GALVANIC

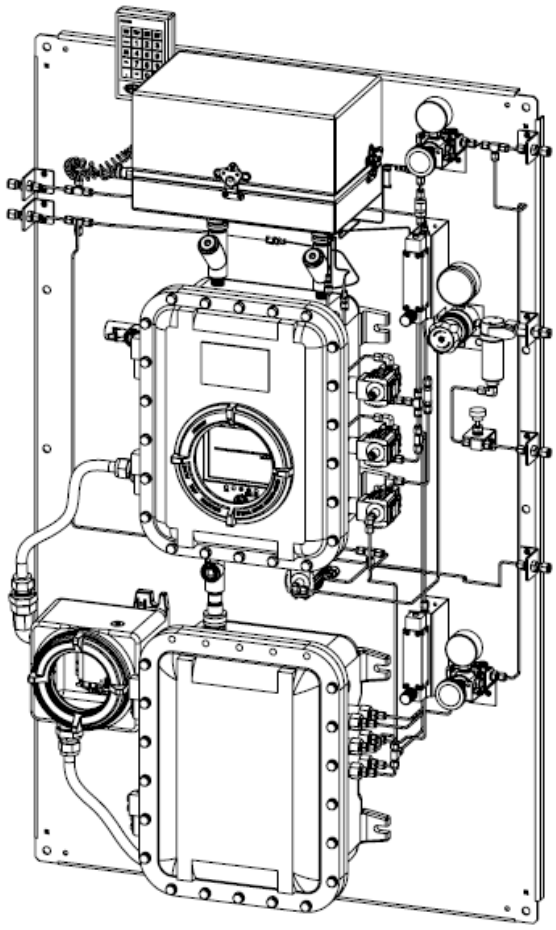
APPLIED SCIENCES

AccuChrome™

GAS CHROMATOGRAPH

Operation Manual Addendum 1 – NEMS C9 Module

Revision 2 March 2023



Galvanic Applied Sciences, Inc.
7000 Fisher Road S.E.
Calgary, Alberta, T2H OW3
Canada
Phone: (403) 252-8470
Toll Free: 1 (866) 252-8470
E-mail: support@galvanic.com
World Wide Web: http://www.galvanic.com

NOTICES

This system is covered by a limited warranty. A copy of the warranty is included with this manual. The operator is required to perform routine maintenance as described herein on a periodic basis to keep the warranty in effect. For routine maintenance procedures, refer to Maintenance Section.

All information in this manual is subject to change without notice and does not represent a commitment on the part of Galvanic Applied Sciences, Inc.

No part of this manual may be reproduced or transmitted in any form or by any means without the written permission of Galvanic Applied Sciences, Inc.

Note: Changes or modifications not expressly approved by Galvanic Applied Sciences, Inc. could void the user's authority to operate the equipment.

Printed in Canada

Table of Contents

Safety Symbols used in Manual

The Danger symbol indicates a hazardous situation that, if not avoided will result in death or serious injury.

The Warning symbol indicates a hazardous situation that, if not avoided could result in death or serious injury.

The Caution symbol with the safety alert symbol indicates a hazardous situation that, if not avoided could result in minor or moderate injury.

The Notice symbol is used to highlight information that will optimize the use and reliability of the system.

Important Safety Guidelines for ACCUCHROME Gas Chromatograph

⚠WARNING This equipment must be used as specified by the manufacturer or overall safety will be impaired.

⚠WARNING Access to this equipment should be limited to authorized, trained personnel ONLY.

⚠WARNING Due to the thermal mass of the hardware, cooling of the items takes substantial time.

⚠WARNING Observe all warning labels on the analyzer enclosures.

The analog outputs and alarm relay contacts may be powered by a source separate from the one (s) used to power the analyzer system. Disconnecting the AC Mains Source (s) may not remove power from the analog output signals or the alarm relay contacts.

Any safety recommendations or comments contained herein are suggested guidelines only. Galvanic Applied Sciences Inc. bears no responsibility and assumes no liability for the use and/or implementation of these suggested procedures.

This system, when operating in its normal mode, and/or when it is being serviced, maintained, installed and commissioned contains items which may be hazardous to humans if handled or operated incorrectly or negligently. These hazards include, but are not limited to:

- High Voltage Electrical Energy
- Toxic and Explosive Gases
- High Temperature Surfaces

⚠CAUTION Access to this equipment should be limited to only to authorized, trained personnel.

Manufacturer's Warranty Statement

Galvanic Applied Sciences Inc. ("Seller") warrants that its products will be free from defects in materials and workmanship under normal use and service in general process conditions for 12 months from the date of Product start-up or 18 months from the date of shipping from Seller's production facility, whichever comes first (the "Warranty Period"). Products purchased by Seller from a third party for resale to Buyer ("Resale Products") shall carry only the warranty extended by the original manufacturer. Buyer agrees that Seller has no liability for Resale Products beyond making a reasonable commercial effort to arrange for procurement and shipping of the Resale Products. Buyer must give Seller notice of any warranty claim prior to the end of the Warranty Period. Seller shall not be responsible for any defects (including latent defects) which are reported to Seller after the end of the Warranty Period.

THIS WARRANTY AND ITS REMEDIES ARE IN LIEU OF ALL OTHER WARRANTIES OR CONDITIONS EXPRESSED OR IMPLIED, ORAL OR WRITTEN, EITHER IN FACT OR BY OPERATION OF LAW, STATUTORY OR OTHERWISE, INCLUDING BUT NOT LIMITED TO, WARRANTIES OR CONDITIONS OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, WHICH SELLER SPECIFICALLY DISCLAIMS.

Seller's obligation under this warranty shall not arise until Buyer notifies Seller of the defect. Seller's sole responsibility and Buyer's sole and exclusive remedy under this warranty is, at Seller's option, to replace or repair any defective component part of the product upon receipt of the Product at Seller's production facility, transportation charges prepaid or accept the return of the defective Product and refund the purchase price paid by Buyer for that Product. If requested by Buyer, Seller will use its best efforts to perform warranty services at Buyer's facility, as soon as reasonably practicable after notification by the Buyer of a possible defect provided that Buyer agrees to pay for travel time, mileage from the Seller's facility or travel costs to the airport / train station closest to Buyer's facility plus all other travel fees, hotel expenses and subsistence.

Except in the case of an authorized distributor or seller, authorized in writing by Seller to extend this warranty to the distributor's customers, the warranty herein applies only to the original purchaser from Seller ("Buyer") and may not be assigned, sold, or otherwise transferred to a third party. No warranty is made with respect to used, reconstructed, refurbished, or previously owned Products, which will be so marked on the sales order and will be sold "As Is".

Limitations

These warranties do not cover:

- Consumable items such as lamps.
- Analyzer components which may be damaged by exposure to contamination or fouling from the process fluid due to a process upset, improper sample extraction techniques or improper sample preparation, fluid pressures in excess of the analyzer's maximum rated pressure or fluid temperatures in excess of the analyzer's maximum rated temperature. These include but are not limited to sample filters, pressure regulators, transfer tubing, sample cells, optical components, pumps, measuring electrodes, switching solenoids, pressure sensors or any other sample wetted components.
- Loss, damage, or defects resulting from transportation to Buyer's facility, improper or inadequate maintenance by Buyer, software or interfaces supplied by Buyer, operation outside the environmental specifications for the instrument, use by unauthorized or untrained personnel or improper site maintenance or preparation.
- Products that have been altered or repaired by individuals other than Seller personnel or its duly authorized representatives, unless the alteration or repair has been performed by an authorized factory trained service technician in accordance with written procedures supplied by Seller.
- Products that have been subject to misuse, neglect, accident, or improper installation.

- The sole and exclusive warranty applicable to software and firmware products provided by Seller for use with a processor internal or external to the Product will be as follows: Seller warrants that such software and firmware will conform to Seller's program manuals or other publicly available documentation made available by Seller current at the time of shipment to Buyer when properly installed on that processor, provided however that Seller does not warrant the operation of the processor or software or firmware will be uninterrupted or error-free.

The warranty herein applies only to Products within the agreed country of original end destination. Products transferred outside the country of original end destination, either by the Seller at the direction of the Buyer or by Buyer's actions subsequent to delivery, may be subject to additional charges prior to warranty repair or replacement of such Products based on the actual location of such Products and Seller's warranty and/or service surcharges for such location(s).

Repaired Products

Repaired products are warranted for 90 days with the above exceptions.

Limitation of Remedy and Liability

IN NO EVENT SHALL SELLER BE LIABLE TO BUYER FOR ANY INDIRECT, CONSEQUENTIAL, INCIDENTAL, SPECIAL OR PUNITIVE DAMAGES, OR FOR ANY LOSS OF USE OR PRODUCTION, OR ANY LOSS OF DATA, PROFITS OR REVENUES, OR ANY CLAIMS RAISED BY CUSTOMERS OF BUYER OR ANY ENVIRONMENTAL DAMAGE OR ANY FINES IMPOSED ON BUYER BY ANY GOVERNMENTAL OR REGULATORY AUTHORITIES, WHETHER SUCH DAMAGES ARE DIRECT OR INDIRECT, AND REGARDLESS OF THE FORM OF ACTION (WHETHER FOR BREACH OF CONTRACT OR WARRANTY OR IN TORT OR STRICT LIABILITY) AND WHETHER ADVISED OF THE POSSIBILITY OF SUCH DAMAGES OR NOT.

Section 1 Overview of the NEMS C9 Module

1.1 Analyzer General Description

The NEMS C9 Module is combined with an AccuChrome GC to provide C6 through C9 hydrocarbon measurement. This allows the AccuChrome GC to perform the measurement of up to C9 hydrocarbons in hydrocarbon gas streams and integrate the results for a more robust range of hydrocarbon characterisation.

The AccuChrome GC is responsible for the measurement of nitrogen, carbon dioxide, methane, ethane, propane, iso-butane, normal-butane, neo-pentane, iso-pentane, and normal-pentane. Oxygen and carbon monoxide can be added optionally. The NEMS C9 Module extends measurement to the hexane isomers, heptane isomers, octane isomers and nonane isomers in parallel. The results of the two analyses are combined to arrive at a full C9 analysis of hydrocarbon gases. If required the analysis can be extended out to C12.

The NEMS C9 Module employs an advanced technology Nano-Electromechanical Systems (NEMS) detector. This type of detector has a response that is proportional to the mass of the molecule being detected. Heavier molecules produce a stronger response which makes this detector ideal for higher molecular mass C6 through C9 detection, even with decreasing concentrations.

1.2 Using This Manual

The user should first become familiar with the AccuChrome manual. This manual is intended to be an addendum to the AccuChrome manual and will highlight the details of operation that are specific to the NEMS C9 Module.

Section 2 NEMS C9 Module Design

2.1 Introduction

The NEMS C9 Module is driven by an APIX Analytical NEMS device and can be considered to be a standalone gas chromatograph unto itself. The device contains the column, heaters, injectors and detectors required for the measurement within a compact package. Figure A1 shows the APIX NEMS device.

Figure A1: The APIX Device

2.2 Mounting

The APIX device is mounted inside an electrical enclosure for use in hazardous conditions. The device plugs into an electronics controller card and power supply. A mounting bracket is used to support the electronics and the device. Figure A2 shows how the device and electronics card are mounted. The entire assembly is then mounted inside an environmental rated electrical enclosure with the power supply as shown in Figure A3.

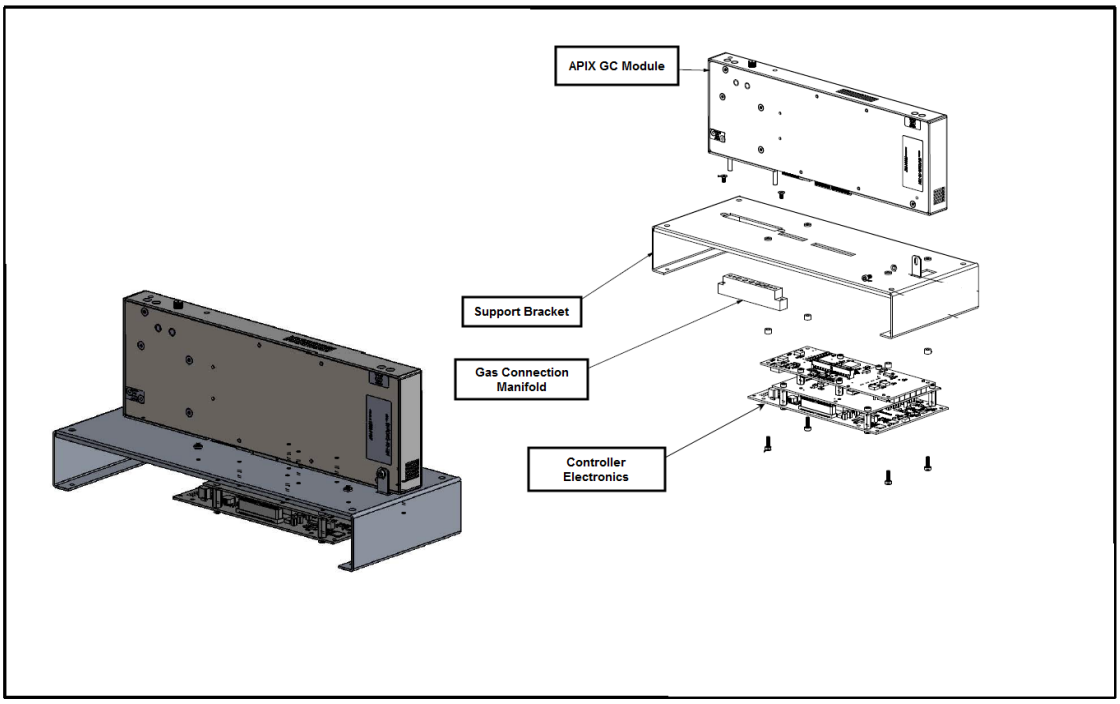
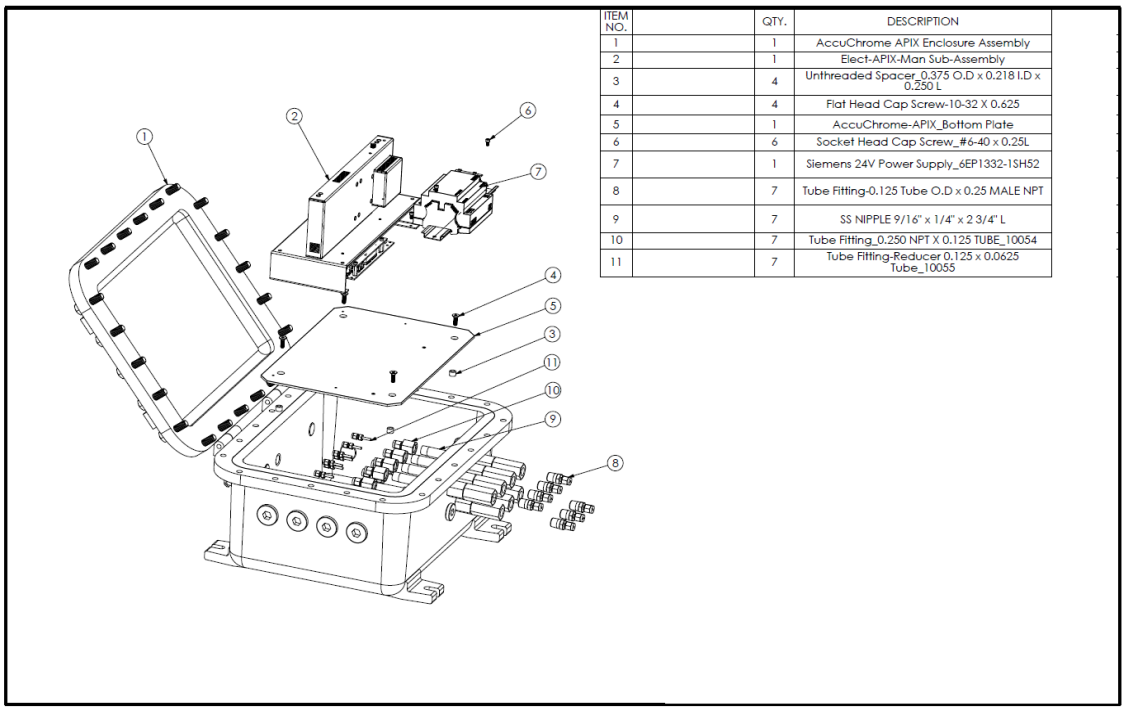


Figure A2: APIX Device Mounting



ITEM NO.		QTY.	DESCRIPTION
1		1	AccuChrome APIX Enclosure Assembly
2		1	Elect-APIX-Man Sub-Assembly
3		4	Unthreaded Spacer_0.375 O.D x 0.218 I.D x 0.250 L
4		4	Flat Head Cap Screw-10-32 X 0.625
5		1	AccuChrome-APIX_Bottom Plate
6		6	Socket Head Cap Screw_#6-40 x 0.25L
7		1	Siemens 24V Power Supply_6EP1332-1SH52
8		7	Tube Fitting-0.125 Tube O.D x 0.25 MALE NPT
9		7	SS NIPPLE 9/16" x 1/4" x 2 3/4" L
10		7	Tube Fitting_0.250 NPT X 0.125 TUBE_10054
11		7	Tube Fitting-Reducer 0.125 x 0.0625 Tube_10055

Figure A3: NEMS C9 Module assembly shown with explosionproof enclosure for Class I Div 2.

2.3 Gas Entry / Exit Connections

Gases are connected to the APIX device via a directly mounted manifold. Connections are by 1/16” inch tubing, welded into the manifold and pass through the wall of the explosionproof enclosure through flame arrestor fittings. The APIX device requires six tubing connections to the mounted gas manifold, inlet and vent pairs for each of actuation gas, carrier gas and sample gas. All gas connections are prearranged on the unit backpanel and have shared unit connections with the GC. The actuation gas is provided by the carrier gas line.

2.3.1 Supply Gas Pressure Requirements

The sample line is shared between the GC oven and the NEMS C9 Module. Two separate flowmeters are used to control the flow of gas to the AccuChrome GC and to the APIX module. Carrier gas and actuation gas are both shared with the rest of the AccuChrome unit. Gas pressure and consumption specifications are provided in Table A1.

Table A1: NEMS C9 Module Gas Requirements

Gas Stream	Min / Max Pressure [bar]	Design Pressure [bar]	Min / Max Flow Rate [cm²/min]	Design Flow Rate [cm²/min]
Carrier Input	1.0 / 2.0	1.0	10 / 20	10
Sample Input	0.3 / 1.5	1.0	50 / 100	50
Sample Vent	-	-	50 / 100	50
Actuation Input	3.5 / 4.5	4.0	-	-

2.4 Sample Injection

The sample injection mechanism consists of a silicon based micro injector which is integrated into the NEMS module. The injection volume is typically on the order of 10 microliters and is controlled via software.

2.5 Separation Column

The separation column is a 5-meter polydimethylsiloxane capillary column. It is housed inside the NEMS module and is temperature controlled to ensure consistent retention times. Typically, the C6 to C9 separation and characterisation can be achieved within 1 minute.

2.6 Detector

The detector is a NEMS resonator. It is very small and sensitive and has the unique characteristic of becoming more sensitive for compounds that have higher molecular weight. In natural gas the concentrations of the hydrocarbons decrease as the molecular weight increases, which make the heaviest compounds the hardest to detect. With the NEMS system the heaviest hydrocarbons have the strongest response.

Section 3 **Installation**

3.1 Dimensions and Space Requirements

The size and weight of the AccuChrome Chromatograph with NEMS C9 Module is presented in Table. The installation site should provide adequate room for opening the cabinet doors for maintenance and repair procedures. Complete dimensional information is provided in Figure A4.

When the system is installed, leave 6” between the unit and other devices.

Table 2: Size and Weight of the AccuChrome Chromatograph with NEMS C9 Module

	Size	Weight
Class I, Div 1	54.875”H x 33.75” W x 10.375”D	107kg (236 lbs)
Class I, Div 2	1397 mm (55”) H x 857.3 mm (33.75”) W x 254 mm (10”) D	73kg (161 lbs)

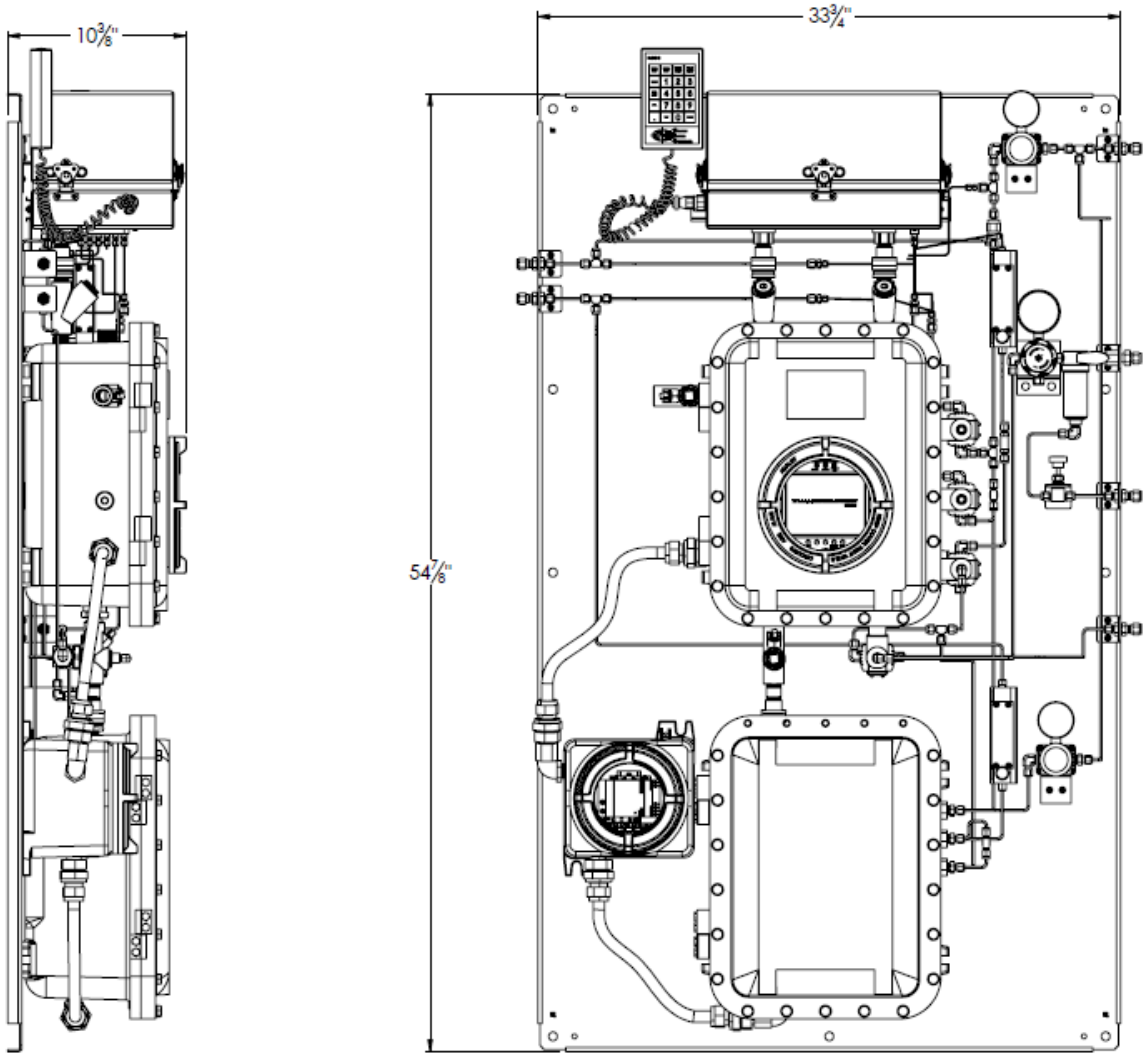


Figure A4: Physical Dimensions - Class I, Div 1 ACCUCHROME Chromatograph

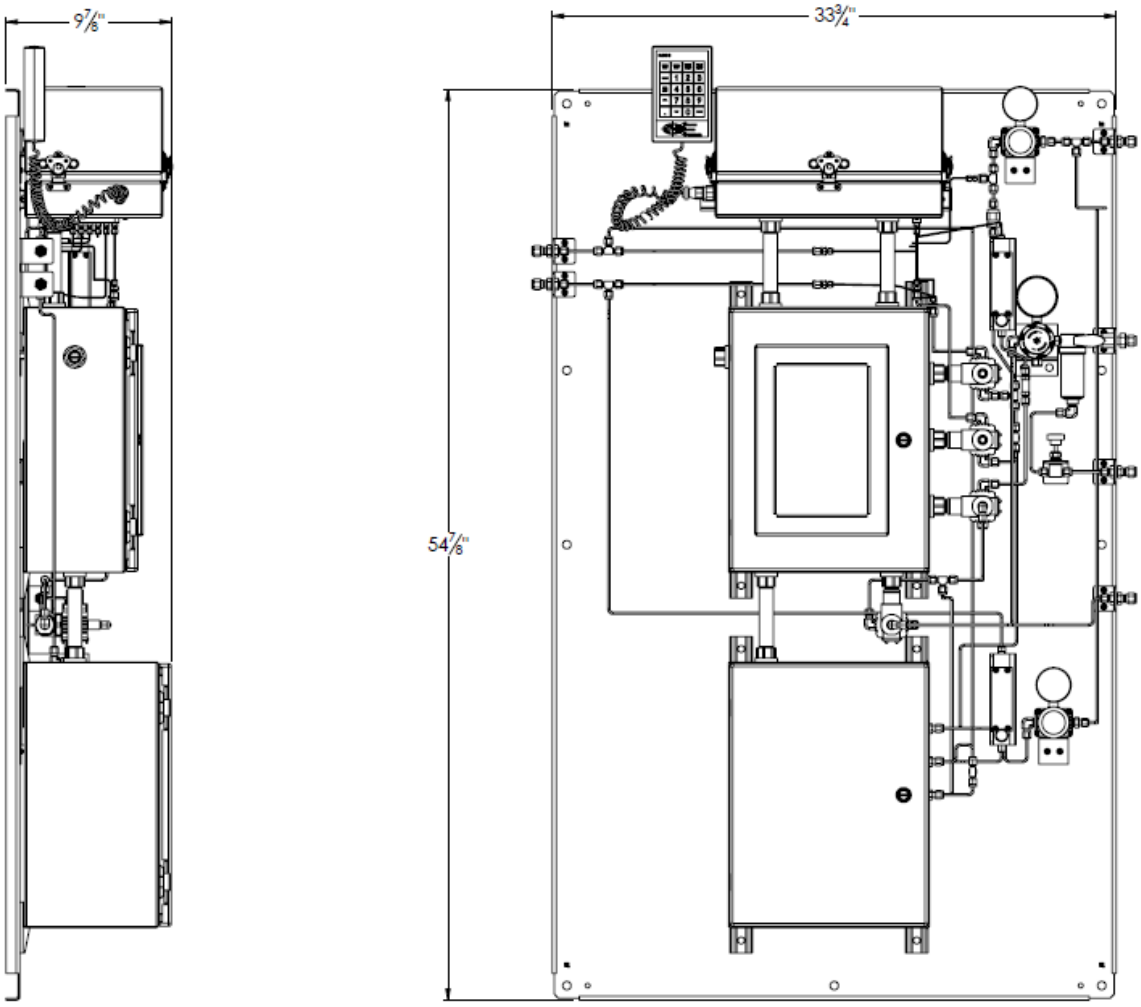


Figure A5: Physical Dimensions - Class I, Div 2 ACCUCHROME Chromatograph

3.2 Sampling Considerations

The AccuChrome Chromatograph with NEMS C9 Module divides a singular sample gas stream between the GC and NEMS module sections of the unit. Refer to Section 3.3 of the AccuChrome manual for more information.

3.1 Electrical Requirements

The AccuChrome Chromatograph with NEMS C9 Module does not have unique electrical requirements to the AccuChrome GC. Refer to Section 3.4 of the AccuChrome manual for more information.

3.2 Installation Steps

The AccuChrome Chromatograph with NEMS C9 Module is tested and configured at the factory. The program parameters are documented in the Configuration Report (enclosed with the AccuChrome manual and Section 4 of this addendum). To install the AccuChrome Chromatograph with NEMS C9 Module, follow the instructions provided by Section 3.5 of the

AccuChrome manual. There are no additional gas connection points for units with a NEMS module installed. All gas inlet and outlet points are common to the NEMS module and GC.

Section 4 Configuring the NEMS Module

For AccuChrome analyzers with a NEMS Module, additional options will be available on the *Configure G.C.* tab in the righthand side navigation menu, “NEMS Setup” and “NEMS Status”. Modifying the component table, NEMS parameters and viewing the NEMS status requires an administrator login. Refer to Section 5 of the AccuChrome User Manual for more information about setting up and modifying configuration settings.

4.1 Component Table

Refer to Section 5.4 of the AccuChrome User Manual for more information about the Component Table.

All the components to be analyzed are defined in the Component Table. The column called “Nems” defines which components are analyzed by the AccuChrome and which components are analyzed by the NEMS module. A check mark placed in the “Nems” column indicates that the component will be analyzed by the NEMS module. See Figure A6. The analyzer is pre-configured at the factory according to the sales specification. Please contact your Galvanic service technician if changes are required.

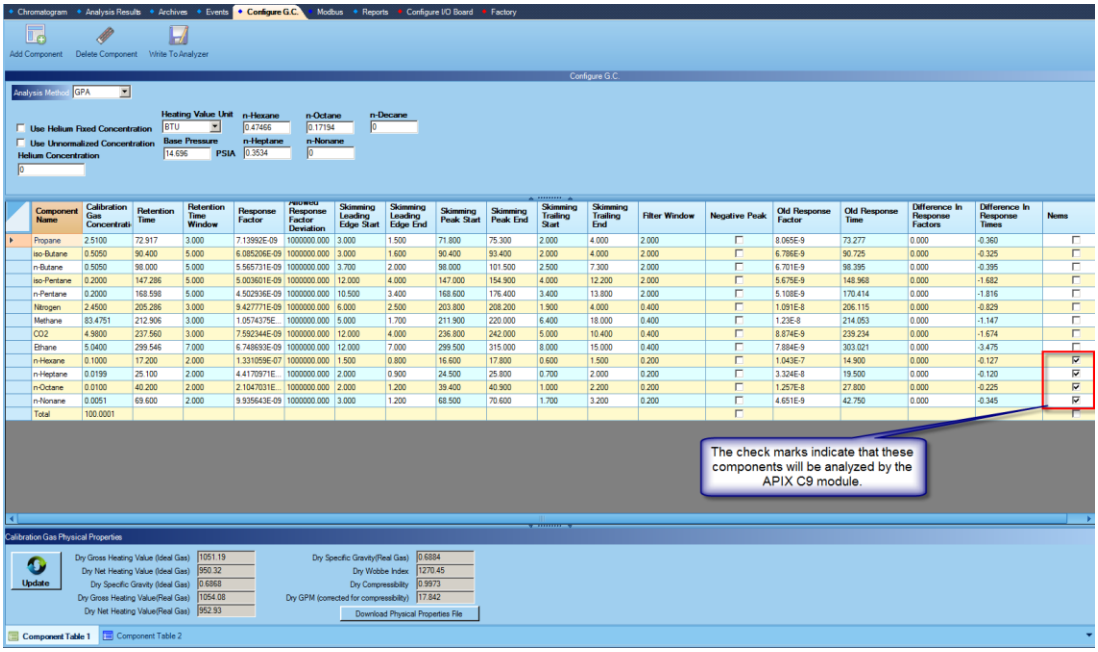


Figure A6: AccuChrome Component Table User Interface

The retention times and peak skimming parameters for the “Nems” components are separate from the other components are and are relative to the start of the “Nems” chromatogram.

4.2 Setting the NEMS Parameters

Parameters for the NEMS module can be access from the *Configure G.C.* tab on the righthand side navigation menu under “NEMS Setup”. Figure A7 provides a screenshot of this page.

The parameters for the NEMS module that can be modified are:

Equilibration Time – The duration, in seconds, allowed for the NEMS device injector to equilibrate to ambient pressure prior to sample injection. Sample gas flow is shutoff to the NEMS module and additional pressure is relieved through the Sample gas vent.

Run Time – The duration, in seconds, permitted for analysis of the Sample Gas by the NEMS device.

Injector Thermal Zone Active – This checkbox indicates that the injector heater is activated.

Injector Temperature – This field defines the temperature setpoint for the injector.

Injector Time – This field defines the length of time the injector stays on to inject a gas sample into the column.

Backflush Active – This checkbox indicates that the column should be backflushed at the end of the analysis cycle. this ensures that any gas species left in the column after the analyzer are removed.

Backflush Time – This field indicates the length of time required to backflush the column.

Column Thermal Zone Active – This checkbox indicates that the column heater is activated.

Column Thermal Zone Setpoint – This field defines the temperature setpoint for the column heater.

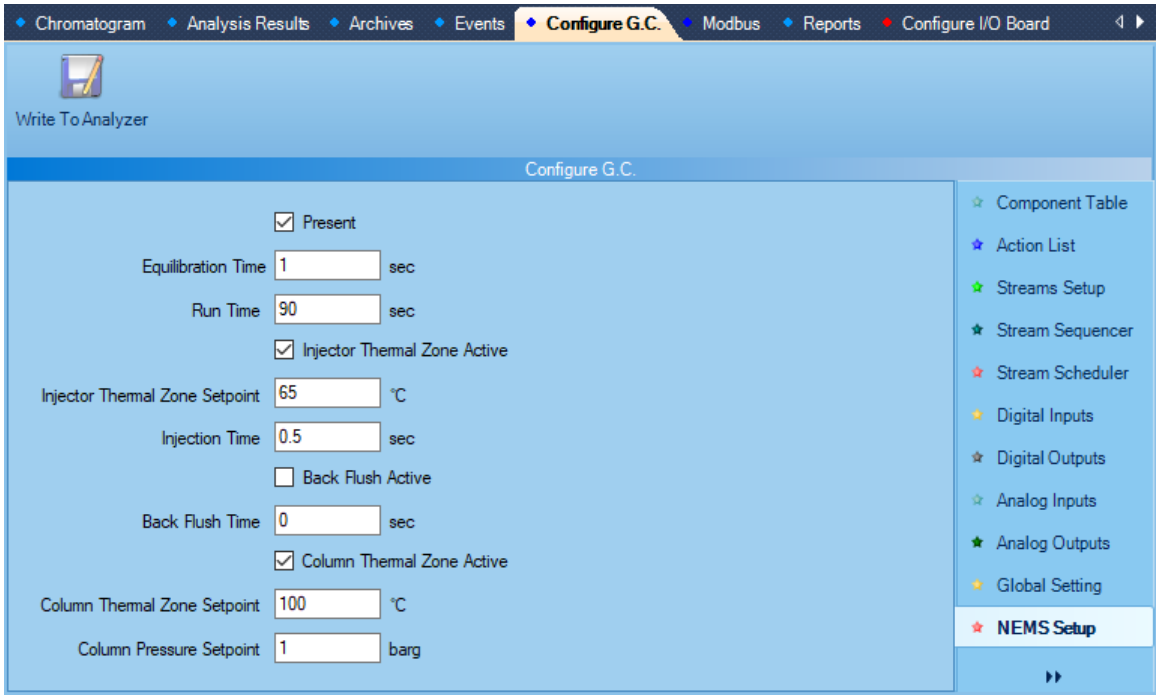


Figure A7: Screenshot of NEMS Setup Page.

4.3 Viewing the NEMS Status

The status of the NEMS module can be viewed on the “NEMS Status” page found under the *Configure G.C.* tab on the righthand side navigation menu (shown in Figure A8). This page will display information about the NEMS State, current NEMS Run Time in seconds and the Cabinet Temperature. You can also view information about the injector temperature and column temperature. Set points may be entered for the Injection Thermal Zone and the Column Thermal Zone within the acceptable operation temperatures are found in Table A3.

Table A3: Operational temperatures for the NEMS Module.

Measurement Point	Operational Range (°C)
Injection Thermal Zone	50°C – 80°C
Column Thermal Zone	80°C – 120°C

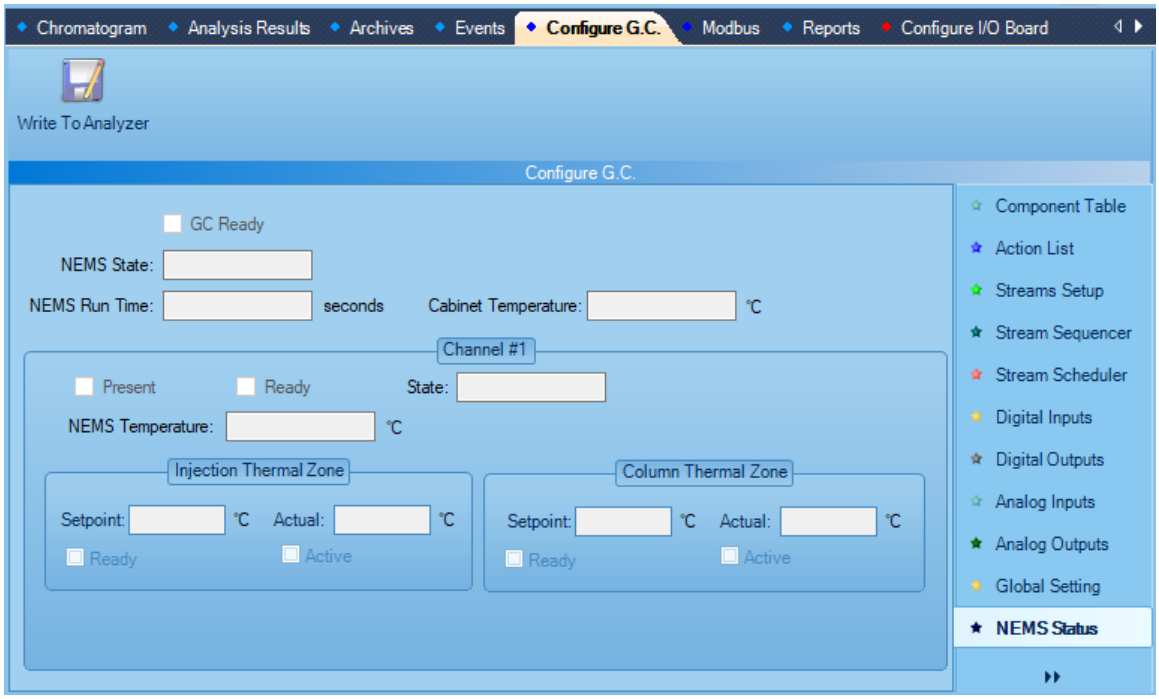


Figure A8: Screenshot of NEMS Status Page

Section 5 Using the Instrument

5.1 Chromatogram

There are two separate chromatograms, one shows the chromatogram generated by the TCD while the other shows the chromatogram generated by the NEMS module. To view the signal from the NEMS module, select NEMS from the righthand-side navigation menu on the *Chromatogram* tab as shown in Figure A9.

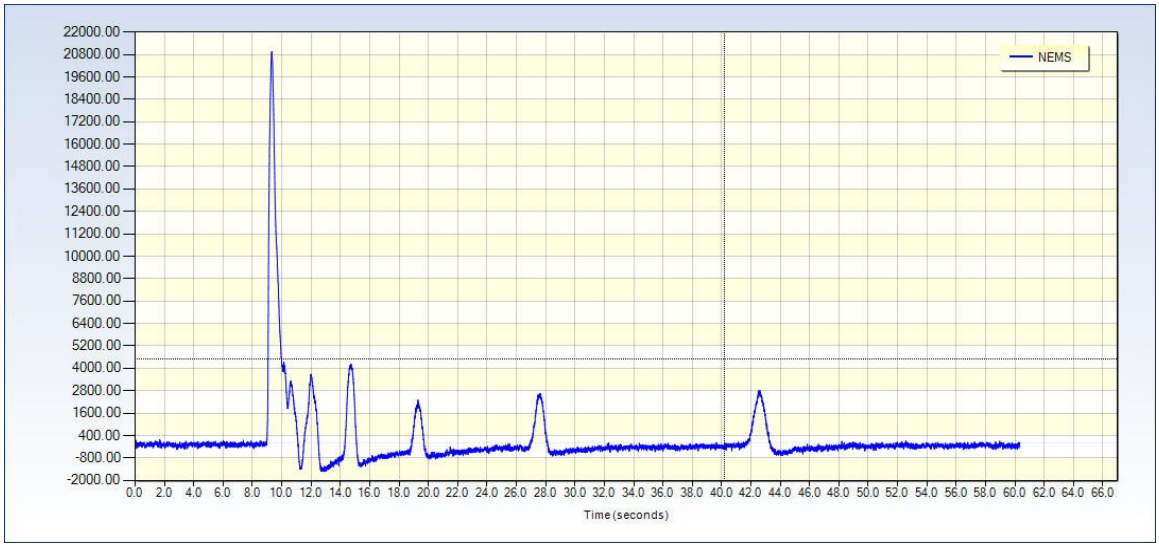


Figure A9: NEMS Module Chromatogram.

To modify the trace color of the chromatograph or viewing properties, you must first select “NEMS” from the “Selected Curve:” drop down menu in the ribbon as shown in Figure A10.

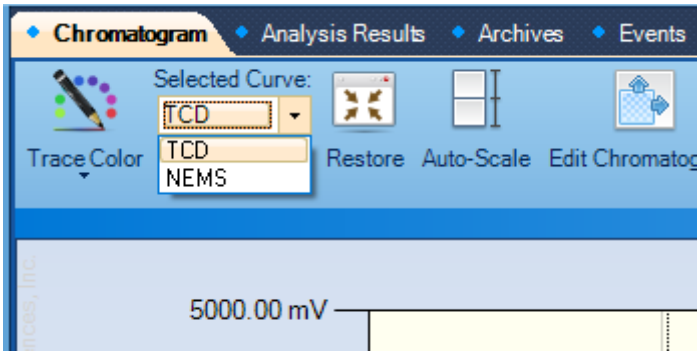


Figure A10: Changing Trace Selection to Modify Viewing Properties.

Section 6 NEMS Validation

Validation of the NEMS C9 Module is performed at the same time as validation of the AccuChrome GC. Refer to Section 7 of the AccuChrome User Manual for more information.

6.1 Performing a Calibration

No specific calibration is required for the NEMS C9 Module that is separate from the AccuChrome GC unit. Refer to section 7.3 of the AccuChrome User Manual for more information.

Section 7 Maintenance

The AccuChrome Gas Chromatograph is designed for automatic trouble-free operation and will provide reliable service with very little attention.

7.1 Cleaning the NEMS C9 Module

The exterior of the unit can be cleaned with a cleaner that is suitable for stainless steel. When cleaning the exterior of the unit, take care that the cleaning material does not enter the interior of the unit. Do not to submerse the unit in water, clean it with a hose or with excessive amounts of water.

Do not attempt to clean any of the electronic equipment within the unit

7.2 Replacing Internal Components

There are no internal components for the NEMS module that are expected to require replacement. If significant malfunction is suspected, contact Galvanic Applied Sciences.

Section 8 Troubleshooting

For a detailed review of troubleshooting the AccuChrome unit, refer to Section 10 of the AccuChrome User Manual. All potential faults from the NEMS C9 Module will be related to potential faults covered there.