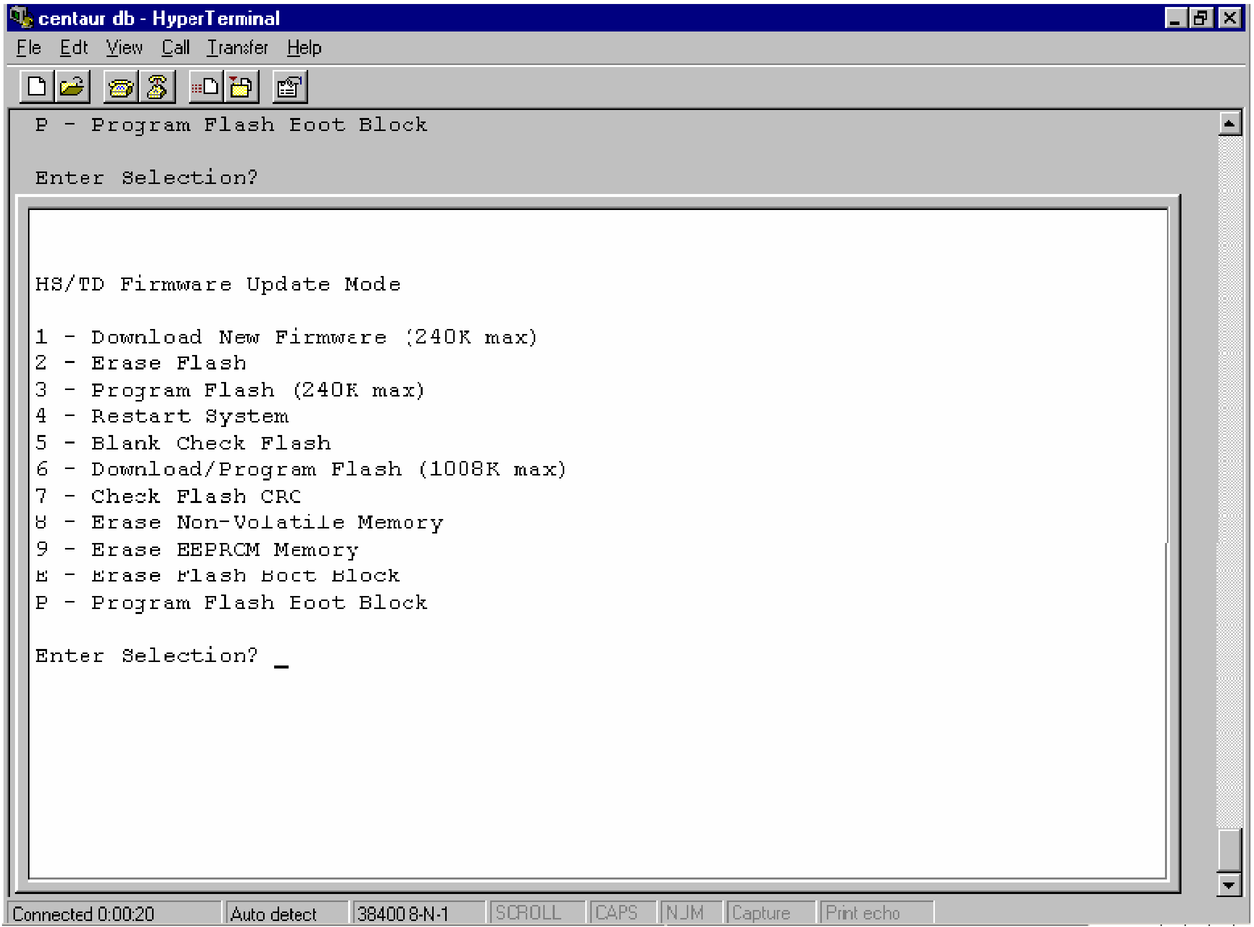


Figure 4-1

2. This cable enables firmware download on power cycle.

NOTE: *This is not a standard cable.*



Screen 4- 7 Hyperterminal Screen

To Download Firmware

1. Start Hyperterminal on the PC with the correct settings.

2. Power up the instrument.

   A menu appears on the PC.

3. Type 2 to erase the flash.

   The PC indicates when erase is complete.

   The SDB associated with the revision of firmware to be downloaded will have instructions on whether to erase non-volatile memory and erase EEPROM need to be executed.

4. Type 8 to erase the non-volatile memory. The PC will indicate when the erase is complete.

5. Type 6 to download the firmware from the PC to the instrument.

The instrument will now wait for you to send a file.

To Send The Firmware

- Select Transfer from the menu followed by Send File.

  You will be prompted to indicate which file to send.

- Type the location of the file or browse the file, example c:\firmware\hs.bin.

  (The HS instruments will need the file HS???.BIN and the TD instruments will need TD???.BIN.)

- Press Send.

  The PC will indicate the progress of the file transfer.

6. When complete, power down the instrument. Disconnect the download cable and replace internal cable plugs into the Clarus and the board.

7. Power up the instrument and perform the touch screen calibration (as the instrument boots up, touch the touch screen to launch the touch screen calibration). Follow directions to calibrate the touch screen (touch the upper left, lower right, and nine other places on the touch screen).

8. Firmware download is complete.

Performance Test 5

Clarus 500 GC Test Specifications 5-3
FID Packed Column 5-3
FID Capillary Column 5-3
TCD Packed Column 5-3
NPD Packed Column 5-3
NPD Capillary Column... 5-3
ECD Packed Column 5-3
ECD Capillary Column... 5-3
FPD Packed Column (Sulfur Mode)... 5-3
ELCD Packed Column.. 5-3
PID Packed Column 5-3
Calibrating the Oven Temperature.. 5-3
Calibrate the Reference Thermometer... 5-3
Place the Thermometer Probe in the Oven 5-3
Equilibrate the Oven Temperature.. 5-3
Enter the Required Offset Value... 5-3
Remove the Thermometer Probe 5-3

Clarus 500 GC Test Specifications

The following Test Specifications are provided.

Specification	**Page**
FID Packed Column	3
FID Capillary Column	3
TCD Packed Column	3
NPD Packed Column	3
NPD Capillary Column	3
ECD Packed Column	3
ECD Capillary Column	3
FPD Packed Column (Sulfur Mode)	3
FPD Capillary Column (Sulfur Mode)	3
FPD Capillary (Phosphorous Mode)	3
ELCD Packed Column	3
PID Packed Column	3
PID Capillary Column	3

FID Packed Column

Test Column: N610 1406 (1/8” S.S., 10% OV-101)
Test Mix: N930 7036 (Universal GC Test Mix)
Syringe: N610 1390 (5 µL Syringe)

Sample Test Conditions

PKD Injector	= 250°C	H_2 Flow	= 45 mL/min
FID Detector	= 300°C	Air Flow	= 450 mL/min
Oven	= 90°C	Column Flow	= 20 mL/min
Time 1	= 6 min	Injection Volume	= 0.5 µL
Range	= 20	Time Constant	= 200
Attenuation	= 64 (TC 0)		

Autosampler Conditions (if fitted)

Injection Volume	= 0.5 µL	Sample/Solvent Wash’s	= 0
Samples Vials	= 1	Sample Pumps	= 6
#Inj’s/Sample	= 15	Viscosity Delay	= 0

Manual Testing

After the thermal zones have stabilized, **inject 0.5 mL** of the GC test mix **(N930 7036**) several times. Modify the oven temperature to correct for column differences such that C9 peak elutes no earlier than 4 minutes.

Autosampler Testing

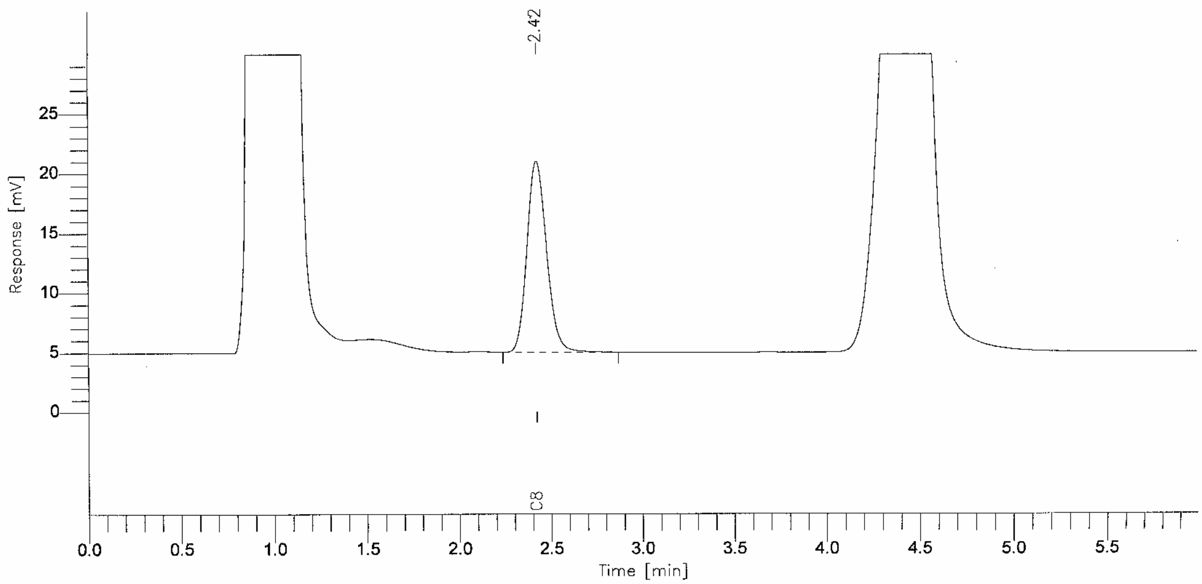
Fill a single vial with the GC test mix. Set up the A/S program to make a minimum of 15 runs. Modify the oven temperature to correct for column differences such that C9 peak elutes no earlier than 4 minutes. Discard the first few runs for conditioning and take the next 10 consecutive runs to use for Autosampler %RSD Test.

Sensitivity

If fitted with an autosampler, select a run from the 10 used to calculate %RSD which closely matches the average area and calculate coulombs/gram for the C8 peak. If not fitted with an autosampler, select a run for calculating coulombs/gram. Using the C8 peak, measure peak height and width at half height. Calculate the detector sensitivity in coulombs/gram of carbon using the equation below.

Specifications

Minimum Specification:> 0.015 Coulombs / Gram
Autosampler %RSD Minimum Specification: ≤ 1% RSD for 10 runs



FID PACKED

Time [min]	Component Name	Area [μV·s]	Height [μV]
2.424	C8	119884.07	16010.37
		119884.07	16010.37

Calculations

S = SENSITIVITY IN COULOMBS / GRAM

S = (H x WH) / V

H = (AMP GAIN RANGE 20) x (INTEGRATOR ATTEN) x (SIGNAL MV)

H = (7×10^{-12} AMP/MV) x (64) x (SIGNAL MV)

WH = (WIDTH AT 1/2 HEIGHT IN SECONDS)

(Note: Width at ½ height in Minutes x 60 = WH in seconds)

V = SAMPLE WEIGHT (C8) IN 0.5 μL

V = (2.965×10^{-6}) GRAMS CARBON

Example: FID Packed Calculation

S = (H) x (WH) / V

H = 7×10^{-12} x (64) x 16 mV = 7.17×10^{-9}

WH = 0.13 min x 60 = 7.8 sec

V = 2.965×10^{-6}

S = 7.17×10^{-9} x 7.8 sec / 2.965×10^{-6}

S = 0.0188 coulombs / gram carbon

FID Capillary Column

Test Column: N931 6008 (15m .25id DB-1)
Test Mix: N930 7036 (Universal GC Test Mix)
Syringe: N610 1390 (5 µL Syringe)

Sample Test Conditions

CAP Injector	= 250°C	H_2 Flow	= 40 mL/min
FID Detector	= 300°C	Air Flow	= 400 mL/min
Oven	= 100°C	Column Flow	= 1 mL/min
Time 1	= 4.5 min	Injection Volume	= 0.5 µL
Range	= 1	Split Flow	= 50 mL/min
Attenuation	= 8 (TC-3)	Time Constant	= 200

Autosampler Conditions (if fitted)

Injection Volume	= 0.5 µL	Sample/Solvent Washes	= 0
Samples Vials	= 1	Sample Pumps	= 6
#Inj's/Sample	= 15	Viscosity Delay	= 0

Manual Testing

After the thermal zones have stabilized, **inject 0.5 mL** of the GC test mix **(N930 7036**) several times. Modify the Oven temperature if necessary such that C9 peak elutes no earlier than 3 minutes.

Autosampler Testing

Fill a single vial with the GC test mix. Set up the A/S program to make a minimum of 15 runs. Modify the oven temperature if necessary such that C9 peak elutes no earlier then 4 minutes. Discard the first few runs for conditioning and take the next 10 consecutive runs to use for Autosampler %RSD Test.

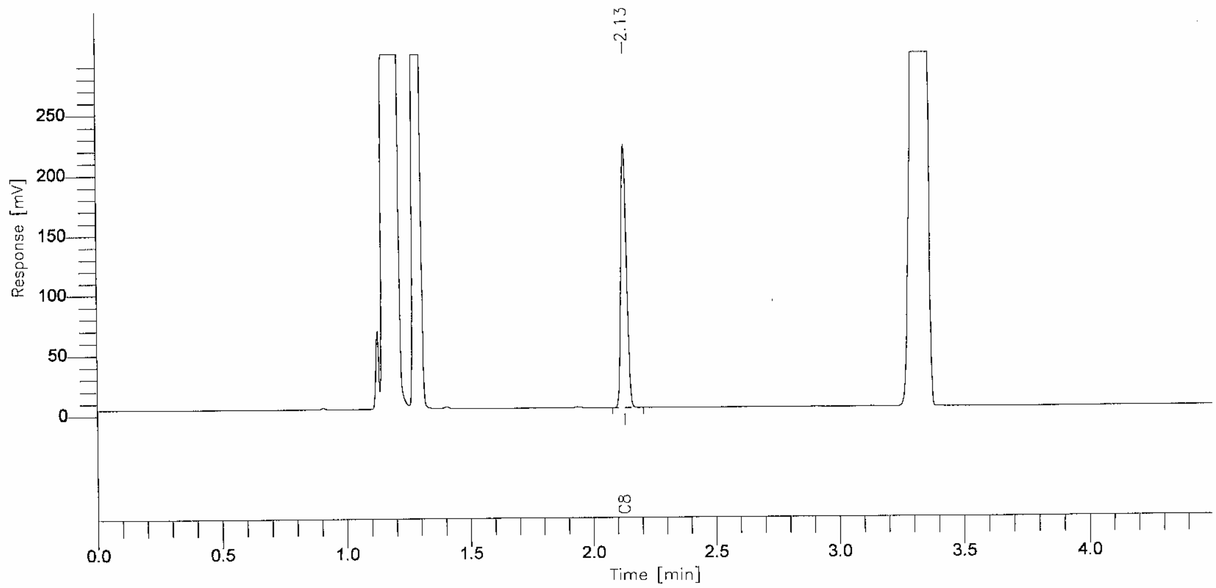
Sensitivity

If fitted with an autosampler, select a run from the 10 used to calculate %RSD which closely matches the average area and calculate coulombs/gram for the C8 peak. If not fitted with an autosampler, select a run for calculating coulombs/gram. Using the C8 peak, measure peak height and width at half height. Calculate the detector sensitivity in coulombs/gram of carbon using the equation below.

Specifications

Minimum Specification:> 0.013 Coulombs / Gram

Autosampler %RSD Minimum Specification: ≤2% RSD for 10 runs



FID CAPILLARY

Time [min]	Component Name	Area [µV·s]	Height [µV]
2.132	C8	350357.33	220202.60
		350357.33	220202.60

Calculations

S = SENSITIVITY IN COULOMBS / GRAM

S = ((H x WH) / V) x (1 + SP / C)

H = (AMP GAIN RANGE 1) x (INTEGRATOR ATTEN) x (SIGNAL MV)

H = (3.33 x 10^{-13} AMP/MV) x (8) x (SIGNAL MV)

WH = (WIDTH AT 1/2 HEIGHT IN SECONDS)

(Note: Width at ½ height in Minutes x 60 = WH in seconds)

V = SAMPLE WEIGHT (C8) IN 0.5 µL

V = (2.965 x 10^{-6}) GRAMS CARBON

SP = SPLIT FLOW IN ML / MIN

C = COLUMN FLOW IN ML / MIN

Example: FID Capillary Calculation

S = ((H) x (WH) / V) x (1 + SP / C)

H = 3.33 x 10^{-13} x (8) x 220 = 5.86 x 10^{-10}

WH = 0.025 min x 60 = 1.5 secs

V = 2.965 x 10-6

SP = 50 mL / min

C = 1 mL / min

S = 5.86 x 10-10 x 1.5 secs / 2.965 x 10-6 x (1 + 50 / 1)
S= 2.96 x 10-4 X (51)
S = 0.015 coulombs / gram carbon

TCD Packed Column

Test Column: N610 1406 (1/8” S.S., 10% OV-101)
Test Mix: N930 7036 (Universal GC Test Mix)
Syringe: N610 1390 (5 µL Syringe)

Sample Test Conditions

PKD Injector	= 250 °C	Column Flow	= 20 mL/min
TCD Detector	= 125°C	Reference Flow	= 20 mL/min
Oven	= 80°C	Range	= 4
Time 1	= 7 min	Injection Volume	= 0.5 µL
Attenuation	= 32 (TC-1)	Time Constant	= 200

Autosampler Conditions (if fitted)

Injection Volume	= 0.5 µL	Sample/Solvent Wash’s	= 0
Samples Vials	= 1	Sample Pumps	= 6
#Inj’s/Sample	= 15	Viscosity Delay	= 0

Manual Testing

After the thermal zones have stabilized, **inject 0.5 mL** of the GC test mix **(N930 7036**) several times. Modify the oven temperature to correct for column differences such that C9 peak elutes no earlier than 4 minutes.

Autosampler Testing

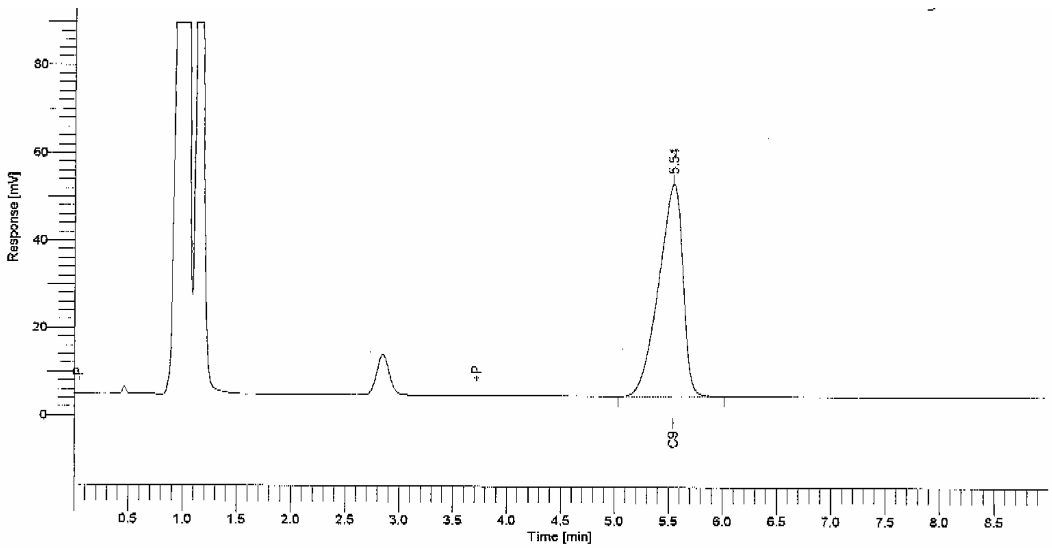
Fill a single vial with the GC test mix. Set up the A/S program to make a minimum of 15 runs. Modify the oven temperature to correct for column differences such that C9 peak elutes no earlier then 4 minutes. Discard the first few runs for conditioning and take the next 10 consecutive runs to use for Autosampler %RSD Test.

Sensitivity

If fitted with an autosampler, select a run from the 10 used to calculate %RSD which closely matches the average area and calculate sensitivity for the C9 peak. If not fitted with an autosampler, select a run for calculating sensitivity. Using the C9 peak, measure peak height and width at half height. Calculate the detector sensitivity in uv/ppm of carbon from the equation below.

Specifications

Minimum Specification:> 5UV / PPM
Autosampler %RSD Minimum Specification: ≤2% RSD for 10 runs



TCD Packed Column

Time [min]	Component Name	Area [µV·s]	Height [µV]
5.541	C9	754254	48527
		754254	48527

Calculations

S = SENSITIVITY IN UV / PPM
S = (F x H x WH) / (V x 1,000,000)
F = COLUMN FLOW IN ML / MIN
H = (AMP GAIN RANGE 4) x (INTEGRATOR ATTEN) x (SIGNAL MV)
H = (8 UV) x (32) x (SIGNAL MV)
WH = (WIDTH AT 1/2 HEIGHT IN MINUTES)
V = GASEOUS VOLUME (C9) IN .5 µL
V = (0 .00678 mL)

Example: TCD Packed Calculation

S = SENSITIVITY IN UV / PPM
S = (F x H x WH) / (V x 1,000,000)
F = 20 mL / min
H = (8uv) x (32) x (48.5) = 12,416
Wh = 0.25min
V = 0.00678
S= (20) x (12,416) x (.25)
S= 62,080 / (0.00678 x 1,000,000)
S= 62,080 / 6780
S = 9.15 uv / ppm

NPD Packed Column

Test Column: N610 1406 (1/8' S.S., 10% OV-101)
Test Mix: N930 7036 (Universal GC Test Mix)
Syringe: N610 1390 (5 µL Syringe)

Sample Test Conditions

PKD Injector	= 250°C	H_2 Flow	= 1-2 mL/min
NPD Detector	= 250°C	Air Flow	= 95-105 mL/min
Oven	= 130°C	He Flow	= 20 mL/min
Time 1	= 6 min	Injection Volume	= 1 µL
Range	= 1	Time Constant	= 200
Attenuation	= 1 (TC -6)	Bead Backgnd	= 0.5 - 0.75mV

Autosampler Conditions (if fitted)

Injection Volume	= 1 µL	Sample/Solvent Wash's	= 0
Samples Vials	= 1	Sample Pumps	= 6
#Inj's/Sample	= 15	Viscosity Delay	= 0

Bead Conditioning

Cap the NPD inlet and establish normal flows for Air and H_2, adjust the NPD bead current to bring the mV background to 997.61. Allow background to reduce to below 50 mV (approx. 1 - 2 hrs), reduce current to below 600, remove cap and install column. Adjust current for background of 0.5 - 0.75 mV.

Manual Testing

After the baseline has stabilized, **inject 1mL** of the GC test mix **(N930 7036)** several times. Modify the oven temperature to correct for column differences such that DMA peak elutes no later then 4 minutes.

Autosampler Testing

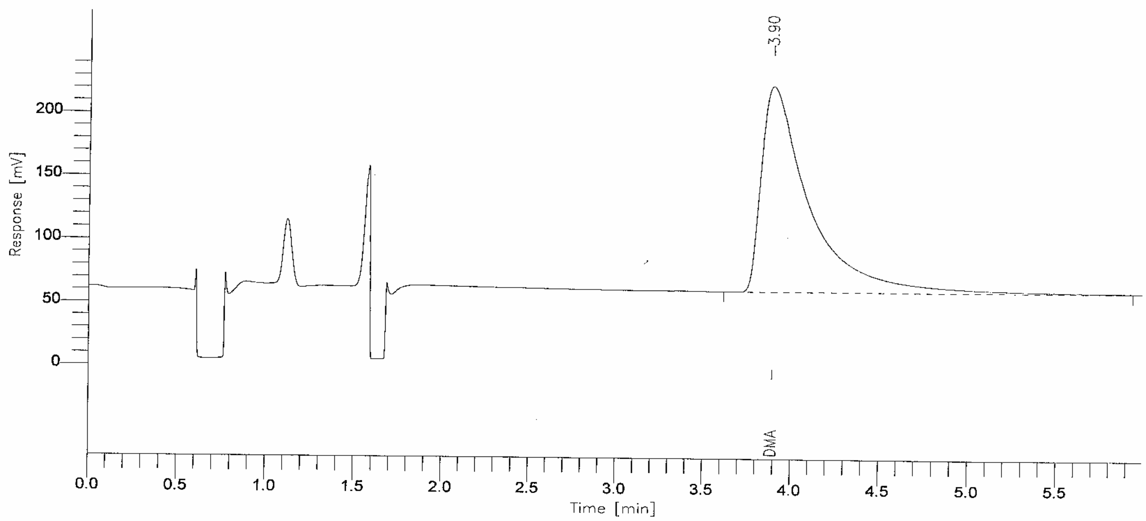
Fill a single vial with the GC test mix. Set up the A/S program to make a minimum of 15 runs. Modify the oven temperature to correct for column differences such that DMA peak elutes no later than 4 minutes. Discard the first few runs for conditioning and take the next 10 consecutive runs to use for Autosampler %RSD Test.

Sensitivity

If fitted with an autosampler, select a run from the 10 used to calculate %RSD which closely matches the average area and calculate minimum detectable quantity for the DMA peak. If not fitted with an autosampler, select a run for calculating minimum detectable quantity for the DMA peak. Using the DMA peak, measure peak height and width at half height. Calculate the NPD Minimum Detectable Quantity (MDQ) in grams of nitrogen/second from the equation below.

Specifications

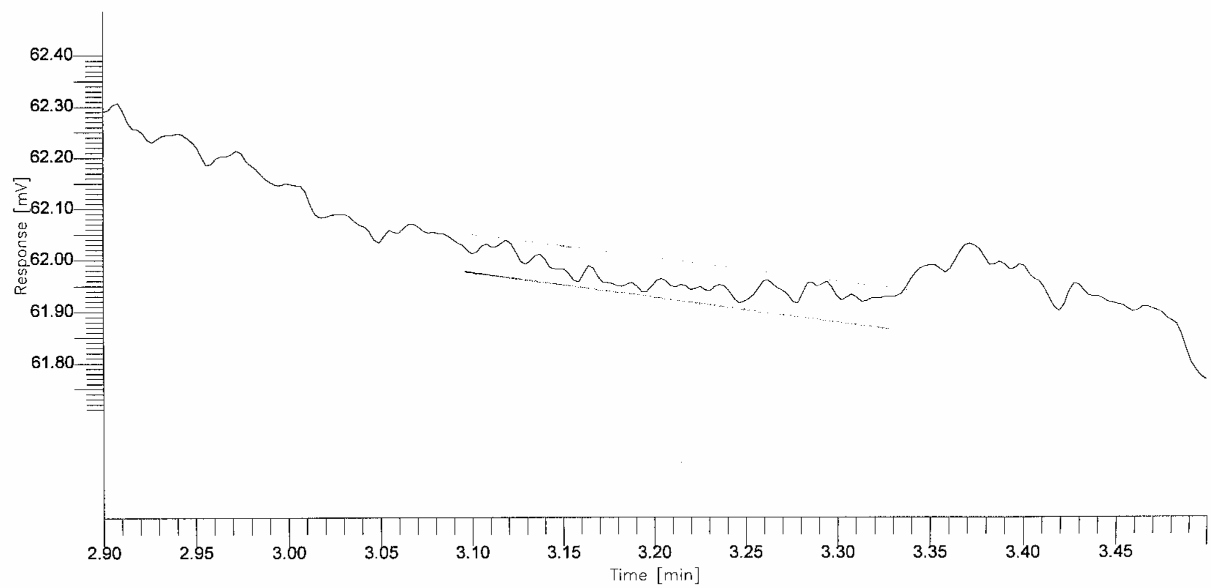
Minimum Specification: < 5 x10^{-13} Grams Nitrogen / sec Autosampler % RSD Minimum Specification: ≤ 2% RSD for 10 runs



NPD PACKED

Time [min]	Component Name	Area [μV·s]	Height [μV]
3.90	DMA	3159691.00	163421.31
		3159691.00	163421.31

Noise = .14mv p-p



NPD PACKED

Calculations

MDQ = (2 x N x V) / (H x WH)

N = (AMP GAIN) x (INTEGRATOR ATTEN) x (Noise in MV)

N = (3.33×10^{-13}) x (1) x (Noise in MV)

H = (AMP GAIN) x (INTEGRATOR ATTEN) x (Peak height in MV)

H = (3.33×10^{-13}) x (1) x (Peak height in MV)

WH = (WIDTH AT 1/2 HEIGHT IN SECONDS)

(Note: Width at ½ height in Minutes x 60 = WH in seconds)

V = SAMPLE WEIGHT (DMA) IN 1µL

V = (1.156×10^{-9}) Grams Nitrogen

Example: NPD Packed Calculation

MDQ = (2 x N x V) / (H x WH

N = (3.33×10^{-13}) x (1) x (0.14) = 4.66×10^{-14}

V = (1.156×10^{-9}) Grams Nitrogen

H = (3.33×10^{-13}) x (1) x (163) = 5.43×10^{-11}

WH = 0.25 x 60 seconds = 15 secs

MDQ = 2 x 4.66 x 10-14 x (1.156 x 10-9) / 5.43 x 10-11 x 15 sec

MDQ = 1.08 x 10-22 / 8.14 x 10-10

<u>MDQ = 1.33 x 10-13 Grams Nitrogen / second</u>

NPD Capillary Column

Test Column: N931 6008 (15m .25 DB-1)
Test Mix: N930 7036 (Universal GC Test Mix)
Syringe: N610 1390 (5 µL Syringe)

Sample Test Conditions

CAP Injector	= 250°C	H_2 Flow	= 1 - 2 mL/min
NPD Detector	= 250°C	Air Flow	= 95 - 105 mL/min
Oven	= 130°C	He Flow	= 1 mL/min
Time 1	= 5 min	Injection Volume	= 1 µL
Range	= 1	Split Flow	= 50 mL/min
Attenuation	= 1 (TC-6)	Bead Background	= 0.5 - 0.75 mV
Time Constant	= 200		

Autosampler Conditions (if fitted)

Injection Volume	= 1 µL	Sample/Solvent Wash's	= 0
Samples Vials	= 1	Sample Pumps	= 6
#Inj's/Sample	= 15	Viscosity Delay	= 0

Bead Conditioning

Cap the NPD inlet and establish normal flows for Air and H2. Adjust the NPD current to bring the mV background to 997.61. Allow background to reduce to below 50 mV (approx. 1 - 2 hrs). Reduce current to below 600, remove cap and install column. Adjust current for background of 0.5 - 0.75 mV.

Manual Testing

After the baseline has stabilized, **inject 1 mL** of the GC test mix **(N930 7036)** several times. Modify the oven temperature to correct for column differences such that DMA peak elutes no later than 4 minutes.

Autosampler Testing

Fill a single vial with the GC test mix. Setup the A/S program to make a minimum of 15 runs. Modify the oven temperature to correct for column differences such that DMA peak elutes no later then 4 minutes. Discard the first few runs for conditioning and take the next 10 consecutive runs to use for Autosampler %RSD Test.

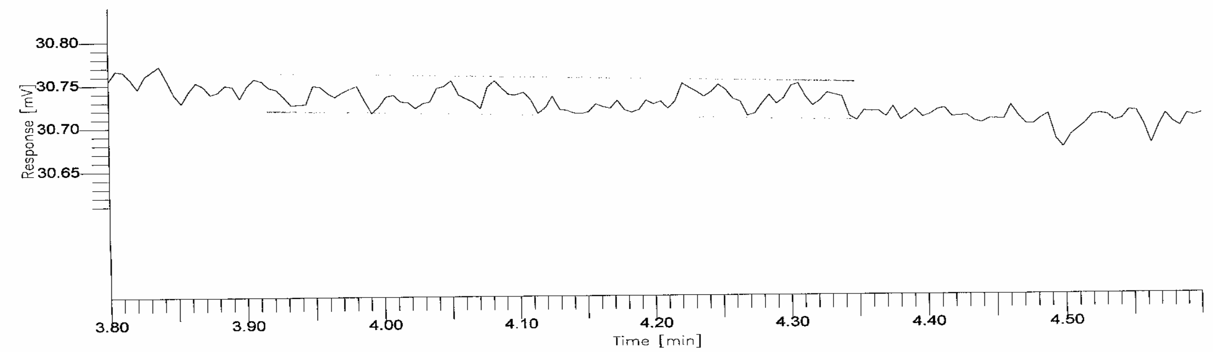
Sensitivity

If fitted with an autosampler, select a run from the 10 used to calculate %RSD which closely matches the average area and calculate minimum detectable quantity for the DMA peak. If not fitted with an autosampler, select a run for calculating minimum detectable quantity for the DMA peak. Using the DMA peak, measure peak height and width at half height. Calculate the Minimum Detectable Quantity (MDQ) in grams of nitrogen / second from the equation below.

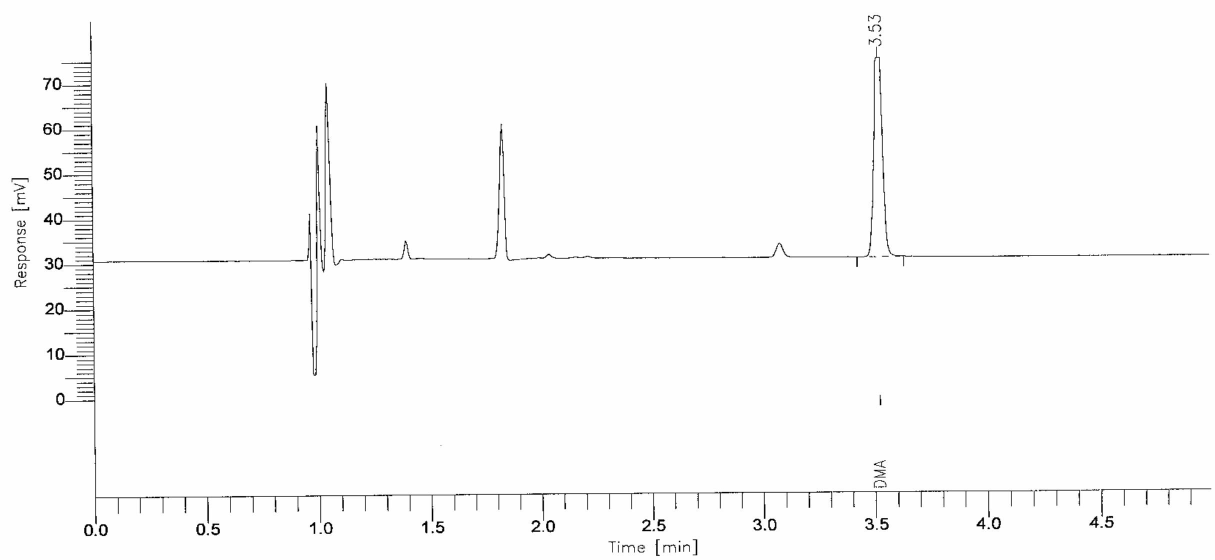
Specifications

Minimum Specification: < 5 x10^{-13} Grams Nitrogen / sec Autosampler %RSD Minimum Specification: ≤ 3% RSD for 10 runs

Noise = 0.05 mV p-p



NPD CAPILLARY



NPD CAPILLARY

Time [min]	Component Name	Area [μV·s]	Height [μV]
3.53	DMA	131649.26	57554.80
		131649.26	57554.80

Calculations

MDQ = ((2 x N) / (H x WH)) x ((C x V) / (C + S))
N = (AMP GAIN) x (INTEGRATOR ATTEN) x (Noise in MV)
N = (3.33×10^{-13}) x (1) x (Noise in MV)
H = (AMP GAIN) x (INTEGRATOR ATTEN) x (Peak height in MV)
H = (3.33×10^{-13}) x (1) x (Peak height in MV)
WH = (WIDTH AT 1/2 HEIGHT IN SECONDS)
(Note: Width at ½ height in Minutes x 60 = WH in seconds)
V = SAMPLE WEIGHT (DMA) IN 1μL (V = 1.156×10^{-9})
C = COLUMN FLOW IN ML/MIN
S = SPLIT FLOW IN ML/MIN

Example: NPD Capillary Calculation

MDQ = ((2 x N) / (H x WH)) x ((C x V) / (C + S))
N = (3.33×10^{-13}) x (1) x (.05) = 1.67×10^{-14}
V = (1.156×10^{-9}) Grams Nitrogen
H = (3.33×10^{-13}) x (1) x (57.5) = 1.91×10^{-11}
WH = 0.04 x 60 seconds = 2.4 seconds
C = 1 mL/min
S = 50 mL/min
MDQ = (2 x 1.67×10^{-14}) / ((1.91×10^{-11}) x (2.4))
= (3.34×10^{-14}) / (4.58×10^{-11})
= (0.29×10^{-4}) x ((1 x 1.156×10^{-9}) / (1 + 50)
= (7.29×10^{-4}) x (2.27×10^{-11})
= 1.65 x 10-14
<u>MDQ = .165 x 10^{-13} Grams Nitrogen / second</u>

ECD Packed Column

Test Column: N610 1406 (1/8” S.S., 10% OV-101)
Test Mix: N930 7036 (Universal GC Test Mix)
Syringe: N610 1390 (5 µL Syringe)

Sample Test Conditions

CAP Injector	= 250°C	Column Flow	= 20 mL/min
ECD Detector	= 375°C	Makeup Flow	= 10 - 20 mL/min
Oven	= 80°C	Gas Type	= Argon/Methane or Nitrogen
Time 1	= 7 min	Injection Volume	= 1 µL
Attenuation	= 32 (TC-1)	Time Constant	= 200

Autosampler Conditions (if fitted)

Injection Volume	= 1 µL	Sample/Solvent Wash’s	= 0
Samples Vials	= 1	Sample Pumps	= 6
#Inj’s/Sample	= 15	Viscosity Delay	= 0

ECD Cell Conditioning

Cap the ECD and Bakeout at 375 while conditioning the column at 250. Continue baking the ECD cell until the background mV has dropped below 10 mV. Cool the ECD to below 100°C, attach the column to the ECD inlet and establish proper flows and temperature. Allow some time for the baseline to stabilize.

Manual Testing

After the baseline has stabilized, **inject 1 mL** of the GC test mix **(N930 7036)** several times. Modify the oven temperature to correct for column differences such that the perchlorethylene peak elutes between 2 to 4 minutes.

Autosampler Testing

Fill a single vial with the GC test mix. Set up the A/S program to make a minimum of 15 runs. Modify the oven temperature to correct for column differences such that the perchlorethylene peak elutes between 2 to 4 minutes. Discard the first few runs for conditioning and take the next 10 consecutive runs to use for Autosampler %RSD Test.

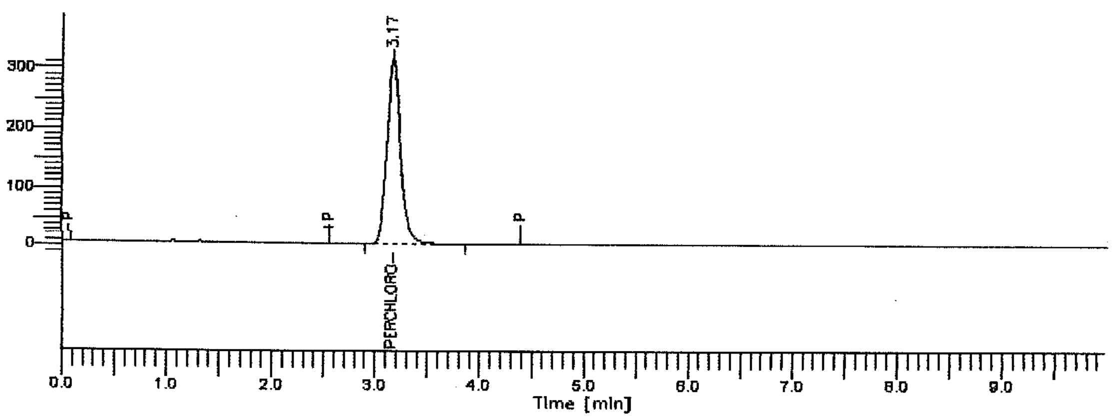
Sensitivity

If fitted with an autosampler, select a run from the 10 used to calculate %RSD which closely matches the average area and calculate minimum detectable quantity for the perchlorethylene peak. If not fitted with an autosampler, select a run for calculating minimum detectable quantity for the perchlorethylene peak from the equation below.

Specifications

Minimum Specification: < 100 x 10^{-15} grams
Autosampler %RSD Minimum Specification: ≤2% RSD for 10 runs

Noise = 0.002 mV



ECD PACKED

Time [min]	Component Name	Area [µV·s]	Height [µV]
3.170	PERCHLOROETHYLENE	2895246.19	312723.39
		2895246.19	312723.39

Calculations

MDQ = (2 x N x V) / H
N = (Amplifier Gain) x (Integrator Atten) x (Noise in MV)
N = (2.34) x (32) x (Noise in MV)
V = Sample Weight of Perchlorethylene in 1 µL
V = 1 x 10^{-9} Grams Perchlorethylene in 1 µL
H = (Amplifier Gain) x (Integrator Atten) x (Peak Height in MV)
H = (2.34) x (32) x (Peak Height in MV)

Example: ECD Packed Calculation

MDQ = (2 x N x V) / H
N = (2.34) x (32) x (0.002) = 0.149
V = 1 x 10^{-9} Grams Perchlorethylene in 1 µL
H = (2.34) x (32) x (312) = 23,362
MDQ = (2 x .149) x (1 *x* 10^{-9}) / 23,362
= 1.275 x 10^{-14}
<u>MDQ = 12.75 x10^{-15} grams</u>

ECD Capillary Column

Test Column: N931 6008 (15 m 0.25 DB-1)
Test Mix: N930 7036 (Universal GC Test Mix)
Syringe: N610 1390 (5 µL Syringe)

Sample Test Conditions

CAP Injector	= 250°C	Column Flow	= 1.0 mL/min (Helium)
ECD Detector	= 375°C	Gas Type	= Argon/Methane or Nitrogen
Oven	= 80°C	Makeup Flow	= 30 mL/min
Time 1	= 7 min	Split Flow	= 50 mL/min
Attenuation	= 4 (TC-4)	Injection Volume	= 1 µL
Time Constant	= 200		

Autosampler Conditions (if fitted)

Injection Volume	= 1 µL	Sample/Solvent Wash's	= 0
Samples Vials	= 1	Sample Pumps	= 6
#Inj's/Sample	= 15	Viscosity Delay	= 0

ECD Cell Conditioning

Cap the ECD and Bakeout at 375 while conditioning the column at 250. Continue baking the ECD cell until the background mV has dropped below 10 mV. Cool the ECD to below 100°C, attach the column to the ECD inlet and establish proper flows and temperature. Allow some time for the baseline to stabilize. Precondition test column for 1 hr. Attach to the ECD inlet and establish flows for column and makeup gases. Allow time for the baseline to stabilize (approx.1 - 2 hrs.)

Manual Testing

After the baseline has stabilized, **inject 1 mL** of the GC test mix **(N930 7036)** several times. Modify the oven temperature to correct for column differences such that the perchlorethylene peak elutes between 2 to 4 minutes.

Autosampler Testing

Fill a single vial with the GC test mix. Set up the A/S program to make a minimum of 15 runs. Modify the oven temperature to correct for column differences such that the perchlorethylene peak elutes between 2 to 4 minutes. Discard the first few runs for conditioning and take the next 10 consecutive runs to use for Autosampler %RSD Test.

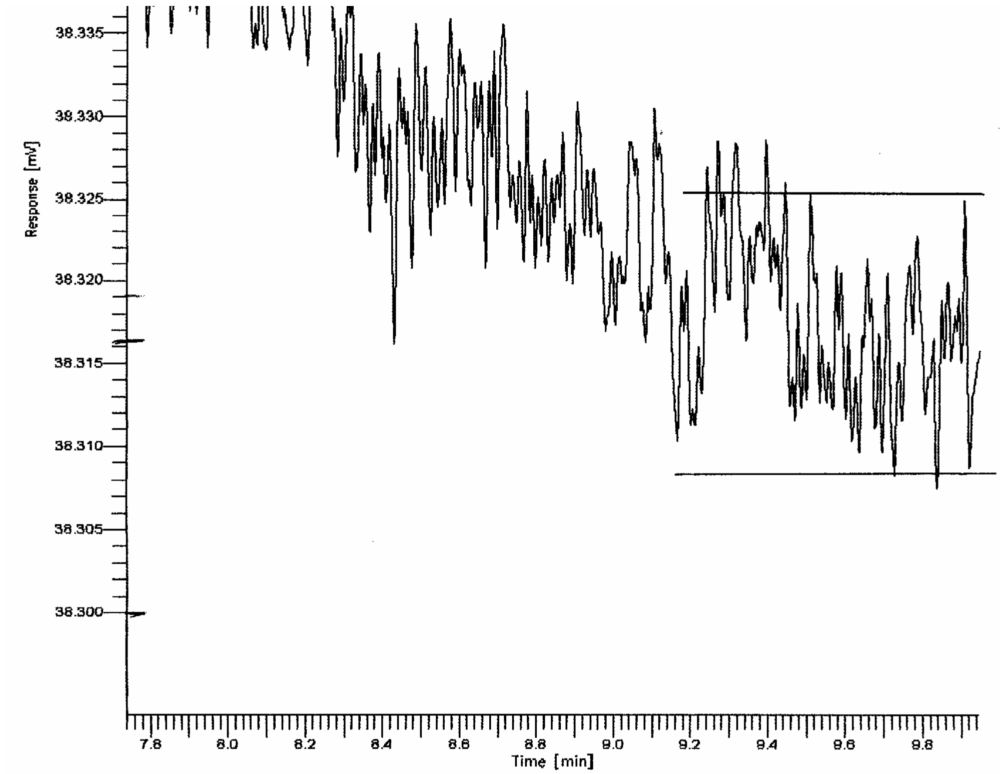
Sensitivity

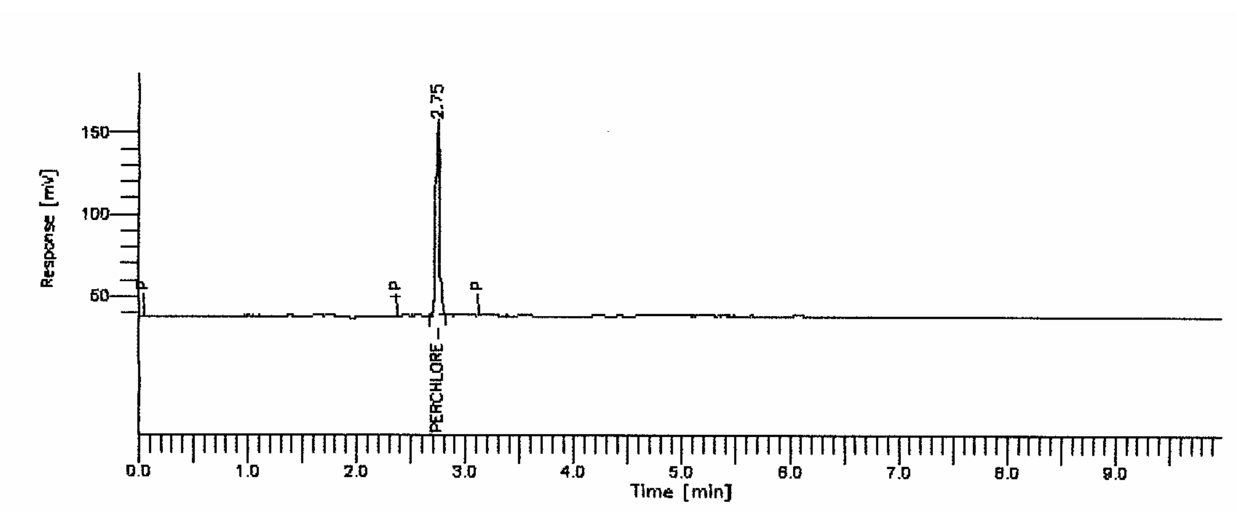
If fitted with an autosampler, select a run from the 10 used to calculate %RSD which closely matches the average area and calculate minimum detectable quantity for the perchlorethylene peak. If not fitted with an autosampler, select a run for calculating minimum detectable quantity for the perchlorethylene peak from the equation below.

Specifications

Minimum Specification: < 100 x 10^{-15} grams
Autosampler %RSD Minimum Specification: ≤3% RSD for 10 runs

Noise = 0.016 mV





ECD Capillary

Time [min]	Component Name	Area [µV·s]	Height [µV]
2.745	PERCHLORETHYENE	292574.36	113288.51

Calculations

MDQ = (2 x N) / H) x ((C x V) / (C + S))
N = (AMP GAIN) x (INTEGRATOR ATTEN) x (Noise in MV)
N = (2.34) x (4) x (Noise in MV)
H = (AMP GAIN) x (INTEGRATOR ATTEN) x (Peak height in MV)
H = (2.34) x (4) x (Peak height in MV)
V = SAMPLE WEIGHT Perchlorethylene in 1µL
V = 1 x 10^{-9} Grams Perchlorethylene in 1 µL
C = Column Flow in ML/Min
S = Split Flow in ML/min

Example: ECD Capillary Calculation

MDQ = ((2 x N) / H)) x ((C x V) / (C + S))
N = (2.34) x (4) x (0.016) = 0.149
H = (2.34) x (4) x (112.8) = 1055.8
V = 1 x 10^{-9} Grams Perchlorethylene in 1 µL
C = .5 mL/min
S = 50 mL/min
MDQ = ((2 x .149) / (1055.8)) x (0.5 x 1 x 10^{-9}) / (0.5 + 50))
= (2.82 x 10^{-4}) x (9.9 x 10^{-12})
<u>MDQ = 2.79 x 10^{-15} grams</u>

FPD Packed Column (Sulfur Mode)

Test Column: N610 1406 (1/8"S.S., 10% OV-101)
Test Mix: N930 7036 (Universal GC Test Mix)
Syringe: N610 1390 (5 µL Syringe)

Sample Test Conditions

PKD Injector	= 250°C	Column Flow	= 20 mL/min
FPD Detector	= 300°C	H2 Flow	= 75-85
Oven	= 90°C	Air Flow	= 85-105
RunTime	= 6 mins	PMT Voltage	= 70-80%
Attenuation	= 8 (TC –3)	Linearization	= OFF
Injection Volume	= 0.5 µL	Time Constant	= 800

Autosampler Conditions (if fitted)

Injection Volume	= .5 µL	Sample/Solvent Washes	= 0
Samples Vials	= 1	Sample Pumps	= 6
#Inj's/Sample	= 15	Viscosity Delay	= 0

Detector Setup

The FPD PMT should be adjusted to produce approximately 0.02 - 0.04 mV of baseline noise. Time constant of **800** and attenuation of 8 (TC –3) **MUST** be used. The air flow should be adjusted to produce a maximum signal response for Thiophene. Be aware of the Thiophene's peak retention time. If it co-elutes with the C6 solvent, "quenching" will occur and the response will be diminished. Modify the oven temp so the Thiophene peak comes out between 1 - 2 minutes. Allow ample time for the C9 hydrocarbon to come out before making the next injection.

Manual Testing

After the thermal zones have stabilized, **inject 0.5 mL** of the GC test mix **(N930 7036)** several times. Modify the oven temp so the Thiophene peak comes out between 1 - 2 minutes.

Autosampler Testing

Fill a single vial with the GC test mix. Setup the A/S program to make a minimum of 15 runs. Modify the oven temp so the Thiophene peak comes out between 1 - 2 minutes. Discard the first few runs for conditioning and take the next 10 consecutive runs to use for Autosampler %RSD Test.

Clarus 500 GC Test Specifications (cont.)

FPD Packed Column (Sulfur Mode) (cont.)

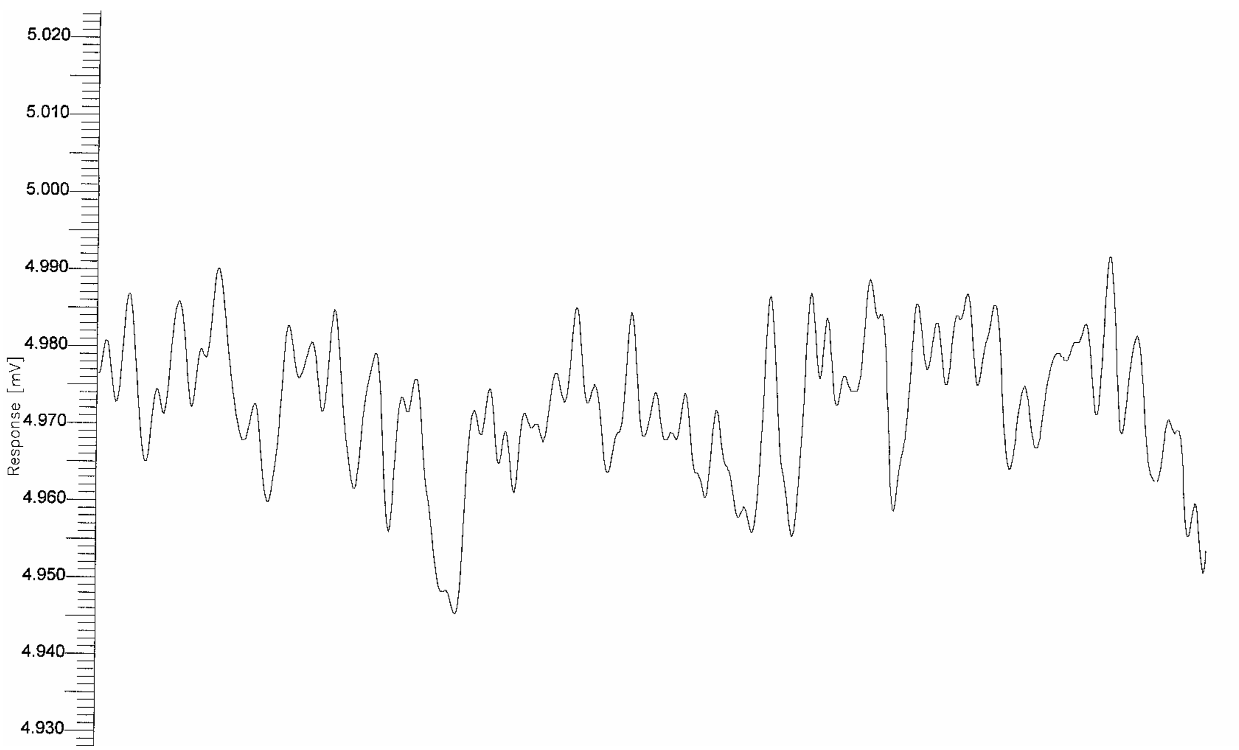
Sensitivity

If fitted with an autosampler, select a run from the 10 used to calculate %RSD that closely matches the average area and calculate the MDQ for the Thiophene peak. If not fitted with an autosampler, select a run for calculating the minimum detectable quantity (MDQ) from the equation below.

Specifications

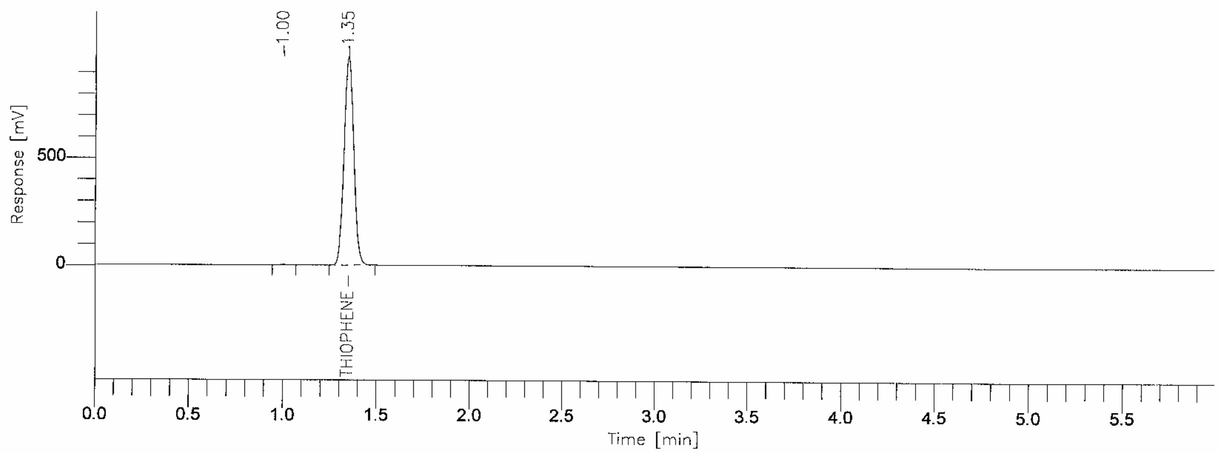
Minimum Specification: < 1 x 10^{-11} Grams Sulfur / Sec.
Autosampler % RSD Minimum Specification: ≤4% RSD for 10 runs

Noise = 0.03 mV



Clarus 500 GC Test Specifications (cont.)

FPD Packed Column (Sulfur Mode) (cont.)



FPD SULFUR PACKED

Time [min]	Component Name	Area [μV·s]	Height [μV]	BL
1.350	Thiophene	3514315.90	972552.19	BB
		3514315.90	972552.19	

Clarus 500 GC Test Specifications (cont.)

FPD Packed Column (Sulfur Mode) (cont.)

Calculations

MDQ = (square root of (2 x N) / H)) x V / WH
N = (AMP GAIN) x (INTEGRATOR ATTEN) x (Noise in MV)
N = (3.13×10^{-11}) x (8) x (Noise in MV)
H = (AMP GAIN) x (INTEGRATOR ATTEN) x (Peak height in MV)
H = (3.13×10^{-11}) x (8) x (Peak height in MV)
V = SAMPLE WEIGHT Thiophene 0.5µL
V = 5×10^{-9} Grams Sulfur in 0.5µL
WH = peak width at 1/4 height in seconds
NOTE: width in minutes x 60 = width in seconds

Example: FPD Packed Calculation

MDQ = (square root of ((2 x N) / H)) x V / WH
N = $(3.13 \times 10^{-11}) \times (8) \times (.03) = 7.51 \times 10^{-12}$
H = $(3.13 \times 10^{-11}) \times (8) \times (972) = 2.4 \times 10^{-7}$
V = (5×10^{-9}) Grams Sulfur
WH = .1m x 60 = 6 secs

MDQ = SR of $2 \times (7.57 \times 10^{-12}) / 2.4 \times 10^{-7}$
= SR of $(1.54 \times 10^{-11}) / 2.4 \times 10^{-7}$
= (SR of .000063) x (5×10^{-9})
= .00794 x (5×10^{-9})
= 3.97×10^{-11} / 6 sec
= 6.6×10^{-12}

<u>MDQ = $.66 \times 10^{-11}$ Grams Sulfur / Second</u>

Clarus 500 GC Test Specifications (cont.)

FPD Capillary Column (Sulfur Mode)

Test Column: N931 6008 (15 m 0.25 DB-1)
Test Mix: N930 7036 (Universal GC Test Mix)
Syringe: N610 1390 (5 µL Syringe)

Sample Test Conditions

PKD Injector	= 250°C	Column Flow	= 1 mL/min
FPD Detector	= 300°C	Split Flow	= 50 mL/min
Oven	= 90°C	H2 Flow	= 75 - 85
RunTime	= 7 mins	Air Flow	= 85 - 105
Attenuation	= 8 (TC –3)	PMT Voltage	= 70 - 80%
Injection Volume	= 1 µL	Linearization	= OFF
Time Constant	= 200		

Autosampler Conditions (if fitted)

Injection Volume	= 0.5 µL	Sample/Solvent Washes	= 0
Samples Vials	= 1	Sample Pumps	= 6
#Inj's/Sample	= 15	Viscosity Delay	= 0

Detector Setup

The FPD PMT should be adjusted to produce approximately 0.08 - 0.10 mV of baseline noise. Time constant of **200** and attenuation of 8 (TC –3) **MUST** be used. The air flow should be adjusted to produce a maximum signal response for Thiophene. Be aware of the Thiophene's peak retention time. If it co-elutes with the C6 solvent "quenching" will occur and the response will be diminished. Modify the oven temp so the Thiophene peak comes out between 1 - 2 minutes. Allow ample time for the C9 hydrocarbon to come out before making the next injection.

Manual Testing

After the thermal zones have stabilized, **inject 1 mL** of the GC test mix **(N930 7036)** several times. Modify the oven temp so the Thiophene peak comes out between 1 - 2 minutes.

Autosampler Testing

Fill a single vial with the GC test mix. Setup the A/S program to make a minimum of 15 runs. Modify the oven temp so the Thiophene peak comes out between 1 - 2 minutes. Discard the first few runs for conditioning and take the next 10 consecutive runs to use for autosampler %RSD test.

Clarus 500 GC Test Specifications (cont.)

FPD Capillary Column (Sulfur Mode) (cont.)

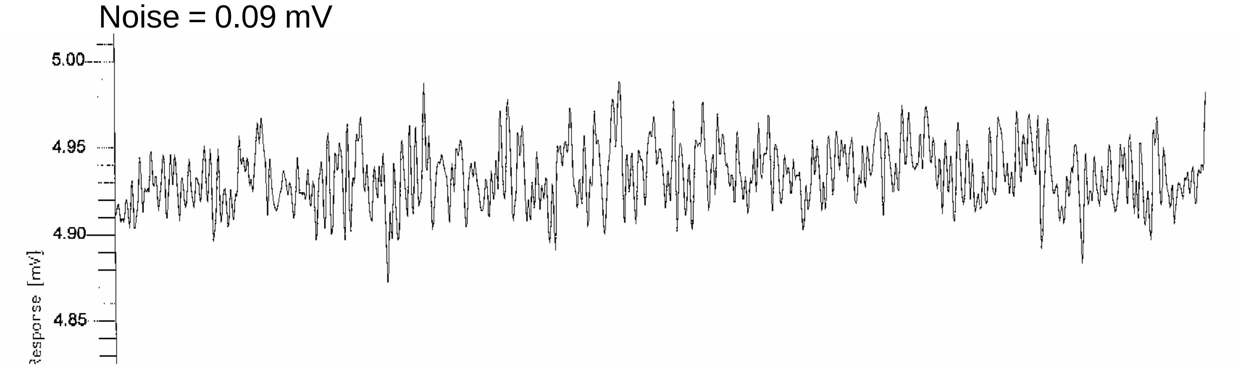
Sensitivity

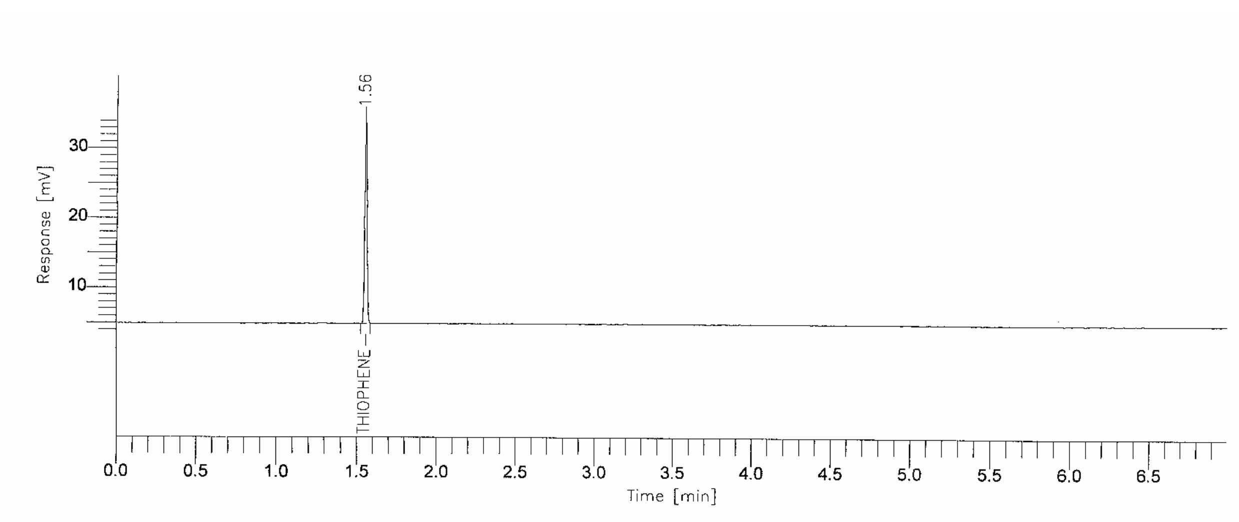
If fitted with an autosampler, select a run from the 10 used to calculate %RSD that closely matches the average area and calculate minimum detectable quantity (MDQ) for the Thiophene peak. If not fitted with an autosampler, select a run for calculating the minimum detectable quantity (MDQ) from the equation below.

Specifications

Minimum Specification: $< 1 \times 10^{-11}$ Grams Sulfur / sec
Autosampler % RSD Minimum Specification: ≤ 4% RSD for 10 runs

Noise = 0.09 mV





Clarus 500 GC Test Specifications (cont.)

FPD Capillary Column (Sulfur Mode) (cont.)

Time [min]	Component Name	Area [μV·s]	Height [μV]
1.556	THIOPHENE	29997.21	29715.49
		29997.21	29715.49

Calculations

MDQ = (square root of (2 x N) / H)) x V / WH
N = (AMP GAIN) x (INTEGRATOR ATTEN) x (Noise in MV)
N = (3.13×10^{-11}) x (8) x (Noise in MV)
H = (AMP GAIN) x (INTEGRATOR ATTEN) x (Peak height in MV)
H = (3.13×10^{-11}) x (8) x (Peak height in MV)
*V = SAMPLE WEIGHT Thiophene 1 μL
*V = 10×10^{-9} Grams Sulfur in 1 μL
= (C x V) / (C + S) for a 50: 1 split
V = 1.96×10^{-10} Grams Sulfur in 1 μL (50:1 split)
WH = Peak width at ¼ height in secs.

Example: FPD Capillary Calculation

MDQ = (square root of ((2 x N) / H)) x V / WH
N = (3.13×10^{-11}) x (8) x (.09) = 2.25×10^{-11}
H = (3.13×10^{-11}) x (8) x (29.7) = 7.4×10^{-9}
V = (1.96×10^{-10}) Grams Sulfur
WH = .03 x 60 = 1.8 seconds
MDQ = SR of 2 x 2.25×10^{-11} / 7.4×10^{-9}
= SR of (4.5×10^{-11}) / 7.4×10^{-9}
= SR of 0.00608 x (1.96×10^{-9})
= .0779 x (1.96×10^{-10})
= 1.052×10^{-11} / 1.8 seconds
<u>MDQ = $.84 \times 10^{-11}$ Grams Sulfur /sec</u>

Clarus 500 GC Test Specifications (cont.)

FPD Capillary (Phosphorous Mode)

Test Column: L483 1404 (DB1 12M X .22mm ID), N931 6008 (15 m 0.25 DB-1)
or N931 5052 PE-1 12M X .2mm ID X .33 film thickness)
Test Mix: L413 1586 GC Test Mix N600-0981 (Filter, Phosphorous)

Sample Test Conditions

CAP Injector	= 300°C	H2 Flow	= 75 - 85 mL/min
FPD Detector	= 50°C	Air Flow	= 85 - 95 mL/min
Oven 1	= 85°C	Column Flow	= 0.5 mL/min approx.
Time 1	= 2 min	Split Flow	= 15 mL/min
Ramp Rate	= 20°C/min	Range	= 1 PMT ON
Oven 2	= 250°C	PMT Voltage	= 70% - 85% (approx. -500VDC)
Auto Zero	= ON	Integrator	= Output
Linearization	= OFF	Time Constant	= 200 µsec
Offset	= 5 mV	Integrator Attn	= 8

Autosampler Conditions (if fitted)

Injection Volume	= 1.0 µL	Sample/Solvent Washes	= 0
Samples Vials	= 1	Sample Pumps	= 6
#Inj's/Sample	= 15	Viscosity Delay	= 0

Detector Setup

Refer to the Operator's Manual maintenance section for instructions on installing the phosphorous filter assembly. The FPD PMT should be adjusted to produce approximately 0.08 - 0.10 mV of baseline noise. The temperature program given in the test procedure was selected to elute the hydrocarbons from the column in a reasonable time. Be sure the hydrocarbons have had sufficient time to exit the column before starting a new run. Test Mix, L413 1586 contains the following;

2.1125×10^{-8} g/µL of dodecanethiol
2.4475×10^{-8} g/µL of tributylphosphate

Manual Testing

After the baseline has stabilized, **inject 1.0 mL** of the GC Test Mix (L413 1586) several times. Modify the oven temperature to correct for column differences such that Tributylphosphate elute between 7.2 - 8.0 minutes.

Autosampler Testing

Fill a single vial with the GC test mix. Set up the A/S program to make a minimum of 15 runs. Modify the oven temp so the Tributylphosphate peak comes out between 7.2 - 8.0 minutes. Discard the first few runs for conditioning and take the next 10 consecutive runs to use for autosampler %RSD test.

Clarus 500 GC Test Specifications (cont.)

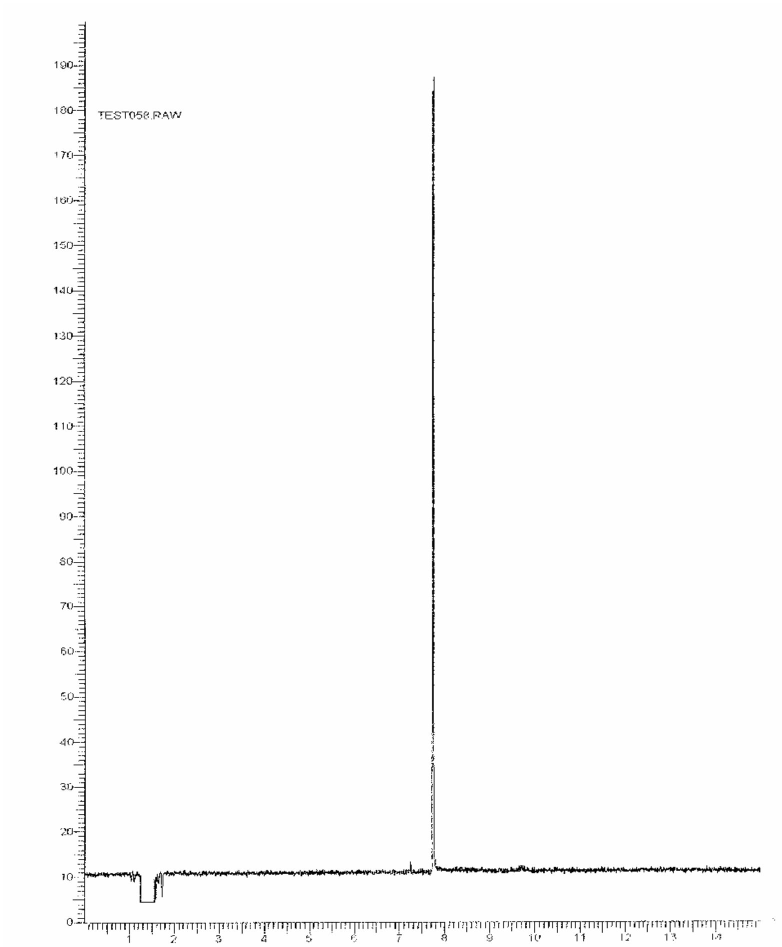
FPD Capillary (Phosphorous Mode) (cont.)

Sensitivity

If fitted with an autosampler, select a run from the 10 used to calculate %RSD that closely matches the average area and calculate minimum detectable quantity (MDQ) for the Tributylphosphate peak. If not fitted with an autosampler, select a run for calculating the minimum detectable quantity (MDQ) from the equation below.

Specifications

Minimum Specification: < 1 x 10^{-12} Grams of Phosphorus
Autosampler % RSD Minimum Specification: ≤ 4% RSD for 10 runs



Clarus 500 GC Test Specifications (cont.)

FPD Capillary (Phosphorous Mode) (cont.)

Calculations

Calculate the MDQ using the Tributylphosphate peak.

MDQ = V x (2 x N) **/** H
N = Peak to Peak Noise in Amps.
N = (Gain 3.13×10^{-11} A/MV) x (Integrator Attenuation*) x (Peak - Peak Noise in MV)
H = Peak Height in Amps.
H = (Gain 3.13×10^{-11} A/MV) x (Integrator Attenuation*) x (Peak Height in MV)
*Integrator Attenuation setting on GC for the Noise Run or Peak Height (They may be different).
V = Sample Amount Injected
V = 2.85×10^{-9} x (C **/** (C + S))*
Sample Weight (1.0µl) (2.85×10^{-9} Grams of Phosphorus)
* 2.85×10^{-9} = Sample weight in 1.0µl of GC Test Mix L413 1586
* C = Column flow in mL/min
* S = Split flow in mL/min

MDQ < 1×10^{-12} Grams of Phosphorus

Example: FPD Capillary (Phosphorous Mode) Calculation

MDQ = V x (2 x N) / H
V = C x V / C x S
$.5 \times 2.85 \times 10^{-9} / .5 + 15$
V = 9.19×10^{-11} grams of phosphorous
N = $3.13 \times 10^{-11} \times 8 \times .9$ MV = 2.25×10^{-10}
H = $3.13 \times 10^{-11} \times 8 \times 175$ MV = 4.38×10^{-8}
MDQ = $9.19 \times 10^{-11} \times (2 \times 2.25 \times 10^{-10})$
= $9.19 \times 10^{-11} \times 4.5 \times 10^{-11}$
= $4.135 \times 10^{-20} / 4.38 \times 10^{-8}$
MDQ = < $.94 \times 10^{-12}$ Grams of Phosphorus

Clarus 500 GC Test Specifications (cont.)

ELCD Packed Column

Test Column: N610 1406 (1/8" st stl, 10% OV-101)

Test Mix: 0330 2677 (ELCD Test Mix)

<u>Sample Test Conditions:</u>

PKD Injector	= 250°C	H2 Flow	= 24 - 26 mL/min
ELCD Detector	= 250°C	Column	= 24 - 26 mL/min
Oven 1	= 70°C	Valve 3	= .OFF
Time 1	= 1 min	Split Flow	= 10 - 15 mL/min
Ramp Rate	= 120°C/min	Range	= 1
Rate	= 8°C	Int Atten	= 1
Oven 2	= 100 °C		
Time 2	= 3 min		

<u>Hall Box (if fitted)</u>

Filter	= Medium	Solvent Flow	=0.6 mL/min
Zero	= OFF	Solvent	= ON
Reactor	= 850	Rector	= ON
Hall Jumper	= X10		

Detector Setup

With the hydrogen needle valve off (fully CW), and the vent solenoid valve OFF (Valve 3 OFF), no flow should come out the vent. Adjust the helium carrier column flow for 25 mL/min out of the reactor tube. Adjust the hydrogen needle valve for a total flow of 50 mL/min out of the reactor tube. Confirm that the transfer line between the reactor and the conductivity cell is disconnected. Turn the ELCD control unit on. Turn the reactor temp switch on and set the reactor temperature to 850°C. Allow the system to bake out for two to four hours. After bake out, turn the reactor temp control OFF and allow the system to cool. Reconnect the transfer line between the reactor and the conductivity cell. Disconnect the drain tube (which goes to the bottom of the conductivity cell) from the reservoir and place it in a 10 mL graduated cylinder. Switch the solvent flow ON and adjust the flow rate to 0.6 mL/min. After the flow has been set, return the drain tube to the solvent reservoir and turn the reactor temperature ON and to 850°C.

Manual Testing

After the baseline has stabilized, **inject 0.5 mL** of test mix **(0330 2677)** several times. Modify the oven temperature to correct for column differences such that Dibromochloro Methane elutes between 2.0 - 4.0 minutes.

Clarus 500 GC Test Specifications (cont.)

ELCD Packed Column (cont.)

Autosampler Testing

Fill a single vial with the GC test mix. Set up the A/S program to make a minimum of 15 runs. Modify the oven temperature so the Dibromochloro Methane elutes between 2.0 - 4.0 minutes. Discard the first few runs for conditioning and take the next 10 consecutive runs to use for autosampler %RSD test.

Sensitivity

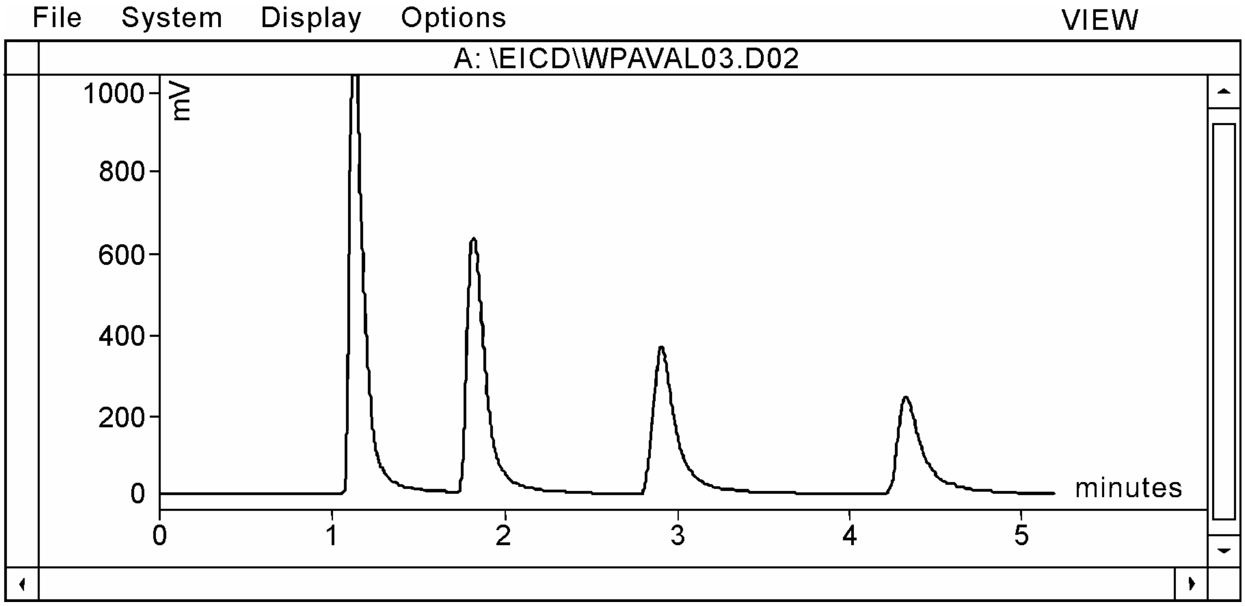
The following results are from the 10 V output of the Hall Box. If fitted with an autosampler, select a run from the 10 used to calculate %RSD that closely matches the average area and calculate the signal to noise ratio from the equation below. If not fitted with an autosampler, select a run for calculating the signal to noise ratio.

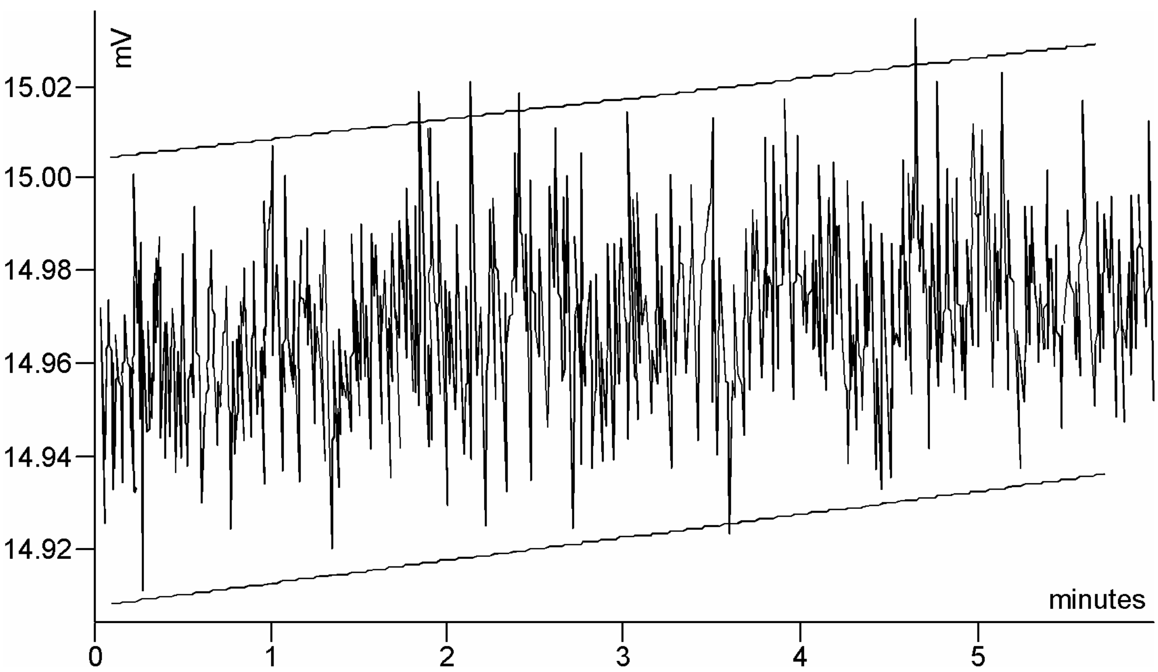
Specifications

Minimum Specification: Chloroform S/N > 1600
Minimum Specification: Dibromochloro Methane S/N > 200
Autosampler %RSD Minimum specification: ≤3% RSD for 10 runs

Clarus 500 GC Test Specifications (cont.)

ELCD Packed Column (cont.)





Clarus 500 GC Test Specifications (cont.)

ELCD Packed Column (cont.)

Calculations

Four major peaks will elute in the following order:

1. Choloroform	0.0 - 2.0 min
2. Bromodichloro Methane	1.0 - 3.0 min
3. Dibromochloro Methane	2.0 - 4.0 min
4. Bromoform	5.0 - 8.0 min

Calculate the Signal-to-Noise Ratio for the first and third peaks.

1. Chloroform	S/N > 1600
3. Dibromochloro Methane	S/N > 200

Signal noise = H / N

\N = (AMP GAIN) x (INTEGRATOR ATTEN) x (PEAK TO PEAK NOISE IN MV)
N = (156 µV / 1mV) x (INT ATTEN) x (NOISE IN MV)
H = (AMP GAIN) x (INTEGRATOR ATTEN) x (PEAK HEIGHT IN MV)
H = (156 µV / 1 mV) x (INT ATTEN) x (PEAK HEIGHT IN MV)

Reference Only:

V = Sample weight in 0.5 µL of 0330-2677 test mix
V = 1.0 x 10^{-7} grams of Chloroform
V = 1.0 x 10^{-7} grams of Dibromochloro Methane

Chloroform	Dibromochoromethane
N = 156 x 1 x .1	N = 156 x 1 x .1
N = 15.6	N = 15.6
H = 156 x 1 x 1000	H = 156 x 1 x 400
H = 156,000	H = 62,400
S/N = 156,000 / 15.6	S/N = 62,400 / 15.6
S/N = 10,000	S/N = 4000

Clarus 500 GC Test Specifications (cont.)

PID Packed Column

Test Column: N610 1406 (1/8" st stl, 10% OV-101)
Test Mix: 0330 2826 (PID Test Mix)

Sample Test Conditions

PKD Injector	= 250°C	Column Flow	= 20
PID Detector	= 250°C	Make Up	= 0 mL/min
Oven 1	= 70°C	Atten	= 1 (TC-6)
Time 1	= 1 min	Lamp	= ON
Rate	= 8°C/min		
Oven 2	= 100°C		

Autosampler Conditions (if fitted)

Injection Volume	= 0.5 µL	Sample/Solvent Washes	= 0
Samples Vials	= 1	Sample Pumps	= 6
#Inj's/Sample	= 15	Viscosity Delay	= 0

Detector Setup

PID optimum operating point:

After the setup conditions are reached, set the lamp intensity control to minimum and press the autozero key. Read the autozero display and note millivolt reading. Slowly increase the lamp intensity control until the autozero display increases 4 mV.

Manual Testing

After the baseline has stabilized, inject 0.5 µL of PID Test Mix 0330 2826 several times. Modify the oven temperature to correct for column differences such that the Benzene peak elutes between 1.5 and 2.5 minutes.

Autosampler Testing

Fill a single vial with the PID test mix. Set up the A/S program to make a minimum of 15 runs. Modify the oven temperature to correct for column differences such that the Benzene peak elutes between 1.5 and 2.5 minutes. Discard the first few runs for conditioning and take the next 10 consecutive runs to use for autosampler %RSD test.

Sensitivity

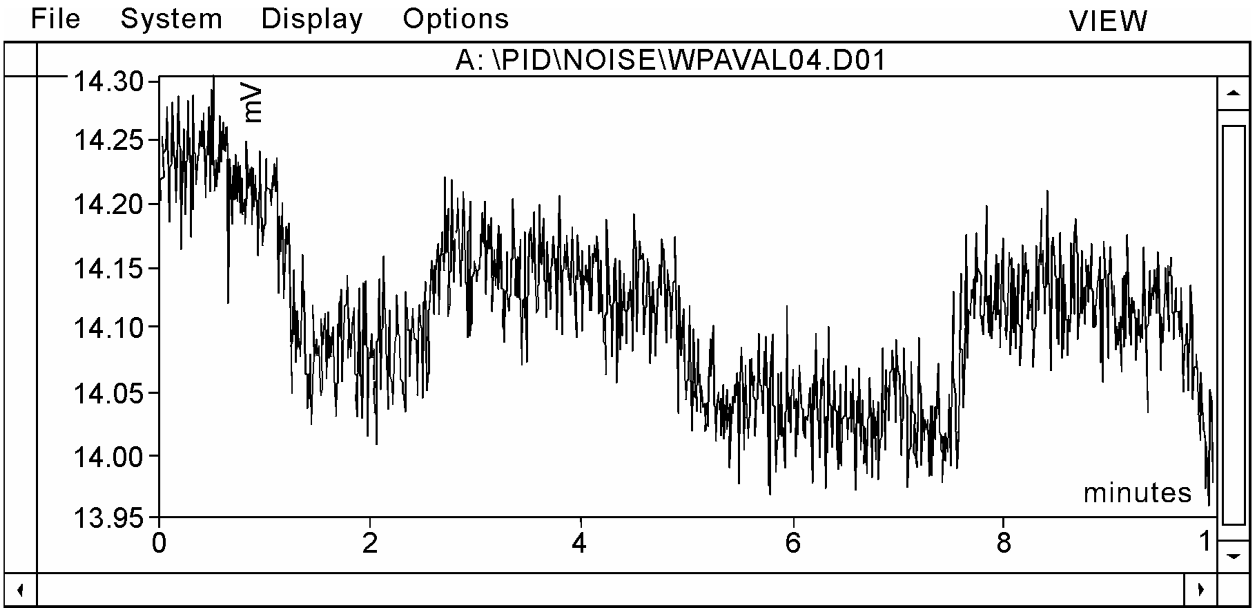
If fitted with an autosampler, select a run from the 10 used to calculate %RSD which closely matches the average area and calculate minimum detectable quantity (MDQ) for the Benzene peak from the equation below. If not fitted with an autosampler, select a run for calculating minimum detectable quantity for the Benzene peak from the equation below.

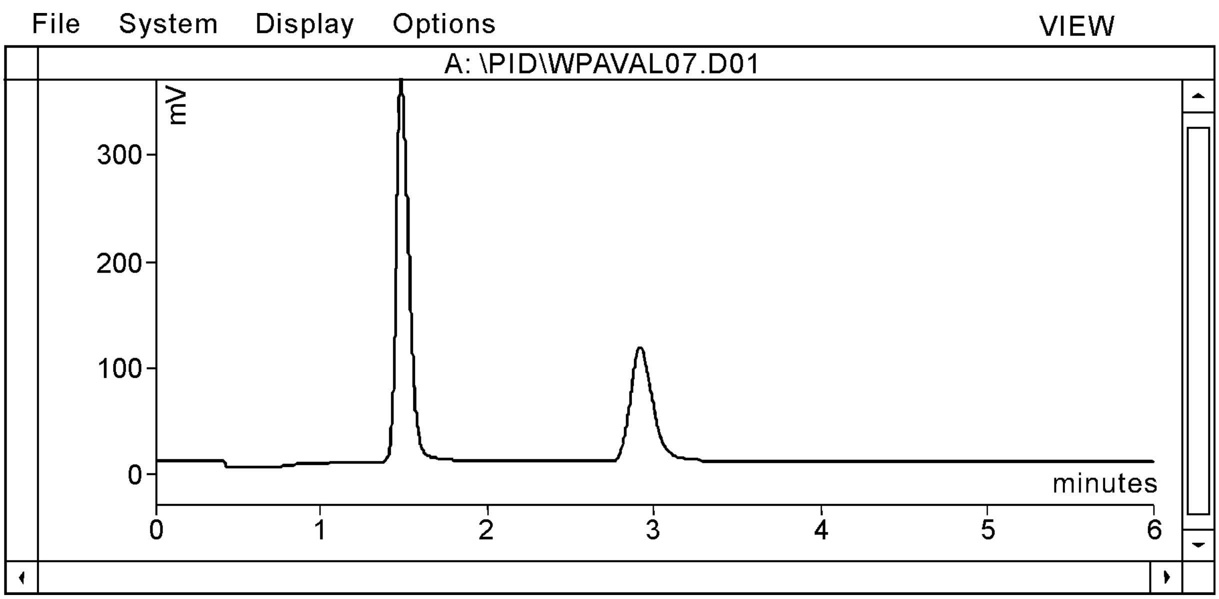
Clarus 500 GC Test Specifications (cont.)

PID Packed Column (cont.)

Specifications

Minimum Specification: < 10 x 10^{-12} Grams of Benzene
Autosampler %RSD Minimum specification: ≤ 3% RSD for 10 runs





Clarus 500 GC Test Specifications (cont.)

PID Packed Column (cont.)

Calculations

MDQ < 10 x 10^{-12} grams of Benzene
MDQ = (2 x N x V) / H
N = (AMP GAIN) x (INTEGRATOR ATTEN) x (NOISE IN MV)
N = (3.33 x 10^{-13}) x (INT ATTEN) x (NOISE IN MV)
H = (AMP GAIN) x (INTEGRATOR ATTEN) x (PEAK HEIGHT IN MV)
H = (3.33 x 10^{-13}) x (INT ATTEN) x (PEAK HEIGHT IN MV)
V = SAMPLE WEIGHT BENZENE IN .5ul
V = (22 x 10^{-9}) GRAMS BENZENE

N = 3.33 x 10^{-13} x 1 x .09
= 2.99 x 10^{-14}

H = 3.33 x 10^{-13} x 1 x 400 mV
= 1.33 x 10^{-10}

V = 22 x 10^{-9}

MDQ = 2 x (3.33 x 10^{-14}) x 22 x 10^{-9}

= 1.31 x 10^{-21} / 1.33 x 10^{-10}

MDQ= 9.91 x 10^{-12}

Clarus 500 GC Test Specifications (cont.)

PID Capillary Column

Test Column: N930 6008 (15m .25id DB-1)
Test Mix: 0330 2826 (PID Test Mix)
Syringe: N610 1390 (5 µL Standard)

Sample Test Conditions

CAP Injector	= 250°C		
PID Detector	= 250°C	Makeup Flow	= 10mL/min
Oven	= 90°C	Column Flow	= 1 mL/min
Time 1	= 5.0 min	Injection Volume	= 0.5 µL
Range	= 1	Split Flow	= 50 mL/min
Attenuation	= 2 (TC-5)	Time Constant	= 200

Autosampler Conditions (if fitted)

Injection Volume	= 0.5 µL	Sample/solvent wash's	= 0
Samples vials	= 1	Sample pumps	= 6
#Inj's/sample	= 15	Viscosity delay	= 0

Detector Setup

PID Optimum Operating Point:

After the setup conditions are reached, set the lamp intensity control to minimum and press the autozero key. Slowly increase the lamp intensity control setting while monitoring the autozero display value. The autozero display should increase with the lamp intensity control setting. At some point the signal should suddenly decrease to a lower value. Optimize the lamp intensity control setting around this point to the lowest autozero display value.

Manual Testing

After the baseline has stabilized, **inject 0.5mL** of PID Test Mix **0330 2826** several times. Modify the oven temperature to correct for column differences such that the Benzene peak elutes between 1.5 and 2.5 minutes.

Autosampler Testing

Fill a single vial with the PID test mix. Set up the A/S program to make a minimum of 15 runs. Modify the oven temperature to correct for column differences such that the Benzene peak elutes between 1.5 and 2.5 minutes. Discard the first few runs for conditioning and take the next 10 consecutive runs to use for autosampler %RSD test.

Clarus 500 GC Test Specifications (cont.)

PID Capillary Column (cont.)

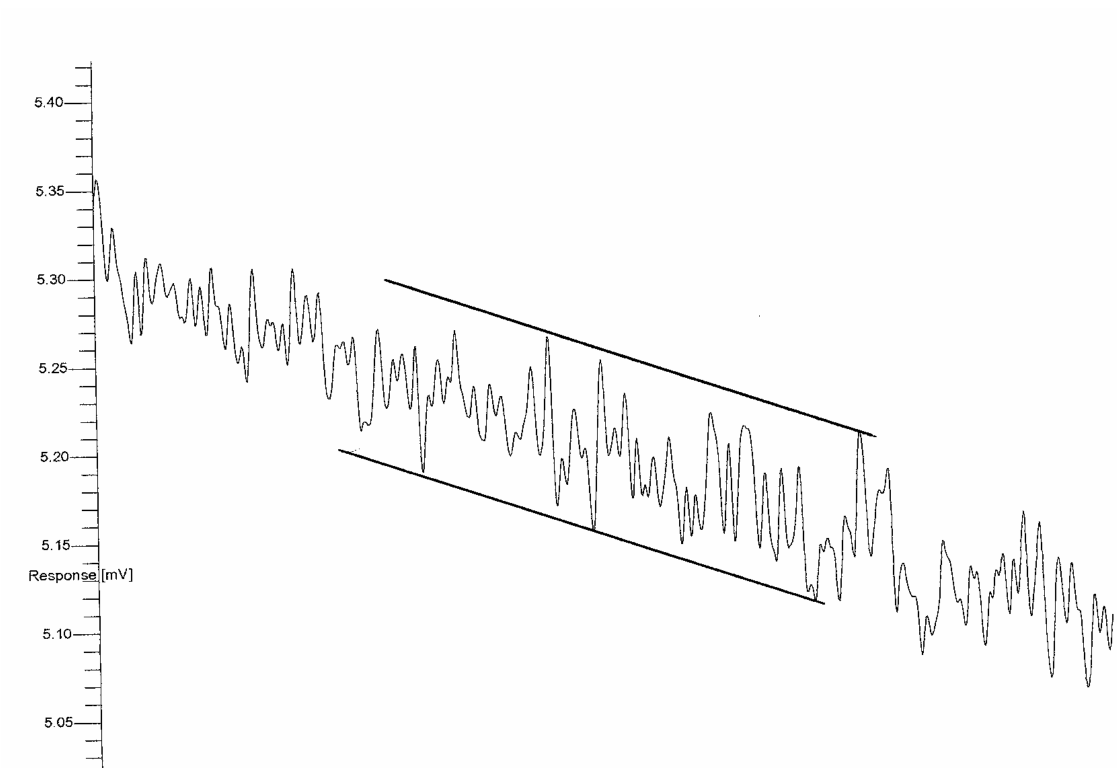
Sensitivity

If fitted with an autosampler, select a run from the 10 used to calculate %RSD which closely matches the average area and calculate minimum detectable quantity (MDQ) for the Benzene peak from the equation below. If not fitted with an autosampler, select a run for calculating minimum detectable quantity for the Benzene peak from the equation below.

Specifications

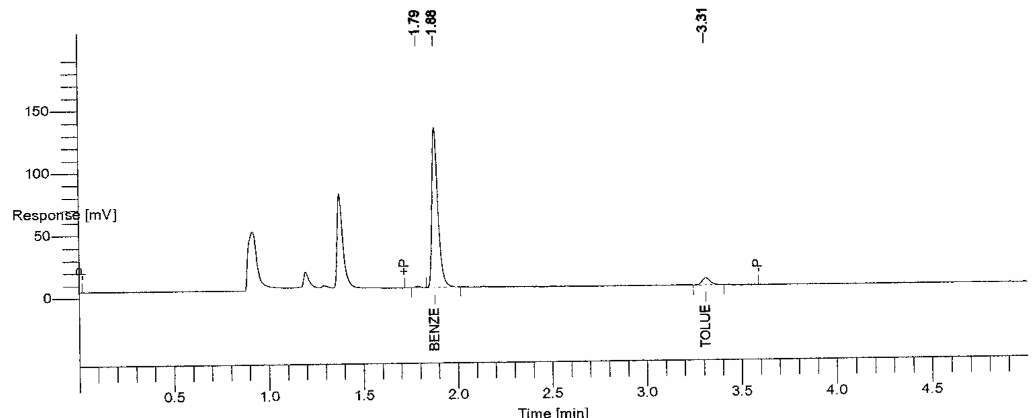
Minimum Specification: < 10 x 10^{-12} Grams of Benzene
Autosampler %RSD Minimum specification: ≤ 3% RSD for 10 runs

Noise = 0.1 MV



Clarus 500 GC Test Specifications (cont.)

PID Capillary Column (cont.)



PID CAPILLARY IQOQ

Component Name	Time [min]	Area [μV·s]	Height [μV]
BENZENE	1.880	283159.44	128089.59
TOLUENE	3.311	16884.94	5798.76
		300044.37	133888.35

Calculations

MDQ = (2 x N / H) x (C x V / C + S)

N = (AMP GAIN RANGE 1) x (INTEGRATOR ATTEN) x (NOISE in MV)

N = (3.33×10^{-13}) x (2) x (NOISE IN MV)

H = (AMP GAIN RANGE 1) x (INTEGRATOR ATTEN) x (SIGNAL MV)

H = (3.33×10^{-13}) x (2) x (SIGNAL MV)

V = SAMPLE WEIGHT of Benzene IN 0.5 μL

V = (22×10^{-9}) GRAMS Benzene

C = Column Flow

S = Split Flow

Clarus 500 GC Test Specifications (cont.)

PID Capillary Column (cont.)

Example: PID Capillary Calculation

MDQ = (2 x N / H) x (C x V / C + S)

N = 3.33×10^{-13} x (2) x .1mv = 6.66×10^{-14}

H = 3.33×10^{-13} x (2) x 128 mv = 8.52×10^{-11}

V = 22×10^{-9}

C = 1 mL/min

S = 50 mL/min

MDQ = (2 x 6.66×10^{-14} / 8.52×10^{-11}) x (1 x 22×10^{-9} / 1 + 50)

= (1.33×10^{-13} / 8.52×10^{-11}) x (22×10^{-9} / 1 + 50)

= 1.56×10^{-3} x 4.31×10^{-10}

= 6.7×10^{-13}

MDQ = 0.67×10^{-12} Grams of Benzene

Calibrating the Oven Temperature

The Clarus 500 GC oven temperature is controlled by a sophisticated software routine that permits adjustment of the actual oven temperature inside the oven up or down within a ±10 °C window. This calibration utility is intended for applications which require precisely matching oven temperatures across several Clarus 500 GCs, such as the determination of retention indices. The calibration information is stored in a reserved area of the battery-backed memory.

Required Equipment: A calibrated precision platinum resistance thermometer with 0.01 °C readout and a probe capable of insertion into the GC oven.

The following steps summarize how to calibrate the oven temperature:

1. Calibrate the reference thermometer
2. Place the thermometer probe in the oven
3. Equilibrate the oven temperature
4. Enter the required offset value
5. Remove the thermometer probe

Calibrate the Reference Thermometer

Calibrate your reference thermometer according to its instructions. If the thermometer has been calibrated by an outside service, there is no reason to recalibrate it yourself.

Place the Thermometer Probe in the Oven

CAUTION	*The thermometer probe must be placed as close as possible to the same position in each GC oven to be calibrated. Access to the oven is provided on the left-side oven wall.*

1. Turn off the power and allow the oven to cool.
2. Remove the left-side instrument cover.

NOTE: *The location of three approximately 1-inch diameter holes that correspond to the hole on the left side of the oven. One or more of these holes may be occupied by gas sampling valves.*

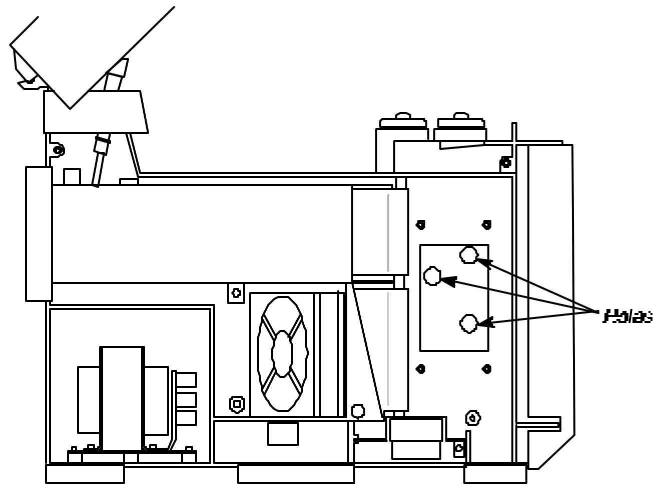


Figure 5- 1 Left panel removed to reveal left side of the oven exterior.

3. Insert the temperature probe through the exposed white insulation covering one of the holes so that the probe tip is positioned in the center of the oven cavity.

   Note which hole you used and measure the length of the probe that protrudes into the oven. Use the same position for subsequent oven calibrations.

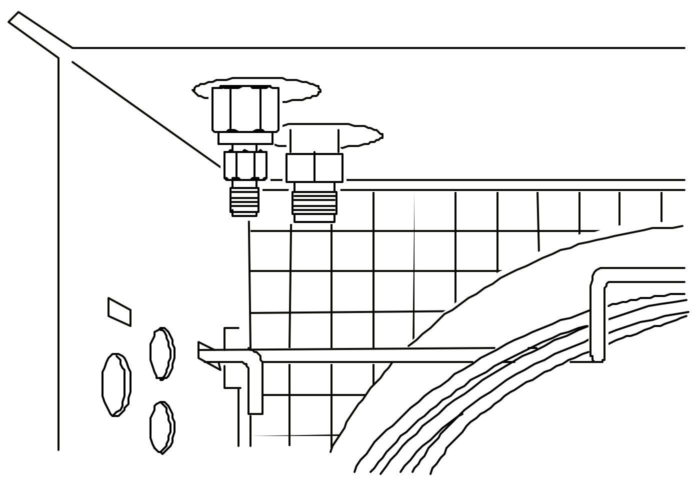
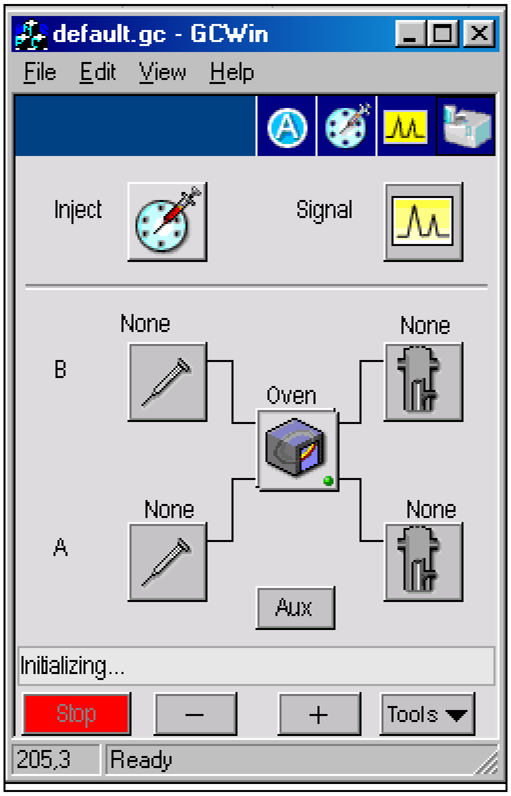


Figure 5- 2 Holes on the left side of the oven exterior.

Equilibrate the Oven Temperature

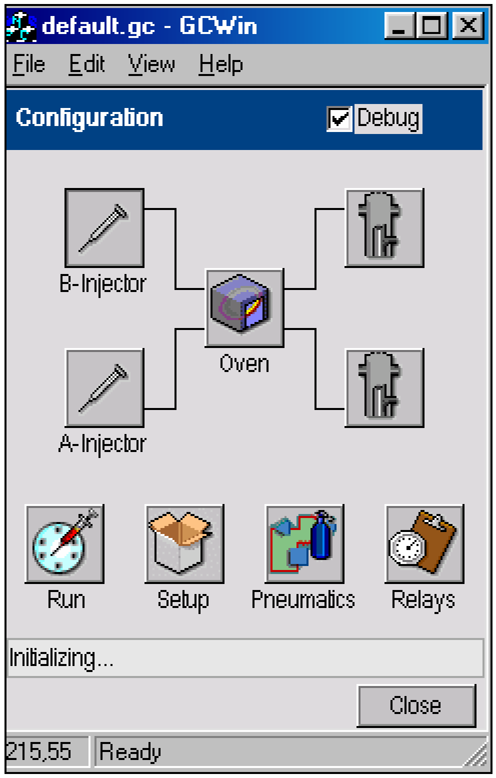
1. From the **Active Method**, create an isothermal method with an oven temperature for the desire calibration point (100 °C is recommended).

2. Set the time to 40 minutes and start the run.



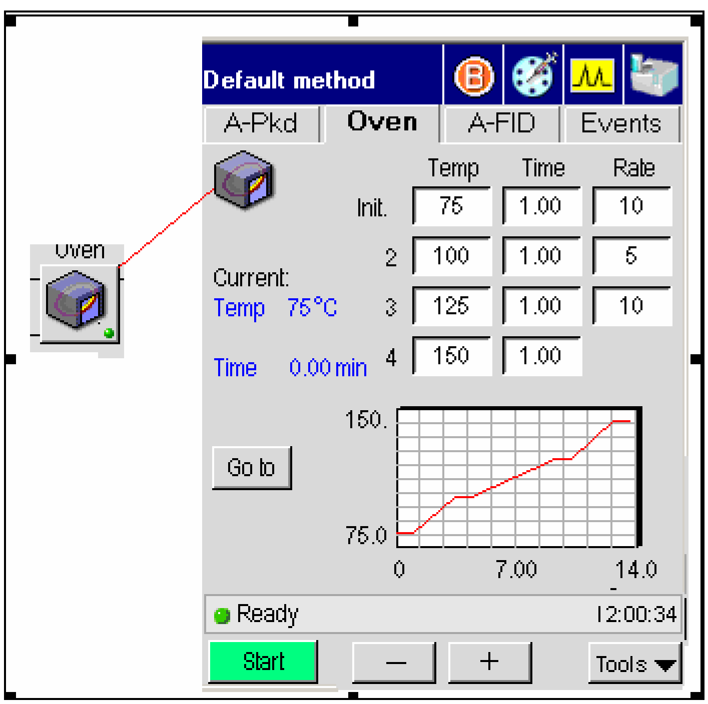
Screen 5- 1 System Status Screen

3. Touch the **Tools** button to view the drop down menu and select **Configuration.**



Screen 5- 2 Configuration Screen

4. In the configuration screen, select the **Oven** icon.



Screen 5- 3 Oven Configuration Screen

5. Single Point is the default setting. When the Single Point Calibration radio button is selected, the Offset field is active and the GC Tune drop down field is inactive. (GC Tune is only available if it is downloaded. A successful tune must be performed in order for GC tune to be enabled. Only those channels for which a valid tune exists will be available on the drop down list. The selection will be made from the external GC Tune software, but the user may override this.)

   The actual temperature under the single point radio button is the time-averaged actual oven temperature.

Enter the Required Offset Value

1. After the temperature has stabilized, subtract the thermometer reading from the actual oven temperature shown on the previous screen.

2. Using the plus and minus keys enter a value into the above screen, then press OK. For example, if the thermometer reads 101.55 °C, and the oven temperature reads 100 °C, type a value of -1.55°C.

Remove the Thermometer Probe

After temperature calibration is satisfactory:

1. Open the oven door and allow the oven to cool until the fan stops.

2. Remove the temperature probe.

3. Fill in any hole left by the probe in the oven insulation.

4. Replace the left-side instrument cover.

Autosampler 6

About this Chapter ... 6-3
Overview of the Autosampler ... 6-4
Tower Interface PC Board ... 6-5
Replacing a Syringe ... 6-6
Servicing Idle Syringes ... 6-8
Cleaning the 5-µl and 50-µl Syringe Plungers ... 6-8
Accessing the Autosampler Diagnostics ... 6-9
Carousel Service Procedures ... 6-10
Replacing the Carousel Motor ... 6-15
Tower Sevice Procedures ... 6-20
Replacing and Aligning the Tower Sensor ... 6-20
Replacing the Plunger Sensor ... 6-24
Replacing the Vial Locator Sensor ... 6-32
Replacing the Vial-Locator Mechanism ... 6-35
Replacing the Door Sensor ... 6-36
Replacing the Tower Motor ... 6-38
Replacing the Elevator Motor ... 6-40
Disassembling and Reassembling the Tower ... 6-42
Replacing the Elevator Leadscrew /Supernut Assembly ... 6-46
Replacing the Plunger Motor ... 6-48
Replacing the Plunger Leadscrew /Supernut Assembly ... 6-50
Replacing the Plunger Flag Assembly ... 6-52
Replacing the Needle Guide ... 6-54
Replacing the Vial Locator ... 6-55
Replacing the Tower Disk Assembly ... 6-56

About this Chapter

This chapter describes how the Clarus 500 GC Autosampler operates and how to perform service on autosampler components, assuming you have already diagnosed the problem correctly. The chapter is divided into the following sections:

- Troubleshooting the Autosampler
- Overview of the Autosampler
- Replacing a Syringe
- Cleaning the 5 µl and 50 µl Syringe Plungers
- Accessing the Autosampler Diagnostics
- Carousel Service Procedures
- Disassembling and Reassembling the Tower
- Tower Service Procedures

Overview of the Autosampler

The Clarus 500 GC Autosampler automates the drawing of a sample from a vial and the injection of the sample into the system. The autosampler comprises three main assemblies: the tower, the tray, and the carousel. The carousel is shipped already mounted into the Clarus 500 GC and holds the wash and waste vials. The tray mounts onto the carousel and holds the sample vials. The tower mounts onto the instrument in front of the carousel and tray.

The tower assembly includes all the mechanical and electrical components needed to draw a sample from a vial and inject that sample into the instrument injector. A syringe is mounted in the tower inside the carriage assembly, which moves the syringe up and down. The syringe plunger is moved up and down to draw and inject samples by the plunger assembly. Together, the plunger assembly and the carriage assembly comprise the elevator assembly.

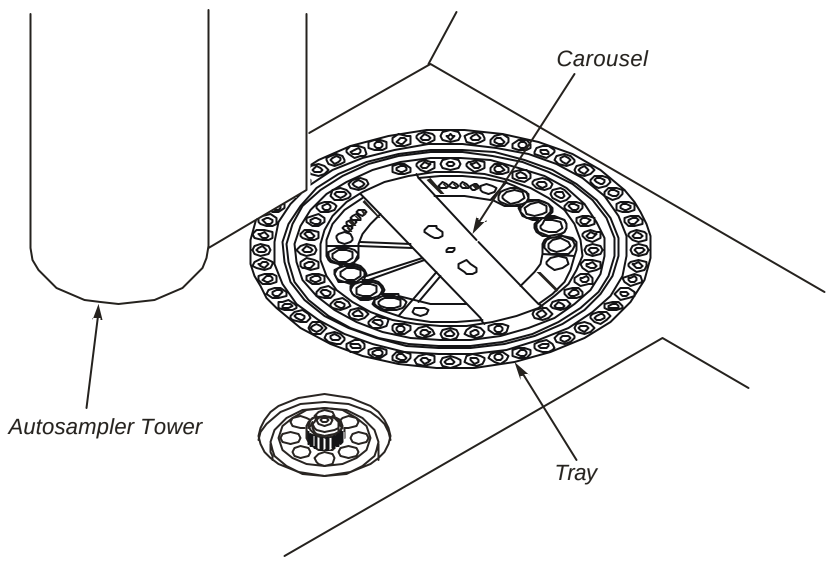


Figure 6-1 The Autosampler Tower, Tray, and Carousel.

The tower has three axes of motion. The first axis of motion is the rotation of the tower over ten discrete positions on the top of the instrument. The tower rotates from the Home position, to six positions over the vials in the tray, to two injector positions, and to the Park position. This is the position at which the tower faces the front of the instrument. Signals from the instrument software control the movement of a motor, called the tower motor, which is connected to a series of pulleys that rotate the tower to the correct position. The tower motor is mounted on the underside of the tower near the tower pivot assembly.

The second axis of motion is the up and down movement of the syringe. Signals from the instrument software control the movement of a second motor, called the elevator motor, which moves a leadscrew assembly up and down. The leadscrew assembly in turn moves the plunger assembly and the carriage assembly together, thereby moving the syringe up and down. The elevator motor is mounted on top of the tower.

The third axis of motion is the up and down movement of the syringe plunger, which draws and injects samples. The instrument software controls the movement of a third motor mounted on the underside of the tower, called the plunger motor, which moves a second leadscrew assembly. This leadscrew assembly in turn moves the plunger assembly up and down, thereby moving the syringe plunger up and down.

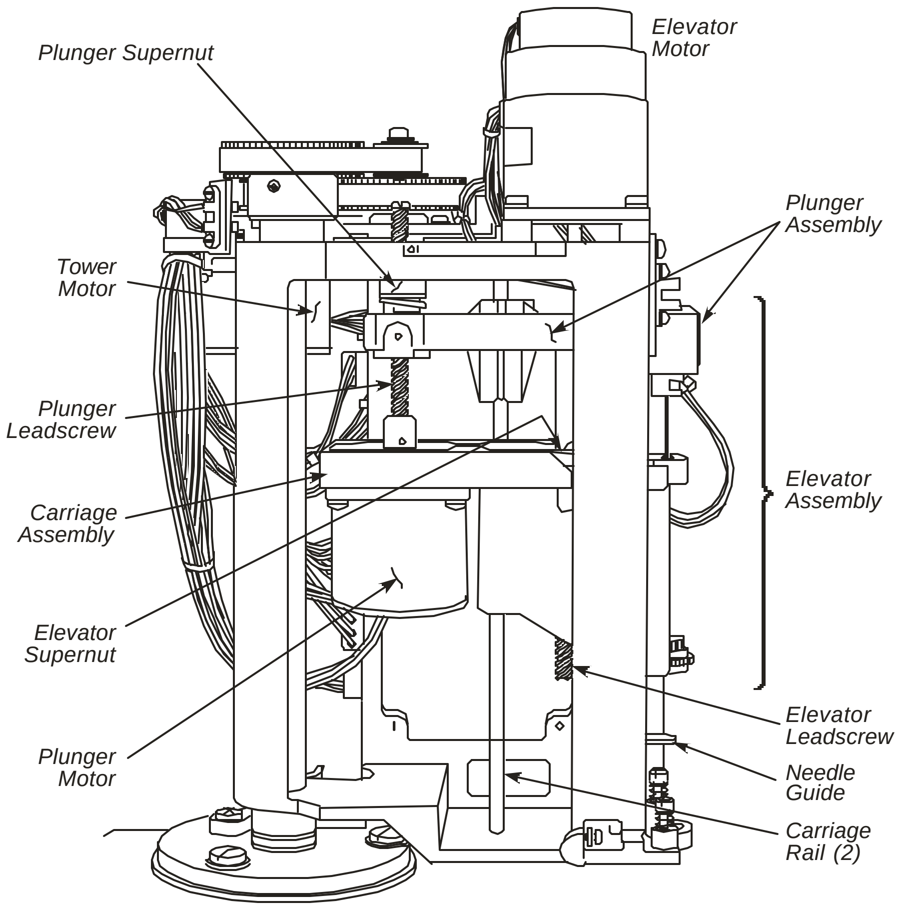


Figure 6-2 Components of the Autosampler Tower.

The carousel rotates to a point at which the tower intersects with a row of vials in the tray. Instrument software controls the movement of a motor , mounted beneath the carousel, which is connected to a series of pulleys that rotate the carousel for the accurate positioning of the vials. This motor and pulley configuration is identical to the one that rotates the tower. A sensor mounted beneath the carousel senses when the carousel is in the Home position (see "Replacing and Aligning the Carousel Sensor" later in this chapter).

Tower Interface PC Board

The Tower Interface P.C.Board, located in the autosampler tower, provides an interface between the Motor Drive Board and the three motors and five sensors in the autosampler tower. This is its only function.

Replacing a Syringe

This section describes how replace a syringe. The procedure comprises the following steps:

1. Remove the Old Syringe

2. Install a New Syringe

Remove the Old Syringe

Perform the following steps to remove the old syringe:

3. Send the autosampler to the PARK position and open the front cover.

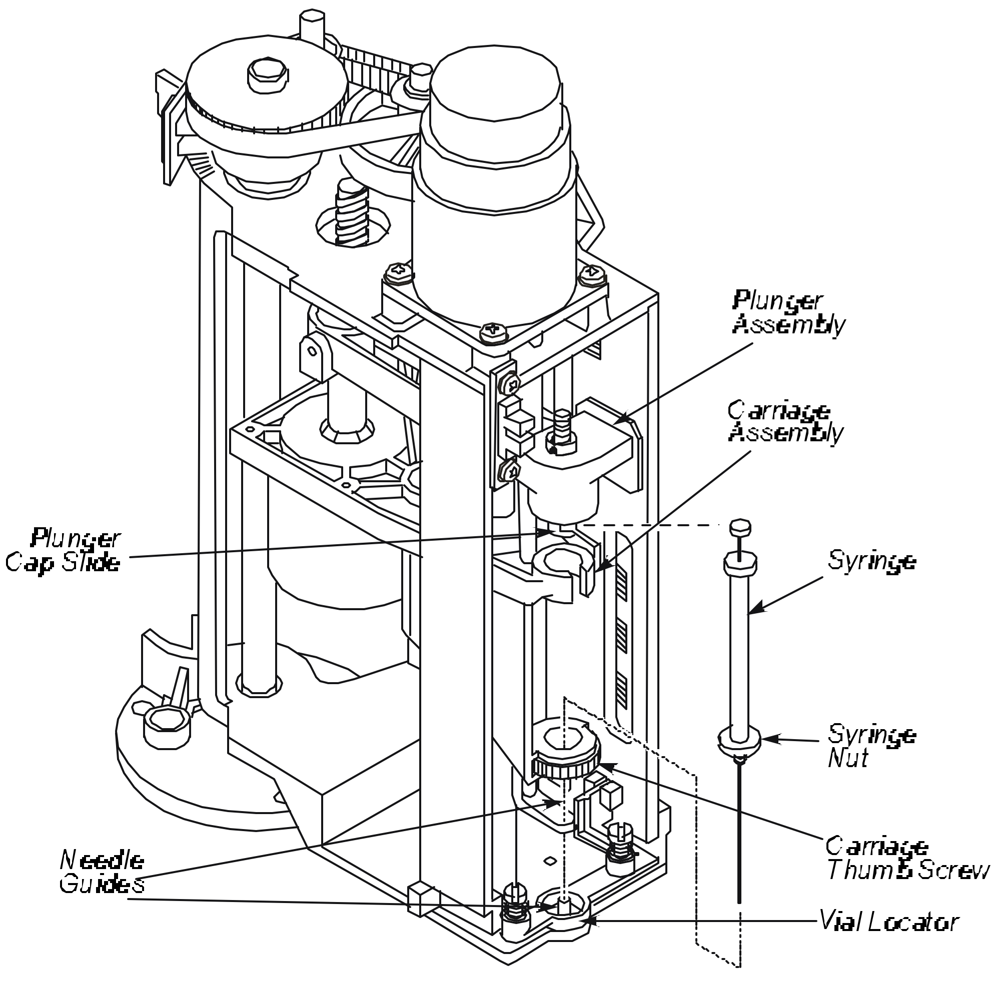


Figure 6- 3 Location of the plunger assembly

4. Locate the plunger assembly in Figure 6-3. Lift up the plunger cap handle as shown in the following figure and rotate it until it rests on the collar. Then release the plunger cap handle.

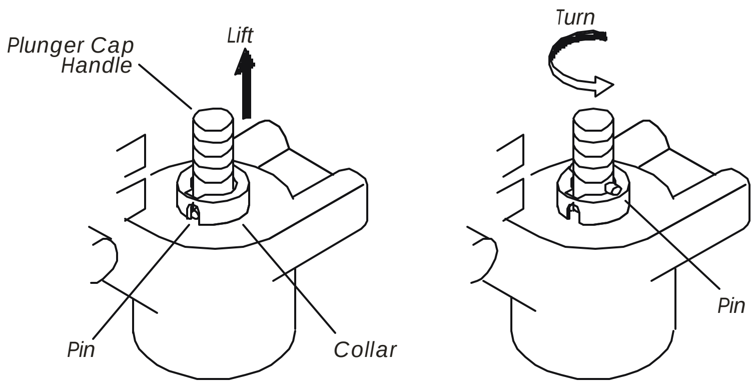


Figure 6-4 Lifting the plunger cap handle.

5. Holding the syringe by the barrel or syringe nut, turn the carriage thumb screw clockwise until the syringe is free.
6. Gently pull the top of the syringe forward until it just clears the carriage assembly.
7. Gently lift the syringe out of the carriage assembly.

Install a New Syringe

Perform the following steps to install a new syringe:

1. Guide the needle through the hole in the carriage thumb screw, then thread the needle through the needle guide. Use your fingers as a guide.
2. Rest the top of the plunger on the plunger cap slide, which is a shelf located on the underside of the plunger assembly.
3. While holding the syringe nut, engage the carriage thumb screw on the threaded part of the syringe by turning the carriage thumb screw counterclockwise.
4. Continue turning the thumb screw counterclockwise. This slowly lowers the needle. Carefully guide the needle through the needle guide into the vial locator.
5. Tighten the carriage thumb screw.

Servicing Idle Syringes

Syringes that are not used for several hours could "freeze," i.e., the syringe plunger will not move. To avoid this condition, PARK the tower , then remove and clean the syringe plunger as described above.

CAUTION	*If you notice your precision degrading, replace the syringe. The autosampler syringe is a consumable part. After extended use, you will need to replace it.*

Cleaning the 5-µl and 50-µl Syringe Plungers

The 5-µl and 50-µl syringe plungers should be cleaned regularly, after approximately 500 injections, since insolubles can build up and cause friction.

To clean the syringe plunger:

1. Remove the syringe as described in "Replacing a Syringe," earlier in this chapter.
2. Remove the plunger from the syringe barrel.
3. Wipe the plunger with a tissue soaked in an appropriate solvent.
4. Replace the plunger.
5. Pull and expel the same solvent through the barrel several times.
6. Replace the syringe using the procedure in the preceding section.

NOTE: *Only syringes distributed by PerkinElmer should be used with the Clarus 500 GC.*

Plungers are not interchangeable from syringe to syringe.

Accessing the Autosampler Diagnostics

This section describes how to access the Autosampler Diagnostics. The Autosampler Diagnostics are used in the following procedures:

- Replacing the Carousel Sensor
- Replacing the Carousel Motor
- Replacing the Tower Sensor
- Replacing the Plunger Sensor
- Replacing the Elevator Sensor
- Replacing the Vial Locator Sensor
- Replacing the Door Sensor
- Replacing the Plunger Flag Assembly
- Replacing the Vial Locator
- Replacing the Tower Disk Assembly

Accessing the Autosampler Sensor Diagnostics (Diagnostics Mode)

Log In

If the password is not enabled:

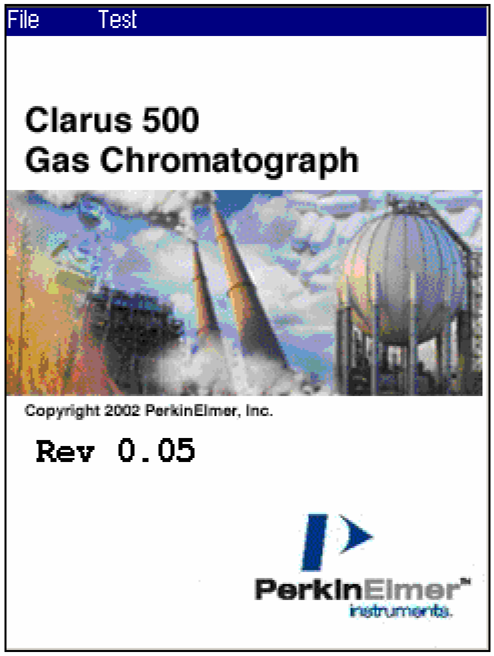
1. From the START screen touch **Tools** button.
2. In the drop down **Tools** screen touch **Configuration** and then **Setup**. Check **Enable Password**. Touch **Cancel** to close this screen. Touch **OK** on the Setup screen to close the Configuration screen.
3. From the Tools screen touch **Logout** and then **Yes**. On the touch screen touch **Start**. Select the **Num** tab and enter **65535** and touch **OK**.

If the password is not enabled:

1. From the Tools drop down screen touch **Logout** and then **Yes**.
2. On the touch screen touch **Start**. Select the **Num** tab and enter **65535** and touch **OK**.

Log In

Enter 65535 from the “Password” screen to enter diagnostics mode. The following graphics represents the top-level diagnostics screen. The splash screen is in the background. From the **Test** menu, select **Autosampler** (autosampler will initialize).



Screen 6- 1 Top Level Diagnostic Screen

Carousel Service Procedures

This section describes how to perform the following procedures on the autosampler carousel:

- Replacing and Aligning the Carousel Sensor
- Replacing the Carousel Motor

Make sure you have correctly diagnosed the problem before performing either of the above procedures.

Replacing the Carousel Sensor

Replace a failed carousel sensor as described in the following procedure. You will have to align the sensor after you install it. The entire procedure is comprises the following steps:

- Replace the Carousel Sensor
- Align the Carousel Sensor

Special Tools Required

Make sure you have the following items before you align the new sensor:

- T-shaped Carousel Alignment Tool (Part No. N610-T002)

Replace the Carousel Sensor

1. Loosen the two screws securing the instrument top and lift the instrument top until it locks in the up position.

   You don't have to remove the autosampler tower to work on the carousel. However, make sure there is enough room above the AutoSystem for the tower before you lift up the instrument top.

2. Remove the two screws securing the carousel sensor to the sensor mounting bracket (see the following figure) and remove the sensor.

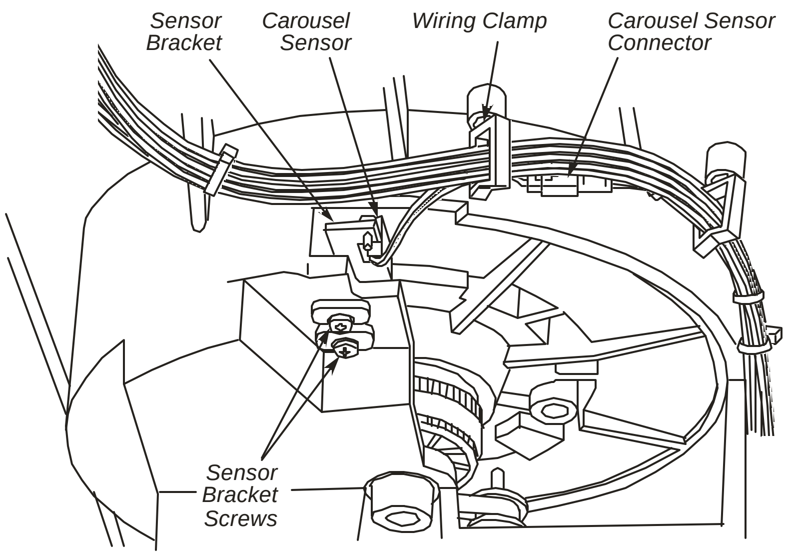


Figure 6- 5 Location of the Carousel Sensor.

3. If the sensor wires are tiewrapped to the tower harness, cut the tie wrap. Unplug the sensor connector and discard the sensor.

4. Attach the new sensor to the sensor mounting bracket using the two screws you removed from the old sensor. Plug in the connector.

5. Close and secure the instrument top.

6. Log into Service Diagnostics.

Proceed to the next procedure “Align the Carousel Sensor.”

Align the Carousel Sensor

Align the sensor as described below.

1. Place the alignment tool on the tray as shown in Figure. Make sure the pins on the tool are seated properly in the holes in the tray and the tool is flush with the left side of the instrument top.

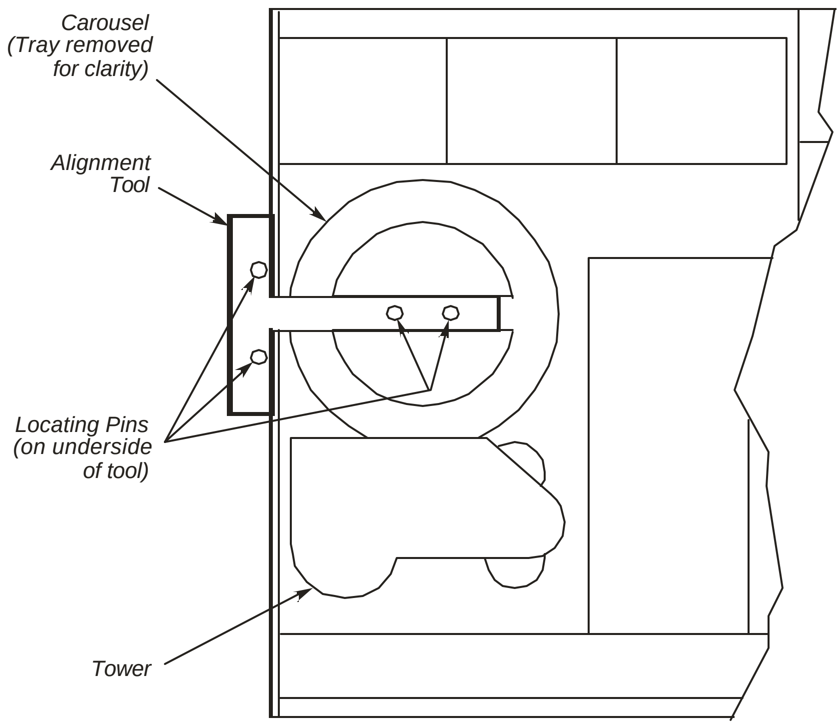


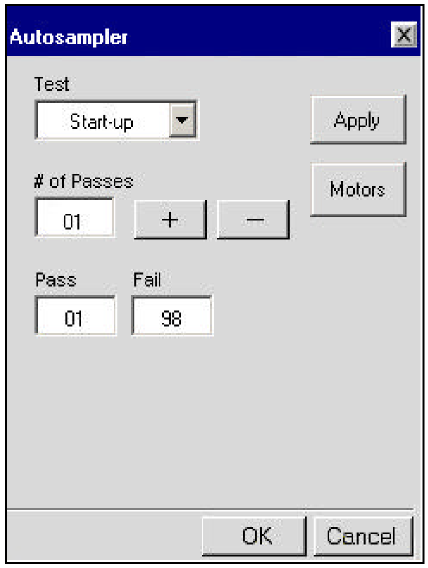
Figure 6- 6 Correct Position of the Alignment Tool on the Tray.

2. Hold the tool in place and open the instrument top.

3. Loosen, but do not remove, the two screws securing the sensor mounting bracket.

To view the Autosampler screen

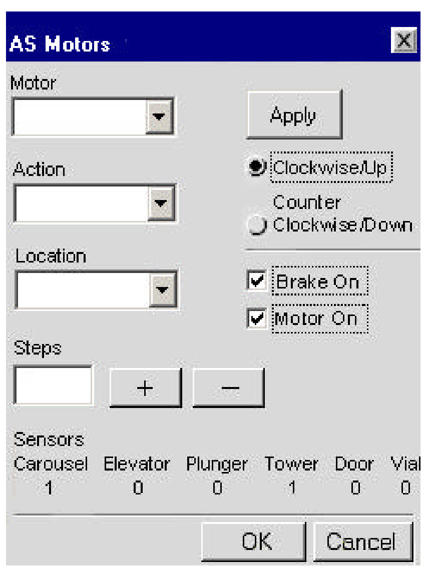
- On the Service screen, touch the **Test** menu.
- From the drop down, select **Autosampler**.



Screen 6-2 Autosampler Screen

To view the AS Motors screen

- On the Autosampler screen touch the **Motors** button.
- **AS Motors** screen is displayed below.



Screen 6-3 AS Motors Screen

4. Move the sensor bracket to the right as far as it will it go, then slowly move it to the left until the sensor beam is just unbroken on the slit home edge (see Figure 6-7). The number 1 will change to 0 for the carousel sensor at the bottom of the window.

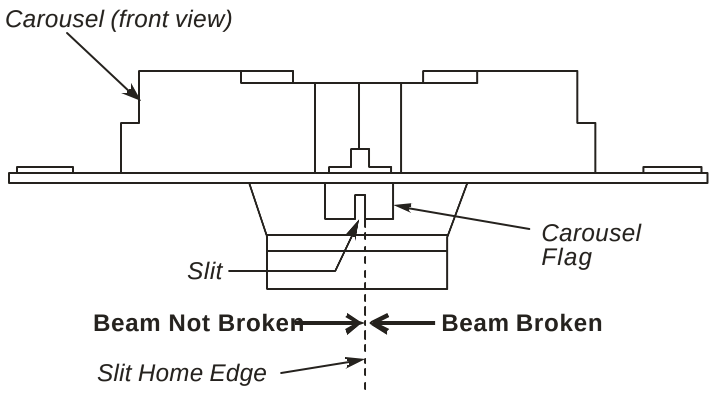
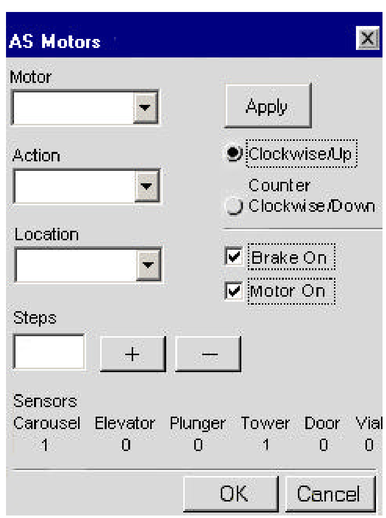


Figure 6-7 Aligning the Carousel Sensor

5. Remove the tool, then manually rotate the carousel to verify that the carousel flag doesn't touch the sensor. (If the movement is locked, touch **Brake On** and wait several seconds).
6. If the flag touches the sensor, loosen the sensor bracket, reinstall the tool, and repeat Steps 4 and 5, then check the flag again.
7. Close and secure the instrument top.

Verifying the Carousel Sensor alignment using the touch screen:

- On the **AS Motors** screen, use the **Motor** drop down menu and select **Carousel**.
- Move the carousel away from its name position.
- Select **Home** from the **Action** drop down menu.



Screen 6-4 AS Motors Screen

The carousel will move to its home position.

8. Using the alignment tool, verify that the carousel and tray are aligned correctly. If they are not, repeat the entire alignment procedure.

9. If the carousel and tray are correctly aligned, set up and run an Autosampler Method. We recommend that you use an old syringe with the needle removed.

10. Logout and go back into the User screen. Place capped vial in Position 1.

11. Verify that the syringe is centered over the vial cap. If not, go back to step 4 and realign the sensor carefully.

Replacing the Carousel Motor

Perform the following procedure if the carousel motor/encoder fails. The entire procedure comprises the following steps:

1. Remove the **Old** Motor

2. Install the New Motor

3. Align the Carousel Sensor (see the previous procedure page 6-12).

Remove the Old Motor

1. Turn off the instrument. Loosen the two screws securing the instrument top and lift the instrument top until it locks in the up position.

   You don't have to remove the autos ampler tower to work on the carousel. However, make sure there is enough room above the AutoSystem for the tower before you lift up the instrument top.

2. Loosen the idler locking screw located on the underside of the instrument top next to the carousel motor (Figure 6- 8).

3. Remove the idler adjustment screw, the compression spring and the two flat washers (see Figure 6- 8). This reduces the tension on the belts connected to the idler pulleys.

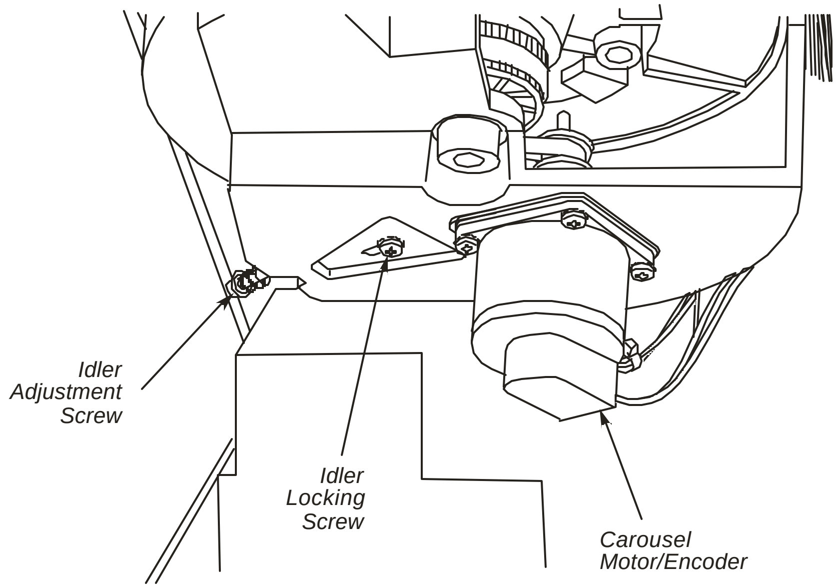


Figure 6-8 Location of the Carousel Motor, Idler Adjustment Screw, and Idler Locking Screw

4. Unplug the encoder connector from the encoder.

5. Remove the instrument back panel and unplug the carousel motor connector from J6 on the Quarter Step Motor Drive Board. Remove the motor wires from the wiring clamps attached to the underside of the instrument top.

6. Slip the belt off the motor Pulley mounted on the motor shaft (see the following figure).

7. Remove the four screws securing the motor to the underside of the instrument top, and remove the motor. The motor pulley will come out with the motor.

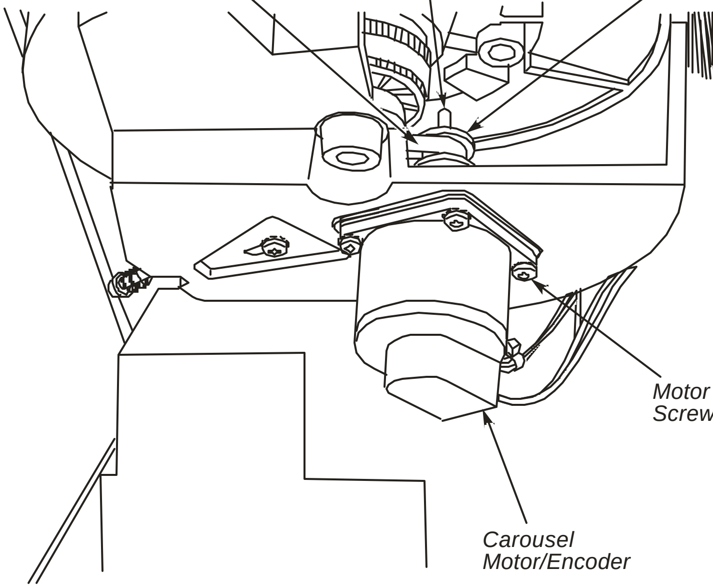


Figure 6-9 Carousel Motor, Motor Pulley, and Belt

Install the New Motor

1. Loosen the two setscrews on the motor pulley and slide the pulley off the motor shaft (see Figure 6-10). Discard the motor.

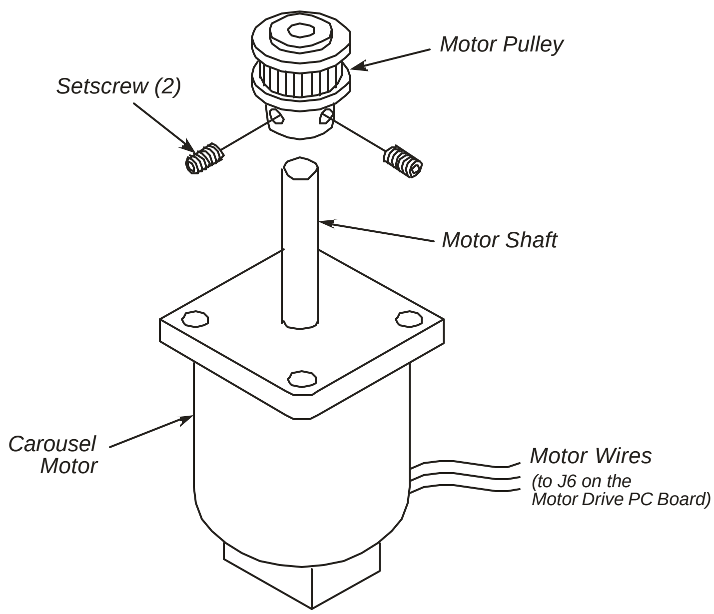


Figure 6-10 Remove the Motor Pulley from the Motor.

2. Slide the pulley over the shaft of the new motor. Do not tighten the setscrews.

3. Install the new motor using the four screws, shock mounts, and washers from the old motor, then slip the belt around the motor pulley. The belt will be loose.

4. Finger tighten the idler locking screw to hold the idler pulley in place.

5. Replace the idler adjustment screw, the spring and the two washers.

6. Turn the adjustment screw until the length of the spring is 1/2-in ± 1/64-in.

   At this point, the motor pulley is loose on the motor shaft but the belt on the motor pulley now has tension.

   Figure 6- 11 shows how the pulleys and belts are connected.

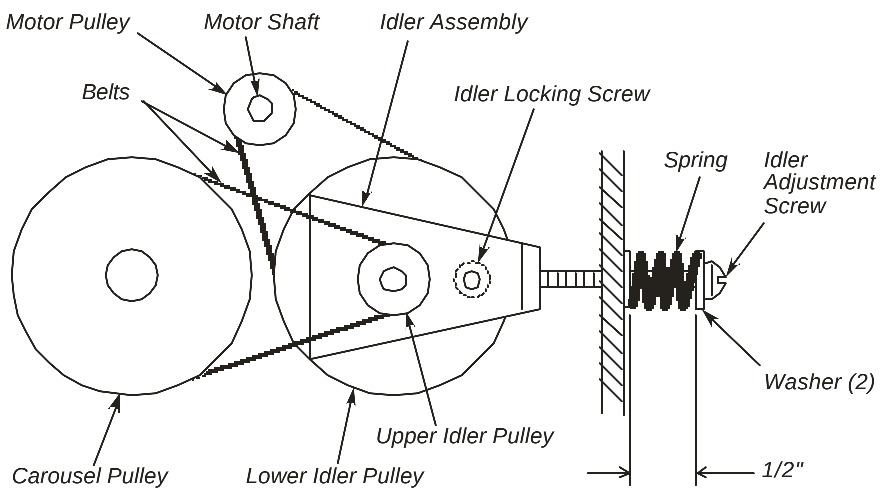


Figure 6- 11 Configuration of Carousel Pulleys and Belts.

7. Work through the opening on the underside of the instrument top behind the carousel to turn the carousel with one hand. Turn it just enough to manually center the belt on the lower idler pulley with your other hand (see the following figure).

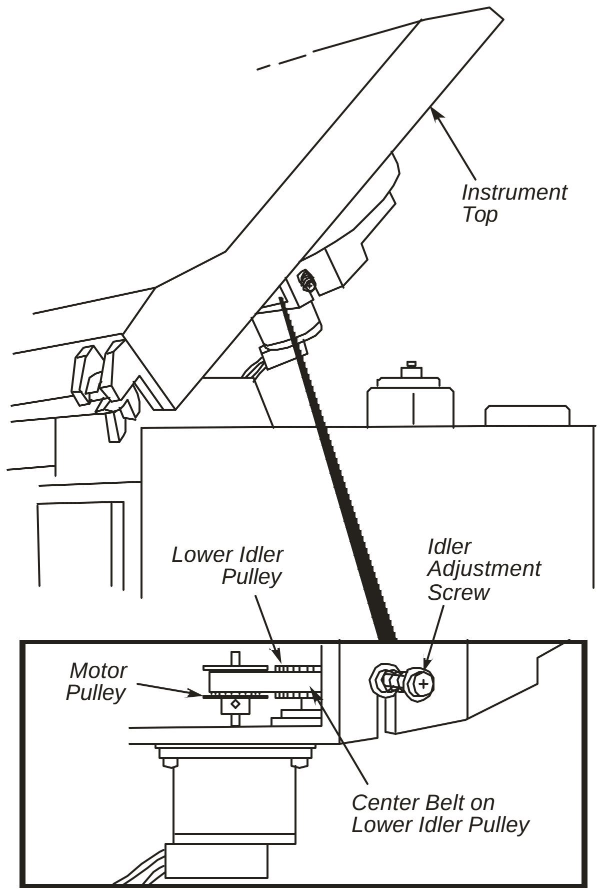


Figure 6- 12 Center the Belt on the Lower Idler Pulley

8. Tighten the motor pulley setscrews (see the Figure 6-10).

9. Loosen the idler locking screw turn the carousel around a few times. Verify that the working length of the idler adjustment screw is 1/2 inch ± 1/64-in. Retighten the locking screw to secure the idler assembly (see the Figure 6-11).

10. Verify that all the belts and pulleys are aligned.

11. Connect the motor wire to J6 on the Motor Drive Board and connect the encoder connector to the encoder. Secure the encodere connector to the encoder body with a nylon tie wrap. Replace the instrument back panel.

    Make sure the wires are secured in the wiring clamps located on the underside of the instrument top.

12. Log in the Autosampler Diagnostics as described in "Accessing the Autosampler Diagnostics," earlier in this chapter (see page 6-9).

13. Align the carousel sensor as described on page 6-12.

Tower Sevice Procedures

This section describes how to perform the following procedures on the autosampler:

- Replacing and Aligning the Tower Sensor
- Replacing and Aligning the Plunger Sensor
- Replacing and Aligning the Elevator Sensor
- Replacing and Aligning the Vial Locator Sensor
- Replacing the Vial-Locator Mechanism
- Replacing and Aligning the Door Sensor
- Replacing the Tower Motor
- Replacing the Elevator Motor Disassembling the Tower
- Replacing the Elevator Leadscrew/Supernut Assembly
- Replacing the Plunger Motor
- Replacing the Plunger Leadscrew/Supernut Assembly
- Replacing the Plunger Flag Assembly
- Replacing the Needle Guide
- Replacing the Vial Locator

NOTE: *Make sure you have correctly diagnosed the problem before performing any of the above procedures. See the troubleshooting tables n the Toubleshooting chapter (8) for detailed autosampler troubleshooting information.*

Replacing and Aligning the Tower Sensor

Replace a failed tower sensor as described in the following procedure. You will have to align the sensor after you install it. The entire procedure comprises the following steps:

1. Replace the Tower Sensor
2. Align the Tower Sensor

Special Tools required

Make sure you have the following tool before you align the new sensor:

- Tower Sensor Alignment Tool (Part No. N610- T103) see Figure 6-14

Replace the Tower Sensor

1. Turn the instrument off,. Then remove the two screws securing the tower cover to the tower and carefully lift off the cover .
2. The tower sensor is located on top of the tower at its pivoting end. Manually rotate the tower until the sensor is easily accessible.
3. Unplug the tower sensor connector from J6 on the Tower Interface Board.
4. Remove the two screws securing the tower sensor to the tower sensor bracket and remove the sensor. Discard the old sensor.

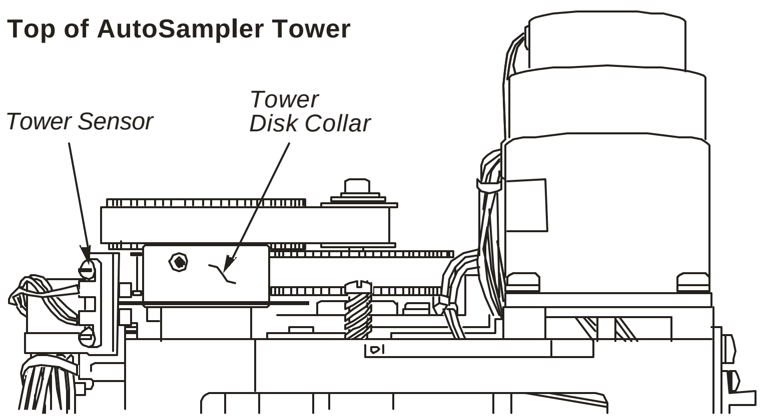


Figure 6- 13 Location of the Tower Sensor.

5. Install a new sensor using the two screws you removed in Step 3. Do not tighten the screws.

   The letters "E" and "S" are printed on the sensor. Install the new sensor with the "E" on top.
6. Plug the sensor connector into J6 on the Tower Interface Board.
7. Loosen the screws securing the sensor mounting bracket.
8. Position the tower sensor alignment tool between the tower sensor and the tower disk collar .

   The tool verifies that the sensor has been installed correctly.
9. Tighten the two bracket screws, then tighten the two sensor screws.

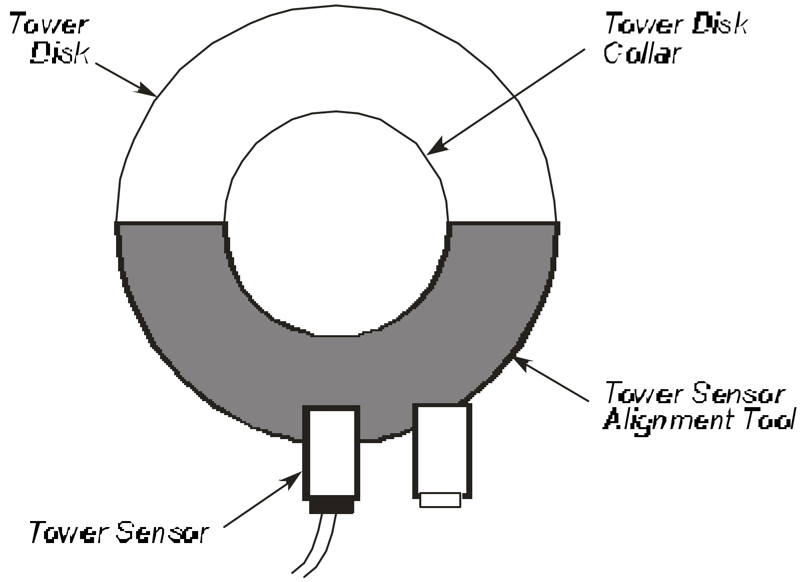


Figure 6- 14 Using the Tower Sensor Alignment Tool.

10. Log in to the Autosampler Diagnostics as described in "Accessing the Autosampler Diagnostics," see page 6-9.

11. Align the carousel sensor as descibed on page 6-12.

12. Align the tower sensor as described in the following section.

Align the Tower Sensor

- Replace the syringe with one that has no needle.

1. Loosen the two setscrews on the tower disk collar (see Figure 6- 15).

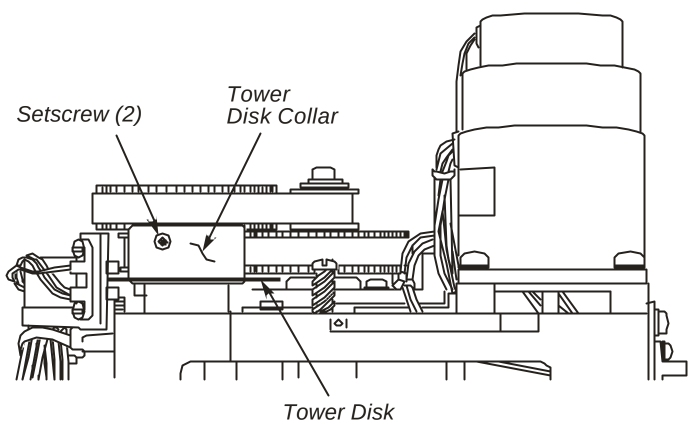


Figure 6- 15 Location of Tower Disk Collar Setscrews

2. Manually rotate the tower until the center of the vial locator is directly over the center of the front injector port (Injector 1) within 0.010 inches.

3. Carefully rotate the tower disk counterclockwise until the sensor beam breaks on the trailing edge of slit #9. The screen should display 1 , indicating that the tower (T) sensor beam is blocked (see Screen 6-5).

4. Tighten either one of the setscrews on the tower disk collar .

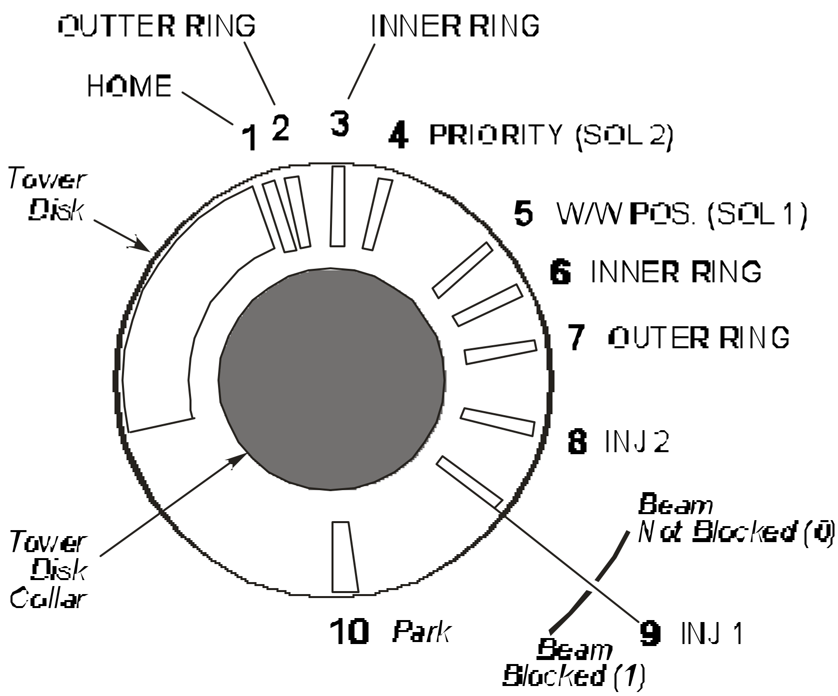
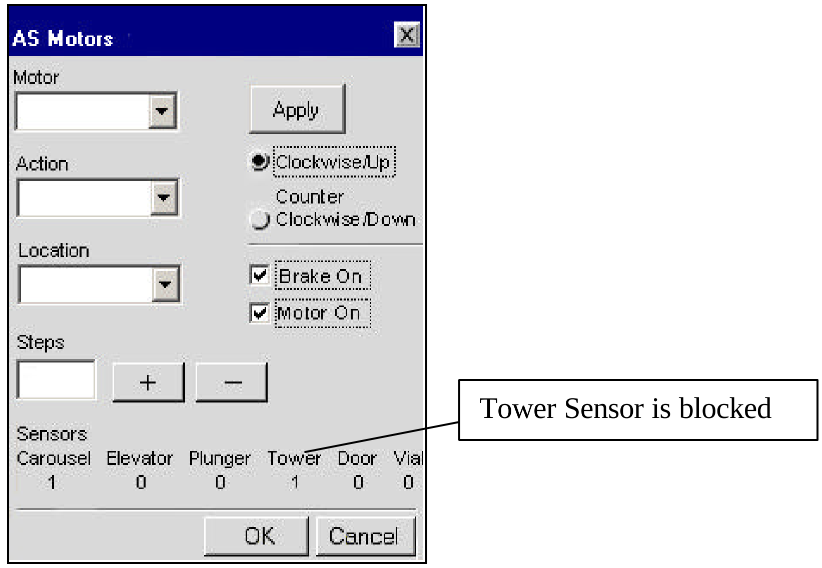


Figure 6- 16 Figure Aligning the Tower Disk.

Verifying the Alignment the Tower Disk using the touch screen

- On the **Motor** drop down menu, select **Tower**.
- Then use the the drop down from the **Location** menu to select **Inj 1**.
- Manually move the tower away from the injector area. (It may be necessary to touch **Brake On** to free the tower).
- Touch **Apply**. The autosampler will move until it steps over Injector 1.



Screen 6- 5 AS Motors

5. If the center of the vial locator is directly over the front injector port (Injector 1) within 0.010 inches, tighten the other setscrew on the tower disk collar.

   - If the center of the vial locator is not directly over the front injector port (Injector 1) within 0.010 inches, repeat the entire alignment procedure.

   - Uncheck BRAKE ON and go back to step 1.

This concludes the procedure.

Replacing the Plunger Sensor

The entire procedure comprises the following steps:

1. Replace the Plunger Sensor (See Figure 6-19)

2. Align the Plunger Sensor (See Figure 6-19)

Special Tools Required

Make sure you have the following items before you align the new sensor:

- Plunger Sensor Alignment Tool (Part No. N610-T003)

- Plunger Flag Alignment Tool (Part No. N610-T00l)

Replace the Plunger Sensor

1. Move the tower to the Park position, turn off the instrument, then remove the screws securing the tower cover to the tower and carefully lift off the cover.

   Block the door sensor with a folded piece of paper, or a septum.

2. The plunger sensor is attached to the right side of the plunger assembly. Manually rotate the tower until the sensor is easily accessible.

3. Unplug the plunger sensor connector from J8 on the Tower Interface Board.

4. The plunger sensor wires are attached to the tower frame with a tie-wrap. Mark the location of the tie-wrap on the frame and on the old sensor harness with a felt-tip marker, then cut and remove the tie-wrap.

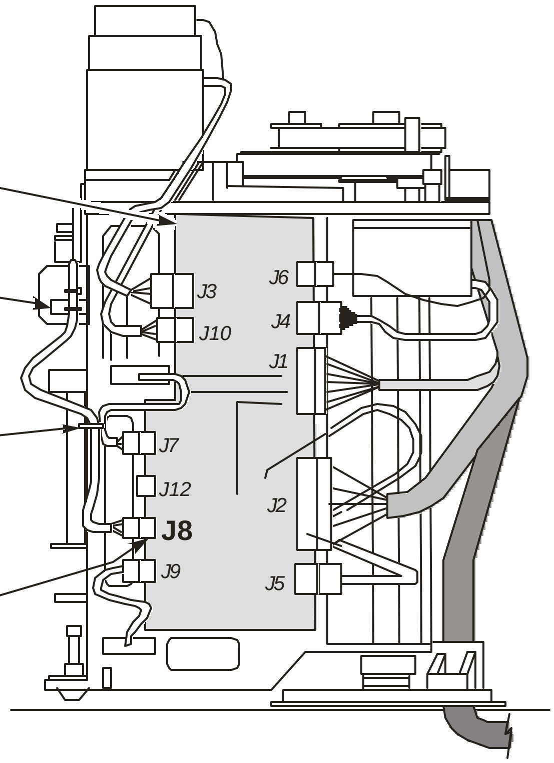


Figure 6- 17 Location of the Plunger Sensor and Plunger Sensory Conector

5. Remove the two screws securing the plunger sensor to the plunger sensor bracket and remove the sensor. Discard the old sensor.

6. Make a 3/4-in. loop in the sensor wires at the back of the plunger sensor by threading the sensor connector between the two pairs of wires (see Figure 6- 18). Secure the loop with a tie-wrap. Make sure the loop goes through the channel in the back of the sensor.

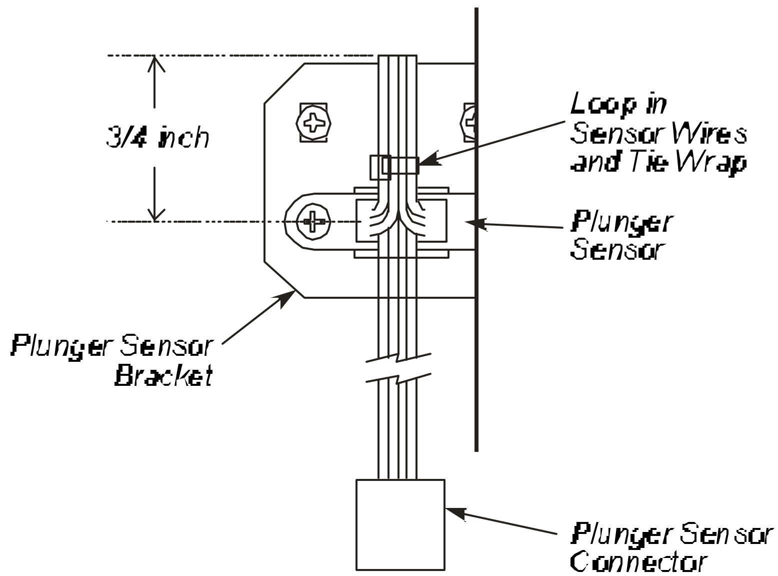


Figure 6- 18 The ¾-in. Loop in the Plunger Sensor Wires

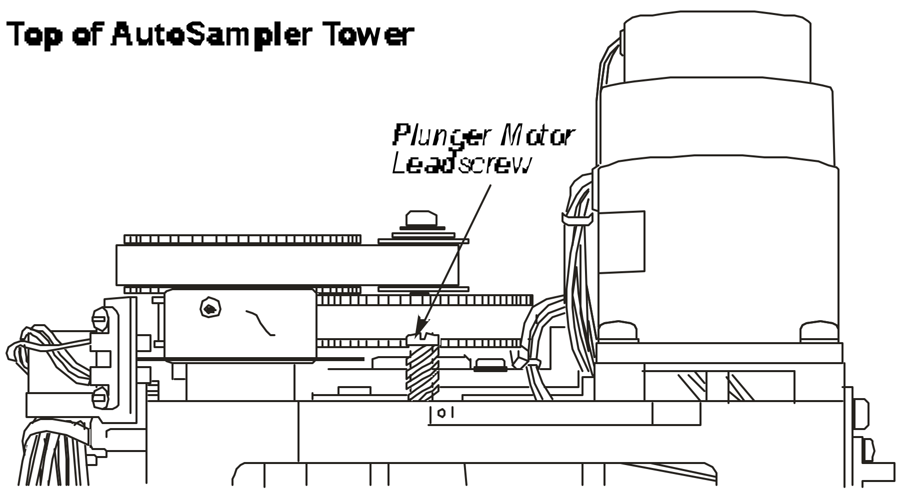


Figure 6- 18a Location of the Plunger Motor Leadscrew

7. Secure the new plunger sensor to the plunger sensor bracket using the two screws from the old sensor .

8. Plug the new sensor connector into J8 on the Tower Interface Board and secure the sensor wires to the previously marked location on the tower frame using a new tie-wrap.

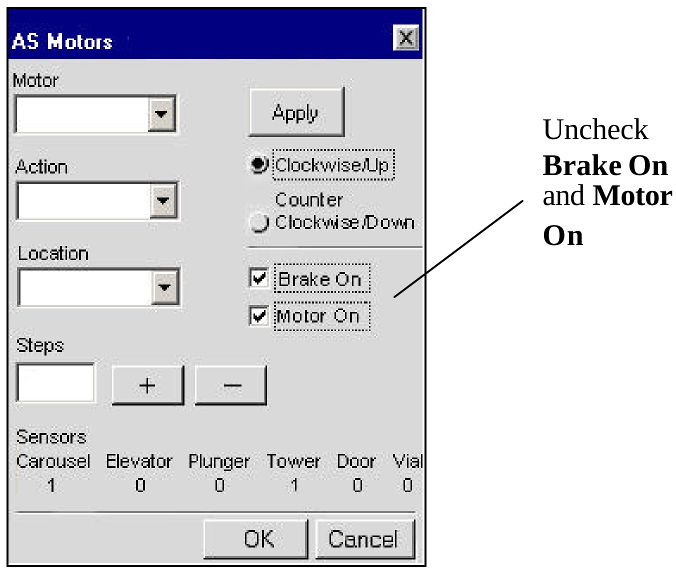
9. Log in to the Autosampler Diagnostics as described in *Accessing the Autosampler Diagnostics* (page 6-9).

10. Align the plunger sensor as described in the following section.

Align the Plunger Sensor

NOTE: *When entering Autosampler diagnostics the plunger is "Homed." If for any reason this does not take place, it must be done prior to this Plunger Alignment Procedure (Select:* ***Plunger-Home-Apply****, see the following screen).*

1. Uncheck **Brake On** and **Motor On** from the **AS Motors** screen.



Screen 6- 6 AS Motors

2. In the Motor field select **Plunger** from the drop down menu. In the Action field select **Home** from the drop down menu. In the Steps field use the plus minus buttons to input **300** and touch the **Apply** button.

3. Remove the syringe (if installed). Install the the plunger flag alignment tool (Part No. N610-T001). See Figure 6-19.

   Move the plunger assembly up or down manually to fit the tool in, if necessary. See Figure 6-16a.

4. Manually move the plunger assembly by turning the plunger motor leadscrew until the bottom of the mark on the plunger stem just shows at the top of the tool body.

5. Loosen the plunger stem locking screw on the plunger flag alignment tool and loosen the two plunger sensor bracket mounting screws.

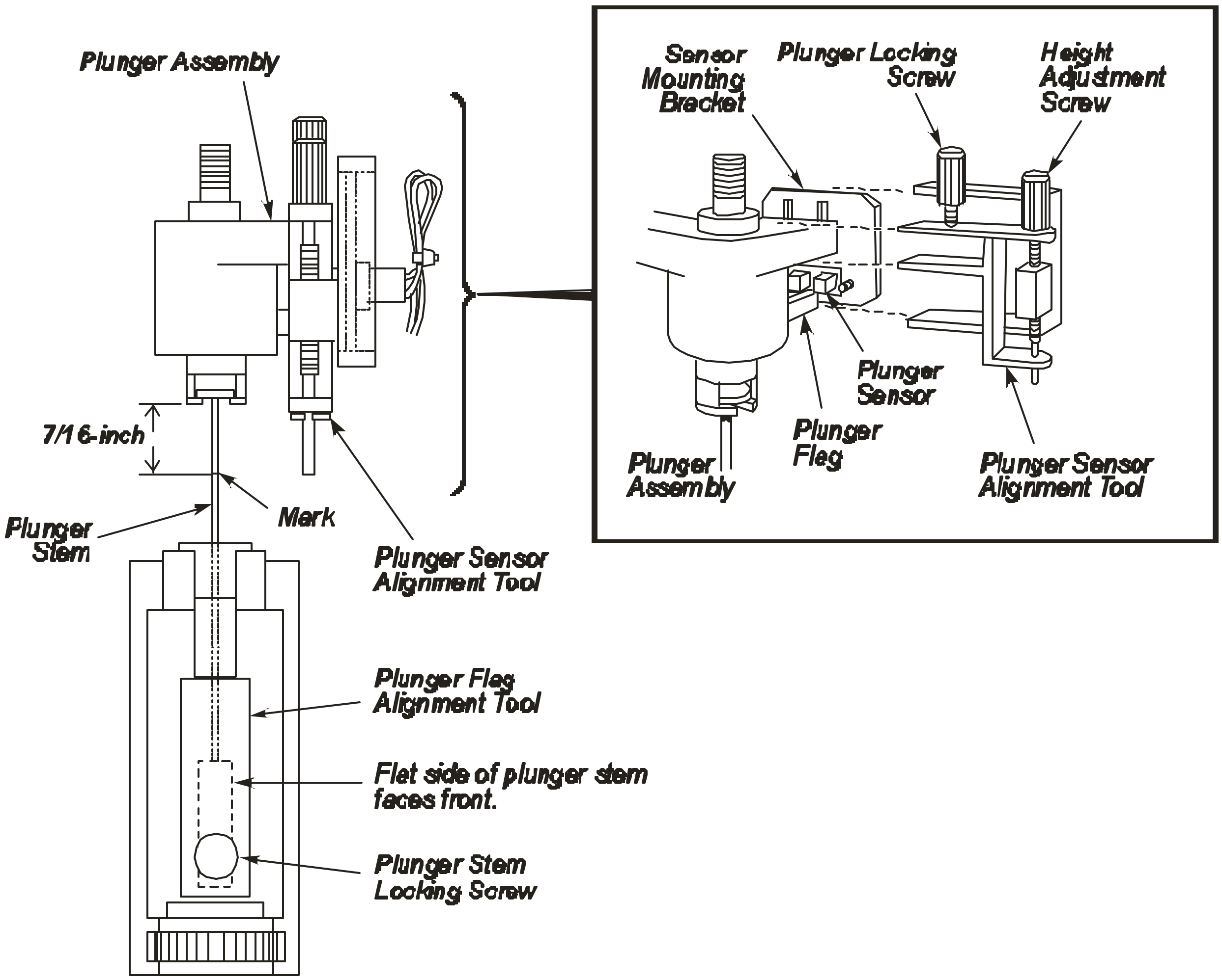


Figure 6- 19 Plunger Sensor and Plunger Flag Alignment Tools Installed

6. Install the plunger sensor alignment tool (Part No. N610-T003) and tighten the locking screw on the tool (see Figure 6-19).

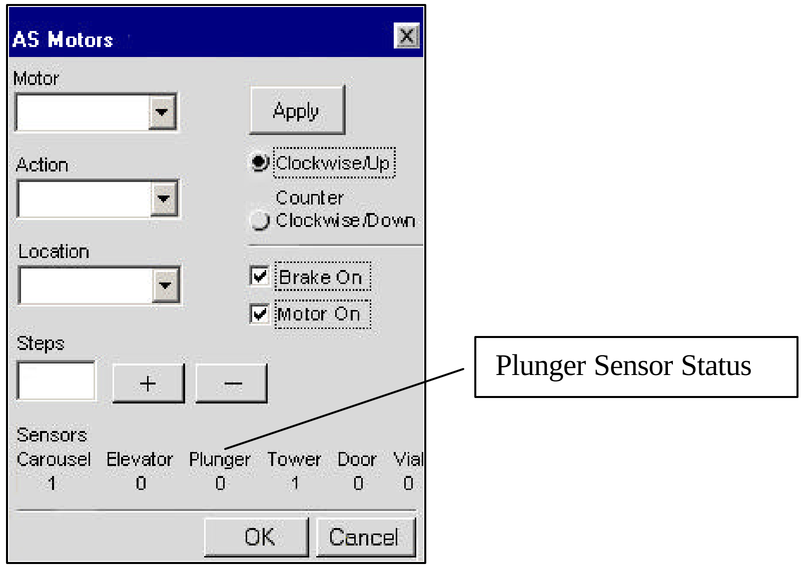
7. Make sure the mark on the plunger stem just shows.

8. Using the touch screen, under the **Motor** drop down menu, select **Plunger**.

9. Under the Action drop down menu, select **Step**.

10. Highlight the **Steps** box and use the  button to enter -100, then touch **Apply**.

11. When the plunger has completed its movement, tighten the plunger stem locking screw on the plunger flag alignment tool.



Screen 6- 7 AS Motors

12. Highlight the **Steps** box and modify the step count to -50 and press **Apply** in order to move the plunger assembly down again.

13. Monitor the plunger sensor status on the screen (P), which will display 0 or 1 for either an unblocked or a blocked beam (see Screen 6-7).

14. Turn the height adjustment screw on the plunger sensor alignment tool clockwise to move the plunger sensor to its highest position. Then turn it counterclockwise until the sensor beam just breaks and 1 appears on the display. Tighten the two sensor bracket mounting screws

15. To verify the plunger alignment loosen the plunger stem locking screw on the plunger flag tool.

16. In the AS Motors screen (see Screen 6-7) enter **150** in the Steps field using the plus minus buttons. Touch the **Apply** button. The plunger will move up until the stem mark is visible. If this does not happen, go to step 8 and repeat the alignment.

17. Alignment is complete. Remove your tools and replace the syringe.

Replacing the Elevator Sensor

Replace a failed elevator sensor as described in the following procedure. The entire procedure comprises the following steps:

1. Replace the Elevator Sensor

2. Align the Elevator Sensor

Replace the Elevator Sensor

1. Replace the syringe with a service syringe (no needle).

2. Turn off the instrument, then remove the two screws securing the tower cover to the tower and carefully lift off the cover.

3. The elevator sensor is mounted to the tower frame just above connector J7 on the Tower Interface Board. Manually rotate the tower until the sensor is accessible from the front of the instrument (see Figure 6-20).

4. Unplug the elevator sensor connector from J7 on the Tower Interface Board (see Figure 6-20).

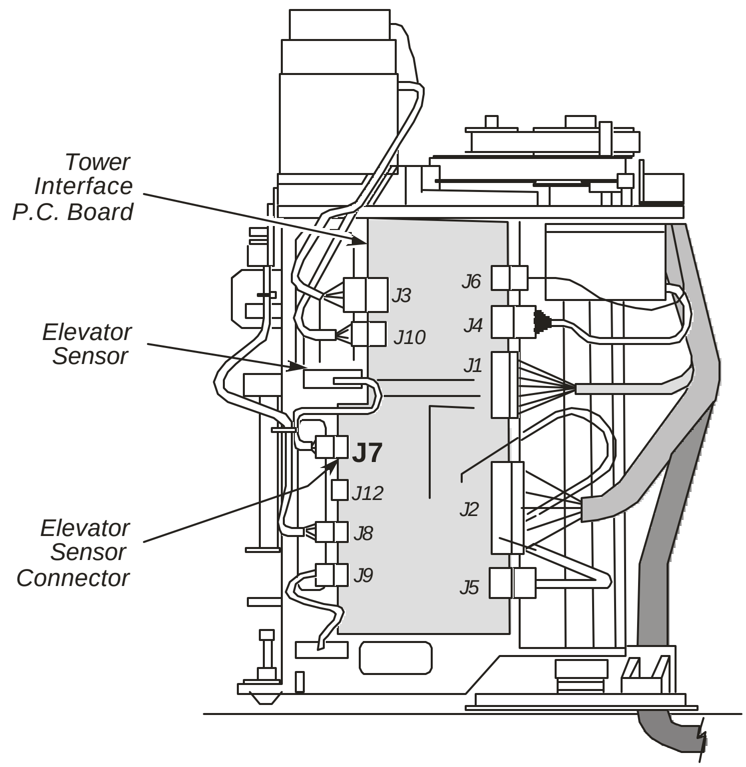


Figure 6- 20 Location of the Elevator Sensor

5. Remove the two screws securing the sensor to the frame and remove the sensor. Discard the old elevator sensor.

6. Log in to the Autosampler Diagnostics as described in *Accessing the Autosampler Diagnostic* on page 6-9.

7. Align the elevator sensor as described in the following section.

Align the Elevator Sensor

1. Monitor the **Elevator** sensor at the bottom of the **AS Motors** screen (see Screen 6- 7).

2. Rotate the autosampler tower to the Park position. Verify that the elevator sensor flag is centered in the elevator sensor and that the sensor is mounted securely to the tower frame. If necessary, touch **Brake On** to free the instrument.

3. Manually move the elevator assembly up and down with the lead screen so that the elevator sensor flag moves in and out of the elevator sensor (see the following figure).

4. Verify that the Autosampler Elevator Sensor displays 1 when the elevator sensor flag blocks the elevator sensor beam, and 0 when the flag is out of the sensor beam. The top edge should be centered in the sensor block.

   If the sensor is not properly aligned, the correct number will not display on the screen. Should this happen, check the position of the sensor flag in the sensor.

   If the flag is not centered in the sensor, remove the Tower Interface Board, loosen the elevator flag mounting screws, and manually center the flag in the sensor. Tighten the mounting screws and replace the board.

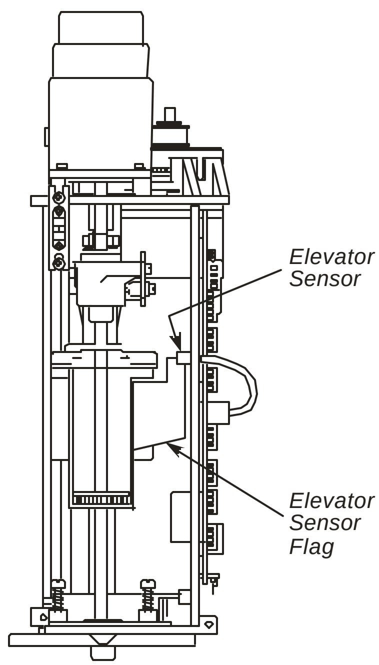


Figure 6- 21 Elevator Sensor Flag and Elevator Sensor.

Replacing the Vial Locator Sensor

Replace a failed vial locator sensor as described in the following procedure. The entire procedure comprises the following steps:

1. Replace the Vial Locator Sensor
2. Align the Vial Locator Sensor

Special Tools Required

Make sure you have the following items before you align the new sensor:

- Vial Locator Alignment Tool (Part No. N610-T102) (see Figure 6-23)

Replace the Vial Locator Sensor

1. Turn off the instrument, then remove the two screws securing the tower cover to the tower and carefully lift off the cover .

2. The vial locator sensor is mounted to the tower frame just below connector J9 on the Tower Interface Board. Manually rotate the tower until the sensor is accessible from the front of the instrument.

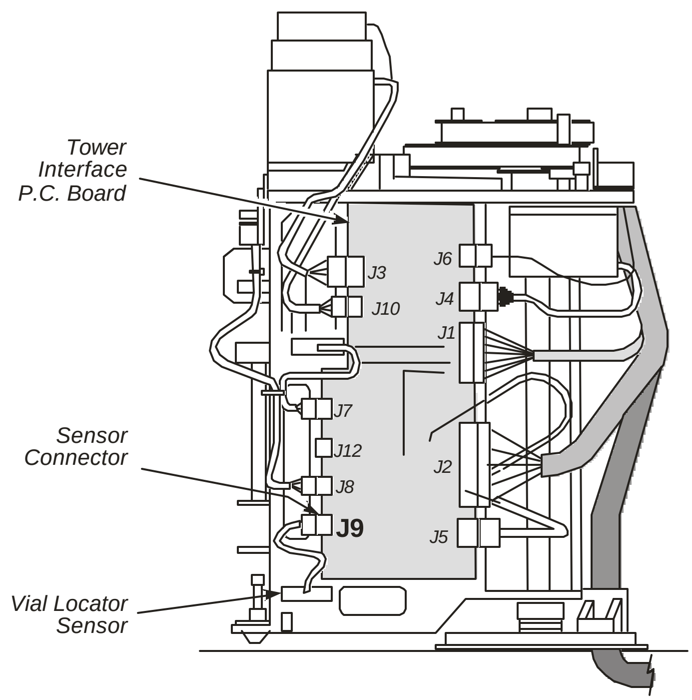


Figure 6- 22 Location of the Vial Locator Sensor and Sensor Connector

3. Unplug the vial locator sensor connector from J9 on the Tower Interface Board.

4. Remove the two screws and bolt plate securing the vial locator sensor to the tower frame, and remove the sensor.

5. Install the new sensor using the same screws and bolt plate you removed in Step 4, leaving the screws loose, and plug the connector into J9 on the Tower Interface Board.

6. Log in to the Autosampler Diagnostics as described in *Accessing the Autosampler Diagnostics* (see page 6-9).

7. Align the vial locator sensor as described in the following section.

Align the Vial Locator Sensor

1. Monitor the status of the vial locator sensor, which is represented on the screen by **Vial** at the bottom of the **AS Motors** screen (see Screen 6- 7).

2. Insert the vial locator alignment tool between the vial locator and the tower frame as shown in the following figure.

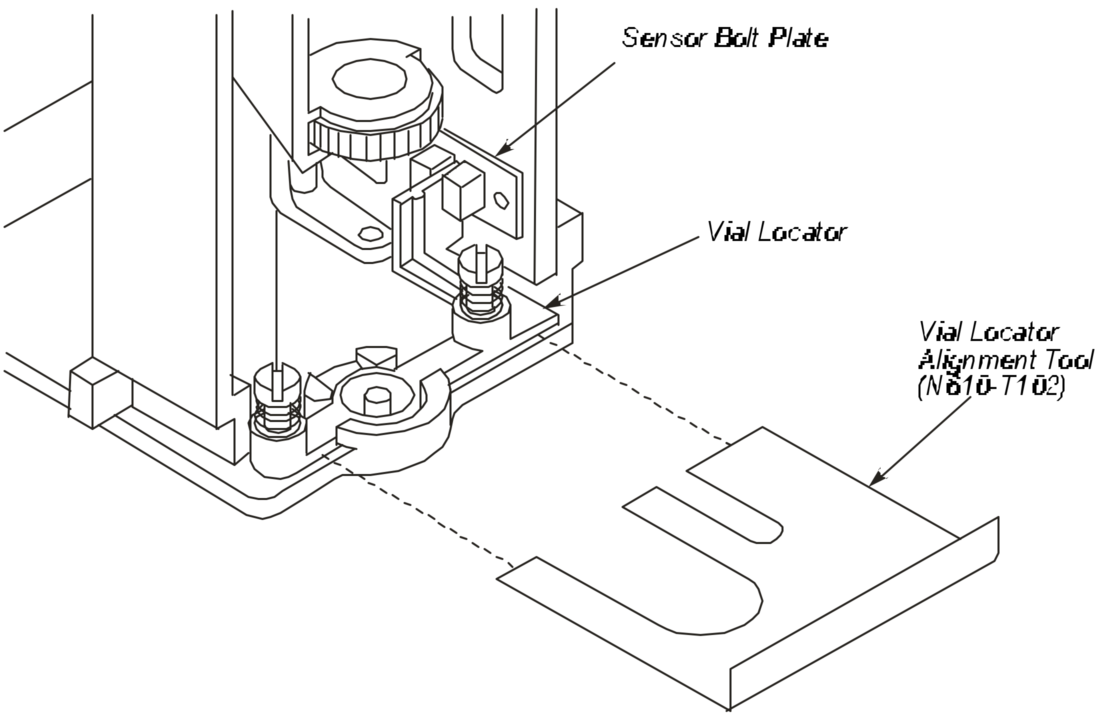


Figure 6- 23 Inserting the Vial Locator Alignment Tool

3. Move the vial locator sensor to its highest position.

4. Slowly slide the sensor down until the sensor beam is just broken (the screen will display 1).

5. Tighten the sensor mounting screws and remove the alignment tool. Verify that the sensor beam is unblocked (the screen will display 0).

6. Reinstall the alignment tool and verify that the sensor beam is blocked (the screen will display 1).

If the beam doesn't break at this position, repeat Steps 4 to 6.

This concludes the procedure.

Replacing the Vial-Locator Mechanism

The vial-locator mechanism will wear with extended use and require replacement. If the autosampler begins missing vials, or if the hole for the syringe begins to plug, it is an indication that you should replace the vial- locator mechanism.

To replace a vial-locator mechanism:

1. Remove the vial locator:

   a. Remove the two shoulder screws that secure the locator to the autosampler tower frame.

   b. Remove the two springs, then remove the vial locator (see the following figure).

   c. Discard the vial locator.

2. Mount the new vial locator on the tower frame.

3. Install the two shoulder screws through the two springs and into the vial locator. This secures the vial locator to the tower frame.

CAUTION	*When securing the vial-locator molding, be sure that the flag is cantered (not touching either side) in the sensor. If it touches a side, adjust the flag by loosening and then tightening the screws.* ***DO NOT ADJUST THE SENSOR.***

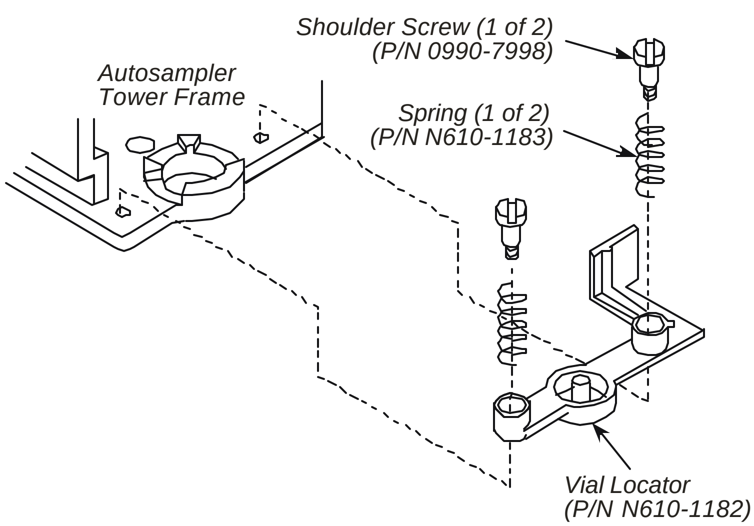


Figure 6- 24 Vial Locator (Exploded View)

Replacing the Door Sensor

Replace and align a failed tower door sensor as described below. The entire procedure comprises the following steps:

1. Replace the Door Sensor
2. Align the Door Sensor

Replace the Door Sensor

1. Turn off the instrument, then remove the two screws securing the tower cover to the tower and carefully lift off the cover.
2. The door sensor is mounted to the tower frame above and to the left of the plunger assembly. Manually rotate the tower until the sensor is accessible from the front of the instrument 2 (see the following figure).
3. Unplug the door sensor connector from J10 location on the Tower Interface Board, remove the two screws securing the door sensor to the tower frame, and remove the sensor .
4. Install the new sensor using the same screws you removed in Step 3, and plug the connector into J10 location on the Tower Interface Board. Do not tighten the screws.

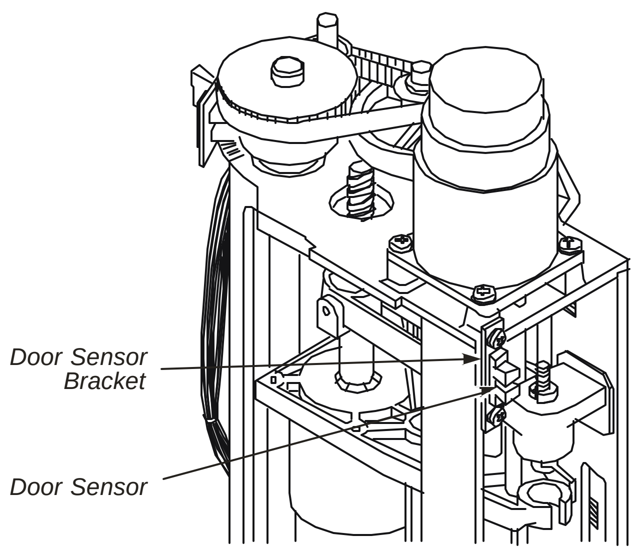


Figure 6- 25 Location of the Door Sensor

5. Login to the Autosampler Diagnostics as described in *"Accessing the Autosampler Diagnostics,"* (see page 6-9).
6. Align the door sensor as described in the following section.

Align the Door Sensor

1. Monitor the status of the **Door** sensor located at the bottom of the **AS Motors** screen (see Screen 6-7).

2. Re-install the tower cover.

   Position the sensor bracket so that the door flag located inside the door is centered in the sensor when the door is closed. Retighten the screws.

3. Verify that the sensor works properly by opening and closing the cover door. The screen will display 1 when the door is closed and 0 when the door is open.

Replacing the Tower Motor

Replace a failed tower motor as described in the following procedure.

1. Turn off the instrument, remove the two screws securing the tower cover to the tower and carefully lift off the cover.

2. The tower motor is located on the underside of the top of the tower frame (see figure below), and is connected by a pulley and belt to the idler assembly.

   Remove the idler adjustment screw, the compression spring and the flat washer to reduce the tension on the belts connected to the idler pulleys.

3. Loosen the idler locking screw.

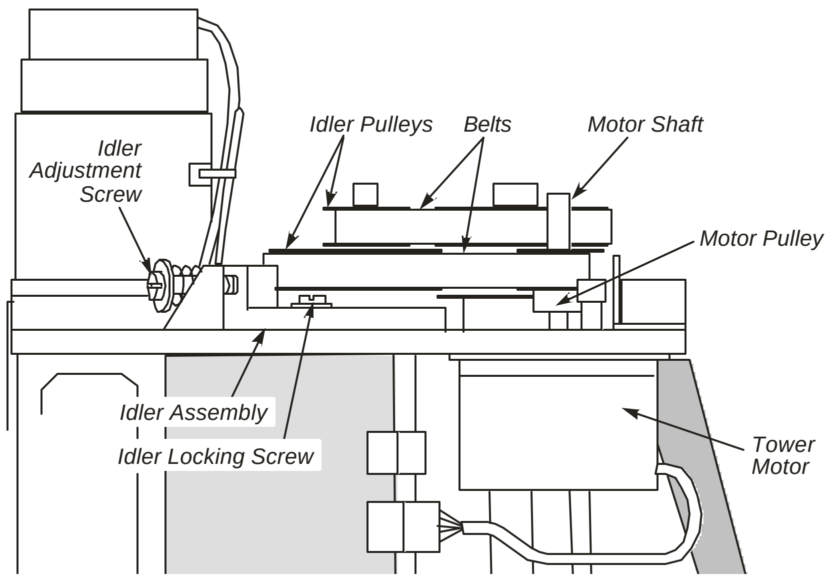


Figure 6- 26 Location of the Tower Motor, Idle Assembly, Belts, and Pulleys.

4. Unplug the tower motor connector from J4 on the Tower Interface Board.

5. Slip the belt off the pulley mounted on the motor shaft (see the following figure).

6. Loosen the two setscrews securing the pulley to the motor shaft and slide the pulley off.

7. Remove the four screws securing the motor to the underside of the tower frame and remove and discard the motor.

8. Install the new motor using the four screws you removed in the last step.

9. Slide the pulley over the shaft of the new motor. Do not tighten the setscrews.

10. Slip the belt around the motor pulley, then turn the idler locking screw until it is fingertight.

11. Replace the idler adjustment screw, the spring and the flat washer. Turn the adjustment screw until the length of the spring is 1/2-in ± 1/64-in.

    At this point, the motor pulley is loose on the motor shaft but the belt on the motor pulley now has tension.

    The following figure shows how the pulleys and belts are connected.

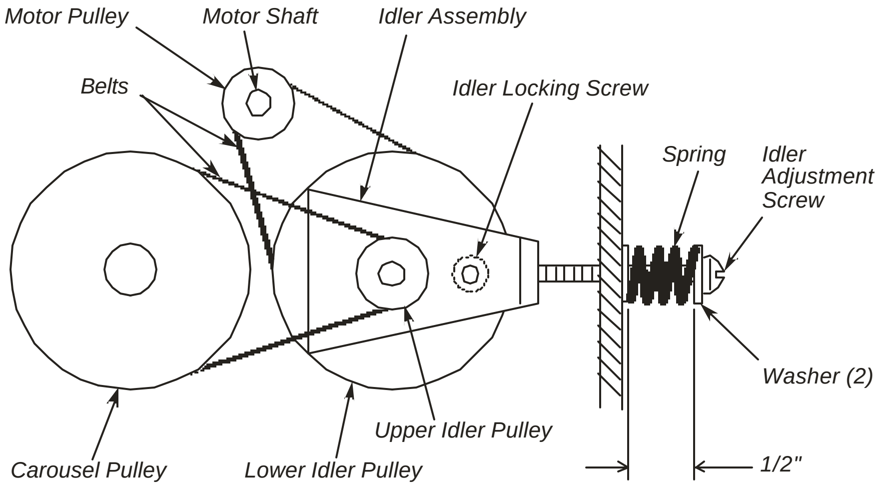


Figure 6- 27 Configuration of Tower Pulleys and Belts

12. Loosen the idler locking screw then retighten it.

13. Rotating the tower shaft, center the belt on the lower idler pulley. Then, while moving the motor pulley up or down, tighten the setscrews on the motor pulley.

14. Loosen the idler locking screw and verify that the working length of the idler adjustment spring is 1/2 inch ± 1/64-in. Retighten the locking screw to secure the idler assembly in its correct position.

15. Plug the motor connector into J4 on the Tower Interface Board.

Replacing the Elevator Motor

Replace the elevator motor if either the motor or the brake fails. Use the following procedure.

1. Remove the two screws securing the tower cover to the tower and carefully lift off the cover.

2. The elevator motor is mounted to the top of the tower frame and connects to J3 on the Tower Interface Board. Unplug the connector from J3 and remove the four screws securing the elevator motor to the tower frame.

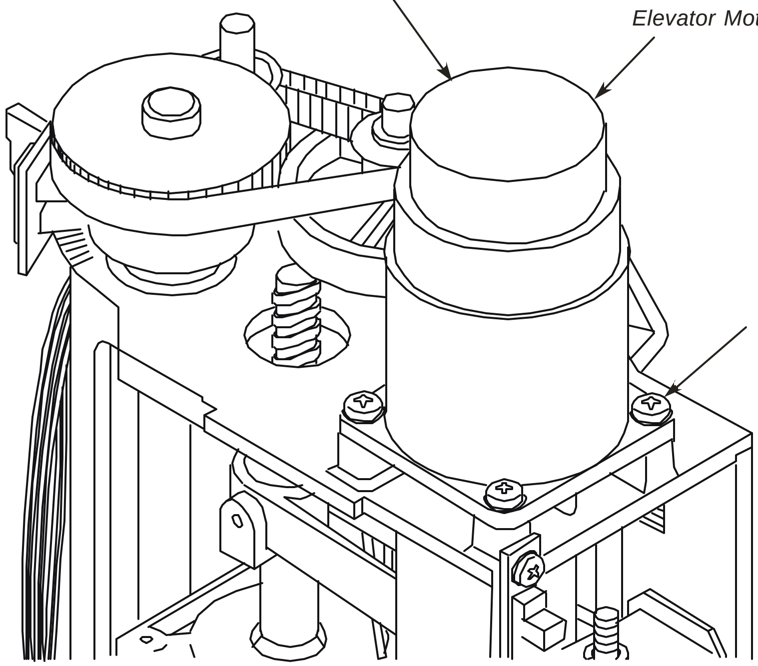


Figure 6- 28 Removing the Elevator Motor.

3. The elevator leadscrew is mounted onto the elevator motor shaft. Remove the motor and leads crew assembly by turning the motor counterclockwise.

4. Remove the roll pin securing the leadscrew assembly to the motor shaft. Discard the roll pin and the motor (see Figure 6-29).

5. Mount the leadscrew to the shaft of the new elevator motor (See figure 6-31). Install a new 1/2-in. roll pin (Part No.0991-1438) to secure the leadscrew to the motor shaft.

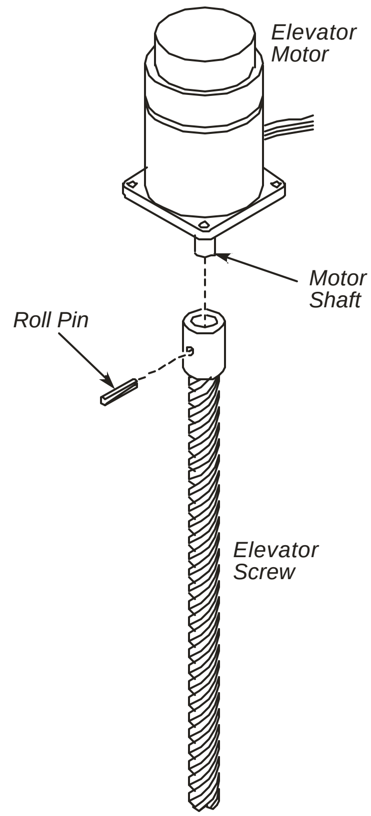


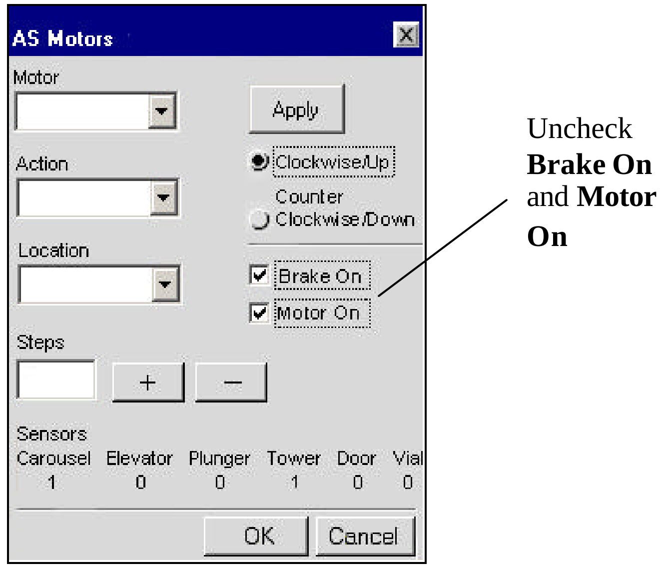
Figure 6-29 Removing and Mounting Leadscrew to the Elevator Motor Shaft.

6. Install the motor with the leadscrew mounted on its shaft into the tower by turning the motor clockwise to screw the leadscrew into its mating supernut.

Note: *The elevator leadscrew and supernut are a matched set. Never mount a new leadscrew into an old supernut and vice versa.*

7. Secure the motor to the top of the tower with the four screws you removed in Step 2. Do not tighten these screws.

8. Uncheck **Brake On** and **Motor On** located on the **AS Motors** screen (see screen 6-8).



Screen 6- 8 AS Motors

9. Manually lower the plunger assembly as far as it will go, then move the elevator assembly up and down a few times to line up the motor.

10. Move the elevator assembly to its highest position and tighten the four motor mounting screws.

11. Plug the motor connector into J3 on the Tower Interface Board to complete the procedure.

Disassembling and Reassembling the Tower

This section describes how to disassemble and reassemble the autosampler tower when performing one of the following procedures:

- Replacing the Elevator Leadscrew/Supernut Assembly
- Replacing the Plunger Motor
- Replacing the Plunger Leadscrew/Supernut Assembly
- Replacing the Plunger Flag Assembly
- Replacing the Needle Guide

Make sure the instrument is disconnected from line power and the syringe, if installed, has been removed from the tower before you begin.

Disassemble the Tower

1. Remove the two screws securing the tower cover to the tower and carefully lift off the cover.

2. Unplug the two Tower Harness connectors from Jl and J2 on the Tower Interface Board.

3. Remove the cable clamp securing the Tower Harness to the tower frame. Leave the clamp attached to the harness.

4. Remove the three screws securing the tower base to the top of the instrument, and lift the tower off the instrument. Place the tower on a convenient working surface.

5. Unplug all connectors from the Tower Interface Board. Remove the five screws securing the Tower Interface Board to the tower frame and remove the board.

6. Remove the four screws securing the elevator motor to the tower frame. The elevator leadscrew is mounted onto the elevator motor shaft. Remove the motor and leadscrew assembly by turning the motor counterclockwise.

7. When you remove the elevator motor and elevator leadscrew, the tops of the two carriage rails will be exposed. Using pliers, carefully remove the external retaining rings securing these rails to the tower frame. Discard both retaining rings.

8. Carefully slide each rail out of the bottom of the tower frame.

Note*: Replace all retaining rings whenever you perform this procedure.*

9. The carriage rails secure the elevator assembly to the tower. When you remove the rails, the needle guide will easily slide off and the elevator assembly will be loose inside the tower.

10. The elevator assembly comprises the plunger assembly, carriage assembly, elevator supernut, plunger motor, and plunger leadscrew/supernut (see the following figure).

Carefully remove this assembly from the tower. You are now ready to replace individual components.

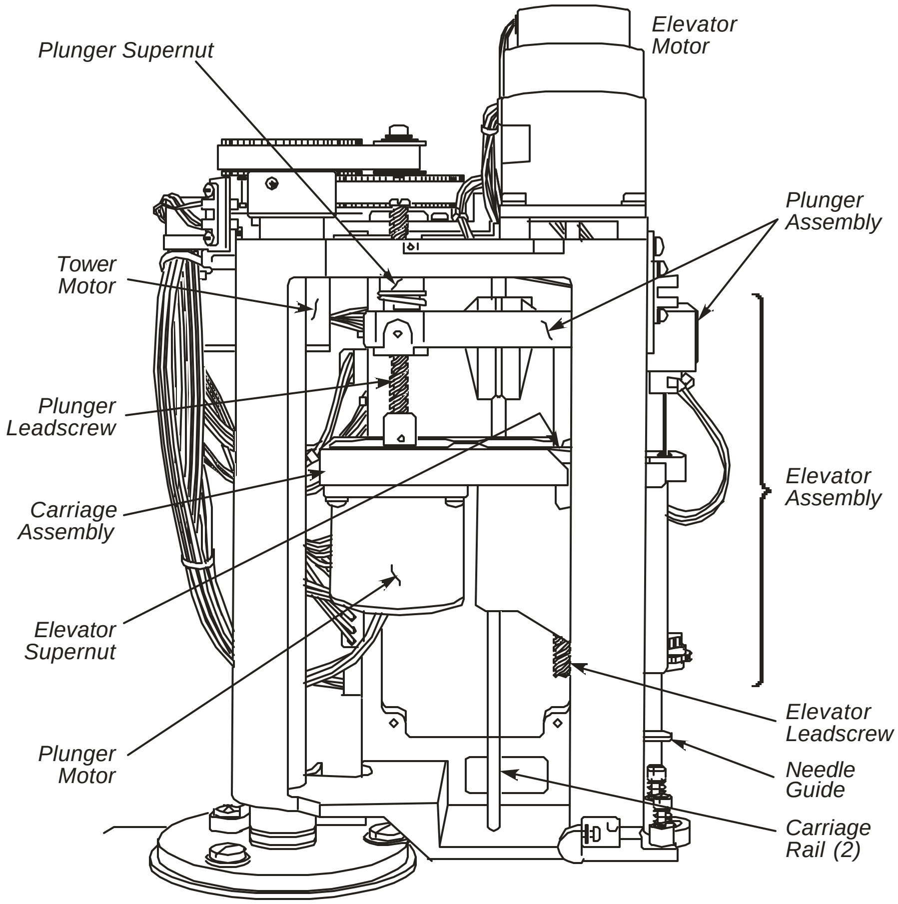


Figure 6- 30 Parts of the Autosampler Tower.

Reassemble the Tower

You will need two clip-to-clip wire jumpers approximately 18 inches long for part of this procedure.

1. Install a new external grip ring (Part No.0991-1387) on the one end of each carnage rail, using pliers or another appropriate tool.

2. Slide the carnage rails into the holes in the top of the tower frame, then through the plunger assembly and the carriage assembly. Slide the needle guide onto the front carriage rail.

3. Make sure the ends of the carriage rails protrude out the holes in the bottom of the tower frame but do not extend beyond the bottom of the casting, then install a new external grip ring on the end of each rail.

4. Install the elevator motor with the leadscrew mounted on its shaft into the tower by turning the motor clockwise while holding the elevator assembly centered in the tower frame. Make sure the leadscrew goes into its mating supernut.

5. Secure the motor to the top of the tower with the four mounting screws you removed from the old motor. Do not tighten these screws.

6. Remove the instrument right-side panel and turn on the instrument.

7. Attach the two clip-to-clip jumpers between the 24 VDC and 24V RTN posts on the main power supply and Pins 5 and 6 on the elevator motor connector to apply 24 VDC to energize the elevator motor brake.

8. Manually slide the elevator assembly up and down as far as it will go to ensure that the elevator motor centers itself.

9. With the elevator assembly at its maximum upward position, tighten the four elevator motor mounting screws.

10. Verify that that the elevator assembly moves freely without binding.

11. Turn off the instrument, remove the jumpers. and replace the right-side panel.

12. Manually move the elevator assembly to the nominal home position, such that the top of the elevator flag is centered in the elevator sensor.

13. Mount the Tower Interface Board to the tower frame (five screws) and plug in all sensor and motor connectors.

Replacing the Elevator Leadscrew /Supernut Assembly

Perform this procedure to replace the elevator leadscrew/supernut assembly. The entire procedure comprises the following steps:

1. Replace the Elevator Leadscrew/Supernut Assembly
2. Reassemble the Autosampler Tower

Replace the Elevator Leadscrew /Supernut Assembly

1. Disassemble the autosampler tower as described in "Disassembling and Reassembling the Tower," earlier in this chapter.
2. The elevator leadscrew should be mounted to the shaft of the elevator motor. Push out the roll pin securing the leads crew to the motor shaft, remove the leadscrew, and discard the roll pin and leadscrew.

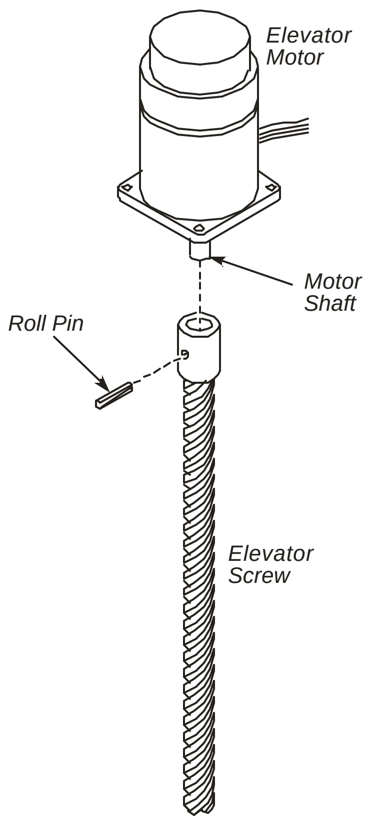


Figure 6- 31 Removing and Mounting the Elevator Leadscrew and Roll Pin from the elevator Motor shaft.

3. The plunger assembly is connected to the carriage assembly by the plunger leadscrew. You must separate these two assemblies enough to gain access to the elevator supernut, which is mounted to the carriage assembly when you begin.

   To gain access to the elevator supernut, turn the plunger leadscrew collar clockwise until the plunger assembly is as far away from the carriage assembly as possible, then swing the plunger assembly around 180°.

4. Remove the three screws securing the supernut to the carriage assembly, then remove and discard the supernut (see the following figure). Save the screws.

Note: *The elevator leads crew and supernut are a matched set. Never mount a new leads crew into an old supernut, and vice versa.*

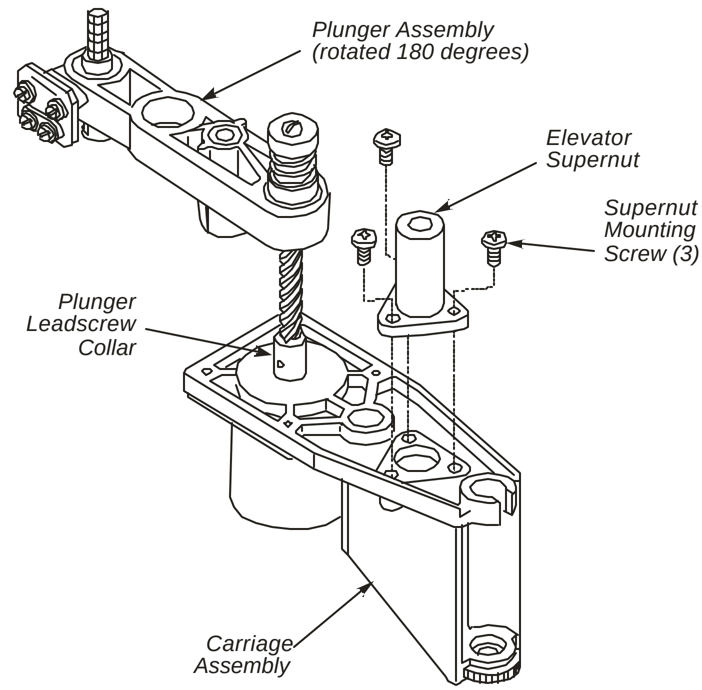


Figure 6- 32 Removing the Elevator Supernut.

5. The replacement elevator leadscrew and supernut are packed mounted together. Unpack the assembly and separate the two pieces.

6. Mount the new elevator leadscrew to the shaft of the elevator motor using a new 1/2-in. long roll pin (Part No.0991-1438).

7. Install the new supernut onto the carriage assembly using the three screws you removed in Step 3.

8. Swing the plunger assembly back to its original position, then turn the plunger leadscrew collar until the plunger and carriage assemblies are as close together as possible.

9. Reassemble the tower as described in the "Disassembling and Reassembling the Tower," on page 6-41.

Replacing the Plunger Motor

Replace a failed plunger motor as described in the following procedure. The entire procedure comprises the following steps:

- Remove the Old Plunger Motor
- Install a New Plunger Motor

Remove the Old Plunger Motor

1. Disassemble the autos ampler tower as described in *"Disassembling and Reassembling the Tower,"* on page 6-41.

2. Remove the screw from the top of the plunger supernut. The top half of the plunger supernut and the supernut spring will come off the plunger assembly (see the following figure).

3. Turn the plunger leads crew collar clockwise while immobilizing the half of the plunger supernut still mounted in the plunger assembly.

   The plunger assembly will separate from the carriage assembly and the bottom half of the supernut will remain in the plunger assembly.

4. Remove the four screws securing the plunger motor to the underside of the carriage assembly, and remove the motor. The plunger leadscrew will come out with the motor.

5. Remove and discard the roll pin securing the plunger leadscrew to the shaft of the plunger motor. Save the leadscrew, and discard the motor.

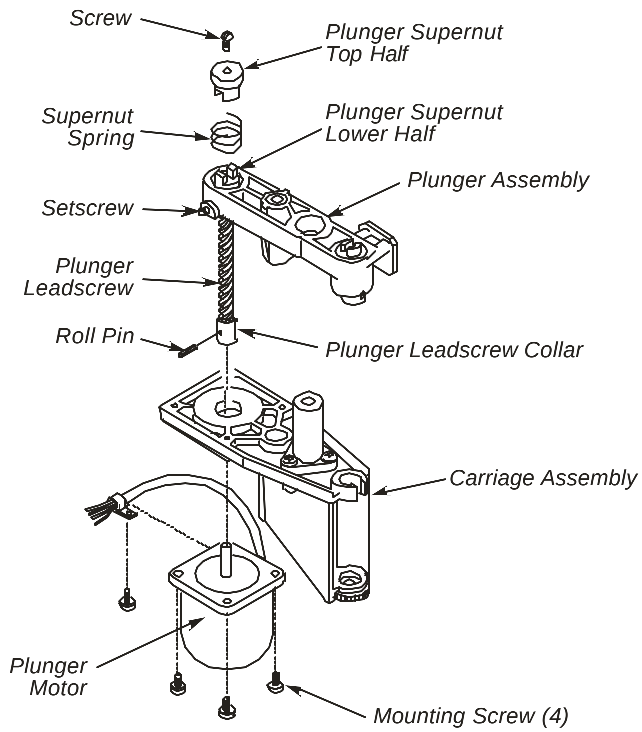


Figure 6- 33 Removing the Plunger Motor

6. Now install the new plunger motor:

Install a New Plunger Motor

1. Mount the plunger leadscrew onto the new motor, securing the leadscrew collar to the motor shaft using a new 1/2-in. roll pin (Part No.0991-1438).

2. Mount the motor, with the leadscrew attached, to the underside of the carriage assembly using the four screws from Step 4.

3. Connect the plunger assembly to the carriage assembly by mounting the bottom half of the supernut (still mounted in the plunger assembly) onto the plunger leadscrew and turning the leadscrew collar counterclockwise.

4. Fill the insides of the two supernut halves with Molykote grease, Part No. 0992-3016. Then connect the supernut top half to the bottom half, fully compressing the supemut spring between the two halves (see the following figure).

5. Install the screw you removed in Step 2 into the top of the supernut.

Figure 6-34 Assembling the Plunger Supernut.

6. Swing the plunger assembly back to its original position, then turn the plunger leadscrew collar until the plunger and carriage assemblies are as close together as possible.

7. The elevator assembly is now complete. Reassemble the autosampler tower as described in *"Disassembling and Reassembling the Tower,"* on page 6-41.

Replacing the Plunger Leadscrew /Supernut Assembly

Use the following procedure to replace a failed plunger leadscrew/supernut assembly. The entire procedure comprises the following steps:

1. Remove the Old Plunger Leadscrew/Supernut Assembly

2. Install a New Plunger Leadscrew/Supernut Assembly

Remove the Old Plunger Leadscrew /Supernut Assembly

1. Disassemble the autosampler tower as described in "Disassembling and Reassembling the Tower," on page 6-41.

2. Remove the screw from the top of the plunger supernut. The top half of the plunger supernut and the supernut spring will come off. Discard both of these parts.

3. Turn the plunger leads crew collar clockwise while immobilizing the half of the plunger supernut still mounted in the plunger assembly.

   The plunger assembly will separate from the carriage assembly and the bottom half of the supernut will remain in the plunger assembly.

4. Remove and discard the roll pin securing the plunger leadscrew to the shaft of the plunger motor. Discard the leads crew.

5. Loosen the setscrew securing the bottom half of the supernut to the plunger assembly. Using a pliers, remove and discard the bottom half of the supernut.

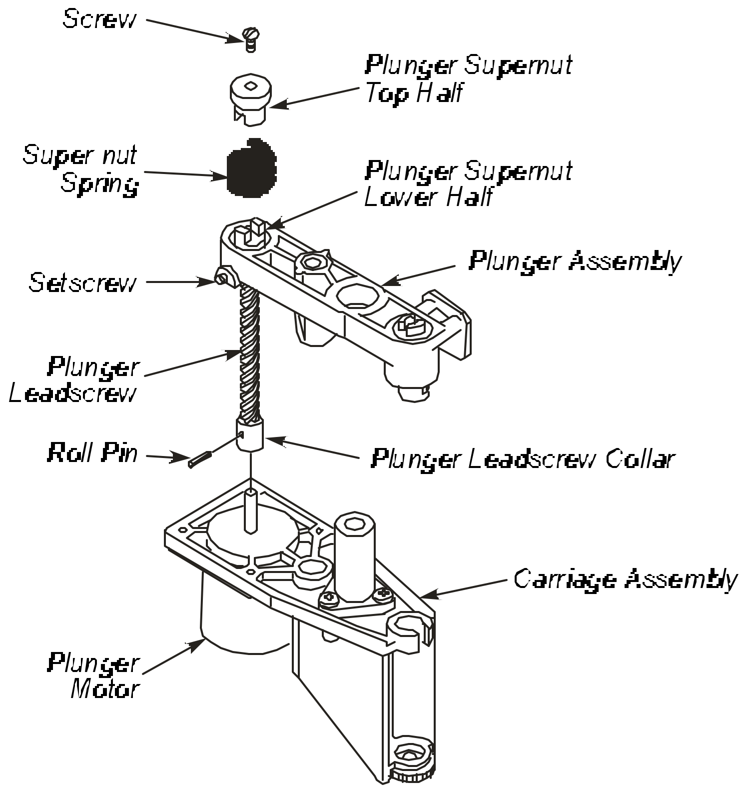


Figure 6- 35 Removing the Plunger Leadscrew/Supernut Assembly.

6. Install the new plunger leadscrew/supernut as described in the next section.

Install the New Plunger Leadscrew /5upernut Assembly

1. The replacement plunger leadscrew and supernut are packed mounted together. Unpack the assembly and separate the two pieces.

2. With the spring at maximum compression between the two halves of the supernut, screw the leads crew into to the supernut.

3. Screw the bottom half of the supernut into the plunger assembly as tight as possible while keeping the leadscrew free-running in the supernut. Make sure that the supernut doesn't collapse or bind on the leadscrew.

4. Tighten the setscrew to secure the bottom half of the supernut to the plunger assembly. Make sure that the supernut doesn't bind on the leadscrew.

5. Unscrew the leads crew from the supernut and install it onto the motor, securing the leadscrew collar to the motor shaft using a new 1/2-in. roll pin (Part No.0991-1438).

6. Fill the insides of the supernut halves with Molykote grease, (Part No. 0992-3016), then connect the supernut top half to the bottom half, fully compressing the supernut spring between the two halves.

7. Install the screw you removed in Step 1 into the top of the supernut.

8. Swing the plunger assembly back to its original position, then turn the plunger leads crew collar until the plunger and carriage assemblies are as close together as possible.

   The elevator assembly is now complete.

9. Reassemble the autosampler tower as described in *"Disassembling and Reassembling the Tower,"* see page 6-41.

Replacing the Plunger Flag Assembly

Use the following procedure to replace a broken plunger flag assembly. The entire procedure comprises the following steps:

1. Replace the Plunger Flag Assembly

2. Align the Plunger Sensor

Replace the Plunger Flag Assembly

1. Disassemble the autosampler tower as described in "Disassembling and Reassembling the Tower," see page 6-41.

2. To access the plunger flag assembly, turn the plunger leads crew collar clockwise until the plunger assembly is as far away from the carriage assembly as possible, then swing the plunger assembly around 180°. See the following figure.

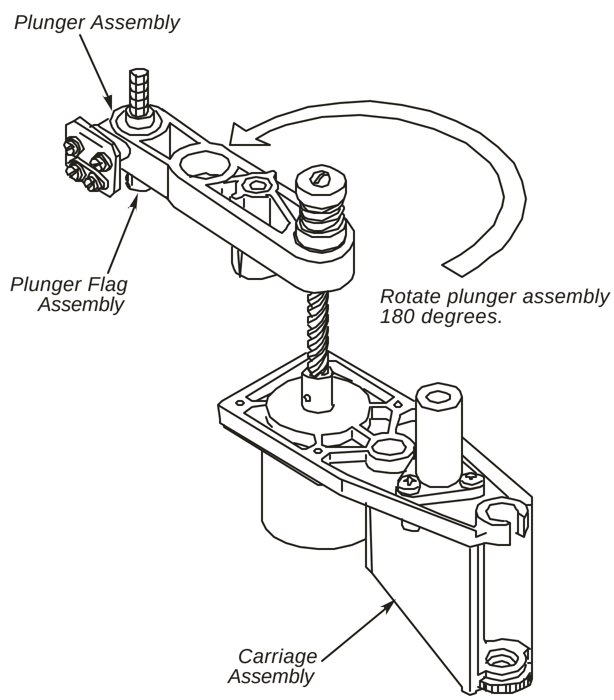


Figure 6- 36 Accessing the Plunger Flag Assembly.

3. Lift and turn the plunger cap handle to lock the plunger in the up position.

4. Using internal retaining ring pliers, remove the internal retaining ring securing the plunger flag assembly to the plunger assembly (see the following figure). Discard the retaining ring.

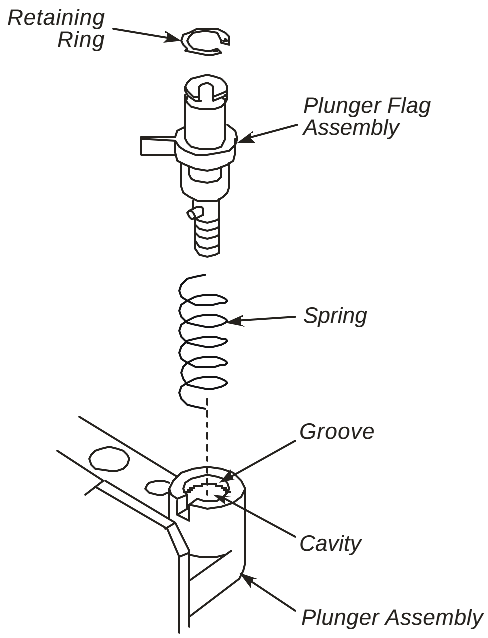


Figure 6- 37 Replacing the Plunger Assembly.

5. Remove the plunger flag assembly and the spring. Discard both parts. While it is not required, we recommend replacing the spring whenever you replace the plunger flag assembly.

6. Clean the old grease out of the plunger flag assembly cavity in the plunger assembly. Apply a bead of grease (Part No.0992-3016) to the inside wall of the cavity.

7. Put a new spring (Part No. N610-1192) into the cavity, then install the new flag assembly over the spring, pulling the plunger cap handle through from the other side of the plunger assembly.

   Turn the plunger cap handle 90° to lock it in the up position.

8. Using internal retaining ring pliers, install a new internal retaining ring. Make sure the ring is seated in the groove inside the plunger flag assembly wall.

9. Reassemble the tower as described in *"Disassembling and Reassembling the Tower,"* earlier see page 6-41.

10. Get to the Autosampler Diagnostics as described in *"Accessing the Autosampler Diagnostics,"* see page 6-9.

11. Align the plunger sensor as described in *"Replacing the Plunger Sensor,"* see page 6-28.

Replacing the Needle Guide

Use the following procedure to replace a broken needle guide.

Make sure the instrument is disconnected from line power and the syringe, if installed, has been removed from the tower before you begin.

1. Remove the two screws securing the tower cover to the tower and carefully lift off the cover.

2. Unplug the two tower harness connectors from Jl and J2 on the Tower Interface Board.

3. Remove the cable clamp securing the Tower Harness to the tower frame. Leave the clamp attached to the harness.

4. Remove the three screws securing the tower base to the top of the instrument, and lift the tower off the instrument. Place the tower on a convenient working surface.

5. Remove the four screws securing the elevator motor to the tower frame. The elevator leads crew is mounted onto the elevator motor shaft. Remove the motor and leads crew assembly by turning the motor counterclockwise.

6. When you remove the elevator motor and elevator leadscrew, the tops of the two carriage rails will be exposed. U sing external retaining ring pliers, carefully remove the external retaining ring securing the front rail to the tower frame. Discard the grip ring.

7. Carefully slide the rail out of the bottom of the tower frame.

8. The carriage rails secure the elevator assembly to the tower. When you remove the front rail, the needle guide will easily slide off. Discard the needle guide.

9. Slide the carriage rail back into the tower frame, sliding the new needle guide onto the rail. Make sure the rail slides through the hole in the carriage assembly, and that the needle guide slides through the slot in the carriage assembly.

10. Install a new external retaining ring (Part No.0991-1387) to the top of the carriage rail to secure it to the tower frame. Make sure that the rail sits tight against the frame and that there is no axial play in the retaining ring.

11. Reassemble the tower as described in *"Disassembling and Reassembling the Tower,"* see page 6-41.

Replacing the Vial Locator

Replace a broken or worn vial locator as described in the following procedure.You may have to realign the vial locator sensor after you install the new vial locator.

1. Remove the two shoulder screws securing the vial locator to the tower frame, remove the two springs, and remove the vial locator.

   Discard the vial locator .

2. Apply a small amount of grease (Part No.0992-3016) inside the shoulder screw cavities in the vial locator .

3. Mount the new vial locator onto the tower frame. Install the two shoulder screws through the two springs into the vial locator to secure the vial locator to the tower frame.

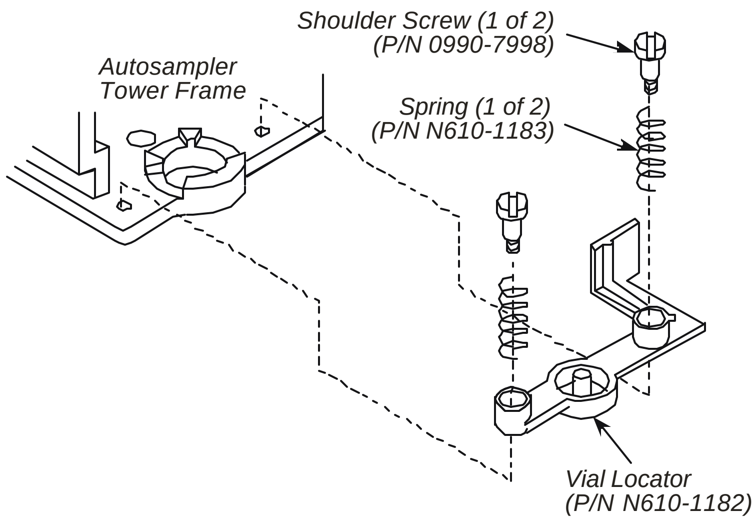


Figure 6- 38 Replacing the Vial Locator.

4. Align the vial locator sensor as described *"Replacing the Vial Locator Sensor,"* see page 6-33.

Replacing the Tower Disk Assembly

Replace the tower disk if it becomes bent or broken. The tower disk is pressed into the tower disk collar and cannot be disassembled.

1. Remove the two screws securing the tower cover to the tower and carefully lift off the cover.

2. Unplug the two tower harness connectors from Jl and J2 on the Tower Interface Board.

3. Remove the cable clamp securing the Tower Harness to the tower frame. Leave the clamp attached to the harness.

4. Remove the three screws securing the tower base to the top of the instrument, and lift the tower off the instrument.

   Place the tower on a convenient working surface.

5. Loosen the idler locking screw (see Figure 6-).

6. Remove the idler adjustment screw, spring and flat washer.

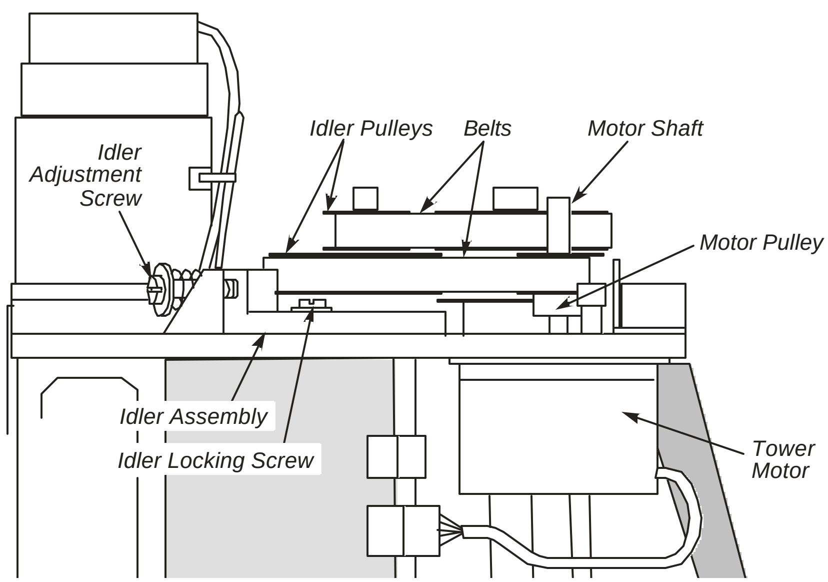


Figure 6- 39 Location of Idler Assembly, Belts, and Pulleys.

7. Loosen the two tower disk pulley setscrews completely, then remove the tower disk pulley (see the following figure).

8. Loosen the tower sensor mounting bracket screw farthest from the sensor, then remove the mounting bracket screw closest to the sensor.

9. Swing the mounting bracket out of the way of the sensor.

10. Loosen the two tower disk collar setscrews completely, then remove the collar with the disk pressed to it.

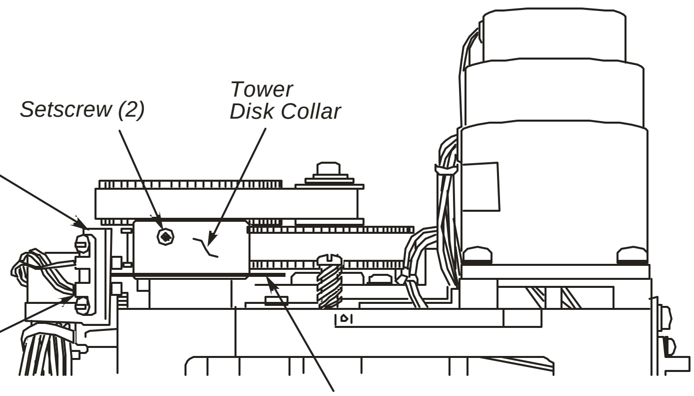


Figure 6- 40 Parts of the Tower Disk Assembly.

11. Apply a small amount of grease (Part No.0992-3016) to the center hole on the new tower disk collar, then install the new tower disk assembly onto the tower shaft.

    Secure the assembly to the shaft using brass-tipped setscrews (Part No. 0992-0604).

12. Apply a thin film of grease (Part No.0992-3016) over the top surface of the the tower disk collar.

13. Apply a small amount of grease to the center of the tower disk pulley, then install the pulley onto the shaft over the collar. Make sure one of the pulley setscrews in perfectly centered on the flat side of the tower shaft. Leave the pulley setscrews loose so that they just touch the shaft.

14. While pressing down on the pulley, tighten the pulley setscrew that is centered on the flat side of the tower shaft.

15. Tighten the other pulley setscrew. There should be no up or down movement of the pulley.

16. Swing the tower sensor mounting bracket back to its original position and reinstall the mounting bracket screw that you removed earlier.

    Do not tighten the mounting bracket screws.

17. Loosen the tower sensor mounting screws.

18. Slip the belt onto the tower pulley, then pull the upper idler pulley to put tension on the belts.

    Tighten the idler locking screw.

19. Reinstall the idler adjustment screw, spring, and flat washer.

20. Loosen the idler locking screw.

    Make sure the working length of the idler adjustment spring is 1/2-in. ± 1/64-in.

21. Manually rotate the tower base two or three times to center the belts on the pulleys.

22. Tighten the idler locking screw.

23. Install the tower onto the instrument.

24. Loosen the two setscrews on the motor pulley and slide the pulley off the motor shaft. Discard the motor.

25. Slide the pulley over the shaft of the new motor. Do not tighten the setscrews.

26. Install the new motor using the four screws, shock mounts, and washers from the old motor, then slip the belt around the motor pulley. The belt will be loose.

27. Get to the Autosampler Diagnostics as described in "Disassembling and Reassembling the Tower," see page 6-40.

28. Align the tower sensor as described in *"Replacing the Tower Sensor,"* see page 6-22.

    This concludes the procedure.

Diagnostics 7

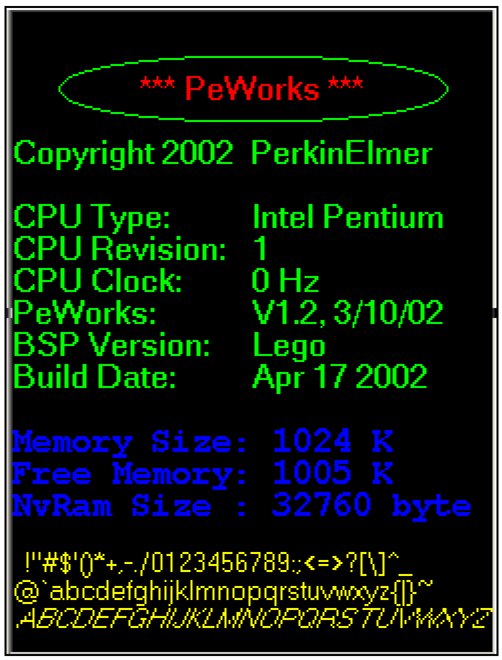
Instrument Start Up 7-3
Power on Diagnostics 7-3
Power Failure Recovery 7-5
Diagnostics Mode 7-5
Autosampler 7-11
Chromatograph Mode 7-14
Splash Screen 7-14
Chromatograph Mode 7-18

Instrument Start Up

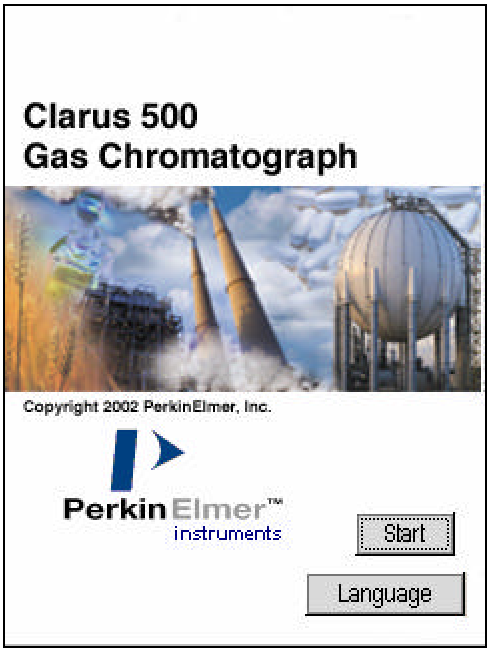
Power on Diagnostics

The touch screen provides entry to either the diagnostic or chromatograph mode of operation. The diagnostics mode is reserved for service-related tasks and uses a separate interface. Diagnostic Screens are in English only. Upon startup, the instrument displays the splash screen and indicates the success or failure of the power on diagnostics (POD) as they run in sequence. Upon successful POD completion the instrument main power is enabled and the instrument PPC, inlet, Aux, and detector zones are activated. After the power-on heating delay, if any, has expired the instrument oven heating is activated. The method that was active at power off remains active.

After the instrument runs Power on Diagnostics (POD), a summary screen displays status information for approximately 2 seconds before the Splash screen appears.

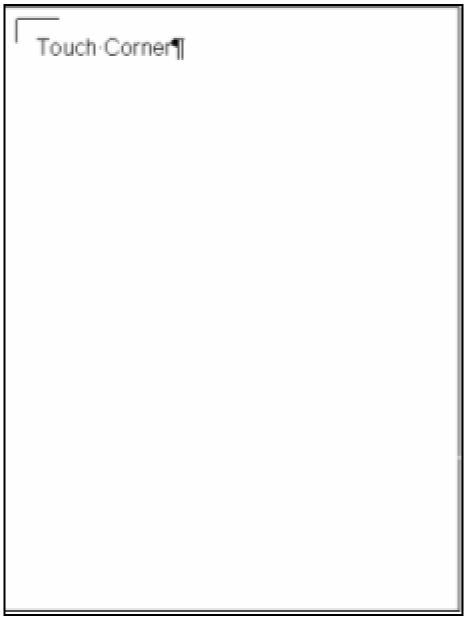


Screen 7- 1 Summary Screen



Screen 7- 2 Splash Screen

If the user touches the splash screen during power up and maintains pressure for at least 2 seconds, the calibration screen appears.



Screen 7- 3 Calibration Screen

The arrows direct the user to touch the upper left and lower right corners. Touch the screen 10 more times to exit. Once this is complete the main splash screen comes up.

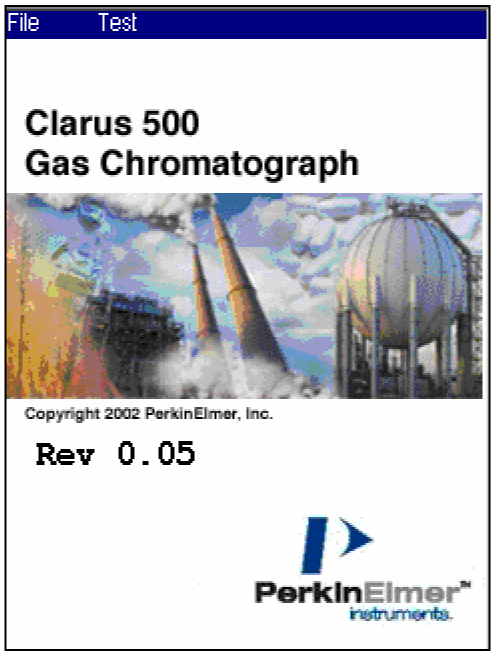
Power Failure Recovery

The Clarus 500GC includes provision for autosampler program recovery after power failure/restoration. If the Auto Resume flag is set in Automation configuration then the auto resume sequence will execute without a user login, if the option is enabled.

Diagnostics Mode

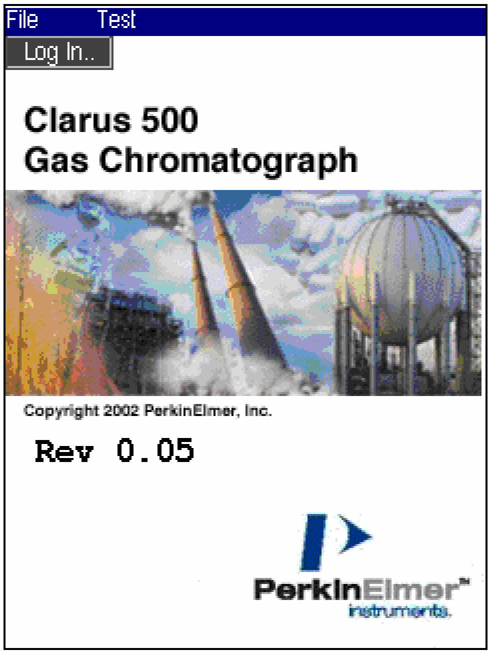
Log in

Enter 65535 from the "Password" screen to enter diagnostics mode. If the password is not enabled, go to the Tools menu configuration option, and touch the Setup icon to access the setting. The following graphic represents the top-level diagnostics screen. The splash screen is in the background.



Screen 7- 4 Splash Screen

File menu



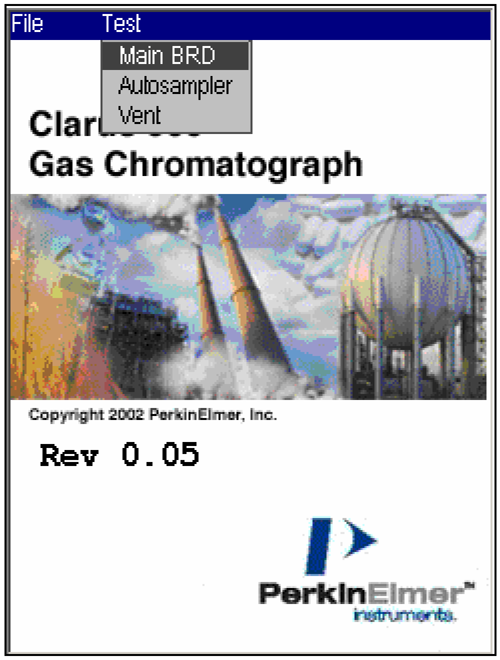
Screen 7- 5 Top Level Diagnostic Screen

Log In - When you touch “Log In” the instrument performs a power on reset.

Erase Local nvRam - This displays a warning message and then erases the non-volatile RAM on the Clarus board.

Test menu

The following screen capture displays the Test menu options.



Screen 7- 6

When you touch “Test” this drop down menu appears.

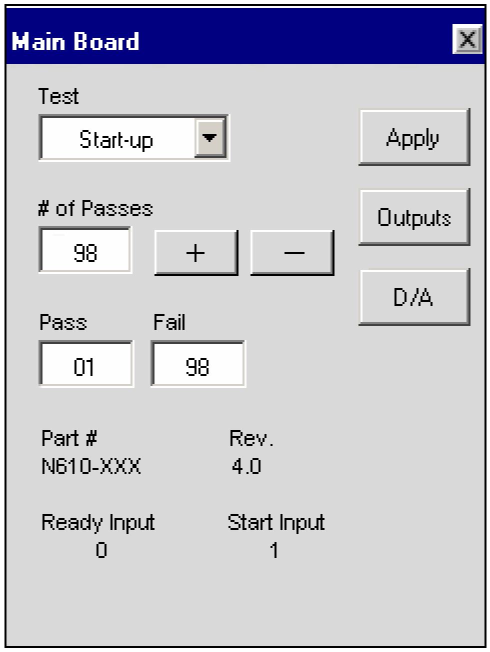
Main Board – Runs the Main Board diagnostics.

Autosampler – Runs the Autosampler Diagnostics

Vent Door – Opens and closes the oven vent door.

Touch Screen– Toggles the visible cursor. The visible cursor becomes active upon exit from diagnostics, and it remains active until the instrument is reset or power is cycled.

Main Board



Screen 7- 7 Main Board

When you touch **"Test" "Main Board"** from the top screen, will bring up this screen.

Touching the top right X will close the window.

TEST – Start-Up Cycle Diagnostic, A/D T Channel, A/D Loop Back, Ram, Bram1, Clear Bram, Prom. Multiple passes can be run on each test, by highlighting "# of Passes" and using the plus and minus buttons to change the number and then press "Apply", default is 1.

Start-Up Cycle Diagnostic runs once and launches a window, see below.

The A/D T Channel and A/D Loop Back and Clear Bram only run one time. # of Passes is grayed out at 1. A/D Loop Back will generate a information screen, see below.

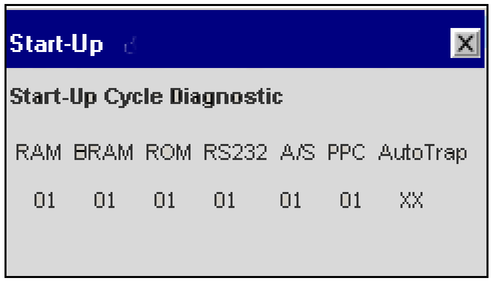
OUTPUTS - The Outputs button jumps to another window allowing the user to toggle the following output relays open and close – Ready, Start, Valve1, Valve2, Valve3, Valve4 and toggle the solenoid valves on for 5 seconds.

D/A – The D/A button runs the D/A test.

In the lower part of the screen, the current revision level and the part number of the Eprom appear.

At the bottom of the screen is the status of the Ready In and Start In signal.

Start-Up Diagnostic



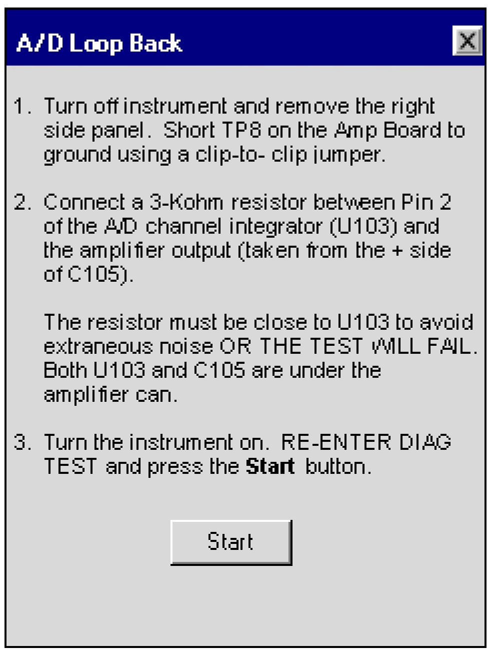
Screen 7- 8 Start-Up Dialog

This box floats over the above screen. These are the same start-up diagnostics that occur during power-up. The results line indicates if the test passed (1) or failed (0) or is not configured.

RAM

This test writes 55 (01010101) Hex and then AA (10101010) Hex to all memory locations. If it detects a failure, it increments the Fail counter.

A/D Loop Back

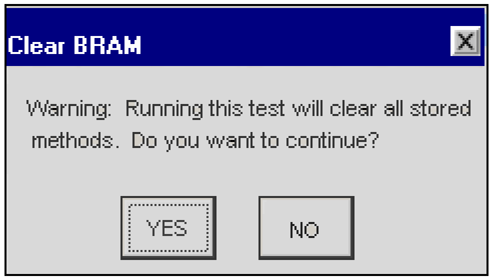


Screen 7- 9 A/D Loop Back Screen

BRAM

This diagnostic performs a checksum of the battery ram and compares it to the checksum stored in the last two bytes. If the test fails, it increments the Fail counter.

CLEAR BRAM



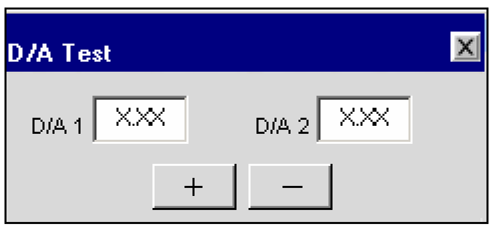
Screen 7- 10 Clear Bram Dialog

Clear BRam test will clear all battery backed memory. The information box appears instructing the service that running this test will clear all stored methods.

PROM Test

If it detects a failure, it increments the Fail counter.

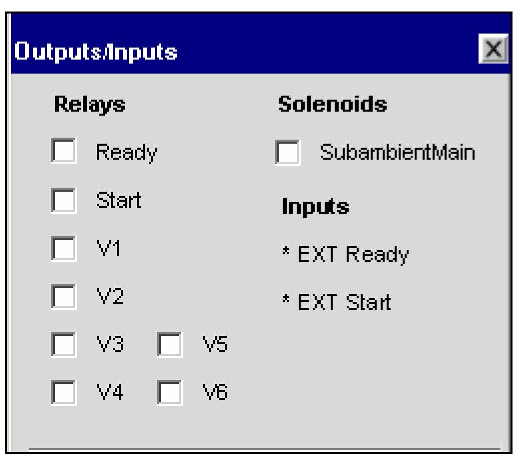
D/A Diagnostics



Screen 7- 11 D/A Diagnostics

The D/A test lets you set the output of the D/A to a specific voltage.

Outputs/Inputs (Remote Outputs)



Screen 7- 12 Outputs/ Inputs (Remote Outputs) Dialog

Outputs

When the "Output" button is touched, this screen launches. Touching the boxes in front of the descriptions, places a check mark in the box (TurboMatrix style) and closes the relay. Touching the box again will uncheck the box and open the relay.

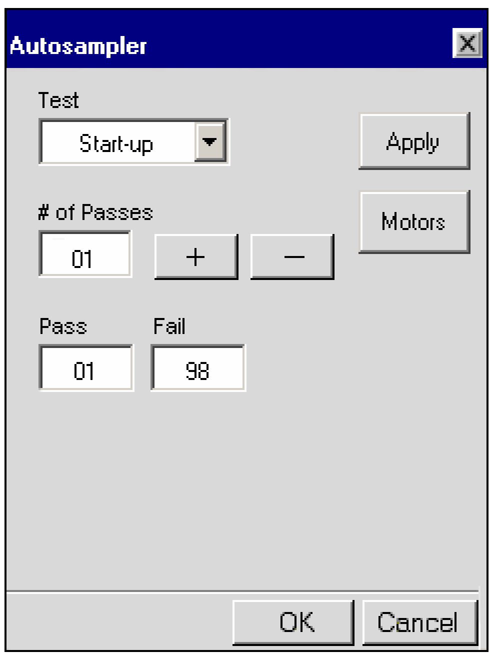
When the Subambient/Main box is checked the Subambient Valve and Main Instrument Relays will both turn ON for 5 seconds and then turn OFF. The check in the box will disappear after the 5 seconds indicating the change back to the off state.

Inputs

When the EXT Ready or Start pins are shorted a star will appear next to the function.

Autosampler

Touching **"Test" "Autosampler"** from the top screen, will bring up this screen.



Screen 7- 13 Autosampler Screen

TEST – ASRAM, ASPROM, ASUART1, ASUART2, ASPIA and ASPTM. Multiple passes can be run on each test, by highlighting "# of Passes" and using the plus and minus buttons to change the number and then press "Apply". The number of pass/fail is provided in the boxes.

MOTORS - Pressing the "Motors" button brings up a window.

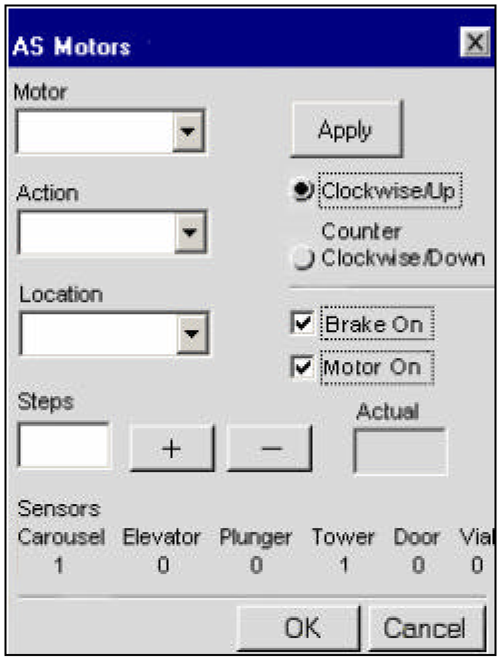
ASRAM

If a failure occurs during the ASRam test, it increments the Fail counter.

ASPROM

If an error occurs during the ASPROM test, it increments the Fail counter.

AS Motors



Screen 7- 14 AS Motors Screen

MOTOR – Tower, Carousel, Elevator and Plunger

The motor selected determines which actions are available. Steps and location may be grayed out.

ACTION – Tower Motor

- Step (Note: Steps can be a plus or minus entry.)
- Cycle
- Home
- Scan
- Position
  - Location
    - Park, Inj1, Inj2, Out1, In1, Sol1,Sol2, In2, Out2, Home
  - Vial
    - Location (Vial number 1 – 101)

Carousel Motor

Step (Note: Steps can be a plus or minus entry.)
Cycle
Home
Scan

Elevator

Step (Note: Steps can be a plus or minus entry.)
Cycle
Home
Scan

Plunger

Step (Note: Steps can be a plus or minus entry.)
Cycle
Home
Scan

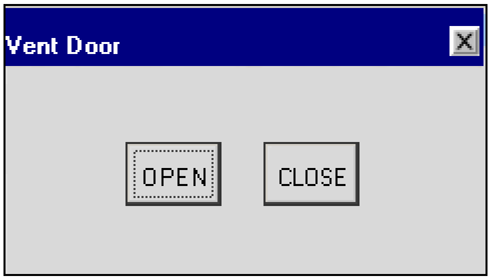
Clockwise/Up and Counter Clockwise/Down radio buttons, only one can be checked. They only apply to the scan test.

The Brake On checkbox selects brakes on if checked.

The Motor On checkbox selects the autosampler motors if checked.

The +/- buttons are to change the number of steps when selected.

Vent Door



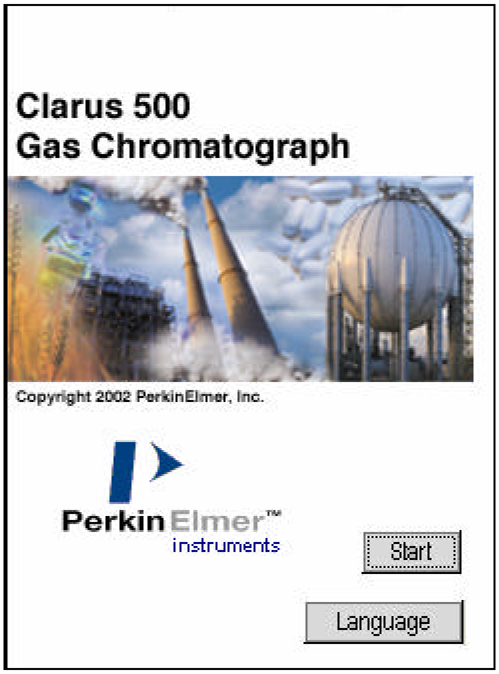
Screen 7- 15 Vent Door Screen

Pressing the CYCLE button opens and then closes the Vent Door.

Chromatograph Mode

Splash Screen

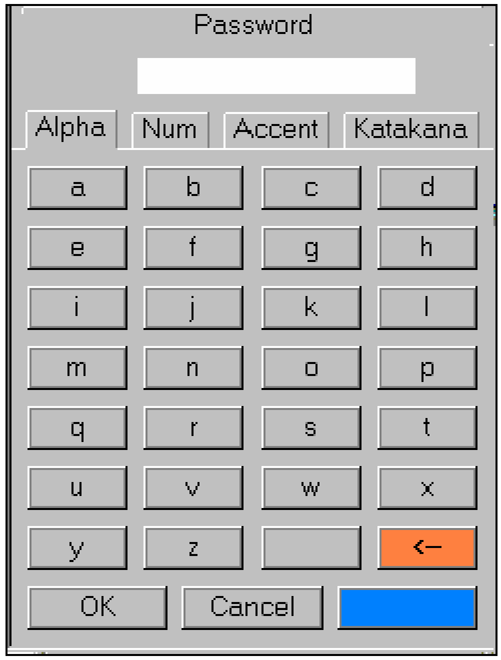
The calibration screen closes and the splash screen appears.



Screen 7- 16 Splash Screen

Start Button

The password setting is disabled by default and is accessed via the Tools Configuration Setup option. If the password is disabled, touching the Start button displays the Status screen. If the password is enabled, the following alphanumeric keypad appears for the user to enter the password.



Screen 7- 17 Alphanumeric Touch Keypad Screen

The default password is Clarus. Touch each character to display it in the field at the top of the keypad. Passwords can be a combination of numbers and letters and are case sensitive. The limit is 8 characters. When the password is entered, touch OK to close the keypad. If the password is valid, touching OK on the keypad displays the Status screen. If the password is invalid, the following message appears. Touch OK to display the keypad again.

Screen 7- 18 Error Dialog

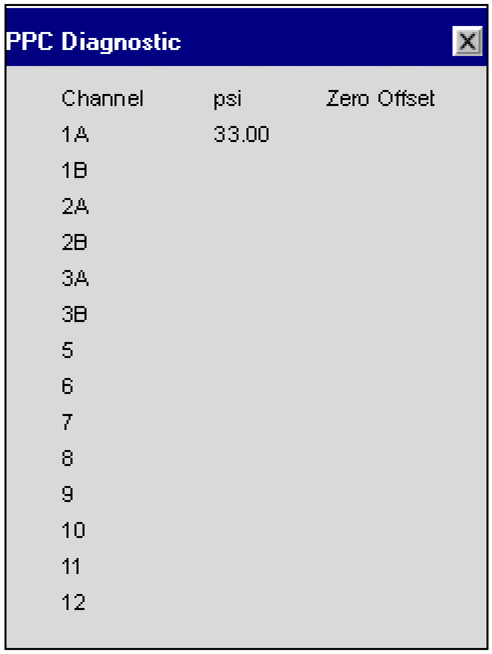
Language Button

The Language button provides a quick link to the language option setting on the setup screen. The button is disabled if a login is required. The following capture shows the Setup screen that includes the Password and Language options.

Screen 7- 19 Setup Screen

After setting the language, touch OK to close Setup and display the Status screen. Touch Cancel to return to the splash screen.

PPC Diagnostic

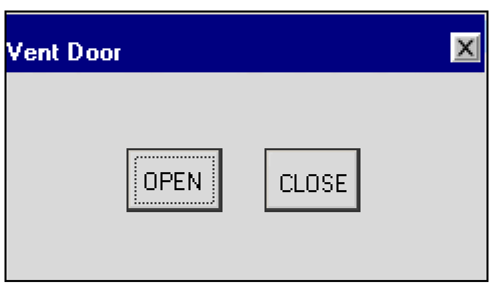


Screen 7- 20 PPC Diagnostic

This screen displays the output in psi of all the pressure transducers.

This screen displays the output in psi of all the pressure transducers.

Vent Door

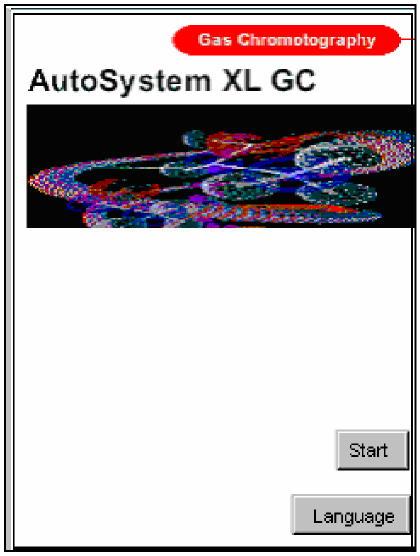


Screen 7- 21 Vent Door Dialog

Chromatograph Mode

Log in

The calibration screen closes and the splash screen appears.



Screen 7- 22 Splash Screen

The Start button prompts the login dialog box if the password option is enabled. The password setting is enabled by default and is accessed via the Tools menu System option. If the password is not enabled, touching the Start button displays the Status screen.

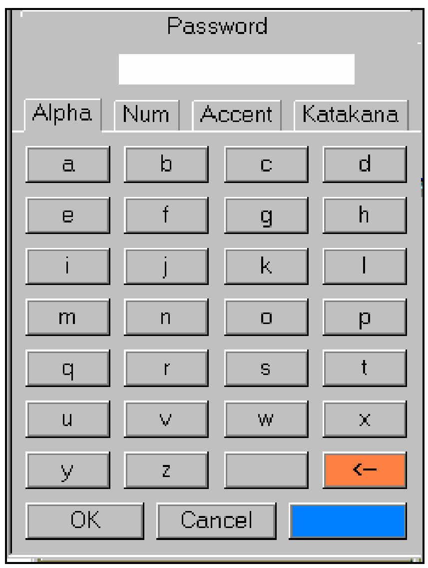
The Language button provides a quick link to the language option setting on the setup screen. The button is enabled only if login is not required. The following capture shows the Setup screen that includes the Password and Language options. Touch **Cancel** or **OK** to return to the Splash screen.

Screen 7- 23 Setup Screen

If the password is enabled, touching the Start button displays the following Log in dialog box.

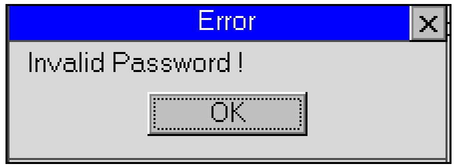
Screen 7- 24 Log In Dialog

Touch OK to display the alphanumeric keypad.



Screen 7- 25 Alphanumeric Keypad Screen

Touch each character to display it in the field at the top of the keypad. The default password is Clarus. Passwords can be a combination of numbers and letters and are case sensitive. The limit is 8 characters. When the password is entered, touch OK to close the keypad. If the password is invalid, the following message appears.



Screen 7- 26 Error Dialog

If the password is valid, touching OK on the keypad displays the Status screen.

Trouble Shooting 8

Chapter Overview.. 8-3
Solving GC Problems 8-3
Troubleshooting General Instrument Problems.................................. 8-5
Error Messages.. 8-5

Chapter Overview

This chapter includes some basic information on GC troubleshooting; and lists all of the error messages that may appear on the display, what they mean, and how to correct the problem.

The following sections are included:

- Solving the GC Problems
- Password
- Toubleshooting General Instrument Problems
- Error Messages

Solving GC Problems

There are several sources of problems in gas chromatography:

The operator
An inexperienced operator and/or a new instrument can cause problems during the learning curve.

The Sample
Unlike clean standards, real world samples such as environmental samples can cause problems because they are difficult to handle, have complicated matrices, contain unknown constituents, etc.

The Column
The column is often a major cause of ananlysis problems. The more a column is used, the greater the possiblity of contamination, loss of substrate, etc. Columns should be changed when results become suspect.

The Gas Flow System
Leaks are a major concern in GC and can cause many problems.

The Electronics
The problem must be identified as hardware or chromatographic. Electronics used in the system can malfunction.

Data Handling
Data handling systems are often used to integrate results. Incorrect data handling parameters can casue problems.

Spare Components

Keep these items with you to help solve chromatographic problems:

New Syringes
A syringe can break, become plugged, or begin leaking. Always have spares available.

Duplicate columns
A column does not last forever, therefore a duplicate column should be on hand if separation begins to degrade. Also, capillary can be damaged if oxygen is introduced at high temperatures. A duplicate column allows you to determine if the column is the cause of the problem.

Septa
This is one area of the instrument that requires routine maintenance. Always have spare septa available.

Leak detector
The gas flow system can be a problem, fittings wear with age and can begin to leak. A leak detector should be available to help find and fix leaks.

Injector liners
The injector liners are made of glass and can be easily broken when removed for cleaning or repacking with silanized wool. A supply of spare liners should be kept on hand.

Logical Troubleshooting Steps

Here are some simple steps that you should take when trying to identify a problem:

- Note the symptoms – define the problem. Compare the runs with the results normally obtained.

- Systematically eliminate possible casues.

The first rule here is "what was changed last." Many times a problem arises when a change is made to the system such as changing a gas tank, septum, glass linear, etc. If the problem occurred after such a change, then the change is the most likely cause of the problem.

Change the simplest thing first. For example, if you suspect a gas leak, the easiest change to make is the GC septum instead of replumbing the internal pneumatics.

Change only one thing at a time and check for its effect. If you change three things at once and the problem goes away, you may not know which change corrected the problem.

Dual Identical Channels Only

If the instrument is a dual channel system (dual identical detectors and dual indentical injectors)

- Try switching the column to the second channel. If the problem is corrected then it was caused by the detector, injector, amplifier, or the pneumatics.

- Replace each of the above components one at a time to identify which one is defective. If the problem is the same as before you switched the column, you should suspect the column, syringe, standard or sample, electronics, or data handling device.

In the Event the Customer Forgets Their Password

If a customer were to forget their password on a Clarus 500 GC, we have built in a 'back-door' password which will enable the user to access the normal user's working portion of the GUI (everything except for diagnostics). The user at thispoint will have to contact PerkinElmer for this 'back-door' password. However, the same 'back-door' password is not accepted when the user tries to change the previously entered (but now forgotten) password. In order to allow a password change, the user must have a PerkinElmer service representative enter the diagnostics mode and clear the Local nvRAM (Non-Volatile). This will do three things:

1. The names of methods will be changed to the 'default' names i.e. Method 1, Method 2, etc…
   Note: *The Method parameters are stored – it is just any special naming is lost.*

2. The touch screen calibration is lost. When logging back in (from diagnostics back to the user interface, the service representative should hold a finger on the touch screen to initiate the touch screen calibration sequence.)

3. The old (forgotten) password is now cleared. The user may enter a new password and confirm. This is the same as the first password entered in a Clarus 500 GC system. If desired, the previously stored (user defined) method names will be re-set to names like Method 1, Method 2, Method 3, Method 4, or Method 5 – the user may re-name these back to the desired customized names (it probably wouldn't hurt to also go and check that each method has the correct settings for the oven, detectors, injectors, timed events, AutoSampler programs, etc…).

Troubleshooting General Instrument Problems

Error Messages

This section describes the following types of error messages that may appear on the instrument display and what they mean. ASXL local display error strings, the error strings are shown as the same two lines that are shown on the ASXL display. Italicised entries contained in angle brackets correspond to variable entries in the error message. The data are collected in a series of tables:

- Fixed-format error messages

- Nominally fixed-format errors (error that only differ by the xone identifier or an sutosampler error)

- Formated errors messages

Table 1 – Fixed format errors

Error code	Error strings
ER_32	**Timed Events Error** Events table is full. 32 events are the maximum allowed.
ER_DUP_TE	**Timed Events Error** Duplicate event time. Enter a value at least 0.1 minute different.
ER_232	**RS 232 Timeout Error.** **Device failed to respond within specified time frame.**
ER_COOL	**Oven Control Error** No Coolant available. Check coolant supply.
ER_PSHUT	**PPC Hardware Fault** Power instrument OFF, wait 10 seconds and then power ON. If problem persists Call PE Service Center.
ER_NO_VIAL	**AutoSampler Error** No vial found at location xx.
ER_NO_PROG	**AutoSampler Error** No autosampler programs active.
ER_CAL_ISO	**Background Calibration Error** Isothermal Method selected. Background calibration required temperature program method.
ER_CAL_NEG	**Background Calibration Error** Negative temperature ramp specified. Background calibration requires positive temperature ramps.
ER_CAL_SHORT	**Background Calibration Error** Run Time is less than 1.0 minute.
ER_CAL_LONG	**Background Calibration Error** Run Time is greater than 999 minutes.
ER_CAL_HOLD	**Background Calibration Error** HOLD Event is present in temperature program ramp. This is not permitted.
ER_DOOR	**Oven Door Open** Close oven door.
ER_INJ	**No Inlet Configured** Select Configuration on the Tools menu to access configuration settings.
ER_DET	**No Detector Configured** Select Configuration on the Tools menu to access configuration settings.
ER_CAL_LO	**Flow Calibration Error** Flow too high for ‘low' calibration. Check flow and repeat calibration.
ER_CAL_HI	**Flow Calibration Error** Flow too low for 'hi' calibration. Please check flow and repeat calibration.
ER_AS_DOOR	**AutoSampler Error** Access door open. Close door.
ER_NO_WASH	**AutoSampler Error** No post wash specified. Set post-inject field in configuration to a minimum of 1.
ER_CON_BAD	**Relay Fault** Turn power OFF for 10 seconds and then ON. If problem persists Call PerkinElmer Services.

ER_COOL_OUT	**Temperature Error** Unable to reach specified temperature. Check coolant.
ER_PPCNOCONN	**PPC Error** PPC Carrier xx not connected. Check PPC Carrier module connections.
ER_PPCNOCONN	**PPC Error** PPC Detector xx not connected. Check PPC Detector module connections.
ER_PPCNOCONN	**PPC Error** The AUX flow PPC module being calibrated is not connected. Connect the AUX PPC flow module and calibrate.
ER_DUP_CONN	**PPC Error** Selected connection is currently assigned. Select another connection.
ER_ALARM_WARN	**PPC Error** Warning: the PPC Alarm is OFF! If this is correct, press OK. To enable the PPC Alarm, select PPC Alarm ON in configuration setup.
ER_FLAME_FAIL	**Ignite Error** The detector xx failed to ignite. Check the hydrogen and air flows.
ER_FLAME_NOGAS	**Ignite Error** The detector xx failed to ignite. The hydrogen and air supplies are OFF. Turn the gases ON.
ER_TUNEMAXLIM	**GC Tune Error** **GC Tuning has turned Off due to instrument exceeding the maximum allowable pressure limit.** **GC Tune encountered a pressure problem.**
ER_TUNERANGLIM	GC Tuning exceeds the maximum allowable limit. **GC Tune encountered a pressure problem.**

Table 2 – Nominally fixed-format errors

	Parameter	Error strings
ER_OPEN	Zone – see zone table below for <zone> strings	*<zone>* Temperature sensor fault OPEN. Cycle the power OFF for 10 seconds then ON. If the error persists call PerkinElmer Services.
ER_SHORT	Zone – see zone table below for <zone> strings	*<zone>* Temperature sensor fault SHORT. Cycle the power OFF for 10 seconds then ON. If the error persists call PerkinElmer Services.
ER_HEAT	Zone – see zone table below for <zone> strings	*<zone>* No Heat. Cycle the power OFF for 10 seconds then ON. If the error persists call PerkinElmer Services.
ER_RUNAWAY	Zone – see zone table below for <zone> strings	*<zone>* Temperature exceeds setpoint! Instrument has shut down. Cycle the power OFF for 10 seconds then ON. If the error persists call PerkinElmer Service.
ER_AS	The parameter is translated into an autosampler error. See table below for <autosampler errors>.	**A/S control error** *<autosampler error>*
ER_PPC_HW	*(TEXT *)parm*	
ER_PZONESHUT	*(TEXT *)parm*	

Table 3 – The zone descriptions are tabulated below.

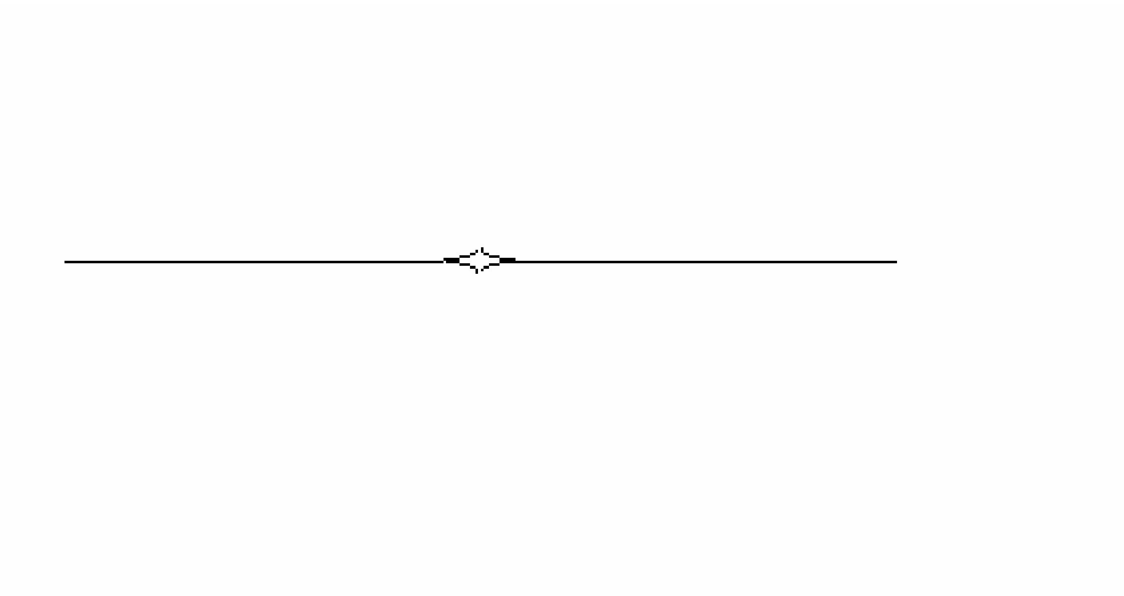
Zone	Description strings
Oven	Oven
Detector 1	**OUTPT** **FID A** **ECD A** **TCD A** **FPD A** **NPD A** **PID A**
Detector 2	**OUTPT** **FID B** **ECD B** **TCD B** **HECD B** **FPD B** **NPD B** **PID B**
Injector 1	**Pkd A** **Cap A** **GSV A** **PSS A** **POC A**
Injector 2	**Pkd B** **Cap B** **GSV B** **PSS B** **POC B**
Auxilliary	**AUX**
	Can
	Vlv
	Xfr

Table 4 –The autosampler error strings are tabulated below.

Autosampler error	Description string
NO_SENSOR	Bad Sensor state
BAD_MODE	Bad motor mode
BAD_SPEED	Bad motor speed
ELV_NOT_INIT	Elevator not initialising
PLN_NOT_INIT	Syringe error. Input value exceeds maximum volume of installed syringe.
CAR_NOT_INIT	Carousel not initialising
TOW_NOT_INIT	Tower not initialising
NO_WW_VIAL	No W/W vial present
BAD_VIAL	Invalid vial number
BAD_PORT	Invalid injection port
SLOT_NOT_FOUND	Slot not found, firmware to clarify Tower location sensor not finding slot.
NOVIAL	No vial at position xx.
BAD_SYRINGE	Invalid syringe size
BCD_ERROR	Encoder read error (reserved)
DOOR_OPEN	Encoder position err
ENC_READ_ERR	Bar Code error (reserved)
ENC_POS_FAIL	Encoder position err
BAR_READ_ERR	Bar Code error (reserved)
VIAL_SENSOR	Vial Sensor not initialising
PHASE_ERR	Phase error
BAR_ERR	Reserved for barcode reader
BAD_SLOT	Bad slot firmware to clarify Tower slot is wrong width.
BAD_VOLUME	Bad volume firmware to clarify incorrect volume for syringe.
BAD_INJECT	Bad injection firmware to clarify Injection failed.
BAD_MOTOR	Bad motor id firmware to clarify tried to move invalid motor.
BAD_COMMAND	Illegal command firmware to clarify Illegal command to autosampler

Table 5 –Formatted errors

Error code	Parameter	Error strings
ER_DEL_STEP	Single digit step number	**Can't delete oven program step** *<step number>*
ER_TPI_DEL	Single digit step number	**Cannot Delete Inlet Program Step** *<step number>*
ER_SEQ_METH	Two digit method number	**INVALID METHOD** *<method number>* IN SEQUENCE
ER_LEAK_CHK	Single digit carrier number	**Carrier** *<carrier number>* **unable to maintain pressure**
ER_SPLLEAK_CHK	Single digit split number	**Split** *<split number>* **leaking flow above max**
ER_FLAME_OUT	Single digit flame number	**FID** *<flame number>* **flame out** Press CE to continue
ER_PINLET_LOW	Single digit inlet number	**Warning: Car***<inlet number>* **Inlet < 50 Psi, Press CE**
ER_TUNEMAXLIM	-	**GC Tuning Turned Off max limit exceeded**
ER_TUNERANGLIM	-	**GC Tuning exceeds max limit. Press CE**



Electrical System 9

Clarus Interface P. C. Board Overview 9-5
RS232 Interface (Sheet 3 on the LEGO Interface Board Schematic) .9-10
Overview of the Electrical System 9-13
Power Supply 9-15
AC Distribution PC Board 9-15
Heater, Solenoid, and Fan Control 9-16
Interrupt Generation 9-16
Main PC Board 9-16
CPU 9-17
Display and Keyboard Control 9-17
Solenoid and Motor Control 9-17
AC Distribution PC Board Interface 9-18
RS232 Interface 9-18
Slave Interface 9-19
Analog Section 9-19
Connector Description List 9-20
Power On Diagnostics Bits 9-21
Interrupts 9-21
Memory Map 9-22
Autosampler PC Board 9-23
Signal Name Notation 9-23
Microprocessor 9-23
Memory 9-24
Main Board Interface 9-24
Input/Output 9-24
System Operation 9-24

Motor Control....9-25
Current Control....9-28
Block Diagram/Overview....9-29
Microprocessor....9-29
Main Board Interface....9-29
Memory....9-30
Xilinx Field Programmable Gate Array PWM Control....9-30
Analog Input / Analog to Digital Conversion....9-30
On Board Ambient Pressure Transducer....9-32
Voltage References....9-33
Pressure Modules Interface....9-34
Switching Power Supply....9-34
FID Amplifier PC Board....9-35
Polarizing Voltage....9-35
Electrometer....9-35
A/D Converter Front End Stages....9-36
Analog Signal Output....9-37
Voltage Reference....9-37
Electrometer Balance Adjustment....9-37
ECD Amplifier PC Board....9-37
Standing Current Feedback Control Loop....9-37
Frequency-to- Voltage Converter....9-38
A/D Converter Front End Stage....9-38
Analog Signal Output....9-39
Voltage Reference....9-40
TCD Amplifier PC Board....9-40
Command Decoding....9-40
Bridge Ground System....9-41
Safety Circuits....9-41
A/D Converter Front End Stage....9-42
Analog Signal Output....9-43
Voltage Reference....9-43
TCD Range Values....9-44
FPD Amplifier PC Board....9-45
High Voltage Section....9-45
Electrometer....9-45
A/D Converter Front End Stage....9-45
Analog Signal Output....9-46
Voltage Reference....9-47
NPD Amplifier PC Board....9-47
Polarizing Voltage....9-47
Electrometer....9-48
A/D Converter Front End Stages....9-48
Analog Signal Output....9-49
Voltage Reference....9-49
Bead Voltage Conversion (RMS-to-DC)....9-49
Pulse Width Modulation Control....9-50
NPD Transformer....9-50
PID Amplifier PC Board....9-51
Polarizing Voltage....9-51

Electrometer..9-51
A/D Converter Front End Stage 9-52
Analog Signal Output..9-53
Voltage Reference..9-53
Electrometer Balance Adjustment 9-53
External Amplifier PC Board...9-53
Differential Analog Input...9-54
A/D Converter Front End Stage 9-54
Analog Signal Output..9-55
Voltage Reference..9-55
Pressure Transducer PC Board...9-55
Keypad/Display...9-56
I/O PC Board...9-56
Timed Event Drivers..9-56
(Sheet 1 on the 1/0 Board Schematic)...9-56
Position Gas Sampling Valve Interface...9-57
(Sheet 2 on the 1/0 Board Schematic)...9-57
Analog Inputs 9-58
D / A & Communications 9-58
Power..9-59
Servicing the Electrical System..9-59
Accessing the PC Boards...9-59
Pressure Transducer Zero Adjustment 9-60
Pressure Transducer Span Adjustment..9-60
Removing the Pressure Transducer Board.......................................9-61
Replacing the Gate Array on the Autosampler Control PC Board.....9-61
Replacing Fuse 9-61
AC Distribution Board Fuses...9-62
TCD Power Supply Board Fuses..9-62
Autosampler Transformer Fuses...9-62
Check Resistance Values...9-63
Schematics Diagrams 9-64

Clarus Interface P. C. Board Overview

The Clarus Interface Board is a Motorola MC68332-based CPU board that provides a new user interface for the Clarus 500. The Lego Interface Board can be divided into three functional sections.

- CPU and Memory Section
- LCD Display and Touch Screen Interface
- RS232 Interface

General

The Lego Interface board is a Motorola MC68332 microprocessor based CPU board that provides a new user interface for the Clarus 500 Gas Chromatograph. The board can be divided into 3 sections: the core CPU together with its memory, LCD display and Touch Screen Interface, and the RS232 interface. Each of these sections will be discussed individually.

The display and touch screen portion of this design is based on an adaptation of the TurboMatrix Video PC Board (M0414024). Portions of the design and description are from the original system.

CPU and Memory
(Sheets 1 and 4 on the LEGO Interface Board Schematic)

The CPU section of the board consists of the MC68332 microprocessor, RAM, FLASH, Non-volatile RAM, and the necessary random logic for address decoding, reset, clock drivers, together with address and data bus buffers. These are contained on pages 1 and 4 of the Lego Interface board schematic (N650-9000). The CPU (U1) is run at a clock rate of 16.2525 MHz. The clock is generated by the MC68332's internal phase locked loop generated from a 32.768 KHz crystal (Y1).

The memory portion of the design is shown on sheet 4 of the LEGO Interface board schematic. The FLASH MEMORY (U2 & U3) are configured as 512Kx16 each, using AM29F800BB-70EC, for a total available FLASH memory of 1Mx16. This FLASH has a bottom sector boot architecture. The board layout is arranged such that two AM29F160DB75EC's could be installed in place of the AM29F800B's. Using LINK1 or LINK2 with AM29F160D's provides a hardware protected boot sector (not used with the AM29F800B's) but only half of the devices memory can be accessed since the 68332's internal chip select is limited to a 1 MegaByte range. RAM (U5, U6) use two TC554001AF-70L chips, each with 512Kx8 of storage, providing a total of 512Kx16 of static memory. U5 is connected to the lower byte of the data bus and U6 is in the upper byte. The non-volatile RAM (U4) is a Dallas Semiconductor DS1230YP providing 32Kx8 of RAM. U4 is used with a Dallas Semiconductor DS9034PC Powercap which contains an integral lithium battery good for 10 years storage. This non-volatile RAM is located on the upper 8 bits of the data bus and starts at A0, this is the configuration required by the MC68332 to allow contiguous memory access. Only the above devices directly load the microprocessor data bus.

All accesses to other devices go through a bus driver chip 74AC245 (U14) to a remote bus which is only active when communicating with those remote devices. The quad AND gate 74AC08 (U12) controls when the bus driver becomes active. This is done to reduce noise from radiating across the entire board. Interrupt handling, wait state generation, and some address decoding, are done internally to the MC68332 in its System Integration Module (SIM). The remainder of the address decoding is done with a 74AC138 (U8). The address bus is buffered with two 74AC244 devices, U7 and U9. The CPU's Power On Reset is provided by the 7705 supply-voltage supervisor, U15. A clock driver, U10, is used to buffer the 16.2525 MHz clock running between the MC68332 and the FPGA.

The MC68332 microprocessor can provide external chip selects using its internal System Integration Module (SIM). The chip selects are specified with the following parameters: the number of clock cycles required (wait states); the size of the transfer; whether the chip select is based on address strobe (AS) or data strobe (DS); and whether the transfer is a read or write. The SIM actually generates its own wait states internally, thus removing the need to generate them in external logic. The wait states are used to tell the microprocessor when a device is ready to transfer data. A MC68332 microprocessor running at 16.25 MHz is too fast to talk to some devices without wait states so they are inserted in the read or write cycle to delay the microprocessor until the other device is ready. The microprocessor is effectively idle during the wait states.

LCD Display and Touch Screen Interface (Sheet 2 on the LEGO Interface Board Schematic)

Sheet 2 on the LEGO Interface Board Schematic describes the circuitry necessary to drive the LCD display and the touch screen. This same circuitry is used on the TurboMatrix product line. The display used is a TFT Color LCD Module from NEC, part number NL3224AC35-01. This display's resolution is 320 x 240 pixels and has a 14 cm diagonal display area. The display is driven with separate RGB analog inputs and incorporates a backlight with an inverter. User input is provided for using a 4 wire touch screen interface. This touch screen also includes an RFI shielding layer to prevent radiated emissions caused by the LCD's internal inverter. Two flat cables are used to connect the LEGO Interface Board to the module containing the LCD display and touch screen. The LCD interface cable is 8 inches long to minimize radiated emissions.

The +12 Vdc that the LCD display requires for its backlight inverter and control logic is generated using a standard step-down DC/DC switching regulator, U22. The input to U22 is a filtered source of +24 Vdc, typically drawing 0.3 Amps, from the instruments main power supply. Capacitor and ferrite bead combinations are used throughout the design to minimize radiation.

An FPGA, U23, controls the interface to the video LCD circuitry. It has 3 functions; read/write signals for RAM-DAC, video LCD timing registers and the video memory interface. At startup, the CPU initializes the registers inside the FPGA to setup the required video timing for the horizontal and vertical sync. This results in a horizontal sync with a 16.0 KHz period that goes low for 4 microseconds per period and a vertical sync with a 60.6 Hz period that goes low for 185 microseconds per period. The actual video rate to the LCD is determined by the LCD_CLK and is set to half the CPU clock rate, or 8.1263 MHz. The PCLK to the RAMDAC is set to the same frequency as the LCD_CLK. The Video RAM, U24, contains the data that defines each pixel on the LCD. This data is decoded by the RAM-DAC, U19, into the actual red / green / blue video signals and their respective analog signal levels to create each pixel image. The RAMDAC contains the color palette and three 8-bit D/A converters to do this with. These D/A outputs are provided with ESD and over-voltage protection with an electronic protection array, U21. The video RAM address bus, SA0 – SA16, scrolls through the address space to provide the 8.1263 MHz video rate. As a result, each subsequent address is about half the frequency of the one before it, starting with SA0 at 4.06 MHz and ending with SA16 at 60.6 Hz. Some of the internal operation of the FPGA is described below.

FPGA LCD Timing Registers

The FPGA allows limited control over the horizontal and vertical sync signals and horizontal and vertical blanking signals. The video timing generator is accessed through two registers; An address register video_addr and a data register video_data both of which are accessed as bytes. Video_addr is at address $500810 and video_data at $500820. Video_addr is a 3 bit, write only register that selects one of the 8 timing registers. Video_data is one of the eight 8 bit registers selected by video_addr. They are write only. The eight data registers are described below. The value listed in the table is loaded into the FPGA by the MC68332 firmware at initialization.

Index	Value	Name	Description
0	$fb	HT	Horizontal total. The total number of clocks per line. The actual value is (0x100 | HT) + 1.
1	$5f	HS	HS(0:4) These lower 5 bits set the horizontal sync width MOD 32.
			HS5: Clock select. ‘0’ selects 8MHz (NEC display) and ‘1’ selects 6.4MHz (Philips display)
			HS6: Horizontal active end bit 8
			HS7: Horizontal sync polarity. ‘1’ = invert
2	$44	HAS	Horizontal active start
3	$85	HAE	Horizontal active end. Bit 8 is in HS
4	$07	VT	Vertical total. Number of lines per frame. The actual value is (0x100 | VT) + 1.
5	$ef	VE	Vertical display end. Bit 8 in VSE.
6	$f2	VSS	Vertical sync start. Bit 8 in VSE.
7	$05	VSE	VSE(0:3) Vertical sync end MOD 16
			VSE4: Not used
			VSE5: Vertical display end bit 8
			VSE6: Vertical sync start bit 8
			VSE 7: Vertical sync polarity. ‘1’ = invert

The horizontal units are clock periods. The vertical units are horizontal lines. Horizontal and Vertical in this case are with the display in landscape mode. The drawings below should help clarify the matter.

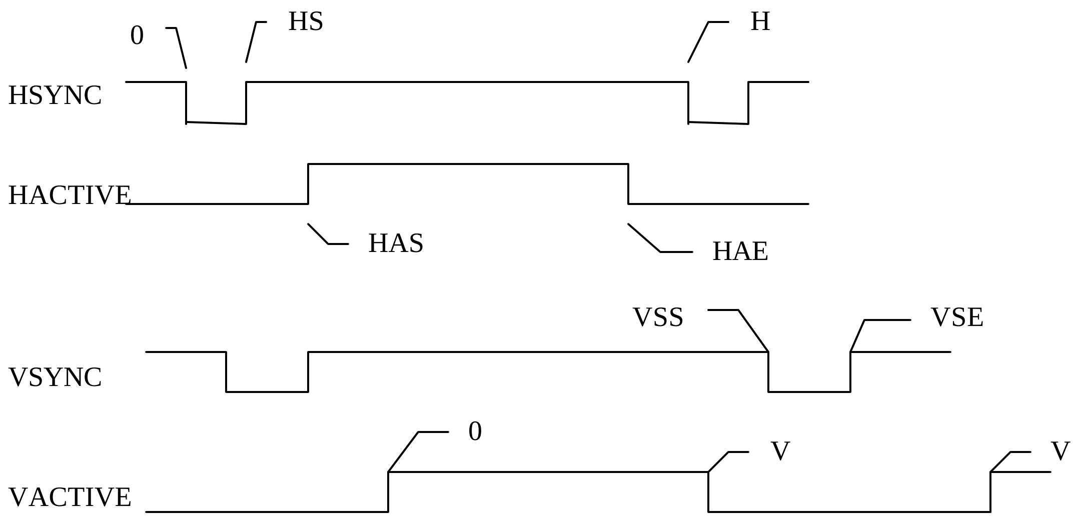


Figure 9- 1

NOTE: *The zero reference point is different for the horizontal and vertical timings.*

Video Memory

Video memory takes up 128K bytes starting at address $400000. A single 128K by 8 fast SRAM is used. Mapping between memory address and pixel address is optimized for viewing the LCD in portrait mode as indicated below. The conversion from the conventional landscape mode to portrait mode is achieved by mixing up the addresses in the FPGA.

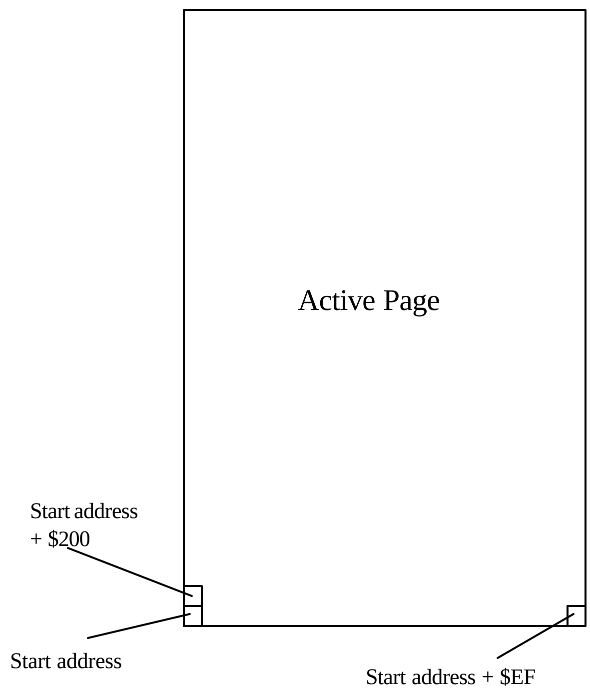


Figure 9- 2

The Start address is given by:

$$Start\_address = Video\_base\_address + \$200 * (HAS + 2)$$

The main processor is able to both read and write to the video memory. The principle of operation is to run a clock at twice the output pixel rate and to ensure that there is a transfer between RAM and the RAM-DAC every second cycle. Processor reads and writes are fitted into the other cycle. During a processor write the address and data are latched internally in the FPGA and a WRITE PENDING flag set. During the next available cycle this is transferred to RAM. This is a one wait state operation which guarantees that continuous writes are possible. During a processor read a READ PENDING flag is set. During the next available cycle the data is read from RAM into an internal latch and this made available to the processor. This is a four wait state operation.

A low cost embedded controller PIC16C72, U17, is used to interface with the 4-wire touch screen overlay. The controller is programmed to interrupt the MC68332 processor when a valid touch point has been pressed. Communications between the two processors is handled as a Master/Slave SPI interface with the MC68332 being the Master. The protocall allows for the display intensity parameter to be passed to the touch screen encoder processor at the same time as the touch point co-ordinate is transmitted. Thus, upon completion of the transfer, the embedded processor will update its' PWM duty-cycle according to the desired display intensity level. A 4 MHz crystal oscillator, U18, provides the clock for this processor. The multipoint calibration of the screen's touch position is performed in the MC68332's firmware.

RS232 Interface

(Sheet 3 on the LEGO Interface Board Schematic)

The RS232 interface is provided by a SCC2692 full duplex Dual UART (U27). The UART's timing comes from a 3.686 MHz crystal (Y1). Two MAX236CWG's (U26, U28) are used, each with 4 transceivers and 3 receivers, to provide the proper RS232 external signal levels. The external RS232 connection (J6) is filtered and goes to an external computer for instrument control by Ruby or to the GC's Internal Link accessory. The internal RS232 connection (J7) goes to the GC's Main PC Board. These are standard RS232 interfaces.

A third RS232 interface is also available for internal diagnostic use during firmware development. This interface is accessed at J9 and uses the spare transceiver / receiver channels on the MAX232's. The control over this RS232 interface comes directly from the MC68332's queued serial module (QSM) and some general purpose I/O off the MC68332.

Also shown on this schematic is the buzzer (BUZZ1) which is driven from the MC68332's TPU channel. The signal is buffered by a 74AC14 inverter and FET (Q1) switches the buzzer on and off. The nominal driving frequency for this buzzer is 2048 Hz.

The Main Power connector (J8) is also shown on this schematic.

Connector Description List

Conn	Destination	Connector Type
J1	Firmware Debug	Samtec, 2 rows x 5 position each, 0.100"
J2	Touch Screen	Berg, 4 position Header, 0.100"
J3	Video	Hirose, 2 row x 15 positions each, 1.000M
J4	PLD Programming Power	Samtec, 2 position Header, 0.100"
J5	PLD Programming	Samtec, 8 position Header, 0.100"
J6	External RS232	Ampmodu IV, 10 position Header, 0.100"
J7	Internal RS232	Ampmodu IV, 8 position Header, 0.100"
J8	Power	Molex, 2 row x 5 position each, 0.165"
J9	Firmware Internal Diagnostic RS232	Samtec, 2 rows x 5 pos each, 0.100"
TST100	+5 Volt Test Point	Bergstik II, 1 position test point
TST200	+ 24 Volt Test Point	Bergstik II, 1 position test point
TST300	Ground Reference Test Point	Bergstik II, 1 position test point

Interrupts

Level	Signal Name	Function
1		not used
2	IRQ2*	RS232 interrupt
3	IRQ3*	Touch screen interrupt
4		not used
5		not used
6		not used
7		not used

Memory Map

Signal Name	Chip Select	Address	Assign	Size (byte)	Byte	R/W	Strbe	dsack
CS_BOOT	CSBOOT*	000000 – 0fffff	16-bit	1M	both	R	AS	0wait
CS_FLASH2	FC0/CS3*	200000 – 2fffff	16-bit	1M	both	R	AS	0wait
CS_VRAM	A21/CS8*	400000 – 41ffff	8-bit	128K	upper	R/W	AS	3wait
CS_VDAC	FC2/CS5*	500000 – 5007ff	8-bit	2K	upper	R/W	AS	0wait
CS_VCTL	A22/CS9*	500800 – 500fff	8-bit	2K	upper	W	AS	0wait
CS_RAML	BR*/CS0*	600000 – 6fffff	16-bit	512K	lower	R/W	AS	0wait
CS_RAMH	BG*/CS1*	600000 – 6fffff	16-bit	512K	upper	R/W	AS	0wait
CS_NVRAM	BGACK*/CS2*	800000 – 807fff	8-bit	32K	upper	R/W	AS	0wait
CS_EXT	FC1/CS4*	900000 – 97ffff	8-bit	512K	upper	R/W	AS	2wait
CS_RS232*	FC1/CS4*	900000 – 90ffff	8-bit	64K	upper	R/W	AS	2wait
CS_TOUCH*	FC1/CS4*	910000 – 91ffff	8-bit	64	upper	R/W	AS	2wait
TP5, spare	A23/CS10*							

Overview of the Electrical System

Voltage from an AC outlet enters the instrument through the line cord. The voltage is filtered, then enters the AC Distribution PC Board. When the power switch is turned on, the AC voltage flows through the switch, then back to the AC Distribution Board, which sends swit~hed AC voltage to the Main Power Supply. The Main\Power Supply develops DC supplies of +5V, +15V, -15V, +24V, and +10V, all ofwhich are routed to the Main P.C. Board. The Main Board distributes these voltages to the on-board circuits and to the Detector Amplifier PC Board(s), the Autosampler Control PC Board, the Pressure Transducer PC Board, the instrument solenoids, and the Smart Door Stepper Motor. The Main Board also sends voltages to the AC Distribution Board for distribution to the detector, injector, and oven heaterS.

Switched AC voltage from the AC Distribution Board is also sent to the TCD Detector Transformer (if a TCD is installed). The TCD Transformer provides AC inputs to the TCD Power Supply PC Board, which generates supplies of 26VDC, +15VDC, and -15VDC. The TCD Power Supply Board sends these voltages to the TCD Detector Amplifier Board, which in turn uses these voltages to drive and control the TCD detector bridge current.

Main AC voltage flows from the AC Distribution Board to the Autosampler Motor Drive Transformer, which sends supplies of 30VDC and 12VDC to the Autosampler Control PC Board. The Motor Drive Board controls the autos ampler tower and turntable sensors and the movements of the four autos ampler motors as dictated by the control signals coming from the Autosampler Control Board. The turntable motor and sensor are connected to the Motor Drive Board directly, but the five tower sensors and three tower motors are connected via the Tower Interface PC Board, located in the autosampler tower. This board functions only as an interface between the tower sensors and motors and the Motor Drive Board.

Figure 9-3 on the next page is a simplified schematic diagram of the Clarus 500 GC electrical system. For complete schematic information, refer to the actual schematic drawings provided throughout this chapter .

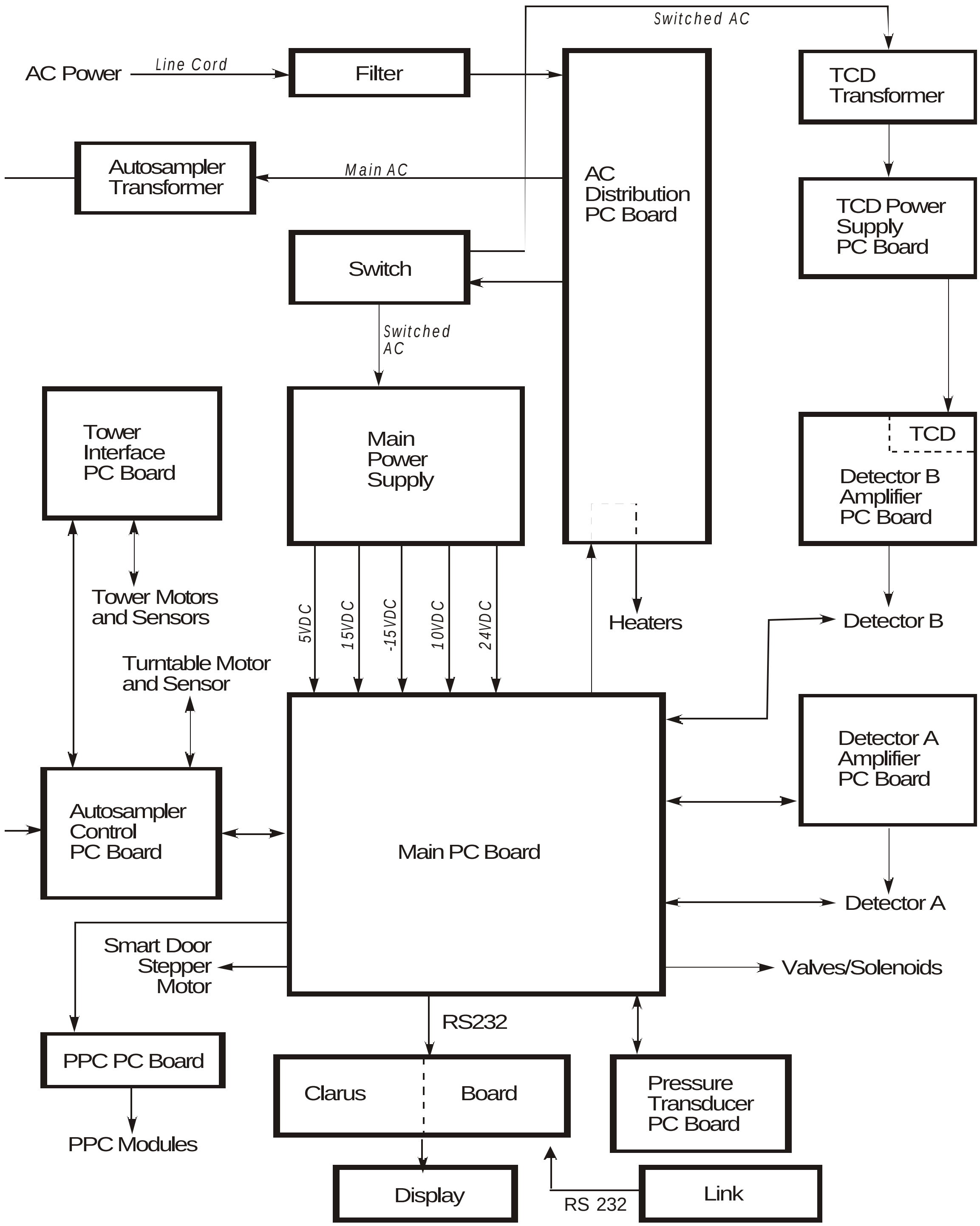


Figure 9- 3 Schematic diagram of the Clarus 500 GC electrical system

Power Supply

The triple linear power supply receives switched AC voltage from the AC Distfbution Board and generates the following regulated DC outputs:

- +24 VDC, 3.5 Amps, to power the instrument solenoids
- ±15 VDC, 1 Amp, to power the PC boards in the instrument
- +5 VDC, 6 Amps, to power the digital circuits on the PC boards.

In addition, a +10-VDC supply is generated in the ±15-V section of the power supply. This supply is generated for line sense reference voltage.

OUTPUT RIPPLE

The output ripple of the +5-V and ±15-V outputs is 5.0 mV peak-to-peak maximum. The output ripple of the +24-V output is 8.0 mV peak-to-peak maximum.

OUTPUT HOLD-UP TIME

The 5- VDC output, with a 4-Amp load, remains in regulation within 4% of nominal voltage for a minimum of 0.02 seconds (one AC cycle at 50 Hz) following an AC dropout from low line conditions. The +5.0-VDC supply has an OVP trip point of +6.2 VDC ±0.4 VDC.

POWER LINE SURGE

The power supply operates within + / -0.05% line regulation for a 10% line change and within the specified output ripple limits under power line surge test bonditions of 120% of nominal AC input (100, 120, 200, 220, or 240 V AC) for tivo line cycles (50 or 60 Hz) every ten seconds for five minutes.

POWER LINE SAG

The supply operates within 4% of nominal output voltages at 50% loads under power line sag test conditions of 80% of nominal AC input (100, 120, 200,1220, or 240 V AC) for 2.5 line cycles (50 or 60 Hz) every ten seconds for five minutes.

AC Distribution PC Board

The AC Distribution PC Board has the following functions:

- Heater, Solenoid, and Fan Control
- Interrurpt Generation

Heater, Solenoid, and Fan Control

The AC Distribution Board controls the heaters, solenoids, and fans in the instrument that use AC power. The main AC power to the AC loads, (other than power supplies), go through the main instrument relay, Kl, on the AC Distribution Board. This relay is controlled by the Main Board and has a 150-ms time out on the control signal. If this signal is not updated every

150 ms by the Main Board, the relay will turn off. and disable all the heaters, solenoids, oven fan and oven cooldown fan. This is a safety feature that prevents a possible thermal runaway if the microprocessor gets lost. The only fan that is not controlled in this way is the electronics cooling fan. The Main Board sends 5- V signals to control the solid state relays K2 -K7 on the AC Distribution Board which control the AC loads.

Interrupt Generation

The AC Distribution Board also generates an interrupt signal, which is sent to the Main Board at a rate based on the line frequency. Ul and U2 on the AC Distribution Board provide a zero crossing interrupt. An interrupt is generated every time the AC line voltage passes through O V. For example, at every 60-Hz line frequency, an interrupt is generated at a

120-Hz rate, and at every 50-Hz line frequency, an interrupt is generated at a lOO-Hz rate. This is the highest priority interrupt on the Main Board, and is used fv~ basic system timing and to control the firing of the AC solid state relays. The relays are actuated only at this interrupi to keep the voltage across the relay low when they are turned on.

Main PC Board

The Clarus 500 Main PC Board is a Motorola MC68332-based CPU .board that the handles general control and data processing of the instrument. The circuit description of the Main Board is divided into seven functional sections:

- CPU Section
- Display and Keyboard
- Solenoid and Motor Control
- AC Distribution PC Board Interface
- RS232 Interface
- Slave Interface
- Analog Section

CPU

(Sheets 11 and 2 on the Main Board Schematic)

The CPU section of the board consists of the MC68332 microprocessor, RAM , EPROM, Non-volatile RAM, and the necessary random logic for address decoding, wait state generation, interrupt control, etc. These are contained on pages 1 and 2 of the GC Clarus 500 main board schematic (N610-9270). The CPU (U8) is run at a clock rate of 16.78 MHz. The clock is generated by the MC68332's internal phase locked loop generated from a 32.768 KHz crystal. The EPROM (U46) is configured as 256Kx16 using a 27C4096 EPROM. RAM (U18, U19) uses two 628128 chips providing 128Kx16 of memory. RAM and ROM are word wide, using the fu1l16 bit data bus of the MC68332. The non-volatile RAM (U38) is a Dallas Semiconductor DS1386 providing 32Kx8 of RAM as well as a Real Time

Clock (RTC) chip with an integral battery good for 10 years storage. It is located on the upper 8 bits of the data bus and starts at AO, this is the configuration required by the MC68332 to allow contiguous memory access. Only the above devices directly load the microprocessor data bus

All accesses to other devices go through a bus driver chip (U20) to a remote bus which is only active when communicating with those remote devices. This is done to reduce noise from radiating across the entire board. Interrupt handling, wait state generation, and some address decoding, are done internally to the MC68332 in its System Integration Module (SIM). The remainder of the address decoding is done with two 74LS138's (U15 and U16).

The MC68332 microprocessor can provide external chip selects using its internal System Integration Module (SIM). The chip selects are specified with the following parameters: the number of clock cycles required (wait . states); the size of the transfer; whether the chip select is based on address strobe (AS) or data strobe (DS); and whether the transfer is a read or write. The SIM actuall)- generates its own wait states internally, thus removing the need to gf!nerate them in external logic. The wait states are used to tell the micropr(.c~ssor when a device is ready to transfer da.:a. A MC68332 microprocessor running at 16.78 :MHz is much too fast to talk to many

devices without wait states so they are inserted in the read or write cycle to delay the microprocessor until the other device is ready. The microprocessor is effectively idle during the wait states.

Solenoid and Motor Control

(Sheet 4 on the Main Board Schematic)

The main Board directly controls the smart door S1.epper motor, the timed event solenoids, and the subanlbient solenoid. The microprocessor writes the solenoid states to U30, a latch, via I/O port SOLW. From there, the signal goes to U42, a ULN2003A driver, which provides the necessary current for the coils.

The subambient solenoid is driven by an open collector signal through connector J4, which also provides +24 V and ground. These signals connect to the Subanlbient Driver PC Board, which drives the solenoid.

The smart door stepper motor is also controlled by the microprocessor directly. I/O port SDW, bits 4 to 7, sends signals to U29, where they are latched, then to U41, a ULN20069B driver, which drives the smart door. The software controls the coil sequencing. The exact sequencing required is shown below.

	A	A*	B	B*	
CW	0	1	0	1	
⇓	1	0	0	1	
	1	0	1	0	⇑
	0	1	1	0	CCW

AC Distribution PC Board Interface

(Sheet 4 on the Main Board Schematic)

The AC Distribution Board is controlled by the ACW and SOLW ports, which are connected to 7406 open collector drivers (U42 through U44). These drivers control solid state relays on the AC Distribution Board that control the heaters, the oven fan, and the oven cool down fan. If the port controlling the heaters is not written to at least once every 150 ms, a one-shot on the Main Board, U45, will reset the port, ensuring that the heaters will shut off if the microprocessor gets lost.

The main instrument relay is controlled by bit 6 of the AMUXW port. If this bit is not toggled low to high once every 150 ms, U45 will time out and turn off the relay drive provided by U42. This is the MAIN TRIG signal. Pin 1 is normally high; Pin 16 is normally low. This is also a safety feature designed to turn off the heaters if the microprocessor gets lost.

RS232 Interface

(Sheet 3 on the Main Board Schematic)

The RS 232 interface is provided by D22, a 2661 UART. The driver is a 75188 chip, U33, and the receiver is a 75189A chip, D40. These components communicate with an external device through connector J8. This is a standard RS232 interface.

Slave Interface
(Sheet 1 on the Main Board Schematic)

The Enhanced GC Clarus 500 communicates with three different slave devices. Each communication is accomplished through the Queued Serial Peripheral Interface (QSPI) which is part of the Queued Serial Module (QSM) located within the MC68332. The three slave devices are: the Enhanced Autosampler Board, the Fresh Aire I/O Board, and the Programmable Pressure Control (PPC) Board. The Enhanced Autosampler Board is controlle~ by a dedicated MC68332 microprocessor and plugs into the main board at connector J26. The Fresh Aire I/O Board is controlled by a Xilinx implemented QSPI and I/O controller, it plugs into the main board at connectors J28 and J29. The PPC Board is controlled by a dedicated MC68332 microprocessor and plugs into the main board at connector J7.

Analog Section
(Sheets 5 and 6 on the Main Board Schematic)

The analog section of the Main Board provides the AID and D/A signals necessary for the operation of the system. The digital sections of the AID and D/A converters are provided by the gate array, U1. The microprocessor determines which detectors are installed by checking the status bits provided by the detector amplifiers. The gate array, U1, has two counters for D/A converters and three for A/D converters, all with clock rates of 24.576 MHz.

The converters are dual slope integrators. The analog circuitry for the D/A outputs and the two A/D inputs from the detectors is located on the appropriate detector Amplifier Board. Analog circuitry for one A/D converter is on the Main Board. This A/D converter is multiplexed between the signals that are needed to be read. These signals include the many PRT temperatures, pressure sensors, the voltage reference. etc.

Multiplexing (or muxing) is done with an ADG506 16-channel analog multiplexing switch, taking 160 readings per second. First, the appropriate mux position is chosen, then capacitor C50 is shorted for 1.56 ms by the microprocessor driving ZEROT* low. Next, the capacitor is charged by the selected mux voltage for 1.56 ms by the microprocessor driving CHGT* low, switching on U35. Finally, the capacitor is discharged by a constant current source through R38 when gate array line DSCHGT* is low. DSCHGT* is removed when the voltage of capacitor C50 drops enough to trigger comparator U24, sending the STOPT signal low .While DSCHGT* is low, a counter in the gate array counts at 24.576 MHz. The amplitude of the voltage read through the mux is directly proportional to the value of this count. The maximum length of the DSCHGT* pulse is 2.67 ms, representing a count value of 65535 counts. If the counter overflows, a flag is set in the gate array so that the microprocessor can determine that an error has occurred. The microprocessor reads the counter value in the gate array and sets the mux to the next value required.

(Sheet 6 on the Main Board Schematic)

The D/A converters are similar, with the charge tIme of a capacitor controlled by the duration of a charge signal provided by the gate array. The value of the count for this width is determined by the software and is loaded into the gate array by the microprocessor. The gate array also provides the clock for the UART (4.9152 MHz). This section of the Main Board also provides a line voltage sense function. Pin 11 of the power connector (J1) is unregulated 10 VDC from the power supply. This is divided down and filtered (to get rid of the 50/60 Hz ripple) by resistors R26, R30, and R33, and capacitors C51 and C53. The filtered signal is then read by the A/D converter in U1, the gate array.

Connector Description List

Conn	Destination	Connector Type
J1	Power Supply	Amp Mate-N-Lok 12 pos 0.250”
J2	Keyboard	Ampmodu IV 14 pin 0.100
J3	Display	Molex 14 pin 0.100
J4	Subambient Solenoid	Molex 4 pin 0.156
J5	Amplifier 1	Amp PCB 36 pin Header
J6	Amplifier 2	Amp PCB 36 pin Header
J7	Programmable Pressure Control	Amp PCB 36 pin Header
J8	RS232	Amp 25 pin Male D-shell
J9	Pressure Transducer A	Molex 8 pin 0.100
J10	Aux B	Ampmodu IV 2 pin 0.100
J11	TE 4	Ampmodu IV 2 pin 0.100
J12	TE 2	Ampmodu IV 2 pin 0.100
J13	AC Distribution Board	3M Header 20 pin
J14	PRT - Oven	Ampmodu IV 2 pin 0.100
J15	PRT – Injector 1	Ampmodu IV 2 pin 0.100
J16	PRT - Detector	Ampmodu IV 2 pin 0.100
J17	Smart Door Stepper Motor	Ampmodu IV 2 pin 0.100
J18	Door Sensor Microswitch	Molex 8 pin 0.100
J19	Aux A	Ampmodu IV 2 pin 0.100
J20	TE 3	Ampmodu IV 2 pin 0.100
J21	TE 1	Ampmodu IV 2 pin 0.100
J22	Pressure Transducer B	Molex 8 pin 0.100
J23	PRT - Aux	Ampmodu IV 2 pin 0.100
J24	PRT – Injector 2	Ampmodu IV 2 pin 0.100
J25	PRT – Detector 2	Ampmodu IV 2 pin 0.100
J26	Autosampler	Ampmodu IV 16 pin 0.100
J27	MC68332 Background Diagnostics	Amp Series 929 2x4 pin 0.100
J28	I/O Board – Digital	Ampmodu IV 20 pin 0.100
J29	I/O Board – Analog	Ampmodu IV 12 pin 0.100
J30	Link Box	Ampmodu IV 10 pin 0.100
J31	Spare Aux	Ampmodu IV 2 pin 0.100
TB1	Customer Accessible Terminal Block	Terminal Block – 16 pin

Power On Diagnostics Bits

At bootup, the main instrument runs a series of power on diagnostics and displays the results of tests on the vacuum florescent display as a string of characters. Each test will display a "1 " for a passed test, a "0" for a failed test, and an "X" if the remote device is not found {only applicable for the -Autosampler, I/O, and PPC). Listed below are the seven diagnostic bits listed from left to right as they would appear on the display.

Bit	**Diagnostic Test**
1	Main Board RAM
2	Main Board BRAM
3	Main Board ROM
4	Main Board RS232
5	Autosampler
6	I/O Board
7	Programmable Pressure Control

Interrupts

Level	**Signal Name**	**Function**
1		Not used
2	TPU*	MC68332 TPU Interrupt
3	QSM*	MC68332 QSM Interrupt
4	COMIRQ*	RS232 interrupt
5	GAIRQ*	Gate Array interrupt request
6	ZCROSS*	Zero Cross
7		Not used

Main Board Memory Map

Signal Name	Chip Select	Address
ROMR*	CSBOOT*	000000-07FFFF
RAMLCS*	BG*/CS1*	080000-0BFFFF
RAMUCS*	BR* / CS0*	080000-0BFFFF
RB*	A19/CS6*	0C0000-OFFFFF
IOCS*	FC1/CS4*	0C0000-DFFFF
AMUXW*	FC1/CS4*	0C0xxx
CLRZCI*	FC1/CS4*	0C0xxx
SOLW*	FC1/CS4*	0C4xxx
EXR*	FC1/CS4*	0C8xxx
SDW*	FC1/CS4*	0C8xxx
ACW*	FC1/CS4*	0CCxxx
KYBDCSR*	FC1/CS4*	0D0xxx
KYBDCSW*	FC1/CS4*	0D4xxx
LCDCSW*	FC1/CS4*	0D8xxx
AUTOR*	FC1/CS4*	0D8xxx
AUTOW*	FC1/CS4*	0DCxxx
DETCSR*	FC1/CS4*	0DCxxx
DETCSW*	FC1/CS4*	0EOxxx
GACS*	FC2/CS5*	0E8xxx
COMRW*	FC0/CS3*	100000-107FFF
BRAMCS*	A22/CS9*	unused
	BGACK*/CS2*	unused
	A20/CS7*	unused
	A21/CS8*	unused
	A23/CS10*	unused

Autosampler PC Board

The Autosampler Quarter Step Control PC Board is a four-layer PC board that, controls the four stepper motors and the fail-safe brake on the autosampler tower. It also reads to the Autosampler tower sensors via the Tower Interface PC Board and has an RS232 for internal use and future enhancements.

The autosampler uses two high-cun-ent motors, each rated at 3.8 Amps per winding, to move the syringe elevator and the plunger. These motors are powered by an unregulated 30- V supply. The autos ampler also uses two low- current motors, each rated at 0.5 Amps per winding, to move the tower and the turntable. These motors are powered by an unregulated 12- V supply.

The elevator motor has an integral fail-safe brake, which engages when power is absent and disengages when power is applied. The brake prevents the elevator from falling when power is removed during a normal power- down sequence or during a power failure mode. The brake is also powered by the unregulated 30- V supply.

This circuit description is divided into the following sections:

- Microprocessor Memory
- Main Board Interface
- Input/Output
- System Operation
- Motor Control
- Cun-ent Control
- Carousel Encoder Interface
- Tower Interface P .C. Board

Signal Name Notation

An “*” (asterisk) or an "N" at the end of a signal name indicates that it is an active low signal, to cause the action to occur .Signal names that do not have an asterisk or "N" at the end of their name are assumed active high unless otherwise indicated.

Microprocessor

(Sheet 1 on the Quartzstep Control Schematic)

The Autosampler Quarter Step Control Board uses a Motorola 68332 32-bit microprocessor as its CPU. The CPU (U3) is run at a clock rate of 16.78 MHz. The clock is generated by the MC68332's internal phase locked loop generated from a 32.768 KHz crystal (Yl). The clock is also outputted on the CLKOUT pin, divided down to -500KHz and sent into the Motorola Gate Array. Once inside the gate array, further clock divisions are made for motor control and carousel encoder digital filtering.

Extensive use of the MC68332's Time Processor Unit (TPU) and Queued Serial Module (QSM) have been made for timing and communication. Chip selects and wait state timing are accomplished with the System Integration Module (SIM).

Memory
(Sheet 1 on the Quarterstep Control Schematic)

The ROM memory is provided by a 27C010 EPROM (U8) and is configured as 128K x 8 (address 0 to lFFFF hex), The RAM memory is provided by a 62256 chip (U4) and is configured as 32K x 8 (address 020000- 027FFF). The partitioning of the memory is controlled by SIM module.

Main Board Interface
(Sheet 1 on the Quarters1ep Control Schematic)

The Autosampler Quarter Step Control Board interfaces with the Clarus 500 Main Board using the QSM acting as a slave to ihe master QSM located on the main board. The Autosampler Control Board interfaces with the Main Board through Jl, a 16-pin connector that plugs directly into connector J26 on the Main Board. +5- V power is supplied by the Main Board through this same connector. Each board interrupts the other for communication, using QSM signal PCS3* for output from the Quarier Step Control Board and a TPU input as the interrupt handler on the Main Board. Each board actively acknowledges a transmission by the other. See the Main Board QSM firmware description for further details.

Input/Output
(Sheet 1 on the Quarterstep Control Schematic)

BCD coded output for the vial position is provided on JlO. The serial interface to the BCD board is accomplished with the TPU. The RS232 communications uses the Serial Peripheral Interface (SPI) which is a subsystem of the QSM. Two additional pins of the TPU create RTS and CTS, completing handshake signals. A MAX232 (UlO) is used for the transceiver. The connector used for the RS232 is a 6-pin in-line connector (J4).

System Operation
(Sheet 1 on the Quarterstep Control Schematic)

The microprocessor sends the control signals to the Moiorola gate array, Ul, for motor selection, motor direction (clockwise or counierclockwise), step rate and mode (full, half, or quarter step). The TPU is used to control the timing of the pulses that drive the stepper motor logic locaied in the gate array. The gate array then interfaces with the motor drivers connected to the motors. Through these control signals, the Autosampler can pre-wash the syringe, draw a sample and inject it, and post-wash the syringe.

The operating currents for the plunger and elevator motors depend on the mode or sequence. During the injection sequence, both of these motors run in the full step mode with 3.8 Amps per willding. This allows maximum torque for the required high speed. During the pre-wash, post-wash, and sample acquisition sequences, the plunger and elevator moiors run in the quarter step mode with 3.0 and 1.5 Amps per winding. The torque requirements are lower in these modes. This also reduces vibration and heat dissipation in the motors.

Only one motor runs at a time when the autosampler is operating. The other motors are in a hold state with a low current in each winding. For the tower and carousel motors, the holding current is 0.1 Amp per winding. For the elevator and plunger motors, the holding current is 1.5 Amps per winding. When the autosampler is not being used, all motors are disabled and the fail-safe brake is engaged.

Motor Control

(Sheets 1 through 4 on the Quarterstep Control Schematic)

figure The gate array, Ul, contains two motor controllers for the high-current motors and two motor controllers for the low-current motors. The design includes a shared four bit counter to generate the address to the look-up table, latches to maintain the present commutation state of each motor, and a delay circuit to control the drive signals to the bridges.

Each motor has two latches associated with its position. One is used to store the output of the address counter and the other is used to store the output of the look-up table. At the beginning of a step sequence for a motor, the counter is loaded with the output of the first latch. This causes the output of the look-up table to synchronize with the current state of the motor. After each step, both latches are loaded with the current data from the counter and the look-up table.

When a motor is going to be moved, it is selected by the signals MSELO, MSEL1, and MSEL2. The LOAD signal is used to load the counter with the address of the motor's present state. This address has been stored in a latch since the last movement of the motor. A signal called CCWCWN is used to control the direction of the motor's rotation. A logic high of this signal causes the counter to count up and the motor to move in a clockwise direction. A logic low causes the counter to count down and the motor to move in a counter-clockwise direction. The falling edge of the MTRCLKN signal increments or decrements the counter and the rising edge of the signal latches the output of the look-up table into a latch. Each clock pulse corresponds to a step of the motor .

The look-up table is set up as 16 bytes of data, each byte corresponding to a commutation state of the motor in a quarter step mode. The table is accessed with an increasing address for clockwise rotation and an decreasing address for counter-clockwise rotation. In the half step mode, the even addresses are accessed and the full step mode, the first, fifth, ninth, and thirteenth addresses are used. To maintain the proper current levels in the windings when changing modes, the motors are left in state 0, 4, 8, or 12. A signal called PHASE is high when the motor is in one of these states and low otherwise.

The look-up table contains the commutation sequence for driving each motor in full, half, or quarter step mode. In the fuJl step mode, both windings are on for each step of the motor. In the half step mode, each winding is off every third step. This results in the motor current alternating between one winding on (the half step position) and both windings on (the full step position). In the quarter step mode, each winding is off every seventh step. In addition, each winding is at half current one step before and one step after it is off. This results in the motor current alternating between one winding on with half current and one winding on with full current (the Quarter step position), one winding on, and both windings on.

Current Control

(Sheets 1 through 4 on the Quarterstep Control Schematic)

The motors are driven in a bipolar configuration using a full H-bridge for each winding. This allows current to flow in either direction in the winding during the stepping sequence. As described earlier, the motors are used in a two-windings-on full step mode, a half step mode and quarter step mode.

The current in the motors is controlled by a pulse width modulated chopper method. The current in each winding passes through a sense resistor (Elevator: R61, R79; Tower: R89, R90; Carousel: R94, R95; Tower: R104, R39) to create a sense voltage, which is compared to a reference voltage that is proportional to the desired current. When the sense voltage exceeds the reference voltage, the drive transistors in the H -bridge are turned off. The current in the motor winding decays through the fly back diodes until the drive transistors are turned on again. This chopper frequency is set at 31.25 KHz with a 10% duty cycle.

The current in each winding can be adjusted by varying the reference voltage for that winding. There is a voltage divider on the reference input for each winding. In each divider, there are two small FET's that are used as saturated switches to ground. When they are turned on, they change the output resistance of the divider by adding resistors in parallel. This lets up to four separate values be used for the different oper3ting modes.

Because the high-current motors cause current spikes to occur during the switching of discrete power transistors, a low pass filter is used on the sense voltage. Without the filter, the resulting voltage spikes would prematurely shut off the current in the winding. The break frequency is set at 2500 Hz. The low-current motors are powered by SGS-Thomson L298 dual full H-bridge drivers, U18 and U20. These drivers do not use a filter in the sense voltage circuit.

The full H-bridge for each high current motor winding is made up of a pair of International Rectifier IRF9530 P-Channel FET's in the upper legs and IRF530 N-channel FET's in the lower legs. The winding of the motor is connected across the legs at the junction between the FET's. Using the Plunger motor winding A as an example, positive current flows through the winding when the right P-channel FET, Q2, and the left N-channel FET, Q4, are turned on. For negative cl,lrrent flow, the left P-channel FET, Q5, and the right N-channel FET, Q3, are turned on. When the direction of the current changes, there is a delay after one set of FET's is turned off and before the next set is turned on. This delay prevents cross current flow and is performed by the gate array circuit.

The pulse-width modulated chopper that controls the current is driven by a 31.25 KHz clock created with a divide down of the 500 KHz clock coming into the gate array. The clock has a 10% low duty cycle. The clock is fed into the active low set input of a Set Reset flip-flop, internal to the gate array, one for each winding of the motor. Setting the flip-flop lets the current flow in the winding by turning on the FETs (in the Plunger example: Q2 -Q4 or Q3- Q5, depending on the direction of the current flow). The active low reset is connected to the output of a voltage comparator, whose inputs are the sense voltage and the reference voltage for that winding. When the current in the winding is below the reference value, the output of the comparator is high. When the current in the winding exceeds the reference value, the comparator output goes low, resetting the flip-flop. The current in the winding is inhibited by enabling the other P-channel FET (Q5 or Q2). This causes both N-channel FET's to turn off. The current in the winding decays slowly as it circulates through the first P-channel FET and fly back diode of the second FET. When the next oscillator pulse sets the flip-flop, the second P-channel FET is turned on. The result is a current in the winding whose peak value corresponds to the reference value with an average value that is slightly less.

The control signals to the FETs are passed through a delay circuit which prevents the P-channel and N-channel FETs on the same side of the bridge from turning on at the same time. The active FET is turned off immediately and the inactive FET is turned on two DELAY-CLK pulses (2 psec) later in ASIC. The output signals to the FETs are active low as they exit the delay circuit. They are inverted by a 7406 open collector inverter. The signal for the P-channel FET drives the gate of a VQ1000 *FET* (U28, U29, U30, and U31), through a voltage divider pulled up to V (+5V). When the input to the inverter is low, the high output turns on the small FET. This pulls a 30- V voltage divider to ground, causing the output to go to 20 V. The output of this divider is connected to the gate of the P-channel FET. Since the source of the FET is tied to 30 V, the FET is on when the gate is at 20V, or -10 V Vgs. If the 30 V is present in the absence of the 5 V, the gate of the VQ1000 is held low and P-channel FET is forced off.

Carousel Encoder Interface

(Sheet 3 on the Quarterstep Control Schematic)

The carousel tray has an incremental quadrature encoder to give its position. The outputs of the encoder are fed into the ASIC to decode the motions of the carousel. The decoding is performed with a 16 bit binary up down state counter with a serial output. Schmitt triggered TTL inputs and a 3 bit digital delay filter allow reliable operation in noisy environments and prevents errors from the encoder outputs due to a cogging effect present when used with stepper motors.

The architecture of the quadrature decoder uses a 3 bit digital filter for each of the two encoder inputs ENA and ENB. Each input is filtered at a a rate of Sl.25 KHz per bit (dived by 16 of the input clock @ 500 KHz). This filtering rejects the short duration noise pulses that cause input logic levels to momentarily change. For each channel, ift the input level has had the same value on three consecutive rising clock edges, that value becomes the new output of the filter, otherwise the output remains unchanged.

These filtered quadrature data lines are then fed into a quadrature decoder which outputs both clock pulses and count direction to a 16 bit up down counter. A low on the SLN input causes the counter data to be loaded in parallel to a 16 bit shift register. After the data has been loaded, each rising edge of the input SCLK shift clock will shift one bit of data out on pin SO. Clocking the SCLK 16 times will output all of the data. If the input ENCLDN (encoder load) is low and the motor select lines are set to: MSELO = 1, MSELl = 1, and MSEL2 = 0, the 16 bit counter can be preloaded to 7FFF hexadecimal.

Tower IInterface PC Board

(Sheet 3 on the Quarterstep Control Schematic)

The Tower Interface PC Board, located in the Autosampler tower, provides an interface between the Motor Drive Board and the three motors and five sensors in the Autosampler tower. This is its only function.

Conn	Destination	Connector Type
J1	Main Board Communications & Power	Ampmodu IV 16 pin 0.100
J2	MC68332 Background diagnostics	Amp Series 929 2x4 pin 0.100
J3	Autosampler Tranformer	Amp Mate-N-Lok 6 pos 0.250
J4	Diagnostics RS232	Ampmodu IV 6 pin 0.100
J5	TOWER MOTOR POWER	Amp Mate-N-Lok 15 pos 0.250
J6	Carousel Motor Power	Amp Mate-N-Lok 4 pos 0.250
J7	Carousel Encoder & Optical Switch	Molex 15 pin 0.100
J8	Tower Optical Switches	Molex 8 pin 0.100
J9	Tower Optical Switches	Molex 10 pin 0.100
J10	BCD Readout	Molex 10 pin 0.100

The Programmable Pressure Control (PPC) PC Board is an accessory board for the Clarus 500 Gas Chromatograph. It performs pressure and temperature compensated flow control of carrier and support gases. It supports twelve external modules in all, where any of the twelve can be configured for pressure control, while only the first eight can be configured for temperature compensated pressure or flow control.

There are currently four types of modules which can be connected to the PPC Controller board. All four modules are derived from four different manifolds and two different Pressure Transducer Boards. The four modules are: Temperature Compensated Flow Control Module, Temperature Compensated Pressure Control Module, Split/Vent Pressure Control Module, and Head Pressure Readout Module. Most of the pressure and flow modules reside on the back of the Clarus 500 behind the oven fan where the carrier and support gases enter the instrument, while a split vent pressure modules reside adjacent to each injector.

Design Specification

- # Valves Controlled = 12
- The maximum number of proportional valves to be controlled
- Valve start of PWM Frequency = 8.192 Khz
- Manufacturer's recommendation of 8 KHz or greater
- Electronic Control Frequency = 4.096 Khz
- The maximum control rate the electronics can vary the PWM width.
- Valve Control Resolution = 15 bits
- Achieved by 11 bits 8.192 KHz with four additional bits summed in hardware to PWM, the four least significant bits giving an effective resolution of 15 bits (8.192 KHz /11 bits /4 bits) at a control rate of 512 Hz
- Valve Readback Frequency = 340 Hz
- The rate the microprocessor will read the AID for a specific valve as scheduled by the firmware (4.096 Irnz * 4 states for each valve /96 states in the multiplexor readback sequence)
- Valve Control Frequency = 170 Hz
- The rate the microprocessor will update the Electronic Control Frequency for any specific valve.
- Temperature / Voltage Readback Frequency = 43 Hz
- The rate as which the microprocessor will read the temperature or voltage reference (4.096 KHz * 1 state for each sensor /96 states in the multiplexor readback sequence)
- A/D Readback Frequency = 8.192 KHz
- The rate that the firmware will read a specific analog channel. Each channel is read twice in a row and averaged giving a frequency of 4.096 KHz per read.
- A/D resolution = 16 bits
- The bit resolution for any analog channel (pressure, temperature, voltage reference).
- Figure PPC block diagram

Block Diagram/Overview

The PPC Board uses a Motorola MC68332 microprocessor (U101). 256K x 16 of ROM (U201) and 128K x 16 of RAM (U202 and U203) are provided. The CPU's clock is outputted to the Xilinx 3090A Field Programmable Gate Array (FPGA). Inside the gate array, twelve channels of pulse width modulated (PWM) proportional valve control logic are created. The output of each PWM channel drives a proportional valve located within a PPC Module. Each module also contains up to two pressure transducer boards. The pressure transducer boards output the pressures to a 32-channel analog multiplexor. The signal is then conditioned with a gain stage and is then converted to 16-bits digital. The serialized digital data is converted to parallel data with the FPGA and is read back by the microprocessor. The +16V required for the valves is created by a switching regulator off the +24V supply.

The PPC Board is a six-layer through hole printed circuit board. When laying it out, noise and EMI concerns were heavily considered. Four separate ground planes and three separate +5V planes were utilized. To reduce digital noise on the analog signals, separate digital (GND1) and analog (GND2B-A) ground planes were provided. To reduce EMI emissions, both the Motorola MC68332 microprocessor and the FPGA each have their own isolated +5V planes which are connected to the main +5V through Murata EMI filters. To reduce EMI susceptibility, a separate analog ground (GND2B-B) exists only under the connectors which go to the remote PPC Modules. It is tied to the main analog ground (GND2B-A) through an EMI filter. Additionally, all connections between the PPC Controller and the PPC Modules have been filtered with EMI filters and 100 pF capacitors to reject high frequency noise. A fourth ground plane (GND3) contains the +24V and +16V switching supply return to keep supply and valve noise separate from the other grounds.

Microprocessor

(Sheet 1 on the Programmable Pressure Control Schematic)

The Programmable Pressure Control Board uses a Motorola MC68332 32-bit microprocessor as its CPU. The CPU (U101) is run at a clock rate of 16.78 MHz. The clock is generated by the MC68332's internal phase locked loop based on a 32.768 KHz crystal (Y101). The clock is outputted on the CLKOUT pin, and sent into the FPGA The MC68332's Time Processor Unit (TPU) is used for timing, edge detection, and bit I/O. The MC68332's Queued Serial Module (QSM) is used for communication with the main instrument. Chip selects and wait state timing are accomplished with the MC68332's System Integration Module (SIM).

Main Board Interface

(Sheet 1 on the Programmable Pressure Control Schematic)

The PPC Board interfaces with the Clarus 500 Main Board through P7, a 36-pin connector that plugs directly into connector J7 on the Main Board. +5V, ±15V, and +24V are supplied by the Main Board. The two boards communicate using the QSM. The PPC is a slave controller to the master controller located on the Main Board. Either board can requests communications from the other using its QSM signal PCS3* to interrupt the other on a TPU port. When the other is ready to respond, it also asserts its PCS3* as an acknowledgment. Only the Main Board Master determines when the actual data will be transmitted. See the Main Board QSM firmware description for further details.

Memory
(Sheet 2 on the Programmable Pressure Control Schematic)

The ROM memory is provided by a UV EPROM. A single 27C4096 EPROM (U201) was provided for the firmware and is configured as 256K x 16 (address O to 7FFFF hex), allowing for down grades to the 27C2048 (128Kx16) or the 27C1024 (64Kx16) without any board changes. A jumper was provided on the ROMCS* line to aid in ATE testing. The RAM memory is provided by two 628128 chip (U202 and U203) and is configured as 128K x 16 (address 080000-09FFFF). The RAM may also be down graded to two 62256 chips (32Kx16 total). The partitioning of the memory is controlled by SIM module.

Xilinx Field Programmable Gate Array PWM Control
(Sheet 3 on the Programmable Pressure Control Schematic)

The microprocessor sends the control and data signals to the FPGA (U301), for 12 channels of independent PWM and address selection for one of 32 analog multiplexer channels. The 16.78 MHz clock is divided down for PWM, A/D conversion, and interrupts. Additionally, the A/D serial output is converted to 16-bit parallel data and read out by the microprocessor. The FPGA also double buffers the current analog multiplexor address to ensure repeatable hold setup and hold times into the A/D. The output of the 12 PWM channels are fed into ULN2003A drivers (U304 and U305) which in turn drive proportional valves. Since the ULN2003A's inputs have a 12.9KΩ series resistance between the input and ground within them, external pull downs are not necessary on the unused input pins.

Inside the FPGA, the PWM is accomplished with a single 12-bit free running counter based on the 16.78 MHz CPU clock and 12 PWM channels. Each PWM channel is made up of an 11-bit compare register, an 11-bit comparitor, a 4-bit adder including a 4-bit compare register and a 4-bit sum register, and adder carry modulation logic. Once every rollover of the 12-bit counter (4.096 KHz/cycle), the microprocessor loads a 15-bit value into the PWM logic to control the pulse-duration. It's load is double buffered, where the microprocessor loads the value into the first buffer, and the hardware loads the value into the compare registers. This ensures the pulse always starts at precisely the same time. The 11 most significant bits are loaded into the l1-bit compare register and the least four significant bits are loaded into the 4-bit compare register associated with the adder. To create the PWM pulse, the 12-bit free running counter sets the adder carry modulation logic high when its count is 0 or 800 hex (8.192 KHz/cycle). The adder then adds the output of the four bit compare register with the 4-bit sum register (initially reset to zero) and latches the sum into the sum register. The first 11 bits of the counter are then compared with the 11-bit compare register, when they are equal, the PWM output returns low. If the adder overflowed, the output of the PWM is extended by one clock cycle in the adder carry modulation thus giving an effective 15 bits of resolution at 512 Hz (8.192 MHz /16 bits). Although the carry bit of the adder register is reset, the contents of the 4-bit adder are not cleared. When the counter reaches 8000 hex, the pulse cycle starts all over including another adder cycle but the 15- bit control word is reused.

Analog Input / Analog to Digital Conversion
(Sheet 4 on the Programmable Pressure Control Schematic)

Thirty-two channels of analog data are brought into a pair of 16-channel ADG506 analog multiplexers (U401 and U402). The output of the muxes are clamped on the positive side to +4.3V and clamped on the negative side to about -2V. The negative value will not hurt the AID because the AID is capable of running in a bipolar mode with a range of +/- the 4.5 V reference voltage. The positive rail is clamped to +3.3V through a lN4148 switching diode (CR402). The +3.3V is created using a 1N5226B 3.3V zener diode (CR401) and two resistors (R402 & R403). The two resistors force 20 mA of current through the zener diode to guarantee a 3.3V zener voltage. The output of the muxes are also clamped on the negative side to about -3V using similar circuitry (CR403, CR405, & R401). However, the larger resistor value allows only 12 mA of current pass through the zener diode giving about -3V zener voltage.

Additionally, to identify different hardware configurations, circuitry is provided to identify the presence of analog signals from each of the twelve modules. The customer can have up to 12 modules in the instrument, and each module may be pressure only (PAx only), temperature compensated pressure *(*PAx and Tx), or flow (PAx, PBx, and Tx). The identification is implemented under firmware control using the IDENT* control line. By forcing IDENT* low, the 2N5086 PNP transistor (U405) turns on providing the correct V_{GS} to turn on the Jl13 NJFET (U406). When on, the NJFET connects the multiplexed signal to -3V from the zener diode (CR405) through a 100KΩ resistor (R410). If a module is present, the opamp in the module will be able to continue to drive the signal to the *ND* (with a slight offset), however, if a module is not present, the signal will be negative, causing the A/D to read zero counts, indicating no signal present, thus telling the microprocessor the hardware configuration. When in normal mode, the IDENT* line remains high, shutting off the very low leakage NJFET (< 1 nA).

The signal is then feed into an AD712 opamp (404B) with a gain of + 1.124 and an offset of 0.496 volts using 0.1 %, 15 ppm/°C resistors. The offset is provided to ensure that a pressure reading of zero psi would generate a non zero A/D count allowing the pressure transducer to be zeroed in firmware.

The A/D used is a Crystal Semiconductor CS5102A 16-bit 20 KHz converter. It provides + /- 0.001% nonlinearity over full scale. The conversion mode used is the Synchronous Self Clocking Mode (SSC). In this mode, the FPGA provides a 1.678 MHz clock to the A/D and the FPGA initiates a conversion every 8.192 KHz by pulsing the HOLD* signal low. Six A/D clock cycles into the conversion, the *ND* sets the SDL line low and then sends out the converted 16-bit serial data and 16 clock pulses concurrently to the FPGA at a 1/4 of the A/D clock rate. Inside the FPGA, the serial data will be converted to parallel data. At the end of the cycle, SDL returns high interrupting the microprocessor that the conversion is complete, and the parallel data can now be read.

Table

MUX Addr	**Signal**	**Description**
00	T0	Module 1 Temperature
01	T1	Module 2 Temperature
02	T2	Module 3 Temperature
03	T3	Module 4 Temperature
04	T4	Module 5 Temperature
05	T5	Module 6 Temperature
06	T6	Module 7 Temperature
07	T7	Module 8 Temperature
08	PB4	Module 5 Secondary Pressure Transducer
09	PB5	Module 6 Secondary Pressure Transducer
0A	PB6	Module 7 Secondary Pressure Transducer
0B	PB7	Module 8 Secondary Pressure Transducer
0C	PRESS-ABS	Absolute Pressure Transducer

0D	PSV	+16V Switching Power Supply
0E	LHREF	Voltage division of HREF (+10V) and LREF (+6V)
0F	GND2B-A	Ground reference
10	PA0	Module 1 Primary Pressure Transducer
11	PA1	Module 2 Primary Pressure Transducer
12	PA2	Module 3 Primary Pressure Transducer
13	PA3	Module 4 Primary Pressure Transducer
14	PA4	Module 5 Primary Pressure Transducer
15	PA5	Module 6 Primary Pressure Transducer
16	PA6	Module 7 Primary Pressure Transducer
17	PA7	Module 8 Primary Pressure Transducer
18	PA8	Module 9 Primary Pressure Transducer
19	PA9	Module 10 Primary Pressure Transducer
1A	PA10	Module 11 Primary Pressure Transducer
1B	PA11	Module 12 Primary Pressure Transducer
1C	PB0	Module 1 Secondary Pressure Transducer
1D	PB1	Module 2 Secondary Pressure Transducer
1E	PB2	Module 3 Secondary Pressure Transducer
1F	PB3	Module 4 Secondary Pressure Transducer

Table

Signal Type	**Minimum**	**Maximum**
Differential Pressure	- 12 psid	100 psid
Absolute Pressure	0 psia	15 psia
Temperature	0ºC	70ºC

On Board Ambient Pressure Transducer

(Sheet 5 on the Programmable Pressure Control Schematic)

The pressure transducer is the heart of the PPC system. Two types are used in this system. A single 15 psi absolute pressure transducer is used to compensate for barometric pressure changes and is located on the PPC Controller board. All PPC modules use 100 psi differential pressure transducers. All of the pressure transducers are specified to have a 1% error in interchangeability.

The transducer requires 1.5 mA of current. The transducer bridge impedance is between 2.5KÙ and 6KÙ, therefore, anyone element is also 2.5KÙ to 6KÙ. Given that 0.75 mA of current flows through either leg of the bridge, the voltage range at the input to the top of the bridge will be between 1.875V and 4.50V.

Therefore, to develop a precision current source that can supply 1.5 mA of current, two voltage references and a precision resistor were used. A +10V reference was chosen because ofits ease to create using an AD587 (U601). The +10V is buffered through an OP400 (U501A) and then fed through a 2.667KÙ 0.1 %, 5 ppm/°C resistor (R501). The second reference of+6V is connected to the output ofR501 causing a 4V drop across the resistor thus creating the 1.5 mA of current. The J176 PJFET (Q501) provides the constant current source to the bridge by operating in its linear range to create the source. Since its $V_{GS(off)}$ is between IV minimum to 4V maximum, and its $V_{GS(on)}$ is OV, the +6V was chosen so that V_{GS} could be drive between OV and +4V without saturating the OP400. The center of the left side of the bridge is referenced to ground through the opamp (U501C), forcing the bottom of the bridge to inversely track the input voltage of the bridge. Since the side of the bridge is referenced to ground, the right side of the bridge will also be referenced to ground eliminating the need to subtract any offsets from the output except for the zero offset error.

The output of the transducer is fed into a non-inverting opamp U501D. The input gain resistor on the negative input is provided by the transducer's on-board compensation resistor. The feedback resistor is a 200KÙ 0.1 %,5 ppm/°C resistor (R506). When the transducer is configured in the circuit as shown on sheet 5, the manufacturer guarantees that when a full scale pressure signal appears across the bridge, the output of the circuit will be 3.012V ±1 %. The output then drives 200Ù and a 0.1µF capacitor as is done on the external pressure transducer boards to avoid any impedance differences between this circuit and the others.

Voltage References

(Sheet 6 on the Programmable Pressure Control Schematic)

The references are all based on an AD587 +10V reference. From the ± l0V reference, +6V, +4.5V, +5.2V (+VA & +VD), and -5.2V (-VA & -VD) were created. To ensure a ratiometric output on all reference voltages, a voltage divider with multiple taps was created using a precision 2K resistor pack with 0.1% absolute tolerance, 0.1% ratio tolerance between resistors, 50 ppm/°C absolute TCR, and a 5 ppm/°C ratio TCR.

The +10V reference is just the output of the AD587 buffered through an OP400 (U602A). To create the +6V reference, the +6V tap of the resistor pack divider was also buffered through an OP400 (U602B). These two references are used with the on-board absolute pressure transducer and the remote differential pressure transducer modules. Because these references are sent out remotely (they can connect to up to 20 pressure transducer boards), they have a chance of being shorted out, so both references are monitored by the microprocessor. This is accomplished by creating a voltage divider using both references and reading its output into A/D channel 14_{10}.

To generate a precision 4.5V reference for the A/D, the +4V tap of the resistor pack divider is fed into the positive side of a non-inverting opamp using the second half of an AD712 (U404). A low drift low error gain of 1.125 is created using one of the 2K resistors (RA601H) from the resistor pack, along with a 249 . 0.1 %, 15 ppm/°C resistor (R603). The output filtering is the A/D manufacturer's recommended configuration.

To generate precision +VA, + VD, -VA and -VD, references for the A/D, the +4V tap of the resistor network is first buffered using U602C. Its output (+4VB) is then fed into a voltage divider which controls the adjustment pin of an LM317T positive adjustable voltage regulator (U604) to create +5.2V (+V A and + VD). The +4 VB is also inverted using two of the 2K resistors from the resistor pack (RA601F & RA601G) and another OP400 (U602D). The opamp's output is fed into a voltage divider which controls the adjustment pin of an LM337T negative adjustable voltage regulator (U605) io create -5.2V (-VA and -VD). For best dynamic signal to noise, the A/D manufacturer's recommends the capacitor coupling and 10.0. series resistor between V_A and V_D as shown on sheet 6.

Pressure Modules Interface

(Sheet 7 on the Programmable Pressure Control Schematic)

The connections to the 12 modules are provided on this sheet. Each module has the +16V for the valve power, DA*x* (16V return for the valve) with the fly back diode, ±15V, +10V, +6V, and analog input PRESSA*x* (the primary pressure readout). The first eight channels also have analog inputs for PRESSB*x* (the secondary pressure readout for flow control). and TEMP*x* (the thermistor temperature readout). To reduce EMI susceptibility, a separate analog ground (GND2B-B) exists under the connectors which go to the PPC Modules. It is tied to the main analog ground (GND2B-A) through an EMI filter. Additionally, all connections between the PPC Controller and the PPC Modules have been filtered with EMI filters and 100 pF capacitors to reject high frequency noise.

Switching Power Supply

(Sheet 8 on the Programmable Pressure Control Schematic)

A + 16V power supply was required to drive up to 12 proportional valves. Each valve is 80 , thus requiring 2.4A. To provide this power, +24V from the main instrument power supply (modified for increased current capacity) is regulated down to +16V using an LM2576T-ADJ adjustable switching regulator (U801). The regulator has a fixed switching frequency of 52 KHz. RB01 and RB02 act as a voltage divider feedback to the regulator which maintains the output voltage. The regulator can be turned on or off by the microprocessor via the PS-EN* signal and is not turned on until after the main instrument is up and running, this prevents a potentially heavy load on the +24V while the main instrument relay is being turned on. Additionally, the +16V output is monitored by the microprocessor using a voltage divider created by RB03 and RB04 via analog channel 13_{10}. If the output is overloaded due to a short in the harness, the microprocessor will detect this, shut down the supply, and inform the user of the problem.

Table

Conn	Destination	Connector Types
P7	Main Board Communications & pwr	Amp PCB 36 pos 1.000” Str Skt
J2	MC68332 Background diagnositics	Amp Series 929 2x4 pin 1.000”
J10	CGS/SGC Module 0	Ampmodu IV 10 pos 1.000” Str Skt
J11	CGS/SGC Module 1	Ampmodu IV 10 pos 1.000” Str Skt
J12	CGS/SGC Module 2	Ampmodu IV 10 pos 1.000” Str Skt
J13	CGS/SGC Module 3	Ampmodu IV 10 pos 1.000” Str Skt
J14	CGS/SGC Module 4	Ampmodu IV 10 pos 1.000” Str Skt
J15	CGS/SGC Module 5	Ampmodu IV 10 pos 1.000” Str Skt
J16	CGS/SGC Module 6	Ampmodu IV 10 pos 1.000” Str Skt
J17	CGS/SGC Module 7	Ampmodu IV 10 pos 1.000” Str Skt
J18	SGC Module 8	Ampmodu IV 10 pos 1.000” Str Skt
J19	SGC Module 9	Ampmodu IV 10 pos 1.000” Str Skt
J20	SGC Module 10	Ampmodu IV 10 pos 1.000” Str Skt
J21	SGC Module 11	Ampmodu IV 10 pos 1.000” Str Skt

FID Amplifier PC Board

The circuit description for the Fill Amplifier Board is divided into the following sections:

- Polarizing Voltage
- Electrometer
- A/D Converter Front End Stage
- Analog Signal Output
- Voltage Reference

Polarizing Voltage

The -200 VDC polarizing voltage for the FID is generated on the FID Amplifier Board. An oscillator circuit comprised of Tl, Q5, Q6, and resistors R13-R16 provides a high voltage, low current secondary signal on the transformer TI by alternately driving Q5 and Q6 into full conduction, saturating the transformer. The frequency of operation is approximately 10 KHz.

The secondary voltage at TI is doubled by capacitors C2 and C4 and rectifiers CR3 and CR4, yielding approximately -240 VDC at the anode of CR3. Pass transistor Q2 supplies the output voltage while operating at a constant current of 0.75 ma regulated by CR6, CR8, R5, and R4. Diode CR10 sets the output voltage at -200 VDC. This voltage is routed to relay K5, which is used to select either -200 VDC or ground at the polarizing voltage connection point E1, depending on the operating mode when using this amplifier with an NPD detector. The voltage is also sent through connector Jl to the NPD power supply to float the supply at -200 VDC.

A voltage doubling circuit using CRl, CR2, Cl, and C3 generates +240 V at the cathode of CRl. This voltage is used to generate the +l00 VDC needed by the electrometer. Pass transistors Q3 and Q4 provide ±100 VDC via the regulation of CR11 and R5, and CRl2 and R6.

Electrometer

The current signal supplied by the FID collector is applied to the inverting input of amplifier U2 via R54. A feedback loop is closed around U2, Q50, and Q51 with precision resistors R53 and R52. With R53 equal to 4 gigohms, 80 VDC is produced at the collector of Q51 for an FID collector current of -20 nanoamperes. This is the nominal full scale range of the FID detector.

Relay K4 is driven by Q52, U106-110, R51, and R50, and is used to decrease the sensitivity of the electrometer by parallp~ing resistor R52, which has a value of 200 megohms. The 80 VDC at the collt:ctor of Q51 corresponds to an Fill collector current of -420 nanoamperes, a decrease in sensitivity of x21.

The electrometer output is scaled by xO.1 via Rl19 and R120, then buffered by Ul05. This provides a nominal 0-to-8-V output to the AID converter front end stage. The time constant of the buffer siage is 20 ms. The break frequency of 8 Hz is one-tenth the conversion period.

A/D Converter Front End Stages

Dual slope analog to digital conversion is performed by a combination of functions on the FID Amplifier Board and the Main Board. On the Amplifier Board, U103 integrates the buffered signal from U105. Resistors R126 and R127 set the charging current for Cl09 as a function of the applied voltage. (Assume that Cl09 has changed to some value during the sample acquisition portion of the conversion cycle.)

The Main Board applies and active low discharge, DSCHG*, every 12.5 ms (80 Hz) to the circuit to discharge Cl09. This signal remains low until the Main Board senses a stop discharge output, STOP*, from the amplifier. The time period from the falling edge of DSCHG* to STOP* is measured by the Main Board. This measurement is the raw digital output of the converter.

Capacitor C109 is discharged through CR23 by a 0.5-mA constant current sink formed by Ql02, U101 (C), and R123. During the charge portion of the cycle when DSCHG* is high, the demanded current is satisfied via CR22 and network Rl05, Rl06, Rl07, and Ul06-6. During this time, CR23 is back-biased since the voltage at its cathode is approximately +1.4 V. When DSCHG* becomes active, the bias network pulls the anode of CR23 down to -2.0 V. This back-biases the diode, forward-biases CR23, and causes C109 to discharge at a constant rate. Resistor network Rl14, R115, and Rl16 supplies a continuous positive bias current, approximately 250 nA to the integrator. The bias compensates for any slight negative drift that may occur in the detector or amplifier under zero signal conditions.

During the charge:

- the voltage developed across C109 = VU1-6 /40K + the bias current through R115.

During the discharge

- the discharge rate = I_{CR22} – V_{U1-6} /40K -the bias current. Discharge time as a function of V_{U1-6} is linear.

Capacitor Cl09 is sized to use the full negative output ofU103 without its output saturating during the 12.5-ms conversion period.

Because of the high resolution requirement for the converter, it is essential that no time ambiguity occur between the discharge of the integrator through zero and the removal of the active low DSCHG* signal. The positive is amplified by UlOl (D) going ramp at UlO3-6 as it passes through zero. The amplified signal is applied to comparator UlO2, which is referenced to 0 V. The high gain of the circuit insures that virtually no uncertainty occurs relative to the period of the Main Board's 24.576-MHz clock (used to measure DSCHG*) from UlO3-6 crossing zero to STOP* (U103-7) going low. R129, CR25, and CR26 are used to limit the output swing of U103 to between 0.6 and -10.6 V. This is the bias voltage from CR26.

Analog Signal Output

An analog output signal, ANALOG, is provided at P1- P12 to drive either an external recorder directly or an integrator (after further signal processing on the Main board). A 640-Hz digital digital pulse train from the Main Board (DAOUT) is applied a three-pole low-pass filter on the NPD Amplifier Board. The pulse width ofDAOUT is a function of the discharge time ofC109 and is determined by the Main Board. When zero input voltage is applied to R126, the integrator bias current (via R115) results in a DAOUT low pulse width of 1.5 ~ each period. When 8 V is applied, the DAOUT low pulse width is approximately 1.3 ms (provided the instrument is configured for Integrator output, Attn. X64, A/Z Off, and 0% offset).

The analog output signal is driven through CR20 by a 1.17 -mA constant current sink comprising Q101, U101 (A), and R124. When CR20 is conducting (corresponding to the low portion of DAOUT), the output of U104 goes positive. The maximum output of CR20 always conducting is 11.7 V. During the high portion of each DAOUT period, CR20 is back-biased and CR21 provides the demanded current. A network comprising of R104, R102, R103, and U106-2 sets up the proper bias levels for CR20 and CR21. The output of U104 is attenuated by a factor of 10 and becomes the ANALOG signal.

Voltage Reference

A +10-V reference source from the Main Board, +10V REF, is used to generate the current sinks. The -5 and -10 V used by the current sink circuits are provided by U101(A) and RA10.

Electrometer Balance Adjustment

The FID Amplifier Board has a trimpot (R59), which can be adjusted to balance the electrometer output. This is normally done in Electronic Test. To adjust this trimpot, first powerup the FIDA for five minutes. Then short E8 to TP9 and adjust R59 (in the center of FIDA can) until the voltage read at TPB is zero ±10 mV with respect to ground (TP4). Note that the center conductor of the coax cable is E8 and its shield is ground.

ECD Amplifier PC Board

The circuit description of the ECD Amplifier Board is divided into the following sections:

- Standing Current Feedback Control Loop
- Frequency-to- Voltage Co-nverter
- A/D Converter Front End Stage
- Analog Signal Output
- Voltage Reference

Standing Current Feedback Control Loop

The standing current is set directly by resistors R17 and R18, and indirectly by resistors R30 and R31. These resistors set a voltage drop of 3 V across R19. One end of R19 (TPI6) is at 2 V while the other end

(E12) assumes -1.0 V, since Pin 2 of U4 reflects the -1.0 V set at Pin 3. This is tied to the -15-V supply. The resulting bias current through R19 is therefore 0.75 nA The total standing current resulting from the detector current and the bias current is monitored through R20 at the inverting input of U4. Under normal conditions, with only carrier gas flowing through the detector cell, a reference level standing current is established at the input of U4. The integrator produces an output voltage which is applied to a voltage to frequency converter, U3, via R12 and R13. The voltage at TP15 is nominally -3.1 V referenced to ground. If the signal applied to U3 becomes more negative, U3's output frequency will increase; if the signal becomes less negative, U3's output frequency will decrease.

The square wave output of U3 is applied to a retriggerable one-shot, U2, which produces a nominal one-microsecond pulse for each negative transition at its input. The output of U2 drives FET Ql, which in turn drives the primary winding of pulse transformer T1 via resistors R4 and R5. The wave for: at TP12 is a -15-V pulse lasting 1 µs. The circuitry associated with U3 and U2 is all referenced to -15 V to accommodate the negative output of the integrator, U4.

The secondary winding of the pulse transformer (T1), is connected to the collector of the detector cell and produces a potential (+45 V pulsed) on the collector that attracts the free electrons available in the cell. This action, taken together with the current produced by resistors R17, R18, R19, R30, and R31 determines the instantaneous standing current.

If a sample with an affinity for electrons enters the ECD cell from the column were free electrons will be available at the CJ collector and the standing current will tend to drop off. This results in an increasing negative signal at the output ofU4 in proportion to the decrease in standing current. The increased negative signal results in an increased frequency at the output ofU3 and, consequently, U2. This increased frequency provides more pulses at the cell collector, which attracts more free electrons, thus returning the standing current to its set value. Once the sample component passes through the cell and more free electrons become available at the collector, the standing current begins to increase. This causes a decreasing negative signal at the output of U4 that results in a lower frequency at the outputs of U3 and U2. Fewer pulses at the secondary winding of Towers the potential of the cell collector and reduces the standing current to its set value.

Frequency-to- Voltage Converter

The output of U2 also drives FET Q2, which produces clean -l5-V pulses. These are integrated by Ul. As the frequency of the pulse increases, the average DC value at Pin 3 of Q2 becomes more negative. The integrator supplies a positive DC output proportional to the frequency of the pulses at its input, thus performing a frequency-to-voltage conversion. The output of Ul is applied to the *ND* converter front end circuitry common to all detector amplified Boards.

A/D Converter Front End Stage

Dual slope analog to digital conversion is performed by a combination of functions on the ECD Amplifier Board and the Main Board. On the Amplifier Board, U103 integrates the buffered amplifier signal from Ul. Resistors R126 and R127 set the charging current for C109 as a function of applied voltage. (Assume that C109 has charged to some value during the sample acquisition portion of the conversion cycle.)

The Main Board applies an active low discharge signal, DSCHG*, every 12.5 ms (80 Hz), to the circuit to discharge C109. This signal remains low until the Main Board senses a stop discharge output, STOP*, from the amplifier. The time period from the falling edge of DSCHG* to STOP* is measured by the Main Board. This measurement is the raw digital output of the converter.

Capacitor C109 is discharged through CR23 by a 0.5-mA constant current sink formed by Q102, U101 (C), and R123. During the charge portion of the cycle when DSCHG* is high, the demanded current is satisfied via CR22 and the network R105, R107, R106, and U106-6. During this time, CR23 is back-biased since the voltage at its cathode is approximately +1.4 V. When DSCHG* becomes active, the bias network pulls the anode of CR22 down to - 2.0 V. This back-biases the diode, forward-biases CR23, and causes C109 to discharge at a constant rate.

Resistor network Rl14, Rl15, and Rl16 supplies a continuous positive bias current, approximately 250 nA, to the integrator. This bias compensates for any slight negative drift that may occur in the detector/amplifier under zero signal conditions.

During the charge:

- The voltage developed ~cross C109 = Vul-sl40K + the bias current through Rl15.

During the discharge:

- The discharge rate = IcR22 -V ul-sl40K -the bias current.

Discharge time as a function OfVUl-6 is linear.

Capacitor C109 is sized to use the full negative output of U103 without its output saturating during the 12.5-ms conversion period.

Because of the high resolution requirements for the converter, it is essential that no time ambiguity occur between the discharge of the integrator through zero and the removal of the active low DSCHG* signal. U101(D) amplifies the positive going ramp at U103-6 as it passes through zero. The amplified signal is applied to comparator U102, which is referenced to zero V. The high gain of this circuit insures that virtually no uncertainty occurs relative to the period of the Main Board's 24.576 MHz clock (used to measure DSCHG*) from U103-6 crossing zero to STOP* (U102-7) going low. Resistor R129, CR25, and CR26 are used to limit the output swing of U103 to between 0.6 and -10.6 V.

Analog Signal Output

An analog output signal, ANALOG, is provided at P1-P12 to drive either an external recorder directly or an integrator (after further signal processing on the Main Board). A 640-Hz digital pulse train from the Main Board, DAOUT, is applied to a 3-pole low pass filter on the ECD Amplifier Board. The pulse width of DAOUT is a function of the discharge time of C109 and is determined on the Main Board. When zero input voltage is applied to R126, the integrator bias current (via Rl15) results in a DAOUT low pulse width of 1.5 µs each period. When 8.0 V is applied, the DAOUT low pulse width is 1.3 ms.

The analog output filter is driven through CR20 by a 1. 17-mA constant current sink comprising Q101, U101(A), and R124. When CR20 is conducting (corresponding to the low portion of DAOUT), the output of U104 goes positive. The maximum output of CR20 always conducting is 11.7 V. During the high portion of each DAOUT period, CR20 is back-biased and CR21 provides the demanded current. A network comprising of R104, R102, R103, and U106-2 sets up the proper bias levels for CR20 and CR21. The output of U104 is attenuated by a factor of 10 and becomes the ANALOG signal.

Voltage Reference

A + 10-V reference source from the Main Board, + 10V REF, is used to generate the current sinks. U101(A) and RA10 provide the -5 V and -10 V used by the current sink circuits.

TCD Amplifier PC Board

The circuit description of the TCD Amplifier PC Board is divided into the following sections:

- Command Decoding
- Bridge Ground System
- Bridge Current Range Select
- Bridge Current Control
- Bridge Output Circuits
- Safety Circuits
- A/D Converter Front End Stage
- Analog Signal Output
- Voltage Reference

Command Decoding

Control lines DETCONO* through DETCON4* from the Main Board are used to control the operation of the amplifier. Pulsing DETCONO* low via the software resets the HWD ERROR flag. This flag is set whenever an overheating condition (filament resistance is too high) occurs in the bridge. Resetting the error will enable current drive to the bridge if the overall bridge resistance returns to within normal operating limits.

DETCON1* through DETCON3* are decoded to select the bridge operating current. Four ranges are provided (see the table on the TCD Amplifier Board Schematic, N610-9110). Resistors R2 through R5 determine the bridge operating current and are sized for 160, 120, 80, and 40 mA. The decoding is accomplished via U4, a 74LS145, whose outputs in turn drive optocoupler U3. The optocoupler separates the digital system ground from that of the analog circuitry used to set and regulate the selected bridge current.

Control signal DETCON4* is used to change the polarity of the amplified bridge Output signal prior to the on-board A/D converter circuitry , which permits only positive input. The polarity reversal circuitry allows the system to operate with positive or negative differential output from the bridge. U11, U15, and U16 are used to implement the polarity reversal. This is described in the section "Bridge Output Circuits."

Bridge Ground System

The TCD ground system floats with respect to the normal analog ground system of the Clarus 500 GC. All bridge operating Current selection, current drive, and thermal protection circuitry are returned to the secondary of the TCD power Supply. This supply provides 26 V (+26 VB) to the bridge constant current circuitry as ±15 V (±15 VB) to power particular IC's.

Bridge Current Range Select

IC Ul provides a –l0-V reference with respect to the ±l5-VB supplies. This reference voltage is applied to one of four resistors (R2, R3, R4, or R5) by closing the appropriate channel in analog switch U2. The channel is actuated by optocoupler U3, which is controlled by the DETCON1* - DETCON3* signals from the Main Board. The selected resistor is used to set the current through the TCD bridge.

Bridge Current Control

Resistor R14 is in series with the output of the detector bridge and is used to monitor current flow. The voltage developed across this resistor will under steady state conditions develop the same current flow in R13 as the –l0-V reference develops in the selected current set resistor. This is accomplished by error amplifier U7, bias voltage regulator U17, and power transistor Q2, which along with resistors R13 and R14 form a closed loop constant current control circuit. The control loop attempts to drive the inverting input of U7 toward the detector bridge circuitry ground (COM). Assume that the voltage across R14 is too low. This causes U7-2 to be negative, which in turn drives U7-6 more positive. As a result, U17 provides more drive to Q2, increasing the voltage across it and the current through the bridge and R14.

Bridge Output Circuits

The output of the bridge is amplified by U12, which has a gain of 20 set by resistors R23 through R28. The amplified signal is applied to U16, which can be configured via the DETCON4* bit to have a gain of tl. When DETCON4* is high, control line Pin 1 of an analog switch U15 is low, activating (or closing) section 1 of that device. At the same time, control line Pin 16 of U15 is high, opening section 4 of that device. This arrangement configures U16 as a non-inverting amplifier and the polarity of the amplified bridge output signal remains unchanged. When DETCON4* is held low, the states of the U15 control lines are reversed and U16 is configured as an inverting amplifier and the polarity of the amplified bridge output signal is reversed.

Amplifier U8 averages differential noise from the output of the bridge and provides common mode noise rejection by returning the inverted average noise signal to the floating TCD ground.

Safety Circuits

There are two safety features built into the amplifier circuit to protect the detector bridge from damage during normal operation. The first safety circuit detects a large imbalance in the detector output (for example, due to a large sample) and automatically cuts off the bridge current. The output of U12 is applied to the inverting input of comparator U13 via resistor R30 and to the non-inverting input of comparator U14 via resistor R31. The open collector outputs of these IC's are tied together and are normally inactive. When the threshold of either U13 or U14 is exceeded, the input of optoisolator U10 is enabled, resulting in a decreased bridge current. The threshold for U13 is approximately 10.8 V while the threshold for U14 is approximately -10.8 V.

The collector output of U10 is connected to the positive input terminal of voltage regulator U17. When activated by either U13 or U14, U10 clamps the input of U17 to COM ground, thereby removing drive to bridge current regulator Q2. The bridge current will return to normal when the output of bridge output amplifier U12 returns to within the threshold limits of comparators U13 and U14. The ERROR flag to the Main Board is not set for output overloads of this type.

The second safety circuit protects the bridge from excessive total current (caused, for example, by air in the carrier gas), even though the differential bridge current may still be a balanced signal.

If all the hot wire filaments overheat and their resistance approaches 171 ohms each, the protection circuitry stops the bridge current. Resistors R6 through R10 are selected to set the threshold. When the signal at the inverting input of U5 exceeds the signal at its positive input, its output is driven negative, and Q1 is turned off. This in turn enables optoisolator U6, saturating its output transistor at digital ground (GND1), and presenting a logic low to the flip-flop comprising U11 sections A and B. The output Ull-3 goes high, signaling an ERROR condition to the Main Board. Output U11-6 goes low activating the input of optoisolator U9. The transistor collector output of U9 drives the same input to voltage regulator U17 as optoisolator U10. The error condition removes the drive to bridge current regulator Q2. Since the error condition is remembered by latch U11, the bridge current cannot be restored until an error reset is sent by the Main Board via control line DETCONO*. If the thermal overload condition has been eliminated, then the bridge current will be restored. Note that latch U11 is cleared to the error-not condition at power-up by the hardware reset signal RESET*.

A/D Converter Front End Stage

Dual slope analog to digital conversion is performed by a combination of function on the TCD Amplifier Board and the Main Board. U103 on the Amplifier Board integrates the buffered amplifier signal from U105. Resistors R126 and R127 set the charging current for C109 as a function of applied voltage. (Assume that,C109 has charged to some value during the sample acquisition portion of the conversion cycle.)

The Main Board applies an active low discharge signal, DSCHG*, every 12.5 ms (80 Hz) to the circuit to discharge C109. This signal remains low until the Main Board senses a stop discharge output, STOP*, from the amplifier. The time period from the falling edge of DSCHG* to STOP* is measured by the Main Board. This measurement is the raw digital output of the converter .

C109 is discharged through CR23 by a 0.5-mA constant current sink formed by Q102, U101 (C), and R123. During the charge portion of the cycle when DSCHG* is high, the demanded current is satisfied via CR22 and the network R105, R107, R106, and U106-6. During this time, CR23 is back- biased since the voltage at its cathode is approximately + 1.4 V. When DSCHG* becomes active, the bias network pulls the anode of CR22 down to - 2.0 V. This back-biases the diode, forward-biases CR23, and causes C109 to discharge at a constant rate.

Resistor network R114, Rl15, and Rl16 supplies a continuous positive bias current, (250 nA) to the integrator. This compensates for any negative drift that may occur in the detector/amplifier under zero signal conditions.

During the charge:

- The voltage developed across C109 = $V_{u1\text{-}6}$ /40K + the bias current through R115.

During the discharge:

- The discharge rate = I_{CR22} –$V_{U1\text{-}6}$ /40K -the bias current. Discharge time as a function Of $V_{U1\text{-}6}$ is linear.

C109 is sized to use the full negative output of U103 without its output saturating during the 12.5-ms conversion period.

Because of the high resolution requirements for the converter, it is essential that no time ambiguity occurs between the discharge of the integrator through zero and the removal of the active low DSCHG* signal. U101(D) amplifies the positive going ramp at U103-6 as it passes through zero. The amplified signal is applied to comparator U102, which is referenced to 0 V. The high gain of this circuit ensures that virtually no uncertainty occurs relative to the period of the Main Board's 24.576 MHz clock (used to measure OSCHG*) from U103-6 crossing zero to STOP* (U103-7) going low. R129, CR25, and CR26 are used to limit the output swing of U103 to between 0.6 and -10.6 V.

Analog Signal Output

An analog output signal, ANALOG, is provided at P1-P12 to drive either an external recorder directly or an integrator (after further signal processing on the Main Board). A 640-Hz digital pulse train from the Main Board, DAOUT, is applied to a 3-pole low pass filter on the TCD Amplifier Board. The pulse width of DAOUT is a function of the discharge time of C109 and is determined on the Main Board. When zero input voltage is applied to R126, the integrator bias current (via Rl15) results in a DAOUT low pulse width of 1.5 µs each period. When 8.0 V is applied, the DAOUT low pulse width is 1.3ms.

The analog output filter is driven through CR20 by a 1. 17-mA constant current sink comprising Q101, U101(A), and R124. When CR20 is conducting (corresponding to the low portion of DAOUT), the output of U104 goes positive. The maximum output of CR20 always conducting is 11.7 V. During tile high portion of each DAOUT period, CR20 is back-biased and CR21 provides the demanded current. A network comprising of R104, R102, R103, and U106-2 sets up the proper bias levels for CR20 and CR21. The output of U104 is attenuated by a factor of 10 and becomes the ANALOG signal.

Voltage Reference

A + 10- V reference source from the Main Board, + 10V REF, is used to generate the current sinks. U101(A) and RA10 provide the -5 and -10 V used by the current sink circuits.

TCD Range Values

TCD sensitivity is set by the operator by entering the TCD range value via the keyboard. TCD range options are: O (Off), 1, 2, 3, 4 (maximum sensitivity), and -1, -2, -3, or -4. A negative value reverses the polarity. The TCD range values corresponding to bridge current are shown below.

Bridge Current (mA)	**Range Entry**
Off	±0
40	±1
80	±2
120	±3
160	±4

FPD Amplifier PC Board

The circuit description for the FPD Amplifier Board is divided into the following sections:

- High Voltage Section
- Electrometer
- A/D Converter Front End Stage
- Analog Signal Output
- Voltage Reference

High Voltage Section

In the center of the high voltage power supply is an adjustable constant source made up of Ql, Q2, R9 -Rll and C8 –C1O. The range of current is 45 to 100mA, with a nominal current of 75mA This current is supplied from the +15V supply with Ll and Cl as a line filter to keep noise from leaving the board. The output of the constant current source feeds into the high voltage section. Q3, R12, R13, C6, C7 and T1 make up a 40kHz (6V nominal adjustable up to 8- 10V) oscillator on the primary side of Tl (pins 3 and 4). T1 has 10 turns on the primary with 400 turns on secondary (pins 1 and 2). The secondary of TI feeds a voltage doubler CRl, CR2, C4 and C5. The full - 500V nominal is developed across C5, this is adjustable up to -700V. CI2 and R7 sense the high voltage output and feed this back into the non-inverting input of Ul. This feed backed voltage is compared to the control signal with R6 and Ul. U3 is a serial driven D/A which controls the high voltage output. A setting of 67.7% (3433 DAC counts) produces -500V nominal, a setting of 100% (4095 DAC counts) delivers -741V.

Electrometer

The Currrent signal supplied by the Photomultiplier tube is applied to the inverting input of amplifier U2 via R2. A feedback loop is closed around U2 with resistors Rl. This provides a nominal 0-to-8- V output to the A/D converter front end stage.

A/D Converter Front End Stage

Dual slope analog to digital conversion is performed by a combination of functions on the FPD Amplifier Board and the Main Board. On the Amplifier Board. Ul03 integrates the buffered amplifier signal from U2. Resistors Rl26 and Rl27 set the charging current for ClO9 as a function of applied voltage. (Assume that ClO9 has charged to some value during the sample acquisition portion of the conversion cycle.)

The Main Board applies an active low discharge signal, DSCHG*, every 12.5 ms (80 Hz), to the circuit to discharge C109. This signal remains low until the Main Board senses a stop discharge output, STOP*, from the amplifier. The time period from the falling edge ofDSCHG* to STOP* is measured by the Main Board. This measurement is the raw digital output of the converter.

Capacitor C109 is discharged through CR23 by a 0.5-mA constant current sink formed by Q102, U101 (C), and R123. During the charge portion of the cycle when DSCHG* is high, the demanded current is satisfied via CR22 and the network R105, R107, R106, and U106-6. During this time, CR23 is back-biased since the voltage at its cathode is approximately + 1.4 V. When DSCHG* becomes active, the bias network pulls the anode of CR22 down to - 2.0 V. This back-biases the diode, forward-biases CR23, and causes C109 to discharge at a constant rate.

Resistor network R114, R115, and Rl16 supplies a continuous positive bias current, approximately 250 nA, to the integrator. This bias compensates for any slight negative drift that may occur in the detector/amplifier under zero signal conditions.

During the charge:

- The voltage developed across C109 = $V_{U1\text{-}6}$/40K + the bias current through Rl15.

During the discharge:

- The discharge rate = I_{CR22} –$V_{U1\text{-}6}$ /40K -the bias current. Discharge time as a function Of $V_{U1\text{-}6}$ is linear.

Capacitor C109 is sized to use the full negative output of U103 without its output saturating during the 12.5-ms conversion period.

Because of the high resolution requirements for the converter, it is essential that no time ambiguity occur between the discharge of the integrator through zero and the removal of the active low DSCHG* signal. The positive is amplified by U101(D) going ramp at U103-6 as it passes through zero. The amplified signal is applied to comparator U102, which is referenced to 0 V. The high gain of this circuit insures that virtually no uncertainty occurs relative to the period of the Main Board's 24.576-MHz clock (used to measure DSCHG*) from U103-6 crossing zero to STOP* (U103-7) going low. R129, CR25, and CR26 are used to limit the output swing of U103 to between 0.6 and -10.6 V. This is the bias voltage from CR26.

Analog Signal Output

An analog output signal, ANALOG, is provided at P1-P12 to drive either an external recorder directly or an integrator (after further signal processing on the Main Board). A 640-HZ digital pulse train from the Main Board, DAOUT, is applied to a 3-pole low pass filter on the FPD Amplifier Board. The pulse width of DAOUT is a function of the discharge time of C109 and is determined on the Main Board. When zero input voltage is applied to R126, the integrator bias current (via Rl15) results in a DAOUT low pulse width of 1.5 µs each period. When 8.0 V is applied, the DAOUT low pulse width is approximately 1.3 ms.

The analog output filter is driven through CR20 by a 1.17-mA constant current sink comprising Q101, U101(A), and R124. When CR20 is conducting (corresponding to the low portion of DAOUT), the output of U104 goes positive. The maximum output of CR20 always conducting is 11.7 V. During the high portion of each DAOUT period, CR20 is back-biased and CR21 provides the demanded current. A network comprising of R104, R102, R103, and U106-2 sets up the proper bias levels for CR20 and CR21. The output of U104 is attenuated by a factor of 10 and becomes the ANALOG signal.

Voltage Reference

A +10-V reference source from the Main Board, +10V REF, is used to generate the current sinks. The -5 and -10 V used by the current sink circuits are provided by U101(A) and RA10.

NPD Amplifier PC Board

The Circuit description of theNPD Amplifier PC Bnard is divided into the following sections:

- Polarizing Voltage
- Electrometer
- A/D Converter Front End Stages
- Analog Signal Output
- Voltage Reference
- Bead Voltage Conversion (RMS-to-DC)
- Pulse Width Modulation Control
- NPD Transformer

Polarizing Voltage

The -36- VDC polarizing voltage for the NPD is generated on the NPD Amplifier Board.

An oscillator circuit comprised of Tl, Q5, Q6, and resistors R13 -R16 provides a high-voltage, low-current secondary signal on transformer T1 by altemately driving Q5 and Q6 into full conduction, saturating the transformer. The frequency of operation is approximately 10 Khz.

The secondary voltage at T1 is doubled by capacitors C2 and C4 and rectifiers CR3 and CR4 providing approximately -240 VDC at the anode of CR3. A voltage doubling circuit using CR2, CR2, Cl, and C3 generates a +240 V at the cathode of CR1. This voltage is used to generate the + lOO VDC needed by the electrometer. Pass transistors Q3 and Q4 provide ±100 VDC (which can be measured at TP10 and TPll, respectively) via the regulation of CRll and R5, and CR12 and R6.

The regulation of CR53 and R149 provide the -36 VDC polarizing voltage which is filtered via C142 and C145 with R151 being used to limit short circuit current.

Electrometer

The current signal from the NPD collector is applied to the inverting input of amplifier U2 via R54. A feedback loop is closed around U2, Q50, and Q51 with precision resistors R53 and R52. With R53 being equal to 4KM (4 gigohms), +80 VDC is produced at the collector of Q51 for an NPD collector circuit of -20 nA which is the nominal full scale range of the NP detector.

Relay K4 (which is driven by Q52, U106 Pin 10, R51, and R50) is used to decrease the sensitivity of the electrometer by paralleling the 200M resistor, R52. The +80 VDC at the collector Q51 corresponds to an NPD collector circuit of -420 nA, a x21 decrease in sensitivity.

The electrometer ouput is scaled by x0.1 via Rl19 and R120, then buffered by U105. This provides a nominal 0 -8- V output (measured at TP8) to the A/D converter front end stage. The time constant of the buffer stage is 20 ms. The break frequency of 8 Hz is 1/10 the conversion period.

A/D Converter Front End Stages

Dual slope A/D conversion is performed by a combination of functions on the NPD Amplifier Board and the Main Board. On the Amplifier Board, U103 integrates the buffered signal from U105.

Resistors R126 and R127 set the charging current for Cl09 as a function of the applied voltage. (Assume that Cl09 has changed to some value during the smaple acquisition portion of the conversion cycle.)

The Main Board applies and active low discharge, DSCHG*, every 12.5 ms (80 Hz) to the circuit to discharge Cl09. This signal remains low until the Main Board senses a stop discharge output, STOP*, form the amplifier. The time period form the falling edge of DSCHG* to STOP* is measured by the Main Board. This measurement is the raw digital output of the converter .

Capacitor C109 is discharged through CR23 and CR28 by a 0.5-mA constant current sink formed by Ql02, U101 (C), and R123. During the charge portion of the cycle when DSCHG* is high, the demanded current is satisfied via CR22, a resistor network comprised of Rl05, Rl06, Rl07, and Ul06 Pin 6. During this period, CR23 is back-biased since the voltage at its cathode is approximately 1.4 V. When DSCHG* becomes active (goes low), the bias network pulls the anode of CR22 down to -2.0 V. This back-biases CR22, forward-biases CR23, and causes C109 to discharge at a constant rate.

Resistor network Rl14, R115, and Rl16 supplies a continuous positive bias current of approximately 400 nA to the integrator (U103). The bias compensates for any slight negative drift in the detector or amplifier under zero signal conditions.

During the charge:

- the voltage developed across C109 = V u105/40K the bias current through R115.

During the discharge

- the discharge rate = Icr -Vu105/40K -the bias current. Discharge time as a function of Vu105-6 is linear.

Capacitor Cl09 is sized to use the full negative output of U103 without its output saturating during the 12.5-ms conversion period.

Because of the high resolution requirement for the converter, it is essential that no time ambiguity occur between the discharge of the integrator through zero and the removal of the active low DSCHG* signal.

Ul0l (D) amplifies the positive going ramp at Ul03 Pin 6 as it passes through zero. The amplified signal is applied to comparator Ul02, which is referenced to 0Volts. The high gain of the circuit ensures that no uncertainty occurs relative to the period of the Main Board's 24.576-Mhz clock (used to measure DSCHG*) from Ul03 Pin 6 crossing zero to STOP* (U103 Pin7) going low. R129 and CR25 are used to limit the output swing of U103 to -10.6 V.

Analog Signal Output

An analog output signal (ANALOG) is provided at P1 Pin 12 to drive either an integrator or chart recorder.

A 640-Hz digital digital pulse train from the Main Board (DAOUT) is applied a three-pole low-pass filter on the NPD Amplifier Board. The pulse width of DAOUT is a function of the discharge time of C109 and is determined by the Main Board.

When zero input voltage is applied to R126, the integrator bias current (via R115) results in a DAOUT low pulse width of 1.5 µs each period. When 8 V is applied, the DAOUT low pulse width is approximately 1.3 ms (provided the instrument is configured for Integrator output, Attn. X64, A/Z Off, and 0% offset).

The analog output signal is driven through CR27 and CR20 by a 1.17 -mA constant current sink formed by Q101, U101 (B), and R124.

When CR20 is conducting (corresponding to the low portion of DAOUT), the output of U104 goes positive. The maximum output of CR20 always conducting is 11.7 V. During the high portion of each DAOUT period, CR20 is back-biased and CR21 provides the demanded current. A resistor network made up of R102, R103, R104, and R106 Pin 2 sets up the proper bias levels for CR20 and CR21. The output of U104 is attenuated by a factor of ten and becomes the ANALOG signal.

Voltage Reference

A +10-V reference source from the Main Board (+10V REF is used to generate the current sinks. The -5 V and -10 V used by the current sink circuits are provided by U101 (A) and RA10.

Bead Voltage Conversion (RMS-to-DC)

The NPD bead is suspended on a 7-mil platinum wire 5-mm long. The bead is heated by controlling the voltage drop across the platinum wire. The bead voltage is driven by the NPD transformer's secondary winding operating from a closed loop, 40-KHz pulse width modulated control circuit.

The bead is polarized to -36 VDC by tying the floating secondary winding to -36 VDC. The other side of the secondary winding is AC-coupled to the amplifier via C128 and J3 Pin 1.

The AC-coupled bead voltage is fed to U107 Pin 1 for RMS-to-DC conversion. The nominal l.0-V RMS signal is converted to a 5-VDC signal via U107 with C129 setting the average time constant and R130 with R131 setting a gain of 5.

Potentiometer R131 is adjusted such that if 1.0 VDC is applied at TP15 (or 1.0- V RMS via a 40-Khz sine wave applied to J3 Pin 1), the resulting voltage at TP14 is 5 VDC ±25 mV with respect to ground S (TP17).

Pulse Width Modulation Control

The bead voltage setpoint is provided by a 20-K panel-mounted potentiometer, which is connected across J4 Pin 3 and J4 Pin 1, with its wiper connected to J4 Pin2.

This setpoint is compared to the actual bead voltage (U107 Pin 6) and the difference is integrated using the error amplifier inside U108 (the PWM Controller) in conjunction with R133, R134, R135, and C130.

R150, which is between U108 Pin 1 and 5.1-V reference (UI08 Pin 16), ensures that the control pulses will not be active until the setpoint exceeds 0.75 V.

A soft start to U108 (the PWM Controller) is provided by C143 (to Pin 8) keeps the circuit shut down following a reset condition until C143 changes to approximately 1.0 V or higher.

C132 provides decoupling for the internal logic supply (Vcc at Pin 15). R136 and C133 provide filtering and decouple the gate current supply (Vcc at Pin 13). The internal oscillator is set for approximately 80 Khz with R140 and C136. R137 and C134 filter the turn-on current spike associated with HEXFETs Q103 and Q104 to stop the turn-on current from erroneously triggering the current limit (1.0 VDC) or current shut-down (1.4 VDC) protection feature built into the PWM controller (on Pin 9).

Let's assume that the bead requires a 50% on/off duty cycle. Under this condition, OUTput A (U108 Pin 11) will to +15 V for 6.25 µs .,then off for 18.75µs. OUTput B (U108 Pin 14) will do the same as OUTput A, but is delayed 12.5µs (one cycle). The high pulse to the gate drives the HEXFETs Q103 and Q104 into conduction, putting 23 V across one half of the primary transformer winding (determining which half of the primary winding gets the 23 V will depend on which HEXFET is conducting). This results in + 1.5 V (peak) on the secondary winding (driving the bead).

During conduction, the primary winding current is sensed across R147 and R148, where it is limited to approximately 2 A and a portion (25% or 0.5 A) is fed back via R138, R139, and C135 to control the symmetry of adjacent pulses.

The pulse exists while the ramp input (Ul08 Pin 7) is less than the integrating error amplifier output (Ul08 Pin 3). Most of the ramp is derived from the chip oscillator via Rl38, Rl39, and Cl35.

NPD Transformer

The NPD toroidal transformer consists of a 60-turn center-tapped primary (30 turns on either side of center) and a two-turn secondary.

The center tap is tied to +24 VDC while the other two ends of the primary are alternately switched to ground (GND P) via the HEXFETs in a push-pull configuation. The resulting secondary waveform consists of a + 1.5 V pulse followed by a -1.5 V pulse. This voltage is superimposed on the -36 VDC polarizing voltage (on which the secondary winding floats). The primary inductance of either winding to the center tap is approximately 3mh.

PID Amplifier PC Board

The circuit description for the PID Amplifier Boards is divided into the following sections:

- Polarizing Voltage
- Electrometer
- A/D Converter Front End Stage
- Analog Signal Output
- Voltage Reference

Polarizing Voltage

The +100 VDC polarizing voltage for the PID is generated on the PID Amplifier Board. An oscillator circuit comprised of Tl, Q5, Q6, and resistors R13-R16 provides a high voltage, low current secondary signal on the transformer Tl by alternately driving Q5 and Q6 into full conduction, saturating the transformer. The frequency of operation is approximately 10 KHz.

The secondary voltage at Tl is doubled by capacitors C2 and C4 and rectifiers CR3 and CR4, yielding approximately -240 VDC at the anode of CR3. Pass transistor Q2 supplies the output voltage while operating at a constant current of 0.75 ma regulated by CR6, CR8, R5, and R4. Diode CR10 sets the output voltage at -200 VDC. This voltage is routed to relay K5, which is used to select either -200 VDC or ground at the polarizing voltage connection point E1, depending on the operating mode when using this amplifier with an NPD detector. The voltage is also sent through connector J1 to the NPD power supply to float the supply at -200 VDC.

A voltage doubling circuit using CR1, CR2, Cl, and C3 generates +240 V at the cathode ofCR1. This voltage is used to generate the +100 VDC needed by the electrometer. Pass transistors Q3 and Q4 provide 1:100 VDC via the regulation of CRll and R5, and CR12 and R6.

Electrometer

The current signal supplied by the PID collector is applied to the inverting input of amplifier U2 via R54. A feedback loop is closed around U2, Q50, and Q51 with precision resistors R53 and R52. With R53 equal to 4 gigohms, 80 VDC is produced at the collector of Q51 for an Pill collector current of -20 nanoamperes. This is the nominal full scale range of the PID detector.

Relay K4 is driven by Q52, U106-110, R51, and R50, and is used to decrease the sensitivity of the electrometer by paralleling resistor R52, which has a value of 200 megohms. The 80 VDC at the collector of Q51 corresponds to an pm collector current of -420 nanoamperes, a decrease in sensitivity of x21.

The electrometer output is scaled by x0.1 via R119 and R121, then inverted by U105. This provides a nominal 0-to-8 V output to the A/D converter front end stage. The time constant of the buffer stage is 20 ms. The break frequency of 8 Hz is one-tenth the conversion period.

A/D Converter Front End Stage

Dual slope analog to digital conversion is performed by a combination of functions on the pm Amplifier Board and the Main Board. On the Amplifier Board, U103 integrates the buffered amplifier signal from U105. Resistors R126 and R127 set the charging current for C109 as a function of applied voltage. (Assume that C109 has charged to some value during the sample acquisition portion of the conversion cycle.)

The Main Board applies an active low discharge signal, DSCHG*, every 12.5 ms (80 Hz), to the circuit to discharge C109. This signal remains low until the Main Board senses a stop discharge output, STOP*, from the amplifier. The time period from the falling edge of DSCHG* to STOP* is measured by the Main Board. This measurement is the raw digital output of the converter .

Capacitor C109 is discharged through CR23 by a 0.5-mA constant current sink formed by Q102, U101 (C), and R123. During the charge portion of the cycle when DSCHG* is high, the demanded current is satisfied via CR22 and the network R105, R107, R106, and U106-6. During this time, CR23 is back-biased since the voltage at its cathode is approximately +1.4 V. When DSCHG* becomes active, the bias network pulls the anode of CR22 down to - 2.0 V. This back-biases the diode, forward-biases CR23, and causes C109 to discharge at a constant rate.

Resistor network R114, Rl15, and Rl16 supplies a continuous positive bias current, approximately 250 nA, to the integrator. This bias compensates for any slight negative drift that may occur in the detector/amplifier under zero signal conditions.

During the charge:

- The voltage developed across C109 = V_{U1-6}/40K + the bias current through Rl15.

During the discharge:

- The discharge rate = I_{CR22} -V_{U1-6}/40K -the bias current. Discharge time as a function Of V_{U1-6} is linear.

Capacitor C109 is sized to use the full negative output of U103 without its output saturating during the 12.5-ms conversion period.

Because of the high resolution requirements for the converter, it is essential that no time ambiguity occur between the discharge of the integrator through zero and the removal of the active low DSCHG* signal. The positive is amplified by U101(D) going ramp at U103-6 as it passes through zero. The amplified signal is applied to comparator UI02, which is referenced to 0 V. The high gain of this circuit insures that virtually no uncertainty occurs relative to the period of the Main Board's 24.576- MHz clock (used to measure DSCHG*) from U103-6 crossing zero to STOP* (U103-7) going low. R129, CR25, and CR26 are used to limit the output swing of U103 to between 0.6 and -10.6 V. This is the bias voltage from CR26.

Analog Signal Output

An analog output signal, ANALOG, is provided at P1-P12 to drive either an external recorder directly or an integrator (after further signal processing on the Main Board). A 640-HZ digital pulse train from the Main Board, DAOUT, is applied to a 3-pole low pass filter on the PID Amplifier Board. The pulse width of DAOUT is a function of the discharge time of C109 and is determined on the Main Board. When zero input voltage is applied to R126, the integrator bias current (via Rl15) results in a DAOUT low pulse width of 1.5 µs each period. When 8.0 V is applied, the DAOUT low pulse width is approximately 1.3 ms.

The analog output filter is driven through CR20 by a 1.17-mA constant current sink comprising Q101, U101(A), and R124. When CR20 is conducting (corresponding to the low portion of DAOUT), the output of U104 goes positive. The maximum output of CR20 always conducting is 11.7 V. During the high portion of each DAOUT period, CR20 is back-biased and CR21 provides the demanded current. A network comprising of R104, R102, R103, and U106-2 sets up the proper bias levels for CR20 and CR21. The output of U104 is attenuated by a factor of 10 and becomes the ANALOG signal.

Voltage Reference

A + 10- V reference source from the Main Board, + 10V REF, is used to generate the current sinks. The -5 and -10 V used by the current sink circuits are provided by U101(A) and RA10.

Electrometer Balance Adjustment

The pm Amplifier Board has a trimpot (R59), which can be adjusted to balance the electrometer output. This is normally done in Electronic Test. To adjust this trimpot, first powerup the PIDA for five minutes. Then short E8 to TP9 and adjust R59 (in the center of PIDA can) until the voltage read at TP8 is zero ±10 m V with respect to ground (TP4). Note that the center conductor of the coax cable is E8 and its shield is ground.

External Amplifier PC Board

The circuit description of the External Amplifier PC Board is divided into the following sections:

- Differential Analog Input
- A/D Converter Front End Stage
- Analog Signal Output
- Voltage Reference

Differential Analog Input

The analog front end of the External Amplifier is clamped and current limited in reference to GND5. This is accomplished by the combination of the four 12 V zener diodes CR1 -CR4 and RA2. The diodes clamp the input voltage to approximately +/- 13 V in respect to GND5. SELECT INPUT RANGE jumper SP1 adjusts the input voltage range between 1 V full scale or 10 V full scale. With the jumper in the 1 V position, a 1 V full scale signal will drive the voltage at TP8 to about *B* V. With the jumper in the 10 V position, a 10 V full scale signal will drive the voltage at TP8 to about *B* V. The combination of the three U1 amplifiers form a Differential amplifier,

high impedance and low noise. The jumper SP1 changes the gain of this circuit to produce the full scale BV output for the 1 V or 10 V inputs.

A/D Converter Front End Stage

Dual slope analog to digital conversion is performed by a combination of functions on the External Amplifier Board and the Main Board. U103 on the Amplifier Board integrates the buffered amplifier signal from U105. Resistors R126 and R127 set the charging current for C109 as a function of applied voltage. (Assume that C109 has charged to some value during the sample acquisition portion of the conversion cycle.)

The Main Board applies an active low discharge signal, DSCHG*, every 12.5 ms (80 Hz) to the circuit to discharge C109. This signal remains low until the Main Board senses a stop discharge output, STOP*, from the amplifier. The time period from the falling edge of DSCHG* to STOP* is measured by the Main Board. This measurement is the raw digital output of the converter.

C109 is discharged through CR23 by a 0.5-mA constant current sink formed by Q102, U101 (C), and R123. During the charge portion of the cycle when DSCHG* is high, the demanded current is satisfied via CR22 and the network R105, R107, R106, and U106-6. During this time, CR23 is back- biased since the voltage at its cathode is approximately +1.4 V. When DSCHG* becomes active, the bias network pulls the anode of CR22 down to - 2.0 V. This back-biases the diode, forward-biases CR23, and causes C109 to discharge at a constant rate.

Resistor network Rl14, Rl15, and Rl16 supplies a continuous positive bias current, (250 nA) to the integrator. This compensates for any negative drift that may occur in the detector/amplifier under zero signal conditions.

During the charge:

- The voltage developed across C109 = VU1-6 /40K + the bias current through Rl15.

During the discharge:

- The discharge rate = ICR22 –VU1-6 /40K -the bias current. Discharge time as a function of VUl-6 is linear.

C109 is sized to use the full negative output of U103 without its output saturating during the 12.5-ms conversion period.

Because of the high resolution requirements for the converter, it is essential that no time ambiguity occurs between the discharge of the integrator through zero and the removal of the active low DSCHG* signal. U101(D) amplifies the positive going ramp at U103-6 as it passes through zero. The amplified signal is applied to comparator U102, which is referenced to 0 V. The high gain of this circuit ensures that virtually no uncertainty occurs relative to the period of the Main Board's 24.576 MHz clock (used to measure DSCHG*) from U103-6 crossing zero to STOP* (U103-7) going low. R129, CR25, and CR26 are used to limit the output swing of U103 to between 0.6 and -10.6 V.

Analog Signal Output

An analog output signal, ANALOG, is provided at P1-P12 to drive either an external recorder directly or an integrator (after further signal processing on the Main Board). A 640-Hz digital pulse train from the Main Board, DAOUT, is applied to a 3-pole low pass filter on the External Amplifier Board. The pulse width of DAOUT is a function of the discharge time of C109 and is determined on the Main Board. When zero input voltage is applied to R126, the integrator bias current (via R115) results in a DAOUT low pulse width of 1.5 µs each period. When 8.0 V is applied, the DAOUT low pulse width is 1.3ms.

The analog output filter is driven through CR20 by a 1. 17-mA constant current sink comprising Q101, U101(A), and R124. When CR20 is conducting (corresponding to the low portion of DAOUT), the output of U104 goes positive. The maximum output of CR20 always conducting is 11.7 V. During the high portion of each DAOUT period, CR20 is back-biased and CR21 provides the demanded current. A network comprising of R104, R102, R103, and U106-2 sets up the proper bias levels for CR20 and CR21. The output of U104 is attenuated by a factor of 10 and becomes the ANALOG signal.

Voltage Reference

A +10-V reference source from the Main Board, +10V **REF,** is used to generate the current sinks. U101(A) and RA10 provide the -5 and -10 V used by the current sink circuits.

Pressure Transducer PC Board

The pressure transducer is a Sensym Model SCX100DNC, which is a 100-psi differential device with an output sensitivity of .8333 mV/l PSID when driven by 10 VDC. Internally, this sensor looks like a resistance bridge with a normal input and output resistance of 4,000 ohms. Its output is differential (developed across Pins3 and 5) and Pin 3 will be positive with respect to Pin 5 when the middle transducer, Port B, is at the higher pressure. Liquids must not enter Ports A or B or the transducer output will drift until the liquid evaporates.

The transducer is driven by a precision +10-VDC reference from the Main Board. This reference voltage is inverted to make -10-VDC available at Ul, Pin 1. Trimpot Rl provides an adjustment range of ±100 m V at Ul, Pin 7. This lets you zero the transducer offset error.

Touch Screen Display

The display is controlled by the LCDSW input/output port of the Main Board microprocessor. Data is written to this port to the microprocessor and the DE bit (bit 6) of the touch port is toggled to latch data into the display. The microprocessor scans the touch screen directly; there is no touch screen encoding chip used. Row information written to the microprocessor on the KYBDCSW line while the KYROCSR line is read to determine which, if any, has been pressed.

I/O PC Board

The I/O Board (N630-9020) is a two-layer PC board that is designed as the electrical interface to the GC Clarus 500 for sampling of gaseous Volatile Organic Compounds (VOC). The samples may be supplied from partially evacuated canisters, pressured canisters, or from on-line gas sampling. Simplistically, the samples are fed into a cold trap retarding their entry into the GC Clarus 500 chromatographic column, and when sampling is ready, the cold trap is heated at 40 °C/second to vaporize them allowing their entry into the column.

This circuit description is divided into the following sections:

- Timed Event Drivers
- Position Gas Sampling Valve Interface
- Analog Inputs
- D/A and Communications
- Power

Timed Event Drivers

(Sheet 1 on the 1/0 Board Schematic)

Sheet 1 contains four power drivers, three ULN2003's and a ULN2069.

U104 drives six +24- V low current time event relays. TE-30, TE-31, TE-34, and TE-35 drive two rotational pneumatic valves. Each has a maximum of 28 mA TE-32 and TE-33 drive 3 way, 2 position Teflon solenoid valves. Each has a maximum of 160 mA The spare output UNUSED-U104-EN is connected to an open collector output driver whose output is connected to an unterminated pullup, thus allowing other voltages for this currently unused output.

U105 drives six +24 V low current time event relays. They drive timed event solenoid valves. Each has a maximum of 28 mA The spare output UNUSED-U105-EN is connected to an open collector output driver whose output is connected to an unterminated pullup, thus allowing other voltages for this currently unused output.

U106 drives up to seven +5 V solid state relays uspd to turn on heaters. Each relay control line has a maximum of 28 mA. The driver outputs are held in reset by a retriggerable one shot when it times out. The one shot acts as a firmware fault protection device to prevent thermal runaway should the firmware get lost. To prevent the reset from occurring, the one shot must be retriggered prior to timing out (< 170 ms). The one shot is retriggered automatically in hardware by writing to this I/O port address.

The output register to the driver is double buffered into two registers inside the Xilinx. The first register is loaded during the serial communication, but does not load the second register. This first load is initiated by a zero cross interrupt to the 68332 microprocessor located on the Main Board. The second register is loaded when the next zero cross occurs (the zero cross signal is connected to both the Main Board and the I/O Board) if the output register is not being held in reset by the one shot. This is done to guarantee that the solenoids are actuated at zero cross without the burden of serial communication la tency time. Only the second register is cleared lithe watchdog times out, but since read back is performed only on the first register, the actual output value will not be read.

The spare outputs UNUSED-UlO6-l-EN and UNUSED-UlO6-2-EN are connected to open collector output drivers whose outputs are connected to unterminated pullups, thus allowing other voltages for these currently unused outputs. The second watchdog (WDOG2-TRIGGER and WDOG2- RESET) are not currently used.

UlO7 drives four high current +24 V Timed Event relays. TE-50 (Vortex Cooler Valve Solenoid) has a maximum of 250 mA and TE-52 (Sub-ambient Valve Solenoid assembly N6l0-9l82) has a maximum of 625 mA. The other two outputs are unused at this time.

Position Gas Sampling Valve Interface

(Sheet 2 on the 1/0 Board Schematic*)*

The components on sheet 2 interface to the two Valco Valve 16 position rotational gas sampling valves. The valves can be commanded to one of 16 discrete valve positions using a BCD output format. Similarly the current position of the valves can be read back in a BCD input format.

U201 and half of U202 provide six optically isolated status bits from the Valco Valve #1. The first five are inputs from the valve and indicates its position *in* BCD format. The sixth input is a spare from the valve and may have future use, but is undefined at this time. U204 and half of U205 perform the same function for Valco Valve #2.

U207 is an external register which controls which position Valco Valve #1 should move to, it is represented in BCD format It also contains the data strobe to latch in the position to the valve. Half of U202 and all of U203 provide optical isolation to the valve. In order to move the valve to the specified location, the position bits must be written on the first transmission while the strobe remains low, and then on a subsequent transmission, the strobe must be set high to latch the data while leaving the BCD position unchanged. A further subsequent transmission should reset the strobe low while maintaining the current BCD position. U208, half of U205, and U206 perform the same function for Valco Valve #2.

These bits will not control the Valco Valves until the BCDx-CTRL-EN* bits from the CTRL-CS* register in the Xilinx are set low as they enable the outputs of the 7 4HCT37 4 's. This is done to prevent illegal

BCD values from being sent to the Valco Valve; illegal values will cause the valve to spin in an uncontrolled fashion. Therefore a valid BCD position must be loaded and the strobe set low before the BCDx-CTRL-EN* is set low.

Analog Inputs
(Sheet 3 on the 1/0 Board Schematic)

Sheet 3 is the analog interface to the I/O Board. Analog signals come into the board on this sheet, are passed through an analog multiplexer (selected by the Xilinx), and then sent onto the Main Board to one of its spare analog multiplexer channels. The analog input channels include two mass flow controllers, two K type thermocouples, one thermistor, three PRT's, and two pressure transducers.

The two mass flow controllers output a 0 -5 v output corresponding to 0 -100 m1/min. The signal is conditioned with a 5x voltage divider at the front end and is then buffered using an OP400 op amp. A 100K pullup to +10V reference is placed on the output for a zero offset.

Two type thermocouple inputs are provided. This is accomplished wiih AD595 special purpose op amps U302 and U303. These IC's provide an pnp transistor alarm pin (ALM) to detect an open circuit to the K type thermocouple. The alarm pin is configured as an open collector driver by tying the -ALM pin to ground and pulling up the +ALM output pin. Each signal is then fed into one of the Xilinx status pins. When an open circuit is deiected on the thermocouple inputs, the pin will be driven low. Each of the thermocouple inputs can be shorted out to make reference measurements using K301 and K302. The outputs of the opamps are scaled with R305 and R307 with an offset added with R306 (R309, R311, and R306 respectively for channel 2) and then buffered with an OP400 op amp.

An onboard thermistor reference is also provided. Its output is buffered through an OP07 opamp. Should the onboard reference need to be relocated or calibrated, an external thermistor may be connected in place of TH301 using J3.

Three PRT inputs are provided from the heated canister rack system. They are for a heated transfer line, heated Valco valve, and a heated canister oven. These inputs are pulled up to + 10 V reference for offset purposes and are then fed directly into the analog multiplexer.

Two pressure transducer board inputs are provided for reading canister pressure (pressure transducers 3 and 4). These inputs are fed directly into the analog multiplexer. These boards are identical to those used by the Main Board for pressure transducer 1 (J22) and pressure transducer 2 (J7).

D / A & Communications
(Sheet 4 on the 1/0 Board Schematic)

Sheet 4 contains a dual channel 12-bit D/A converter, the Xilinx controller, and its serial boot prom. The dual channel 12-bit D/A converter gives a 0-5V output on each channel and is used to control two mass flow controllers. They have flow rate of 0 -100 ml/min. corresponding to the 0-5V output. The Xilinx communicates with the Main Board as a slave through the Motorola QSPI. The communication lines include: SCLK, SLAVE- SELECT*, SLAVE-IN, SLAVE-OUT, SLAVE-IRQ*, and RESET*. See the write-up on the Xilinx schematics following Sheet 5 for further information.

Power

(Sheet 5 on the 1/0 Board Schematic)

Sheet 5 is just the power entry into the I/O Board. +5 V, ±15 V, and the +10 V reference come from the Main Board. +24 V is also needed and is created on this board using a bridge and an LM350 adjustable voltage regulator mounted to the sheet metal (it is shown for clarity only). The AC for the bridge comes from a new winding added to the Autosampler transformer. The +24 V is used currently for valves, solenoids, and solid state relay applications. There may be other as yet undetermined uses in the future, therefore, a potentiometer has been added to keep the supply within tolerance for those future devices.

Servicing the Electrical System

This section includes the following procedures:

- Pressure Transducer Zero Adjustment
- Pressure Transducer Span Adjustment
- Replacing the Gate Array on the Motor Drive Board
- Replacing Fuses

Observe the following precautions when servicing electrical system components:

CAUTION	*A caution indicates an operation that could cause instrument damage if precautions are not followed.*

WARNING	*A warning indicateds an operation that could lead to a personal injury if precautions are not followed.*

Accessing the PC Boards

The Main Board, the AC Distribution Board, the Detector Amplifier Boards, the TCD Power Supply Board, and the Autosampler Control Board are all located on the right side of the Clarus 500 GC.

To gain access to these boards, remove the three screws securing the instrument right side panel, then remove the panel.

Pressure Transducer Zero Adjustment

Perform the following procedure to zero the transducer offset error on the Pressure Transducer PC Board. The Pressure Transducer Board is located under the instrument top, near the bulkhead. To gain access to this board, remove the two screws securing the instrument top. One screw is located under the detector access cover and the other is located under the electronics access cover. Lift the top until it locks in the open position.

1. Turn the instrument on and let the Pressure Transducer PC Board power up for five minutes.
2. Open the instrument top
3. With 0.0 psid input {both ports open), adjust trimpot R1 until the output voltage at Pin 8 on connector Jl is +10 mV with respect to ground.

NOTE: *This output voltage is read into the Main Board maxing A/D , which reads 0.0 to +1.28 V. By offsetting the output voltage by 10 mV, the transducer can read -1.0 psid before clamping the displayed output. The two remaining amplifiers in U1 amplify the transducer output voltage by a factor of 12 seen by U1-8. Trimpot R6 allows for span calibration such that system sensitivity 1s 10 mV /psid.*

Pressure Transducer Span Adjustment

Perform the following procedure to calibrate the span (or gain) on the Pressure Transducer Board.

1. Turn the instrument on and let the Pressure Transducer Board power up for five minutes.
2. Open the instrument top and apply 90 psid to the input bulkhead at the rear of the Clarus 500 GC.
3. Remove the injector output fitting and install a 0 -60 psi pressure gauge (Part No.0330-1458) to the regulator output fitting.
4. Adjust the instrument carrier regulator to 50 psi.
5. Monitor Pin 8 of connector J1 on the Pressure Transducer Board. The voltage should be + 510m V.
   - If the voltage is not + 510 mV adjust R6.
6. Repeat the zero adjustment and the span adjustment since these functions interact with each other.

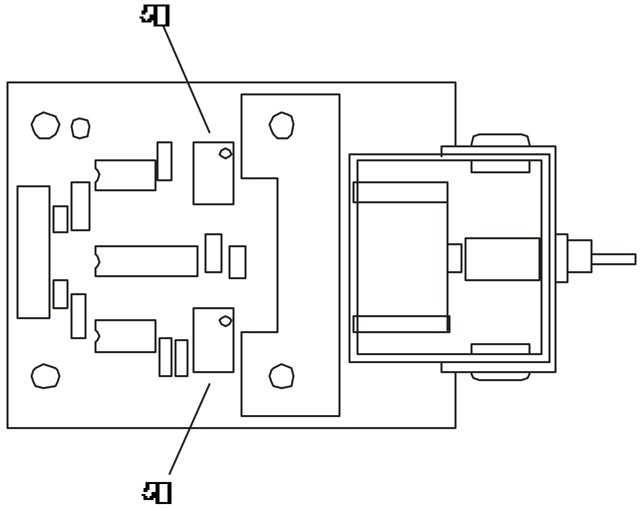


Figure 9- 4 The pressure Transducer PC Board.

Removing the Pressure Transducer Board

To remove the Pressure Transducer PC Board, perform the following steps:

1. The Pressure Transducer Board is mounted to the underside of the instrument top with four white spacers. Push these spacers in from the back of the instrument.

2. Loosen the two screws securing the instrument top, then lift the instrument top.

3. Disconnect the tubing and wires from the Pressure Transducer Board and remove the board.

Replacing the Gate Array on the Autosampler Control PC Board

Should it become necessary to replace the gate array on the Autosampler Control PC Board, use the following tool:

- PLCC Extractor (Part No. 0946-6572)

Replacing Fuse

The Clarus 500 has fuses in three locations:

- on the bottom of the AC Distribution Board

- on the left side of the TCD Power Supply Board (if installed)

- on the autosampler transformer (if an autosampler is installed)

AC Distribution Board Fuses

To gain access to the AC Distribution Board, remove the three screws securing the right side instrument panel and remove the panel. The AC Distribution Board has two fuse configurations: one for a 120- V instrument and one for a 240- V instrument.

120- V Instrument:

- One 20-Amp, 250-V Fuse (F2) (Part No.0998-1621
- One 4-Amp, 250-V Slo-Blo Fuse (F1) (Part No.0998-1616)

240- V Instrument:

- One 2-Amp, 250-V Slo-Blo Fuse (F1) (Part No.0998-1614)
- Two 10-Amp, 250-V Slo-Blo Fuses (F2 and F3) (Part No.0998-1602)

TCD Power Supply Board Fuses

To gain access to the TCD Power Supply Board, remove the three screws securing the right side instrument panel and remove the panel. Remove the SEMS screw securing the TCD Power Supply transformer, then slide out the transformer. The TCD Power Supply Board is located behind the transformer. There are three fuses on the board:

- One 1-Amp, 250-V Slo-Blo Fuse (FS1) (Part No.0998-1611)
- Two 1/4-Amp, 250-V Slo-Blo Fuses (FS2 and FS3) (Part No.0998-1609)

Autosampler Transformer Fuses

To gain access to the autos ampler transformer, remove the two screws securing the left side instrument panel, remove the panel, then remove the ground lead from the stud located on the inside of the panel. Remove the screw securing the transformer to the instrument base, then slide out the transformer. There are three fuses attached to the side of the transformer that faces the front of the instrument:

- Two 4-Amp, 250-V Slo-Blo Fuses (Part No.0998-1616)
- One 10-Amp, 250-V Slo-Blo Fuse (Part No.0998-1602)

Check Resistance Values

Whenever you check the resistance of the sensors, heaters, and TCD filaments, make sure they are equal to the following values at room temperature:

ALL TEMPERATURE SENSOR'S: 110

TCD HEATER: 142

OVEN HEATER: 10

ALL DETECTOR AND INJECTOR ZONES: 148

TCD FILAMENTS:

65 across bridge

49 across one leg

Schematics Diagrams

N610-0998	Interconnect Diagram, AS-XL, 230V (2 sheets)
N610-0999	Interconnect Diagram, AS-XL, 120V (2 sheets)
N610-90l0	Power Distr. Schematic, 120V, 9000
N610-9030	FID Amp Schematic, 9000
N610-9080	Pressure Trans Schematic, 9000
N610-9090	FPD Amp Schematic, 9000
N610-9l00	ECD Amp Schematic, 9000
N610-9ll0	HWD Amp Schematic, 9000
N610-92l0	EXTN Amp Schematic, 9000
N610-9230	PID Amp Schematic, 9000
N610-9250	PID Volt Supply Schematic, 9000
N610-9260	NPD Amp Schematic, 9000
N610-9270	Main PCB 68332 Schematic, 9000 (7 sheets)
N610-9280	Qtr Step 68332 Schematic, 9000 (4 sheets)
N610-9290	PCBS PPC Control (8 sheets)
N650-9000	Clarus Schematic

Schematics 10

Schematic Diagrams

Part Number	Diagrams
N610-0998	Interconnect Diagrams, AS-XL, 230V (2 sheets)
N610-0999	Interconnect Diagram, AS-XL, 120V (2 sheets)
N610-9010	Power Distr. Schematic, 120V, 9000
N610-9030	FID Amp Schematic, 9000
N610-9080	Pressure Trans Schematic, 9000
N610-9090	FPD Amp Schematic, 9000
N610-9100	ECD Amp Schematic, 9000
N610-9110	HWD Amp Schematic, 9000
N610-9210	EXTN Amp Schematic, 9000
N610-9230	PID Amp Schematic, 9000
N610-9250	PID Volt Supply Schematic, 9000
N610-9260	NPD Amp Schematic, 9000
N610-9270	Main PCB 68332 Schematic, 9000 (7 sheets)
N610-9280	Qtr Step 68332 Schematic, 9000 (4 sheets)
N610-9290	PCBS PPC Control (8 sheets)

Hardware System 11

About this Chapter....11-2
Detectors....11-3
Flame lonization Detector (FID)....11-3
Electron Capture Detector (ECD)....11-4
Thermal Conductivity Detector (TCD)....11-5
Flame Photometric Detector (FPD)....11-6
Nitrogen Phosphorus Detector (NPD)....11-7
Photoionization Detector (PID)....11-8
Electrolytic Conductivity Detector (ELCD)....11-9
Injectors....11-12
Packed Column Injector....11-12
Capillary (Split/Splitless) Injector....11-13
Programmable Split/Splitless (PSS)....11-15
Programmable On-Column (POC)....11-18
Pneumatic Controls....11-19
Manual Pneumatic Controls....11-19
Programmable Pneumatic Control....11-19
Oven....11-27

About this Chapter

This chapter briefly describes the components of the Clarus 500 GC mechanical system, which includes detectors, injectors, pneumatic controls, and the oven. Since we assume that you have working knowledge of gas chromatography, some basic information has been omitted.

The following sections are included in this chapter:

- Detectors
- Injectors
- Pneumatic Controls
- Oven

Detectors

The Clarus 500 GC can be ordered with any of the following detectors:

- Flame Ionization Detector (FID)
- Electron Capture Detector (ECD)
- Thermal Conductivity Detector (TCD)
- Flame Photometric Detector (FPD)
- Nitrogen Phosphorus Detector (NPD)
- Photoionization Detector (PID)
- Electrolytic Conductivity Detector (ELCD)

Each detector has one analog output that can be attached to either an integrator or a recorder, with the signals routed under instrument control.

Flame Ionization Detector (FID)

The Flame Ionization Detector is used for the destructive analysis of organic compounds. Sample enters the detector, mixes with hydrogen and is then burned in air which is introduced around the jet tip. The ions formed by burning the organic compound are collected by an electrode and the resultant current is measured. The current is proportional to the amount of compound present. Ion collection is enhanced due to a polarized electric field created by applying a negative voltage (-200 volts) to the jet tip. The sensitivity is affected primarily by the hydrogen flow.

WARNING

Flame Ionization Detectors use hydrogen as fuel. If the hydrogen is turned on without a column attached to the detector fittings inside the oven, hydrogen could diffuse into the oven creating the possibility of an explosion. **To avoid possible injury, do not *turn* on the hydrogen unless a column is attached to the detector fittings inside the oven and all fittings have been leak tested.**

Before disconnecting a column, make sure that the hydrogen has been turned off.

If two FIDs are installed and only one has a column attached to it, make sure you cap off the unused detector inlet fitting with a 1/8-inch stainless steel plug (Part No. N930-0061).
The hydrogen needle valve has been set very low to avoid potential damage to the FID. Set both the hydrogen and air inlet pressures to 30 psig for manual pnuematics and 90 psig for PPC. Then measure and set the flows.

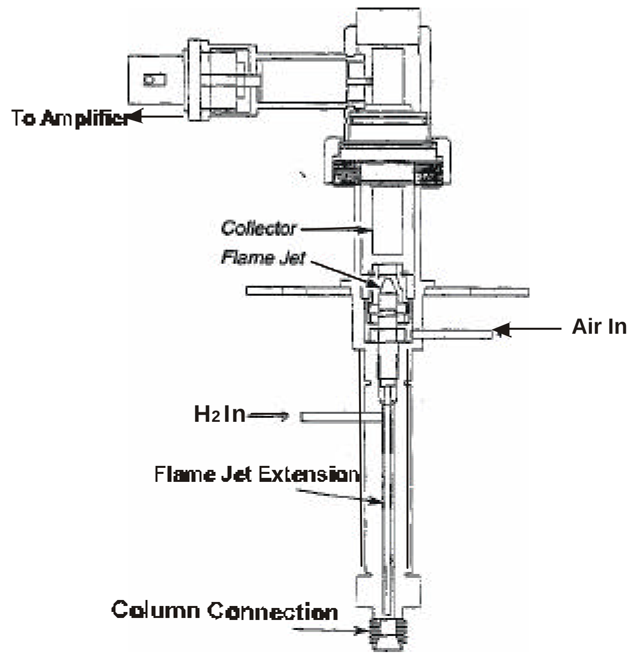


Figure 11- 1 Cross-Section of the Flame Ionization Detector.

Electron Capture Detector (ECD)

The electron Capture Detector is the most sensitive detector available for the non-destructible analysis of electrophilic compounds, such as chlorinated hydrocarbons. The ECD is particularly useful for the analysis of pesticide residues.

The ECD cell contains a nickel foil in a cylinder through which the carrier gas flows. The coating of the foil's inner surface contains 15 millicuries of the radioactive istope Nickel-63.

Beta particle emitted from the isotope ionize the carrier gas. The resultant ions and electrons travel to the collector anode assembly under the influence of a pulsed polarizing voltage applied between the source and the collector. The pulse frequency is varied to maintain a constant average current. The presence of an electron absorbing species in the detector decreases the current as the absorbed electrons form ions, which travel more slowly than electrons. The pulse frequency of the polarizing supply is automatically controlled to maintained a constant current and is used to form the detector output signal.

Make-up gas is combined with column effluent to optimize the detector response.

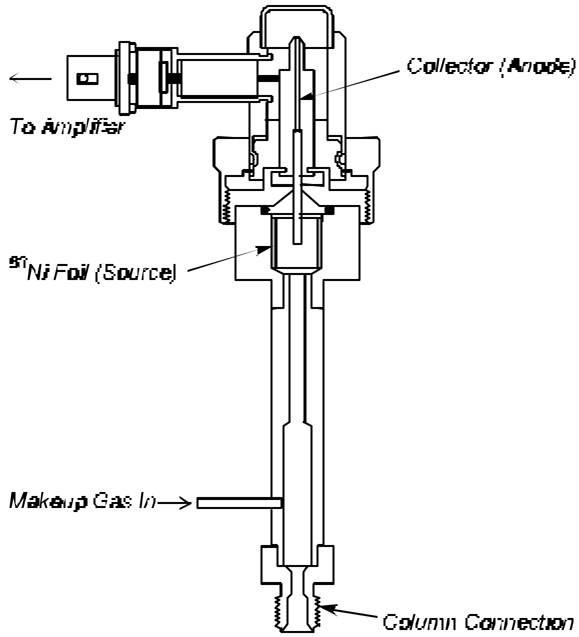


Figure 11- 2 Cross Section of the ECD

Thermal Conductivity Detector (TCD)

The Thermal Conductivity Detector is a dual channel detector that measures the difference in thermal conductivity between carrier gas flowing through a reference channel and carrier gas and sample flowing through an analytical channel.

Four tungsten-rhenium filaments are connected in a bridge circuit, two in each channel. The TCD is set up with the same amount of carrier gas flowing through both channels. The presence of a sample component in the carrier gas flowing through the analytical channel changes the resistance of the filaments to the amount of sample.

The TCD sensitivity depends on the filament current, component concentrations and the difference in thermal conductivity between the carrier gas and the component.

The TCD is non-destructive and therefore can be used in series with other detectors.

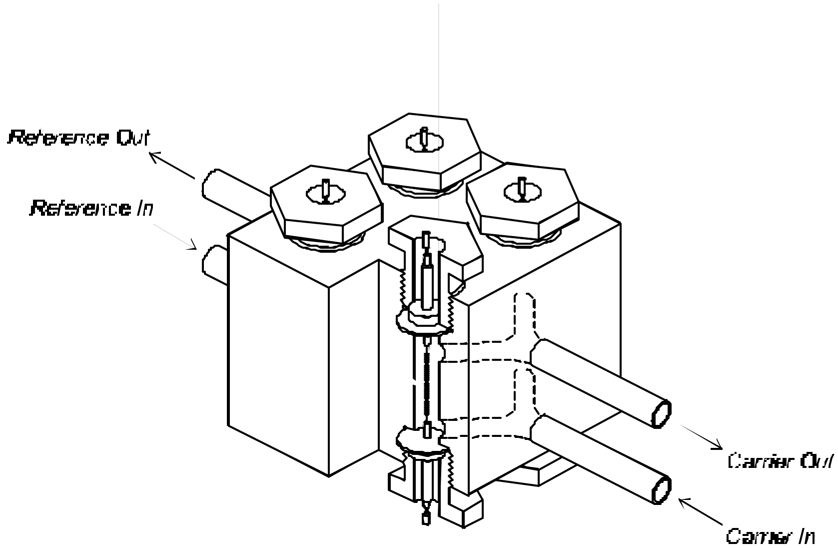


Figure 11- 3 Thermal Conductivity Detector

Flame Photometric Detector (FPD)

WARNING

Flame lonization Detectors use hydrogen as fuel. If the hydrogen is turned on without a column attached to the detector fittings inside the oven, hydrogen could diffuse into the oven creating the possibility of an explosion. **To avoid possible injury, do not *turn* on the hydrogen unless a column is attached to the detector fittings inside the oven and all fittings have been leak tested.**

Before disconnecting a column, make sure that the hydrogen has been turned off.

If two FIDs are installed and only one has a column attached to it, make sure you cap off the unused detector inlet fitting with a 1/8-inch stainless steel plug (Part No. N930-0061).
The hydrogen needle valve has been set very low to avoid potential damage to the FID. Set both the hydrogen and air inlet pressures to 30 psig for manual pnuematics and 90 psig for PPC. Then measure and set the flows as stated in this chapter.

In the FPD, the column effluent is mixed with hydrogen and then burned in air. Light emitted from the flame passes through a lens, a filter, and to a photomultiplier tube, which generates an electrical signal.

The Flame Photometric Detector is used for detecting sulfur, phosphorus, or tin compounds, which produce chemiluminescent reactions with emissions at wavelengths characteristic of the S2 and SN HPO species.

A filter that isolates sulfur emissions is supplied with the detector. A filter that isolates phosphorus emissions, and a filter that isolates tin emissions are also available.

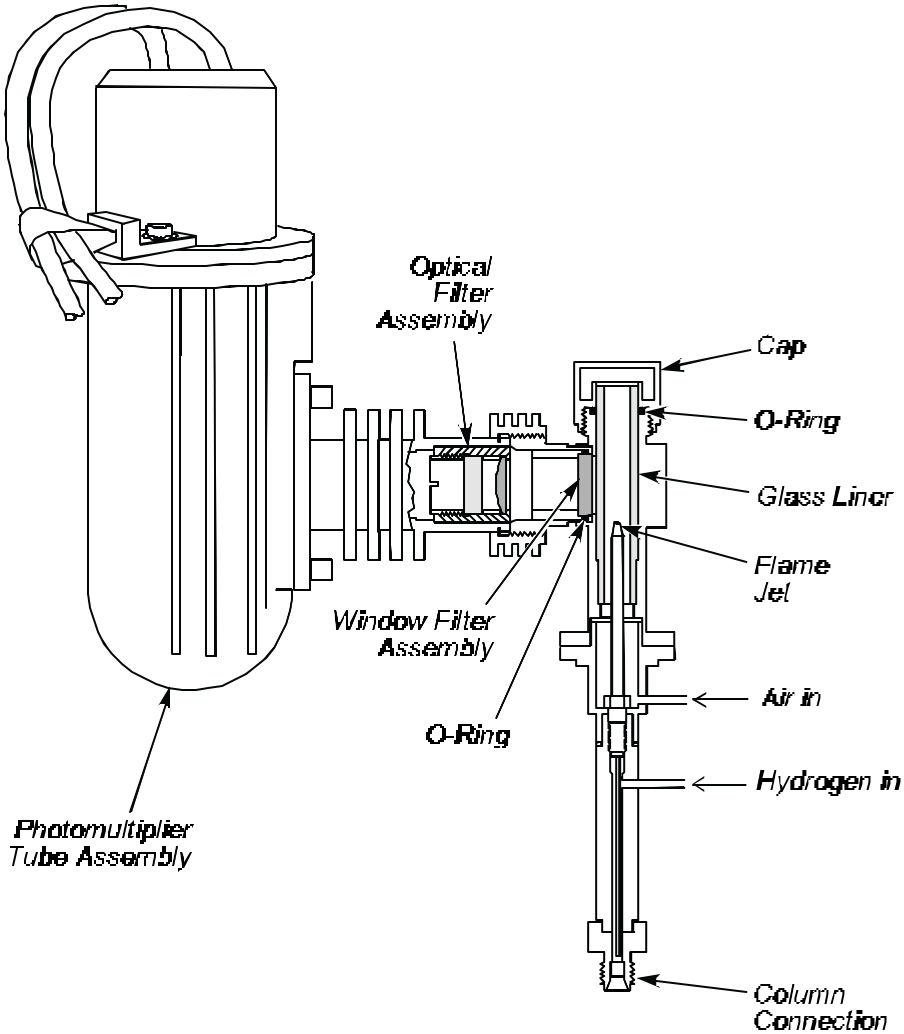


Figure 11- 4 Flame Photometric Detector

Nitrogen Phosphorus Detector (NPD)

The Nitrogen Phosphorus Detector (NPD) is a highly specific thermionic detector for organically-bound nitrogen and phosphorus.

The detector operates by electrically heating a glass bead, that contains an alkali metal, to the point where it emits electrons. A mixture of hydrogen gas and air flows around the bead to produce a hydrogen plasma. Stable intermediated are formed in the hydrogen plasma which then capture the electrons emitted from the bead to produce ions. A polarizing field directs these ions to the collector electrode, thereby creating a current which is amplified.

Sensitivity is affected primarily by the air flow, and selectivity is affected primarily by the hydrogen flow.

CAUTION	*Chlorinated solvents **MUST NOT** be used with this detector. The life and performance of the alkali bead will be severely impaired by contact with chlorinated compounds. In general, any halogenated compounds will degrade bead performance; therefore, avoid using stationary phases containing these compounds whenever possible. The use of solvents such a water, methanol or ethanol will also reduce bead performance and life. Although these solvents may still be used, they should be avoided whenever possible.*

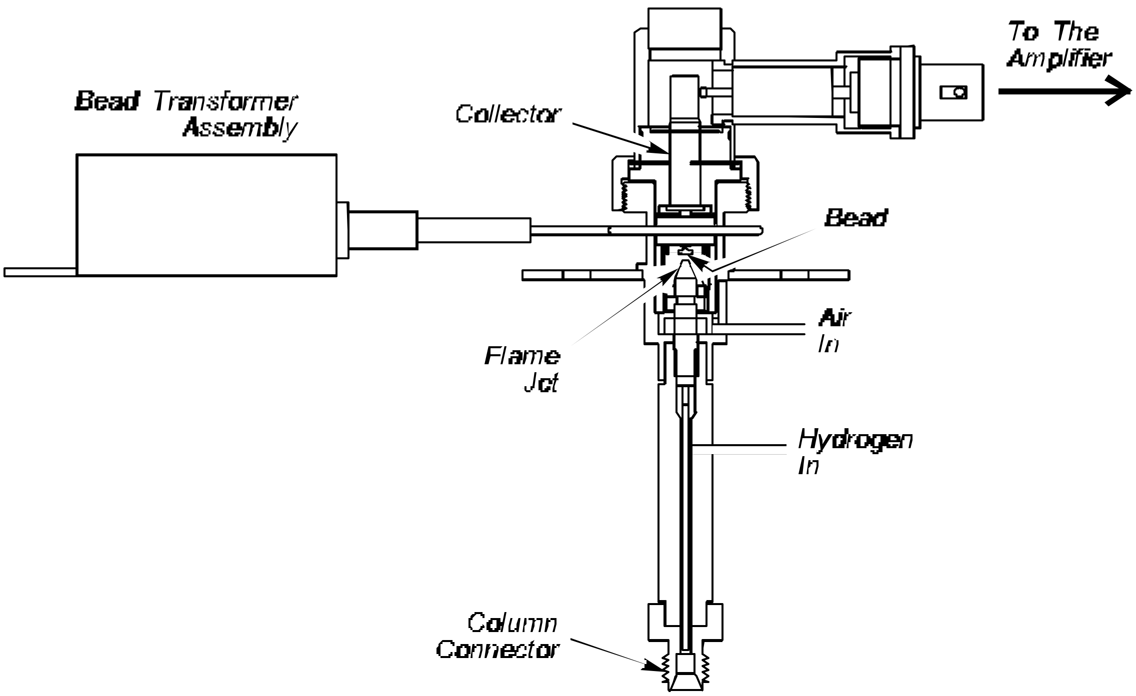


Figure 11- 5 Nitrogen Phosphorus Detector.

Photoionization Detector (PID)

The Photoionization Detector (PID) is designed to allow the effluent from a chromatographic column to be ionized by ultraviolet light (provided the ionization potential of the effluent is less than that of the UV source). The current produced by the ion flow is measured by the detector and is proportional to the concentration of the ionized material.

CAUTION	*The optimum operating temperature for a photoinization detectors 250°C. PIDs may be operated at 350°C for short periods of time with a subsequent loss in lamp life.*

The PID is equipped with a glass lined inlet and exhaust that permit series operation with another detector.

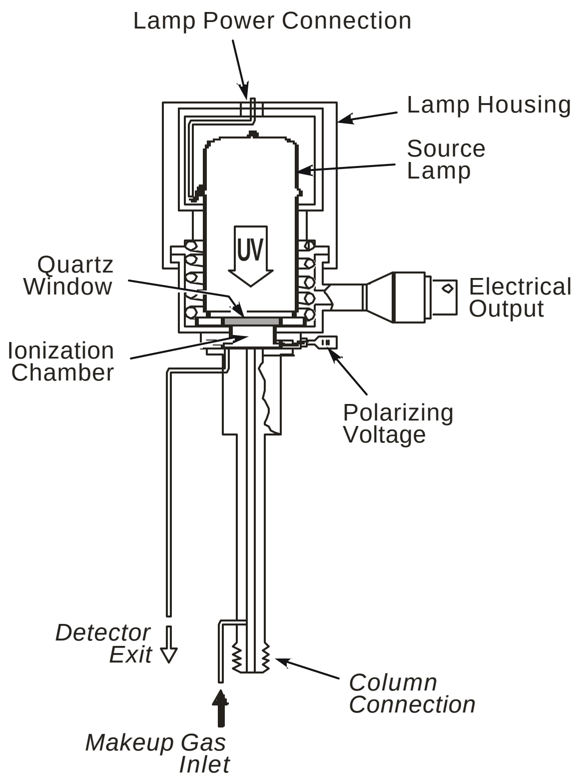


Figure 11- 1 Schematic of a PID.

Electrolytic Conductivity Detector (ELCD)

Electrolytic Conductivity Detectors (often referred to as Hall detectors) are halogen specific. GC column effluent is mixed with hydrogen and passed through a heated nickel reactor\tube where the halogen is reduced forming an acid (HC1, HBr, HI or HF). The acid is absorbed in n-propanol. The increased conductivity of the acid in n-propanol is measured and the signal is proportional to the amount of converted halogen.

The illustration below shows a schematic of the ELCD components and the route taken by the column effluent and solvent.

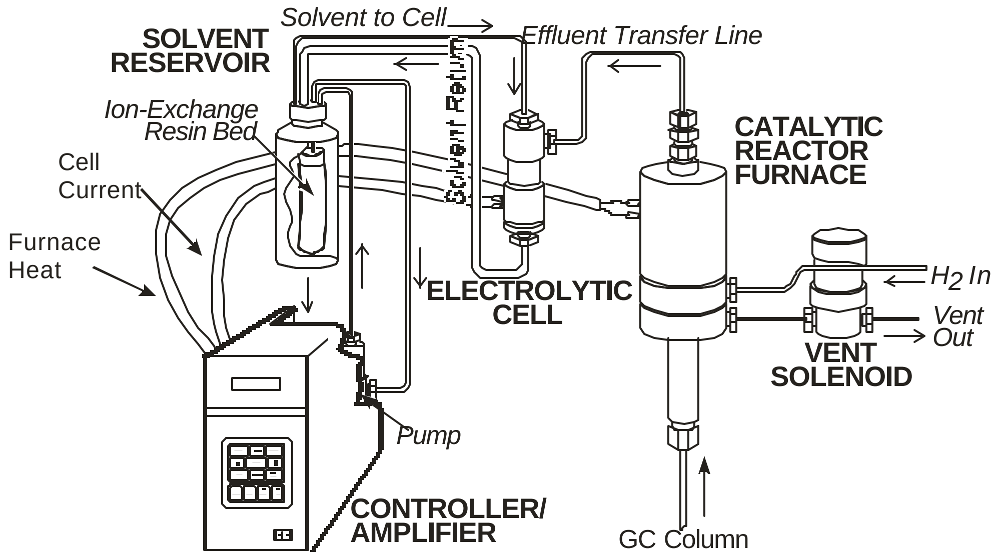


Figure 11- 2 ELCD Flow Chart

Reactor assembly and conductivity cell details are shown in the illustration on the next page.

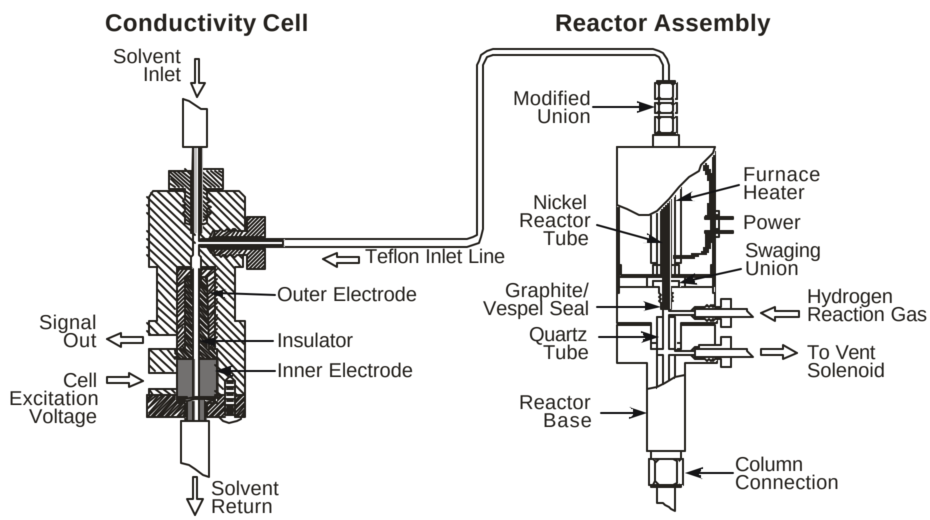


Figure 11- 3 ELCD reactor assembly and conductivity cell.

ELCD Control Unit

The ELCD is operated using the control unit, which is shown below.

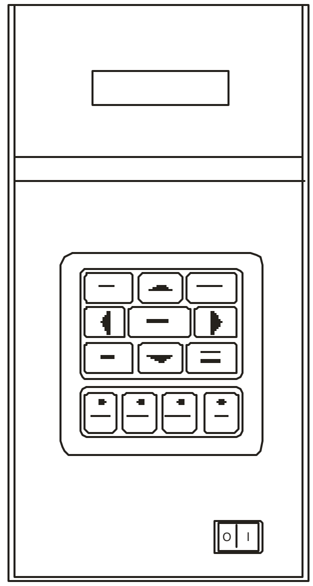


Figure 11- 4 ELCD Control Unit

Injectors

The Clarus 500 GC can be ordered with any of the following injectors:

- Packed Column
- Capillary (Split/Splitless)
- Programmable Split/Splitless (PSS)
- Programmable On-Column (POC)

The instrument can be fitted with two injectors, one in each channel. Refer to the *Clarus 500 GC User's Manual* for additional details (0993-6073).

Packed Column Injector

The packed column injector consists of a septum cap, needle guide, quartz injector liner, and the injector body. This injector is used with 1/8-inch or 1/4-inch glass or metal packed columns. In addition, by installing the 530 Micron Wide-Bore Adapter Kit (P/N N612-0001) you can convert the injector to accept wide-bore capillary columns.

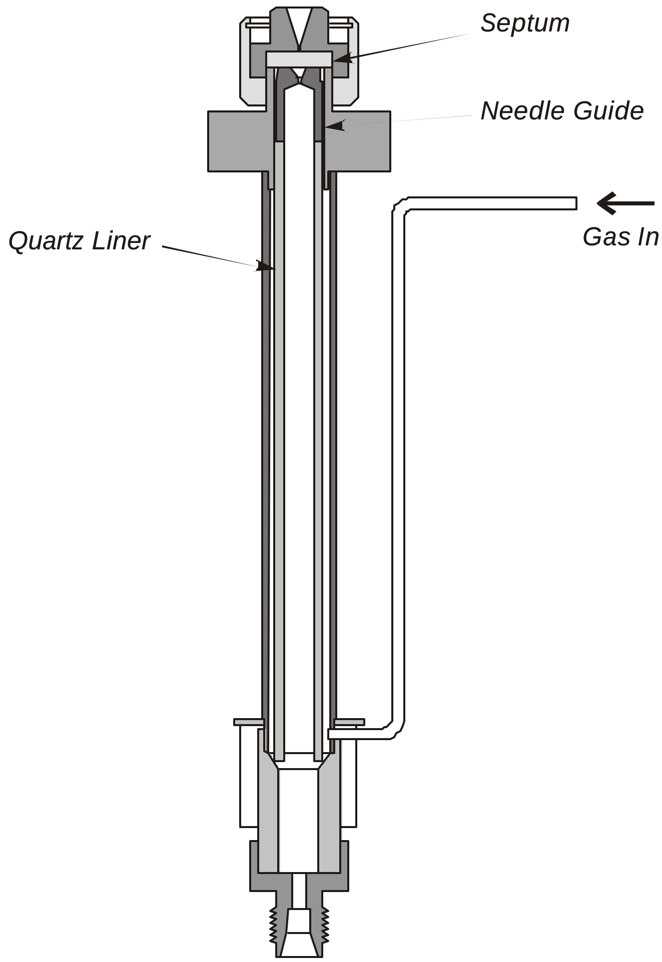


Figure 11- 9a Packed Column Injector

Capillary (Split/Splitless) Injector

The Capillary (Split/Splitless) Injector consists of a septum purge assembly and the injector body. Carrier gas enters the injector body at the point just above the O-ring and, flows through the quartz liner past the column tip.

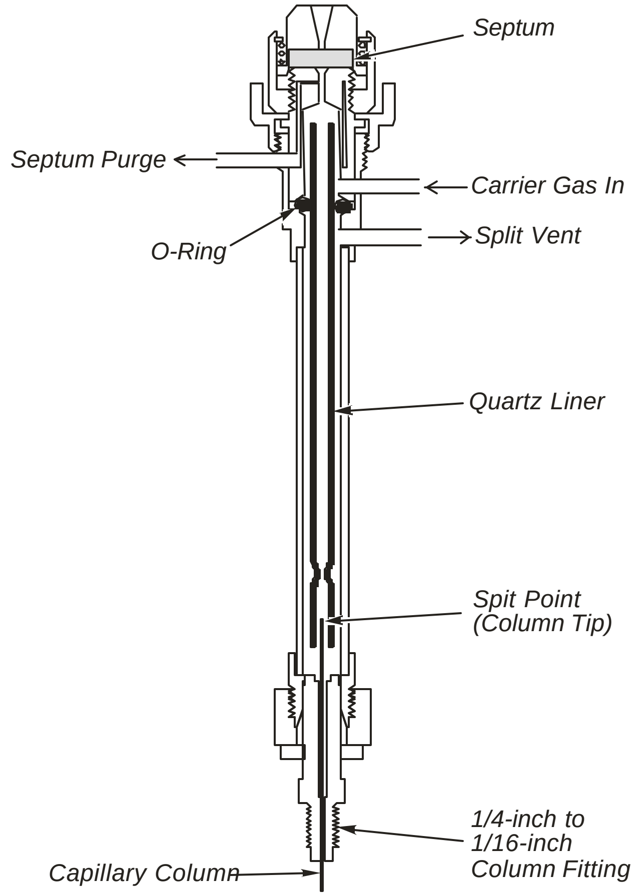


Figure 11- 5 Cutaway schematic of the Split/Splitless Injector.

The CAP injector uses the following two quartz liners:

- Narrow-bore (2-mm i.d.) liner (P/N N612-1002).
- Wide-bore (4-mm i.d.) liner (P/N N612-1001).

The narrow-bore liner is generally used for splitless injections and the wide-bore liner is generally used for split injections. Due to its small internal volume (0.3 mL), the amount of sample injected into the narrow-bore liner should be limited to about 0.5 uL. This prevents the solvent expansion upon injection from overfilling the liner with vapor.

To wipe the syringe needle, we recommend packing a small amount of quartz wool in the top portion of all liner types or injection modes (for example, split or splitless). Each liner should be packed with the quartz wool as described later in this chapter.

Splitless Injections

In the splitless injection mode, the narrow-bore quartz liner is typically used without quartz-wool. The narrow-bore decreases the sample residence time in the liner and making it useful for trace analysis with smaller sample volumes (0.5 uL or less). By closing the split vent, most of the sample mixture enters the column. Then opening the split vent, clears the inlet of residual solvent.

For splitless injection volumes over 0.5 uL, the wide-bore liner with an internal volume of 1.25 mL should be used. However, the amount of sample should be limited to a maximum of 2 uL for hydrocarbon solvents and less than that for high-expansion solvents such as water or CH C. Refer to Table 10-1 for examples of gas volumes formed upon sample injection for selected solvents.

If the wide-bore liner is used for splitless injection, the splitless sampling time (vent-on time) should be at least one minute or more. Also, lower initial oven temperatures may be required to produce good solute resolution in the first few minutes after the solvent peak. The wide-bore liner should be used with columns having an i.d. of 0.32 mm or greater.

Table 11-1. Gas Volumes Formed Upon Sample Injection (Injector 250 °C, Inlet pressure 10 psig)

Solvent	Volume Injected (µL)	Gas Volume Generated (µL)
Methylene Chloride	1	333
	2	571
Methanol	1	475
	2	768
Water	1	823
	2	1166

Split Injections

In the split injection mode, the wide-bore quartz liner is packed with quartz wool to ensure thorough mixing of the sample and carrier gas before they encounter the column tip. The split vent is open at the time of injection so that a fraction of the sample mixture enters the column while the remainder is routed out through the split vent.

Programmable Split/Splitless (PSS)

The Programmed Split/Splitless Injector (PSS) consists of a septum purge assembly and the injector body. Carrier gas enters the injector at a point just above the O-ring and flows through the quartz liner past the column tip.

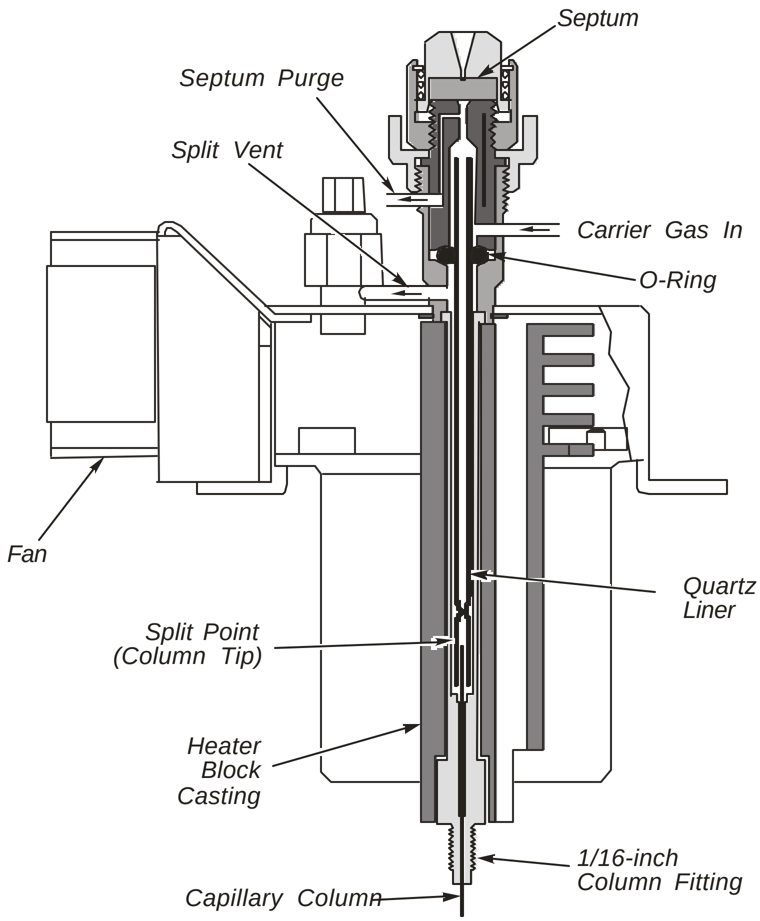


Figure 11- 6 Schematic of a Programmed Split/Splitless Injector (PSS)

The PSS injector uses the following three quartz liners:

- 2.0-mm i.d. (wide-bore) liner (P/N N612-1004)
- 1-mm i.d. (narrow-bore) liner (P/N N612-1006)
- hourglass liner (N610-1539)

In general, for split or splitless injections, use the 2-mm or 1-mm i.d. liner and operate the PSS in the inlet-programmed mode. For on-column operation, use the hourglass liner and the oven program mode. The 2-mm i.d. liner should be packed with quartz wool as described in this chapter and used for either split or splitless operation. The 1-mm i.d. liner may give better resolution of the early-eluting peaks in the split or splitless mode and it is better for labile compounds; however, it should be used for those samples with early-eluting peaks for which additional solute trapping focusing cannot be obtained by lowering the initial oven temperature or by using a column with a thicker stationary phase film.

To wipe the syringe needle, in all liner types (wide-bore or narrow-bore) or injection modes (split or splitless), we recommend packing a small amount of quartz wool in the top portion of the liner.

The sample is injected into the PSS injector at a "cool" temperature. The injector temperature is then programmed to increase. This is useful for samples that are thermally labile and/or have a wide molecular weight range. The PSS injector can also be used in a programmed on-column mode by replacing the quartz liner with the hourglass liner and closing the split vent flow.

CAUTION	*The PSS can be used in the "hot" split or splitless mode. This, however, is not recommended for use with the 1mm i.d. liner; it could cause solvent flashback in the injector. This mode should be used with caution depending upon the solvent and temperatures you choose. See Table 11-1.*

CAUTION	*When using the PSS in the on-column mode with the autosampler, you must us a special syringe that has a needle o.d. of 0.47 mm (P/N N610-1253 or N610-1380). Refer to Chapter 6, "Controlling the Autosampler" for more detail. You must use only the "Norm" injection speed with this syringe in the on-column mode. The "Fast" injection speed will bend this thin needle; the "Slow" injection speed may produce double peaks due to the momentary stoppage of column flow during the longer injection. You can achieve better precision in the on-column mode when sample volumes of 1.0 µL or greater are injected.*

Split Injections

In the split mode, the wide-bore quartz liner is packed with quartz wool to insure thorough mixing of the sample and carrier gas before they reach the column tip. The split vent is open at the time of injection so that a fraction of the sample mixture enters the column while the remainder is routed out through the split vent.

Splitless Injections

In the splitless mode, the narrow-bore quartz liner is typically used without tightly packed quartz wool for mixing. Instead, a small amount of quartz wool in the center is recommended. This is useful for trace analysis with smaller sample volumes (less than 1 uL). By closing the split vent, most of the sample mixture enters the column, then the split vent is opened to clear the injector inlet of residual solvent.

Solvent Purge Injections

In applications where the sample is in a trace concentration and has a high molecular weight, this sample can be injected into the PSS with the vent open and the starting temperature near the boiling point of the solvent. In this way, only the solvent is purged out through the vent, then the vent is closed and the injector temperature is programmed up to elute the peaks of interest onto the column. This technique allows larger quantities of sample to enter the column without large solvent effects.

Programmable On-Column (POC)

The Programmed On-Column Injector (POC) consists of an hourglass adapter, a deactivated 0.53-mm ID fused-silica pre-column, and a fused-silica universal connector. The pneumatics consist of a flow controller with a 0-10 ml/min flow element. The sample is injected into the POC at a "cool" temperature; the injector temperature is then programmed to increase. This is helpful for samples that are thermally labile and/or of a wide molecular weight range. This injector is used only for trace analysis or diluted solutions.

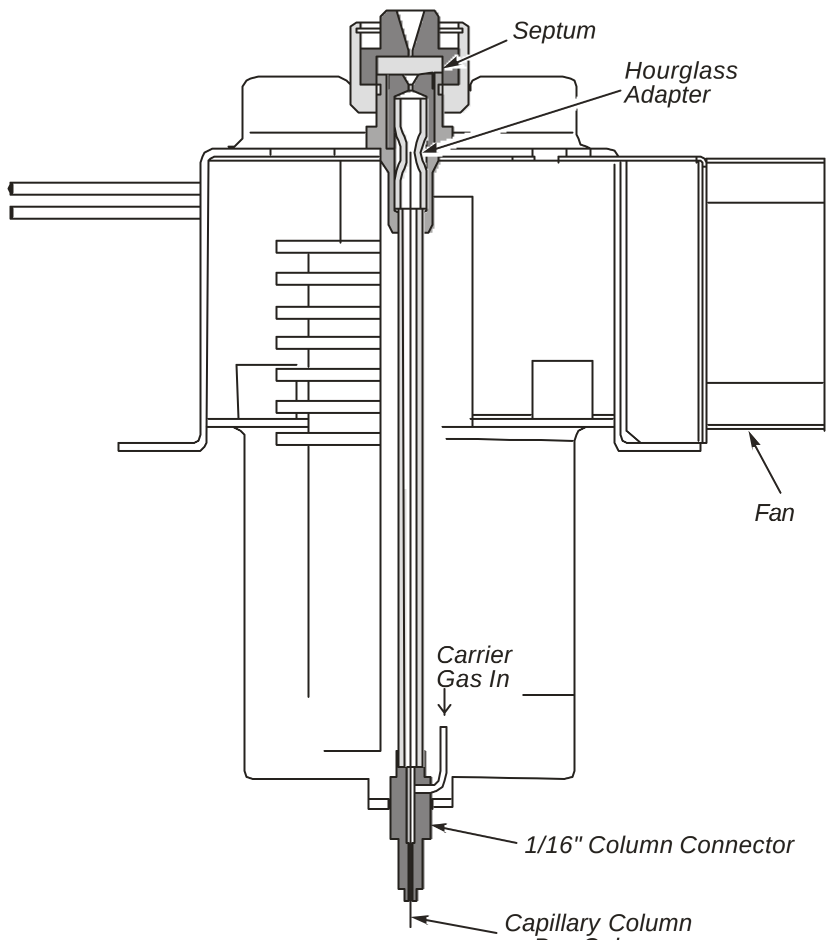


Figure 11- 7 Schematic of a Programmed On-Column Injector (POC).

Pneumatic Controls

The Clarus 500 GC can be ordered with manual or programmable pneumatic controls. This section describes both types of pneumatic controls.

Manual Pneumatic Controls

There are carrier gas controls and detector gas controls built into the Pneumatics Control Panel, located on the instrument top. Carrier gas controls include flow control for packed columns or wide bore capillary columns, and pressure control for narrow bore capillary columns. Detector gas controls include E/air for the FID, reference gas for the TCD, and makeup gas for the ECD.

The following illustration is an example of a dual channel pneumatics panel for a capillary injector with an FID in Channel 1, and a packed injector with an ECD in Channel 2. For each channel, the injector pneumatics controls are on the left, while the detector pneumatics controls are on the right.

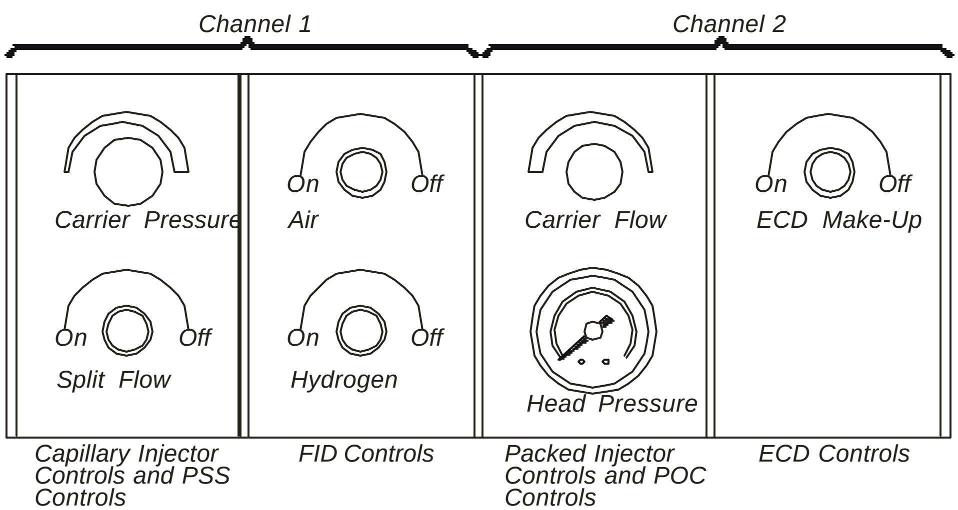


Figure 11-8 Example of a Pneumatic Control Panel.

Programmable Pneumatic Control

Programmable Pneumatic Control (PPC) implements electronic control of pressures and flows for inlet, detector, and auxiliary gases. PPC control modules regulate pressures and flows using electronically driven variable restrictors. The control modules also include pressure and flow transducers that provide feedback. A PPC controller board drives the variable restrictors on the control modules by comparing actual pressures and flows to setpoints determined from user-entered values. The firmware also compensate for the following changing conditions:

Changes in the gas: The firmware compensate for changes in the gas type in a flow controller by adjusting the flow calibration according to a table of gas constants (in the same way as now done in the Clarus 500 GC). This is applicable only to Carrier-Gas flow controller implementations, and not to Detector-Gas devices.

Changes in the ambient temperature (at the individual PPC controllers): by measuring ambient temperature and compensating for its effect on gas viscosity. Setpoints are taken to be specified at 25 °C.

Changes in ambient pressure : by using a single ambient-pressure transducer to measure and compensate for Pa. Setpoints are taken to be specified at 1 atmosphere.

There are five discrete PPC modules:

- Carrier-gas flow control
- Detector-gas flow control
- Split control
- Pressure readout
- Pressure control

The modules are configured individually or combined for specific instrument requirements.

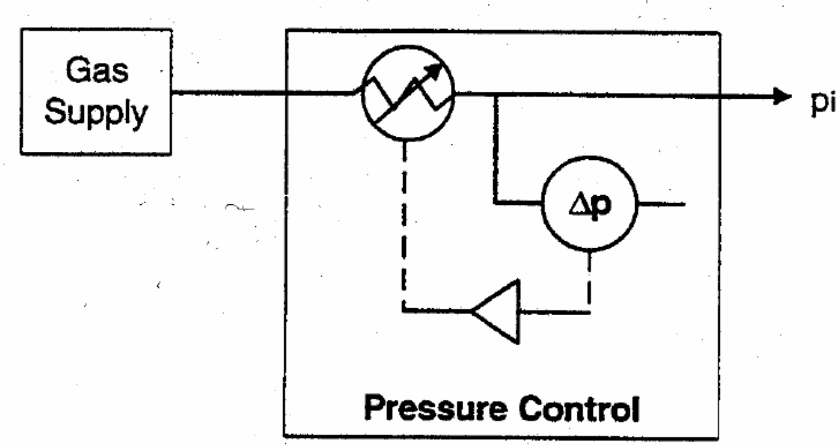


Figure 11- 9 Pressure-Control PPC Module.

A simple pressure-controller PPC module uses a variable restrictor to deliver a set output pressure. The user would enter a pressure set point from the touch screen.

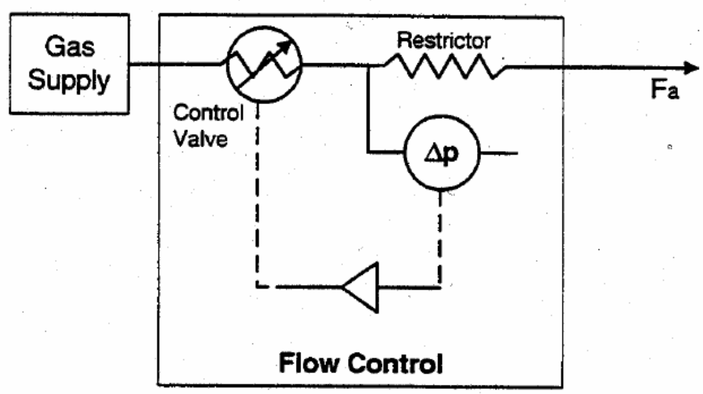


Figure 11- 10 PPC Detector-gas Flow Control Module.

This is a detector flow module capable of providing simple pressure control to a frit. The user would enter a flow from the Keyboard and the software will calculate the pressure required to obtain this flow into atmospheric pressure. It is designed to operate into a constant outlet pressure and uses only one pressure transducer. It must be calibrated at a fixed supply pressure. To compensate for tolerances in the module components, the user will be able to calibrate the flows using a calibration procedure.

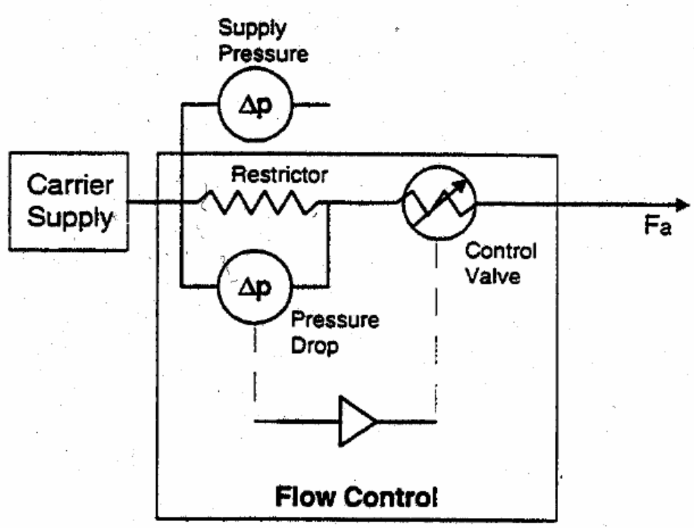


Figure 11- 11 PPC Carrier-gas flow control module.

The Carrier-gas flow module operates by controlling the pressure drop across a calibrated restrictor "FRIT", relative to the gas-supply pressure. This module is capable of delivering constant mass flow into a variable backpressure. The user enters a flow value from the keyboard and the software calculates the pressure drop required across the restrictor to obtain this flow. This may be adjusted by setting a flow program and/or by timed events (either up or down) in the method. If the set-point cannot be attained at any time (e.g. if carrier gas has run out), the system will enter a '**NOT READY**' conditions. To compensate for tolerances in the module components, the user will be able to calibrate the flows using a calibration procedure.

Flow Control/ Pressure Readout:

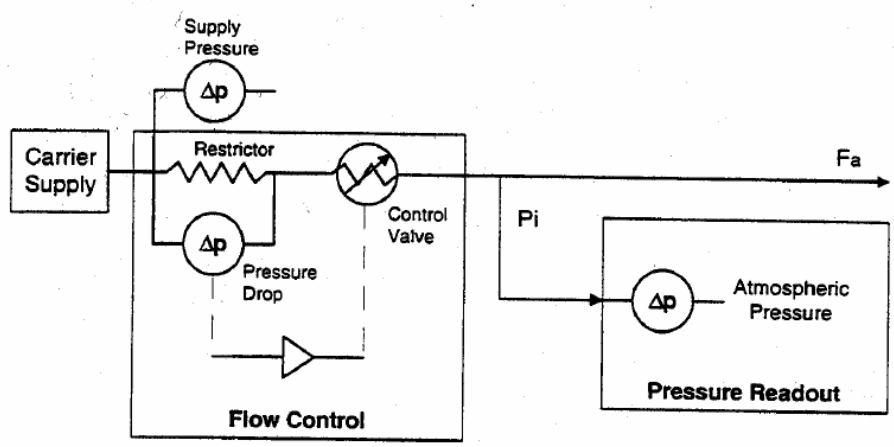


Figure 11- 12 Carrier-Gas Flow-control with Pressure-readout PPC Module

In order to read the back pressure, an optional pressure-readout PPC module must be connected. With the addition of the Pressure Readout module the user is able to define a window for which the column head pressure should remain. If the column head pressure leaves this defined window the instrument would become '**NOT READY'**.

Pressure Control/Flow Readout:

This module contains the same components of the previous module. The two configuration (flow or pressure control) can be switched via software configuration. In this configuration the module can control carrier-gas pressure and display mass-flow rate. Once again user defined windows can be set to monitor chromatographic conditions (e.g. column head pressure, carrier flow).

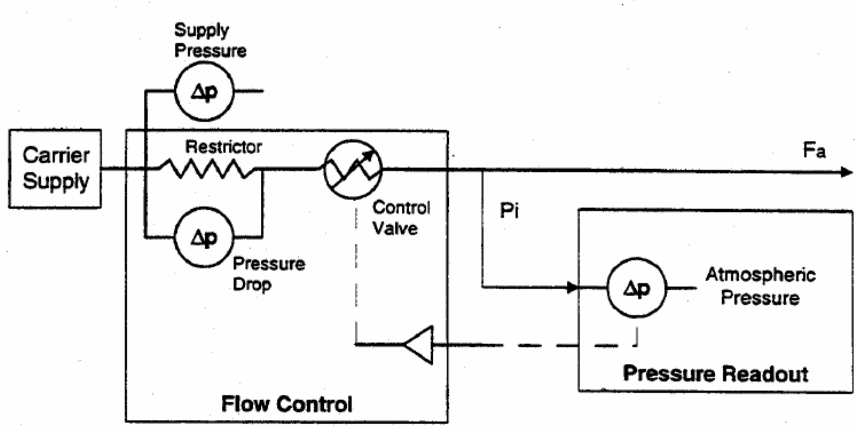


Figure 11- 13 Carrier-Gas Pressure Control with Flow readout PPC Configuration

Splitless Control Pneumatics (Foward Pressure)

For a split injection system, a Carrier Flow module is combined with a split-control version of the pressure-control module. In this system (foward pressure), the total flow is delivered through the calibrated frit (A), the pressure drop across the frit is used to calculate total inlet flow. The inlet pressure (B) is controlled by the pressure-control module. The total inlet flow value plus the information defined by the method (Inlet pressure, Split information and Purge value) are used to control the split flow. The split-control requires knowledge of the septum-purge flow rate (Fsp) in order to calculate the split ratio. The septum-purge flow is either a)entered by the user or b) measured periodically by shutting off the split vent flow and subtracting the column flow rate from the total inlet flow rate. Ambient pressure is also measured to determine the column outlet pressure (for flow and velocity calculations).

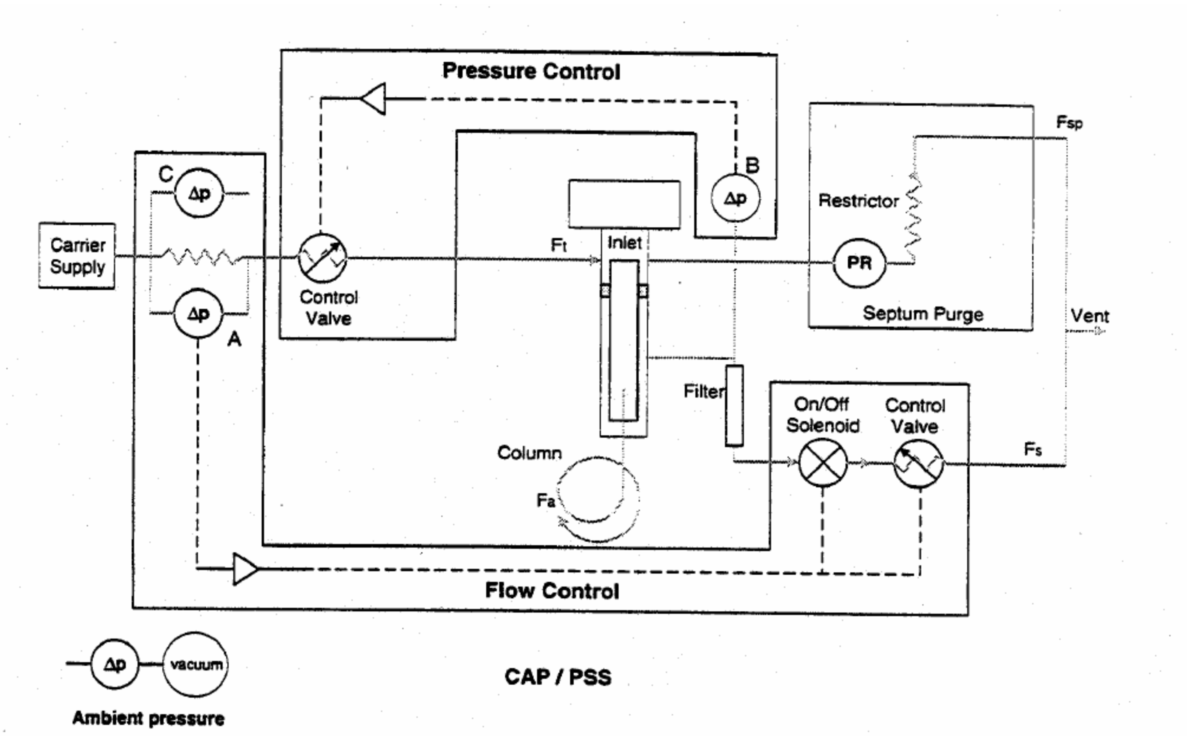


Figure 11- 14 Splitless-Control PPC pneumatics. Foreward-pressure mode.

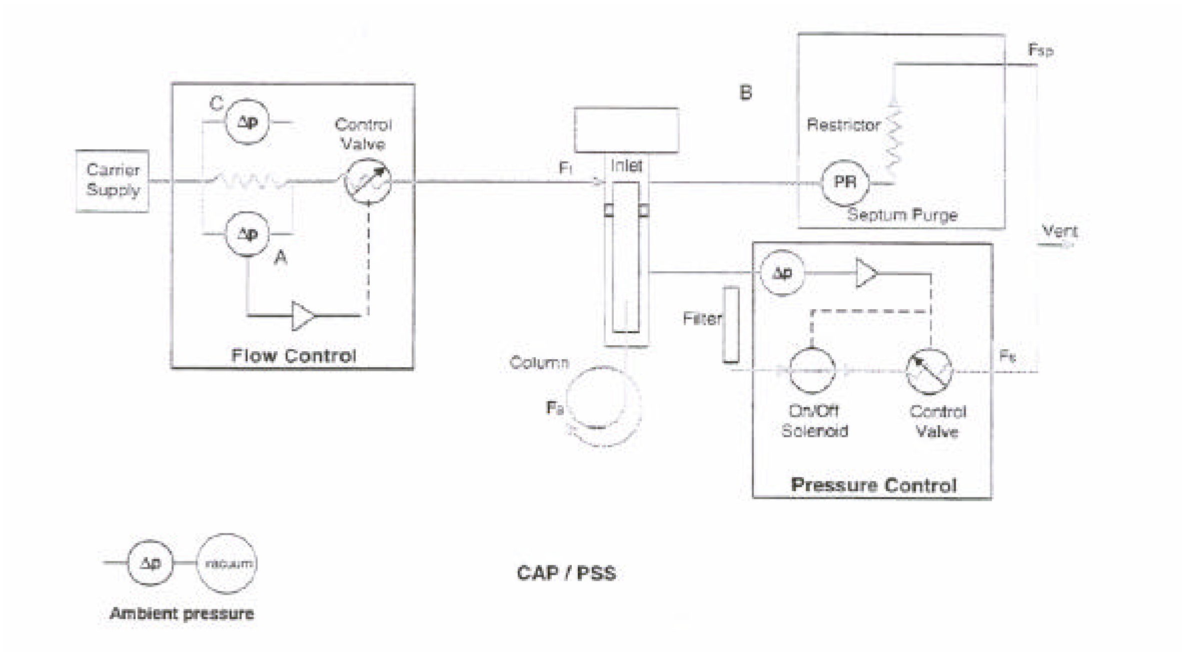


Figure 11-19a Splitless-Control PPC pneumatics. Back-pressure mode.

In this system (back pressure), the total flow is delivered through the calibrated frit. The pressure drop across the frit (A) is used to control the total inlet flow. The inlet pressure (B) is controlled by the pressure-control module with the variable restrictor at the split vent. The inlet pressure could be a set value or a programmed value as determined by the users method. Ambient pressure is also measured to determine the column outlet pressure (for flow and velocity calculations).

The Flow modules are outfitted with restrictors (frits) that determine the useful flow ranges. The restrictors will be designated with a number, 1-10, in order of increasing permeability. Each restrictor will then have a nominal flow range, from 0-maximum, depending on the type of gas in use with that frit. This maximum flow will correspond to approximately 10 psi pressure drop across the frit. These nominal flow ranges will be stored in a table in ROM. Each flow controller/transducer must be calibrated with an individual frit and a specific gas.

Table 11-2. Detector Gases to be Supported by PPC

Detector	Gas	Flow Range, ml/min
FID	H,	30-70
FID	Air	400 - 600
BCD	N,*	10-60
ECD	Ar/CH,	10-60
TCD	He*	5-60
TCD	N,	5-60
TCD	AT	5-60
FPD	H,	50-90
FPD	Air	80 - 170
NPD	H,	1-5
NPD	Air	100 - 200
Hall	H,*	40 - 80
PID	He*	10-40

* Default gas

The following table defines what frits are available for PPC applications. They are being calibrated with 30 psig of Helium being applied to one side of the frit while the other side is vented to the atmosphere. Flow is specified in terms of standard cubic centimeters per minute (seem) where the standard has been specified as 14.7 psi and 25 ° C, our GC standard. The rule of thumb is "use the most restrictive frit possible that allows the instrument to remain ready during your analysis".

Table 11-3.

PE Part#	Frit#	Frit Color	Calibrated with Helium at 30 psig to produce flows, within +/- *7.5* %, of:
N610-0321	1	Clear	1.0 seem
N610-0322	2	Red	3.0 seem
N6 10-0323	3	Yellow	10 seem
N610-0324	4	Black	30 seem
N6 10-0325	5	Green	100 seem
N610-0326	6	Blue	300 seem

Table 11-4 lists the operating range required for each columnm type.

Table 11-4. Carrier Gas Operating Rtanges for PPC

Injector	Column	Control	Flow Range in ml/min	Pressure Range in psig
Packed/GSV	Packed	Flow	5-100	5-100
Packed	0.53mm	Flow	5-20	1-10
POC	0.22 - 0.32mm	Flow	0.8 - 3.0	5-100
POC	0.53mm	Flow	5-20	1-10
Split/Splitless ,PSS	0.1 - 0.32mm	Pressure	0-300	5-100

Table 11-5 lists the carrier gas typed to be supported by PPC.

Table 11-5. Carrier Gas Types to be supported by PPC.

Hydrogen
Helium
Nitrogen
5% Methane in Argon*
Argon*

* Packed columns only

The following table defines which frit will be used with a particular injector type for mass flow control. The items shown in bold type will be shipped with the instrument. The other items will be available in accessory kits as needed for special, low flow requirements. When Nitrogen or Argon/Methane is used, its performance will be similar to Helium's with respect to the flow rate shown. The frit inlet pressure, set at 90 psig as is currently used on the Clarus 500 GC, is the applied tank pressure which must not exceed 100 psig (the specified pressure transducer range). The differential pressure across the frit, shown in the table as 10 psid or 16.7 psid, sets its flow rate, for a given gas, in an approximately linear manner.

Table 11-6. Frits used with Different injector types.

Injector Type	**Frit#**	**Frit Inlet Pressure (psig)**	**Frit Outlet Pressure (psig)**	**Flow Rate vs. Applied Gas (typically)**
Packed	4 (standard)	90	80 80 73.3	30 sccm with He ~60 sccm with H_2 50 sccm with He
Capillary or PSS	6 (standard)	90	80 80 73.3	300 sccm with He ~600 sccm with Hg 500 sccm with He
POC	3 (standard)	90	80 80 73.3	10 sccm with He ~20 sccm with H_2 16.7 sccm with He
Capillary or PSS	4 (as accy)	90	80 80 73.3	30 sccm with He ~60 sccm with H_2 50 sccm with He
POC	2 (as accy)	90	80 80 73.3	3.0 sccm with He ~6.0 sccm with H_2 5.0 sccm with He

Table 6-6. Clarus 500 GC PPC Carrier-Gas Control Modes.

Hardware Options	**Mass-flow control,** includes multi-ramp programming of carrier flow (PFlow)	**Pressure control,** includes multi-ramp programming of carrier pressure (PRess)	**Capillary control,** includes multi-ramp programming of capillary column pressure, flow, or velocity (PFlow, PRess, PVel, CFlow)
Carrier mass flow controller (CarrF)	✓		
Carrier pressure controller (PCtrl)		✓	
Carrier mass flow controller with pressure readout (CarrF + PRead)	✓	✓	
Carrier split/splitless pneumatics (CarrF + SplitC)		✓	✓

Column dimensions must be entered for the capillary control mode.

Oven

The Clarus 500 GC chromatographic oven has an operating range of -99 °C to 450 °C, and uses a three-ramp temperature program. All temperature zones are controlled by the instrument software. The following illustration shows the flow of air into and out of the oven.

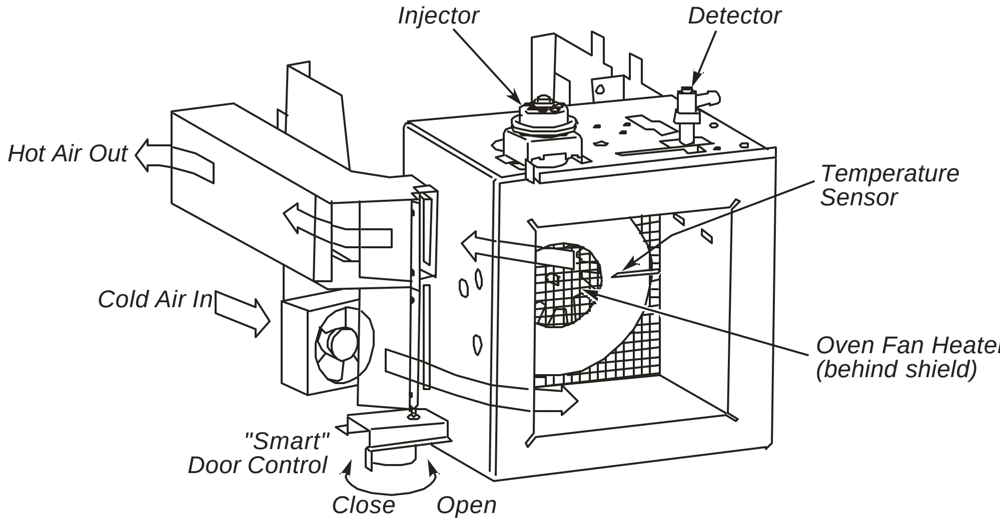


Figure 11- 15 Clarus 500 GC Oven Air Flow.

Pneumatics 12

Pneumatics..12-3
Auxiliary Pneumatics 12-3

Pneumatics

A full range of pneumatics options provides optimum performances with all types of columns and detectors. The Clarus 500 GC may be ordered with or without PPC™, (Progammable Pneumatic Control). If the instruments is ordered with PPC, each option may be ordered with PPC or conventional pneumatics.

Carrier Gas Pneumatics

- Carrier gas pneumatics are configured with the Clarus 500 GC Injector
- PPC or conventional pneumatics are available for all injectors
- Two carrier zones
- Carrier PPC zones compensate for variations in ambient temperature and pressure for maximum reproducibility.

Split Vent Pneumatics

- Split vent pneumatics are configured with the Clarus 500 GC injector
- PPC or conventional split vent pneumatics are available
- Two split vent zones
- Mass flow controller
- PPC provides direct setting of split flow rates and ratios
- Split Vent PPC zones compensate for variations in ambient temperature for maximum reproducibility.

Detector Pneumatics

- PPC or conventional pneumatics are available for all detectors
- Fourdetector pneumatics zones
- Flame-out testing with PPC
- PPC provides direct setting in mL/min, Psig, or kPa
- Detector PPC zones compensate for variations in ambient temperature for maximum reproducibility.

Auxiliary Pneumatics

- Four auxilary zones
- PPC provides direct setting in mL/min, Psig, or kPa
- Auxiliary PPC zones compensate for variations in ambient temperature for maximum reproducibility.

Service Data Bulletin 13

701 Bridgeport Ave
Shelton, CT 06484 USA

Chromatography Division

Product Service Information

Index of Service Information

Clarus 500 GC

Technical SDB: CLRINDA.XXS

L. Romano

Date: April 11, 2002

For Perkin-Elmer Internal Distribution Only

CLRS001A.SBS	Pre-Installation Checklist	04/11/02
CLRS002A.SIS	Installation Checklist	04/12/02
CLRS003A.SIS	Customer Orientation Script	04/26/02
CLRS004A.SCS	Preventive Maintenance Checklist	04/26/02
CLRS005A.SGS	IPV Certificate / Procedure	04/26/02

710 Bridgeport Ave

Shelton, CT 06484 USA

Chromatography Division

Product Service Information

Pre-Installation Checklist

Clarus 500 GC — Technical SDB: CLRS001A.SBS

L Romano — Date: April 11, 2002

For Perkin-Elmer Internal Distribution Only

PROBLEM:

N/A

PURPOSE:

To provide the field with an Clarus 500 GC Pre-Installation Checklist.

MATERIAL:

N/A

GENERAL:

The requirements given in each category should be met to ensure that the customer's lab is prepared to properly install the Clarus 500 GC.

The Customer Service Engineer should use a copy of the checklist as a sign-off. A copy of the signed document must be given to the customer. Remove this cover page before presenting to customer.

PROCEDURE:

N/A

Customer Signature:___________________ CSE Signature:_______________ Date:__

PRE-INSTALLATION CHECKLIST

Clarus 500 GC

Customer: ______________________________ Date:

______________________________ Phone ☐ Site Visit ☐

______________________________ SPO #:

______________________________ CSR #:

A pre-installation checklist (PIC) should be completed prior to any installation either when in area or by telephone.

SPO Review:

Review SPO with customer. Record any agreements or commitments made by Sales person NOT listed on SPO.

LAB SPACE REQUIREMENTS:

Instrument Size:

GC:	66cm (26 in.) wide X 40cm (19 in.) high X 64cm (25 in.) deep
Autosampler:	13cm (5 in.) wide X 36cm (14 in.) high X 24cm (9.5 in.) deep

Instrument Weight:

GC:	49kg (108 lbs.)
Autosampler:	4.5kg (10 lbs.)

Bench Space:

The laboratory bench should be sturdy enough to support the full weight of the GC as well as any additional equipment (i.e., computer and/or printer). Expect the total weight of the GC and accessory equipment to weigh at least 91kg (200 lbs.).

Allow a minimum of 10.2cm (4 in.) of clearance on each side, 15.2cm (6 in.) of clearance at the rear of the GC and 126.8cm (4.5 ft.) of clearance at the top of the GC. If this is not possible, install the GC on a bench that has wheels.

Peripherals, Accessories or PCs:

Allow at least 60.8cm (2 ft.) on either side of the GC to accommodate additional equipment.

***Customer Signature:*____________________ *CSE Signature:*________________ *Date:*___**

PRE-INSTALLATION CHECKLIST

Clarus 500 GC

POWER REQUIREMENTS:

Power Consumption:

2400 watts for the GC. Add 100 watts for the computer and 108 watts for the printer.

Power Specifications:

All electrical supplies must be smooth, clean and free of transients greater than 40 volts peak to peak and must meet and remain within the following tolerances:

120 VAC +/- 10% @ 50/60 Hz +/- 1%

220 VAC +/- 10% @ 50/60 Hz +/- 1%

Instruments & peripherals should not be connected to or near circuits with large inductive or large and frequent loads (i.e., large motors, discharge lamps, photocopy systems, radio transmitters, etc.)

Power Outlets:

A minimum of on dedicated 120 VAC outlet at 20 Amps or one 220 VAC outlet at 10 Amps is required for the GC. Additional equipment, such as computers, printers, etc., should be connected as per their specifications.

GAS REQUIREMENTS:

Carrier Gas:

Helium or Nitrogen or 8.5% Hydrogen/91.5% Helium or Make-up - 95% Argon/5% Methane:

A number 1A (200 cubic feet) gas cylinder should be used for all carrier gasses. Filter all gasses (except Argon/Methane) through a moisture filter and/or hydrogen trap and de-oxo filter. Argon/Methane should be filtered through a moisture filter and de-oxo filter. Gas delivery pressure to the GC should be 60 - 90 PSI.

Air:

A number 1A (200 cubic feet) gas cylinder of compressed air can be used. All air should be filtered through a moisture filter. Do NOT use "Breathing Air". Gas delivery pressure to the GC should be 70 - 90 PSI.

Hydrogen:

A number 2 (62 cubic feet) gas cylinder or a hydrogen generator can be used. All hydrogen should be filtered through a moisture filter. Gas delivery pressure to the GC should be 60 - 90 PSI.

***Customer Signature:*____________________ *CSE Signature:*________________ *Date:*___**

PRE-INSTALLATION CHECKLIST

Clarus 500 GC

GAS REQUIREMENTS: (CONTINUED)

Other:

All gasses MUST have a minimum purity of 99.995%. Gasses for GC systems using either a mass spectrometer or an ElCD detector MUST have a minimum purity of 99.999%. Always use either copper or stainless steel tubing that is free of grease, oil and organic material for all gasses delivered to the GC.

Cryogenic liquids:

LN2:

For liquid nitrogen, use a supply with a liquid delivery pressure of 20 to 30 psi. Use the six foot length of 1/4" insulated tubing supplied to connect the AutoSystem XL to the dewar. Longer lengths will decrease pressure at the nozzle and will cause the liquid to heat up and boil.

CO2:

For liquid carbon dioxide, use a size 1A cylinder equipped with a fitting containing a full-length dip (eductor) tube. The tank should contain approximately 60 lbs. of carbon dioxide.

Protect the CO2 supply system from undue heating. CO2 is a gas above 31^{o}C (87.5^{o}F) at a pressure of 1069 psi. The pressure increases rapidly at temperatures above 31^{o}C. The CO2 supply system contains liquid CO2 pressurized at 6000 kPa (850 psi) at 20^{o}C.

ENVIRONMENTAL REQUIREMENTS:

Laboratory Environment:

Install the GC in an indoor laboratory environment that is clean, free of drafts and direct sunlight.

The laboratory should be free of flammable, explosive, toxic caustic or corrosive vapors and should be relatively free of dust.

The ambient temperature of the lab should be between 15 and 32 degrees C (60 and 90 degrees F) with a relative humidity between 20 and 80% with no condensation.

***Customer Signature:*____________________ *CSE Signature:*________________ *Date:*___**

PRE-INSTALLATION CHECKLIST

Clarus 500 GC

SAFETY REQUIREMENTS:

Gas Cylinders and Gas Delivery Lines:

Gas cylinders should be located outside the laboratory whenever possible. All gas cylinders should always be stored and operated in the vertical position and should be firmly clamped to a suitable surface. Care must be taken not to kink or overstress the gas delivery lines.

Combustible Gases:

Hydrogen:

Ensure that all hydrogen lines and connections are leak free. When using a hydrogen tank, install an in-line hydrogen snubber (P/N 0009-0038) between the tank regulator and delivery tubing.

Ventilation:

Always provide adequate ventilation. When analyzing hazardous compounds, such as pesticides, it may be necessary to arrange for venting the detector effluent into a fume hood.

PRODUCT LINE EXPERIENCE:

Basic knowledge of chromatography is required.

INSTALLATION OUTLINE OVERVIEW:

Customer to Unpack/Setup Instrument:

Yes, whenever possible

Customer to hold Packing Material for CSE:

Yes. All packing materials should be held by the customer and inspected by the CSE at the time of install to ensure that no small items are mistakenly discarded. The customer should then return the packing material to PE for recycling.

Physical Installation (GC Only)

Approximately 1 - 1.5 hours depending on GC configuration.

Installation Test

Approximately 1 hours depending on GC configuration.

Customer Orientation Script (GC Only)

Approximately 2 hours depending on GC configuration.

Customer Signature: ____________________ ***CSE Signature:*** ________________ ***Date:*** ___

PRE-INSTALLATION CHECKLIST

Clarus 500 GC

REPORT:

Customer: ________________________ **SPO #:** ____________

CSR Name/#: ________________________ **Date:** ____________

Requirement	OK	Preinstallation Action Required
SPO Review		
Power Requirements		
Lab Space Requirements		
Gas Requirements		
Water Requirements		
Environmental Requirements		
Safety Requirements		
Preparation of Samples		
PC Configuration		
OrientationCustomer		
Installation Overview		

Comments: ____

____

____

Customer Signature: ____________ ***CSE Signature:*** ____________ ***Date:*** ___

710 Bridgeport Ave
Shelton, CT 06484 USA

Chromatography Division

Product Service Information

Installation Checklist

Clarus 500 GC

Technical SDB: CLRS002A.SBS

L Romano

Date: April 12, 2002

For Perkin-Elmer Internal Distribution Only

PROBLEM:

N/A

PURPOSE:

To provide the field with an Installation Checklist for the Clarus 500 GC.

MATERIAL:

N/A

GENERAL:

The requirements given in each category should be met to ensure that the customer receives a proper installation.

The Customer Service Engineer should use this checklist as a sign-off sheet. A copy of the sign-off sheet must be given to the customer. Remove this cover page before presenting to customer.

PROCEDURE:

N/A

***Customer Signature:*____________________ *CSE Signature:*________________ *Date:*___**

INSTALLATION CHECKLIST

Clarus 500 GC

Customer: ______________________________ **Date:** ____________________________

______________________________ **Ship Date:** ____________________________

______________________________ **SPO #:** ____________________________

______________________________ **CSR #:** ____________________

INITIAL INSPECTION:

20 min. typical

- ☐ Verify that the instrument was not damaged during shipment.
- ☐ Verify that all accessories were delivered as per the SPO and were not damaged during shipment.
- ☐ Check the Spares Kit, any Accessory Kits and Starter Kits (if sold) for completeness.

PHYSICAL INSTALLATION:

1 - 1.5 hours typical

- ☐ Install any accessories, if applicable, (Not including TurboMatrix or TurboMass Gold).
- ☐ Connect all required gasses & perform a leak check of the complete system.
- ☐ Make all required electrical connections.

INSTALLATION TESTING:

1 Hour

- ☐ Perform a basic functional test of all heated zones.
- ☐ Perform a basic functional test of the Autosampler and Tray.

CUSTOMER ORIENTATION:

2.0 hours typical

- ☐ Refer to Customer Orientation Script for explanation of operation.
- ☐ Explain the warranty and available service contracts.
- ☐ Inform the customer of relevant PE training courses, and provide phone numbers for ordering supplies and requesting service.

Customer Signature: ____________________ ***CSE Signature:*** ________________ ***Date:*** ___

710 Bridgeport Ave
Shelton, CT 06484 USA

Chromatography Division
Product Service Information

Preventive Maintenance Checklist

Clarus 500 GC

Technical SDB: CLRS004A.SBS

L Romano

Date: April 26, 2002

For Perkin-Elmer Internal Distribution Only

PROBLEM:

N/A

PURPOSE:

To provide the field with a Preventive Maintenance Checklist for the Clarus 500 GC.

MATERIAL:

N/A

GENERAL:

The requirements given in each category should be met to ensure that the customer is getting a complete Preventive Maintenance Inspection.

The Customer Service Engineer should use this checklist as a sign-off sheet. Do not leave the Diagnostic Summary Sheets with the customer. The customer receives a copy of the two Checkbox Sheets. Remove this cover page before presenting to customer.

PROCEDURE:

N/A

***Customer Signature:*____________________ *CSE Signature:*________________ *Date:*___**

PerkinElmer™ instruments.

PREVENTIVE MAINTENANCE CHECKLIST

CLARUS 500 GC

Customer:________________________________ Date: ________________

Address: ________________________________ Call Number: ________________

______________________________________ Phone: ________________

______________________________________ Unit Location: ________________

Serial Number: ____________________________ User Name: ________________

General:

- ☐ Ask customer about unit's performance since last visit.
- ☐ Check incoming AC line voltage for proper levels and grounding.
- ☐ Inspect all gas line filters and traps; Replace if necessary with customer supplied spares.
- ☐ Leak check all fittings from gas source to instrument, if possible.
- ☐ Inspect and clean electronic cooling and oven vent fans.
- ☐ Inspect and clean interior as needed.

Mechanical:

- ☐ Check firmware revision. Upgrade to current levels if necessary (Excludes Integral Link).
- ☐ Measure all accessible power supply voltages.
- ☐ Measure all detector polarizing voltages.
- ☐ Check oven fan motor for noise or binding.
- ☐ Check operation of oven door vent.
- ☐ Check oven temperature. Calibrate if necessary.
- ☐ Check sub-ambient option. (If installed).
- ☐ Perform routine maintenance on detector/injector. Replace parts if necessary with customer supplied spares.
- ☐ Check flows, including split flows if applicable. Calibrate if necessary.
- ☐ Check detector gas flows and adjust if necessary.

Customer Signature:____________________ CSE Signature:________________ Date:___

PerkinElmer™ instruments.

PREVENTIVE MAINTENANCE CHECKLIST

CLARUS 500 GC

- ☐ Check autosampler vial sensor for wear and replace if necessary.
- ☐ Remove syringe, manually flush. Replace with customer supplied spare if necessary.
- ☐ Run instrument diagnostics. Refer to AutoSystem / XL Diagnostics Summary Sheet.
- ☐ Run autosampler diagnostics. Refer to AutoSystem / XL Diagnostics Summary Sheet.
- ☐ Clean exterior of instrument.

Review:

- ☐ Review work performed with user.
- ☐ Review routine maintenance procedures with user.
- ☐ Discuss recommended customer supplied consumables to have on hand.

Customer Signature:____________________CSE Signature:________________ Date:___

PerkinElmer™
instruments.

PREVENTIVE MAINTENANCE CHECKLIST

CLARUS 500 GC

Clarus 500 GC DIAGNOSTIC SUMMARY

Instrument Diagnostics

Caution: Entering diagnostics shuts off all PPC pneumatic flows (if equipped) and all heated zones. Cool oven prior to entering diagnostics.

Run the following tests to verify operation of AutoSystem XL GC. Enter the number of repetitions as indicated.

Start-Up Cycle	05	Performs basic power on diagnostics.
A/D T CHAN	01	Tests temperature zone **D/A** and **A/D** outputs.
RAM	05	Tests volatile ram (**DO NOT** run **Clear Bram**).
BRAM	05	Test battery backed ram
PROM	05	Verifies **PROM** checksums.
OUTPUTS	01	Checks operation of **READY**, **RUN**, and Valves 1-6 Check box to activate, Uncheck to deactivate. Verify valve function, monitor **READY/START** OUT contact changes with ohmmeter at **TB1**.
INPUTS	01	Shows status of **EXT**. **READY** and **EXT**. **START** signals. Jumper these terminals at TB1 connector to change.
RELAYS	01	Cycles main instrument relay and subambient valve, if installed. **[Enter]** will cycle relay/valve **ON** then **OFF.**

Autosampler Diagnostics

Select **Auotsampler** from TEST menu to enter Autosampler diagnostics.

Run the following tests to verify operation of autosampler, if installed. Enter the number of repetitions as indicated.

ASRAM	05	Performs autosampler ram test.
ASPROM	05	Performs autosampler **EPROM** test.
ASUART1	05	Tests autosampler internal RS232 port operation
ASPIA	05	Checks autosampler interface adapter chip.
ASPTM	05	Checks autosampler timer chip.

***Customer Signature:*____________________ *CSE Signature:*________________ *Date:*___**

PerkinElmer™ instruments.

PREVENTIVE MAINTENANCE CHECKLIST

CLARUS 500 GC

Motors

TOWER / CYCLE		02	Rotates tower and verifies sensor feedback.
TOWER / POS /			
PARK		01	Rotates tower to the specified position.
	INJ1	01	Checks alignment of vial locator on INJ1.
	INJ2	01	Checks alignment of vial locator on INJ2.
TOWER / SCAN /			
	VIAL	01	Verifies Tower and Carousel location feedback. Put vials in tray positions 1, 25, 57, 76, then enter those positions one at a time to verify proper locations. Enter 91 to check waste vial 1, 95 to check wash vial 1.
CAROUSEL /			
	CYCLE	05	Rotates carousel and verifies sensor feedback.
	ENCD	05	Verifies encoder operation.

Caution: MANUALLY move the tower to the front prior to running this test!

ELEVATOR			
	CYCLE	05	Moves the needle up and down, and verifies sensor feedback.
PLUNGER			
	CYCLE	05	Moves plunger up, down and verifies sensor Feedback.
SENSOR		01	Manually moves tower from one side to the other. Observe change in status of, (**T**) Tower sensor display. (**V**) Vial sensor display. Open tower door, observe change in status of, (**D**) Door sensor display.
VENT		01	Verifies operation of oven vent door.

***Customer Signature:*____________________ *CSE Signature:*________________ *Date:*___**