Proximity Sensors in Harsh Duty Environments: Are they tough enough?
**Proximity Sensors:**
**Are they tough enough?**

Consider this:
*You are a designer for a bottler adding a new line. Frequent washdowns by cleaning/disinfecting agents require you to implement materials and devices able to stand up to these conditions, while ensuring performance.*

*You are an engineer for an automotive manufacturer. The sensors near your weld guns are failing at a rate of one per week per machine. It’s your job to find a way to make this stop.*

In both cases, management has entrusted the job of finding the right components within a system that will cause the least amount of downtime and maintenance, while standing up to the severity of these harsh environments.

Demanding environments, like those involving water, chemicals, extreme temperature, pressure, RFI/EMI, weld fields, fire and explosion are a hindrance to the devices used in these processes. Sensors designed and used in harsh duty applications have been fitted with alterations to the circuitry, housing, connections and inner components to effectively combat the hazards of these environments.

By implementing sensors specifically designed for these applications, operations can experience less downtime and maintenance. Incorporating specialty sensors into these applications will often lengthen the time between replacements and offer an alternative product where there was thought to be none.

So how do you find the right sensor?

**Washdown applications**

Damp or humid industrial environments, like those commonly found in food and beverage industries, such as dairies, breweries, frozen foods, and packaging and filling applications provide adverse conditions for the components operating within them. Frequent washdowns by water, foam or cleaning/disinfecting agents must be performed to adhere to sanitary and hygienic regulations set forth by the FDA and other agencies.

Sensors are used in these environments on conveyors, bottling and canning lines, packaging and filling functions, or other types of machinery. To withstand the rigors imposed by these wet environments, sensors have been designed to resist the ingress of water and vapors while retaining all technical abilities. This is done by integrating design features into the sensor’s front cap and connector insert, and incorporating durable housing materials such as 316 grade stainless steel.
Different manufacturers use different methods to prevent access through the sensor’s front cap; some use plastic or LCP caps, while others modify the inside of the cap by inserting an o-ring. Manufacturers have also potted these sensors with different materials and modified the connector inserts to help prevent moisture ingress. Doing this enables sensors specified for washdown capabilities to resist high pressure, aggressive cleaning agents and sudden temperature variations. Because these sensors are able to function in these environments, they are also rated for IP68 and IP69K environmental protection.

Sensors have also been designed for submersion in applications like those found on oil rigs, offshore drilling, dams, dikes or locks, ships and sewage tanks. These sensors are functional to a certain depth in materials such as oil, water or sea (salt) water. Often these sensors are made with polypropylene housing to resist the ingress of liquids and provide resistance to shock, vibration and caustic chemicals.

Extreme temperature

Applications in ovens, freezers, bakeries, curing, semiconductor, glass and steel mills often necessitate extreme temperatures. Many sensors can withstand a certain degree of temperature variation, but some are more appropriate for extremely low or extremely high environments; some sensors also have a broader range in regard to the temperature extremes it can withstand.

It is important to consider the temperature where the sensor will be located before selecting the sensor to use, as different materials manage these environments better than others. Plastic, stainless steel, Teflon, chrome plated brass and other materials are used for the housing of these sensors. Manufacturers also use proprietary housing materials for the barrel, front cap and connector insert that are specially designed to withstand environments where extreme temperatures are present. Keep in mind that some materials are better suited for lower temperatures – up to -40 degrees Celsius, while others are better suited for high temperatures – up to 160 degrees Celsius.

**IP Ratings**

- **IP67**: Protected against the effects of immersion from 15 centimeters to 1 meter for 30 minutes without water ingress.
- **IP68**: Protected against complete continuous submersion in water without water ingress under conditions that are specified by the manufacturer.
- **IP69K**: Protection against hot steam jet cleaning per EN 60529 and DIN 40050-9. This provides protection against water pressure rated at 100 bar (1450 psi) at a temperature of 80º C. The pressure is applied directly to the sensor in 30 degree angle increments (0, 30, 60 and 90 degrees) for 30 seconds at each point for a total of 120 seconds (two minutes) without water ingress.

These ratings are often misunderstood and misapplied. For example, many users assume that a rating of IP67 or IP68 allows a device to function while under water for the time specified per IP rating. This is not the case, as the rating only ensures that the device will function properly after it is removed from the water.

Another misconception is that an ingress protection rating of IP69K automatically complies with IP67 and IP68. IP69K protects against pressure and jet spray, but the device may not be suitable in applications where it is immersed in water. Therefore IP69K rated devices are often used in washdown environments, such as those found in breweries, carwash, and food and beverage applications, but not in applications where the device is immersed in water.

**Keep in mind**

Variations in the sensor’s temperature ratings, mounting requirements and noise immunity capabilities all affect the sensor’s function and feasibility in certain applications. It is also important to keep in mind that having a sensor function properly in washdown environments is only useful if the components attached to the sensor are also able to function in these environments. For cordset and accessory information see page 6.
**Battery-operated mobile equipment**

Utilizing load dump sensors in mobile equipment is an alternative to multiple electronic and mechanical components for sensing the position of machine parts. A sensor’s reliability and low maintenance also make them a viable replacement for mechanical switches. In heavy duty and off-road applications, switching devices such as relays, intermittent alternator/generator switching or battery to load switching can cause very high electrical transients of up to 600 Volts for durations of 0.5 seconds. Mobile vehicles using 12 or 24-Volt battery systems, such as military vehicles, lift equipment and farm machinery, are susceptible to transients that occur where electronic spikes are generated when certain devices are “powered up”. This undesirable electrical feedback is caused by “dumping” capacitive, inductive or RF energy back into a system when electrical devices turn on or off.

Traditional inductive sensors sense the position of machine components, like the fork on a forklift or the outriggers on a backhoe, yet they can be extremely vulnerable to electronic transients. These electronic transients can cause conventional proximity sensors to either false trip or be permanently damaged. Load dump sensors are immune to electrically conducted transients on power leads, and were developed to reduce equipment downtime, production delays and cost overruns. Solid state load dump sensors can be made to tolerate high overload switching energy, last much longer than relays and are easier to troubleshoot and replace. These sensors have built in protection circuitry, per SAEJ1113-11, to aid in their survival in these very harsh applications.

Load dump sensors were not only designed to withstand electronic spikes, but also work in extreme noise environments while still performing the functions of a traditional non-contact solid stated inductive sensor. These sensors are immune to noise and continue to perform as if there were no disturbance: something a standard inductive sensor or mechanical switch simply cannot do.

**High RFI/EMI environments**

On the plant floor radio frequency (RF) “noise” is caused by the use of variable frequency drives, stepper motors and high powered communication devices, such as AM/FM radios, two-way radios, pagers and some cell phones (among other things). The energy/frequency transmitted from these devices can cause the sensor to switch its output without a target present.
RF noise is generated by the power switching of ON/OFF signals from the aforementioned electronic devices, and is air-coupled to the electronics of nearby sensors. It can be suppressed by on-board filters in the noise emitting devices, or by designing sensors to be tolerant to a level of noise so that operation is not affected.

The International Electrotechnical Commission’s (IEC) 60947-5-2 standard for tolerance of radiated emissions in proximity switches is 3-V/m [volts per meter] or greater over a frequency range of 80 MHz to 1000 MHz. In addition, tests are conducted to measure an electronic products’ tolerance to RF noise, in accordance with IEC 61000-4-3, for 1-V/m, 3-V/m or 10-V/m. It is important to either remove this influence on sensors, or to maintain a very low level of interference – distances typically less than a half inch.

Sensors that have been developed for tolerance to this type of noise have incorporated special inner circuitry, on-board filters, shielding and, in some cases, Zener-diode voltage clamps to reduce their susceptibility to RF noise. Sensor manufacturers continually work to keep all noise influences to a minimum. This is increasingly difficult as sources for these emissions are being developed with more power to get clearer signals at longer ranges.

Stamping applications

Non-contact proximity sensors are used for stamping and die applications in the metalforming industry, for instance in automotive and appliance applications. These sensors are used to detect a number of things including position (over-feeds and under-feeds), part ejection, hole placement and slugs. Sensors verify processes and reduce the potential for damaging the die.

Sensors are mounted directly in the die to determine part position and placement. The number of sensors used in these applications is dependant on the die stages and the bend complexity. In-die sensors are also used for double-stamps, positioning and part ejection.

Environments where robotic arms are used, among other things, to move large parts, weld parts together or hold parts in place, also implement proximity sensors. One way sensors are used in these applications is by placing sensors near the cylinder on the arm mechanism (of the robot) to detect the piston’s movement within the cylinder corresponding to the angle the jaws/grippers open. This method can be configured so the
gripper is allowed to open to a precise position in relation to a specific part. A drawback to this method is that the gripper cannot sense whether the actual part is in the gripper or if the location where this part being moved is in the proper position.

Another sensing method manufacturers use in clamping applications has the ability to detect part in place and/or whether the object (part) is in the grippers. This is done by placing a sensor into a groove within the actual gripper/jaw. By doing this, the sensor is able to detect whether the part is physically in the gripper/jaw, the clamp is in the right position, or the part is being moved to the proper location.

**Weld field**

In the automotive industry welding is used to fuse parts of the car body, and sensors are used to sense where metal car parts are located to ensure proper placement prior to welding. An automated (robotic) weld arm maneuvers into place and welds in multiple locations around the vehicle. This causes sensors in proximity to the weld flash to experience different degrees of exposure to the effects of the weld flash. Sensors fail at a rate dependant on the amount of welding involved and where the sensor is located in relation to the weld tips (the velocity, angle and distance from the weld flash).

Sensors are affected by the conditions resistance welding produces. Strong electromagnetic fields can cause a standard (ferrite core) proximity sensor to false trigger (output) or lock-on. Weld slag and/or splatter can accumulate on the sensor or melt the housing material causing small ‘pock’ holes to form. These areas are particularly vulnerable for the further accumulation of weld slag/splatter.

Some manufacturers tackle this issue by using front caps made from different materials, such as Teflon. Some use different materials for housing, like Teflon or copper, and some use special proprietary weld resistant material on the housing and front cap. It is more important to ensure the front cap (sensing face) has a measure of resistance to the weld field, slag and splatter, while the housing can be less impervious to the slag/splatter and more resistant to the electromagnetic field. This is because the face of the sensor more often is directly exposed to the weld flash, and the slag/splatter will attach to the face but skid off the sides with less likelihood of accumulation.

Sensors for welding environments also incorporate technology into their designs to make the sensors resistant to the strong electromagnetic field. Factor 1 sensors that use separate, independent sender and receiver coils on a PCB and remove the ferrite core.
Many sensors designated for welding applications by their manufacturers are not truly so, and they fail after very few weld flashes. In fact, most sensors designed for weld resistance cannot exceed even 5,000 weld flashes. Withstanding 10,000-20,000 flashes is impressive on the low end and exceptional on the high end. Some sensors can even withstand more than 20,000 flashes - closer to the 30,000 range. With this in mind, it’s good to know that these high-end sensors are the rarity and it’s much more common for sensors to fail after less than 1,000 flashes.

are inherently immune to magnetic field interference that often occurs during electric welding operations, lifts and electronic furnaces. The absence of the ferrite core also allows factor 1 sensors to operate at a higher switching frequency.

It is common for users to cope with sensor malfunction in this environment by simply replacing the sensor. Some are “repaired” using a tool (screwdriver) to chip off built up slag. A sensor that has been “fixed” this way will probably work for a period of time, but fail again and again with fewer welding flashes until rendered useless. It is not advisable to fix a sensor this way, as damage to the face will result in sensor failure. Users need not accept this predicament; with research, a high-end sensor can be found to resist up to 20,000-30,000 weld flashes.

When choosing a sensor for welding environments, keep in mind that depending on the location the sensors may still be susceptible to human or mechanical damage. In these cases, the user needs more protective housing than Teflon or copper. Manufacturers fit these sensors with protective sleeves to prevent side and front impact. Some manufacturers incorporate fitted covers into the sensor prior to sealing the sensor, making it one piece and virtually impervious to physical damage from the side and weld damage from the front (when used with special weld resistance front caps or coatings).

Cordsets

Welding environments also create problems for cordsets. Much like the sensor, the cord can become damaged by the accumulation of weld slag. The connector can also become fused to the sensor by weld slag. Protective sleevings can be used in this and other applications that withstands high temperatures and melting. Weld slag accumulates on the protective sleevings rather than the actual cable jacket, preserving the integrity of the connector and cable. This sleevings is constructed from braided fiberglass and is treated for high temperatures, though it also performs well in low-temperature applications.

Cordsets with PVC jackets are best suited for long term exposure to washdown chemicals such as sodium chloride, sulfamic acid and sulfuric acid that can cause cables made from other materials, like PUR, to become brittle. PVC is immune to these chemicals and a 316 stainless steel coupling nut provides a product perfectly suited for these environments.
There are also cordsets designed as an alternative to conduit wiring for cable trays, direct burial and riser/rafter installations. Aluminum armor and PVC cable jackets provides resistance to chemicals, cutting, abrasion, etcetera, and can also be shielded to the coupling nut.

Utilizing armored ITC cable can provide significant benefits when used in hazardous and non-hazardous locations, as there is no requirement for further mechanical protection. This metal-armored cable grounds itself and is rated for Open Wiring, making it particularly suitable for hazardous locations as allowed by the NEC.

Incorporating components able to withstand the environmental conditions where they are located is a pertinent step for ensuring operations stay up and running. Taking the time to investigate which sensors and corresponding components are best suited for particular environmental conditions can save time and money in the long run, as well as ease troubleshooting and maintenance issues.