Metal Detector Design, Principle of Operation and Installation Requirements

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Damaged Calender Rolls: A Pressing Problem

" …TRAMP METAL IN A RUBBER STRIP DAMAGED OUR CALENDER ROLLS AND PUT OUR LINE DOWN FOR DAYS".
A quote from a Reliability Manager at a major tire manufacturer on how a piece of metal impacted their production.

Despite careful attention and sound manufacturing practices, tramp metal often finds its way into rubber strips prior to calendering causing tens of thousands of dollars in downtime for surface refinishing or worse, the requirement to replace the rolls. This White Paper will take a comprehensive look at balanced coil metal detectors (Figure 1), their design, principle of operation and installation requirements.

Metal Detection Design

A metal detector uses a balanced electrical field that looks for minute changes in the field caused by an electrical disturbance. The major components of a metal detector include:

1. **Shell**
2. **Coil Board/Winding**
3. **Aperture Liner**
4. **Electronics**

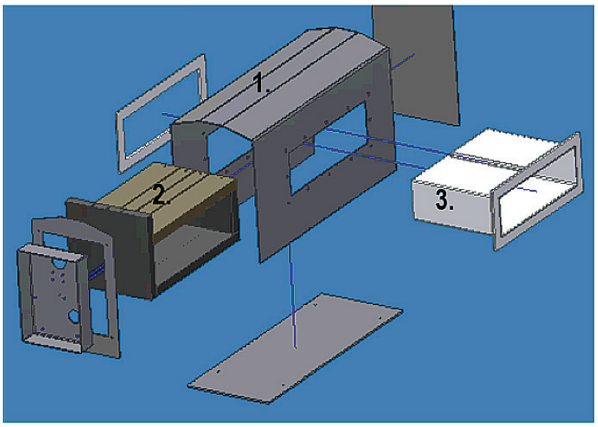
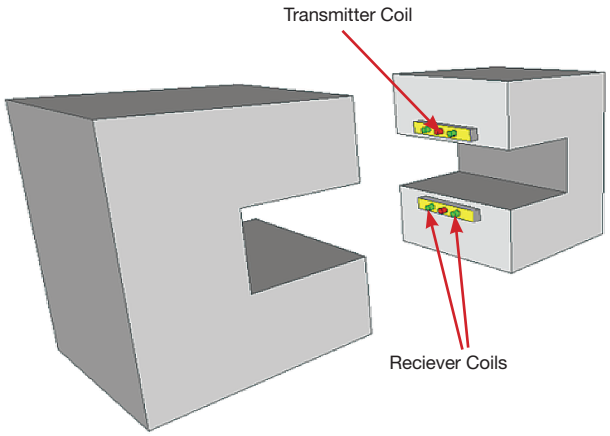


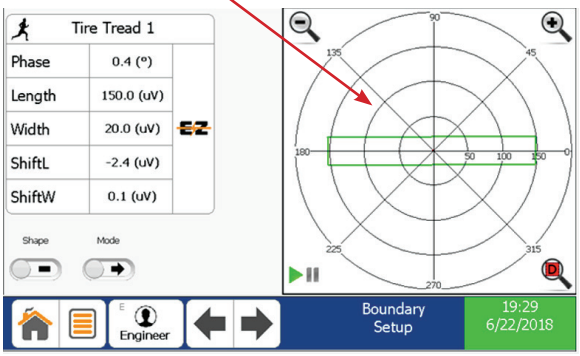
Figure 1: Balanced Coil Aperture Style Metal Detectors

Figure 2: Balanced Coil Architecture



At the heart of the detector is its coil (Figure 2) that consists of a transmitter coil (denoted in red) and two receiver coils (denoted in green) that are wound equidistant. The transmitter emits a signal to the receiver coils and creates a balanced field. If metal is in sufficient measure it will disrupt the balanced state and a detection will occur.

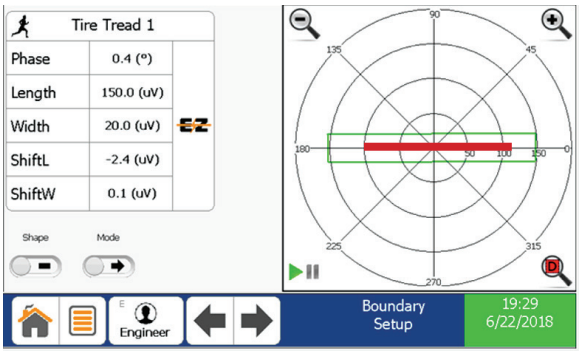
Figure 3: Polar Graph from Eriez Xtreme HMI



Metal Detection Principle of Operation: Detection and Eliminating False Trips

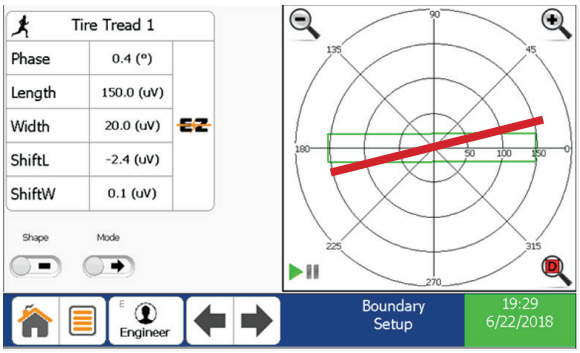
To understand a detection, one must consider that everything looks like something to a metal detector and this "something" is known as phase angle. To better distinguish this concept, we will use the polar graph that is integral to Eriez Xtreme® Metal Detector full color HMI (Figure 3). The polar graph enables users to see real time what is happening with the metal detector. In this screen shot for Tire Tread 1, the rectangular metal detector boundary shown in green is horizontal (set at 0.4 degrees) with a length of 150 and a width of 20. This is a common set up for tire treads.

Figure 4: A Detector that is Set Up Properly



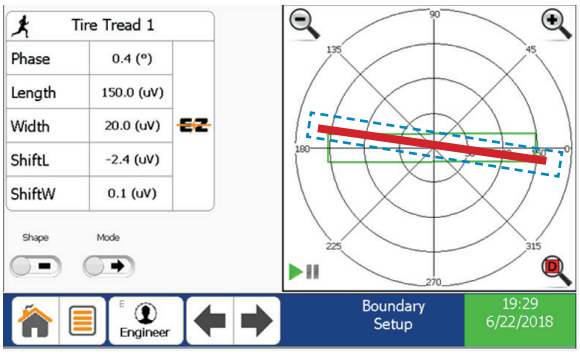
In this screen shot (Figure 4) a rubber strip was passed through the detector. Its signal or phase angle (shown in red) is set up properly as the product phase angle and associated strength (known as amplitude) are contained within the green boundary.

Figure 5: The Detection of a 5mm Ferrous Sphere



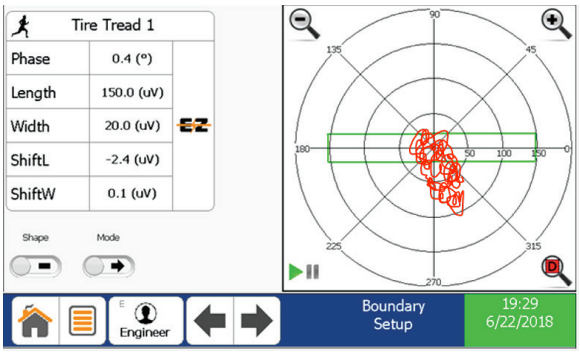
In this image (Figure 5) a 5mm ferrous sphere was placed on the rubber strip and was successfully detected as the signals phase angle and amplitude exceeded the green boundary.

Figure 6: False Trip Caused by Carbon Black



As explained earlier, a metal detector senses slight changes in the balanced field and, in some instances when conductive ingredients such as carbon black are sufficient enough, the signal of the product falls outside of the boundary causing a false trip as shown in Figure 6. To remedy, the Auto Set-Up feature may be used to properly "phase out" the product. The blue dotted rectangle shows what a proper set up would look like.

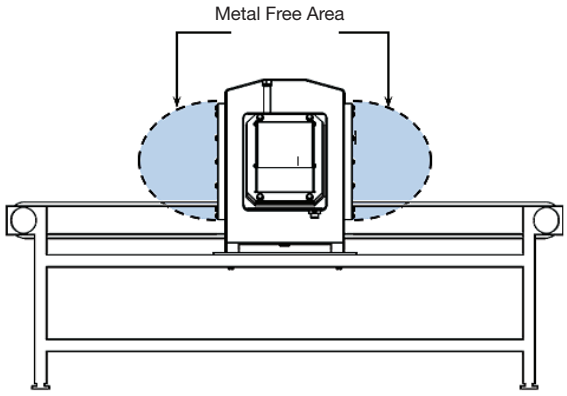
Figure 7: RFI and False Trips



Another factor contributing to false trips is radio frequency interference (RFI) from ancillary machinery. At sufficient levels "noise" will cause a trip just as an improper product set up. Eriez detector can quickly identify noise as it has a unique circular signature as shown in Figure 7. To solve this problem, it is best to know the frequency bandwidth of the detector and surrounding equipment.

Further, other metal detectors may even "talk" electronically to each other and cause false trips. It is always good practice to inform metal detector manufacturers of other detectors that are located nearby.

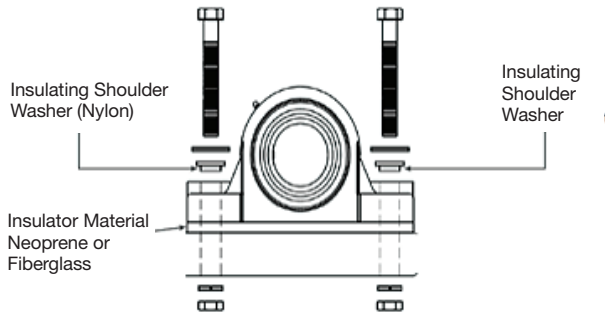
Figure 8: Metal Free Area



Metal Detection Installation Requirements

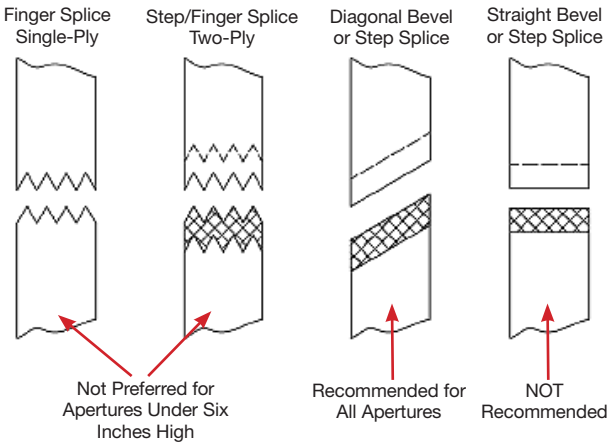
A metal detectors field emanates from the aperture opening, this is known as a fringing field (Figure 8). Accordingly, to calculate the recommended metal free zone, take the smaller aperture dimension and use a 1.5 multiplier to estimate the minimum distance for stationary metal from the aperture and a multiplier of 2 for moving metal. For example, assume a 30-inch wide by 10-inch high aperture was specified, multiply 10-inches by 1.5 for stationary metal or 15-inches and 2 times the 10-inch dimension for moving metal or 20-inches.

Figure 9: Isolation Techniques



Tire processors frequently ask about installing a new detector on an existing conveyor. Although this is possible it poses significant challenges as metal detectors require specific design criteria that include among other things, properly isolating bearings (Figure 9).

Figure 10: Proper Belt Splice



Another less thought of consideration is the belt splicing. If an endless or vulcanized style is used, a bevel or step-splice is best. In Figure 10, we show the differences.
Other considerations include
- Continuous weldments on support frame
- Anti-static slider bed

FAQ's about Metal Detectors

Q. What preventive maintenance is required?

A. Eriez metal detectors require no periodic maintenance or tuning. All critical circuits are continually scanned and if a problem occurs, a warning alarm is initiated.

Q. How much do these system cost?

A. Depending on the size and sophistication you can expect to pay $10-$30K.

Q. Is environmental or product temperature a consideration?

A. Yes. The detector is rated for environments at -10C (14F) to 49C (130F). If product temperature exceeds 150 deg F, a high temperature sensing head is required.

Q. Is product speed important?

A. Yes. The minimum product speed is 2ft/min and the maximum speed is 3000ft/min.

Q. What if my product starts and stops, how do I track where the metal is located?

A. A shift register is integral to the detector and requires a tachometer input from a drive roller. This will enable the detector to reference where the metal is for marking or removal.

Q. What are the electrical requirements and amp draw for a typical metal detector.

A. 100 to 240VAC 50 or 60 Hz.
Amp draw is typically less than 15.

To summarize a metal detector will reduce costly downtime but careful attention to the conveyor design and controlling ambient electrical noise is critical to its success. Further, the sensitivity of a metal detector may be influenced by the products constituents, specifically if it has a high carbon black content.

A review of the proposed installation by a qualified metal detector manufacturer's representative is essential to ensure the right metal detector and size is selected for the application.

Eriez® has been serving the tire industry for more than 30 years supplying metal detectors to every major tire processor worldwide.

Please visit us at the ITEC Booth 532 for more information on our metal detection equipment.

Biography:
Ray Spurgeon Jr. is the Product Manager for the Metal Detection Division at Eriez Magnetics based at Eriez World Headquarters in Erie, PA USA. Since 1995 he has served in various capacities within Eriez inspection divisions including Assistant Product Manager and Technical Sales Representative.

Spurgeon has had numerous white papers published on foreign object detection. In his current role, he oversees all aspects of the metal detection division and has over 23 years of experience in applying metal detection technology in the rubber, plastics, food, aggregate and mining industries.

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