275 series Convection Vacuum Gauge

User Manual

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1 Introduction / General Information

1.1 Description

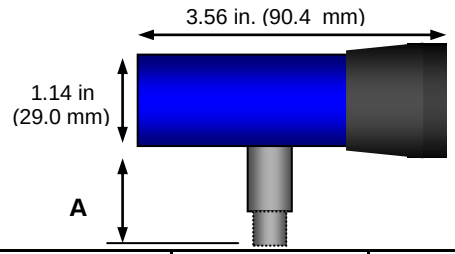
Thermal conductivity gauges measure pressure indirectly by sensing the loss of heat from a sensor to the surrounding gases. The higher the pressure of the surrounding gas, the more heat is conducted away from the sensor. Pirani thermal conductivity gauges maintain a sensor (usually a wire) at some constant 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.

The Kurt J. Lesker Company (KJLC) 275 is a *convection-enhanced* Pirani vacuum gauge sensor that interfaces with external controllers such as the KJL375 series controller. The 275 is also a direct drop-in replacement pin-pin compatible gauge for the Brooks Automation, Inc. / Granville-Phillips® 275 Convectron® gauge. The sensor connector has the same pinouts and signal as the corresponding Convectron®. It is directly interchangeable with your existing Convectron® controllers and cables, so you don't need to change any wiring, hardware, or process recipes.

1.2 Specifications

measurement range	1.00 x 10^{-4} to 1000 Torr 1.33 x 10^{-4} to 1333 mbar 1.00 x 10^{-2} Pa to 133 kPa
accuracy - N_2 (typical)	10^{-4} to 10^{-3} Torr; 0.1 mTorr resolution 10^{-3} to 400 Torr; ± 10% of reading 400 to 1,000 Torr; ±2.5% of reading
bakeout temperature	150 °C maximum, non-operating, with cable or electronics removed
operating temperature	0 to 50 °C
humidity	0 to 95% relative humidity, non-condensing
altitude	
operating	6,560 ft (2,000 m) max
storage	41,000 ft (12,500 m) max
mounting orientation	horizontal recommended
materials exposed to vacuum	gold-plated tungsten, 304 & 316 stainless glass, nickel, Teflon®
internal volume	26 cm^3 (1.589 in^3)
internal surface area	59.7 cm^2 (9.25 in^2)
leak integrity	< 1 x 10^{-9} atm cc/sec He
weight	3 oz. (85 g)
RF/EMI protection	CE compliant
environmental	RoHS

Dimensions



fitting	dimension A	Part Numbers
1/8 in. NPT - 1/8 in. tube	1.00 in (25.4 mm)	KJL275071
NW16KF	1.30 in. (33.0 mm)	KJL275203
NW25KF	1.30 in. (33.0 mm)	KJL275196
NW40KF	1.30 in. (33.0 mm)	KJL275316
1 1/3 in. Mini-Conflat®	1.08 in. (27.4 mm)	KJL275256
2 3/4 in. Conflat®	0.85 in. (21.6 mm)	KJL275238
1/4 in. Cajon® 4VCR	1.86 in. (47.2 mm)	KJL275185
1/2 in. Cajon® 8VCR	1.75 in. (44.5 mm)	KJL275282

2 Important Safety Information

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.**

⚠ WARNING

To avoid serious injury or death, follow the safety information in this document. Failure to comply with these safety procedures could result in serious bodily harm, including death, and or property damage.

Failure to comply with these warnings violates the safety standards of installation and intended use of this instrument. KJLC disclaims all liability for the customer's failure to comply with these instructions.

Although every attempt has been made to consider most possible installations, KJLC cannot anticipate every contingency that arises from various installations, operation, or maintenance of the gauge. If you have any questions about the safe installation and use of this product, please contact KJLC.

2.1 Safety Precautions - General

⚠ **WARNING!** There are no operator serviceable parts or adjustments inside the gauge sensor.

Do not modify this product or substitute any parts without authorization of qualified KJLC service trained personnel. 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.

⚠ **WARNING!** Source power must be removed from the product prior to performing any servicing.

Prior to installing the 275, ensure that all safety checks are made by a qualified service person. When a replacement gauge is required, ensure that the gauge is specified by KJLC. Substitutions of non-qualified parts may result in fire, electric shock or other hazards. Use of unauthorized parts or modifications made to this product will void the warranty.

To reduce the risk of fire or electric shock, do not expose this product to rain or moisture. These products are not waterproof and careful attention must be paid to not spill any type of liquid onto these products. Do not use these products if they have been damaged. Immediately contact KJLC to arrange return of the product if it is damaged.

Due to the possibility of corrosion when used in 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 equipment grounding. Do not use if the equipment grounding or electrical insulation has been compromised.

2.2 Safety Precautions - Service and operation

Ensure that the vacuum port on which the 275 vacuum gauge is mounted is electrically grounded.

Remove cable to the unit before attempting to service the gauge.

Remove cable to the the unit if a cable or plug is damaged or the product is not operating normally according to this User Manual. Contact qualified KJLC service personnel for any service or troubleshooting condition that may not be covered by this User Manual.

It is important that the product be periodically inspected for sound electrical connections and equipment grounding. Do not use if the equipment grounding or electrical insulation has been compromised.

Do not use if the unit has been dropped. Contact KJLC for further instructions regarding evaluation of the damaged sensor.

2.3 Electrical Conditions

⚠ **WARNING!** When high voltage is present in any vacuum system, a life threatening electrical shock hazard may exist unless all exposed electrical conductors are maintained at earth ground potential. This applies to all products that come in contact with the gas contained in vacuum chambers. An electrical discharge within a gaseous environment may couple dangerous high voltage directly to any ungrounded conductor of electricity. A person could be seriously injured or killed by coming in contact with an exposed, ungrounded electrical conductor at high voltage potential. This condition applies to all products that may come in contact with the gas inside the vacuum chamber (vacuum/pressure containment vessel).

2.3.1 Proper Equipment Grounding

⚠ **WARNING!** Hazardous voltages that could seriously injure or cause death are present in many vacuum processes. Verify that the vacuum port on which the 275 vacuum gauge sensor is mounted is electrically grounded. Consult a qualified Electrician if you are in doubt about your equipment grounding. Proper grounding of your equipment is essential for safety as well as intended operation of the equipment. The 275 vacuum gauge sensor must be connected directly to a good quality earth ground. Use a ground lug on the 275 gauge vacuum connection / flange if necessary.

⚠ **WARNING!** In order to protect personnel from electric shock and bodily harm, shield all conductors which are subject to potential high voltage electrical discharges in or around the vacuum system.

2.3.2 Electrical Interface and Control

It is the user's responsibility to ensure that the electrical signals from this product and any connections made to external devices, for example, relays and solenoids, are used in a safe manner. Always double check the system set-up before using any signals to automate your process. Perform a hazardous operation analysis of your

system design and ensure safeguards and personnel safety measures are taken to prevent injury and property damage.

2.4 Overpressure and use with hazardous gases

⚠ **WARNING!** Install suitable protective devices that will limit the level of pressure inside your vacuum chamber to less than what the vacuum chamber system components are capable of withstanding. The 275 gauge should not be used at pressures exceeding 1000 Torr absolute pressure.

In cases where an equipment failure could cause a hazardous condition, always implement fail-safe system operation. For example, use a pressure relief device in an automatic backfill operation where a malfunction could result in high internal pressures if the pressure relief device was not installed on the chamber.

The 275 vacuum gauge sensor is not intended for use at pressures above 20 psia (1000 torr); DO NOT exceed 35 psig (< 2 ½ bars) pressure inside the sensor. If your chamber goes to higher pressures, you should install an isolation valve or pressure relief device to protect the gauge sensor from overpressure conditions. With some fittings, actual safe overpressure conditions may be lower; for example, a quick-connect, O-ring compression fitting may forcibly release the gauge sensor from the vacuum chamber fitting with only a few psi over local uncorrected barometric (atmospheric) pressure.

⚠ **CAUTION! If the internal pressure of a vacuum gauge device is allowed to increase above local uncorrected barometric pressure (atmospheric pressure side), vacuum fittings may release and possible overpressure conditions may cause leaks that would allow the gas inside the gauge sensor to release into the atmosphere of the surrounding environment. Toxic, pyrophoric and flammable gases are examples of hazardous gases that if allowed to leak out of the vacuum/pressure containment vessel into the atmospheric environment, could cause bodily injury and possible damage to equipment. Never expose the gauge sensor internal volume to pressure above local atmospheric pressure when using hazardous gases.**

2.5 Gases other than Nitrogen / air

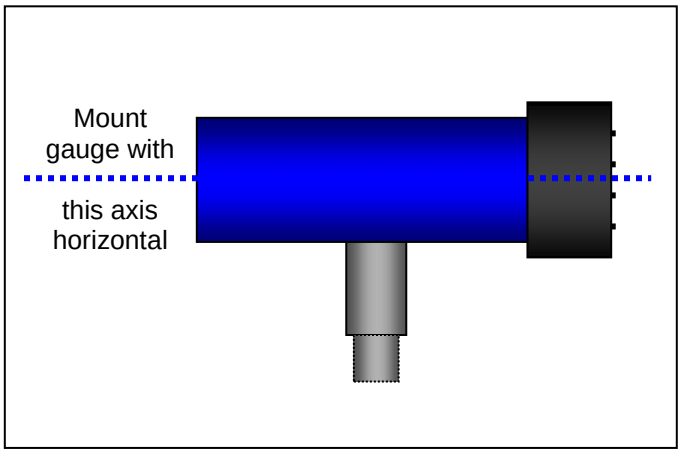
⚠ **WARNING!** Do not attempt to use with gases other than nitrogen (N_2) or air without referring to correction factor data tables.

The 275 gauge is calibrated for direct readout of nitrogen or air. Do not attempt to use with other gases such as argon (Ar) or carbon dioxide (CO_2) unless accurate conversion data for N_2 to other gas is properly used. Refer to the correction factor data listed in the controller User Manual operating this device. The KJL375 controller User Manual provides a more complete discussion of using correction factors when using the gauge on gases other than Nitrogen.

⚠ **WARNING!** Do not use this device in an explosive atmosphere or in the presence of flammable gases, vapors or fumes. Do not use this device to measure the pressure of explosive or combustible gases or gas mixtures. The sensor wire in the gauge normally operates at 125 ^{o}C, but if malfunction should occur, the wire temperature could exceed the ignition temperature of certain combustible gases and gas mixture. This could cause an explosion which could result in serious injury or death.

3 Installation

Mount the 275 as close as possible to the pressure you want to measure. Long or restricted, small diameter tubing will create a pressure difference between your process chamber and the gauge. This may cause a delay in response to pressure changes. Mounting the 275 too close to a gas source inlet may also cause measurement and control instability.



Do not mount the 275 near a source of heating or cooling, such as heaters or air conditioning vents.

Mount the 275 with its main (long) axis horizontal (see diagram at right). The 275 is calibrated in this orientation. Pressure reading errors may occur above 1 Torr if the unit is not mounted horizontally. Below 1 Torr, mounting position has little to no effect.

Mount the 275 with port down, if possible, to help minimize the effect of any particles or condensation from collecting in the gauge.

Do not mount the 275 where it will be subjected to excessive vibration. Vibrations may cause unstable readings, measurement errors and possible mechanical stress to components in the 275.

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

- NPT fittings: When connecting the device using a NPT fitting, apply a thread sealant compound or wrap the threaded portion of the tubing with one-and-a-half to two wraps of pipe thread seal tape such as PTFE (Teflon®) tape and hand tighten the gauge into the gauge port. Do not use a wrench or other tool which may damage the gauge.

4 Using the gauge with different gases

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 conductivity gauges) are calibrated using nitrogen (N_2). When a gas other than N_2 /air is used, correction must be made for the difference in thermal conductivity between nitrogen (N_2) and the gas in use. The gas correction data, charts and tables listed in your controller (such as the KJL375 controller) User Manual, indicates how different gases affect the display and output from a KJLC convection gauge.

⚠ **WARNING!** Using a thermal conductivity gauge with gases other than that for which it is calibrated could result in death or serious injury. Be sure to use the correction factor data listed in the controller User Manual operating this device.

For N_2 the calibration shows excellent agreement between indicated and true pressure throughout the range from 10^{-4} to 1000 Torr. 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 sensor geometry and mounting position as well as gas properties.

Generally, air and N_2 are considered the same with respect to thermal conductivity, but even N_2 and air will exhibit slight differences in readings at higher pressures. For example, when venting a system to atmosphere using N_2, you may see readings change by 30 to 40 Torr after the chamber is opened and air gradually displaces the N_2 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_2 / air

Flammable or explosive gases

⚠ **WARNING!** KJLC convection gauges are neither intrinsically safe nor explosion proof and are not intended for use in the presence of flammable or explosive gases or vapors.

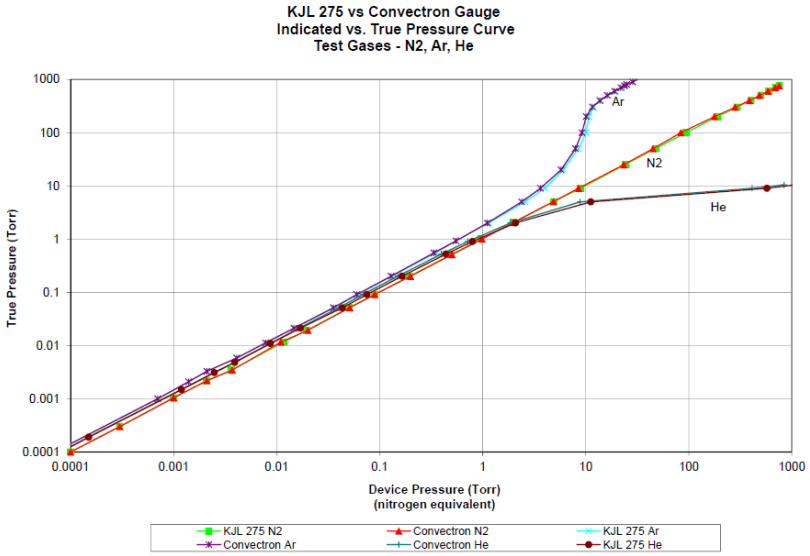
Under normal conditions the voltages and currents in KJLC convection gauges are too low to cause ignition of flammable gases. However, under certain failure conditions, sufficient energy could be generated to cause flammable vapors or gases to ignite or explode. Thermal conductivity gauges like the KJLC convection gauges 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 "span" settings), these changes are small enough to be ignored. If you can't set zero and span, the gauge should be replaced or return to factory for evaluation and possible cleaning.



Gas Correction Chart

The Y- axis of the above chart is actual pressure as 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. This chart shows readings for a KJLC convection gauge (275) and Granville-Phillips® Convectron® gauge to illustrate that the difference in the response for both of these types of gauges is virtually indistinguishable.

CAUTION! Do not assume this data applies to other convection gauges which may or may not be the same. Refer to the correction factor data listed in the controller User Manual operating this device. The KJL375 controller User Manual provides a more complete discussion of using correction factors when using the gauge on gases other than Nitrogen.

Ex A: If the gas is nitrogen (N_2), when the true total pressure is 500 Torr, the gauge will read 500 Torr.

Ex B: If the gas is argon (Ar), when the true pressure is 100 Torr, the gauge will read about 9 Torr. If you are backfilling your vacuum system with Ar, when your system reaches a pressure of 760 Torr true pressure your gauge will be reading about 23 Torr. Continuing to backfill your system, attempting to increase the reading up to 760 Torr, you will over pressurize your chamber which may present a hazard.

Ex C: If the gas is helium (He), the gauge will read 999 Torr when pressure reaches about 10 Torr true pressure and opening the chamber to atmosphere prematurely may present other hazards for both people and product.

CAUTION! What these examples illustrate is that using gases other than nitrogen (N_2) without using accurate gas conversion data and other proper precautions could result in injury to personnel and/or damage to equipment.

Suggested precautions when using gases other than nitrogen (N_2):

Install a pressure relief valve or burst disk on your chamber, to protect it from overpressure. Post a warning label on your gauge readout that states "Do Not Exceed ____ Torr Indicated Pressure" (fill in the blank for maximum indicated pressure for the gas you use) so that an operator using the gauge will not exceed a safe pressure.

5 Service

5.1 Calibration

Every 275 gauge is calibrated prior to shipment using nitrogen (N_2). However, you can calibrate the instrument by adjusting zero and span (atmosphere), using the controller which is operating the gauge.

Zero and span (atmosphere) calibration affect the displayed value and the output signal. Zero calibration optimizes performance of the gauge when operating at a low pressure range of 1×10^{-4} Torr to 1×10^{-3} Torr. If your minimum operating pressure is higher than 1×10^{-3} Torr, it is not normally necessary to perform calibration at zero and thus span calibration should be adequate. If you are able to evacuate your system to below 1×10^{-4} Torr, it is always a good practice to check and set zero if necessary. This will also improve performance in cases where gauge contamination is causing higher readings than 1×10^{-4} Torr, even though the system has been evacuated to below 1×10^{-4} Torr. Care should be exercised when using gases other than nitrogen (N_2) / air.

5.2 Maintenance

In general, maintenance is not required for your KJLC gauge. Periodic performance checks may be done by comparing the gauge to a known reference standard.

5.3 Troubleshooting

Indication	*Possible Cause*	*Possible Solution*
Readings appear very different from expected pressure	The process gas is different from the gas used to calibrate the 275	Correct readings for different gas thermal conductivity. See controller User Manual
	Gauge has not been calibrated or has been calibrated incorrectly	Check that zero and span are adjusted correctly. See controller User Manual
Readings are noisy or erratic	Loose cables or connections	Check and tighten connections
	Contamination	Inspect gauge for signs of contamination such as particles, deposits, discoloration on gauge inlet. Return to factory for possible cleaning
	Vibration	Ensure gauge is not mounted where excessive vibration is present
Gauge cannot be calibrated - zero and span can't be adjusted	Contamination	Return to factory for possible cleaning
	Sensor failure for other cause	Return to factory for evaluation or replace
Controller displayed pressure is too high and cannot be set to correct value	Contamination	Return to factory for possible cleaning
	Sensor wire damaged	Return to factory for evaluation or replace
Controller displayed pressure is too low and cannot be set to correct value	Sensor wire damaged	Return to factory for evaluation or replace
	Contamination	Return to factory for possible cleaning

5.4 Contamination

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 cleaning.

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. The chemistry of the gases used for plasma etching and other reactive semiconductor processes are examples where this failure mode is possible. In this case, cleaning can't solve the problem because the sensor has been destroyed. The 275 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. The standard gold plated tungsten sensor used in the KJLC convection gauge is offered for use with air and inert gases such as N_2, argon, etc. KJLC also offers modules with platinum sensors for applications not compatible with gold plated tungsten.

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 with air.

B) Oil, Condensation, Coatings, and Particles

If the failure is due to an accumulation of material in the gauge, we 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.

Oils and hydrocarbons: Exposure of the gauge internal surfaces to oils and hydrocarbons can result in sensor contamination. Some of these types of contamination may be removed by cleaning the gauge. If there is the possibility of oil back streaming from wet vacuum pumps, it is recommended that a filter or trap be installed to prevent contamination of components of your vacuum system.

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_2 purge will help speed up drying, or the gauge may be gently heated provided temperature doesn't exceed the specified limit of 40 ^{o}C, operating.

Coatings: Some gases can condense on sensor surfaces, forming a solid coating, which changes the rate at which heat is removed from the sensor. Some of these coatings may be removed by cleaning the gauge.

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. In this case cleaning 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.

Particles in the process chamber may be swept into the gauge during the vent cycle. The 275 has 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 the gauge life further.

In some vacuum processes, desorbed and sputtered materials from the process may enter vacuum components connected to the process vacuum chamber by line-of-sight transport especially under high vacuum conditions, i.e., in the molecular flow regime. To prevent materials that may be transported via line-of-sight momentum from entering your vacuum gauge or other components, it is advisable to install some form of apparatus that will block the line-of-sight. In many cases a simple 90^{o} elbow may help prevent or reduce the transport of particles from entering your vacuum gauge.

In the event of gauge contamination please contact the factory to return the gauge for possible cleaning if the gauge has not been exposed to hazardous materials.

5.5 Gauge Replacement

If the 275 gauge fails for any reason, and cleaning does not resolve the issue, the 275 gauge should be replaced.

6 Factory Service and Support

If you need help setting up, operating, or troubleshooting, or obtaining a return materials authorization number to return the gauge for diagnosis, please contact us during normal business hours (8:00am to 5:00pm Eastern Standard Time) Monday through Friday, at 1-412-387-9200. Or e-mail us at gauging@lesker.com

For the safety of our employees, you must provide a history of the gauge detailing what gases have been used. We cannot accept gauges that have been exposed to hazardous materials.

7 Warranty

SELLER warrants that its products are free of defects in workmanship and material and fit for the uses set forth in SELLER's catalog or product specifications, under the normal use and service for which they are intended.

The entire warranty obligation of SELLER is for the repair or replacement, at SELLER's option, of products or parts (examination of which shall disclose to SELLER's satisfaction that it is defective) returned, to SELLER's plant, properly identified within 24 months (unless otherwise noted) after the date of shipment from KJLC Plant. BUYER must obtain the approval of SELLER and a return authorization number prior to shipment.

Alteration or removal of serial numbers or other identification marks renders this warranty void. The warranty does not apply to products or components which have been abused, altered, operated outside of the environmental specifications of the product, improperly handled or installed, or units which have not been operated in accordance with SELLER's instructions. Furthermore the warranty does not apply to products that have been contaminated, or when the product or part is damaged during the warranty period due to causes other than ordinary wear and tear to the product including, but not limited to, accidents, transportation, neglect, misuse, use of the product for any purpose other than that for which it was designed.

THIS WARRANTY IS EXCLUSIVE AND IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. THIS WARRANTY EXTENDS ONLY IN FAVOR OF THE ORIGINAL BUYER. THE BUYER'S SOLE REMEDY SHALL BE THE REPAIR OR REPLACEMENT, AS IS EXPRESSLY PROVIDED HEREIN, OF ANY WARRANTED DEFECTIVE PRODUCT OR PART, AND UNDER NO CIRCUMSTANCE SHALL SELLER BE LIABLE TO BUYER OR ANYONE ELSE FOR ANY CONSEQUENTIAL DAMAGES TO PERSONS OR PROPERTY, FOR INCIDENTAL DAMAGES OR LOSS OF TIME, FOR ANTICPATED OR LOST PROFITS, OR ANY OTHER LOSS INCURRED BY THE BUYER RELATED TO THE PRODUCT COVERED BY THIS WARRANTY. THIS EXCLUSIVE REMEDY SHALL NOT BE DEEMED TO HAVE FAILED OF ITS ESSENTIAL PURPOSE SO LONG AS SELLER IS WILLING AND ABLE TO REPAIR OR REPLACE DEFECTIVE PARTS IN THE PRESCRIBED MANNER. THIS LIMITED WARRANTY MAY NOT BE MODIFIED BY SELLER UNLESS SUCH MODIFICATION OR WAIVER IS IN WRITING, EXECUTED BY AN AUTHORIZED OFFICER OF SELLER.

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