NATIONAL TRANSPORTATION SAFETY BOARD
Investigative Hearing

Norfolk Southern Railway general merchandise freight train 32N derailment with subsequent hazardous material release and fires, in East Palestine, Ohio, on February 3, 2023

GROUP	H
EXHIBIT	
3	

Agency / Organization

Brotherhood of Railroad Signalmen

Title

MS-404 Hot Bearing Detector Systems

MS- 404
HOT BEARING DETECTOR SYSTEMS
Initial date 05/25/93- Revised 01/01/11

PURPOSE:

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

FREQUENCY:

Inspection and tests are to be made every 30 days, every 90 days, every 360 days and as indicated.

NOTE: Hot Bearing Detector locations may also include dragging equipment, height and/or clearance detectors. Refer to the appropriate test section for their tests.

WINTER OPERATIONS:

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

DESCRIPTION OF INSPECTIONS- FOLLOWING EVERY SNOW / ICE EVENT:

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

DESCRIPTION OF INSPECTIONS- Every 30 days:

SENTRY, TSA, SERVO 9000, CYBERSCAN SYSTEMS, MICRO HBD AND SMARTSCAN NG.

General:

1. Record any repairs/adjustments/observations, tests performed, name, and date in detector site log book.

Make the following visual inspections:

1. Check house case, scanners, transducers, junction boxes, protector ramps and associated conduits/cabling for rodents and insects, damage or loose hardware. Repair as necessary.

2. Check scanner heaters for proper operation. Thermostats are set to maintain a range from 75 degrees to 105 degrees F and should be warm to the touch in cold weather.

3. Check scanner mirrors and lenses; clean as required using an appropriate glass cleaning solution and a soft cloth.

4. Inspect inside of scanner for loose or damaged wires and free operation of shutter.

5. Insure transducers are tight to rail and remove metal filings.

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Make the following visual inspections: (continued)

6. Check track connections for damage

7. Check visible ground rod connections, wiring, and lightning protection for damage.

8. During warm and hot weather, check that air intakes are not obstructed, filters where provided are clean, and exhaust fan operates properly and is set to 80 degrees F.

9. During cold weather, check operation of the house heater and thermostat settings (if provided), make sure the heater and exhaust fan do not operate at the same time.

Housekeeping:

1. Clean house air intake filter as needed.

2. Clean equipment, shelves, and floor as needed.

3. Place documentation, test equipment and fixtures, and spare equipment in the proper location.

DESCRIPTION OF INSPECTION AND MAINTENANCE- Every 90 days:

Instrument Housing and Equipment:

Check each battery and charger including AC and DC voltages, charge rate and solution level where applicable. Ensure that battery is clean, dry and connections are tight. (See SP-201 & MS-201) [Also see page MS-404-7]

Heat Calibration:

SENTRY

1. Place heat source unit outside in the shade for 10 minutes to reach ambient temperature. The Sentry heat source unit is not adjustable.

2. Check the calibration of scanner output for both rails with the heat source, which is set at 180 degrees above ambient temperature. Calibrate using the highest temperature reading as the heat source cycles.

   (a) Tolerance is + or – 8 degrees.

   (b) Adjust Sentry heat gains if out of tolerance.

   (c) Do both rails.

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Cyberscan Systems

1. Place heat source outside in the shade for 10 minutes to reach ambient temperature. Under normal testing conditions, do not attempt to calibrate if ambient temperature is above 90 degrees or below 20 degrees F. If calibration is required due to repairs or replacement when ambient temperature is above or below these limits, an additional calibration should be completed as soon as possible after ambient temperature is within specified range.

2. Perform CALIB command operation from laptop and follow the instructions for the heat source setting for calibration. This should be 130 degrees above ambient temperature.

3. Complete calibration by accepting adjustment values. Note: These settings should be between 40 and 60. If they are not, notify your supervisor.

MicroHBD*
* Information in this section copied from GE manual.

To calibrate the scanners with a 227294-100 SIB board ('CAL1' and 'CAL2' sub menu):

1. Allow the Function Simulator it to reach operating temperature and then place it on the scanner to be calibrated.

2. Type '**CALIB**' at the command prompt and press <ENTER>.

3. Type '**CAL1**' to calibrate Channel 1, or '**CAL2**' to calibrate Channel 2.

4. The MicroHBD will display what it thinks the outside temperature is. If an ambient temperature probe is connected to the MicroHBD, accept the value displayed by typing 'Y' and proceed to the next step; otherwise, type 'N'. The MicroHBD will prompt you to enter the ambient temperature (the value must be between –40 and 120 F). Next press any key to start the calibration.

5. The MicroHBD displays the message, "Please Wait - Zero reference alignment in progress * * * * *". After this is complete, you will see the message "Reference Complete - Starting Calibration".

6. The MicroHBD will begin calibrating. It will ask you to wait as it takes 100 heat samples and will display a brief message for each heat sample it takes.

7. Once the sampling is complete, the MicroHBD will adjust the hardware gain of the internal circuit and display the results to you. The MicroHBD will then attempt to validate the hardware gain by taking 100 more heat samples. This process of adjusting the hardware gain and then validating it could repeat as many as 10 times as the MicroHBD attempts to zero in on the correct hardware gain.

8. Once the sampling is complete, the MicroHBD will display the resulting average ADC reading, the new hardware gain factor, and the new absolute gain value.

MicroHBD (continued)

9. Next the MicroHBD will continue with validation. Validation is the process where the MicroHBD applies a new software calibration factor to the heat channel and takes 100 more heat samples to determine if the calibration factor is within the range needed for successful calibration.

10. The MicroHBD will check the new level and then indicate whether calibration was successful. If successful, it will display the new calibration value and ask if you wish to accept it. Press 'Y' to accept the new value and proceed to step 11. (Pressing 'N' will ignore the new value and return you to the Maintenance Mode prompt.) If calibration failed, the MicroHBD will return you to the Maintenance Mode prompt. Proceed to step 1 and try the procedure again.

11. The MicroHBD will store the new value. Repeat steps 1 through 10 to calibrate the other scanner.

TSA and Servo 9000

1. Check for noisy scanners as follows:

   (a) Put the detector in heat test mode (select Test mode on TSA or attach heat source and reset as necessary with Servo 9000) with the heat source ON and in the Gate ON mode, but not on the scanner.

   (b) Cover both scanners with a rag so no heat can be seen.

   (c) Watch the detector heat displays (listen to read out on Servo 9000). The readings should not vary more than three (3) degrees or 1 mm on Servo 9000.

   (d) Return detector to normal operation (select Normal on TSA or on Servo 9000 remove heat source cable and press reset on CPU board).

2. Place heat source outside in the shade for 10 minutes to reach ambient temperature. Unless absolutely necessary, do not attempt to calibrate if ambient temperature is above 90 degrees or below 20 degrees F. If calibration is required due to repairs or replacement when ambient temperature is above or below these limits, an additional calibration should be completed as soon as possible after ambient temperature is within specified range.

3. Set heat source to 130 degrees above ambient temperature. Calibrate using the average temperature between the maximum and minimum heat reading as the heat source cycles to 130 degrees (10 mm for Servo 9000). Heat source should not cycle more than 15 degrees from maximum to minimum (1.1 mm for Servo 9000).

   (a) Tolerance is + or – 8 degrees (+ or – 0.5 mm for Servo 9000)

   (b) Adjust heat gains if out of tolerance.

   (c) Do both rails at temperature before going to the high heat temperature test.

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TSA and Servo 9000 (continued)

4. To check for linearity of heat readings, set the heat source to 180 degrees above ambient or maximum heat attainable from the heat source.
   (a) Allow the heat source to cycle for three (3) cycles.

   (b) Scanner heat reading should register 180 degrees (13.8 mm on Servo 9000)- Tolerance is + or – 15 degrees (+ or – 1.1 mm on Servo 9000)

   (c) Do not adjust during this high temperature test.

   (d) Call your supervisor if this test fails.

SMARTSCAN NG**

To calibrate the type2/type3 bearing scanners:

1 Be sure that you have on hand a STC calibrated heat source and a laptop computer.

2 On the control panel of the calibrated heat source, toggle the **Gating** switch off.

3 Plug the proper end of the calibrated heat source cable into the **six**-contact circular connector on the front of the calibrated heat source.

4 Plug the other end of the calibrated heat source cable into a grounded three-wire 110-120 VAC outlet in the wayside enclosure.

5 Cover the function connector that is not being used with the supplied dust cover.

6 On the control panel of the calibrated heat source, turn the temperature knob to **180**.

7 Put the heat source in a shady area, out of direct sunlight.

8 Wait about 8 minutes for the heat source to reach operating temperature and stabilize. The heat source has reached operating temperature and stabilized when the temperature meter needle remains centered. Once the temperature stabilizes, calibration may begin. Once stabilized, the temperature will change less than plus-or-minus one degree Fahrenheit.

9 Take the calibrated heat source to the bearing scanner on the north or east rail.

10 With the cable to the front of the scanner, place the calibrated heat source on the scanner.

11 Be sure that a computer is plugged into COM1 (on the side of the Controller module), that it is turned on, that it has appropriate communications software installed, that the communications software is set to use full duplex, that the baud rate is set to 19,200, and that a LOG file is opened.

12 Using the serial interface, display the Main menu.

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SMARTSCAN NG (continued)

13 To go to the System Functions menu, type **N**

14 To start auto calibration, type **G**
The SmartScanNG system will now calibrate itself. Follow along on the user interface screen until you see: "Auto-Calibration Disengaged." This message is an indication that the system is finished with the calibration procedure. To abort the process, press **[Esc]** (on your computer) or remove the heat source (from the scanner).

15 When "Auto-Calibration Disengaged" is displayed on your computer, remove the calibrated heat source.

16 Take the calibrated heat source to the bearing scanner on the south or west rail.

17 With the power cord to the front of the scanner, place the calibrated heat source on the scanner.

18 Repeat steps **14** through **15**.

19 To return to the Main menu, type **X**

20. To exit the serial interface and return the system to normal operation, type **X**

** Information in this section copied from Southern Tech manual.

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METER READINGS – Every 90 days or as needed:

Sentry, TSA, Servo 9000, Cyberscan, MicroHBD and Smartscan NG Systems

1. For the 24 volt main battery supply (if equipped), the voltage must be between 26.75 and 27.25 volts. Voltage greater than 27.5 volts on sealed batteries makes the batteries exhaust gas, which reduces their life. See voltage curve in the Sentry System manual to ensure its 24 VDC charger is adjusted properly.
   NOTE: For 12 volt system battery (Cyberscan, MicroHBD and SMARTSCAN NG systems) the voltage must be between 13.6 to 14 volts DC.

2. If a separate charger is installed, use the voltage and current meter mounted on the charger.

3. Measure detector power supply voltage if test points are available.

4. Measure bolometer / pyrometer, scanner voltage on terminal rack, if available.

5. Measure commercial power voltage.

6. Measure inverter output, if in service.

7. If any readings are not within specifications provided on equipment or in manufacturers manuals, or vary from prior readings, notify your supervisor.

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DESCRIPTION OF INSPECTIONS- Every 360 days:

SENTRY, TSA, SERVO 9000, AND CYBERSCAN SYSTEMS

General:

1. Instrument house is to be kept clean and orderly.
2. Check area and see that all scrap material is removed.
3. Keep all weeds and natural growth removed from immediate area.
4. See that all equipment has sufficient paint to prevent rusting and deterioration.
5. Clean scanners with solvent or detergent. Paint Servo scanners with aluminum paint as needed.
6. Check that cable entrances are sealed.
7. Check that all gaskets, hinges, latches, and padlocks are kept in place and lubricated.
8. Ensure that circuit plans are correct and legible.
9. Check that vents are properly set for the season and protected.
10. Log any corrective actions, adjustments, and repairs in the detector log book. Include test date and who performed the test.

Physical alignment of rail mounted scanners:

Cyberscan, MicroHBD, 9000, and Devtronics

1. Triangulation of scanners- Pick a point equal distant between the rails at least ten feet from the scanner. Mark this point on a tie with a nail. Measure from this point to the center of each scanner. The measurements should be equal +/- 0.5 inches. If not, move one or both of the scanners. Scanners should not be touching tie plates, rail anchors, or other items that may induce noise from vibration.
2. Check transducer alignment- "A" transducer is located closest to the scanner and should be 8 inches +/- 0.5 inches from the center of the scanner to the center of the transducer. The center of "B" transducer should be 24 inches +/- 0.5 inches from the center of transducer "A". The advance transducers "C" and "D" (if installed), should be 40 feet +/- 6 inches from their centers to the center of the nearest of either "A" or "B" transducer center.

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Cyberscan, MicroHBD, 9000, and Devtronics: (continued)

3. Check scanner alignment- Procedure for all locations except Sentry, remove the scanner covers and place the mirror target over the lenses. Place the alignment fixture on the rail between the "A" and "B" transducers, approximately 20 inches from the center of the scanner. When the red dot is centered in the circle verify alignment as follows:

   a. Cant angle alignment is good if the index mark on the slide under the upright post is at the 7 inch mark on the scale +/- 0.25 inches.

   b. Scanner elevation angle alignment is good if the fixture bar was not moved more than 1 inch forward or back from the original setting of 20 inches.

   c. For Sentry locations, place the optical alignment device between the "A" and "B" transducers, approximately 22.5" from the middle of the scanner rail bracket. Cant angle and elevation cant angle is good if the alignment of the scanner is at the 14.5 inch mark on the fixture and 18 inches above the top of the rail.

   d. If alignment is necessary because criteria in a, b, or c is not met, then adjust cant nuts on scanner to achieve proper alignment. Note: both cant nuts on the same scanner must be set the same.

   e. If proper alignment cannot be achieved, notify your supervisor.

   f. If track gauge exceeds 57.5 inches, notify the Track Department for corrective action.

SMARTSCAN NG**

To align the bearing scanners:

1. Be sure that you have on hand a short-handle 1-1/2-inch open-end wrench, a combination 9/16-inch open-end box wrench, and a STC alignment fixture.

2. Turn off all power to the SmartScanNG enclosure.

3. On the outside of the rail, mark the midpoint between TO1 and TO2.
Use a permanent marker, magic marker, lumber crayon, or paint pen to mark the rail. Don't use a file or punch to mark the rail.

4. Mark the center of the fourth tie ahead of this midpoint.

5. From this mark on the fourth tie, measure to the midpoint between the transducers.

6. From the mark on the fourth tie, measure the same distance on the opposite rail.

7. On the outside of the rail, mark this location. This mark should correspond to the first mark on the opposite rail. Use a permanent marker, magic marker, lumber crayon, or paint pen to mark the rail. Don't use a file or punch to mark the rail.

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SMARTSCAN NG (continued)

8. Place the alignment fixture across both rails and adjust it so that the north or east side of the adjustable gauge slide is even with the two rail marks.The fixture should be snug against the top and gauge of both rails.

9. Remove the reflector block from the vertical alignment bar.

10. Install the vertical alignment bar with the target sight tilted toward the bearing scanner.

11. Install the reflector block in the top of the scanner cover with the sloping surface facing the target. The setup for the type2 bearing scanner is shown below.

12. Look through the hole in the center of the target and note the relationship of the target cross hairs to the circle in the center of the reflector block. When the cross hairs are centered on the circle, alignment is correct.

13. If the cross hairs are centered on the circle, go to step **19**.

14. If horizontal adjustment is necessary, adjust the upper and lower nuts on the edge of the arm of the bearing scanner mount. Using a combination 9/16-inch open-end box wrench, turn both upper nuts the same number of turns. Turn both lower nuts the same number of turns. Adjusting these four nuts causes the scanner to pivot about the two shock mounts under the rail. This adjustment moves the cross hairs (on the circle) to the right or left.

15. If vertical adjustment is necessary:

    a. Using a short-handle 1-1/2-inch wrench, loosen both nuts on the side of the mount. The inner nut is the clamping nut. The outer nut is the locking nut.

    b. Slide the entire mount toward or away from the alignment fixture. Sliding toward the fixture raises the cross hairs on the circle. Sliding away from the fixture lowers the cross hairs on the circle.

    c. Using a short-handle 1-1/2-inch wrench, tighten the clamping nut to a **torque of 48 to 50 foot-pounds (65.1 to 67.8 newton-meters). Don't exceed a torque of 50 foot-pounds (67.8 newton-meters). Doing so can cause failure of the mount.**

    d Using a short-handle 1-1/2-inch wrench, tighten the locking nut to a **torque of 48 to 50 foot-pounds (65.1 to 67.8 newton-meters). Don't exceed a torque of 50 foot-pounds (67.8 newton-meters). Doing so can cause failure of the mount.**

16. Until the cross hairs are centered on the circle, repeat steps **16** and **17**.

17. Remove the vertical alignment bar, target sight, and reflector block.

18. Repeat steps **10** through **18** for the bearing scanner on the opposite rail.

** Information in this section copied from Southern Tech manual.

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Function Simulator:

Test the function simulator / heat generator for correct heater operation.

1. TSA, SERVO 9000, AND CYBERSCAN SYSTEMS

   (a) Check heater temperature with a heat probe or optical device:

      1. At 100 degrees F above ambient- tolerance + or – 5 degrees (average of heat cycle)

      2. At 150 degrees F above ambient- tolerance + or – 5 degrees

      3. At 200 degrees F above ambient- tolerance + or - 5 degrees

   (b) Use silicon on temperature probe tip to help transfer heat. Remove silicone from heat source after test.

   (c) If simulator is out of calibration, it must be repaired before adjusting the detector. Calibration of the simulators must be performed by qualified personnel with the proper test equipment.

2. SENTRY AND SMARTSCAN NG System Heat Source

   (a) Verify heater temperature of Sentry System function simulator is 180 degrees + or - 8 degrees. Sentry heat source should be checked and calibrated with an optical device only.

   (b) Silicone and metal probes will damage the heat source block surface. The heat source is not field adjustable. Arrange for qualified individual or facility to repair

   (c) Heat source.

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OPERATIONAL TEST

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

TSA and SENTRY

1. Using a metal object to simulate a wheel passing the transducer, gate the A and B transducer 6 to 8 times (do not hit the transducer with any metal objects).
2. Operate the dragging equipment detector before the hotbox detector times out.
3. After the detector times out, listen to the radio message for quality of the transmission and correct information.

Servo 9000 and Cyberscan Systems

1. Activate the short range track circuit to simulate the presence of a train.
2. With the heat source connected and turned ON, but not placed on the scanner, turn the Gate ON to simulate wheel gates.
3. Operate the dragging equipment detector in each direction.
4. Turn the heat source Gate OFF and restore the short range track circuit.
5. Listen to the radio message for quality of the transmission and correct information.

Micro HBD*

1. To simulate a train crossing the detector, use the 'T' command. The Test Train can be used to test trackside equipment: scanners, dragging equipment detector, etc.
2. Executing the 'T' command self-induces wheel gates to simulate a train passing. Heat signals and auxiliary alarms are not simulated. However, you can inject heat into the scanners or kick the dragger to check the health of the system.
3. Test trains are added to the Standard Train Directory. They are *not* added to the defect directory. To distinguish test trains in train lists, the MicroHBD/Talker prints a **'TST'** after the train index number.
4. When you execute the 'T' command, the MicroHBD/Talker prompts you to enter the number of axles to simulate. You can select from 4 to 600 axles to simulate. To cancel the 'T' command, press the <Escape> key.
5. After selecting number of axles to simulate, the MicroHBD prompts you for the direction of train. To select the default direction (transducer A to B), press the <ENTER> key without entering a number.
6. Now select whether or not you want to broadcast the test train over the radio.

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Micro HBD (continued)

7. Next the MicroHBD prompts you to select whether or not you want to simulate a track circuit input.
8. Next the MicroHBD prompts you to select whether or not you want to filter heat. Selecting yes will apply the Median Filter during the test train.
9. Wave heat source (hot soldering iron) over scanner head and kick dragger.
10. Listen to the message (radio or speaker as selected) for quality of the transmission and correct information.
11. To cancel the 'T' command, press the <Escape> key.

* Some information in this section copied from GE manual.

SmartScan NG**

1. From the main menu select N system function.
2. Select E manual test mode
3. Test will run for 76 seconds and simulate axles.
4. Pass heat source (hot soldering iron) over scanner heads and kick dragger.
5. Alarms will sound over system speaker but not be broadcast over the radio.
6. When test is complete exit to main menu.

** Information in this section copied from Southern Tech manual.

OPERATIONAL TEST (continued)

Overlay Track Circuits

1. Test series overlay track circuits, if applicable.

   (a) Devtronics with series overlay track circuit

      1. Apply standard shunt at 60 feet. Shutters should open. Mark rail at 60 feet for future reference.

      2. Apply standard shunt at 70 feet. Shutters should stay closed.

      3. Adjust the circuit to 60 feet if necessary.

   (b) Harmon, Servo 9000, Cyberscan 2000 with series overlay track circuit

      1. Apply standard shunt at 95 feet. Shutters should open. Mark rail at 95 feet for future reference.

      2. Apply standard shunt at 100 feet. Shutters should stay closed.

      3. Adjust the circuit to 95 feet if necessary.

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FINAL OPERATIONAL TEST – ALL SYSTEMS

Purpose:

Perform this test after replacing any detector scanner heads or transducers that have been removed for any reason (site repair, track work, etc.).

Description of Test:

To determine the hot bearing detector is left operating properly, heat must be applied to each rail and verified with the voice message or readout that heat is detected and that the correct rail and correct track are identified.

DATA RETRIEVAL:

SENTRY

1. Unplug AC power to processor to load the batteries. Print the following reports while the detector is unplugged to verify capability of batteries to function under load. Remember to plug AC back in at the end of the print session. **Note:** Data retrieval may be done with a laptop or the supplied printer.

   (a) Select "PRINT" mode.

   (b) Print "EXCEPTIONS" report.

   (c) Print "MON TO MON" report

2. Review information on each print report. Look for abnormal readings, balance in average temperature, excessive filter counts, etc.

TSA, Servo 9000, Cyberscan Systems

1. Using a laptop, review several recent long road trains. Look at bearing temperatures and average bearing temperatures for each rail. The average bearing temperature should be within ten (10) degrees (0.9 mm for Servo 9000).

2. Look for error messages, alarmed trains, or other information, which may indicate error/failure trends as provided by the detector.

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