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1.0 Scope

This document details the requirements, equipment and procedures for inspection of tubulars using the four-function system, Electromagnetic (EMI). This procedure outlines the minimum requirements for EMI when stated on the State Energy work order.

- 1.1 A four-function EMI system has Wall Thickness, Demagnetizing, Longitudinal, and Transverse inspection stations controlled by an Operator.
- 1.2 Areas not covered in this inspection procedure include 18 inches from each end of the pipe body
- 1.3 The minimum material length suited to EMI Inspection is 16 feet
- 1.4 Only ferromagnetic material shall be inspected using this specification.

2.0 Personnel Qualification

- 2.1 Personnel performing this procedure shall be classified, as a minimum, Level I inspector.
- 2.2 Level I Inspectors shall be under the supervision of an on-site Level II or Level III Supervisor.
- 2.3 Personnel performing this procedure must be able to distinguish J1 letters at 12 inches on a Jaeger eye chart and have no color vision impairment.

3.0 Reference Documents

- 3.1 The following documents are referenced in preparation of this procedure.
 - ✓ API Specification 5CT
 - ✓ API RP5A5
 - ✓ Applicable EMI Unit Operations Manual, latest revision
 - ✓ Other necessary State Energy's SOP's, latest revision

4.0 Definitions

- 4.1 Reference RP 5A5 for definitions of wording used in this procedure

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5.0 Equipment

5.1 Equipment required to perform this inspection is as follows:

- a) Model 5700, Size range 2 1/16" O.D. through 7 5/8" OD with computer display, Longitudinal and Transverse electromagnetic, Inspect 2100 wall inspection and Demagnetizing systems or compatible
- b) Model 6000, Size range 2 3/8" through 13 3/8" OD with computer display, Longitudinal and Transverse electromagnetic, Inspect 2100 wall inspection and Demagnetizing systems or compatible
- c) A display and recording system capable of providing a permanent record of the set-up, calibration, and tests conducted on the material. It may be a computer image printed out or recorded to disk
- d) A reference standard of the same diameter and wall thickness as the material to be inspected. It shall have similar magnetic properties as the material being inspected and may be manufactured from a sample of the actual order to be inspected. It shall contain artificial reference indicators (machined holes or notches) oriented in such a fashion as to produce a signal from each sensor bank being utilized for the inspection. Notches and holes shall conform to the applicable section of the API Documents or Customer Specifications governing the product being inspected
- e) Auxiliary equipment for probe grinding of imperfections, including but not limited to grinder, mechanical depth gauge, hand held thickness meter, and portable shear wave device
- f) A mechanical magnetometer or a Hall Effect electronic gauss meter with a range of +/- 50 gauss shall be on-site to verify the adequacy of demagnetization

5.2 The four functions utilized in this procedure are:

- a) Longitudinal Inspection System
- b) Transverse Inspection System
- c) Inspect 2100 Thickness Measurement System
- d) Demagnetizing System

6.0 Preliminary System Checks

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6.1 Prior to beginning inspection sequence, all the following must be checked and adjusted as required.

6.1.1 Mechanical

- a) Clean unit of all dust, scale or loose materials.
- b) Check all safety equipment and verify if functioning properly.
- c) Check belts for tightness, visually inspect unit for loose bolts or wires.
- d) Clean the slip ring and inspect slip rings and brushes for damage and wear.
- e) Check hydraulic system oil level and look for leaks.
- f) Check for proper function of pinch-rolls and entry and exit conveyor rolls.

6.1.2 Computer Display or Computerized data acquisition system, if equipped, require the following checks. *Refer to applicable EMI Unit Operations Manual, Current Revision for system.*

- a) Verify display settings for Wall Thickness, Longitudinal, and Transverse inspection stations per manufactures recommendations. *For example, the 6000 unit all ranges should be set at 0 for lower and 5 for upper.*
- b) Enter and Verify required work order information for file set-up
- c) Verify printer connection, if applicable
- d) Clean and service computer data acquisition system per manufactures recommendations
- e) Verify correct calibration file is used
- f) Remember to save file to computer using work order number, if applicable

6.1.3 Center Section

- a) Raise or lower center section to the correct position for the size of pipe to be inspected. Check proper operation of all handling equipment.
- b) Clean all detectors and brackets. Do not use solvent on the photo cells.
- c) Tighten all screws and nuts; replace any worn fasteners or springs
- d) Check the Demagnetizing coil for proper mounting and also verify that all wiring and connectors have tight connections.
- e) Verify smooth operation of all moving parts and that ALL maintenance items have been done per schedule.

6.1.4 Transverse (stationary head) Inspection System

- a) Verify that all detectors (shoes) are the proper size for the material to be inspected
- b) Observe proper polarity and install all detectors
- c) For the air actuated transverse detectors, the air pressure should be set at approximately 60 psi
- d) Inspect the assemblies for mechanical damage and proper sizing.

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e) Check for correct connection of detector wires to the transverse terminals.

6.1.5 Longitudinal (rotary head) Inspection System

- a) Verify rotating head pole pieces have opposite polarity
- b) Check mounting plate for proper alignment reference marks for the pipe diameter to be inspected
- c) Inspect the shoe bracket assembly for mechanical damage or wear.
- d) Inspect the springs for damage/proper setting.
- e) The rotating active pole head shall be adjusted in such a way that the distance of the pole pieces, measured from their midpoint, shall be no more than one inch greater than maximum outside diameter (including couplings, protectors, and upsets) that could be encountered on the pipe being inspected. Make sure pole pieces clear any protectors used.
- f) Pole piece extensions, if used, must have two bolts with the correct thread length installed for each piece. (Using short bolts or only one bolt can result in injury to operator or damage to the equipment).
- f) Rotating detector housings may be curved to the same radius as the pipe to be inspected or have a flat surface.

6.1.6 Inspect 2100 Thickness Measurement System

- a) Visually examine the electronics for any loose connections or bolts,

6.1.7 Additional Adjustments and Settings

- a) Turn on rotating head to RPM speed recommended for the pipe diameter to be inspected as indicated in Table 1
- b) Turn on all conveyors and allow to warm up
- c) Adjust photoelectric cell timers for correct timing of opening and closing of pinch rollers, transverse air shoes, etc.
- d) The pipe shall be centered in the rotating head

NOTE: The unit should be allowed to warm up for a **minimum of 30 minutes** prior to commencement of calibration

- e) After minimum warm up period has been achieved, turn on all mag coils and pass a length of pipe through the system to verify recommended speed in feet per minute (FPM) for the material to be

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inspected. Adjust as necessary to achieve correct line speed as indicated in Table 1 of this procedure.

f) Any malfunctions or problems detected by the operator or crew during that warm-up and set-up check period must be reported to the Inspection Supervisor, if such malfunctions are not immediately correctable.

g) Check the coil for Demagnetizing to insure proper mounting and also verify that all wiring and connectors have tight connections.

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Table 1								mrp
Conveyor and Rotating Head Speeds for 5500 and 5700 units using radius longitudinal shoes				Conveyor and Rotating Head Speeds for 5500 and 5700 units using flat longitudinal shoes				
Pipe O.D.	Minimum Rotating Head rpm	Maximum Conveyor Speed FPM	Percent of Coverage	Pipe O.D.	Minimum Rotating Head rpm	Maximum Conveyor Speed FPM	Percent of Coverage	
2.375	100	55	117%	2.375	80	60	128%	
2.875	100	55	117%	2.875	80	60	128%	
3.500	100	55	117%	3.500	80	60	128%	
4.000	100	55	117%	4.000	80	60	128%	
4.500	100	55	117%	4.500	80	60	128%	
5.000	100	55	117%	5.000	80	60	128%	
5.500	100	55	117%	5.500	80	60	128%	
6.625	100	55	117%	6.625	80	60	128%	
7.000	100	55	117%	7.000	80	60	128%	
7.625	100	55	117%	7.625	80	60	128%	

Table 1 - Continued

Conveyor and Rotating Head Speeds For 6000 Units using flat or radius longitudinal shoes			
Pipe O.D.	Minimum Rotating Head rpm	Maximum Conveyor Speed FPM	Percent of Coverage
4.500	80	60	128%
5.000	80	60	128%
5.500	80	60	128%
6.625	80	60	128%
7.000	80	60	128%
7.625	80	60	128%
8.625	80	60	128%
9.625	80	60	128%
10.750	80	60	128%
11.750	80	60	128%
13.375	80	60	128%

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7.1 Calibration Standard

- a) The calibration standard shall be the same wall thickness and grade as the material to be inspected. The first length of the string will normally be used to fabricate the calibration standard.
- b) The calibration standard shall contain, at a minimum, one external and one internal longitudinal and one transverse external test notch to be used for calibration and verification of the system.
- c) Notches shall have the dimensions and placement based on applicable API specification as noted in SOP 18.0 Reference Indicators and Wall Reductions, latest revision, or customer specifications for the material being inspected

7.2 Standardization of Longitudinal (rotary) Inspection System. *Refer to applicable EMI Unit Operations Manual, Current Revision for system.*

7.2.1 The following steps are to be followed in calibrating the rotary head for the detection of longitudinal imperfections. ERW “Pig Tails” or filter shoes should not be used on seamless pipe.

- a) Place the calibration joint inside the rotating head so that the longitudinal notch is directly under the sensors
- b) Turn on the rotating head and adjust to the recommended RPM
- c) Turn on the longitudinal magnetic coils to a minimum initial setting of 4 amps
- d) Turn off all amplifiers (8 total per shoe) associated with the a and b detectors
- e) Turn on the opposing coils in each detector beginning with a-1 and b-1
- f) Position the calibration notch directly beneath the activated coils by moving the tubular back and forth with the conveyor system until the peak amplitude from the test notch is obtained.
- g) Turn off channel b-1 and adjust the mag amps for channel a-1 to reach a signal height in amplitude as noted.

Note 1: For calibration on external straight longitudinal notch, the signal to noise ratio should be at least 3:1

Note 2: For calibration on an internal straight longitudinal notch, the signal to noise ratio should be at least 2:1

Note 3: If the pipe is magnetically noisy, the filter circuit may be used at the discretion of the unit operator

- h) Turn off channel a-1 and turn on channel b-1
- i) Adjust the mag amps on channel b-1 so the resultant signal equals the signal obtained while previously calibrating channel a-1.

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- j) Turn on both channels (a-1 & b-1) and observe the signal obtained with both channels activated. The signals obtained should be similar in height and appearance and within the previously described signal to noise ratios.
- k) Turn off channels a-1 and b-1 and turn on channels a-2 and b-2
- l) Repeat the steps above for the remaining channels 2 through 8

7.3 Standardization of Transverse (stationary) Inspection System. *Refer to applicable EMI Unit Operations Manual, Current Revision for system.*

7.3.1 The following steps are to be followed in calibrating the stationary head for the detection of transverse imperfections.

- a) Turn on the pulsar and place the face of the pulsar directly over the coil sensor in the number one detector.
- b) Adjust the pulsar position across the face of the detector until the maximum signal response is displayed.
- c) Adjust the amplifier associated with the number one detector to display a signal to noise ratio response of no less than three to one (3:1) on the recording device.
- d) Place the pulsar over the coil sensor in number two detector and move the pulsar as necessary to achieve the maximum signal response.
- e) Adjust the number two amplifier until the signal response equals or matches the number one detector response on the recording device.
- f) Repeat the process, d and e, for all the remaining detectors in the transverse inspection head.
- g) When all detectors are equalized, the transverse detection system is then “balanced” and is ready for dynamic calibration.
- h) Pulsing the transverse system is required at the start of each job and the beginning of each workday.

7.4 Standardization of the Inspect 2100 wall thickness system. *Refer to applicable EMI Unit Operations Manual, Current Revision for system.*

7.4.1 Preparation for Standardization / Calibration

- a) Mount the proper array (size specific) on the Mag coil using the supplied two (2) screws. Secure all bolts and connectors.
- b) Turn the Inspect 2100 power switch to the on position (up) With the mag power supply in the Off position, when the computer is in VIEW MODE and in RUN position. Set the BIAS control adjustment to about .400” on at least one of the four (4) displayed channels.

Perform the following MAG Current polarization direction test

- a) Turn the Mag current supply ON and increase the current by turning the current potentiometer one (1) or two (2) turns clockwise.

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- b) Observe the thickness reading on the computer display if the readings are decreasing .The direction of the mag current is correct.
- c) If the readings are increasing. The direction of the mag current needs to be reversed.
- d) Turn off Mag power supply switch the current direction by reversing pins A and B on the connector .
- e) Turn on Mag supply and recheck the current direction. To make sure that the displayed wall readings are decreasing with an increase of mag current when the unit is in RUN Mode

7.4.2 This unit allows for a TWO point calibration for increased accuracy.
Calibration Procedure (using nominal and a reduced wall section – 2 point cal.)

- a) Set unit in View Mode ,switch to the RUN position by following the directional arrows
- b) Set the desired current (to at least three (3) amps) and the supply to the Constant Current Mode
- c) Place the test joint in the system array
- d) Set the BIAS potentiometer to indicate the actual wall thickness on at least one quadrant
- e) To the right of Run is the CAL_HI position. Arrow up to the NOMINAL and with the + or – key set the NOMINAL. Followed by the Enter Key.
- f) Using the down arrow key select Reject.The reject is calculated automatically. But can be adjusted with the + or – keys followed by enter.
- g) The left pointing arrow will allow stepping from one quadrant to the next and setting the respective wall thickness with the + and – keys followed by the enter key.
- h) Then bring the reduced wall area into the array.
- i) With the up key to the middle row and the side arrow select CAL_LOW
- j) The down arrow allows selection of individual quadrants and setting the respective low point readings with the + and – keys followed by enter key
- k) Go back to the run mode and verify that the original readings were registered.
- l) Switch the display to the INSPECT MODE and allow the photocell to inhibit the outputs and alarm between pipes by switching it to up position

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Note: The USB port allows the display of minimum to be shown on a personal computer display. Adjust the display COMPRESSION to be able to see a full joint. All other personal computer adjustments are described on the software disk

7.5 Dynamic test run

- a) Place the test length on the conveyor racks and position so the test notch is approximately the 12 o'clock position.
- b) Pass the length completely through the unit at production speed and note the indications on the display from each notch. (Recall display set o to 5)
- c) Repeat this procedure with the test notches in the 3, 6, and 9 o'clock positions..
- d) An acceptable dynamic test run is one in which there is no more than a 25%, (plus 12.5% or minus 12.5%), variation in average signal height, from each clock position, from a test notch.

7.6 Demagnetization procedure. *Refer to applicable EMI Unit Operations Manual, Current Revision for system.*

- a) Each length of pipe inspected will be demagnetized utilizing a single coil demagnetizing (de-mag) system, or other suitable de-mag system. The following instructions apply for a single coil de-mag system.
- b) The remaining residual longitudinal field measured with
 - 1) an electronic Gauss shall not exceed 30 gauss.
 - 2) using a hand held magnetometer should not exceed 30 gauss.
- c) With the de-mag coil power supply set at zero amps, pass a length of pipe completely through the transverse mag coil and through the de-mag coil until approximately 4 feet of pipe has passed through the de-mag coil.
- d) Measure the amount and polarity of gauss on the pipe.
- e) Return the pipe back to the transverse mag coil.
- f) Set the de-mag power supply to the opposite polarity of the pipe and set the amperage to approximately 1 amp.
- g) Pass the pipe through the de-mag coil and measure the amount of gauss remaining in the pipe end. If it is greater than specified in (b) above, increase the amount of current in the de-mag coil. If it is less than specified in (b) it is acceptable.

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- h) After the leading end has been set, pass the length of pipe completely through the system and measure the gauss on the trailing end of the pipe.
- a) Adjust the de-mag power supply until both the leading and trailing ends of the pipe are within values specified in (b) above.

7.7 Standardization Frequency

7.7.1 Standardization using the Calibration Standard shall be done at intervals as follows:

- a) at start of job/order
- b) after 50 length inspected
- c) after meal break
- d) end of shift or shift change
- e) completion of job/order
- f) anytime a malfunction is suspected or any time power is interrupted

7.7.2 Recalibration and re-inspection of the material previously inspected since the last valid calibration is required if any of the following exist.

- a) failure to detect any calibration notch or rejectable natural flaw during an interval
- b) an average signal height variation greater than 50% during a calibration interval

8.0 Acceptance criteria

8.1 Signal Marking procedure

- a) When both OD and ID notches are used for calibration, all signals equal to or greater than the average signal height (as determined in 7.0, standardization procedure) from the ID notch for both longitudinal and transverse signals shall be marked for prove up.
- b) When only OD notches are used for calibration, all longitudinal and transverse signals on the EMI chart that are equal to 50 % of the average signal height (as determined in 7.0, standardization procedure) shall be marked for prove up.
- c) At the end of the first 50 length run evaluate the results of the prove-up of the 50 % signals. If any signal marked is found to be rejectable continue to mark all 50 % signals throughout the remainder of the job.
- d) If no rejects or near rejects are found increase the signal percentage to 70 %. In the second 50 length inspection run, mark all signals having an amplitude equal to 70 % of the average test run.
- e) At the end of the second 50 lengths evaluate the prove-up results. If no rejects or near rejects are found increase the percentage to 90 % and continuing

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throughout the remainder of the job marking for prove up all signals having an amplitude equal to 90 % of the average test run signals.

- f) Wall traces showing a 10% wall loss or gain must be marked for prove up.
- g) Any verification of the grade required by the work order shall be based on the grade designated on the mill stencil. Service stencils shall not be used for grade verification.

8.2 Imperfections detected during EMI inspection will be evaluated in accordance with State Energy's SOP 2.0

9.0 Records

9.1 All EMI inspection charts/records will be retained for a period of three years. All charts/records will be clearly marked with the following information.

- a) Date of inspection
- b) Work order number
- c) Customer name
- d) Pipe size, weight, and grade
- e) Beginning and ending length numbers
- f) Name of EMI inspector and Prove-up inspector.
- g) Unit number
- h) Monitors name and Company name, if listed on work order.

9.2 Before the pipe is released from inspection, confirm the final count, tallies, rejects, good joints, and total joints are correctly reflected in the record.

9.3 Before the pipe is released from inspection, confirm all joints have been banded and stenciled properly. Only non inspected lengths may have no band or stencil.

9.4 Records of EMI are to be kept for a minimum of three years.