

IMPACTS OF SHOCK AND VIBRATION ON A LIMIT SWITCH

A Honeywell White Paper

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ABSTRACT

Industrial limit switches are very popular in sensing and control applications.

Limit switches are used to detect presence or absence in areas where physical contact is allowed. Upon sensing an object, the switch actuator operates and the normally open or closed electrical contacts inside the switch body change state, thereby either making or breaking an ac/dc electrical circuit.

Whether it be the industrial, construction, agriculture, commercial or transportation industry, limit switches have become an integral part of the sensing and control community. There are perhaps trillions of limit switches in use at this very moment in various types of industrial equipment, agriculture or construction machinery, and control systems around the globe. The fact that such a simple device – with normally open or closed contacts coupled with a snap-action switching mechanism – is capable of performing at an enhanced precision level, reliably and safely, in the many harsh environments, is simply astonishing. There is no doubt it would be extremely difficult to find a suitable and appropriate alternative to an industrial limit switch.

Limit switches are tested to their full extent and capabilities when they are installed in heavy-duty construction machinery, agriculture equipment or solid waste-handling vehicles. These applications produce extremely high levels of shock and vibration. These machinery and equipment typically operate in very harsh outdoor and dirty environments throughout the four seasons of the year, and hence are exposed to all environmental elements. Under these circumstances, it is quite a challenge for a limit switch to maintain its performance and function effectively and efficiently every single time. Reliability, durability and safety are the three key factors that will always matter to limit switch buyers.

Honeywell has field-tested solutions and a vast portfolio of reliable and effective electromechanical products for the heavy-duty industries. Honeywell has a wide range of MICRO SWITCH limit switches (both heavy- and medium-duty) that can be a suitable fit for different industrial applications. These heavy-duty electro-mechanical products can deliver enhanced performance for harsh and rigorous industrial applications, while providing a safer environment for workers.

IMPACTS OF SHOCK AND VIBRATION ON A LIMIT SWITCH

Heavy-duty machinery, equipment and vehicles operate in all kinds of weather conditions. These heavy-duty machines are engineered to withstand tremendous amounts of force, vibration, shock, friction and pressure. Any mechanical or electrical components that are embedded in these heavy-duty machines are required to go through standard testing procedures for shock and vibration.

These types of tests are necessary and important to verify whether or not the hardware will be able to survive the dynamic environments that these heavy-duty machines encounter on a daily basis.

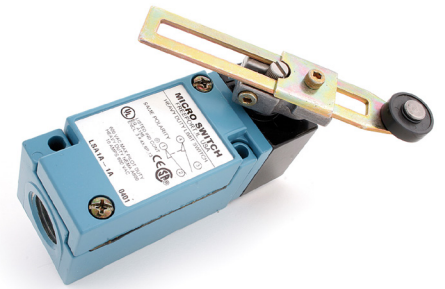
Considering the magnitude of shock and vibration generated by these machines, it is quite possible that an average limit switch may experience:

- switch contacts malfunctioning
- damage to internal mechanical linkages of the switch
- significant reduction in the service life of the switch due to the abrasive powder generated from the internal parts of the switch

Industrial limit switches play a very important role in enabling these heavy-duty machines to perform their daily tasks efficiently, reliably and safely. Limit switches are mainly used for sensing the various mechanical linkages in a heavy-duty machine and then relaying the information to the engine control module. Based on the inputs from the limit switch, the engine control module can adjust the movement of the various electromechanical arms, levers, linkages, booms, etc. or even cut off power to the electrical circuit in case of an emergency or malfunctioning. This way, an operator can more safely operate the heavy-duty machine and may also minimize or prevent any unnecessary and expensive damage to these sophisticated machines.

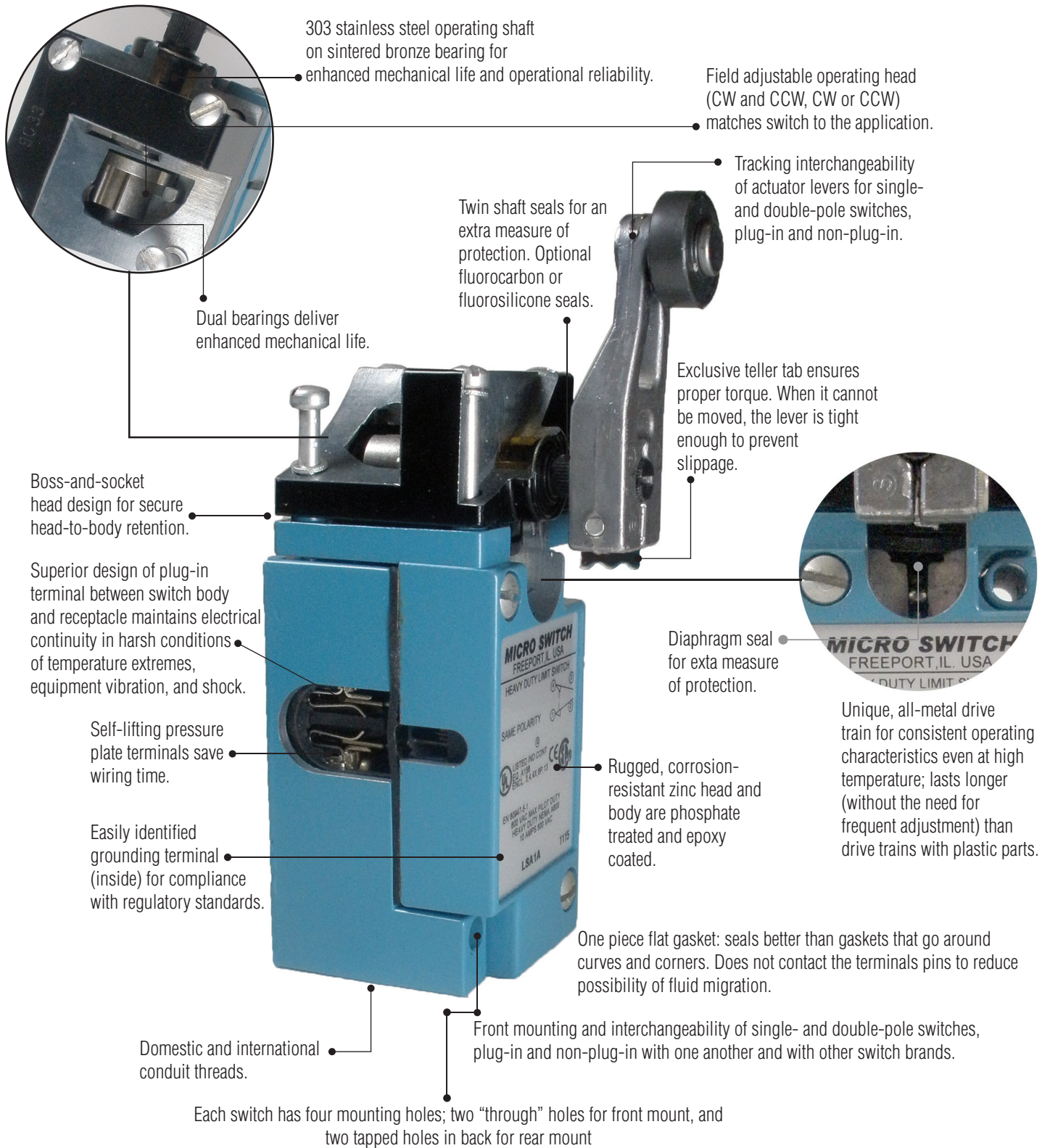
It is true that there are many other sensing solutions available on the market such as photoelectric sensors, mini beams, ultrasonic sensors, proximity sensors, etc. Even though these sensing devices are also capable of withstanding similar amounts of shock, vibration, force and pressure as an industrial limit switch, the operating circumstances and conditions in heavy-duty industrial applications can significantly lower the effectiveness of these types of sensors. For instance, photoelectric sensors can often get clogged or jammed by the debris and pollution created on a construction site, off-road transportation or by solid waste during the collection process. The same is true for mini-beam sensors as well. The ultrasonic waves emitted by an ultrasonic sensor often tend to be diminished or affected by strong wind or rain. This may result in inaccurate sensing data, which may cause nuisance tripping or unsafe operation of the mechanical linkages in these heavy-duty vehicles and machinery. Proximity sensors too have the possibility of getting covered with debris and dirt in the sensing tip, which then would basically render the sensor ineffective.

Honeywell MICRO SWITCH limit switches are resilient to strong vibration, shock and impact forces and can be typically installed very near or directly on a heavy-duty machine in places that experience high force loads. These industrial limit switches have a wide range of NEMA/IP ratings against environmental factors such as rain, moisture, sleet and splashing liquids. These heavy-duty limit switches are designed to function effectively in low (freezing) and high temperatures as well. These limit switches can be prewired with customer-specified connectors to an existing control system. They also come with gold-plated switching contacts, which can be very helpful if the heavy-duty machines have to operate in moist or acidic environments. These limit switches will provide a direct circuit break that, if actuated, can be designed to quickly stop a piece of equipment.



MICRO SWITCH HDLS Limit Switch

Figure 1: Honeywell MICRO SWITCH Heavy-Duty Limit Switch HDLS Series Overview



303 stainless steel operating shaft on sintered bronze bearing for enhanced mechanical life and operational reliability.

Field adjustable operating head (CW and CCW, CW or CCW) matches switch to the application.

Tracking interchangeability of actuator levers for single- and double-pole switches, plug-in and non-plug-in.

Twin shaft seals for an extra measure of protection. Optional fluorocarbon or fluorosilicone seals.

Dual bearings deliver enhanced mechanical life.

Exclusive teller tab ensures proper torque. When it cannot be moved, the lever is tight enough to prevent slippage.

Boss-and-socket head design for secure head-to-body retention.

Superior design of plug-in terminal between switch body and receptacle maintains electrical continuity in harsh conditions of temperature extremes, equipment vibration, and shock.

Self-lifting pressure plate terminals save wiring time.

Easily identified grounding terminal (inside) for compliance with regulatory standards.

Diaphragm seal for extra measure of protection.

Rugged, corrosion-resistant zinc head and body are phosphate treated and epoxy coated.

Unique, all-metal drive train for consistent operating characteristics even at high temperature; lasts longer (without the need for frequent adjustment) than drive trains with plastic parts.

One piece flat gasket: seals better than gaskets that go around curves and corners. Does not contact the terminals pins to reduce possibility of fluid migration.

Domestic and international conduit threads.

Front mounting and interchangeability of single- and double-pole switches, plug-in and non-plug-in with one another and with other switch brands.

Each switch has four mounting holes; two "through" holes for front mount, and two tapped holes in back for rear mount

INTERNATIONAL ELECTROTECHNICAL COMMISSION

The International Electrotechnical Commission (IEC) is the world's leading organization for the preparation and publication of International Standards for all electrical, electronic and related technologies. The object of the IEC is to promote international cooperation on all questions concerning standardization in the electrical and electronic fields.

IEC provides a platform to companies, industries and governments for meeting, discussing and developing the International Standards they require.

All IEC International Standards are fully consensus-based and represent the needs of key stakeholders of every nation participating in IEC work. Every member country, no matter how large or small, has one vote and a say in what goes into an IEC International Standard.

IEC 60068-2-27 (Shock): It provides a standard procedure for determining the ability of a specimen to withstand specified severities of non-repetitive or repetitive shocks.

The purpose of this test is to reveal mechanical weakness and/or degradation in specified performances, or accumulated damage or degradation caused by shocks. In conjunction with the relevant specification, this may be used in some cases to determine the structural integrity of specimens or as a means of quality control. This test is primarily intended for unpackaged specimens and for items in their transport case when the latter may be considered to be part of the specimen.

IEC 60068-2-6 (Vibration): This part of IEC 60068 gives a method of test applicable to components, equipment and other articles which, during transportation or in service, may be subjected to conditions involving vibration of a harmonic pattern, generated primarily by rotating, pulsating or oscillating forces, such as those that occur in ships, aircraft, land vehicles, rotorcraft and space applications or are caused by machinery and seismic phenomena.

This standard consists basically of subjecting a specimen to sinusoidal vibration over a given frequency range or at discrete frequencies, for a given period of time. A vibration response investigation may be specified that aims at determining critical frequencies of the specimen.

The relevant product specification shall indicate whether the specimen shall function during vibration or whether it suffices that it still works after having been submitted to vibration.



Note: For more information on the International Electrotechnical Commission, visit <http://www.iec.ch/>.

MICRO SWITCH LIMIT SWITCH PORTFOLIO

TABLE 1. VIBRATION & SHOCK TABLE FOR HONEYWELL INDUSTRIAL LIMIT SWITCHES

	Limit Type	Rating	Vibration	Shock
	LSA Series: Heavy-Duty Limit Switch (HDLS) Series	Heavy Duty	10 g as per IEC 60068-2-6 ; frequency range 10 Hz to 500 Hz; railway application per IEC 61373 Class I Car B type (actuator not fitted)	50 g as per IEC 60068-2-27 ; railway application per IEC 61373 Class I Car B type (actuator not fitted)
	E6/V6 Series Compact Limit Switch	Medium Duty	10 g (10 Hz to 55 Hz) as per IEC 60068-2-6	30 g (1/2 sine per MIL-S-901) as per IEC 60068-2-27 (actuator not fitted)
	914CE Series Compact Limit Switch	Medium Duty	10 g as per IEC 60068-2-6	50 g as per IEC 60068-2-27
	NGC Series Miniature Limit Switch	Global	10 g as per IEC 60068-2-6 , frequency range 10 Hz to 500 Hz; railway application per IEC 61373 Class I Car B type	50 g for 11 ms as per IEC 60068-2-27 ; railway application per IEC 61373 Class I Car B type
	GLA Series DIN Limit Switch	Global	10 g conforming to IEC 68-2-6 ; railway application per IEC 61373 Class I Car B type (actuator not fitted)	50 g conforming to IEC 68-2-27 ; railway application per IEC 61373 Class I Car B type (actuator not fitted)
	GLL Series Miniature Limit Switch	Global	10 g as per IEC 60068-2-6 (actuator not fitted)	50 g as per IEC 60068-2-27 (actuator not fitted)
	GLC, GLD, & GLE MIN-DIN Limit Switch	Global	10 g per IEC 60068-2-6 ; railway application per IEC 61373 Class I Car B Type	50 g per IEC 60068-2-27 ; railway application per IEC 61373 Class I Car B Type

HEAVY-DUTY LIMIT SWITCH APPLICATIONS

CONCRETE-PUMPING TRUCKS

Concrete-pumping trucks have long articulated arms or booms that deliver concrete to locations that are difficult or impossible to reach by a concrete truck or pumping machine. Honeywell HDLS switches can be installed to sense the position of the boom. When the boom is correctly positioned, the limit switch sends a signal to the operator.

It is equally important to ensure that the concrete box or the hopper is properly closed and positioned for safe and reliable operation of the concrete pumping truck. A Honeywell GLA series limit switch can be used to sense the position of the concrete box/hopper. The limit switch provides an indication to the operator whether or not the concrete box/hopper is closed and if it is safe for the equipment and personnel to start pumping concrete.

When transitioning from working configuration to transport configuration, part of the truck's drive train switches from powering the concrete pump to transport drive. The GLC limit switch mounted on the truck chassis provides feedback to the control system of the truck to notify the operator that the piece of equipment is either engaged in powering the concrete pump or ready for transport.

The reason why three different types of Honeywell industrial limit switches (HDLS, GLA and GLC series) are used in this application is because each limit switch provides the required form and shape factor to fit in the required areas of the truck for proper sensing.

The HDLS is the foremost switch when it comes to reliability and ruggedness. It has an all-metal drive train, sealed internal switch cavity, die-cast zinc housing and a diaphragm seal that separates the head of the switch from the body. The GLA and GLC limit switches have similar reliability and ruggedness to the HDLS limit switch. Both of these limit switches have an environmental protection rating of IP67, a 40°C [-40°F] temperature rating and come standard with a field-adjustable head. All three limit switch series have the required vibration and shock ratings to survive in these type of high vibration and shock environments and function more effectively, reliably and safely.

OFF-ROAD DUMP TRUCKS

Off-road heavy-duty dump trucks are typically equipped with an open box-head or dump that is hinged at the rear end of the truck. The dump or open box-head is generally equipped with hydraulic pistons to lift the front of the dump so that any material sitting in the dump is rolled over to the ground or delivery site behind the truck. It is obvious that these trucks encounter the highest levels of vibration and shock in their normal operation. Furthermore, these trucks operate in the harshest of



weather conditions such as scorching heat, freezing cold, dust, corrosive chemicals, rain and wind.

A Honeywell HDLS series limit switch can be pre-wired and installed at the pivot point of the dump bed of the truck. Because of the presence of salt, grease and other corrosive chemicals during the normal operation of the truck, the limit switch can be equipped with gold-plated switching contacts. The limit switch senses whether the dump bed or box is fully seated or not on the truck frame. This signal is fed into the control system to notify the truck operator.

The modular construction of Honeywell heavy-duty limit switches (HDLS series) allows for a wide variety of actuator styles, operating heads and electrical circuitry options. The plug-in versions can significantly minimize downtime on production lines with high actuation rates, as replacement of the switch can be accomplished in seconds. The HDLS are often ideal for many applications with demanding indoor and/or outdoor environments, where these switches may be subjected to high shock and vibration from operating equipment, temperature extremes, dust, splashing water, coolant and/or hose-directed water.

AGRICULTURE EQUIPMENT

Planters are connected to the rear end of an agriculture tractor with a draw bar, and are subjected to a substantial amount of vibration and shock from both the tractor and often uneven, dry and rough farm terrains.

Two GLE series industrial limit switches can be used to monitor the position of the planter's marker arms, and one GLC series industrial limit switch can be used to monitor the on/off status of the air system. It is important to make sure that the marker's arms are in the rest position and that the air system is off during the transport of the planter from one location to another.

The GLE and GLC series are durable and reliable limit switches and are often suitable for many industrial applications, agriculture equipment, transportation equipment and other applications requiring an environmentally sealed (IP and NEMA) switch. The compact housings are often ideal for equipment where space is at a premium. A wide range of actuators, contact blocks and conduit/connectivity options enhance the product offering. They are also certified for global use with CCC, CSA, CE and UL approvals.

SEA-PORT BRIDGE CRANES

Sea-port bridge cranes are an expensive piece of equipment and if damaged can very easily result in a hefty bill for repair or replacement. And let's not forget about the business downtime due to equipment damage that can cost thousands of dollars. It is critical to have excellent sensing points of the various mechanical linkages and accessories of a sea-port bridge crane for efficient and precise operations and control. Another important criteria for customers in the harbor crane business is overall system reliability and worker safety.

Considering the size and weight of this heavy-duty industrial equipment, it is obvious that there will be extremely high levels of vibration and shock on the various metallic



structures. This vibration and shock can be due to an impact with another structure caused by wind, transport of goods for loading and unloading operations, or maybe faulty operation caused by operator error.

Industrial limit switches are used extensively in harbor crane applications. Honeywell heavy-duty limit switches (HDLS) can be used for detecting the position of the moving cab of the harbor crane. The GLA series industrial limit switches can be used to detect the open and closed status of the various doors on the crane and also to monitor the inner rail's operation status.

With various IP/NEMA ratings, these heavy-duty industrial limit switches are not only certified to function effectively in all weather conditions but are also qualified for the increased levels of shock and vibration that is expected during normal day-to-day operations.

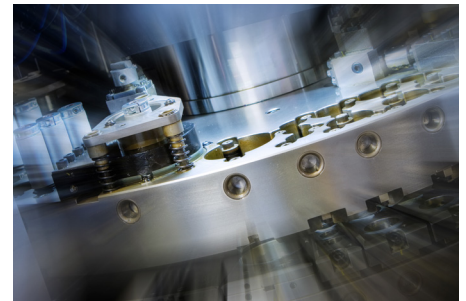
COMPUTER NUMERICAL CONTROL MACHINES

A Computer Numerical Control (CNC) machine is a complex machining tool that can be pre-programmed to perform certain tasks requiring high precision and accuracy, such as fabricating parts and components. A CNC machine can cost anywhere from \$5,000 to hundreds of thousands of dollars. Therefore, proper care needs to be taken during machine operation, maintenance and servicing as repair or replacement can be very expensive.

Industrial limit switches are used for sensing the positions of the various moving parts of a CNC machine such as drilling tools, lathe, milling tools, etc. For example, if a moving tool on a CNC machine is about to reach its motion limit, the limit switch properly positioned to sense this specific tool will actuate. The actuation of the limit switch serves as an input to the control module of the CNC machine and accordingly the computer sends a stop or shutdown command to the machine. In this way, the CNC machine can prevent its machining tool from any further damage as well as prevent damage to the fabricating parts or components.

Even though the CNC machine is a sophisticated piece of machinery, it is not vibration-free. There are actually two types of vibration that occur in a CNC machine – forced vibration and self-excited vibration. These vibrations can be caused by misaligned machining tools, bad gears or drives, shape and structure of the component or part worked on by the CNC machine, etc. There can be times during these operations when the frequency levels of the vibration can be extremely high.

Honeywell 914CE series compact industrial limit switches can be used for sensing the position of various machining tools within the CNC machine. The compact limit switch can be easily mounted or installed in confined spaces within the machine for proper sensing. With a vibration rating of 100 g and a shock rating of 50 g, the 914CE series limit switches are rugged and versatile switches that can be applied indoors in many harsh factory-floor applications, as well as on outdoor equipment in extreme temperatures (-40°C to 100°C [-40°F to 212°F]). A full range of actuators are available, including plain plungers, roller plungers, side rotary, multi-directional wire and manually operated.



CONCLUSION

Heavy-duty equipment and machinery, whether in the transportation, agriculture, solid waste handling, construction or industrial sector, are subjected to extreme operating and harsh environmental conditions.

Honeywell heavy- and medium-duty limit switches are subjected to rigorous vibration and shock test setups and procedures with effects comparable to those likely to be encountered in real-life operations. The vibration and shock test conditions closely mirror the real environment.

The test parameters used during vibration and shock testing are standardized and suitable tolerances chosen in order to obtain similar results when a test is run at different locations by different people using either analog or digital control techniques. The standardization of values also enables components to be grouped into categories corresponding to their ability to withstand certain vibration and shock severities. Honeywell industrial limit switches are IEC certified to withstand very high levels of shock and vibration from heavy-duty equipment and machines, and are certified for various NEMA/IP environmental ratings for temperature extremes, dust, splashing water, coolant and/or hose-directed water. The industrial limit switches also possess UL, CSA, CE and CCC safety certifications for electrical and mechanical specifications that conform to both global and international safety standards.

Enhanced accuracy, accountability and durability are built into every part or construction of Honeywell industrial limit switches, thereby improving performance output and endurance. Honeywell sensing and control solutions are also flexible and can be tailored to exact specifications – for stronger performance and longer which may result in reduced expenditures and operational costs.

WARRANTY/REMEDY

Honeywell warrants goods of its manufacture as being free of defective materials and faulty workmanship during the applicable warranty period. Honeywell's standard product warranty applies unless agreed to otherwise by Honeywell in writing; please refer to your order acknowledgment or consult your local sales office for specific warranty details. If warranted goods are returned to Honeywell during the period of coverage, Honeywell will repair or replace, at its option, without charge those items that Honeywell, in its sole discretion, finds defective.

The foregoing is buyer's sole remedy and is in lieu of all other warranties, expressed or implied, including those of merchantability and fitness for a particular purpose. In no event shall Honeywell be liable for consequential, special, or indirect damages.

While Honeywell may provide application assistance personally, through our literature and the Honeywell web site, it is buyer's sole responsibility to determine the suitability of the product in the application.

Specifications may change without notice. The information we supply is believed to be accurate and reliable as of this writing. However, Honeywell assumes no responsibility for its use.

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WARNING IMPROPER INSTALLATION

Consult with local safety agencies and their requirements when designing a machine control link interface and all control elements that affect safety. Strictly adhere to all installation instructions..

Failure to comply with these instructions could result in death or serious injury.