National Transportation Safety Board
Office of Highway Safety
Washington, DC 20594

RPH23FR013

SIGNAL AND WAYSIDE DETECTOR

Group Chair's Factual Report

A. CRASH

Location: Elliston, VA
Date: July 6, 2023
Time: 7:44 p.m. EST

B. SIGNAL AND WAYSIDE DETECTOR GROUP

Group Chair

Greg Scott, Chair
Rail Accident Investigator
NTSB - RPH

Group Member

Vincent Navarro
Director Communications and Signal Operations
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C. ON-SCENE ACTIVITIES

1.0 Norfolk Southern / Whitehorne District

1.1 District Characteristics

The Whitethorne District extends from MP V 316.8 to MP V 261.9 in a timetable West-East direction. The district consists of single main track with passing sidings. Maximum authorized speed is 40 mph for freight trains. The maximum speed for freight trains in the accident location is 40 mph.

1.2 Description of Signal System

In the vicinity of the accident area, the NS authorizes train movements with a Centralized Traffic Control (CTC). Train movements are coordinated by the New River dispatcher located at the Network Operations Center in Atlanta, GA. Train movements on the Whitethorne District are governed by operating rules, special instruction, timetable instructions, and the signal indications of the traffic control system.

The signal system uses Electro Code 4 and ElectrologIXS track circuits for train occupancy detection at incident location. Wayside signals are colorlight signals for train movements in either direction.

D. WAYSIDE DETECTION

There are two primary forms of bearing monitoring and defect detection used in the rail industry. The first is hot bearing detectors (HBD) and the second is acoustic bearing detection (ABD). Hot bearing detectors are a reactive system that alerts of a possible failure of roller bearing. Acoustic detectors are proactive system that monitors bearing in passing to help determine when preventive maintenance needs to be preformed. While wayside detection is strongly encouraged and there are standards and recommendations provided by the Association of American Railroads (AAR) they do not fall within the Code of Federal Regulations and therefore are not regulated by the Federal Railroad Administration.

2.0 1.0 Hot Bearing Detector (HBD)

The function of hot bearing detectors is to detect overheated journals. Overheated roller bearings occur when inadequate lubrication or mechanical flaws result in an increase in bearing friction. This phenomenon is called a "hot box" in railway industry. The bearing temperature can continue to rise and lead to complete failure of the axle, referred to as a burnt-off journal. The HBD senses radiant heat emitted from the bearing as it passes over the detector scanner **(Figure 1).** The heat signature is then compared to the ambient temperature. The detector then determines whether the bearing is operating at a normal, warm, or hot level. If the temperature sensed by the HBD exceeds preset value, then the detector alerts the train crew or other rail employees, Advanced Train Control (ATC) desk analyst, monitoring this information to take the appropriate action.

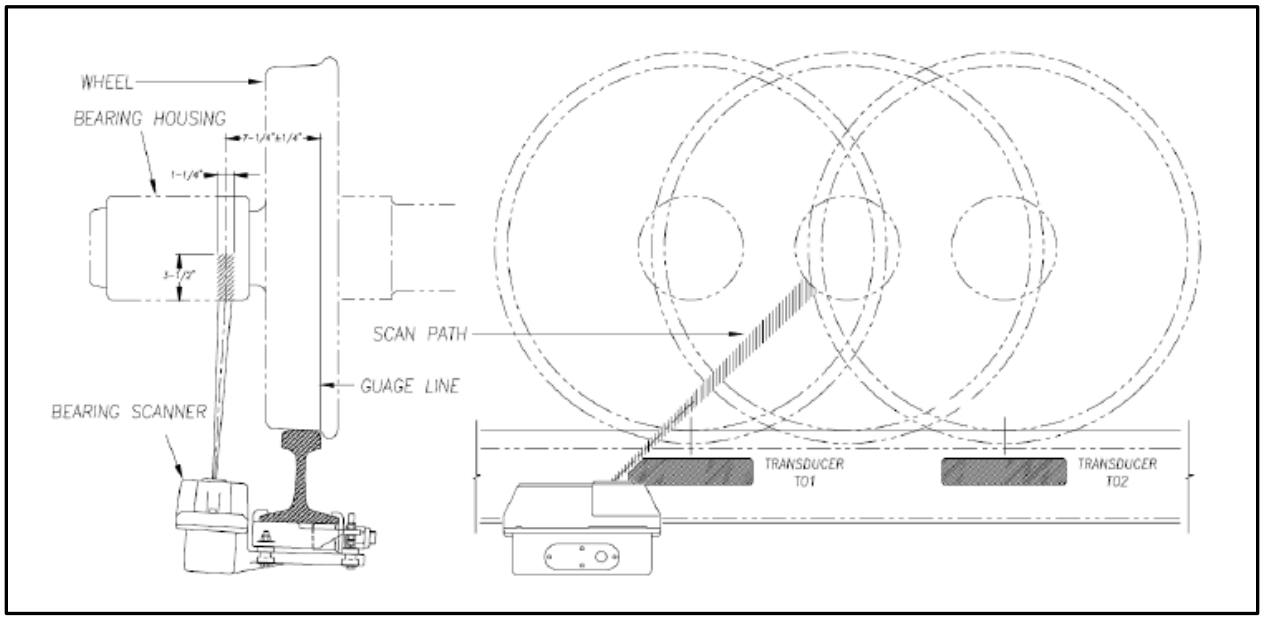

Figure 1. Diagram from courtesy of FRA - Implementation Guide for Wayside Detector Systems.

Norfolk Southern uses two primary different types of equipment in their HBD location. The first type of equipment is Progress Rail Micro HBD system **(Figure 2).** The second is the Southern Technologies Smartscan NG **(Figure 3).**

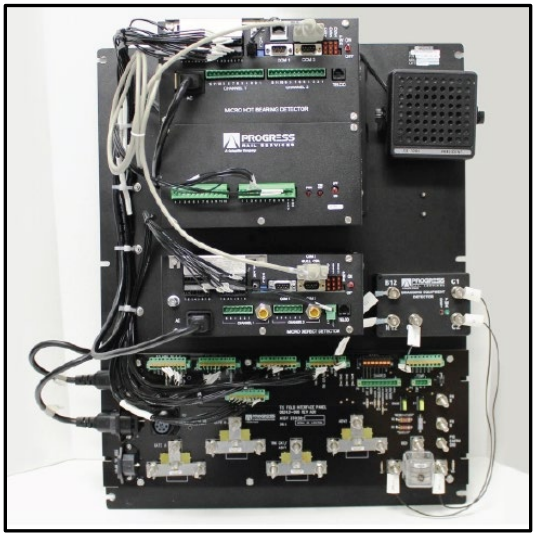

Figure 2. Progress Rail Micro HBD

Figure 3. Southern Tech. Smartscan NG

Norfolk Southern takes the abnormal data form their HBD's and breaks it down into two different categories, critical alarms (talker alerts) and non-critical alarms (alerts). If an HBD detects a critical alarm it will alert the train crew immediately via radio transmission. If the HBD detects a non-critical alarm the HBD will transmit the data to

the ATC desk operator for their evaluation and action. The HBD's will only transmit the data to the ATC desk once the rear of the train clears the HBD field equipment.

2.1 Critical Alarms (Talker Alerts)

Critical alarms can come in the form of a critical bearing talker alert, and a differential talker alert. All critical bearing talker alerts are received via radio directly to the train crew operating over the HBD.

When a train crew receives a critical bearing talker alert it means the HBD has detected bearings which are above temperatures at or above 170. Once the train crew receives this alarm, they are to bring the train to a controlled stop immediately and inspect the alarmed axle location.

A differential alarm means the HBD has detected there is a side to side bearing temperature difference of 115 degrees from the mate bearing on the opposite side of the axle, but not going into the thresholds of Critical Bearing Talker Alert. When a differential talker alert is received it sends a notification to the ATC desk and they interpret the alarm and act according to their standard operating procedures.

The determinations for the critical bearing talker alert temperature threshold is obtained from the Association of American Railroads (AAR) field manual rule 36. The determinations for the differential alarm temperature threshold is determined by Norfolk Southern's SOP as the Association of American Railroads (AAR) field manual rule 36 recommends 95 degrees.

2.2 Non Critical Alarm (Alerts)

Non Critical Alarms are all other information's abnormal that is not grouped in the critical alarm group, but deserve to be monitored or evaluated by the ATC desk operators. Most non-critical alerts are due to above average (4 or greater) bearing temperature "K" values[1]. ATC desk operators will monitor above average "K" values per the NS standard operating procedures (SOP). Once the "K" values exceed the threshold being monitored the ATC desk will alert the train crew to take the appropriate action per SOP's.

2.2.1 ATC Desk

The Norfolk Southern Advance Train Control (ATC) desk monitors wayside detection alerts and alarms of wayside detection systems employed by Norfolk Southern. The ATC desk is monitored twenty-four hours a day seven days a week by one operator working a twelve-hour shift.

[1] K values: Statistical indicators that define the relative variation of one measurement to the population. AAR Manual of Standards and Recommended Practices Sensors

E. INVESTIGATIVE INFORMATION

3.0 Sequence of events

According to voice recordings the Yellow Sulphur HBD (MP276.3) alerted the 814 crew, via radio, of a critical alarm on the 299th axle July 6, 2023 at 5:29pm. The 814 then contacted the dispatcher at 5:32pm telling the dispatcher of the critical alarm. The dispatcher advised the crew to make a visual inspection of the bearing in question and to contact ATC desk.

The crew contacted the ATC desk at 5:35 and advised them of the alarm. The ATC analyst working that evening advised the crew of that critical alarm they received was on the 74th car in the consist, Conrail 507499, #1 wheelset set and to contact them back after they had inspected the wheelset in question.

The ATC analyst contacted the crew at 6:57pm contacted the 814 crew to see if they had inspected the wheelset. The crew advised they had inspected the axle and it had slightly melted the temp stick, and some grease was visible from the bearing on the wheel itself, but there were no other visual defects. The ATC analyst advised the crew with the melted temperature stick and grease showing that the bearing may have substantial internal damage. The ATC analyst advised to the crew talked to dispatch about the next steps and a possible set out location.

At 6:59pm the dispatch contacted 814 crew and stated that he had talked to mechanical and trainmaster and instructed to take car to Fagg siding (MP268.8) at timetable speed and set it off. The crew asked if auto rack cars were still in Fagg siding. The dispatcher confirmed the cars were in fact still there. The crew stated they didn't know if they could shove back into Fagg siding due to grade and asked dispatch if it was ok to take the car in question to Riverside (MP 259.9). The dispatcher stated he would discuss it with mechanical and the trainmaster and get back with them.

The dispatch contacted 814 crew back at 7:10pm and asked if wheelset was glowing when they inspected the car. The crew stated it was not glowing but had some grease leaking. The dispatch then told them it was ok to take train onto Riverside to set the car out.

At 7:20pm dispatch contacted the 814 crew and told them there was a slight change in plans and that they would now be placing the car in the house track. The crew acknowledged the change.

The 814 train then derailed (MP 263.3) at approximately 7:44pm before reaching the set off location. The crew contacted the dispatcher at 7:48 and instructed the dispatcher of the emergency brake application.

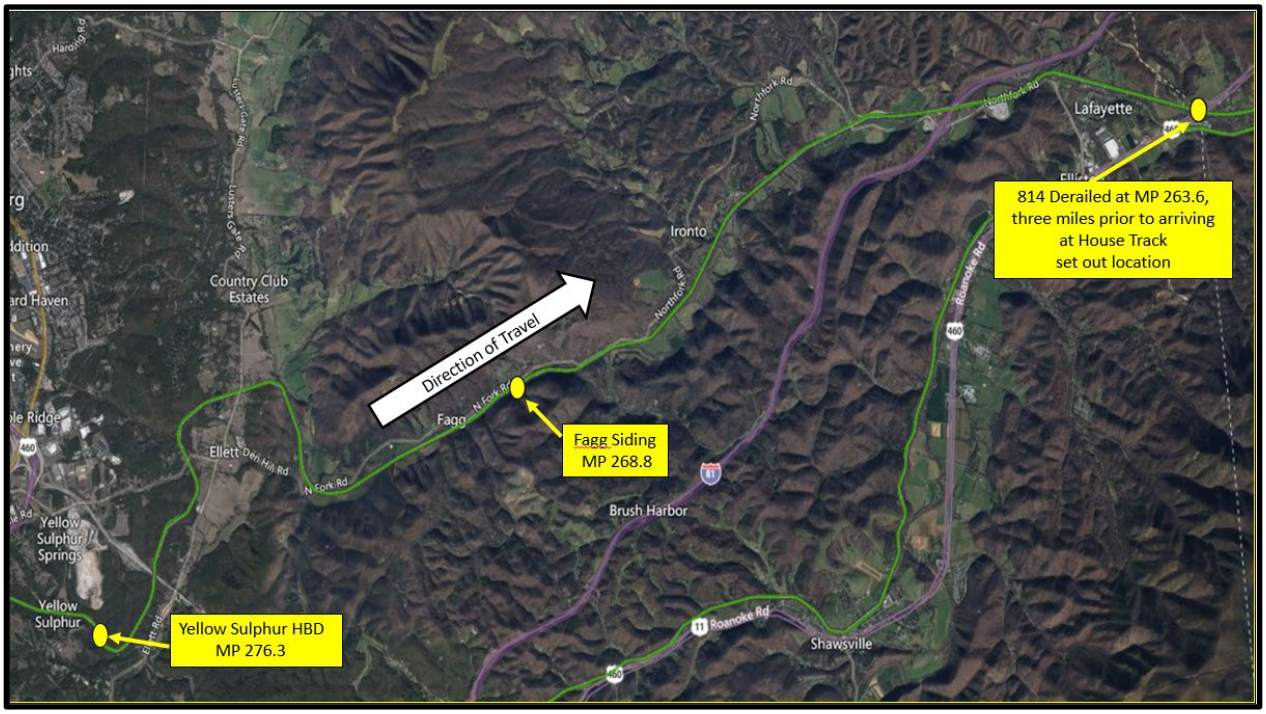

Figure 4: Map of 814 travel and points of interest (Google Earth edited)

3.1 Traversed HBD's

NTSB investigators focused on reviewing the data from the last three HBD's that the 814 traversed before derailing.

3.1.1 HBD Davis

The Davis HBD was located at milepost V312.0. When 814V04 traversed this HBD it showed the R1 axle bearing temperature was 50 degrees and the L1 bearing was 14 degrees and that the train was traveling at 33 mph over the HBD equipment. There was no alert sent to the ATC desk as all temperatures were within tolerance.

3.1.2 HBD Norris

The Norris Run HBD was located at milepost V293.4. When 814V04 traversed this HBD it showed the R1 axle bearing temperature was 65 degrees and the L1 bearing was 16 degrees and that the train was traveling at 32 mph over the HBD equipment. There was no alert sent to the ATC desk as all temperatures were within tolerance.

3.1.3 HBD Yellow Sulphur

The Yellow Sulphur HBD was located at milepost V276.3. When 814V04 traversed this HBD it showed the R1 axle bearing temperature was 253 degrees and

the L1 bearing was 14 degrees and that the train was traveling at 24 mph over the HBD equipment. There was no alert sent to the ATC desk as all temperatures were within tolerance. The HBD gave an audible alert over the radio to the train crew of 814V04 as soon as the CR 507499 traversed the HBD field equipment. The Yellow Sulphur HBD transmitted the data at to the ATC desk 17:30:51.

4.0 Acoustic Bearing Detector (ABD)

Acoustic Bearing Detectors are designed as early warning systems that detect bearing defects prior to them reaching an industry condemnable level for the purpose of preventative maintenance planning. **(Figure 5)**

Figure 5. Photo: Norfolk Southern Ironto acoustic detector MP 266.5

Acoustic detection devices are used as a preventive maintenance tool instead of a critical alarm detection system. Depending on the severity of the reading from the acoustic detector it will determine if the bearing has no issue, needs to be monitored with possible replacement in the future, or if the car needs to be set out at the next location for inspection or repair.

The acoustic detection device records audio from a train passing and produces train and axle based files with four main descriptors: Prefixes, Types, Levels and Suffixes. This data summary uses those descriptors as the vehicle for data exchange with the industry.

Goals of the data summary include:

1. Data summaries are only opened with a high confidence in a rolling surface fault.
2. Data summaries are to contain information suitable for prioritizing bearing removals.
3. Data summaries are to contain information suitable for indicating: remediation of a problem (support for auto close) or a data integrity error that led to a false opening.
4. A good pass is considered a read without a problem (prefix) and has a severity level of 4.

Types: 1, 2, 3, 4

Levels are indicative of the level of noise decibels associated with a type of defect. Level 1 is the most severe with the highest decibels while level 4 is considered not to be a problem and counts towards auto closing the data summary. A level with a null value indicates no reading could be made. All null level readings will be ignored.

Suffixes: _e (extended), _m (multiple), _r(roller), _n(cone), _p(cup)

Suffixes are indicative of a particular aspect associated with a type of defect. Suffixes are based on the speed of the wheel and are a quality indicator.

Locomotives are not analyzed and no values are sent for them.

Common Name	RailBAM	TADS
LAS (large area spall)	Suffix _e	GROWLER
Multiple	Suffix _m	MULTIPLE
Roller	Suffix _r	ROLLER
Cup	Suffix _p	CUP
Cone	Suffix _n	CONE
Unclear	RS1, RS2, RS3	UNKNOWN
No defect	4	null value

Figure 6: Example of common defect names (RAILINC Data Summary)

The rail car CR507499 has been recorded multiple time through acoustical detectors **(Figure 7).** The most recent time was after the critical alarm at the Yellow

Sulphur HBD at MP 276.3, but before the derailment location at MP 236.6. The bearing in question (R1) had a reading of RS1 with no suffix.

Vehicle Tag: **CR 507499** Vehicle Axle Number: **1** Side of Vehicle: **R**

	Data Quality	Train Time	Site	Sensor Type	Vehicle Number	Train Axle Number	Vehicle Type	Axle Speed (km/h)	Lead End	Direction	Side of Track	Bearing Fault	Bearing Alert	Is Consistent	Wheel Flat	EndDB
▶		7/8/2023 19:35:08	Ironto	RAILBAM	74	299	C_71	57	B	East	N	RS2		No	.	64
▶		6/27/2023 07:14:52	Ironto	RAILBAM	50	206	C_47	61	A	East	F	RS1		No	.	70
▶		6/21/2023 22:38:32	Ironto	RAILBAM	51	205	C_49	47	B	East	N	NOISY(RS1)		No	.	74
▶		6/17/2023 08:41:15	Ironto	RAILBAM	73	293	C_71	62	B	East	N	NOISY(RS1)		No	.	73
▶		6/10/2023 20:38:06	Ironto	RAILBAM	78	316	C_76	58	A	East	F	NOISY(RS2)		No	.	73
▶		6/2/2023 03:21:47	Ironto	RAILBAM	102	412	C_100	57	A	East	F	FBS(RS1)		No	.	73
▶		5/10/2023 18:41:44	Ironto	RAILBAM	32	129	C_30	36	B	East	N	NOISY(RS1)		No	.	74
▶		8/15/2022 15:53:04	Marion	RAILBAM	83	333	C_81	71	B	West	F	NOISY(RS1)		No	.	77
▶		7/17/2022 01:48:53	Marion	RAILBAM	18	73	C_16	54	B	East	N	FBS(RS1)		No	.	79
▶		4/2/2021 14:48:47	Ironto	RAILBAM	49	200	C_47	58	A	East	F	NOISY(RS1)		No	.	80

Figure 7. Most recent ABD data of CR 507499. Provided by NS

5.0 Testing and Inspections

Since wayside detectors do not fall within the Code of Federal Regulations and are not regulated by FRA, there is not a requirement to keep formal records of the testing and inspection of wayside detectors. Norfolk Southern does not keep and official records of detectors, but instead relies on their Signal Maintainers to keep a person logbook (paper or electronic) or to use battery cards[2] in each bungalow to verify when the location was last visited[3]. While the last visited date is reference on those cards there is no other records of testing or inspection. Investigators were able to review data logs from the detectors to verify the last time they were calibrated and that the calibrations was successful and feel within Norfolk Southern SOP's.

NS HBDs are scheduled for inspection at one-month intervals. Each HBD undergoes additional inspections every 30, 90, 180, and 365 days, with each interval requiring specific inspection, testing, and/or calibration. [4]

[2] Battery card is a card that records the battery voltage of each location. The card also records the date and initials of the person checking those voltages.

[3] NS is to implement a system during October 2023 to provide basic electronic tracking of inspection dates and results.

[4] Appendix A is NS MS-404 document (updated May 2023) for full HBD maintenance and inspection procedures.

Submitted by:

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Appendix A

MS- 404
HOT BEARING/WHEEL TEMPERATURE DETECTOR SYSTEMS
Initial date 05/25/93- Revised 05/19/2023

1. PURPOSE:

The purpose of this procedure is to ensure that the hot bearing detector and/or wheel temperature detector will notify a passing train about any (or no) defective equipment. This requires the detector to be properly maintained, calibrated, aligned, and all sensors working as intended.

2. FREQUENCY:

When system is placed in service, modified, or disarranged, and thereafter as instructed below (30, 90, 180, 365-day intervals).
NOTE: Hot Bearing/Wheel Temperature Detector locations may also include dragging equipment, height and/or clearance detectors and AEI. Refer to the appropriate test section for their tests.

3. WINTER OPERATIONS:

Insulated covers where provided should be installed and the winter cycle should be activated (Smartscan NG sites) before December 1st every year.

4. DESCRIPTION OF INSPECTIONS - FOLLOWING EVERY SNOW / ICE EVENT:

Inspect and clean detectors following any accumulation of snow or ice.

5. GENERAL:

1. Ensure FINAL OPERATIONAL TEST (located at end of MS 404) is completed prior to leaving location.

DESCRIPTION OF INSPECTIONS - Every 30 days:

1. Scanner heads (Wheel or Bearing):
    a) Ensure proper and secure mounting

b) Clean any debris from drain plug/hole on bottom of scanner head
c) Clean lenses/mirror/filters
d) Verify shutters open and close fully when activating transducer
e) Check scanner head ground connections (Scanner head ground connection tied into house ground)
f) Check scanner heaters for proper operation (CAUTION: DO NOT BURN YOUR HAND)
g) Remove debris and ballast from under scanner head
h) Inspect inside of scanner head for loose/damaged wires

2. Transducers:
    a) Ensure proper and secure mounting
    b) Ensure no metal filings or debris on surface (exercise care when removing debris)
3. Message Checks Over Radio:
    a) Generate test train, activate DED and verify message
    b) Generate test train, activate clearance detector (if applicable), and verify message
    c) Generate test train and verify "No Defect" message
4. Building and General:
    a) Inspect/repair - rodents and insects (bungalow, scanner heads, transducers, junction boxes, ramps, cable, conduit, etc.)
    b) Inspect/repair - Damaged or loose hardware
    c) Ensure flex-conduits/cabling shallow buried under ballast/hidden from view
    d) Check track connections for damage per SP-2001
    e) Check/repair visible ground rod connections, wiring, and lightning protection
    f) Check bungalow interior and exterior lights
    g) Check antenna and connections
    h) Check AC service and connections
    i) Housekeeping
        i Ensure instrument house is kept clean and orderly
        ii Clean equipment, shelves, and floor as needed
        iii Place documentation, test equipment, fixtures, and spare equipment in the proper location
        iv Check area, keep all weeds and natural growth removed, and see that all scrap material is removed

v Check that all gaskets, hinges, latches, and padlocks are in place and kept lubricated
vi Clean house air intake filter as needed, and vents are properly set for the season and protected
    1 Warm/Hot Weather – Check that air intakes are not obstructed, and exhaust fan operates properly and is set to 80 degrees F
    2 Cold Weather – Check operation of bungalow heater, ensure heater and exhaust fan do not operate at the same time

DESCRIPTION OF INSPECTIONS - Every 90 days:

1. Complete all 30-day inspections
2. Standby Battery Checks
    a) Record results on battery card (MS-201 – Form 12075)
    b) Check battery voltage with digital meter
    c) Check the AC supply voltage
    d) Disconnect the charger AC supply
    e) Check battery voltage with digital meter
    f) Restore AC power
    g) Verify system shows AC power on
    h) Disconnect batteries for float voltage check
    i) Check battery float voltage
    j) Reconnect batteries and verify
    k) Check battery connections
    l) Ensure that batteries are clean, dry and connections are tight. NO-OX-ID grease is recommended for all battery connections. (See SP-201 & MS-201)

DESCRIPTION OF INSPECTIONS - Every 180 days:

1. Complete all 30 & 90-day inspections
2. Scanner heads (Wheel or Bearing):
    a. Check for worn, loose, or defective pyro cable connector ends and clean
    b. Alignment
        i. Perform sensor alignment check on each sensor.
        ii. To align scanner heads refer to:
            1. Micro HBD/HWD:
                a. Micro HBD User's Manual

b. Micro Hot Wheel User's Manual

2. Smartscan NG and NG²
   a. SmartScanNG Track Hardware Guide
   b. SmartScanNG2 Track Hardware Guide
   c. Calibration

i. Perform calibration test with outside temperature between 0F-90F

ii. Perform heat calibration on each sensor including hot wheel sensor where equipped

iii. To calibrate scanners, refer to:

1. Micro HBD/HWD:
   a. Calibration Assistant Installation and Service Manual
   b. Micro HBD User's Manual
   c. Micro Hot Wheel User's Manual

2. Smartscan NG and NG²
   a. SmartScanNG Operators Guide
   b. SmartScanNG^2 Operators Guide
   d. Check for proper rail orientation
   e. Check/test for proper track orientation (multi-track sites)

i. North/East compass orientation is recommended, and scanner head is facing into the transducer gate window.

ii. Sites susceptible to sun shot occurrences should be handled individually with C&S Engineering for proper orientation.

3. Transducers:
   a. Check height of transducer:
      i. Micro = 1.75" below top of rail
      ii. NG adjusted to base of alignment Bracket
      iii. Frauscher transducers – per manufacturer spec
   b. Perform transducer cable resistance test and verify from manufacturers manual
   c. Calibration of "Zero Speed" Frauscher transducers (RSR110-001 or -001)
      i. To calibrate transducers, refer to:
         a. SmartScanNG^2 Operators Guide
         b. Comet Electronics TDA-205 Installation and Optimization

DESCRIPTION OF INSPECTIONS - Every 365 days:

1. Complete all 30, 90 & 180-day inspections
2. Series overlay track circuits, if applicable:
    a. Apply .06 shunt at 80 feet. Verify shutters open.
    b. Apply .06 shunt at 100 feet. Verify shutters stay closed.
    c. Adjust the circuit to 80 feet if necessary.
    d. Reference manufacturer's manual for additional information.
3. General:
    a. See that all equipment has sufficient paint to prevent rusting and deterioration
    b. Ensure that circuit plans are correct and legible

6. FINAL OPERATIONAL TEST – ALL SYSTEMS PURPOSE:

This test should be performed after all inspections, tests, and anytime repairs have been made. This should be the last test performed before leaving the site.

7. DESCRIPTION OF TEST:

To determine the hot bearing/hot wheel detector is left operating properly, the following sequence must be performed:

8. Initiate test train (refer to SmartScanNG Operators Guide or Micro User's Manual) or by simulating a train over transducer.
9. Heat source must be applied to scanner head
10. Complete test train (if utilizing transducer)
11. Heat must be verified (along with correct rail, track, and timetable direction) with the voice message and by reviewing detector log history.
    a. Correct direction of travel must be verified by transducer test train method, or observing a train move over detector.