

# **Kurt J. Lesker** Company

## **Gauge with Integrated Controller & Display**

### **275i Series Convection Vacuum Gauge Module**



## **User's Manual**

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## Introduction / General Information

### Description

The Kurt J. Lesker Company (KJLC) module provides the basic signal conditioning required to turn a convection vacuum gauge into a complete measuring instrument. The module provides a non-linear analog output, and one setpoint relay. The non-linear analog output is identical to the Helix/Granville-Phillips "S-curve". A built-in display provides a convenient user interface for setup and operation of the vacuum gauge. This manual applies to KJLC Convectron® Equivalent 275i Series modules.

### Specifications

measurement range (signal)	$1 \times 10^{-4}$ to 1000 Torr / $1 \times 10^{-4}$ to 1333 mbar / $1 \times 10^{-2}$ Pa to 133 kPa
display	3 digit LED (3 digits from 999Torr to 10.0mTorr, 2 digits from 9.9 to 1.0mTorr.)
materials exposed to gases	gold-plated tungsten, 304 & 316 stainless steel, glass, nickel, Teflon
internal volume	26 cm <sup>3</sup> (1.589 in <sup>3</sup> )
internal surface area	59.7 cm <sup>2</sup> (9.25 in <sup>2</sup> )
weight	136 g (4.8 oz)
housing	molded plastic
fittings/flanges	1/8"NPT-1/2" tubulation, 4VCR, 8VCR, Mini-Conflat® (NW16CF), 2-3/4" Conflat®(NW35CF), KF16, KF25, KF40
operating temperature	0 to +40 °C
storage temperature	-40 to +70 °C
bakeout temperature	+70 °C
humidity	0 to 95% RH non-condensing
mounting position	horizontal recommended
output	non-linear analog S-curve 0.375 to 5.659 Vdc (Helix/GP compatible)
input power	11 to 30 Vdc, protected against power reversal, transients, and over-voltages
trippoint relay	one, single-pole double-throw relay (SPDT)
contact rating	1A at 30 Vdc resistive, or ac non-inductive
connector	9-pin D male
RF/EMI protection	CE compliant

### Options & Accessories

#### PS401-A Power Supply

*Description:* Wall-mount AC adapter to power one module.

*Power Input:* 100-240 VAC

*Power Plug:* North America 115VAC Plug

*Output:* 24 VDC @ 500mA

*Output Connector:* 9-pin D sub, pre-wired to mate with module.

Connector can be opened to enable user to make connections to signals and relays.

*Cable Length:* 2m (6ft)



## Safety

The Kurt J. Lesker Company (KJLC) has designed and tested this product to provide safe and reliable service, provided it is installed and operated within the *strict safety guidelines provided in this manual*. **Please read and follow all warnings and instructions. Failure to comply with these safety procedures may result in serious bodily harm, including death, and or property damage.** Failure to comply with these warnings violates the safety standards of the installation and intended use of the instrument. The Kurt J. Lesker Company disclaims all liability for the customer's failure to comply with these requirements.

Although every attempt has been made to consider most possible installations, the Kurt J. Lesker Company cannot anticipate every contingency that arises from various installations, operation, or maintenance of the module. If you have any questions about the safe installation and use of this product, please contact us at the address shown on page 1 of this manual.

### Service and operation:

Do not modify this product or substitute any parts without authorization of a qualified KJLC technician. Return the product to a KJLC qualified service and repair center to ensure that all safety features are maintained. Do not use this product if unauthorized modifications have been made.

After servicing this product, ensure that all safety checks are made by a qualified service person.  
Replacement Parts: When replacement parts are required, ensure that the parts are specified by KJLC. Unauthorized substitutions or non-qualified parts may result in fire, electric shock, or other hazards.

To reduce the risk of fire or electric shock, do not expose this product to rain or moisture. This product is not waterproof and careful attention must be paid to not spill any type of liquid onto this product.

Due to the possibility of corrosion under certain environmental conditions, it is possible that the product's safety could be compromised over time. It is important that the product be periodically inspected for sound electrical connections and grounding. Do not use if the grounding or electrical insulation has been compromised.

### Electrical conditions:

**Danger:** When high voltage is present in any vacuum system, a life threatening electrical shock hazard may exist unless all exposed conductors are maintained at earth ground. This applies to all products that come in contact with the gas.

**Danger:** An electrical discharge through a gas may couple dangerous high voltage directly to any ungrounded conductor. A person may be seriously injured or killed by coming in contact with an exposed ungrounded conductor at a high voltage potential. This applies to all products that may come in contact with the gas.

### Proper Grounding:

Verify that the vacuum port on which the module is mounted is electrically grounded. This is essential for safety as well as proper operation. The gauge and/or case of the module must be connected to earth ground. Use a ground lug on the flange if necessary.

### Overpressure:

**Warning:** Install suitable protective devices that will limit the level of the pressure to less than what the vacuum system can withstand. The gauge should not be used above 1000 Torr absolute pressure.

### Gases other than Nitrogen:

KJLC gauges and modules are calibrated for N<sub>2</sub>. Do not attempt to use with other gases such as argon or CO<sub>2</sub> unless accurate conversion data for N<sub>2</sub> to the other gas is properly used. Refer to Appendix B for a more complete discussion of issues.

Do not use this device in an explosive atmosphere or in the presence of flammable gases or fumes.

Do not use this device to measure the pressure of explosive or combustible gases or mixtures. The sensor wire in the gauge normally operates at 125 °C, but under malfunction the wire temperature could exceed the ignition temperature of combustible mixtures.

### **Installation - Mechanical**

Mount the module as close as possible to the pressure you want to measure. Long or restricted tubing will create a pressure difference (error) between your process and the gauge, and cause a delay in response to pressure changes. Mounting the module too close to a gas source will also cause errors in the readings.

Don't mount the module near a source of heating or cooling, such as heaters or air conditioning vents.

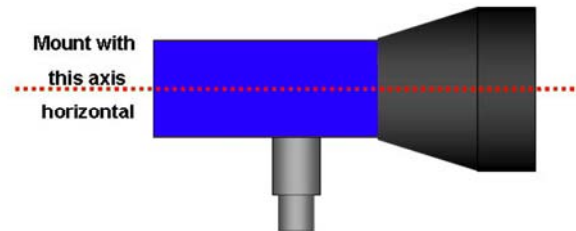
Mount the module with its main (long) axis horizontal (see diagram at right). Pressure reading errors will occur above 1 Torr if the unit is not mounted horizontally. (Below 1 Torr, mounting position has little to no effect.)

Mount the module with port down, if possible, to help minimize the effect of any particles or condensation in the gauge.

Don't mount the module where it will be subjected to excessive vibration, such as on mechanical pumps. Vibrations may cause 'noisy' readings, and reading errors due to induced cooling of the sensor.

Fittings - follow the fitting manufacturer's recommendations and note the following:

- NPT fittings: Wrap the threaded portion of the tubing with Teflon<sup>®</sup> tape and hand tighten the gauge into the gauge port. Do not use a wrench or other tool which may damage the gauge.



**Installation - Electrical**

Grounding: Be sure the vacuum gauge and the rest of your vacuum system are properly grounded to protect personnel from shock and injury. Be aware that some vacuum fittings, especially those with O-rings, do not produce a good electrical connection between the gauge and the chamber it is connected to.

A good recommended practice is to remove power from any cable prior to connecting or disconnecting it.

The KJLC 275i Series module will directly replace GP Mini-Convectron<sup>®</sup> modules that have a 9-pin D connector, and you can use your existing cables and electronics.

For new installations, fabricate a cable to connect to the signals/functions you want to use. Signals and pin assignments are described below:

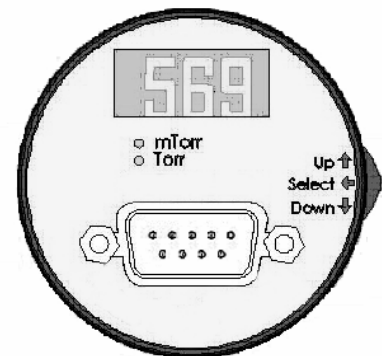
PIN NUMBER	PIN DESCRIPTION
1	Relay 1 Normally Open
2	Relay 1 Normally Closed
3	Power Input (11-30Vdc)
4	Power Ground
5	Analog Output (Non-linear GP Compatible)
6	Relay 1 Common
7	Relay Disable (Disables Relay 1 when pulled low)
8	Analog Ground
9	

## Setup and Operation

### User Interface Basics:

The user interface is designed for easy operation and a natural progression of setup parameters. A complete user interface map is shown in appendix A. This section gives a brief explanation of operation for added clarity.

The KJLC 275i Series module has 4 settings that can be adjusted by the user with the 3 position switch on the side of the module housing. Pressing the switch straight in is referred to as pressing the <select> key. Pressing the switch upward is referred to as pressing the <up> key. Pressing the switch downward is referred to as pressing the <down> key. During setup, and operation, be sure to consider the Torr/mTorr LEDs.



### Setting up the 275i Series Module

1. With the module in the normal pressure display mode, press and hold <select> for 3 seconds.
2. The readout displays the value of the 'setpoint turn-on' pressure. The relay energizes when pressure drops *below* this value. [Factory default = 100 mTorr.]
- 3a. To keep this value and proceed to the next step, press <select>.
- 3b. To change the value, use the <up> <down> keys. Then press <select> to save and go to the next step.
4. The readout displays the value of the 'setpoint turn-off' pressure. The relay de-energizes when the pressure is *above* this value. [Factory default = 200 mTorr.]
- 5a. To keep this value and proceed to the next step, press <select>.
- 5b. To change the value, use the <up> <down> keys. Then press <select> to save and go to the next step.
6. The readout will display '000' to indicate the unit is in the "zero adjust" mode. To properly set "zero", the gauge must be evacuated to a pressure below  $10^{-4}$  Torr. [Factory default = 000 mTorr.]
- 7a. If the gauge is *not* evacuated to a pressure below  $10^{-4}$  Torr, press <select> to proceed to the next step, *without* saving a new "zero" value.
- 7b. If the gauge *is* evacuated to a pressure below  $10^{-4}$  Torr, press <down> to save the new user "zero" and proceed to the next step.
8. The readout will display the current "span" value. To set "span", the gauge must be backfilled with air or  $N_2$  to some known pressure above 400 Torr. (If barometric pressure is known, the gauge may be opened to atmosphere.) [Factory default = 760 Torr.]
- 9a. If you do *not* have a known pressure in the gauge, press <select> briefly (less than 3 seconds) to exit the setup menu and return to the normal pressure display *without* saving a new "span" value.
- 9b. If you *do* have a known pressure in the gauge, use the <up> <down> keys to change the displayed value to agree with the known pressure. Press and hold <select> for 3 seconds until the displayed pressure switches to the new value. This will save the new "span" setting, and return to the normal pressure display.

### Return to Factory Default Settings

You can reset all values to the original factory default settings by holding the <up> key for 5 seconds. The display will read "dEF" until 5 seconds has passed, at which point *all user settings will be replaced by the original factory default values*, and the display will return to the normal pressure display. If you release the <up> key before 5 seconds has passed, the display will return to normal pressure display without resetting to factory defaults.

## Service

### Calibration

Every KJLC module is calibrated prior to shipment using Nitrogen. However, you can adjust the zero and span, using the procedure described above. Zero and span settings affect the displayed value and the output signal. Care should be exercised when using gases other than nitrogen N<sub>2</sub> - See Appendix B for more information.

### Maintenance

Under normal circumstances, there is no maintenance required for your KJLC module. Good manufacturing practice suggests the unit should be periodically calibrated against known calibration standards.

### Cleaning

The most common cause of all vacuum gauge failures is contamination of the sensor. Contamination can be generally characterized as either a reaction of process gases with sensor elements, or an accumulation of material on the sensor elements. Sensors that fail due to chemical reaction are generally not salvageable. Sensors that fail due to coating may *possibly* be restored by cleaning. See Appendix C for a more complete discussion of contamination and cleaning procedures.

### Troubleshooting

<i>Indication</i>	<i>Possible Cause</i>	<i>Possible Solution</i>
Display is off / blank	No power	Check cable connections and verify that power is being supplied.
Readings appear very different from expected pressure	The process gas is different from the gas used to calibrate the module. Module has not been calibrated or has been calibrated incorrectly	Correct readings for different gas thermal conductivity. See Appendix B. Check that zero and span (atm) are adjusted correctly.
Readings are noisy or erratic	Loose cables or connections Contamination	Check and tighten connections. Inspect gauge for signs of contamination such as particles, deposits, or discoloration on gauge inlet. Try cleaning if appropriate.
Gauge cannot be calibrated - zero and span (vacuum & atm)	Contamination. Sensor failure for other cause.	See section below on cleaning. Replace module.
Setpoint does not actuate	Incorrect setup	Check setpoint setup

### Module and Gauge Replacement

The module is factory calibrated for the specific gauge tube installed in it. Since each gauge tube and module calibration is different, the gauge cannot be replaced. If the gauge fails for any reason, the Series 275i module must be replaced. Given the low cost of a new Series 275i module, it is generally considered an expendable item. If your module develops an electronic problem, and you want to return the unit to KJLC for repair, contact us for return authorization, as described below.

### Factory Service and Support

If you need help setting up, operating, or troubleshooting your module, you are welcome to call us during normal business hours (8:00am to 5:00pm Eastern Standard time) Monday through Friday, at 412-387-9200. Or e-mail us at [pressure@lesker.com](mailto:pressure@lesker.com).

If it becomes necessary to return the module to KJLC for service or calibration, please call or e-mail us for a return authorization. For the safety of our employees, you must provide a history of the gauge detailing what gases have been used. We cannot work on gauges that have been exposed to hazardous materials.

## **Trademarks & Acknowledgements**

The following trademarks, used throughout this manual, are owned by the companies indicated:

Convectron® and Mini-Convectron® are registered trademarks of Helix Technology Corp.

Conflat® and Mini-Conflat® are registered trademarks of Varian Vacuum Technology.

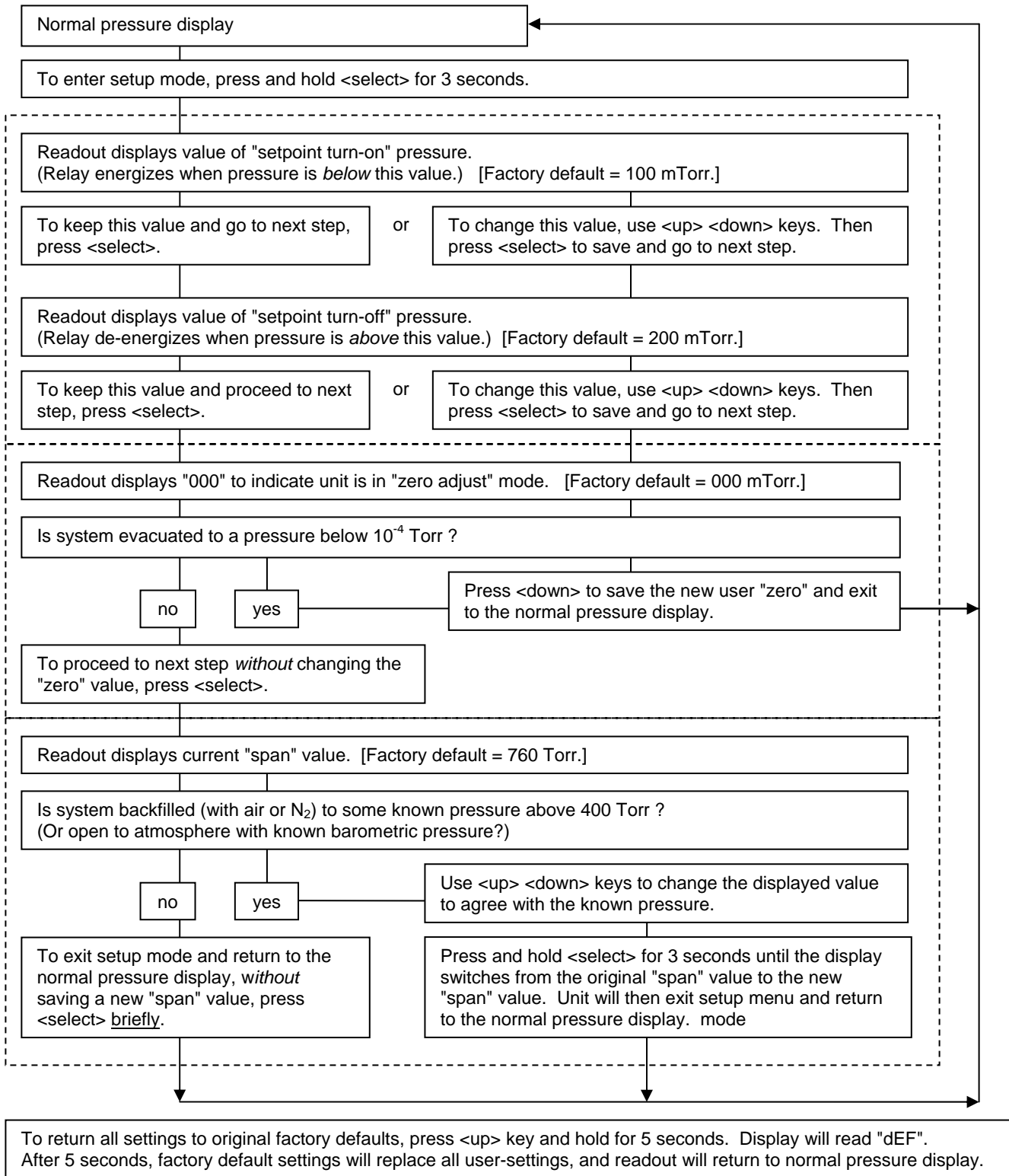
Cajon® and VCR® are registered trademarks of the Swagelok Company.

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## **Appendices**

- A. User Interface Map
- B. Gas Correction
- C. Contamination and Cleaning

Appendix A: Series 275i User Interface Map Map



## Appendix B: *Using thermal vacuum gauges with different gases*

### **Principal of Operation**

Thermal conductivity gauges measure pressure indirectly, by sensing the loss of heat from a sensor to the surrounding gases. The higher the pressure of the surrounding gas, the more heat is conducted away from the sensor. Pirani thermal conductivity gauges maintain a sensor (usually a wire) at some constant temperature, and measure the current or power required to maintain that temperature. A standard Pirani gauge has a useful measuring range of about  $10^{-4}$  Torr to 10 Torr. By taking advantage of convection currents that are generated above 1 Torr, *convection-enhanced* Pirani gauges increase the measuring range to just above atmosphere.

### **Output Signals and Displays**

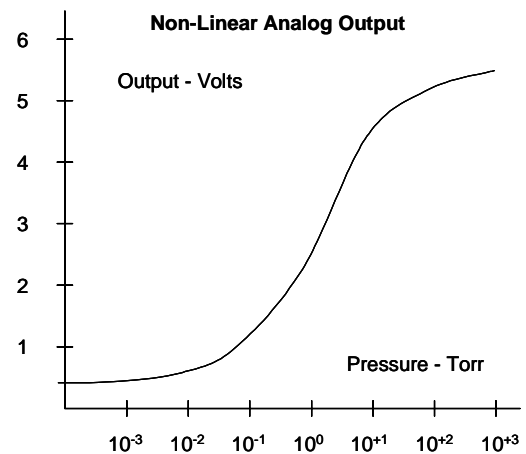
A vacuum gauge sensor, by itself, does not generate any output signal or readout. Electronic signal conditioning is required to convert heat loss into a useable signal and/or readout of pressure. Note that the output signal voltage is not the same as the displayed pressure readings. Table 3 below shows the displayed readings at various pressures for selected gases.

### **Non-Linear Output**

Granville-Phillips' first Convectron<sup>®</sup> gauge controllers produced a non-linear output signal of 0.375 to 5.659 VDC for 0 to 1000 Torr of N<sub>2</sub>, roughly in the shape of an "S" curve, as shown at right. GP adopted the same output curve for most of their Mini-Convectron<sup>®</sup> modules and controllers with non-linear output (though in recent years, some GP controllers produced a different S-curve).

The non-linear output from KJLC convection gauges, modules, and controllers duplicates exactly the original S-curve of 0.375 to 5.659 VDC for 0 to 1000 Torr.

Table 1 below contains the lookup data for converting the non-linear output voltage into pressure values.



The above discussions of output signals assume the gas being measured is Nitrogen. The following discussion illustrates how other gases affect both readings and outputs from thermal vacuum gauges.

### ***Effect of Different Gases on Signals and Displayed Pressure***

A thermal conductivity gauge senses heat loss, which depends on the thermal conductivity of the gas surrounding the sensor. Since different gases, and mixtures, have different thermal conductivities, the indicated pressure readings and outputs will also be different. KJLC convection gauges (and most other thermal gauges) are normally calibrated using nitrogen. When a gas other than N<sub>2</sub> is used, correction must be made for the difference in thermal conductivity, between N<sub>2</sub> and the gas in use. The charts and tables below indicate how different gases affect the display and output from a KJLC convection gauge.

For N<sub>2</sub> the calibration shows excellent agreement between indicated and true pressure throughout the range from 10<sup>-4</sup> to 1000 Torr. (As it *should*, of course, since they're calibrated for N<sub>2</sub>.) At pressures below 1 Torr, the calibration curves for the different gases are similar: the difference in readings at these low pressures is a constant, a function of the difference between thermal conductivities of the gases.

At pressures above 1 Torr, indicated pressure readings may diverge significantly. At these higher pressures, convection currents in the gauge become the predominant cause of heat loss from the sensor, and calibration depends on gauge tube geometry and mounting position, as well as gas properties.

Generally, air and N<sub>2</sub> are considered the same as far as thermal conductivity goes, but even these two gases will exhibit slight differences in readings at higher pressures. For example, when venting a system to atmosphere using N<sub>2</sub>, you may see readings change by 30 to 40 Torr after the chamber is opened and air gradually displaces the N<sub>2</sub> in the gauge.

For most other gases, the effect is much more significant, and may result in a hazardous condition, as described below.

### ***Other considerations when using gases other than N<sub>2</sub>***

#### ***Flammable or explosive gases:***

KJLC convection gauges and modules are not intrinsically safe or explosion proof, and are not intended for the measurement, or use in the presence, of flammable or explosive gases or vapors.

Under normal conditions, the voltages and currents in KJLC Convection Gauges and Modules are too low to cause ignition of flammable gases. However, under certain failure conditions, sufficient energy could be generated to cause flammable vapors or gases to ignite or explode.

Thermal gauges like the KJLC convection gauges and modules are not recommended for use with flammable or explosive gases.

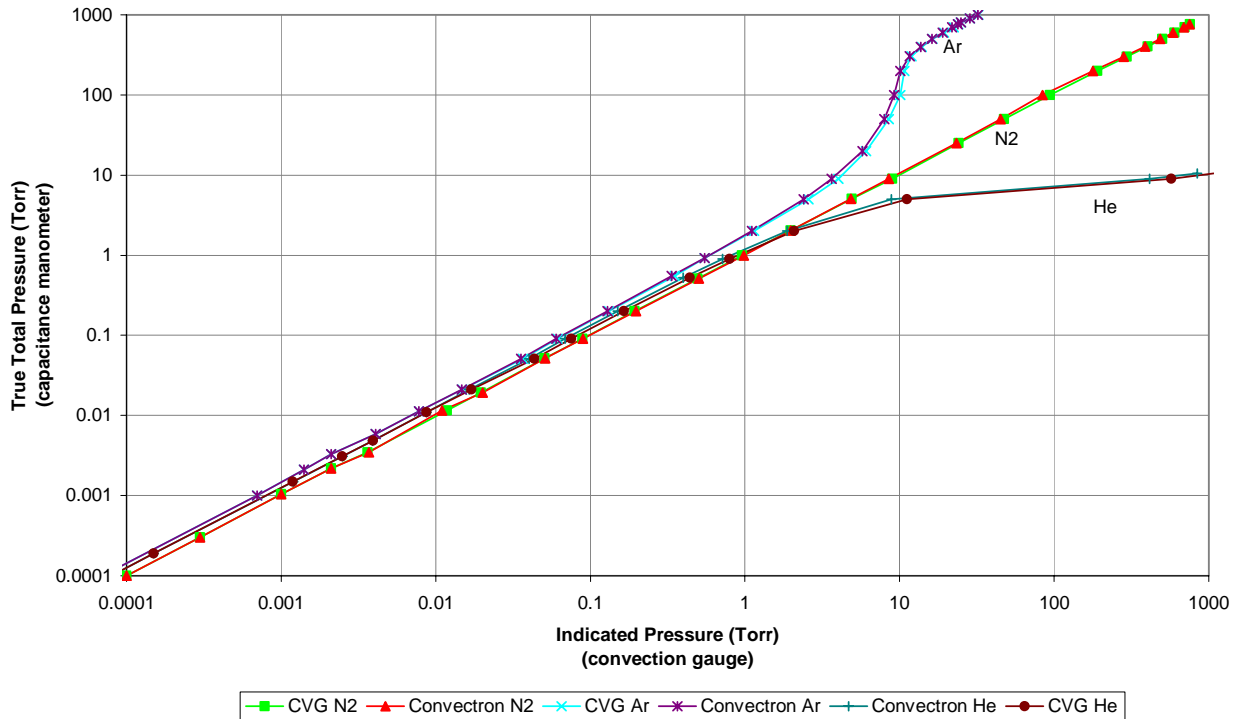
#### ***Moisture / water vapor:***

In some processes (lyophilization, for example). the gas composition may not change significantly, except for moisture content. Water vapor can significantly change the response of a thermal gauge and correction should be made, as you would for any other gas.

#### ***Other contaminants:***

If your gases condense, coat, or corrode the sensor, the gauge calibration and response to different gases will change. Generally, if the gauge can be "calibrated" ("zero" and "atmosphere" settings), these changes are small enough to be ignored. If you cannot set zero and atmosphere, the gauge should be replaced or cleaned. (See the Appendix C on cleaning for more information.)

Convection Vacuum Gauge  
Indicated vs. True Total Pressure  
Test Gases - N<sub>2</sub>, Ar, He



### Gas Correction Chart

The Y-Axis is actual pressure, measured by a capacitance manometer, a diaphragm gauge that measures true total pressure, independent of gas composition.

The X-Axis is the pressure reading indicated by the convection gauge under test.

The chart shows readings for an KJLC CVG as well as for a GP Convector<sup>®</sup> gauge, to illustrate that the response of the gauges to these different gases is virtually indistinguishable. (Caution: Do not assume this data applies to other convection gauges, which may or may not be the same.)

If the gas is N<sub>2</sub>, when the true total pressure is 100 Torr, the gauge will read 100 Torr

If the gas is Ar, when the true pressure is 100 Torr, the gauge will read only 10 Torr.

If you are backfilling your vacuum system with Ar, when your system reaches atmospheric pressure of 760 Torr true pressure, your gauge will be reading about 20 Torr. If you continue to backfill your system, attempting to increase the reading up to 760, you will overpressure your chamber and probably blow up your vacuum system !

If the gas is He, the gauge will read 1000 Torr when pressure reaches about 10 Torr actual pressure.

You probably won't blow up the vacuum system, but opening the chamber to atmosphere prematurely may present other hazards for both people and product.

What these examples illustrate is that, without proper precautions,

**use of different gases can result in injury to personal and/or damage to equipment.**

### Suggested precautions when using gases other than N<sub>2</sub>:

Install a pressure relief valve, or burst disk, on your chamber, to protect it from overpressure.

Post a warning label on your gauge readout "Do Not Exceed \_\_\_\_ Torr Indicated Pressure" (fill in the blank for your gas) so that an operator using the gauge will not exceed a safe pressure.

**Table 1 - Non-Linear Analog Output Voltage vs Pressure, for Selected Gases**

True Total Pressure	N2	Ar	He	O2	CO2	Kr	Freon12	Freon22	D2	Ne	CH4
0 mTorr	0.3751	0.3750	0.3750	0.3750	0.3750	0.3750	0.3750	0.3750	0.3750	0.3750	0.3750
<b>0.1 mTorr</b>	<b>0.3759</b>	<b>0.3757</b>	<b>0.3755</b>	<b>0.3760</b>	<b>0.3760</b>	<b>0.3755</b>	<b>0.3760</b>	<b>0.3760</b>	<b>0.3760</b>	<b>0.3757</b>	<b>0.3766</b>
0.2 mTorr	0.3768	0.3760	0.3765	0.3770	0.3770	0.3768	0.3780	0.3780	0.3770	0.3763	0.3780
0.5 mTorr	0.3795	0.3780	0.3790	0.3800	0.3810	0.3772	0.3820	0.3810	0.3810	0.3782	0.3825
<b>1 mTorr</b>	<b>0.3840</b>	<b>0.3810</b>	<b>0.3820</b>	<b>0.3840</b>	<b>0.3850</b>	<b>0.3790</b>	<b>0.3880</b>	<b>0.3880</b>	<b>0.3860</b>	<b>0.3810</b>	<b>0.3896</b>
2 mTorr	0.3927	0.3870	0.3890	0.3920	0.3950	0.3840	0.4010	0.4000	0.3960	0.3880	0.4030
5 mTorr	0.4174	0.4030	0.4090	0.4170	0.4120	0.3950	0.4370	0.4320	0.4250	0.4050	0.4380
<b>10 mTorr</b>	<b>0.4555</b>	<b>0.4290</b>	<b>0.4410</b>	<b>0.4530</b>	<b>0.4620</b>	<b>0.4150</b>	<b>0.4880</b>	<b>0.4800</b>	<b>0.4700</b>	<b>0.4330</b>	<b>0.4920</b>
20 mTorr	0.5226	0.4770	0.4970	0.5210	0.5360	0.4510	0.5810	0.5660	0.5490	0.4840	0.5840
50 mTorr	0.6819	0.5950	0.6370	0.6790	0.7050	0.5440	0.7780	0.7640	0.7270	0.6080	0.7960
<b>100 mTorr</b>	<b>0.8780</b>	<b>0.7450</b>	<b>0.8140</b>	<b>0.8680</b>	<b>0.9000</b>	<b>0.6680</b>	<b>1.0090</b>	<b>0.9900</b>	<b>0.9440</b>	<b>0.7680</b>	<b>1.0530</b>
200 mTorr	1.1552	0.9620	1.0680	1.1410	1.1790	0.8470	1.3150	1.2910	1.2650	1.0020	1.3920
500 mTorr	1.6833	1.3860	1.5890	1.6640	1.6680	1.1940	1.8260	1.8050	1.9140	1.4690	2.0140
<b>1 Torr</b>	<b>2.2168</b>	<b>1.8180</b>	<b>2.1640</b>	<b>2.1950</b>	<b>2.1720</b>	<b>1.5360</b>	<b>2.2570</b>	<b>2.2470</b>	<b>2.6030</b>	<b>1.9760</b>	<b>2.6320</b>
2 Torr	2.8418	2.3330	2.9390	2.8140	2.6950	1.9210	2.6470	2.6660	3.5080	2.6310	3.3130
5 Torr	3.6753	3.0280	4.3870	3.6720	3.3160	2.4290	3.0290	3.0900	5.0590	3.7150	
<b>10 Torr</b>	<b>4.2056</b>	<b>3.4800</b>	<b>5.7740</b>	<b>4.2250</b>	<b>3.6700</b>	<b>2.7340</b>	<b>3.2040</b>	<b>3.3300</b>	<b>6.3610</b>	<b>4.6050</b>	<b>4.6990</b>
20 Torr	4.5766	3.8010	7.3140	4.6200	3.9030	2.9660	3.3080	3.4140		5.4060	5.1720
50 Torr	4.8464	4.0370		4.9160	4.0710	3.0750	3.4300	3.5090		6.1590	5.5830
<b>100 Torr</b>	<b>4.9449</b>	<b>4.1220</b>		<b>5.0260</b>	<b>4.1540</b>	<b>3.1340</b>	<b>3.6180</b>	<b>3.6600</b>		<b>6.4830</b>	<b>5.7200</b>
200 Torr	5.0190	4.1920		5.1060	4.3360	3.2690	3.8270	3.8830		6.6610	5.8600
300 Torr	5.1111	4.2830		5.2000	4.5020	3.3840	3.9380	4.0050		6.7260	
400 Torr	5.2236	4.3860		5.3150	4.6210	3.4660	4.0160	4.0880		6.7670	6.1030
500 Torr	5.3294	4.4770		5.4220	4.7080	3.5260	4.0760	4.1510		6.8030	
600 Torr	5.4194	4.5500		5.5150	4.7750	3.5730	4.1240	4.2030		6.8430	6.3420
700 Torr	5.4949	4.6110		5.5920	4.8300	3.6130	4.1660	4.2470		6.8900	
760 Torr	5.5340	4.6430		5.6330	4.8600	3.6320	4.1900	4.2710		6.9200	
800 Torr	5.5581	4.6630		5.6580	4.8770	3.6450	4.2030	4.2860		6.9420	6.5190
900 Torr	5.6141	4.7060		5.7130	4.9190	3.6740	4.2370	4.3210		7.0000	
<b>1000 Torr</b>	<b>5.6593</b>	<b>4.7450</b>		<b>5.7620</b>	<b>4.9550</b>	<b>3.6900</b>	<b>4.2700</b>	<b>4.3540</b>		<b>7.0560</b>	<b>6.6420</b>

Note: By design, these values are identical to the outputs from Helix/Granville-Phillips Convector<sup>®</sup> gauges, Mini-Convector<sup>®</sup> modules, and Controllers, so that equivalent units can be interchanged without affecting your process system or software.

Table 3 - Displayed Pressure Readings vs Pressure, for Selected Gases

True Total Pressure	N2	Ar	He	O2	CO2	Kr	Freon12	Freon22	D2	Ne	CH4
<i>0 mTorr</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>	<i>0.0</i>
<i>0.1 mTorr</i>	<i>0.1</i>	<i>0.1</i>	<i>0.1</i>	<i>0.1</i>	<i>0.1</i>	<i>0.1</i>	<i>0.1</i>	<i>0.1</i>	<i>0.1</i>	<i>0.1</i>	<i>0.1</i>
<i>0.2 mTorr</i>	<i>0.2</i>	<i>0.2</i>	<i>0.2</i>	<i>0.2</i>	<i>0.2</i>	<i>0.2</i>	<i>0.2</i>	<i>0.2</i>	<i>0.2</i>	<i>0.2</i>	<i>0.2</i>
<i>0.5 mTorr</i>	<i>0.5</i>	<i>0.5</i>	<i>0.5</i>	<i>0.5</i>	<i>0.5</i>	<i>0.3</i>	<i>0.5</i>	<i>0.5</i>	<i>0.5</i>	<i>0.5</i>	<i>0.5</i>
<b>1 mTorr</b>	<b>1.0</b>	<b>0.7</b>	<b>0.8</b>	<b>1.0</b>	<b>1.1</b>	<b>0.4</b>	<b>1.5</b>	<b>1.5</b>	<b>1.3</b>	<b>0.7</b>	<b>1.7</b>
<b>2 mTorr</b>	<b>2.0</b>	<b>1.4</b>	<b>1.6</b>	<b>2.0</b>	<b>2.3</b>	<b>1.0</b>	<b>3.1</b>	<b>3.1</b>	<b>2.4</b>	<b>1.5</b>	<b>3.3</b>
<b>5 mTorr</b>	<b>5.0</b>	<b>3.3</b>	<b>4.0</b>	<b>5.0</b>	<b>4.4</b>	<b>2.3</b>	<b>7.6</b>	<b>7.0</b>	<b>6.0</b>	<b>3.5</b>	<b>7.7</b>
<b>10 mTorr</b>	<b>10.0</b>	<b>6.6</b>	<b>8.1</b>	<b>9.7</b>	<b>11.0</b>	<b>4.8</b>	<b>14.7</b>	<b>13.5</b>	<b>12.1</b>	<b>7.1</b>	<b>15.3</b>
<b>20 mTorr</b>	<b>20.0</b>	<b>13.1</b>	<b>16.1</b>	<b>19.8</b>	<b>22.2</b>	<b>9.5</b>	<b>29.9</b>	<b>27.2</b>	<b>24.3</b>	<b>14.1</b>	<b>30.4</b>
<b>50 mTorr</b>	<b>50.0</b>	<b>32.4</b>	<b>40.5</b>	<b>49.2</b>	<b>54.9</b>	<b>23.5</b>	<b>72.5</b>	<b>69.0</b>	<b>60.0</b>	<b>34.8</b>	<b>77.2</b>
<b>100 mTorr</b>	<b>100</b>	<b>64.3</b>	<b>82.0</b>	<b>97.2</b>	<b>107</b>	<b>46.8</b>	<b>143</b>	<b>136</b>	<b>121</b>	<b>70.0</b>	<b>159</b>
<b>200 mTorr</b>	<b>200</b>	<b>126</b>	<b>165</b>	<b>194</b>	<b>210</b>	<b>91.1</b>	<b>275</b>	<b>262</b>	<b>250</b>	<b>141</b>	<b>315</b>
<b>500 mTorr</b>	<b>500</b>	<b>312</b>	<b>435</b>	<b>486</b>	<b>489</b>	<b>217</b>	<b>611</b>	<b>594</b>	<b>687</b>	<b>359</b>	<b>781</b>
<b>1 Torr</b>	<b>1.00</b>	<b>600</b>	<b>940</b>	<b>970</b>	<b>950</b>	<b>400</b>	<b>1.05</b>	<b>1.04</b>	<b>1.55</b>	<b>745</b>	<b>1.60</b>
<b>2 Torr</b>	<b>2.00</b>	<b>1.14</b>	<b>2.22</b>	<b>1.94</b>	<b>1.71</b>	<b>700</b>	<b>1.62</b>	<b>1.66</b>	<b>4.13</b>	<b>1.59</b>	<b>3.33</b>
<b>5 Torr</b>	<b>5.00</b>	<b>2.45</b>	<b>13.5</b>	<b>4.98</b>	<b>3.34</b>	<b>1.28</b>	<b>2.45</b>	<b>2.62</b>	<b>246</b>	<b>5.24</b>	<b>7.53</b>
<b>10 Torr</b>	<b>10.0</b>	<b>4.00</b>	<b>OP</b>	<b>10.3</b>	<b>4.97</b>	<b>1.78</b>	<b>2.96</b>	<b>3.39</b>	<b>OP</b>	<b>21.5</b>	<b>27.9</b>
<b>20 Torr</b>	<b>20.0</b>	<b>5.80</b>	<b>OP</b>	<b>22.3</b>	<b>6.59</b>	<b>2.29</b>	<b>3.32</b>	<b>3.72</b>	<b>OP</b>	<b>584</b>	<b>355</b>
<b>50 Torr</b>	<b>50.0</b>	<b>7.85</b>	<b>OP</b>	<b>77.6</b>	<b>8.22</b>	<b>2.57</b>	<b>3.79</b>	<b>4.14</b>	<b>OP</b>	<b>OP</b>	<b>842</b>
<b>100 Torr</b>	<b>100</b>	<b>8.83</b>	<b>OP</b>	<b>209</b>	<b>9.25</b>	<b>2.74</b>	<b>4.68</b>	<b>4.91</b>	<b>OP</b>	<b>OP</b>	<b>OP</b>
<b>200 Torr</b>	<b>200</b>	<b>9.79</b>	<b>OP</b>	<b>295</b>	<b>12.3</b>	<b>3.32</b>	<b>5.99</b>	<b>6.42</b>	<b>OP</b>	<b>OP</b>	<b>OP</b>
<b>300 Torr</b>	<b>300</b>	<b>11.3</b>	<b>OP</b>	<b>380</b>	<b>16.9</b>	<b>3.59</b>	<b>6.89</b>	<b>7.52</b>	<b>OP</b>	<b>OP</b>	<b>OP</b>
<b>400 Torr</b>	<b>400</b>	<b>13.5</b>	<b>OP</b>	<b>485</b>	<b>22.4</b>	<b>3.94</b>	<b>7.63</b>	<b>8.42</b>	<b>OP</b>	<b>OP</b>	<b>OP</b>
<b>500 Torr</b>	<b>500</b>	<b>16.1</b>	<b>OP</b>	<b>604</b>	<b>28.7</b>	<b>4.21</b>	<b>8.28</b>	<b>9.21</b>	<b>OP</b>	<b>OP</b>	<b>OP</b>
<b>600 Torr</b>	<b>600</b>	<b>18.8</b>	<b>OP</b>	<b>730</b>	<b>36.4</b>	<b>4.44</b>	<b>8.86</b>	<b>9.95</b>	<b>OP</b>	<b>OP</b>	<b>OP</b>
<b>700 Torr</b>	<b>700</b>	<b>21.8</b>	<b>OP</b>	<b>859</b>	<b>46.1</b>	<b>4.65</b>	<b>9.42</b>	<b>10.7</b>	<b>OP</b>	<b>OP</b>	<b>OP</b>
<b>760 Torr</b>	<b>760</b>	<b>23.7</b>	<b>OP</b>	<b>941</b>	<b>53.9</b>	<b>4.75</b>	<b>9.76</b>	<b>11.1</b>	<b>OP</b>	<b>OP</b>	<b>OP</b>
<b>800 Torr</b>	<b>800</b>	<b>25.1</b>	<b>OP</b>	<b>997</b>	<b>59.4</b>	<b>4.84</b>	<b>9.95</b>	<b>11.4</b>	<b>OP</b>	<b>OP</b>	<b>OP</b>
<b>900 Torr</b>	<b>900</b>	<b>28.5</b>	<b>OP</b>	<b>OP</b>	<b>79.5</b>	<b>4.99</b>	<b>10.5</b>	<b>12.0</b>	<b>OP</b>	<b>OP</b>	<b>OP</b>
<b>1000 Torr</b>	<b>999</b>	<b>32.5</b>	<b>OP</b>	<b>OP</b>	<b>111</b>	<b>5.08</b>	<b>11.1</b>	<b>12.7</b>	<b>OP</b>	<b>OP</b>	<b>OP</b>

Notes:

- 1) OP = overpressure
- 2) Display auto-ranges between Torr and mTorr at 1Torr  
 Readings in normal font are in Torr. *Readings in blue italics are in mTorr.*

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## Appendix C: *Vacuum gauge contamination and cleaning*

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The most common cause of all vacuum gauge failures is contamination of the sensor. Noisy or erratic readings, the inability to set zero or atmosphere, and total gauge failure, are all possible indications of gauge contamination.

Contamination can be generally characterized as either: A) a reaction of process gases with sensor elements, or B) an accumulation of material on the sensor elements. Sensors that fail due to chemical reaction are generally not salvageable. Sensors that fail due to condensation, coatings, or particles may possibly be restored by following the cleaning procedure described below.

### A) Reactive Gases

If process gases react with the materials of construction of the sensor, the result is corrosion and disintegration of the sensor over time. Plasma etching and other reactive semiconductor processes are examples where this failure mode is common. In this instance, cleaning can not solve the problem, because the sensor has been destroyed; the gauge or module must be replaced.

If you experience this failure mode quickly or frequently, you should consider a different vacuum gauge for your application. Thermal vacuum gauges may be available with different sensor materials that are not as reactive with your particular process gases. Or you may consider a different type of gauge, such as a capacitance diaphragm gauge, which exposes only stainless steel or ceramic to the gases.

*There is no material that is universally chemical resistant; your choice of vacuum gauge (as well as all other vacuum components) should take into consideration the potential reactions between your process gases and the materials of construction. Consider what effect water vapor will have when combined with your process gases because a finite amount of water will enter the chamber during venting to atmosphere.*

### B) Condensation, Coatings, and Particles

If the failure is due to an accumulation of material in the sensor, you may be able to restore your gauge or module by cleaning. Contamination may be as simple as condensed water, or as difficult as solid particles.

*Condensation:* Some gases (such as water vapor) can condense on sensor surfaces, forming a liquid coating that changes the rate at which heat is removed from the sensor (which changes the calibration). The sensor can often be restored simply by pumping on the gauge between process cycles. A dry N<sub>2</sub> purge will help speed up drying, or the gauge may be gently heated, provided temperature doesn't exceed the specified limit (150°C with cables or electronics removed).

*Coatings:* Some gases can condense on sensor surfaces, forming a solid coating, which again changes the rate at which heat is removed from the sensor. Some of these coatings may be removed using an appropriate solvent, following the procedure described below.

*Particles:* Particles generated by the process may enter the gauge during the process cycle or during the venting cycle. The result is interference with heat removal from the sensor. The cleaning procedure described below may be able to remove particles from the gauge. However, particulate contamination is the most difficult to remove as particles can become stubbornly trapped inside the gauge.

In some processes, solid particles are created during the process, throughout the chamber, including inside the gauge. Particles tend to form on cooler surfaces, such as in a gauge at room temperature. You may slow down the build-up of particles in the gauge, by keeping the gauge warm (within specified limits) during the process cycle.

More commonly, particles in the process chamber are swept into the gauge during the vent cycle. KJLC gauges have a screen built into the gauge port, to help keep the largest particles out of the gauge. In very dirty applications, or where particles are small enough to get through the screen, an additional filter installed on the inlet may help prolong gauge life further.

### C) Cleaning Procedures

***Caution: Cleaning chemicals and their handling pose a variety of health, safety, and environmental issues. Protect yourself, your co-workers, and your surroundings, by using protective clothing (gloves, eyewear, etc), performing the cleaning in a well-ventilated area, and disposing of waste materials in a responsible manner.***

*Cleaning solvents:*

To be effective, the cleaning agent should be one that is likely to remove the suspected contaminant. It must also be compatible with the gauge materials of construction. Alcohol and water are recommended cleaning solvents, as they are compatible with most vacuum systems and components, and will remove many contaminants commonly found in vacuum processes, such as pump oil. However, depending on your particular contamination, you may need to use a more aggressive solvent.

*Cleaning procedure:*

1. With the gauge port up, pour your cleaning solution into the gauge port until it is full. Note: The fine mesh of the port screen may not allow the solution into the gauge tube because of surface tension effects. You may need to insert a small tool into the gauge vacuum port to push the port screen slightly away from the tube wall to allow solvent into the gauge. ("Slightly away" means less than about a millimeter.) Make sure the tool is not plated with high vapor pressure material such as zinc plating.
2. Let the solution sit for a while, 10-20 minutes should be sufficient. Gentle agitation will help disperse the solution throughout the gauge, but do not shake the gauge vigorously. (While the KJLC gauge is constructed to be rugged, it was not designed to withstand forces exerted by *liquids* in motion.)
3. With the gauge port down, pour the solution out of the gauge and leave it to drain and dry for several hours or overnight. Warming the gauge, and/or pumping on it, will speed up the drying time.
4. When you are sure the gauge is completely dry, install it on a vacuum system, apply power, and run through the calibration setup. Pump the gauge below  $10^{-4}$  Torr and confirm that the zero/vacuum can be set. If zero is ok, raise pressure and set the atmosphere adjustment.
  - 5a. If both zero and atm can be set properly, you have successfully cleaned your gauge.
  - 5b. If zero or atm cannot be set, the gauge has been contaminated beyond recovery and must be replaced. (You can try cleaning it again, but if the first pass doesn't recover the gauge, additional cleanings are not likely to succeed.)