Proximity sensors – are they tough enough? Demanding environments, like those involving water, chemicals, extreme temperature, pressure, RFI/EMI, weld fields, fire and explosion are a hindrance to devices used in 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 tough 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 rigorous impinged 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 submission 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, cutting, 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°C, while others are better suited for high temperatures – up to 160°C.

Battery-operated mobile equipment

Utilising 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 V for durations of 0.5 s. Mobile vehicles using 12 or 24-V 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 RF/EMI environments

On the plant floor radio frequency (RF) “noises” 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 fore mentioned 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.

When tested according to IEC 60947-5-2, a 5 W walkie-talkie could be within 2 to 3 m from a sensor and cause a false trip (keeping in mind that a 5 W walkie-talkie can transmit approximately 200 to 500 V per metre at the antenna). Subsequently, a device with higher emissions would trigger the sensor at further distances. When tested according to IEC 61000-4-3, the same 5 W walkie-talkie could be within a few inches of a sensor that is tolerant to 10-V/m without causing a false trip. Some sensors are even capable of performing at 15-V/m, in which case the 5 W walkie-talkie could be within a fraction of an inch to the sensor without causing the sensor to false trip.

The International Electrotechnical Commission’s (IEC) 60947-5-2 standard for tolerance of radiated emissions in proximity switches is 3-V/m (volts per metre) 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 metre.

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 metal forming industry, for instance in automotive and appliance applications. These sensors are used to detect a number of things including position (over-feeds and underfeeds), 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 dependent 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).

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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 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 to 30,000 weld flashes.

When choosing a sensor (Fig. 2) 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).