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International Frequency Sensor Association (IFSA).
Pressure-Resistant Proxes: New Generation Switches for Hydraulic Applications

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1. Introduction

In 2002, Dave Douglass from Gates Rubber Company said: “Five years ago 95% of Gates Spiral-wire hose orders were for 4000 psi or less…now 75% of our sales are for 4000psi hoses, and 25% are for 5000 + psi hoses”

The highest of high temperatures and pressures pervade the Hydraulics business. If component selections are incorrect, downtime and injury will plague the hydraulics industry.

In May of 2004, Parker Hannifin Corporation’s Hose Products Division announced the availability of Parker 781 hose designed specifically for high pressure, high impulse applications. This product is engineered to perform with a constant working pressure of 5000 psi in any working environment, hot or cold.

2. What is High Pressure

Pressure is equal to total force (in pounds) divided by the area (in square inches).

French scientist and philosopher Blasé Pascal pioneered Hydrodynamics and “fluid mechanics” which are the basis of hydraulic power. Pascal showed that pressure in an enclosed body of fluid arising from forces applied to its boundaries is transmitted equally in all directions with unchanged intensity. (Think of a toothpaste container with holes poked in it and pressure applied to it—toothpaste would be forced out all the holes at the same time) This pressure acts at right angles to the surface of the container. So pressure exerted on the boundaries creates a powerful exertion moving in several
directions. The greater the pressure, the greater the power. In the case of hydraulics, liquids and gases exert this pressure.

The control of fluid power has changed dramatically over the last 20-30 years. The high pressures needed in this industry today, 5000 psi or 6000 psi are double what they were in the late 90’s. With the high pressure requirements comes a higher risk of injury or downtime.

Now Contrinex has hit the jackpot with a 7000 plus psi rated end of stroke sensor that gives this 5000 psi market a 40% safety factor. Read on…

3. History of Hydraulics and Sensing

In ancient Rome, hitting a hard stopping place was the only way to decelerate the incredible speed of the moving arm of a catapult. This hit caused great stress on the arm, which in turn, over time, made the catapult less reliable and in need of repair. To stop the battle to fix it was fatal. So it was constructed for heavy duty use, which affected the load capacity and the efficiency. So really here’s where the problem began in history.

Sound familiar? Today hydraulic cylinders are used in all kinds of industries. Heavy loads cause damage, disrepair and a need to control deceleration.

Shock absorbers have been used. They take up a lot of space. Proportional valves are expensive and wear down with environmental and vibration erosion affects.

Other options used over time include a cushion designed into the cylinder. As the cylinder reaches end of stroke, this cushion brings the load more gently to a halt.

A garbage truck example: the dumpster is made to lift, and rotate and extend. When it’s filled, it tips to discharge contents. The hydraulic cylinder must stop the mechanism. The stop must be controlled or the machine will fatigue, and cause damage either from going too fast and stopping too hard, or from the internal pressure of being held back too much: by the resistance being applied.

With the advances in electronics over the last decade and the ability of electronics to integrate with hydraulics, the use of hydraulic cylinders is continuing to grow. Manufacturers are embedding electronic sensors in the hydraulic chassis and creating designs to interface directly with standard electronics controllers.

A key issue here is the increased need for higher and higher operating pressures. If this is achieved, the sky’s the limit. The mobile hydraulics segment accounts for about half of the fluid power industry (a $13.5 billion market in 1998). This mobile segment is the most volatile, expanding and shrinking more than any other segment; it has expanded nicely as of late, and is expected to continue with the global demand for capital equipment with the rebuilding infrastructures in Eastern Europe, Asia and South America. The Department of Agriculture projects 5.5% growth through 2006 with 20% of this in cylinders.

4. What is Stroke

A hydraulic system with a double acting cylinder system can exert force in both directions. In one direction, oil rushes to the piston side of the cylinder, which makes it extend. On the rod side, oil
passes from the valve back to the reservoir. In a neutral position oil is trapped and stays fixed when the valve is shifted in the opposite way, the rod retracts when oil is shifted into it.

Cylinder extend force is the result of the pressure (psi) times the piston area. Retract force is pressure (psi) times the area differences between the rod and the piston. A relief valve limits pressure to a preset amount, and is part of the directional control valves. Hydraulic cylinders are used to guide large and small implements traveling at enormous speeds, which reverse at any moment, one way and then another. This momentum impacts the end covers. The locked up oil or fluid pressure decelerates the end stroke, and allows a smooth stop, or change in velocity.

4.1. End of Stroke

One of the most necessary signals needed to be monitored in a hydraulic system. Originally, mechanically monitored, this signal allowed the hydraulic designer to determine when the cylinder had completed its motion in a given direction.

Mechanical switches were found to have many shortcomings. These include short cycle life, constant readjusting, damage-prone to a variety of external forces, lack of precision switching points, low repeatability of the switch points, accidental actuations, and others. Their strengths include only low initial cost and the fact that they are “outside” the hydraulic system and therefore not affected by psi.

Replacing the external limit switch with a proximity sensor solved some of these shortcomings. Cycle life improved, as did repeatability, and switch points. Standard proximity switches are still half mechanical due to their need to “read a flag” or metal target that is moving in unison with the cylinder rod. The” flag” system has all the mechanical shortcomings of the old limit switches. The flag can become misadjusted or damaged affecting repeatability and switch points. The proximity switch needs to be mechanically adjusted to read the target. Damage can occur to the switch or flag due to external forces. Why not place a switch inside the end cap to read the cushion sleeve. Some of the first switches designed for placement in the end caps were conical plunger limit switch actuators. These combined the technology of the previously employed limit switches and placed them into the end caps of the cylinder. They provided the user with a more stable sensing system; however they employed many of the mechanical shortcomings of limit switches. These included plungers, retracting springs, o-rings and of course the mechanical switch itself. Limited to just 3000 psi they were prone to leak and many times failed before 1 million cycles were completed.

The introduction of high-pressure proximity switches allowed this technology to migrate into the cylinder business. Now we can place specially designed proximity switches into the end caps of hydraulic cylinders and have them safely and reliably operate at pressures beyond 5000 PSI.

No more mechanical adjustments. Vast cycle life. Precise switching points and spectacular repeatability. The switches are located away from the motion in an area less prone to damage and easier to protect. Several companies have designed special proximity switches to do this.

Contrinex is one that makes an electronic proximity switch which replaces the mechanical limit switches to produce precise, accurate end of stroke signals.

Some of the highlights of these electronic proximity sensors are:

1. Accuracy and precision
2. Resistant to environmental hazards such as temperature, dust particles etc.
3. Easily connected to PLC’s
4. Automatically protects against short circuits for safety standards.
5. Pressure tight
6. No contact solid-state switches that can last a lifetime.

The proximity sensor switches by sensing the cushion sleeve in the cylinder at the end position.

The basis of this technology is an oscillator coil that can be influenced from an external source. The oscillator creates a high frequency alternating effect over the surface. An interaction is initiated by the cushion sleeve being brought into the alternating field. When the active surface is completely damped, the vibration of the oscillator is stopped entirely. The proximity switch is activated only at this time.

5. Conclusion

As the hydraulics industry continues to advance higher pressures are being used in more applications. When End of Stroke signals are required a switch located in the end cap is most reliable. The sensor industry has evolved with us to produce reliable End of Stroke sensors that can operate in today’s high pressure environment with safety margins approaching 40%.

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Aims and Scope

*Sensors & Transducers Journal* (ISSN 1726-5479) provides an advanced forum for the science and technology of physical, chemical sensors and biosensors. It publishes state-of-the-art reviews, regular research and application specific papers, short notes, letters to Editor and sensors related books reviews as well as academic, practical and commercial information of interest to its readership. Because it is an open access, peer review international journal, papers rapidly published in *Sensors & Transducers Journal* will receive a very high publicity. The journal is published monthly as twelve issues per annual by International Frequency Association (IFSA). In additional, some special sponsored and conference issues published annually.

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Contributions are invited on all aspects of research, development and application of the science and technology of sensors, transducers and sensor instrumentations. Topics include, but are not restricted to:

- Physical, chemical and biosensors;
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- Theory, principles, effects, design, standardization and modeling;
- Smart sensors and systems;
- Sensor instrumentation;
- Virtual instruments;
- Sensors interfaces, buses and networks;
- Signal processing;
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- Technologies and materials;
- Nanosensors;
- Microsystems;
- Applications.

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Smart Sensors and MEMS

Edited by
Sergey Y. Yurish and Maria Teresa S.R. Gomes

The book provides an unique collection of contributions on latest achievements in sensors area and technologies that have made by eleven internationally recognized leading experts ... and gives an excellent opportunity to provide a systematic, in-depth treatment of the new and rapidly developing field of smart sensors and MEMS.

The volume is an excellent guide for practicing engineers, researchers and students interested in this crucial aspect of actual smart sensor design.

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