Defect Detector Training Manual

Produced by

CSX Transportation
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Defect Detector Subcommittee

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DEFECT DETECTOR TRAINING MANUAL
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Preface

This manual is designed for all signal maintainers, signal technicians, and other signal department employees who are involved in installation and maintenance of defect detector equipment. The specific goals of the defect detector training program are to:

- **Prevent derailments due to equipment malfunction.**
- **Reduce false stops due to improper defect detector equipment operation.**
- **Standardize work procedures for testing defect detector equipment.**
- **Promote familiarity with equipment manuals.**
- **Promote confidence in job performance.**

Section 1: Overview

Advances in railroad technology have led to vastly improved car wheel bearing performance. At the same time, these advances—along with longer runs, higher train speeds, and heavier car loadings—have intensified the need for new ways of assuring that performance.

Defect detection is a systematic method to detect dragging equipment and abnormal temperatures of journals—the section of an axle that rotates inside a wheel bearing— on moving trains. It is critical that detection be accurate, reliable, and timely in order to prevent potential disasters, such as axle burn-off.

Because of the importance of detection, every signal department employee needs an understanding of the basics of wheel journal operations, as well as the specifics of defect detector equipment.

How do wheel journals normally operate?

All wheel journals generate heat while the train is moving. This heat is caused by normal friction between the axle, oil, and bearings. Some of the heat is transmitted to the bearing housing. The magnitude of this transmitted heat depends on the amount of friction between axle and bearing. If the journal lacks lubrication or if the axle or bearing have mechanical flaws, the heat generated will increase in proportion to the increased friction.

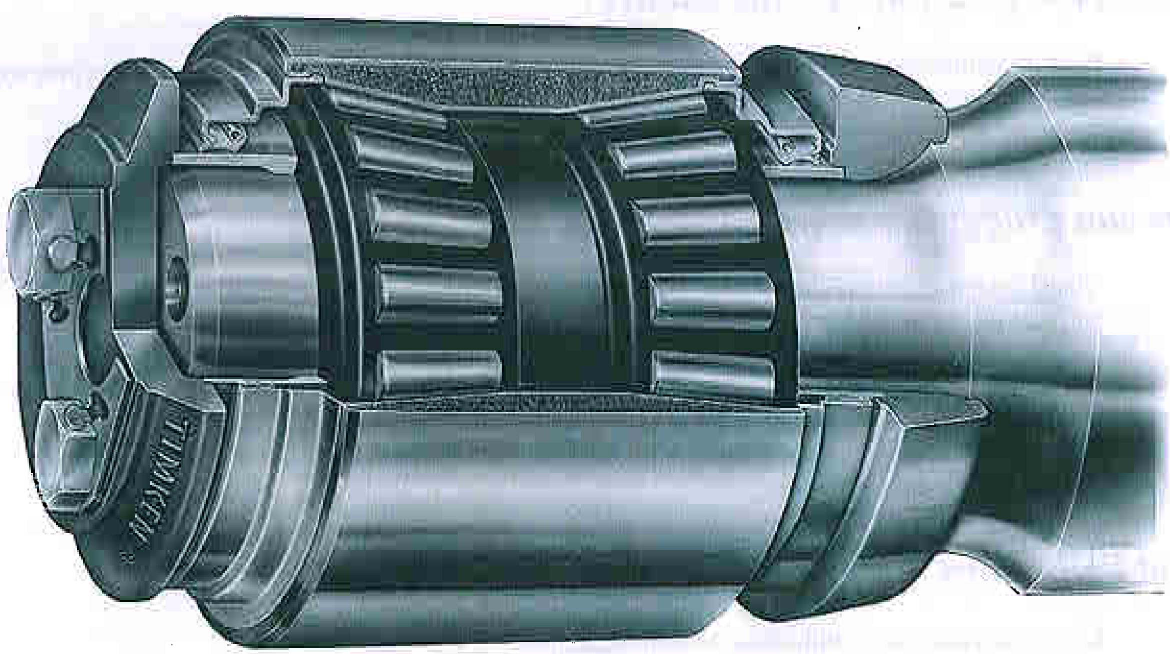

Figure 1-1: A wheel bearing mounted on an axle/wheel set

Why do variations in bearing temperatures occur?

Bearings on a train are considered normal if they run within 40 degrees F of the average bearing temperature for that train. Because they generate heat, all bearings run warmer than the surrounding air.

Variations can be caused by:
- Car loading
- Train speed
- Bearing design
- New bearing break-in period
- Other factors

Why do hot journals occur?

Hot journals (also called hot boxes) occur when inadequate wheel bearing lubrication or mechanical flaws cause a significant increase on bearing friction which in turn results in an increase of the wheel bearing temperature. When the bearing temperature rises to an abnormally high level, bearing failure results.

What is the result of bearing failure?

Bearing failures constitute a major cause of train derailments, endangering life, destroying property, and resulting in costly delays.

How can dragging equipment and hot boxes be detected?

Visual detection of dragging equipment and hot boxes has been the responsibility of train crews, wayside operators, and maintenance forces for as long as trains have been operating.

Because of certain limitations associated with visual detection, the electronic dragging equipment detector (DED) and electronic defect detector (DD) were developed. In the recent past, these devices have been installed every 20-25 miles of track throughout most of the system.

What limitations are associated with visual detection?

Limitations associated with visual detection include:

- When a journal is hot enough to be seen by the train crew, it is sometimes too late to take action to stop the train.

- When wayside operators or maintenance forces detect dragging equipment or a hot journal on a passing train, they can only communicate with the crew by hand signals or radio.

Both problems can result in serious derailment.

What happens to a wheel bearing when lubrication is inadequate?

Except during the short running period, while high spots are being polished off, a normal bearing runs without direct metal-to-metal contact. If a breakdown of the lubricant film permits metal to rub on metal, friction increases and much more heat is generated. Failure then is usually progressive as increased heat breaks down the remaining lubricating film.

Bits of metal from the journal and the brass "pick up" and weld to one another. As these small welds are made and broken, both parts score and roughen. Consequently, friction heat is generated more rapidly. If the train continues to move, temperature can rise to extremes where the axle itself is weakened, causing a fracture. An axle can burn off as a result.

How does roller bearing failure differ?

The beginning of a roller bearing failure is somewhat different, but the end result is the same. Normally the rollers of an anti-friction bearing are highly finished and extremely uniform metallurgically. If a minute flaw should develop in one of these surfaces, caused by foreign material or metal fatigue, continued running tends to enlarge that flaw. Any bits of metal dislodged will tend to start more flaws.

As the bearing gets dirtier or rougher, more frictional heat is generated and the destructive action of further running progresses the potential failure more rapidly. Eventually the entire bearing structure may be destroyed, rollers may be mangled, and the bearing may lock as a welded mass.

Axle burn-off usually occurs at this point.

How does an electronic defect detector work?

An electronic defect detector system is comprised of infrared heat scanners, wheel pick-up transducers, an electronics chassis, and necessary cabling. The system scans passing trains for overheated bearings and gives the train a computer generated report of any defects via the radio.

What is an infrared heat scanner?

The scanner contains a sensor, an aperture control, heaters, and a cable junction box. The sensor, which is the heart of the scanner, contains the optical system, thermistor bolometer or other infrared sensing devices, and a pre-amplifier.

In an infrared heat scanner, the sensor "sees" radiant energy, which is another form of electromagnetic radiation like X-rays or ultraviolet light. In the electromagnetic spectrum, infrared radiation lies between visible light and microwave. Like visible light, it travels in straight lines and can be focused by lenses and reflected by mirrors.

How does an infrared heat scanner work?

Every object with a temperature above absolute zero (-460 degrees F) radiates infrared energy. The higher the object's temperature, the greater the infrared energy it radiates.

The scanner's line of sight is focused at a relatively small spot on the side of the journal box. As the train approaches, the spot moves downward along a vertical line. As the train moves away, the scanned path is the same but the spot moves upward. A gating interval helps ensure that this scanning pattern yields the most significant results and the most reliable detection of overheated bearings.

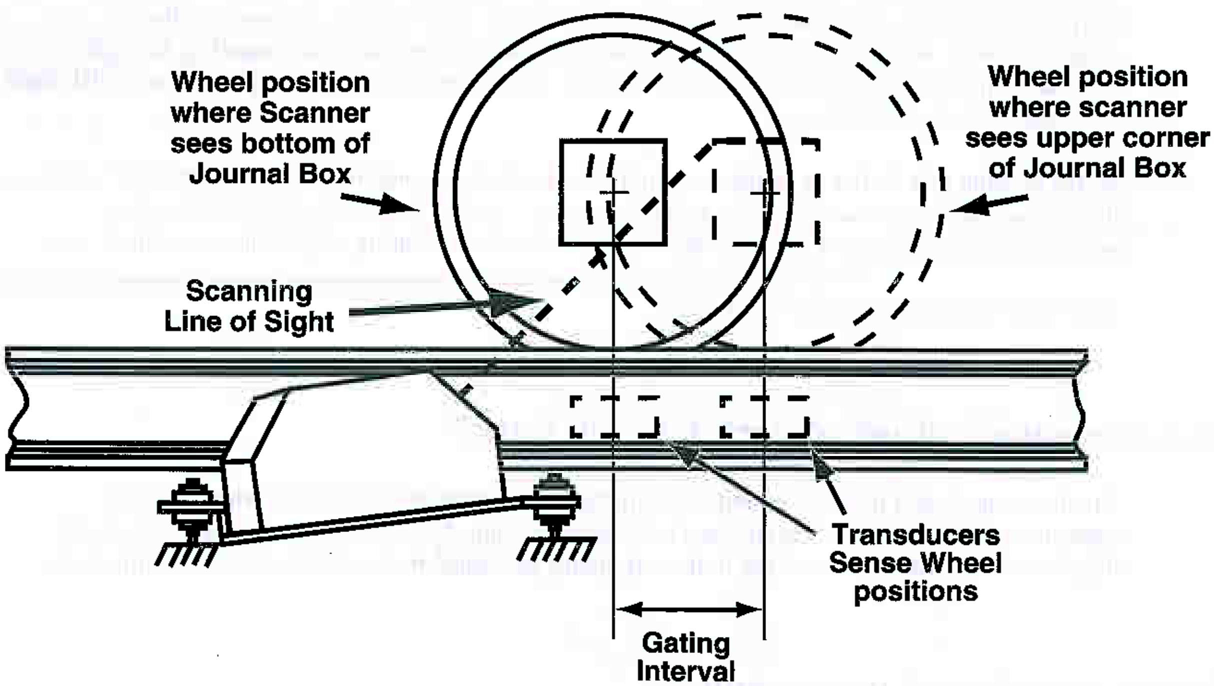

Figure 1-2: Diagram of the scanning process showing the gating interval

What is a "gating interval"?

Gating is the method used to control the output of the sensors so that the scanner looks only at the infrared signals from the journal of each passing wheel. A gating interval refers to the time during which the wheel is in scanning position.

What are the problems associated with electronic defect detectors?

This equipment is extremely sensitive and requires careful calibration and regular maintenance. The slightest amount of AC noise or miscalibration can result in false alarms.

A variety of environmental factors can impact the performance of electronic defect detectors. This chart outlines some of the common problems and how they can be prevented or resolved.

Environmental Factors Affecting DD Reliability

Problem	Prevention/Solution
Lightning/voltage surges	Maintain proper grounding and lightning protection.
Temperature variations	"Winterize" and "summerize" the location.
Poor track conditions	Work with roadmaster to correct conditions.
Dust/dirt on equipment	Keep equipment clean.

NOTES

Section 2: Terminology

absolute alarm: indication that a bearing has exceeded a set value.

ACIA (asynchronous communications interface adapter): a device that links the Devtronics CPU to the printer.

ACS: Advanced Concept Scanner manufactured by Servo Corporation of America.

alarm criteria: the firing level calculated by the processor for each carside; also called heat criterion.

alignment fixture: a device used to align trackside scanners.

algorithm: a mathematical procedure used to determine defect detector alarm levels.

alphanumeric: consisting of alphabetical letters or numbers.

ambient temperature: the temperature of the surrounding air which comes in contact with equipment; obtained by measuring in the shade and used in the heat level calibration of defect detectors.

analog: linear; a signal or circuitry that varies continuously and smoothly over a certain range.

baud: a unit of signaling speed equal to the number of signal events per second.

benchmark: a reference level the ServoTrim system sets during integrity test.

bias voltage: regulating signal voltage.

bolometer: an infrared detector bridge used to sense changes in temperature.

bolometer bias supply: unit used in Servo Model 8909 to supply plus or minus 300VDC to the bolometer low noise regulators in the scanner junction boxes.

buss: a common connecting point for several different circuits or a terminating point.

carside average: average heat for journals on one side of a railcar.

calibration: process of adjusting to specified limits.

chart recorder: any analog recorder connected to a defect detector that is used to record train data such as wheel gates, heat levels, hotboxes, and dragging equipment.

clearance detector: a device used to detect high or wide loads of passing railcars; also called high/wide load detector.

CPU (central processing unit): part of a computer that performs arithmetic operations, controls instruction processing, and provides timing signals.

CS (carside) limit: a minimum heat value which is used in making a carside ratio alarm decision in the Harmon system.

CS (carside) ratio: a set value which governs the ratio used in making a carside ratio alarm decision in the Harmon system.

data control: a unit used in Servo Model 7707 detectors that programs the operation of the system and controls operation of the recorder, scanner aperture blade and mechanism, heaters, and signal gating.

DB: an abbreviation for decibel.

decibel: a unit used for expressing relative differences in power.

DED (dragging equipment detector): a device consisting of segments and paddles used across the track to detect dragging equipment on passing trains.

differential alarm: indication that the temperature difference between bearings on opposite ends of the same axle has exceeded a set value.

digital: numeric; not continuous; information in discrete or quantized form such as 0/1 or on/off.

DIP (dual in-line package): semiconductor device.

directional data control: a unit used in Servo Model 8909 detectors that programs the operation of the system and controls operation of the recorder, scanner aperture blade and mechanism, heaters, and signal gating.

Edco device: a quick acting surge suppression device used in defect detectors to protect sensitive electronic equipment.

EPROM (erasable programmable read-only memory): IC memory chip whose stored data can be read at random or erased and replaced with new data.

equipment defect detector: a system that scans passing trains for defects.

heat criterion: the firing level calculated by the processor for each carside; also called alarm criteria.

high limit: the heat range that sets the maximum value for an absolute alarm decision in the Harmon system.

high/wide load detector: a device used to detect high or wide loads of passing railcars; also called clearance detector.

hot box: an overheated journal.

hot box detector: an electronic chassis connected with trackside equipment that scans railcar journals for overheating.

hot wheel detector: an electronic chassis connected with trackside equipment that scans railcar wheels for overheating.

infrared: radiant heat energy outside the range of human vision.

inside scan: a type of scanner that is positioned trackside to view the inside portion of the bearing closest to the wheel.

I/O (input/output): hardware by which data is entered into a digital system or by which data is output for immediate or future use.

integrity test: a self-test of the hot box detector system.

interface: a point at which independent systems or diverse groups interact.

inverter: a device used to convert DC voltage to AC voltage.

journal: a section of an axle that rotates inside a bearing.

LED (light emitting diode): a semiconductor device that illuminates when a current is passed through it in a particular direction.

lo-limit: the heat range that sets the minimum heat value used in a single axle ratio alarm in the Harmon system.

millimeter: a unit of measure commonly used to represent journal bearing heat on a recorder.

modem: equipment that connects data terminal equipment to a communication line.

multiplexer: a device that allows the routing of two or more signals on a single line or terminus.

noise: undulations or waves of AC voltage riding on a DC voltage; also called ripple.

optical isolator/optocoupler: a lightning or surge protection device that utilizes optics and electronics.

outside scan: a type of scanner that is positioned trackside to view the outside portion of the bearing farthest from the wheel.

overlay: a term used to refer to Harmon Electronics Model 75 equipment connected to trackside equipment manufactured by another supplier.

pedestal: a minimum pulse used in defect detectors to deflect the recorder for each wheel gate of a passing train even in the absence of heat.

PIA (peripheral interface adapter): a semiconductor device used by the CPU to input and output information for processing.

piezoelectricity: the generation of electricity in dielectric crystals subjected to mechanical stress.

port: a connecting point for peripheral equipment such as a recorder or printer.

post-train test: an integrity test performed after train passage.

pre-train test: an integrity test performed before train passage.

peripheral: equipment external to a basic unit.

pre-amp: an amplifier connected to a low level signal source to present suitable input and output impedances and provide gain so that the signal may be further processed.

pyrometer: a piezoelectric infrared sensor used in some hot box detector scanners.

RAM (random access memory): a unit of a computer where data can be written (stored) or read (recovered) in any order at random.

ratio alarm: indication that one end of an axle has exceeded the other by a set ratio, such as 3 to 1.

reference voltage standard: a unit used in Servo Model 7621/7707 systems to provide the bias voltage for the thermistor bolometers in the sensors.

ripple: undulations or waves of AC voltage riding on a DC voltage; also called noise.

ROM (read-only memory): a unit of a computer where permanent data, which cannot be changed by the user, is stored.

scanner: a complete trackside device that scans passing railcar journals for infrared heat.

sensor: the infrared detection portion of a scanner.

shutter: solenoid operated protective device used to protect the sensor from elements of weather.

thermistor: a resistor that changes value with temperature in a predictable manner.

trackside: any equipment located physically along the rail or ballast.

transducer: a rail-mounted electromagnetic device that produces a voltage pulse when a railcar wheel passes over it.

transorb: a semiconductor device used for surge suppression.

triangulation: a procedure used to square scanners to each other in reference to A and B transducers.

wheel gate: a unit of measurement representing the center to center spacing between the wheel gate transducers.

wheel impact load detector: a flat wheel detector.