BAe 146 NO_{XY} OPERATION MANUAL

AQD-307200

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1. GENERAL SYSTEM DESCRIPTION

1.1 THEORY OF OPERATION

The detection mechanism for the measurement system involves the oxidation of NO (nitric oxide) by an excess of O_3 (ozone),

$NO + O_3 \rightarrow NO_2 + O_2$.

The chemiluminescence from the relaxation of the electronically excited NO_2 (nitrogen dioxide) is measured with a photomultiplier tube. The background signal, which arises from a variety of sources, is accounted for by using a pre-reactor volume. The difference in signal observed between the measure mode (ozone added to the reaction volume) and the zero mode (ozone added to the pre-reaction volume) is proportional to the NO concentration in the air. In this way the concentration of NO can be measured directly. The concentration of NO_2 is determined by first converting the NO_2 to NO photolytically using LED lamps, followed by chemiluminescence as described above. The concentration of NOy is measured using a heated molybdenum catalyst to reduce NOx, HNO_3, organic nitrates, etc., to NO.

1.2 SYSTEM DESCRIPTION

The BAE NOxy system is comprised of five separate components, including the 2-channel NO snooper, a 2-channel ozonizer, a calibration/control box, an inlet panel, and a data acquisition instrument. In addition there is an external vacuum pump for the system. The NO detector, data system, calibration box, and ozonizer are housed in the rack-mount shipping box along with a main power distribution box. An overview photograph of the system identifying the major components is shown in **Figure 1**.

Figure 1. Photograph of the BAe 146 NOxy system.

1.2.1 Inlet box.

The inlet box includes calibration and zero air valves, the NO_2 and NOy converters, and the sample mass flow controllers. A photograph of the sample inlet is shown in **Figure 2**.

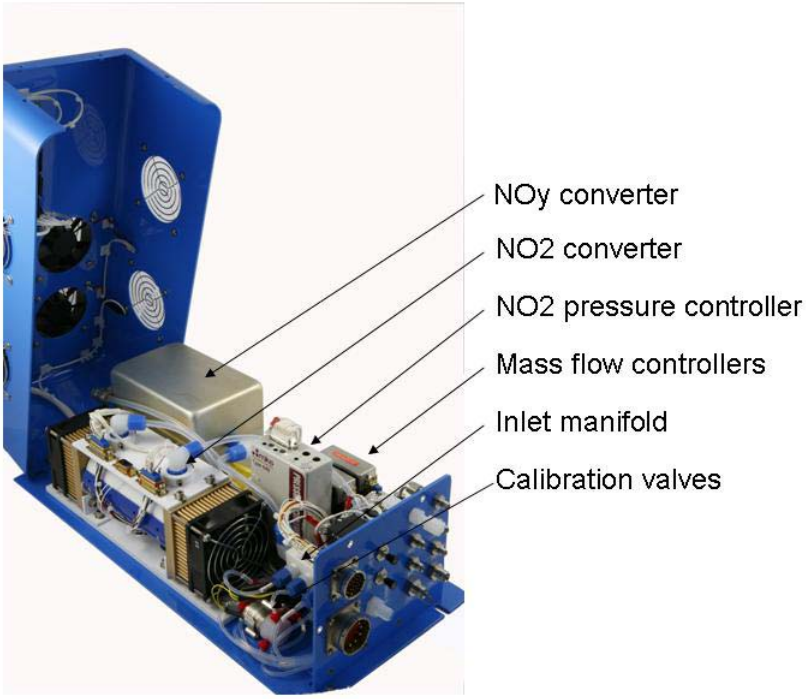

Figure 2. Photograph of the NOxy inlet box.

Calibration valves

There is one calibration valve for NO/ and NO_2 and one calibration valve for HNO3 on the inlet panel that serves both channels. There is an additional calibration valve in the control box that directs the NO and NOx calibration gas to the inlet. The NO2 titration lamp (located in the calibration box) is switched on in order to achieve the NO2 cals, and is left off for the NO calibrations. The zero air valve allows zero air displacement calibrations and zero air artifact tests.

Photolytic NO2 converter

The photolytic NO2 converter is a Blue-Light-Converter (BLC) manufactured by Droplet Measurement Technologies, Inc (Boulder, CO).

Molybdenum NO_y converter

The molybdenum NOy converter is a manufactured by Thermo Environmental Instruments (TEI).

Pressure controller

The pressure controller is manufactured by MKS. A separate manual for this instrument is attached as an appendix to this manual. The pressure controller is used to maintain a pressure of 200 torr in the photolysis cell.

Mass flow controller

There are two mass flow controllers in the inlet, one for each channel. The mass flow controllers are manufactured by Celerity. A separate manual for this instrument is attached as an appendix to this manual.

1.2.2 Calibration/control instrument

The calibration/control instrument includes the mass flow controller for the NO calibration gas, a temperature controller for the NOy converter, a temperature controller for the HNO_3 permeation tube, the gas phase titration cell, and front panel controls for the inlet valves. A photograph of the control box is shown in **Figure 3**.

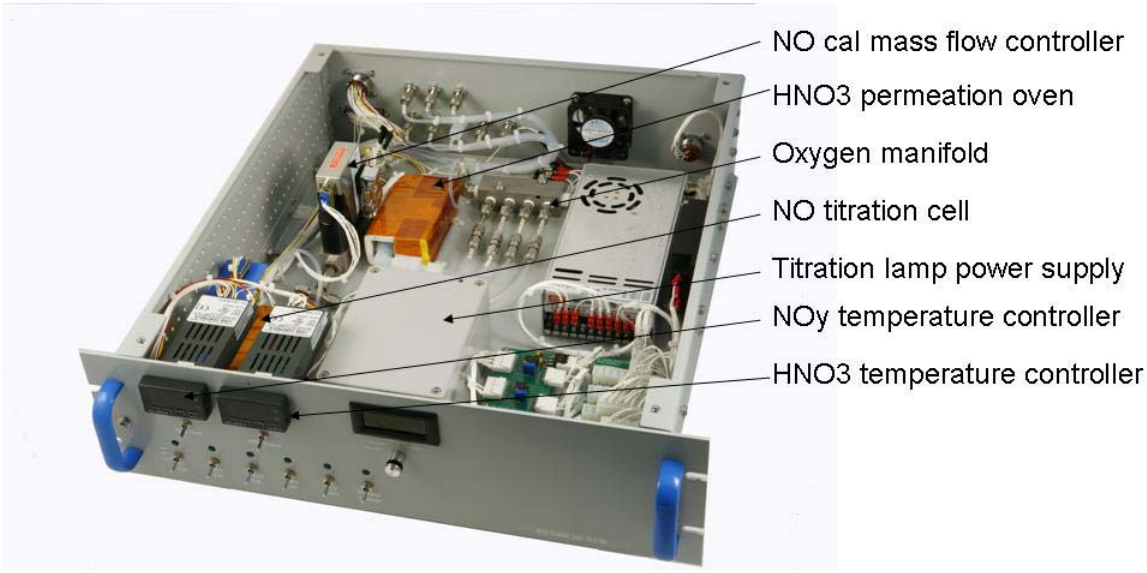

Figure 3. Photograph of the control box identifying the major components.

The front panel controls and readouts on this instrument include:

Temperature controllers – The temperature controllers for the NO_y converter and inlet heater are located on the front panel of the calibration box. Operation of the temperature controller is presented in a separate manual.

Valve switches – all of the valves/calibration modes can be manually activated using the On/Off/Auto switches on the front panel. In the Auto mode the valves can be controlled by applying a TTL level signal (3.5-5 VDC, 3-15 mA) through the rear panel connector (connector pin outs are described in **Section 7**).

Mass flow controller readout– The digital panel meter and selector switch can be used to view the set point and read voltages from the Channel 1 flow, Channel 2 flow, the readout from the pressure controller, and the calibration mass flow controller.

The rear panel of the calibration/control instrument includes the plumbing, power and signal connections that tie this instrument to the data system, NO snooper, and inlet panel. These connections include:

Power input module – This is a standard 3 prong power plug with an On/Off switch for the instrument and a voltage selectable fuse holder.

Circular connectors – There is 1 26-pin connector that connects the signal and DC power wires from the control box to the inlet panel. The 26-pin connector contains the valve and temperature control signal wires.

Data system connector – There is a 25-pin D-connector on the rear panel of the calibration/control instrument that is used to connect this instrument to the data system via a shielded cable. This cable contains both the analog signal and digital control wires.

The plumbing connections route the calibration gas and zero air to the inlet panel.

In addition to the calibration valves there are two critical orifices used to control zero air flows in the inlet system, including:

1. 10 sccm flow of oxygen through the NO2 titration cell.
2. 2.5 slpm air flow for zero air displacement tests. (Attached to the ZA regulator).

The zero air delivery pressure must be maintained at >50 psig to maintain the appropriate head-pressure for the critical orifices.

NO2 titration cell.

The NO2 titration cell is an aluminum block that houses a Teflon tube through which flows a small amount of zero air and NO calibration gas. When this mixture is illuminated by the Pen-ray lamp also housed in the block the NO calibration gas is titrated to NO2. The amount of titration achieved is controlled by the trim pot mounted on the aluminum Pen-ray lamp power supply enclosure. The amount of NO titration should be adjusted to some value between 50-95% of the standard addition NO concentration. This is easily done by manually activating the NO and NO_2 calibration valves with the BLC lamp off and adjusting the titration lamp trim pot until the desired level of titration is reached.

1.2.3 **Snooper**

The NO snooper contains the cooled housing for the photomultiplier tube, the pre-reaction volume and reaction volume, the pulse amplifier/discriminator, a pressure sensor, and the high voltage and DC power supplies for the snooper instrument. The snooper instrument includes temperature controllers for the Reaction volume, Zero volume (pre-reactor), and the PMT cooler. A photograph of the snooper is shown in **Figure 4**.

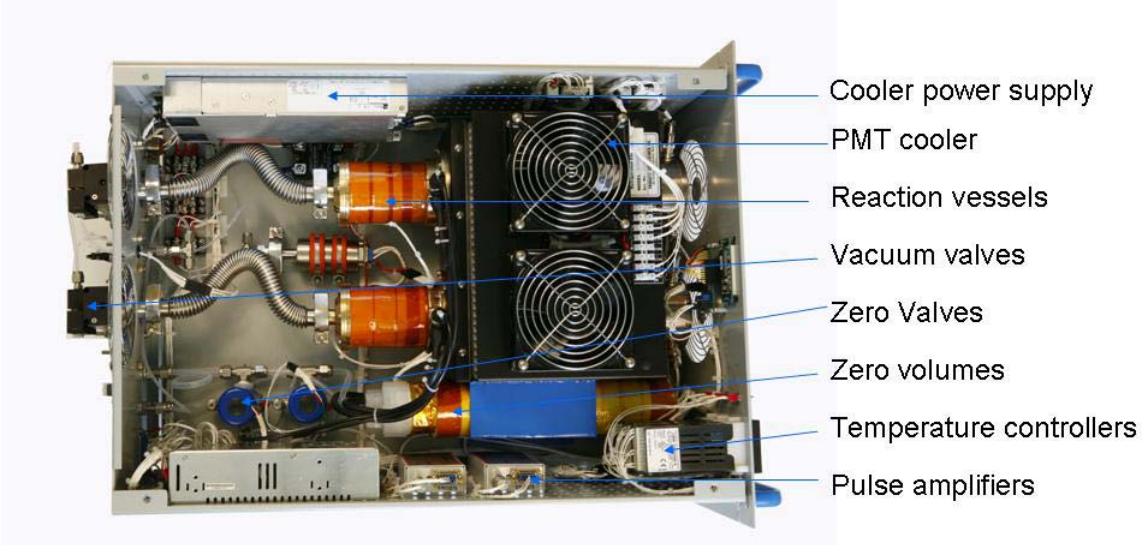

Figure 4. Top view of the Snooper with major components identified.

Snooper Readouts

Main LED display – Includes readouts for the reaction vessel pressure (direct readout in torr), PMT high voltage.

Temperature controllers – Actual and set-point values are displayed for the reaction vessel, zero volume, and PMT cooler. The power to the heaters and the PMT cooler power supply are controlled with the On/Off switch located directly beneath the temperature controllers. This switch is normally left on.

Snooper Controls

HV On/Off/Auto – These switches control the high voltage applied to the PMTs. The Auto position allows control of the high voltage by the data system by providing TTL level signal on the appropriate pins of the 25 pin rear panel data system connector (see section 7, Connector Pin-outs). The front panel includes 2 HV switches, one for each channel.

Zero Valve On/Off/Auto – These switches control the zero valves. The Auto position allows control of the zero valve by the data system by providing TTL level signal on the appropriate pins of the 25 pin rear panel data system connector (see section 7, Connector Pin-outs). The front panel includes 2 zero valve switches, one for each channel.

Vacuum Valve On/Off/Auto – These switches control the vacuum valves. The Auto position allows control of the vacuum valves by the data system by providing TTL level signal on the appropriate pins of the 25 pin rear panel data system connector (see section 7, Connector Pin-outs). The front panel includes 2 vac valve switches, one for each channel.

High voltage and pulse discriminator adjustments

The PMT high voltage and the pulse height discriminator levels can be adjusted for each of the channels via trim pots located on the HV supply and the PAD enclosures, respectively.

Rear panel connections

The rear panel connections for the NO snooper instrument include the following:

Plumbing connections – There are plumbing connections for the sample in, ozone in, and air in on the rear panel of the snooper. The air in (or inert gas in) is used to power the pneumatic vacuum valve.

Signal connections – There is a BNC connector on the rear panel that connect to the output of the PAD located inside the instrument. The signal at this connector is a TTL pulse proportional in frequency to the light measured at the PMT cathode. There is a 25 pin D-connector that contains the analog signals and digital control wires for the snooper that connects to the data system.

There is a standard 3 prong power plug with an On/Off switch for the instrument and a voltage selectable fuse holder.

1.2.4 Ozonizer

The ozone for the system is generated from oxygen using a corona discharge tube. The ozone generator is a commercial device manufactured by Ozone Services. A manual for this device is included separately. Operation of the ozonizer is controlled by the On/Off/Auto switch on the front of the ozonizer instrument. The oxygen flow through the discharge tube is also controlled by an On/Off/Auto switch located on the front of the instrument. The oxygen flow is controlled by a 500 sccm MFC with a set point of 100 sccm (1.00 volts on the front panel display. The other controls on the front panel of the instrument are needle valves that control the pressure inside the discharge tube. The

pressure sensors are the front panel-mounted bourdon gages. The BAE system includes 2 complete ozone cells/power supplies. A photograph of the ozonizer is shown in **Figure 5**.

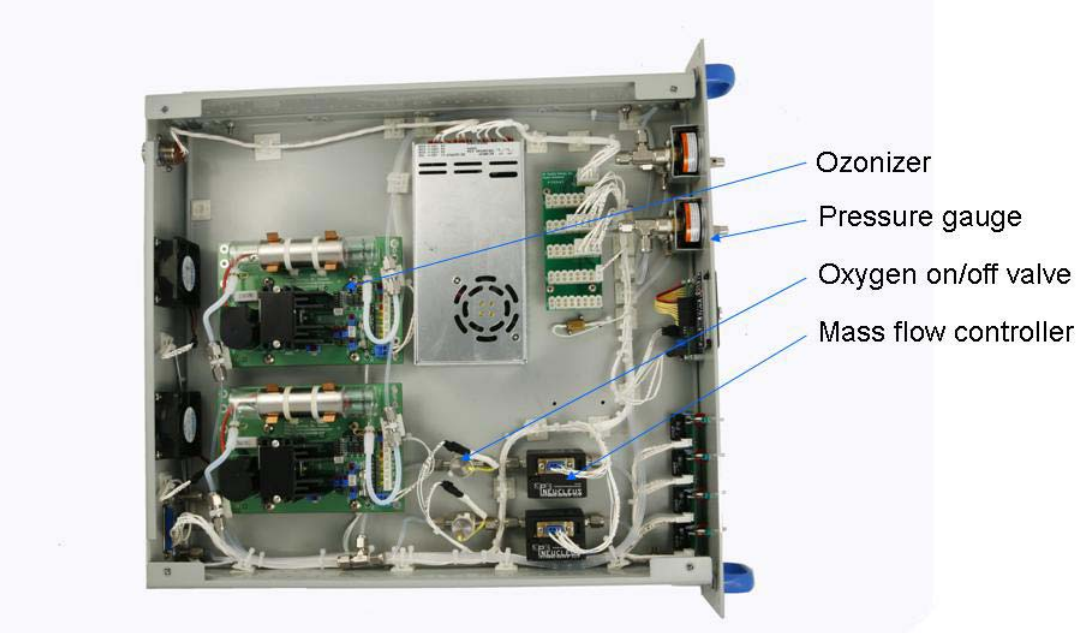

Figure 5. Photograph of the ozonizer identifying the major components.

1.2.5 Data acquisition system

The data acquisition instrument includes a USB port accessible data acquisition board (LabJack), a connection panel that includes connections for each of the instruments, and a laptop computer. The LabJack data acquisition card is controlled using DaqFactory software as described in section 5 (Software operation). Manual for the LabJack hardware is included separately as a PDF file.

2. SYSTEM SETUP

The BAE NOxy system was shipped in multiple containers, including:

1. The rack mount enclosure that includes most of the instrument as well as the bulkhead connections for power input/output and gases in and out, and

2. A large box that contains the vacuum pump, the NOx inlet box, all of the interconnection cables and tubes, a spare parts box, the system computer, and all of the documentation. This box also contains the wheels for the rack mount box.

Set up

1. The system setup should start by unpacking the large parts box2. Set the inlet box on the top side of the rack mount box
3. Connect the inlet tubing and cables. The inlet tubing connects to the bulkheads on both the back of the instrument housing and on the inlet box. Attach the end with longer 1/8" tubes to the instrument housing. The 26 pin connector attaches to the inlet bulkhead and to the back of calibration box. The power connector for the inlet box attaches via a 3-pin power connector to the inlet bulkhead and to the power distribution box on the instrument enclosure.
4. Connect the vacuum pump. Place the vacuum pump within 2 feet to the rear of the instrument enclosure. Connect the ozone destruction trap to the vacuum pump by the end with the elbow fitting attached (bottom of the trap faces down). Connect the trap to the NO instrument using the 3 ft. flexible stainless steel bellows tube. Connect the exhaust line to the exit of the pump and route the exhaust to a hood or outdoors. Connect the pump power plug to the power distribution box at the rear of the instrument.
5. Connect the gases to the instrument bulkheads.
6. Connect the main power plug to the instrument and to the building power (user supplied plug). The instrument is setup to receive 240 VAC and will require ~ 5 Amps.
7. Remove the system computer from its case and place on the sliding shelf. Plug the power connector into the computer.
8. Place all of the front panel controls of the instrument into the OFF position.

3. START UP PROCEDURE.

The instrument Startup procedure is shown on the Signals page of the DaqFactory software and includes:

1. Turn on Main Power, NO Inst, Control Inst., and Ozonizer.
2. Turn on Vacuum pump.
3. Turn on oxygen and NO gases at cylinders.
4. Turn on Instrument with the START button.
5. Turn on manual heater switches.

Once these steps have been followed the user should press the on-screen START button.

4. SHUT DOWN PROCEDURE

The instrument Shutdown procedure is largely automated and is initiated by pressing the onscreen STOP button, followed by the following actions:

1. Turn off Heaters
2. Turn off Vacuum pump
3. Turn off Main Power

5. SOFTWARE OPERATION

The data acquisition program for the NOxy instrument is written using DaqFactory software. The software is designed for automatic operation of the system and includes automatic control of the zero valves, serial data output, and automatic file save operations. The software contains several pages or screens, including SIGNALS, COUNTERS, and TIME SERIES. The default start page is the SIGNALS page shown below:

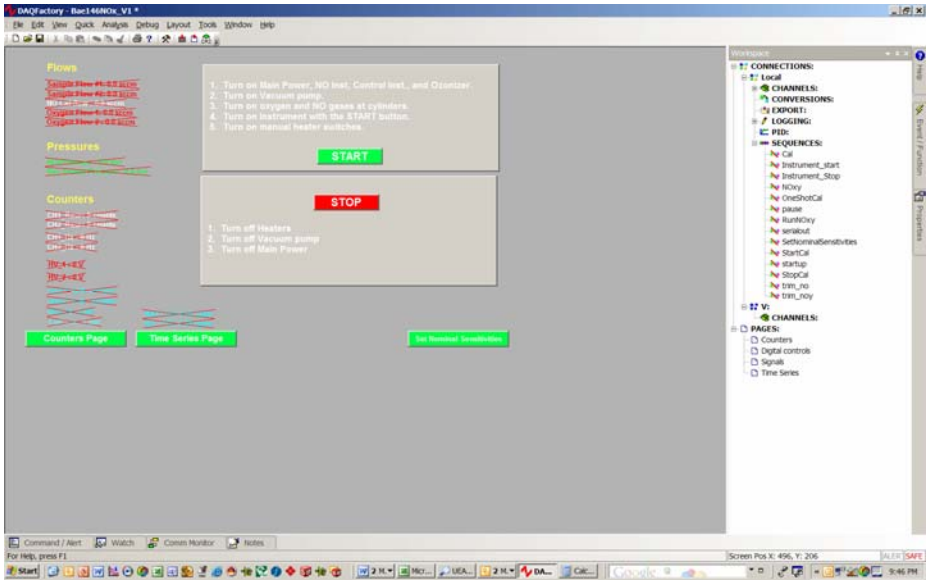

Figure 6. Image of the Signals page.

The COUNTERS page is a nice diagnostic page since it shows the detectors signals in hertz. This page looks like this:

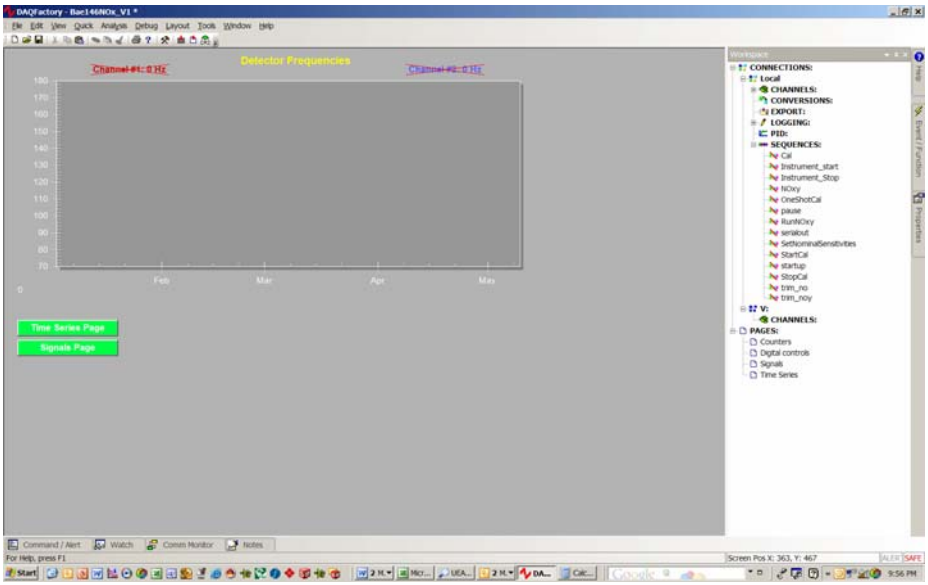

Figure 7. Image of the Counters page

Most of the time the user will use the TIME SERIES page which shows the calculated NOxy concentrations and as well has buttons to start and stop calibrations and to pause the zeros for a defined length of time. This page looks like this:

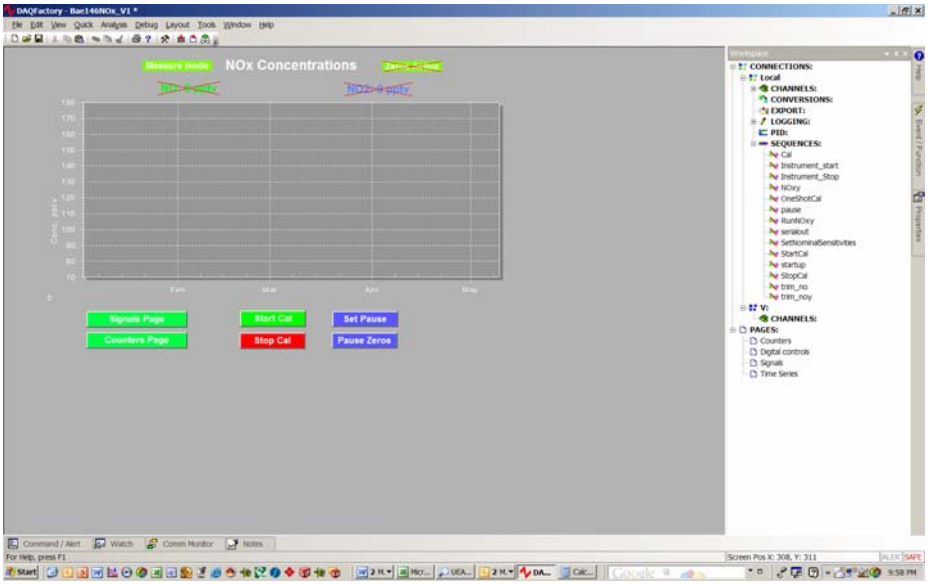

Figure 8. Image of the Time Series page

The DaqFactory program is automatically launched when the computer is turned on and the program worksheet BAe146NOx_V1.ctl is loaded. Once the program has started a control sequence for the various signal controls automatically begins (the control sequences are described below). The display elements of the program show several important instrument parameters (detector frequency), the current state of each of the system valves, and a time series of the last hour of observations. All of the values displayed are also saved to file (located in the desktop folder) every day. The filenames are BAE146_yymmdd_hhmmss.asc.

5.1 INSTRUMENT CONTROL SEQUENCES

The instrument control sequence programmed into the sequence generator module can be examined by clicking on the tab labeled “Sequences” in the Workspace panel of the DaqFactory program. Within that box click on the any of the five sequences present to view the commands. The sequences are:

1. **Startup** – This sequence runs automatically whenever the DaqFactory program begins. It initializes all of the system variables and starts the **RUNNOxy** and **SerialOut** sequences. This sequence is shown below:

```
include("c:\program files\labjack\drivers\labjackud.h")
```

```
using("device.labjack")

AddRequest(1,LJ_ioPUT_COUNTER_ENABLE,0,1)
GoOne(1)
AddRequest(1,LJ_ioPUT_COUNTER_MODE,0,1)
GoOne(1)
AddRequest(1,LJ_ioPUT_COUNTER_ENABLE,1,1)
GoOne(1)
AddRequest(1,LJ_ioPUT_COUNTER_MODE,1,1)
GoOne(1)

global cycle=0
global zero1=0
global zero2=0
global no_b=0
global trim1=1
global trim2=1
global no_c1=0
global no_cnox1=0
global no_cnox1=0
global no_c2=0
global no_t1=0
global no_t2=0
global no_l1=0
global no_l2=0
global sens1=4.8
global sens2=2.7
global NO2CE=0.55
global noyce=.95
global startcal=0
global pausezeros=0
global pauselength=600
global no_amb1=0
global no_amb2=0
global no_ambnox=0
global tankconc=5.09 //Set cal tank NO concentration here in ppmv
global calconc=12725

Zero_valve_1.AddValue(0) //Initialize all digital channels to 0 for proper serial
communication!
Zero_valve_2.AddValue(0)
zero_air_valve.AddValue(0)
Vac_valve_1.AddValue(0)
Vac_Valve_2.AddValue(0)
ozone_1.AddValue(0)
ozone_2.AddValue(0)
```

```
oxygen_valve_1.AddValue(0)
oxygen_valve_2.AddValue(0)
Nox_cal.AddValue(0)
no2_converter.AddValue(0)
no_valve.AddValue(0)
no_cal.AddValue(0)
Hv_1_cntl.AddValue(0)
hv_2_cntl.AddValue(0)
hno3_cal.AddValue(0)

beginseq(runnoxy)
beginseq(serialout)
```

2. **RunNOxy** – This sequence has overall control of the instrument functions of measure, zeroing, and calibration. It simply evaluates whether a calibration of pause has been requested and initiates the appropriate sequence. If no calibrations or pauses are called for it runs the **NOxy** sequence. The sequence is:

```
beginseq(noxy)
while(1)
if((StartCal==0) && (pausezeros==0))
  beginseq(noxy)
   else
      if (startcal==1)
        startcal=2
        beginseq(cal)
        else
          if(pausezeros==1)
            endseq(noxy)
            zero_valve_1=0
            zero_valve_2=0
          endif
     endif
endif
wait(1)
endwhile
```

3. **Serial Out –** The Serial_out sequence is launched at the start of the DaqFactory program by the **Startup** sequence. It ports the results of the running NOxy calculations and the various instrument states to the computer serial port. The sequence is shown below. The sequence updates the values on the serial port every second in the order shown following the Write command.

```
While(1)
  device.serialout.Write(FormatDateTime("%c",systime()) + "," +
Format("%.1f",no_conc[0]) + "," + Format("%.1f",no2_conc[0]) + "," +
Format("%.1f",ch1_hz[0]) + "," + Format("%.1f",ch2_hz[0])  + "," +
```

```
doubletostr(hno3_cal[0]) + "," + doubletostr(hv_1[0]) + "," + doubletostr(hv_1_cntl[0]) +
"," + doubletostr(hv_2[0]) + "," + doubletostr(hv_2_cntl[0]) + "," +
doubletostr(no_cal[0]) + "," + Format("%.4f",no_cal_flow[0]) + "," +
doubletostr(no_valve[0]) + "," + Doubletostr(No2_converter[0]) + "," +
doubletostr(nox_cal[0]) + "," + Format("%.4f",nox_pressure[0]) + "," +
doubletostr(oxygen_valve_1[0]) + "," + doubletostr(oxygen_valve_2[0]) + "," +
Format("%.4f",oxygenflow_1[0]) + "," + Format("%.4f",oxygenflow_2[0]) + "," +
doubletostr(ozone_1[0]) + "," + doubletostr(ozone_2[0]) + "," +
Format("%.3f",rxn_vessel_pressure[0]) + "," + Format("%.4f",sampleflow_1[0]) + "," +
Format("%.4f",sampleflow_2[0]) + "," + doubletostr(vac_valve_1[0]) + "," +
doubletostr(vac_valve_2[0]) + "," + doubletostr(zero_air_valve[0]) + "," +
doubletostr(zero_valve_1[0]) + "," + doubletostr(zero_valve_2[0]))
delay(1)
endwhile
```

4. **Instrument_Start** – This sequence is called when the START button is pressed. It initializes all of the instrument controls and brings the instrument to life in a controlled manner and begins the measurement sequence NOxy. The sequence is shown below:

```
time 0
  endseq(NOxy)
  no_valve=0
  no_cal=0
  nox_cal=0
  hno3_cal=0
  zero_air_valve=0
  NO2_converter=0
  zero_valve_1=0
  zero_valve_2=0
  vac_valve_1=1
time 2
  vac_valve_2=1
Time 10
  oxygen_valve_1=1
  oxygen_valve_2=1
time 20
  ozone_1=1
time 25
  ozone_2=1
time 30
  HV_1_CNTL=1
  HV_2_CNTL=1
time 45
  BeginSeq(NOxy)
```

5. **NOxy** – This is the standard measurement sequence that cycles the instrument through its various measurement and zeroing states. The sequence is shown below. The sequence as shown is on a 240 second zeroing cycle. That period can be lengthened or shortened by changing the value in the "time 240" line.

```
time 0
  beginseq(trim_no)
  zero_valve_1=1
  zero_valve_2=1
  no2_converter=0
time 13
  beginseq(trim_noy)
  beginseq(trim_no)
  zero1=(mean(ch1_hz[2,11]))
  zero2=(mean(ch2_hz[2,11]))
time 14
  zero_valve_1=0
  zero_valve_2=0
  beginseq(trim_no)
  beginseq(trim_noy)
time 30
  no_b=(mean(ch1_hz[1,9]))
time 31
  beginseq(trim_no)
  no2_converter=1
time 240
  goto 0
```

6. **Cal** – The **Cal** sequence should be run in preflight and post-flight if possible. The sequence takes 10 minutes to complete and set the instrument sensitivities. The sequence cal be started and stopped from the Time Series page of the program. The sequence is as follows:

```
time 0
  endseq(noxy)
  nox_cal=1
  no_valve=1
  zero_valve_1=1
  zero_valve_2=1
  no2_converter=0
time 13
  beginseq(trim_noy)
  beginseq(trim_no)
  zero1=(mean(ch1_hz[2,11]))
  zero2=(mean(ch2_hz[2,11]))
time 14
  zero_valve_1=0
```

```
   zero_valve_2=0
   beginseq(trim_no)
time 30
   no_b=(mean(ch1_hz[1,9]))
   beginseq(trim_no)
time 31
   no2_converter=1
time 120
   zero_valve_1=1
   zero_valve_2=1
   no2_converter=0
time 133
   beginseq(trim_noy)
   beginseq(trim_no)
   zero1=(mean(ch1_hz[2,11]))
   zero2=(mean(ch2_hz[2,11]))
time 134
   zero_valve_1=0
   zero_valve_2=0
   beginseq(trim_no)
time 150
   no_b=(mean(ch1_hz[1,9]))
   beginseq(trim_no)
time 151
   no2_converter=1
time 240
   no2_converter=0
   no_cal=1
   no_amb1=no_b[0]
   no_amb2=mean(ch2_hz[1,30])
   no_ambnox=mean(ch1_hz[1,30])
time 390
   no_l1=mean(ch1_hz[1,30])
   no_l2=mean(ch2_hz[1,30])
   no2_converter=1
time 450

calconc=(((no_cal_flow[0]*(10/5))*(tankconc[0]*1e6))/((sampleflow_1[0]*(2000/5))+(s
ampleflow_2[0]*(2000/5))))
   no_t1=mean(ch1_hz[1,30])
   no_t2=mean(ch2_hz[1,30])
   nox_cal=0
   no2_converter=0
time 540
   no_c1=mean(ch1_hz[1,30])
   no_c2=mean(ch2_hz[1,30])
```

```
   no2_converter=1
time 600
   no_cnox1=mean(ch1_hz[1,30])
   sens1=((no_c1[0]-no_amb1[0])/calconc)
   no2ce=(((no_t1-no_ambnox[0])-(no_l1[0]-no_amb1[0]))/(no_cnox1[0]-
no_ambnox[0]))
   sens2=((no_c2[0]-no_amb2[0])/calconc)
time 601
   no_cal=0
   no_valve=0
   StartCal=0
```

5.2 DATA FILE FORMAT

The data file format is set to ASCII – readable by most windows programs. There are several alternative formats that are more efficient in terms of file size (binary formats). Changes to the data file format may be made under the "logging" tab in the DaqFactory software.

5.3 DATA REDUCTION NOTES.

The basic relationship used to calculate concentration for NO and NO_2 is

$$[X] = (X\_meas - X\_zero_{int})/X\_sens_{int}$$

where [X] is the concentration of X in pptv, X_meas is the counts recorded by the photomultiplier tube while in measure mode, X_zero_{int} is the interpolated value of the averaged counts recorded while in zero mode and X_sens_{int} is the interpolated value of the sensitivity.

The sensitivity of the X channel for a given species Y (NO or NO2) is given by

$$X\_sens = (X\_Ycal - X\_meas_{int})/X\_Ycalconc$$

where X_Ycal is the average counts recorded by the X channel during a calibration of Y, X_meas_{int} is the interpolated value of counts while in measure mode, and X_Ycalconc is the concentration of Y introduced during calibration in units of pptv. This concentration is calculated by the following relationship:

X_Ycalconc = (cylinder concentration in ppm * 1e6* NOcalQ)/ Sample flow.

Zero mode sequences are usually performed for 30 seconds every 1 minutes, while calibration mode sequences are performed every 5-23 hours. Data obtained immediately after a change in mode should be deleted from all calculations (approximately 10-30 seconds). In the entire notation which follow, a subscript of "int" indicates a linear interpolation between data points, where the first and last data values have been copied and inserted at the beginning and the end of the data column, respectively.

NO calculations.
The calculation for NO proceeds directly. The equation used is

$[NO] = NO\_meas - NO\_zero_{int})/NO\_NOsens_{int}$.

The sensitivity for the NO instrument is given by

$NO\_NOsens_{int} = (NO\_NOcal - NO\_meas_{int})/NO\_NOcalconc$.

NO2 calculations.

The method for calculating NO2 concentration is similar to that of NO,

$[NO2] = (NO2\_meas – NO2\_zero_{int})/NO2\_NO_2sens_{int}$,

Where NO2_meas is the number of counts recorded by the photomultiplier tube while in measure mode, $NO2\_zero_{int}$ is the interpolated value of the average counts measured in the zero mode, and $NO2\_NO_2sens_{int}$ is the interpolated NO_2 sensitivity for the instrument. Sensitivity is calculated as

$NO2\_NO_2sens = (NO2cal - NO2\_meas_{int}/NO2\_NO_2calconc$

Where NO2cal is the average of counts from the instrument in calibration mode, $NO2\_meas_{int}$ is the interpolated value of the measure-mode counts and NO2calconc is the concentration of the NO_2 calibration.

NO_y concentration is calculated in a similar fashion to the NO_2 concentration.

Corrections:

Several conditions may contribute to an inaccurate measurement of NO and NOy. While the instrument is designed to keep the post-experiment corrections to a minimum, several important corrections are still necessary.

Calibrations/Sensitivities. Of major importance is the ability to accurately measure the amount of reference gas added to the sample during calibration. The flow meters for the reference gas need to be calibrated before, during and after the campaign to assure

accurate readings. Also, the reference gas concentration needs to be checked against the manufacturer's stated concentration. These corrections were made before any others and come into play only for the calculations of sensitivity.

H_2O. Ambient water vapor is a known quencher of reaction (1). In the presence of water the excited NO_2 may transfer its energy to water and thus the amount of NO recorded is less than the actual value. In a similar way, ambient water vapor will quench reactions that give rise to the instrument background signal. The result is that water vapor tends to reduce both the system sensitivity and the system background. For systems operated aboard aircraft, where the water vapor concentration may change more rapidly than the system is zeroed and calibrated correction for the effect is necessary. This effect is made less variable by the addition of water through a capillary tube prior to the zero volume, but is still present. Others have noted this effect and have corrected developed correction algorithms (See for example, Ridley et al.[1]). The algorithms described therein are recommended for correction of both sensitivity and zero levels for rapidly changing water vapor concentrations.

O_3 corrections. The reaction of ambient O_3 with NO upstream of the reaction vessel can affect the measured concentration of NO for the NO channel since the residence time is relatively long. For the NOy channel the effect is negligible since ozone is destroyed in the catalytic converter. Correction for the titration of ambient NO is best done by developing a system specific correction algorithm. This can be done by accurately by plotting the NO_NO sensitivity measured over several calibration cycles versus the coincidentally measured ozone concentration.

Artifact. The artifact is the apparent signal measured while the instrument is sampling zero air. Typical artifacts are ca 2 pptv for the NO channel for the NO2 channel. For accurate measurements of very low concentrations the artifact signal should be subtracted from the ambient signal.

[1] Ridley, B.A, J.G. Walega, J.E. Dye, and F.E. Grahek, Distributions of NO, NOx, NOy, and O_3 to 12 km altitude during the summer monsoon season over New Mexico, Journal of Geophysical Research, 25529-25534, 1994.

6. **Routine maintenance and troubleshooting**

Routine maintenance

Gases

1. Oxygen. A full oxygen cylinder (nominally 2200 psi) should last 21 days, leaving 100 psi in the tank. To change the oxygen, first turn of the ozonizer HV and O2 flow switches. Replace the tank and turn both switches back on. We have 9.75 tanks of UHP oxygen. Please reserve 2 for the month(s) of sunrise. In the meantime use aviators oxygen if the rest of the UHP does not show up.

2. Zero Air. Two zero air tanks should last for an entire year. Assuming that we get one zero air tank use that first, then switch to UHP nitrogen.

3. Cal gas. We have three NO cal cylinders. The one attached to the system should last for the duration. The others are backups.

Flows

The sample and calibration gas flows should be checked periodically to ensure accurate concentration measurements. In addition, the critical orifice controlled flows should be checked periodically to ensure that the nominal flow rates are still correct. These flows should be checked every few months.

Titration cell

The NO2 titration efficiency should be between 50-90 %. Adjustment of the pen-ray lamp intensity of the titration cell may be necessary (only if the cal tank is changed).

NOy converter

If the NOy_NO2 calibration indicates that the NOy converter efficiency has fallen below ca. 95% the NOy converter should be baked out under flow of an inert gas (N2 or H2 if desired) at ca. 450 ^{o}C for a couple of hours. This procedure should return the conversion efficiency of the NOy converter to > 95%.

Leak checking

It is a good idea to periodically leak check the system. This is easily done by sampling zero air and methodically spraying all of the connections from the inlet to the reaction vessel with the NO cal gas. A leak will be readily evident in the detector signal.

Troubleshooting

The NOxy system is a relatively complex array of plumbing and electrical connections, and troubleshooting this system requires a general familiarity with these types of systems. In most cases an improper flow and a missing signal can be traced to a loose or broken plumbing or electrical connection. The first steps in trouble-shooting are to ensure that the primary system components are operational. These include:

1. Vacuum is operational (nominal 10 torr reaction vessel pressure).
2. Compressed gases are on and at nominal head-pressure.
3. Sample flows are operational (nominal 1 slpm flow)
4. All control switches are in either on or auto position.
5. Calibration flow is operational (nominal 1-10 sccm)
6. Ozonizer is functional (oxygen flow is ca 100 mL/min, ozone cell pressure is nominal 3 psig). Turning the ozone HV on and off while the rest of the system is running should result in relatively large changes in the detector signal.

If these conditions are met and there is still no detector signal please contact Air Quality Design, Inc. for further assistance:

Tel: 303-225-0287
marty@airqualitydesign.com

7. Instrument connections and wiring

Snooper

25 PL D-SUB Connector Snooper					
Channel Name	**A: Internal connection**	**Pin Type**	**B: Amphenol DSUB 25 F MIL-C-24308**	**Pin Type**	**Wire Type**
HV1 Sig +	J2-P HV #1 pin 7	Molex PN: 08-56-0110	1	AMP PN: 205090-1	M22759/32-24-9
HV2 Sig+	J2-P HV #2 pin 7	Molex PN: 08-56-0110	2	AMP PN: 205090-1	M22759/32-24-9
HV1 Cntrl+	HV1 VDB pin 2	Molex PN: 08-56-0110	3	AMP PN: 205090-1	M22759/32-24-9
HV2 Cntrl+	HV2 VDB pin 2	Molex PN: 08-56-0110	4	AMP PN: 205090-1	M22759/32-24-9
ZV1 Cntrl+	ZV1 VDB pin 2	Molex PN: 08-56-0110	5	AMP PN: 205090-1	M22759/32-24-9
ZV2 Cntrl+	ZV2 VDB pin 2	Molex PN: 08-56-0110	6	AMP PN: 205090-1	M22759/32-24-9
Vac Valve1 Cntrl+	Vac Valve1 VDB pin 2	screw terminal	7	AMP PN: 205090-1	M22759/32-24-9
Vac Valve2 Cntrl+	Vac Valve2 VDB pin 2	screw terminal	8	AMP PN: 205090-1	M22759/32-24-9
RXN Pressure Transducer +	MKS 722 Transducer pin 1	AMP PN: 205090-1	9	AMP PN: 205090-1	M22759/32-24-9
	NC	NC	10	NC	NC
	NC	NC	11	NC	NC
	NC	NC	12	NC	NC
	NC	NC	13	NC	NC
HV1 Sig C	J2-P HV #1 pin 3	Molex PN: 08-56-0110	14	AMP PN: 205090-1	M22759/32-24-9
HV2 Sig C	J2-P HV #2 pin 3	Molex PN: 08-56-0110	15	AMP PN: 205090-1	M22759/32-24-9
HV1 Cntrl-	HV1 VDB pin 1	Molex PN: 08-56-0110	16	AMP PN: 205090-1	M22759/32-24-9
HV2 Cntrl-	HV2 VDB pin 1	Molex PN: 08-56-0110	17	AMP PN: 205090-1	M22759/32-24-9
ZV1 Cntrl-	ZV1 VDB pin 1	Molex PN: 08-56-0110	18	AMP PN: 205090-1	M22759/32-24-9

ZV2 Cntrl-	ZV2 VDB pin 1	Molex PN: 08-56-0110	19	AMP PN: 205090-1	M22759/32-24-9
Vac Valve1 Cntrl-	Vac Valve1 VDB pin 1	screw terminal	20	AMP PN: 205090-1	M22759/32-24-9
Vac Valve2 Cntrl-	Vac Valve2 VDB pin 1	screw terminal	21	AMP PN: 205090-1	M22759/32-24-9
RXN Pressure Transducer C	MKS 722 Transducer pin 8	AMP PN: 205090-1	22	AMP PN: 205090-1	M22759/32-24-9
	NC	NC	23	NC	NC
	NC	NC	24	NC	NC
	NC	NC	25	NC	NC

Channel Name	A: Valve Driver Board	Pin Type	B: Connection	Pin Type	Wire Type
ZV1 PWR +	ZV1 VDB Molex pin 1	Molex PN: 08-56-0110	Molex C-Grid 2PL F	Molex C-Grid PN:16-02-0103	M22759/32-22-9
ZV1 PWR -	ZV1 VDB Molex pin 2	Molex PN: 08-56-0110	Molex C-Grid 2PL F	Molex C-Grid PN:16-02-0103	M22759/32-22-9
GND	ZV1 VDB Molex pin 3	Molex PN: 08-56-0110	PWR Distribution Board	Molex MiniFit PN: 39-00-0182	M22759/32-22-9
+ 24 VDC	ZV1 VDB Molex pin 4	Molex PN: 08-56-0110	PWR Distribution Board	Molex MiniFit PN: 39-00-0182	M22759/32-22-9
ZV1 CNTL+	ZV1 VDB Molex pin 5	Molex PN: 08-56-0110	Amphenol DSUB 25 F MIL-C-24308	AMP PN: 205090-1	M22759/32-22-9
ZV1 CNTL-	ZV1 VDB Molex pin 6	Molex PN: 08-56-0110	Amphenol DSUB 25 F MIL-C-24308	AMP PN: 205090-1	M22759/32-22-9

Channel Name	A: Valve Driver Board	Pin Type	B: Connection	Pin Type	Wire Type
ZV2 PWR +	ZV2 VDB Molex pin 1	Molex PN: 08-56-0110	Molex C-Grid 2PL F	Molex C-Grid PN:16-02-0103	M22759/32-22-9
ZV2 PWR -	ZV2 VDB Molex pin 2	Molex PN: 08-56-0110	Molex C-Grid 2PL F	Molex C-Grid PN:16-02-0103	M22759/32-22-9
GND	ZV2 VDB Molex pin 3	Molex PN: 08-56-0110	PWR Distribution Board	Molex MiniFit PN: 39-00-0182	M22759/32-22-9
+ 24 VDC	ZV2 VDB Molex pin 4	Molex PN: 08-56-0110	PWR Distribution Board	Molex MiniFit PN: 39-00-0182	M22759/32-22-9
ZV2 CNTL+	ZV2 VDB Molex pin 5	Molex PN: 08-56-0110	Amphenol DSUB 25 F MIL-C-24308	AMP PN: 205090-1	M22759/32-22-9
ZV2 CNTL-	ZV2 VDB Molex pin 6	Molex PN: 08-56-0110	Amphenol DSUB 25 F MIL-C-24308	AMP PN: 205090-1	M22759/32-22-9

Channel Name	A: Valve Driver Board	Pin Type	B: Connection	Pin Type	Wire Type
HV #1 PWR +	HV #1 VDB Molex pin 1	Molex PN: 08-56-0110	Molex C-Grid 2PL F	Molex C-Grid PN:16-02-0103	M22759/32-22-9
HV #1 PWR -	HV #1 VDB Molex pin 2	Molex PN: 08-56-0110	Molex C-Grid 2PL F	Molex C-Grid PN:16-02-0103	M22759/32-22-9
GND	HV #1 VDB Molex pin 3	Molex PN: 08-56-0110	PWR Distribution Board	Molex MiniFit PN: 39-00-0182	M22759/32-22-9
+ 24 VDC	HV #1 VDB Molex pin 4	Molex PN: 08-56-0110	PWR Distribution Board	Molex MiniFit PN: 39-00-0182	M22759/32-22-9
HV #1 CNTL +	HV #1 VDB Molex pin 5	Molex PN: 08-56-0110	Amphenol DSUB 25 F MIL-C-24308	AMP PN: 205090-1	M22759/32-22-9
HV #1 CNTL -	HV #1 VDB Molex pin 6	Molex PN: 08-56-0110	Amphenol DSUB 25 F MIL-C-24308	AMP PN: 205090-1	M22759/32-22-9

Channel Name	A: Valve Driver Board	Pin Type	B: Connection	Pin Type	Wire Type
HV #2 PWR +	HV #2 VDB Molex pin 1	Molex PN: 08-56-0110	Molex C-Grid 2PL F	Molex C-Grid PN:16-02-0103	M22759/32-22-9
HV #2 PWR -	HV #2 VDB Molex pin 2	Molex PN: 08-56-0110	Molex C-Grid 2PL F	Molex C-Grid PN:16-02-0103	M22759/32-22-9
GND	HV #2 VDB Molex pin 3	Molex PN: 08-56-0110	PWR Distribution Board	Molex MiniFit PN: 39-00-0182	M22759/32-22-9
+ 24 VDC	HV #2 VDB Molex pin 4	Molex PN: 08-56-0110	PWR Distribution Board	Molex MiniFit PN: 39-00-0182	M22759/32-22-9
HV #2 CNTL +	HV #2 VDB Molex pin 5	Molex PN: 08-56-0110	Amphenol DSUB 25 F MIL-C-24308	AMP PN: 205090-1	M22759/32-22-9
HV #2 CNTL -	HV #2 VDB Molex pin 6	Molex PN: 08-56-0110	Amphenol DSUB 25 F MIL-C-24308	AMP PN: 205090-1	M22759/32-22-9

Channel Name	A: Valve Driver Board	Pin Type	B: Connection	Pin Type	Wire Type
VAC #1 PWR +	VAC #1 VDB Molex pin 1	Molex PN: 08-56-0110	Molex C-Grid 2PL F	Molex C-Grid PN:16-02-0103	M22759/32-22-9
VAC #1 PWR -	VAC #1 VDB Molex pin 2	Molex PN: 08-56-0110	Molex C-Grid 2PL F	Molex C-Grid PN:16-02-0103	M22759/32-22-9
GND	VAC #1 VDB Molex pin 3	Molex PN: 08-56-0110	PWR Distribution Board	Molex MiniFit PN: 39-00-0182	M22759/32-22-9

+ 24 VDC	VAC #1 VDB Molex pin 4	Molex PN: 08-56-0110	PWR Distribution Board	Molex MiniFit PN: 39-00-0182	M22759/32-22-9
VAC #1 CNTL +	VAC #1 VDB Molex pin 5	Molex PN: 08-56-0110	Amphenol DSUB 25 F MIL-C-24308	AMP PN: 205090-1	M22759/32-22-9
VAC #1 CNTL -	VAC #1 VDB Molex pin 6	Molex PN: 08-56-0110	Amphenol DSUB 25 F MIL-C-24308	AMP PN: 205090-1	M22759/32-22-9

Channel Name	**A: Valve Driver Board**	**Pin Type**	**B: Connection**	**Pin Type**	**Wire Type**
VAC #2 PWR +	VAC #2 VDB Molex pin 1	Molex PN: 08-56-0110	Molex C-Grid 2PL F	Molex C-Grid PN:16-02-0103	M22759/32-22-9
VAC #2 PWR -	VAC #2 VDB Molex pin 2	Molex PN: 08-56-0110	Molex C-Grid 2PL F	Molex C-Grid PN:16-02-0103	M22759/32-22-9
GND	VAC #2 VDB Molex pin 3	Molex PN: 08-56-0110	PWR Distribution Board	Molex MiniFit PN: 39-00-0182	M22759/32-22-9
+ 24 VDC	VAC #2 VDB Molex pin 4	Molex PN: 08-56-0110	PWR Distribution Board	Molex MiniFit PN: 39-00-0182	M22759/32-22-9
VAC #2 CNTL +	VAC #2 VDB Molex pin 5	Molex PN: 08-56-0110	Amphenol DSUB 25 F MIL-C-24308	AMP PN: 205090-1	M22759/32-22-9
VAC #2 CNTL -	VAC #2 VDB Molex pin 6	Molex PN: 08-56-0110	Amphenol DSUB 25 F MIL-C-24308	AMP PN: 205090-1	M22759/32-22-9

POWER BREAKOUT BOARD

Channel Name	**A: Astrodyne QP150-D**	**Pin Type**	**B:**	**Pin Type**	**Wire Type**
+ 5VDC	Pins 6,7	Screw Terminal	JB 5 Pin 1	Molex MiniFit PN: 39-00-0182	M22759/32-16-9
+ 12 VDC	Pin 10	Screw Terminal	JB 4 Pin 1	Molex MiniFit PN: 39-00-0183	M22759/32-16-9
+ 24 VDC	Pin 5	Screw Terminal	JB 3 Pin 1	Molex MiniFit PN: 39-00-0184	M22759/32-16-9
- 12 VDC	Pin 4	Screw Terminal	JB 2 Pin 1	Molex MiniFit PN: 39-00-0185	M22759/32-16-9
POWER COMMON	Pins 8,9	Screw Terminal	JB 5, 4, 3, 2, 1 Pin 2	Molex MiniFit PN: 39-00-0186	M22759/32-16-9

Channel Name	**A: Dwyer(Love Controls) 32A-021**	**Pin Type**	**B: connection**	**Pin Type**	**Wire Type**

PMT COOLER RTD +	Pin 1 Input RTD +	Screw Terminal	PMT COOLER	Screw Terminal	M22759/32-22-9
PMT COOLER RTD -	Pin 2 Input RTD -	Screw Terminal	PMT COOLER	Screw Terminal	M22759/32-22-9
PMT COOLER RTD-	Pin 3 Input RTD -	Screw Terminal	PMT COOLER	Screw Terminal	M22759/32-22-9
NA	Pin 4	Screw Terminal	NC	NC	NC
Option/NA	Pin 5	Screw Terminal	NC	NC	NC
Option/NA	Pin 6	Screw Terminal	NC	NC	NC
PMT Cooler Cntl +	Pin 7 Out A +	Screw Terminal	PMT SSR CNTL +	Screw Terminal	M22759/32-22-9
PMT Cooler Cntl -	Pin 8 Out B +	Screw Terminal	PMT SSR CNTL -	Screw Terminal	M22759/32-22-9
Out B +	Pin 9	Screw Terminal	NC	NC	NC
Out B -	Pin 10	Screw Terminal	NC	NC	NC
AC N	Pin 11 AC N	Screw Terminal	AC Line	Screw Terminal	M27500-16SR3523
AC L	Pin 12 AC L	Screw Terminal	AC Neutral	Screw Terminal	M27500-16SR3523

Channel Name	**A: Dwyer(Love Controls) 32A-021**	**Pin Type**	**B: Connection**	**Pin Type**	**Wire Type**
RXN Heater RTD +	Pin 1 Input RTD +	Screw Terminal	Molex C-Grid 5PL F RXN Heater RTD +	Molex C-Grid PN:16-02-0103	M22759/32-22-9
RXN Heater RTD -	Pin 2 Input RTD -	Screw Terminal	Molex C-Grid 5PL F RXN Heater RTD -	Molex C-Grid PN:16-02-0103	M22759/32-22-9
RXN Heater RTD -	Pin 3 Input RTD -	Screw Terminal	Molex C-Grid 5PL F RXN Heater RTD -	Molex C-Grid PN:16-02-0103	M22759/32-22-9
NA	Pin 4	Screw Terminal	NC	NC	NC
Option/NA	Pin 5	Screw Terminal	NC	NC	NC
Option/NA	Pin 6	Screw Terminal	NC	NC	NC
Out A +	Pin 7	Screw Terminal	NC	NC	NC
Out A -	Pin 8	Screw Terminal	NC	NC	NC
Out B +	Pin 9 Out B + (ACL in)	Screw Terminal	Molex C-Grid 5PL F RXN Heater	Molex C-Grid PN:16-02-0103	M22759/32-22-9
Out B -	Pin 10 Out B - (ACL out)	Screw Terminal	Molex C-Grid 5PL F RXN Heater	Molex C-Grid PN:16-02-0103	M22759/32-22-9
AC N	Pin 11 AC N	Screw Terminal	AC Line	Screw Terminal	M27500-16SR3523
AC L	Pin 12 AC L	Screw Terminal	AC Neutral	Screw Terminal	M27500-16SR3523

Channel Name	A: Dwyer(Love Controls) 32A-021	Pin Type	B: Connection	Pin Type	Wire Type
ZV Heater RTD +	Pin 1 Input RTD +	Screw Terminal	Molex C-Grid 5PL F ZV Heater RTD +	Molex C-Grid PN:16-02-0103	M22759/32-22-9
ZV Heater RTD -	Pin 2 Input RTD -	Screw Terminal	Molex C-Grid 5PL F ZV Heater RTD -	Molex C-Grid PN:16-02-0103	M22759/32-22-9
ZV Heater RTD -	Pin 3 Input RTD -	Screw Terminal	Molex C-Grid 5PL F ZV Heater RTD -	Molex C-Grid PN:16-02-0103	M22759/32-22-9
NA	Pin 4	Screw Terminal	NC	NC	NC
Option/NA	Pin 5	Screw Terminal	NC	NC	NC
Option/NA	Pin 6	Screw Terminal	NC	NC	NC
Out A +	Pin 7	Screw Terminal	NC	NC	NC
Out A -	Pin 8	Screw Terminal	NC	NC	NC
Out B +	Pin 9 Out B + (ACL in)	Screw Terminal	Molex C-Grid 5PL F ZV Heater	Molex C-Grid PN:16-02-0103	M22759/32-22-9
Out B -	Pin 10 Out B - (ACL out)	Screw Terminal	Molex C-Grid 5PL F ZV Heater	Molex C-Grid PN:16-02-0103	M22759/32-22-9
AC N	Pin 11 AC N	Screw Terminal	AC Line	Screw Terminal	M27500-16SR3523
AC L	Pin 12 AC L	Screw Terminal	AC Neutral	Screw Terminal	M27500-16SR3523

Power Display Board

Channel Name	A: Power Display Board	Pin Type	B: Connection	Pin Type	Wire Type
+ 12 VDC	+ 12 VDC	Molex C-Grid PN:16-02-0103	Power Break Out Board JB 4, Pin 1	Molex MiniFit PN: 39-00-0182	M22759/32-22-9
+ 5 VDC	+ 5 VDC	Molex C-Grid PN:16-02-0103	Power Break Out Board JB 5, Pin 1	Molex MiniFit PN: 39-00-0182	M22759/32-22-9
COM	COM	Molex C-Grid PN:16-02-0103	Power Break Out Board JB 5, Pin 2	Molex MiniFit PN: 39-00-0182	M22759/32-22-9
HV1+	S1+	Molex C-Grid PN:16-02-0103	HV1 J2-P, Pin 7	Molex PN: 08-56-0110	M22759/32-24-9
HV1-	S1-	Molex C-Grid PN:16-02-0103	HV1 J2-P, Pin 3	Molex PN: 08-56-0110	M22759/32-24-9
NC	S2+	NC	NC	NC	NC
NC	S2-	NC	NC	NC	NC
RXN P+	S3+	Molex C-Grid PN:16-02-0103	AMP D-SUB 9PL F, Pin 1	AMP PN: 205090-1	M22759/32-24-9

RXN P-	S3-	Molex C-Grid PN:16-02-0103	AMP D-SUB 9PL F, Pin 8	AMP PN: 205090-1	M22759/32-24-9
NC	S4+	NC	NC	NC	NC
NC	S4-	NC	NC	NC	NC
HV2+	S5+	Molex C-Grid PN:16-02-0103	HV2 J2-P, Pin 7	Molex PN: 08-56-0110	M22759/32-24-9
HV2-	S5-	Molex C-Grid PN:16-02-0103	HV2 J2-P, Pin 3	Molex PN: 08-56-0110	M22759/32-24-9

Control Box

25 PL D-SUB Conncetor Control Box

Channel Name	A: Internal conncectioin	Pin Type	B: Amphenol DSUB 25 F MIL-C-24308	Pin Type	Wire Type
NO Cal Cntrl +	NO Cal VDB pin2	Molex PN: 08-56-0110	1	AMP PN: 205090-1	M22759/32-24-9
NOx Cal Cntrl +	NOx Cal VDB pin 2	Molex PN: 08-56-0110	2	AMP PN: 205090-1	M22759/32-24-9
HNO3 Cal Cntrl +	HNO3 Cal VDB pin 2	Molex PN: 08-56-0110	3	AMP PN: 205090-1	M22759/32-24-9
ZA Valve Cntrl +	ZA Valve VDB pin 2	Molex PN: 08-56-0110	4	AMP PN: 205090-1	M22759/32-24-9
NO2 Converter Cntrl +	NO2 Converter VDB pin 2	Molex PN: 08-56-0110	5	AMP PN: 205090-1	M22759/32-24-9
NO Cal On/Off Cntrl +	Release Hounds VDB pin 2	Molex PN: 08-56-0110	6	AMP PN: 205090-1	M22759/32-24-9
NC	NC	NC	7	NC	NC
NC	NC	NC	8	NC	NC
MFC1 Sig +	MS3470L1626S pin K	size 20 socket MIL-C-22520	9	AMP PN: 205090-1	M22759/32-24-9
MFC2 Sig +	MS3470L1626S pin N	size 20 socket MIL-C-22520	10	AMP PN: 205090-1	M22759/32-24-9
NO Cal MFC Sig +	Unit 180 pin 2	AMP PN: 205090-1	11	AMP PN: 205090-1	M22759/32-24-9
Pressure Controller Sig +	MS3470L1626S pin c	size 20 socket MIL-C-22520	12	AMP PN: 205090-1	M22759/32-24-9
	NC	NC	13	NC	NC
NO Cal Cntrl -	NO Cal VDB pin2	Molex PN: 08-56-0110	14	AMP PN: 205090-1	M22759/32-24-9
NOx Cal Cntrl -	NOx Cal VDB pin 2	Molex PN: 08-56-0110	15	AMP PN: 205090-1	M22759/32-24-9
HNO3 Cal Cntrl -	HNO3 Cal VDB pin 2	Molex PN: 08-56-0110	16	AMP PN: 205090-1	M22759/32-24-9
ZA Valve Cntrl -	ZA Valve VDB pin 2	Molex PN: 08-56-0110	17	AMP PN: 205090-1	M22759/32-24-9
NO2 Converter Cntrl -	NO2 Converter VDB pin 2	Molex PN: 08-56-0110	18	AMP PN: 205090-1	M22759/32-24-9
NO Cal On/Off Cntrl -	Release Hounds VDB pin 2	Molex PN: 08-56-0110	19	AMP PN: 205090-1	M22759/32-24-9
NC	NC	NC	20	NC	NC
NC	NC	NC	21	NC	NC
Sig Com for pins 9,10, 11, 12	MS3470L1626S pin L,b,R/ Unit 180 pin 8	AMP PN: 205090-1	22	AMP PN: 205090-1	M22759/32-24-9

NC	NC	NC	23	NC	NC
NC	NC	NC	24	NC	NC
NC	NC	NC	25	NC	NC

NO Calibration Valve	A: NO Calibration Valve	Pin Type	B: Connection	Pin Type	Wire Type
NO CAL+	NO CAL VDB Molex pin 1	Molex PN: 08-56-0110	Molex C-Grid 2PL F	Molex C-Grid PN:16-02-0103	M22759/32-22-9
NO CAL-	NO CAL VDB Molex pin 2	Molex PN: 08-56-0110	Molex C-Grid 2PL F	Molex C-Grid PN:16-02-0103	M22759/32-22-9
GND	NO CAL VDB Molex pin 3	Molex PN: 08-56-0110	PWR Distribution Board	Molex MiniFit PN: 39-00-0182	M22759/32-22-9
+ 24 VDC	NO CAL VDB Molex pin 4	Molex PN: 08-56-0110	PWR Distribution Board	Molex MiniFit PN: 39-00-0182	M22759/32-22-9
NO CAL CNTL+	NO CAL VDB Molex pin 5	Molex PN: 08-56-0110	Amphenol DSUB 25 F MIL-C-24308	AMP PN: 205090-1	M22759/32-22-9
NO CAL CNTL-	NO CAL VDB Molex pin 6	Molex PN: 08-56-0110	Amphenol DSUB 25 F MIL-C-24308	AMP PN: 205090-1	M22759/32-22-9

HNO3 Calibration Valve	A: HNO3 Calibration Valve	Pin Type	B: Connection	Pin Type	Wire Type
HNO3 CAL +	HNO3 CAL VDB Molex pin 1	Molex PN: 08-56-0110	Molex C-Grid 2PL F	Molex C-Grid PN:16-02-0103	M22759/32-22-9
HNO3 CAL -	HNO3 CAL VDB Molex pin 2	Molex PN: 08-56-0110	Molex C-Grid 2PL F	Molex C-Grid PN:16-02-0103	M22759/32-22-9
GND	HNO3 CAL VDB Molex pin 3	Molex PN: 08-56-0110	PWR Distribution Board	Molex MiniFit PN: 39-00-0182	M22759/32-22-9
+ 24 VDC	HNO3 CAL VDB Molex pin 4	Molex PN: 08-56-0110	PWR Distribution Board	Molex MiniFit PN: 39-00-0182	M22759/32-22-9
HNO3 CAL CNTL+	HNO3 CAL VDB Molex pin 5	Molex PN: 08-56-0110	Amphenol DSUB 25 F MIL-C-24308	AMP PN: 205090-1	M22759/32-22-9
HNO3 CAL CNTL-	HNO3 CAL VDB Molex pin 6	Molex PN: 08-56-0110	Amphenol DSUB 25 F MIL-C-24308	AMP PN: 205090-1	M22759/32-22-9

ZERO AIR VALVE	A: ZERO AIR VALVE	Pin Type	B: Connection	Pin Type	Wire Type
ZA +	ZA VDB Molex pin 1	Molex PN: 08-56-0110	Molex C-Grid 2PL F	Molex C-Grid PN:16-02-0103	M22759/32-22-9
ZA -	ZA VDB Molex pin 2	Molex PN: 08-56-0110	Molex C-Grid 2PL F	Molex C-Grid PN:16-02-0103	M22759/32-22-9
GND	ZA VDB Molex pin 3	Molex PN: 08-56-0110	PWR Distribution Board	Molex MiniFit PN: 39-00-0182	M22759/32-22-9
+ 24 VDC	ZA VDB Molex pin 4	Molex PN: 08-56-0110	PWR Distribution Board	Molex MiniFit PN: 39-00-0182	M22759/32-22-9
ZA CNTL +	ZA VDB Molex pin 5	Molex PN: 08-56-0110	Amphenol DSUB 25 F MIL-C-24308	AMP PN: 205090-1	M22759/32-22-9

ZA CNTL -	ZA VDB Molex pin 6	Molex PN: 08-56-0110	Amphenol DSUB 25 F MIL-C-24308	AMP PN: 205090-1	M22759/32-22-9

NO2 TITRATION LAMP	A: NO2 TITRATION LAMP	Pin Type	B: Connection	Pin Type	Wire Type
NO2 +	NOx CAL VDB Molex pin 1	Molex PN: 08-56-0110	Molex C-Grid 2PL F	Molex C-Grid PN:16-02-0103	M22759/32-22-9
NO2 -	NOx CAL VDB Molex pin 2	Molex PN: 08-56-0110	Molex C-Grid 2PL F	Molex C-Grid PN:16-02-0103	M22759/32-22-9
GND	NOx CAL VDB Molex pin 3	Molex PN: 08-56-0110	PWR Distribution Board	Molex MiniFit PN: 39-00-0182	M22759/32-22-9
+ 24 VDC	NOx CAL VDB Molex pin 4	Molex PN: 08-56-0110	PWR Distribution Board	Molex MiniFit PN: 39-00-0182	M22759/32-22-9
NO2 CNTL +	NOx CAL VDB Molex pin 5	Molex PN: 08-56-0110	Amphenol DSUB 25 F MIL-C-24308	AMP PN: 205090-1	M22759/32-22-9
NO2 CNTL -	NOx CAL VDB Molex pin 6	Molex PN: 08-56-0110	Amphenol DSUB 25 F MIL-C-24308	AMP PN: 205090-1	M22759/32-22-9

NO2 Converter	A: NO2 Converter	Pin Type	B: Connection	Pin Type	Wire Type
NO2 Conv +	NO2 Conv VDB Molex pin 1	Molex PN: 08-56-0110	Molex C-Grid 2PL F	Molex C-Grid PN:16-02-0103	M22759/32-22-9
NO2 Conv -	NO2 Conv VDB Molex pin 2	Molex PN: 08-56-0110	Molex C-Grid 2PL F	Molex C-Grid PN:16-02-0103	M22759/32-22-9
GND	NO2 Conv VDB Molex pin 3	Molex PN: 08-56-0110	PWR Distribution Board	Molex MiniFit PN: 39-00-0182	M22759/32-22-9
+ 5 VDC	NO2 Conv VDB Molex pin 4	Molex PN: 08-56-0110	PWR Distribution Board	Molex MiniFit PN: 39-00-0182	M22759/32-22-9
NO2 Conv CNTL +	NO2 Conv VDB Molex pin 5	Molex PN: 08-56-0110	Amphenol DSUB 25 F MIL-C-24308	AMP PN: 205090-1	M22759/32-22-9
NO2 Conv CNTL -	NO2 Conv VDB Molex pin 6	Molex PN: 08-56-0110	Amphenol DSUB 25 F MIL-C-24308	AMP PN: 205090-1	M22759/32-22-9

NO Cal Gas ON/OFF (Release Hounds)	A:NO Cal Gas ON/OFF (Release Hounds	Pin Type	B: Connection	Pin Type	Wire Type
NO Cal ON/OFF +	NO Cal ON/OFF VDB Molex pin 1	Molex PN: 08-56-0110	Molex C-Grid 2PL F	Molex C-Grid PN:16-02-0103	M22759/32-22-9
NO Cal ON/OFF -	NO Cal ON/OFF VDB Molex pin 2	Molex PN: 08-56-0110	Molex C-Grid 2PL F	Molex C-Grid PN:16-02-0103	M22759/32-22-9
GND	NO Cal ON/OFF VDB Molex pin 3	Molex PN: 08-56-0110	PWR Distribution Board	Molex MiniFit PN: 39-00-0182	M22759/32-22-9
+ 24 VDC	NO Cal ON/OFFVDB Molex pin 4	Molex PN: 08-56-0110	PWR Distribution Board	Molex MiniFit PN: 39-00-0182	M22759/32-22-9
NO Cal ON/OFF Cntrl+	NO Cal ON/OFF VDB Molex pin 5	Molex PN: 08-56-0110	Amphenol DSUB 25 F MIL-C-24308	AMP PN: 205090-1	M22759/32-22-9

NO Cal ON/OFF Cntrl -	NO Cal ON/OFF VDB Molex pin 6	Molex PN: 08-56-0110	Amphenol DSUB 25 F MIL-C-24308	AMP PN: 205090-1	M22759/32-22-9

POWER BREAKOUT BOARD

Channel Name	A: Astrodyne QP150-D	Pin Type	B:	Pin Type	Wire Type
+ 5VDC	Pins 6,7	Screw Terminal	JB 1 Pin 1	Molex MiniFit PN: 39-00-0182	M22759/32-16-9
+ 12 VDC	Pin 10	Screw Terminal	JB 2 Pin 1	Molex MiniFit PN: 39-00-0183	M22759/32-16-9
+ 24 VDC	Pin 5	Screw Terminal	JB 3 Pin 1	Molex MiniFit PN: 39-00-0184	M22759/32-16-9
- 12 VDC	Pin 4	Screw Terminal	JB 4 Pin 1	Molex MiniFit PN: 39-00-0185	M22759/32-16-9
POWER COMMON	Pins 8,9	Screw Terminal	JB 5, 4, 3, 2, 1 Pin 2	Molex MiniFit PN: 39-00-0186	M22759/32-16-9

Channel Name	A: Internal Conncetion	Pin Type	B: Amphenol Mini Cylindrical MIL-C-26482-16-26	Pin Type	Wire Type
NOy T Chromel	NOy Temp Controller Pin 1	Screw Terminal	A	AMP: 10-252900-21P	OMEGA: FF-K-20S-TWSH
NOy T Cntrl +	NOy Temp Controller Pin 7	Screw Terminal	B	M39029/5-115	M22759/32-22-9
NOy T Cntrl -	NOy Temp Controller Pin 8	Screw Terminal	C	M39029/5-115	M22759/32-22-9
NOy Alumel	NOy Temp Controller Pin 2	Screw Terminal	D	AMP: 10-252900-22P	OMEGA: FF-K-20S-TWSH
NO Cal Valve +	NO Cal Valve Driver Board Pin 5	Molex PN: 08-56-0110	E	M39029/5-115	M22759/32-22-9
NO Cal Valve -	NO Cal Valve Driver Board Pin 6	Molex PN: 08-56-0110	F	M39029/5-115	M22759/32-22-9
HNO3 Cal Valve +	HNO3 Cal Valve Driver Board Pin 5	Molex PN: 08-56-0110	G	M39029/5-115	M22759/32-22-9
HNO3 Cal Valve -	HNO3 Cal Valve Driver Board Pin 6	Molex PN: 08-56-0110	H	M39029/5-115	M22759/32-22-9
NO2 Conv. Lamp +	NO2 Conv. Lamp Driver Board Pin 5	Molex PN: 08-56-0110	S	M39029/5-115	M22759/32-22-9
NO2 Conv. Lamp -	NO2 Conv. Lamp Driver Board Pin 6	Molex PN: 08-56-0110	J	M39029/5-115	M22759/32-22-9
Sample MFC 1 Sig	Sample MFC 1 Flow Controller Board Pin 5	Molex PN: 08-56-0110	K	M39029/5-115	M22759/32-22-9

Sample MFC 1 Sig C	Sample MFC 1 Flow Controller Board Pin 6	Molex PN: 08-56-0110	L	M39029/5-115	M22759/32-22-9
Sample MFC 1 Set	Sample MFC 1 Flow Controller Board Pin 8	Molex PN: 08-56-0110	M	M39029/5-115	M22759/32-22-9
Sample MFC 2 Sig	Sample MFC 2 Flow Controller Board Pin 5	Molex PN: 08-56-0110	N	M39029/5-115	M22759/32-22-9
Sample MFC 2 Sig C	Sample MFC 2 Flow Controller Board Pin 6	Molex PN: 08-56-0110	b	M39029/5-115	M22759/32-22-9
Sample MFC 2 Set	Sample MFC 2 Flow Controller Board Pin 8	Molex PN: 08-56-0110	P	M39029/5-115	M22759/32-22-9
Pressure Controller Sig	Pressure Controller Board Pin 5	Molex PN: 08-56-0110	c	M39029/5-115	M22759/32-22-9
Pressure Controller Sig C	Pressure Controller Board Pin 6	Molex PN: 08-56-0110	R	M39029/5-115	M22759/32-22-9
Pressure Controller Set	Pressure Controller Board Pin 8	Molex PN: 08-56-0110	a	M39029/5-115	M22759/32-22-9
+12 VDC	Power Breakout Board JB 2 Pin 1	Molex PN: 08-56-0110	T	M39029/5-115	M22759/32-22-9
-12 VDC	Power Breakout Board JB 4 Pin 1	Molex PN: 08-56-0110	U	M39029/5-115	M22759/32-22-9
PWR COM	Power Breakout Board JB 2 Pin 2	Molex PN: 08-56-0110	V	M39029/5-115	M22759/32-22-9
+15 VDC	Astrodyne MTCC-1511 V+	Screw Terminal	W	M39029/5-115	M22759/32-22-9
-15 VDC	Astrodyne MTCC-1511 V-	Screw Terminal	X	M39029/5-115	M22759/32-22-9
PWR COM	Astrodyne MTCC-1511 COM	Screw Terminal	Y	M39029/5-115	M22759/32-22-9
NC	NC	NC	Z	NC	NC

NOy T Controller

Channel Name	**A: Dwyer(Love Controls) 32A-021**	**Pin Type**	**B: Conncetion**	**Pin Type**	**Wire Type**
NOy T Chromel	Pin 1 Input + Chromel	Screw Terminal	Amphenol Mini Cylindrical MIL-C-26482-16-26 pin A	AMP: 10-252900-21P	OMEGA: FF-K-20S-TWSH
NOy T Alumel	Pin 2 Input - Alumel	Screw Terminal	Amphenol Mini Cylindrical MIL-C-26482-16-26 pin D	AMP: 10-252900-22P	OMEGA: FF-K-20S-TWSH
NA	Pin 3	Screw Terminal	NC	NC	NC
NA	Pin 4	Screw Terminal	NC	NC	NC
Option/NA	Pin 5	Screw Terminal	NC	NC	NC
Option/NA	Pin 6	Screw Terminal	NC	NC	NC

NOy T Cntl +	Pin 7 Out A +	Screw Terminal	Amphenol Mini Cylindrical MIL-C-26482-16-26 pin B	M39029/5-115	M22759/32-22-9
NOy T Cntl -	Pin 8 Out A -	Screw Terminal	Amphenol Mini Cylindrical MIL-C-26482-16-26 pin C	M39029/5-115	M22759/32-22-9
Out B +	Pin 9	Screw Terminal	NC	NC	NC
Out B -	Pin 10	Screw Terminal	NC	NC	NC
AC N	Pin 11 AC N	Screw Terminal	AC Line	Screw Terminal	M27500-16SR3523
AC L	Pin 12 AC L	Screw Terminal	AC Neutral	Screw Terminal	M27500-16SR3523

HNO3 T Controller

Channel Name	**A: Dwyer(Love Controls) 32A-021**	**Pin Type**	**B: Conncetion**	**Pin Type**	**Wire Type**
HNO3 T Chromel	Pin 1 Input + Chromel	Screw Terminal	HNO3 Heater Type K +	NA	M22759/32-22-9
HNO3 T Alumel	Pin 2 Input - Alumel	Screw Terminal	HnO3 Heater Type K -	NA	M22759/32-22-9
NA	Pin 3	Screw Terminal	NC	NC	NC
NA	Pin 4	Screw Terminal	NC	NC	NC
Option/NA	Pin 5	Screw Terminal	NC	NC	NC
Option/NA	Pin 6	Screw Terminal	NC	NC	NC
Out A +	Pin 7	Screw Terminal	NC	NC	NC
Out A -	Pin 8	Screw Terminal	NC	NC	NC
Out B +	Pin 9 Out B + (ACL in)	Screw Terminal	Molex C-Grid 2PL F	Molex C-Grid PN:16-02-0103	M22759/32-22-9
Out B -	Pin 10 Out B - (ACL out)	Screw Terminal	Molex C-Grid 2PL F	Molex C-Grid PN:16-02-0103	M22759/32-22-9
AC N	Pin 11 AC N	Screw Terminal	AC Line	Screw Terminal	M27500-16SR3523
AC L	Pin 12 AC L	Screw Terminal	AC Neutral	Screw Terminal	M27500-16SR3523

Power Display Board

Channel Name	**A: Power Display Board**	**Pin Type**	**B: Conncetion**	**Pin Type**	**Wire Type**
+ 12 VDC	+ 12 VDC	Molex C-Grid PN:16-02-0103	Power Break Out Board JB 4, Pin 1	Molex MiniFit PN: 39-00-0182	M22759/32-22-9
+ 5 VDC	+ 5 VDC	Molex C-Grid PN:16-02-0103	Power Break Out Board JB 5, Pin 1	Molex MiniFit PN: 39-00-0182	M22759/32-22-9
COM	COM	Molex C-Grid PN:16-02-0103	Power Break Out Board JB 5, Pin 2	Molex MiniFit PN: 39-00-0182	M22759/32-22-9

CH1 Flow +	S1+	Molex C-Grid PN:16-02-0103	Sample MFC 1 Flow Controller Board Pin 5	Molex PN: 08-56-0110	M22759/32-24-9
CH1 Flow -	S1-	Molex C-Grid PN:16-02-0103	Sample MFC 1 Flow Controller Board Pin 6	Molex PN: 08-56-0110	M22759/32-24-9
CH2 Flow+	S2+	Molex C-Grid PN:16-02-0103	Sample MFC 2 Flow Controller Board Pin 5	Molex PN: 08-56-0110	M22759/32-24-9
CH2 Flow-	S2-	Molex C-Grid PN:16-02-0103	Sample MFC 2 Flow Controller Board Pin 6	Molex PN: 08-56-0110	M22759/32-24-9
CH2 Pressure+	S3+	Molex C-Grid PN:16-02-0103	Pressure Controller Board Pin 5	Molex PN: 08-56-0110	M22759/32-24-9
CH2 Pressure-	S3-	Molex C-Grid PN:16-02-0103	Pressure Controller Board Pin 6	Molex PN: 08-56-0110	M22759/32-24-9
Cal Flow+	S4+	Molex C-Grid PN:16-02-0103	Cal Flow Board Pin 5	Molex PN: 08-56-0110	M22759/32-24-9
Cal Flow-	S4-	Molex C-Grid PN:16-02-0103	Cal Flow Board Pin 6	Molex PN: 08-56-0110	M22759/32-24-9
NC	S5+	NC	NC	NC	NC
NC	S5-	NC	NC	NC	NC

Ozonizer

25 PL D-SUB Connector Ozonizer

Channel Name	A: Internal conncectioin	Pin Type	B: Amphenol DSUB 25 F MIL-C-24308	Pin Type	Wire Type
O2 1 Cntrl +	O2 1 VDB pin 2	Molex PN: 08-56-0110	1	AMP PN: 205090-1	M22759/32-24-9
O2 2 Cntrl +	O2 2 VDB pin 2	Molex PN: 08-56-0110	2	AMP PN: 205090-1	M22759/32-24-9
O3 1 Cntrl +	O3 1 VDB pin 2	Molex PN: 08-56-0110	3	AMP PN: 205090-1	M22759/32-24-9
O3 2 Cntrl +	O3 2 VDB pin 2	Molex PN: 08-56-0110	4	AMP PN: 205090-1	M22759/32-24-9
O2 MFC1 Sig +	Pnucleus MFC 1 DSUB 9PL F pin	AMP PN: 205090-1	5	AMP PN: 205090-1	M22759/32-24-9
O2 MFC2 Sig +	Pnucleus MFC 2 DSUB 9PL F pin	AMP PN: 205090-1	6	AMP PN: 205090-1	M22759/32-24-9
NC	NC	NC	7	NC	NC
NC	NC	NC	8	NC	NC
NC	NC	NC	9	NC	NC
NC	NC	NC	10	NC	NC
NC	NC	NC	11	NC	NC
NC	NC	NC	12	NC	NC
NC	NC	NC	13	NC	NC
O2 1 Cntrl -	O2 1 VDB pin 1	Molex PN: 08-56-0110	14	AMP PN: 205090-1	M22759/32-24-9
O2 2 Cntrl -	O2 2 VDB pin 1	Molex PN: 08-56-0110	15	AMP PN: 205090-1	M22759/32-24-9
O3 1 Cntrl -	O3 1 VDB pin 1	Molex PN: 08-56-0110	16	AMP PN: 205090-1	M22759/32-24-9
O3 2 Cntrl -	O3 2 VDB pin 1	Molex PN: 08-56-0110	17	AMP PN: 205090-1	M22759/32-24-9
O2 MFC1 Sig C	Pnucleus MFC 1 DSUB 9PL F pin	AMP PN: 205090-1	18	AMP PN: 205090-1	M22759/32-24-9
O2 MFC2 Sig C	Pnucleus MFC 2 DSUB 9PL F pin	AMP PN: 205090-1	19	AMP PN: 205090-1	M22759/32-24-9
NC	NC	NC	20	NC	NC
NC	NC	NC	21	NC	NC
NC	NC	NC	22	NC	NC

NC	NC	NC	23	NC	NC
NC	NC	NC	24	NC	NC
NC	NC	NC	25	NC	NC

Channel Name	A: Valve Driver Board	Pin Type	B: Connection	Pin Type	Wire Type
O3 #1 PWR +	O3 #1 VDB Molex pin 1	Molex PN: 08-56-0110	Molex C-Grid 2PL F	Molex C-Grid PN:16-02-0103	M22759/32-22-9
O3 #1 PWR -	O3 #1 VDB Molex pin 2	Molex PN: 08-56-0110	Molex C-Grid 2PL F	Molex C-Grid PN:16-02-0103	M22759/32-22-9
GND	O3 #1 VDB Molex pin 3	Molex PN: 08-56-0110	PWR Distribution Board	Molex MiniFit PN: 39-00-0182	M22759/32-22-9
+ 24 VDC	O3 #1 VDB Molex pin 4	Molex PN: 08-56-0110	PWR Distribution Board	Molex MiniFit PN: 39-00-0182	M22759/32-22-9
O3 #1 CNTL+	O3 #1 VDB Molex pin 5	Molex PN: 08-56-0110	Amphenol DSUB 25 F MIL-C-24308	AMP PN: 205090-1	M22759/32-22-9
O3 #1 CNTL-	O3 #1 VDB Molex pin 6	Molex PN: 08-56-0110	Amphenol DSUB 25 F MIL-C-24308	AMP PN: 205090-1	M22759/32-22-9

Channel Name	A: Valve Driver Board	Pin Type	B: Connection	Pin Type	Wire Type
O3 #2 PWR +	O3 #2 VDB Molex pin 1	Molex PN: 08-56-0110	Molex C-Grid 2PL F	Molex C-Grid PN:16-02-0103	M22759/32-22-9
O3 #2 PWR -	O3 #2 VDB Molex pin 2	Molex PN: 08-56-0110	Molex C-Grid 2PL F	Molex C-Grid PN:16-02-0103	M22759/32-22-9
GND	O3 #2 VDB Molex pin 3	Molex PN: 08-56-0110	PWR Distribution Board	Molex MiniFit PN: 39-00-0182	M22759/32-22-9
+ 24 VDC	O3 #2 VDB Molex pin 4	Molex PN: 08-56-0110	PWR Distribution Board	Molex MiniFit PN: 39-00-0182	M22759/32-22-9
O3 #2 CNTL+	O3 #2 VDB Molex pin 5	Molex PN: 08-56-0110	Amphenol DSUB 25 F MIL-C-24308	AMP PN: 205090-1	M22759/32-22-9
O3 #2 CNTL-	O3 #2 VDB Molex pin 6	Molex PN: 08-56-0110	Amphenol DSUB 25 F MIL-C-24308	AMP PN: 205090-1	M22759/32-22-9

Channel Name	A: Valve Driver Board	Pin Type	B: Connection	Pin Type	Wire Type
O2 #1 PWR+	O2 #1 VDB Molex pin 1	Molex PN: 08-56-0110	Molex C-Grid 2PL F	Molex C-Grid PN:16-02-0103	M22759/32-22-9
O2 #1 PWR-	O2 #1 VDB Molex pin 2	Molex PN: 08-56-0110	Molex C-Grid 2PL F	Molex C-Grid PN:16-02-0103	M22759/32-22-9
GND	O2 #1 VDB Molex pin 3	Molex PN: 08-56-0110	PWR Distribution Board	Molex MiniFit PN: 39-00-0182	M22759/32-22-9
+ 24 VDC	O2 #1 VDB Molex pin 4	Molex PN: 08-56-0110	PWR Distribution Board	Molex MiniFit PN: 39-00-0182	M22759/32-22-9
O2 #1 CNTL+	O2 #1 VDB Molex pin 5	Molex PN: 08-56-0110	Amphenol DSUB 25 F MIL-C-24308	AMP PN: 205090-1	M22759/32-22-9

O2 #1 CNTL-	O2 #1 VDB Molex pin 6	Molex PN: 08-56-0110	Amphenol DSUB 25 F MIL-C-24308	AMP PN: 205090-1	M22759/32-22-9

Channel Name	A: Valve Driver Board	Pin Type	B: Connection	Pin Type	Wire Type
O2 #2 PWR+	O2 #2 VDB Molex pin 1	Molex PN: 08-56-0110	Molex C-Grid 2PL F	Molex C-Grid PN:16-02-0103	M22759/32-22-9
O2 #2 PWR-	O2 #2 VDB Molex pin 2	Molex PN: 08-56-0110	Molex C-Grid 2PL F	Molex C-Grid PN:16-02-0103	M22759/32-22-9
GND	O2 #2 VDB Molex pin 3	Molex PN: 08-56-0110	PWR Distribution Board	Molex MiniFit PN: 39-00-0182	M22759/32-22-9
+ 24 VDC	O2 #2 VDB Molex pin 4	Molex PN: 08-56-0110	PWR Distribution Board	Molex MiniFit PN: 39-00-0182	M22759/32-22-9
O2 #2 CNTL+	O2 #2 VDB Molex pin 5	Molex PN: 08-56-0110	Amphenol DSUB 25 F MIL-C-24308	AMP PN: 205090-1	M22759/32-22-9
O2 #2 CNTL-	O2 #2 VDB Molex pin 6	Molex PN: 08-56-0110	Amphenol DSUB 25 F MIL-C-24308	AMP PN: 205090-1	M22759/32-22-9

POWER BREAKOUT BOARD

Channel Name	A: Astrodyne QP150-D	Pin Type	B:	Pin Type	Wire Type
+ 5VDC	Pins 6,7	Screw Terminal	JB 1 Pin 1	Molex MiniFit PN: 39-00-0182	M22759/32-16-9
+ 12 VDC	Pin 10	Screw Terminal	JB 2 Pin 1	Molex MiniFit PN: 39-00-0183	M22759/32-16-9
+ 24 VDC	Pin 5	Screw Terminal	JB 3 Pin 1	Molex MiniFit PN: 39-00-0184	M22759/32-16-9
- 12 VDC	Pin 4	Screw Terminal	JB 4 Pin 1	Molex MiniFit PN: 39-00-0185	M22759/32-16-9
POWER COMMON	Pins 8,9	Screw Terminal	JB 5, 4, 3, 2, 1 Pin 2	Molex MiniFit PN: 39-00-0186	M22759/32-16-9

Power Display Board

Channel Name	A: Power Display Board	Pin Type	B: Conncetion	Pin Type	Wire Type
+ 12 VDC	+ 12 VDC	Molex C-Grid PN:16-02-0103	Power Break Out Board JB 4, Pin 1	Molex MiniFit PN: 39-00-0182	M22759/32-22-9
+ 5 VDC	+ 5 VDC	Molex C-Grid PN:16-02-0103	Power Break Out Board JB 5, Pin 1	Molex MiniFit PN: 39-00-0182	M22759/32-22-9
COM	COM	Molex C-Grid PN:16-02-0103	Power Break Out Board JB 5, Pin 2	Molex MiniFit PN: 39-00-0182	M22759/32-22-9
NC	S1+	NC	NC	NC	NC

NC	S1-	NC	NC	NC	NC
Oxygen Flow 1 +	S2+	Molex C-Grid PN:16-02-0103	Oxygen Flow 1 Controller Board Pin 5	Molex PN: 08-56-0110	M22759/32-24-9
Oxygen Flow 1 -	S2-	Molex C-Grid PN:16-02-0103	Oxygen Flow 1 Controller Board Pin 6	Molex PN: 08-56-0110	M22759/32-24-9
NC	S3+	NC	NC	NC	NC
NC	S3-	NC	NC	NC	NC
Oxygen Flow 2 +	S4+	Molex C-Grid PN:16-02-0103	Oxygen Flow 2 Board Pin 5	Molex PN: 08-56-0110	M22759/32-24-9
Oxygen Flow 2 -	S4-	Molex C-Grid PN:16-02-0103	Oxygen Flow 2 Board Pin 6	Molex PN: 08-56-0110	M22759/32-24-9
NC	S5+	NC	NC	NC	NC
NC	S5-	NC	NC	NC	NC

Inlet box

Channel Name	A: Internal conncectioin	Pin Type	B: Amphenol MS3470L1626S 26 P	Pin Type	Wire Type
NOy T Chromel	NOY type K	screw terminal	A	M39029/4-110	OMEGA: FF-K-20S-TWSH
NOy T Cntrl +	Crydom SSR +	screw terminal	B	M39029/4-110	M22759/32-22-9
NOy T Cntrl -	Crydom SSR -	screw terminal	C	M39029/4-110	M22759/32-22-9
NOy T Alumel	NOY type K	screw terminal	D	M39029/4-110	OMEGA: FF-K-20S-TWSH
NO Cal Valve +	NO Cal valve Via c-grid 2PL M	C-grid PN: 16-02-0103	E	M39029/4-110	M22759/32-22-9
NO Cal Valve -	NO Cal valve Via c-grid 2PL M	C-grid PN: 16-02-0103	F	M39029/4-110	M22759/32-22-9
HNO3 Cal Valve +	HNO3 Cal Valve Via C-Grid 2PL M	C-grid PN: 16-02-0103	G	M39029/4-110	M22759/32-22-9
HNO3 Cal Valve _	HNO3 Cal Valve Via C-Grid 2PL M	C-grid PN: 16-02-0103	H	M39029/4-110	M22759/32-22-9
NO2 Conv Lamp +	Constellation Board Via C-Grid 4PL M	C-grid PN: 16-02-0103	S	M39029/4-110	M22759/32-22-9
NO2 Conv Lamp -	Constellation Board Via C-Grid 4PL M	C-grid PN: 16-02-0103	J	M39029/4-110	M22759/32-22-9
Sample MFC1 Sig +	Sample MFC1 Via 9PL DSUB F	AMP PN: 205090-1	K	M39029/4-110	M22759/32-22-9
Sample MFC1 Sig C	Sample MFC1 Via 9PL DSUB F	AMP PN: 205090-1	L	M39029/4-110	M22759/32-22-9
Sample MFC1 SET	Sample MFC1 Via 9PL DSUB F	AMP PN: 205090-1	M	M39029/4-110	M22759/32-22-9
Sample MFC2 Sig +	Sample MFC2 Via 9PL DSUB F	AMP PN: 205090-1	N	M39029/4-110	M22759/32-22-9
Sample MFC2 Sig C	Sample MFC2 Via 9PL DSUB F	AMP PN: 205090-1	b	M39029/4-110	M22759/32-22-9
Sample MFC SET	Sample MFC2 Via 9PL DSUB F	AMP PN: 205090-1	P	M39029/4-110	M22759/32-22-9
Pressure Controller Sig +	PC Via 15PL DSUB F	Solder	c	M39029/4-110	M22759/32-22-9
Pressure Controller Sig C	PC Via 15PL DSUB F	Solder	R	M39029/4-110	M22759/32-22-9
Pressure Controller SET	PC Via 15PL DSUB F	Solder	a	M39029/4-110	M22759/32-22-9

+ 12 VDC	Sample MFC1/2 Via 9PL DSUB F	AMP PN: 205090-1	T	M39029/4-110	M22759/32-22-9
- 12 VDC	Sample MFC1/2 Via 9PL DSUB F	AMP PN: 205090-1	U	M39029/4-110	M22759/32-22-9
PWR COM	Sample MFC1/2 Via 9PL DSUB F	AMP PN: 205090-1	V	M39029/4-110	M22759/32-22-9
+ 15 VDC	PC Via 15PL DSUB F	Solder	W	M39029/4-110	M22759/32-22-9
- 15 VDC	PC Via 15PL DSUB F	Solder	X	M39029/4-110	M22759/32-22-9
PWR COM	PC Via 15PL DSUB F	Solder	Y	M39029/4-110	M22759/32-22-9
NC	NC	NC	Z	NC	NC

Channel Name	**A: Internal Conncetion**	**Pin Type**	**B: Amphenol MS3470L 2212S P**	**Pin Type**	**Wire Type**
Chassis / Ground	chassis	Screw Terminal	A	M39029/4-113	M22759/32-12-9
+28V DC Feed	to + 28 VDC Commomor Via Breaker	Screw Terminal	B	M39029/4-113	M22759/32-12-9
28V DC Return	DC Return Commoner	Screw Terminal	C	M39029/4-113	M22759/32-12-9
NC	NC	NC	D	NC	NC
230V 50Hz Live	to NOy heater via SSR and AC Breaker	Screw Terminal	E	M39029/4-113	M22759/32-12-9
230V 50Hz Neutral	to NOy heater	Screw Terminal	F	M39029/4-113	M22759/32-12-9
NC	NC	NC	G	NC	NC
NC	NC	NC	H	NC	NC
NC	NC	NC	J	NC	NC
NC	NC	NC	M	NC	NC
NC	NC	NC	L	NC	NC
NC	NC	NC	K	NC	NC

Data system

A: UE9 DSUB 37 PL pin	Lab Jack channel	Pin Type	Channel Name	B: COMPONENT	Connector	Pin #	Pin Type	Wire Type
1	GND	NC	NC	NC	NC	NC	NC	NC
2	TX0	NC	NC	NC	NC	NC	NC	NC
3	FIO6	AMP PN: 205090-1	HV1 Cntrl +	Snooper	DSUB 25 PL F	3	AMP PN: 205090-1	M22759/32-24-9
4	FIO4	AMP PN: 205090-1	HV2 Cntrl +	Snooper	DSUB 25 PL F	4	AMP PN: 205090-1	M22759/32-24-9
5	FIO2	AMP PN: 205090-1	ZV1 Cntrl+	Snooper	DSUB 25 PL F	5	AMP PN: 205090-1	M22759/32-24-9
6	FIO0	AMP PN: 205090-1	CH 1 HZ	Snooper	BNC #1	1	AMP PN: 205090-1	M22759/32-24-9
7	MIO1	NC	NC	NC	NC	NC	NC	NC
8	GND	NC	NC	NC	NC	NC	NC	NC
9	Vm-	NC	NC	NC	NC	NC	NC	NC
10	GND	NC	NC	NC	NC	NC	NC	NC
11	DAC0	NC	NC	NC	NC	NC	NC	NC
12	AIN13	AMP PN: 205090-1	HV1 Sig +	Snooper	DSUB 25 PL F	1	AMP PN: 205090-1	M22759/32-24-9
13	AIN11	AMP PN: 205090-1	HV2 Sig +	Snooper	DSUB 25 PL F	2	AMP PN: 205090-1	M22759/32-24-9
14	AIN9	AMP PN: 205090-1	Rxn Pressure Sig +	Snooper	DSUB 25 PL F	9	AMP PN: 205090-1	M22759/32-24-9
15	AIN7	AMP PN: 205090-1	O2 MFC 1 Sig +	Ozonizer	DSUB 25 PL F	5	AMP PN: 205090-1	M22759/32-24-9
16	AIN5	AMP PN: 205090-1	O2 MFC 2 Sig +	Ozonizer	DSUB 25 PL F	6	AMP PN: 205090-1	M22759/32-24-9
17	AIN3	AMP PN: 205090-1	Sample MFC 1 Sig +	Control	DSUB 25 PL F	9	AMP PN: 205090-1	M22759/32-24-9
18	AIN1	AMP PN: 205090-1	Sample MFC 2 Sig +	Control	DSUB 25 PL F	10	AMP PN: 205090-1	M22759/32-24-9

19	GND	NC	NC	NC	NC	NC	NC	NC
20	RX0	NC	NC	NC	NC	NC	NC	NC
21	FIO7	AMP PN: 205090-1	ZV2 Cntrl+	Snooper	DSUB 25 PL F	6	AMP PN: 205090-1	M22759/32-24-9
22	FIO5	AMP PN: 205090-1	Vac Valve 1 Cntrl +	Snooper	DSUB 25 PL F	7	AMP PN: 205090-1	M22759/32-24-9
23	FIO3	AMP PN: 205090-1	Vac Valve 2 Cntrl +	Snooper	DSUB 25 PL F	8	AMP PN: 205090-1	M22759/32-24-9
24	FIO1	AMP PN: 205090-1	CH 2 HZ	Snooper	BNC #2	2	AMP PN: 205090-1	M22759/32-24-9
25	MIO0	NC	NC	NC	NC	NC	NC	NC
26	MIO2	NC	NC	NC	NC	NC	NC	NC
27	Vs	NC	NC	NC	NC	NC	NC	NC
28	Vm+	NC	NC	NC	NC	NC	NC	NC
29	DAC1	NC	NC	NC	NC	NC	NC	NC
30	AGND	NC	NC	NC	NC	NC	NC	NC
31	AIN12	NC	NC	NC	NC	NC	NC	NC
32	AIN10	AMP PN: 205090-1	NO Cal MFC Sig +	Control	DSUB 25 PL F	11	AMP PN: 205090-1	M22759/32-24-9
33	AIN8	AMP PN: 205090-1	Pressure Controller Sig +	Control	DSUB 25 PL F	12	AMP PN: 205090-1	M22759/32-24-9
34	AIN6	NC	NC	NC	NC	NC	NC	NC
35	AIN4	NC	NC	NC	NC	NC	NC	NC
36	AIN2	NC	NC	NC	NC	NC	NC	NC
37	AIN0	NC	NC	NC	NC	NC	NC	NC

A: UE9 DSUB 15 PL pin

1	Vs	NC	NC	NC	NC	NC	NC	NC
2	CIO1	AMP PN: 205090-1	O2 1 Cntrl +	Ozonizer	DSUB 25 PL F	1	AMP PN: 205090-1	M22759/32-24-9
3	CIO3	AMP PN: 205090-1	O2 2 Cntrl +	Ozonizer	DSUB 25 PL F	2	AMP PN: 205090-1	M22759/32-24-9
4	EIO0	AMP PN: 205090-1	O3 1 Cntrl +	Ozonizer	DSUB 25 PL F	3	AMP PN: 205090-1	M22759/32-24-9
5	EIO2	AMP PN: 205090-1	O3 2 Cntrl +	Ozonizer	DSUB 25 PL F	4	AMP PN: 205090-1	M22759/32-24-9
6	EIO4	AMP PN: 205090-1	NO On/Off Cntrl +	Control	DSUB 25 PL F	6	AMP PN: 205090-1	M22759/32-24-9
7	EIO6	AMP PN: 205090-1	NO2 Conv Cntrl +	Control	DSUB 25 PL F	5	AMP PN: 205090-1	M22759/32-24-9
8	GND	NC	NC	NC	NC	NC	NC	NC
9	CIO0	NC	NC	NC	NC	NC	NC	NC
10	CIO2	NC	NC	NC	NC	NC	NC	NC
11	GND	NC	NC	NC	NC	NC	NC	NC
12	EIO1	AMP PN: 205090-1	NOx Cal Cntrl +	Control	DSUB 25 PL F	2	AMP PN: 205090-1	M22759/32-24-9
13	EIO3	AMP PN: 205090-1	ZA Valve Cntrl +	Control	DSUB 25 PL F	4	AMP PN: 205090-1	M22759/32-24-9
14	EIO5	AMP PN: 205090-1	NO Cal Cntrl +	Control	DSUB 25 PL F	1	AMP PN: 205090-1	M22759/32-24-9
15	EIO7	AMP PN: 205090-1	HNO3 Cal Cntrl +	Control	DSUB 25 PL F	3	AMP PN: 205090-1	M22759/32-24-9

8. Appendices

Love controls model 32A manual

MKS model 640 pressure controller manual