



Industrial
Automation

Factor 1 Sensors:
*Proximity sensors that detect all metals
at the same range without adjustment.*

A White Paper



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A photograph of the TURCK Inc. building, a modern structure with a large circular skylight and a brick facade, viewed from a low angle.

Factor 1 Sensors:

Proximity sensors that detect all metals at the same range without adjustment.

Overview

Standard proximity sensors have long been used on plant floors for metal detection. Whether to detect aluminum cans on a line or a steel gate on a tank, these sensors were one of the first implemented in the field and remain popular today.

Though these sensors serve their purpose well, they are still far from perfect as they are unable to detect all metals at the same rated distance and therefore need to be replaced every time a different form of metal is being detected. This can get sticky when going from metals like steel to aluminum, as the sensor either has to get closer to the target or has to be replaced with a larger sensor to maintain the same sensing distance – which can lead to mounting adjustments that don't necessarily fit into the operations specifications. Moving sensors closer to the target makes them particularly susceptible to physical and environmental damage caused by the target hitting the sensor as it passes on a line. Most proximity sensors are of the no frills genre and are used because they are a standard in the market. It's accepted that if they are harmed from being hit by a target or say, a person using them as a step, that they can easily be replaced with little fanfare.

These sensors cause many a user's headache by having to keep multiple different sensor types on hand to account for the many types of sensors needed to run an operation – sometimes thousands of sensors can be in place at a single plant. Often different sensor types are required for applications with different sensing ranges and unique mounting requirements, which can cause a sizeable sensor inventory.

This needn't be a concern any longer, as some sensor manufacturers have developed a different kind of proximity sensor that uses innovative technology to bring sensors in line with today's modern industrial environment. Now a single sensor, known as a factor 1 sensor, can be used to sense aluminum, stainless steel, mild steel, copper, lead, brass and other metals at the same rated distance without changing the position of the sensor. Some factor 1 sensors are also capable of performing in harsh industrial environments, and have the potential to vastly reduce the number of sensors needed for plant operations.

The Standard Prox

Traditional inductive proximity sensors are designed for wear-free and non-contact detection of metal objects. The sensor consists of a coil and ferrite core arrangement, an oscillator and detector circuit, and a solid-state output (Figure 1). They operate with a high-frequency electromagnetic field generated by a LC-resonance circuit with a ferrite core and a single coil [that is wrapped around the ferrite core]. When a metal object (target) enters the high-frequency field, eddy currents are induced on the surface of the target resulting in a loss of energy in the oscillator and generating a signal that turns the solid-state output to 'ON' or 'OFF'. When the metal object leaves the sensing area the oscillator regenerates, allowing the sensor to return to its normal state.

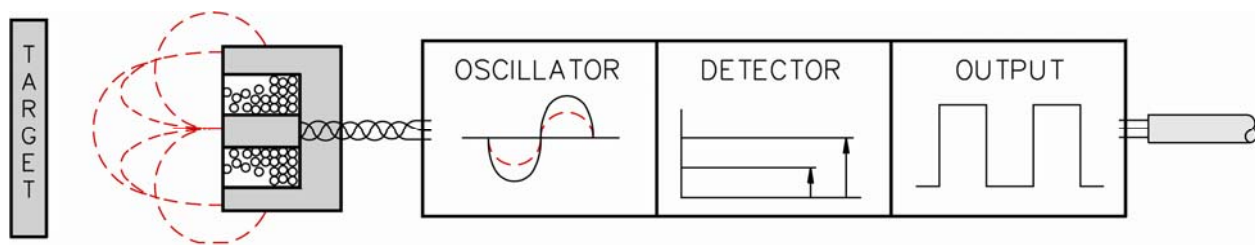


FIGURE 1

Sensing Range Considerations

In standard proximity sensors the operating distance of a sensor is basically a function of the diameter of the sensing coil, and the *rated* operating distance is a quantity used to designate the nominal operating distance. This rated operating distance does not take into account manufacturing tolerances or variations due to external conditions such as voltage and temperature, which can affect the sensors performance.

Ferrous and nonferrous metals effect proximity sensors differently and are sensed at different ranges depending upon the metal being detected. To sense different metals the sensing range must be adjusted to accommodate what is commonly referred to as a correction factor (Figure 2).

Typical correction factors apply to standard inductive sensors when a nonferrous target is being detected.

Aluminum foil	1.00
Stainless steel	0.60 to 1.00
Mercury	0.65 to 0.85
Lead	0.50 to 0.75
Brass	0.35 to 0.50
Aluminum (massive)	0.35 to 0.50
Copper	0.25 to 0.45

The correction factors are nominal values. Deviations may be due to variations in oscillator frequency, alloy composition, purity and target geometry.

FIGURE 2

A proximity sensors' standard operating range is based on its response to a 1 millimeter thick square piece of mild steel. When sensing metal other than mild steel, the sensor must be adjusted (or corrected) to the sensing distance per metal. The more conductive the metal, the less the sensor's range. For example, an 18 millimeter standard ferrite core proximity sensor has a range of 7-8 millimeters when sensing steel; if this same sensor is used to sense aluminum its range is reduced by 20-30 percent making the range approximately 2 millimeters.

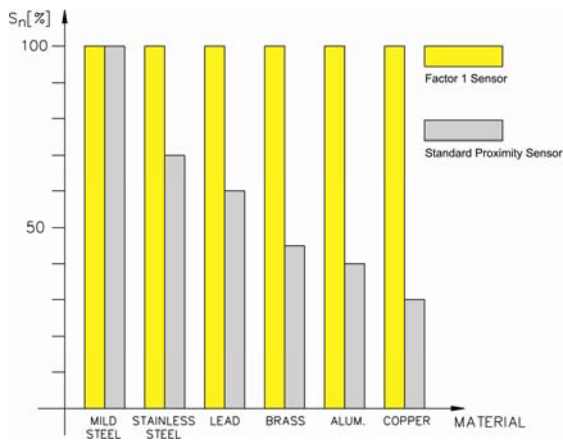
Proximity sensors are designated for embeddable or non-embeddable mounting, which indicates the location of the sensors' face in reference to the mounting surface.

Non-embeddable sensors do not have an internal metal band surrounding the sensor (non-shielded) and have a longer sensing range, but they require a metal free mounting area around the entire sensor (all sides and front). Metal parts near a non-embeddable sensor (in the metal free zone) can influence the electromagnetic field and the operation of the sensor, i.e. increasing or decreasing the sensing range. Because a non-embeddable sensor is not shielded the mounting surface may trigger the sensor, therefore it must extend past the mounting surface making it more vulnerable to mechanical damage. Non-embeddable sensors are appropriate when a longer sensing range is desired, and the sensing area has no metal in the metal free zone to interfere with the sensor. There must also be room for the sensor to be placed further from the target to allot for the space needed for the longer front cap.

Embeddable construction includes an internal metal band (shield) that surrounds the ferrite core and coil arrangement and helps direct the electromagnetic field to the front of the sensor. Embeddable sensors can be flush mounted in metal making them better protected from mechanical damage, but causing a reduction in the sensing range. Embeddable sensors do not require a metal free zone around the sensor body, as all sides can be surrounded by metal. They are appropriate when the sensor is mounted in an area where metal is near the sensor, when the sensor needs to be mounted closer to the actual target, or when the sensor needs to be out of the way of machine parts. For example, when using a sensor to detect aluminum cans on a line the sensor can be mounted between *and* flush with the tracks of the line. This prevents the sensor from getting hit by the cans as they pass, while also allowing the sensor to maintain optimum range.

Standard proximity sensors can also be negatively affected if several sensors are mounted in a limited space. This can cause coupling between the oscillator coils, which in turn causes the sensors to trigger each other. Sensor manufacturers have different requirements for the mounting space between their sensors, but the space can be lessened by using sensors with different frequencies.

Factor 1 Sensors



Sensor technology has evolved so that correction factors need not be applied; this is widely referred to as factor 1 sensing. Factor 1 sensors detect all metals at the same range without adjustment, giving them a longer overall sensing range than standard proximity sensors (Figure 3).

FIGURE 3

This allows a factor 1 sensor to sense copper, aluminum and other metals at the same operating range it is rated for mild steel. Rather than adjusting the sensing distance to sense different metals (like copper in the fore mentioned example), the sensor can remain in its original location. This can lead to reduced inventories and lessen maintenance and downtime by having one sensor to sense all metals. The technology used in factor 1 sensors can be applied to basically all specifications, even applications that require a different type of sensor, i.e. rectangle, washdown capable, giving factor 1 sensors the ability to be used in place of a variety of conventional sensors.

Instead of a single coil inducing and being affected by eddy currents on a target as in standard proximity sensing, factor 1 sensors use separate, independent sender and receiver coils on a PCB and remove the ferrite core (Figure 4). Because of this, ferrous and nonferrous metals have the same effect on factor 1 sensors and are rated for the same operating distance. Not all manufacturers' factor 1 sensors are the same: some operate using two coils, some three or four; some even incorporate a ferrite core into the design.

Factor 1 sensors without ferrite cores 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.



FIGURE 4
A FACTOR 1 SENSOR
WITH COILS ON PCB

Mounting Flexibility

Since non-embeddable proximity sensors protrude from the mounting surface, they are more susceptible to physical damage from the target hitting the sensor or from accidental human contact. Other influences make both embeddable and non-embeddable sensors mechanically vulnerable, including temperature and voltage variations, and environmental factors like exposure to washdown, high levels of noise or weld fields.

As mentioned, factor 1 sensors are able to sense all metals at the same rated distance without observing correction factors, are able to be mounted further away from the target, and do not require alterations for different types of metal. Factor 1 technology also allows the same sized sensor to be applied where different metal types are detected, eliminating the need to manually change the sensors distance from the target and allowing the user to keep the same sized sensor in place. This is good when mounting space is limited and applying a larger [diameter] sensor is not feasible.

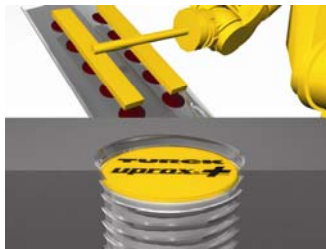


FIGURE 5

The coil technology used in factor 1 sensors makes them able to observe smaller metal free mounting zones and be mounted in closer to other sensors. Additionally, some factor 1 sensors allow for limited recessed mounting in embeddable designs without a reduction in sensing distance (Figure 5), and recessed mounting of traditional non-embeddable sensors with only a slight decrease in the sensing range.

The ability to recess a sensor in metal further aids in the prevention of mechanical damage from physical contact by the target or the user. For example, using a sensor for an application where the target is passing directly [flush] against the sensor face, like a metal sheet passing over a sensor on a conveyor belt. If the sensor is recessed in the mounting it has much more protection from mechanical damage.

There is also a new type of coil technology that is used in some factor 1 sensors that allows it to be incorporated into multiple housing styles. Instead of the sensors diameter being dictated by the size of the ferrite core/coil arrangement, a PCB can virtually be designed for any size and style sensor. This allows a factor 1 sensor to be implemented into unique housings and used in place of many different sensor styles. For example, using factor 1 technology in rectangular style housing for small part detection on the outside of the tube instead of using a standard ring style proximity sensor (Figure 6). Factor 1 technology can also be used to make a sensor thin enough to place under a conveyor belt to detect objects as the pass.



FIGURE 6

Wet Environments

Damp or humid industrial environments, or those that require frequent washdowns by water, foam or cleaning/disinfecting agents commonly found in food and beverage industries, produce adverse conditions for proximity sensors. It is increasingly important that sensors have the inherent ability to function in these applications to lessen downtime, maintenance and ensure proper function of the processes.

Standard proximity sensors fail in these applications because residue penetrates through the front cap and connector insert due to ingress from temperature shock, or the housing materials cannot tolerate the acidity or alkalinity of the cleaning agent. To withstand the rigors imposed by these wet environments, sensors have integrating design features into the front cap and connector insert, and use different housing materials like stainless steel to resist the ingress of water and vapors.

Different manufacturers use different methods to prevent access through the sensors' front cap: some use plastic 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.

Variations in the sensors' temperature ratings, mounting requirements and noise immunity capabilities have an effect on the sensors function and feasibility in washdown applications. To counter these common industrial issues, manufacturers have incorporated washdown technology with other sensors, like factor 1. Combining factor 1 and washdown technology allows the sensor to withstand harsh, wet environments *and* can be incorporated into unique housing styles with the ability to sense all metals: All contributing to an efficient industrial operation.

Conclusion

Because factor 1 sensors lack a ferrite core they are inherently weld field immune, and are unaffected by strong electromagnetic AC or DC fields found in weld applications such as resistance welding. Factor 1 sensors are ideal for industries that need to sense multiple different metals and have unique sensing environments. Whether the user needs a sensor with extended range, recessed mounting capabilities, a unique housing design or washdown suitable properties, factor 1 sensors can be used for almost any application. The flexibility and applicability of factor 1 sensors make them a viable alternative to standard proximity sensors: reducing inventory, maintenance and above all, increasing the bottom line.