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MANDATORY APPENDIX II EDDY CURRENT EXAMINATION OF NONFERROMAGNETIC HEAT EXCHANGER TUBING	MANDATORY APPENDIX VIII EDDY CURRENT EXAMINATION OF NONMAGNETIC HEAT EXCHANGER TUBING
II-810 SCOPE This Appendix provides the requirements for bobbin coil, multifrequency, multiparameter, eddy current examination for installed nonferromagnetic heat exchanger tubing, when this Appendix is specified by the referencing Code Section.	VIII-810 SCOPE This Appendix provides the requirements for bobbin coil, multifrequency, multiparameter, eddy current examination for installed nonmagnetic heat exchanger tubing, excluding nuclear steam generator tubing, when this Appendix is specified by the referencing Code Section.
II-820 GENERAL This Appendix also provides the methodology for examining nonferromagnetic, heat exchanger tubing using the eddy current method and bobbin coil technique. By scanning the tubing from the boreside, information will be obtained from which the condition of the tubing will be determined. Scanning is generally performed with a bobbin coil attached to a flexible shaft pulled through tubing manually or by a motorized device. Results are obtained by evaluating data acquired and recorded during scanning.	VIII-820 GENERAL This Appendix also provides the methodology for examining nonferromagnetic heat exchanger tubing using the electromagnetic method known as near field eddy current testing (the coil that generates the magnetic field also senses changes in the magnetic field). The method may employ one or more bobbin wound coils. By scanning the tubing from the boreside, information will be obtained from which the condition of the tubing will be determined. Scanning is generally performed with the bobbin coil(s) attached to a flexible shaft pulled through tubing manually or by a motorized device. Results are obtained by evaluating data acquired and recorded during scanning. This Appendix does not address tubing with enhanced heat transfer surfaces or saturation eddy current testing.
II-821 WRITTEN PROCEDURE REQUIREMENTS II-821.1 Requirements. Eddy current examinations shall be conducted in accordance with a written procedure which shall contain, as a minimum, the requirements listed in Table II-821. The written procedure shall establish a single value, or range of values, for each requirement. II-821.2 Procedure Qualification. When procedure qualification is specified by the referencing Code Section, a change of a requirement in Table II-821 identified as an essential variable shall require requalification of the written procedure by demonstration. A change of a requirement identified as a nonessential variable does not require requalification of the written procedure. All changes of essential or nonessential variables from those specified within the written procedure shall require revision of, or an addendum to, the written procedure.	VIII-821WRITTEN PROCEDURE REQUIREMENTS VIII-821.1 Requirements. Eddy current examinations shall be conducted in accordance with a written procedure, which shall contain, as a minimum, the requirements listed in Table VIII-821. The written procedure shall establish a single value, or range of values, for each requirement. VIII-821.2 Procedure Qualification. When procedure qualification is specified by the referencing Code Section, a change of a requirement in Table VIII-821 identified as an essential variable shall require requalification of the written procedure by demonstration. A change of a requirement identified as a nonessential variable does not require requalification of the written procedure. All changes of essential or nonessential variables from those specified within the written procedure shall require revision of, or an addendum to, the written procedure. VIII-821.3 Personnel Requirements. The user of this Appendix shall be responsible for assigning qualified personnel to perform eddy current examination in accordance with requirements of the referencing Code Section.

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II-822 PERSONNEL REQUIREMENTS The user of this Appendix shall be responsible for assigning qualified personnel to perform eddy current examination in accordance with the requirements of this Appendix and the referencing Code Section.	VIII-821WRITTEN PROCEDURE REQUIREMENTS VIII-821.3 Personnel Requirements. The user of this Appendix shall be responsible for assigning qualified personnel to perform eddy current examination in accordance with requirements of the referencing Code Section.
II-830 EQUIPMENT II-830.1 Data Acquisition System. II-830.1.1 Multifrequency-Multiparameter Equipment. The eddy current instrument shall have the capability of generating multiple frequencies simultaneously or multiplexed and be capable of multiparameter signal combination. In the selection of frequencies, consideration shall be given to optimizing flaw detection and characterization. (a) The outputs from the eddy current instrument shall provide phase and amplitude information. (b) The eddy current instrument shall be capable of operating with bobbin coil probes in the differential mode or the absolute mode, or both. (c) The eddy current system shall be capable of real time recording and playing back of examination data. (d) The eddy current equipment shall be capable of detecting and recording dimensional changes, metallurgical changes and foreign material deposits, and responses from imperfections originating on either tube wall surface.	VIII-830 EQUIPMENT VIII-831 DATA ACQUISITION SYSTEM VIII-831.1Multifrequency-Multiparameter Equipment The eddy current instrument shall have the capability of generating multiple frequencies simultaneously or multiplexed and be capable of multiparameter signal combination. In the selection of frequencies, consideration shall be given to optimizing flaw detection and characterization. (a) The outputs from the eddy current instrument shall provide phase and amplitude information. (b) The eddy current instrument shall be capable of operating with bobbin coil probes in the differential mode or the absolute mode, or both. (c) The eddy current system shall be capable of real time recording. (d) The eddy current equipment shall be capable of sensing and recording discontinuities, dimensional changes, resistivity/conductivity changes, conductive/magnetic deposits, and responses from imperfections originating on either tube wall surface.
II-830.2 Analog Data Acquisition System. II-830.2.1 Analog Eddy Current Instrument. (a) The frequency response of the outputs from the eddy current instrument shall be constant within 2% of full scale from dc to Fmax, whereFmax (Hz) is equal to 10 Hz-sec/in. (0.4 Hz-s/mm) times maximum probe travel speed in./sec (mm/s). (b) Eddy current signals shall be displayed as twodimensional patterns by use of an X-Y storage oscilloscope or equivalent. (c) The frequency response of the instrument output shall be constant within 2% of the input value from dc to Fmax, whereFmax (Hz) is equal to 10 Hz-sec/in. (0.4 Hz-sec/mm) times maximum probe travel speed.	VIII-832 ANALOG DATA ACQUISITION SYSTEM VIII-832.1 Analog Eddy Current Instrument. (a) The frequency response of the outputs from the eddy current instrument shall be constant within 2% of full scale from dc to Fmax, where Fmax (Hz) is equal to 10 Hz-s/in. (0.4 Hz-s/mm) times maximum probe travel speed [in./sec (mm/s)]. (b) Eddy current signals shall be displayed as twodimensional patterns by use of an X-Y storage oscilloscope or equivalent.

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II-830.2 Analog Data Acquisition System. II-830.2.2 Magnetic Tape Recorder. (a) The magnetic tape recorder used with the analog equipment shall be capable of recording and playing back eddy current signal data from all test frequencies and shall have voice logging capability. (b) The frequency response of the magnetic tape recorder outputs shall be constant within 10% of the input value from dc to Fmax, where Fmax (Hz) is equal to 10 Hz-sec/in. (0.4 Hz-s/mm) times maximum probe travel speed. (c) Signal reproducibility from input to output shall be within 5%. II-830.2.3 Strip Chart Recorder. (a) Strip chart recorders used with analog equipment shall have at least 2 channels. (b) The frequency response of the strip chart recorder shall be constant within 20% of full scale from dc to Fmax, where Fmax (Hz) is equal to 10 Hz-sec/in. (0.4 Hz-s/mm) times maximum probe travel speed.	VIII-832 ANALOG DATA ACQUISITION SYSTEM VIII-832.2 Magnetic Tape Recorder. (a) The magnetic tape recorder used with the analog equipment shall be capable of recording and playing back eddy current signal data from all test frequencies and shall have voice logging capability. (b) The frequency response of the magnetic tape recorder outputs shall be constant within 10% of the input value from dc to F max, where Fmax (Hz) is equal to 10 Hz-s/in. (0.4 Hz-s/mm) times maximum probe travel speed [in./sec (mm/s)]. (c) Signal reproducibility from input to output shall be within 5%. VIII-832.3 Strip Chart Recorder. (a) Strip chart recorders used with analog equipment shall have at least 2 channels. (b) The frequency response of the strip chart recorder shall be constant within 20% of full scale from dc to Fmax, where Fmax (Hz) is equal to 10 Hz-s/in. (0.4 Hz-s/mm) times maximum probe travel speed [in./sec (mm/s)].
II-830.3 Digital Data Acquisition System. II-830.3.1 Digital Eddy Current Instrument. (a) At the scanning speed to be used, the sampling rate of the instrument shall result in a minimum digitizing rate of 30 samples per in. (25 mm) of examined tubing, use dr = sr/ss, where dr is the digitizing rate in samples per in., sr is the sampling rate in samples per sec or Hz, and ss is the scanning speed in in. per sec. (b) The digital eddy current instrument shall have a minimum resolution of 12 bits per data point. (c) The frequency response of the outputs of analog portions of the eddy current instrument shall be constant within 2% of the input value from dc to Fmax, where Fmax (Hz) is equal to 10 Hz-s/in. (0.4 Hz-sec/mm) times maximum probe travel speed. (d) The display shall be selectable so that the examination frequency or mixed frequencies can be presented as a Lissajous pattern. (e) The Lissajous display shall have a minimum resolution of 7 bits full scale. (f) The strip chart display shall be capable of displaying at least 2 traces. (g) The strip chart display shall be selectable so either the X or Y component can be displayed. (h) The strip chart display shall have a minimum resolution of 6 bits full scale.	VIII-833 DIGITAL DATA ACQUISITION SYSTEM VIII-833.1 Digital Eddy Current Instrument. (a) At the scanning speed to be used, the sampling rate of the instrument shall result in a minimum digitizing rate of 30 samples per in. (1.2 samples per mm) of examined tubing, use dr = sr/ss, where dr is the digitizing rate in samples per in., sr is the sampling rate in samples per sec or Hz, and ss is the scanning speed [in./sec (mm/sec)]. (b) The digital eddy current instrument shall have a minimum resolution of 12 bits per data point. (c) The frequency response of the outputs of analog portions of the eddy current instrument shall be constant within 2% of the input value from dc to Fmax, where Fmax (Hz) is equal to 10 Hz-s/in. (0.4 Hz-s/mm) times maximum probe travel speed [in./sec (mm/s)]. (d) The display shall be selectable so that the examination frequency or mixed frequencies can be presented as a Lissajous pattern as shown in Figure VIII-864.1. (e) The Lissajous display shall have a minimum resolution of 7 bits full scale. (f) The strip chart display shall be capable of displaying at least 2 traces. (g) The strip chart display shall be selectable so either the X or Y component can be displayed. (h) The strip chart display shall have a minimum resolution of 6 bits full scale.

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II-830.3 Digital Data Acquisition System II-830.3.2 Digital Recording System. (a) The recording system shall be capable of recording and playing back all acquired eddy current signal data from all test frequencies. (b) The recording system shall be capable of recording and playing back text information. (c) The recording system shall have a minimum resolution of 12 bits per data point.	VIII-833 DIGITAL DATA ACQUISITION SYSTEM VIII-833.2 Digital Recording System. (a) The recording system shall be capable of recording and playing back all acquired eddy current signal data from all test frequencies. (b) The recording system shall be capable of recording and playing back text information. (c) The recording system shall have a minimum resolution of 12 bits per data point.
II-830.4 Bobbin Coils. II-830.4.1 General Requirements. (a) Bobbin coils shall be able to detect artificial discontinuities in the calibration reference standard. (b) Bobbin coils shall have sufficient bandwidth for operating frequencies selected for flaw detection and sizing.	VIII-834 BOBBIN COILS VIII-834.1 General Requirements. (a) Bobbin coils shall be able to detect artificial discontinuities in the calibration reference standard. (b) Bobbin coils shall have sufficient bandwidth for operating frequencies selected for flaw detection and sizing. (c) Coils shall be mounted as close to the outside of the probe as practical while providing sufficient protection against coil damage. (d) The probe fill factor (probe diameter/tube inside diameter) shall be a minimum of 0.80.
II-830.5 Data Analysis System. II-830.5.1 Basic System Requirements. (a) The data analysis system shall be capable of displaying eddy current signal data from all test frequencies. (b) The system shall have multiparameter mixing capability. (c) The system shall be capable of maintaining the identification of each tube recorded. d) The system shall be capable of measuring phase angles in increments of one degree or less. (e) The system shall be capable of measuring amplitudes to the nearest 0.1 volt.	
II-830.6 Analog Data Analysis System. II-830.6.1 Display. Eddy current signals shall be displayed as Lissajous patterns by use of an X-Y storage display oscilloscope or equivalent. The frequency response of the display device shall be constant within 2% of the input value from dc to Fmax, where Fmax (Hz) is equal to 10Hz-sec/in.(0.4Hz-s/mm) times maximum probe travel speed. II-830.6.2 Recording System. (a) The magnetic tape recorder shall be capable of playing back the recorded data. (b) The frequency response of the magnetic tape recorder outputs shall be constant within 10% of the input value from dc to Fmax, where Fmax (Hz) is equal to 10 Hz-sec/in. (0.4 Hz-s/mm) times maximum probe travel speed in./sec (mm/s). (c) Signal reproducibility input to output shall be within 5%.	

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II-830.7 Digital Data Analysis System. II-830.7.1 Display. (a) The analysis display shall be capable of presenting recorded eddy current signal data and test information. (b) The analysis system shall have a minimum resolution of 12 bits per data point. (c) The Lissajous pattern display shall have a minimum resolution of 7 bits full scale. (d) The strip chart display shall be selectable so either the X or Y component of any examination frequency or mixed frequencies can be displayed. (e) The strip chart display shall have a minimum resolution of 6 bits full scale. II-830.7.2 Recording System. (a) The recording system shall be capable of playing back all recorded eddy current signal data and test information. (b) The recording system shall have a minimum resolution of 12 bits per data point.	
II-830.8 Hybrid Data Analysis System. (a) Individual elements of hybrid systems using both digital elements and some analog elements shall meet specific sections of II-830, as applicable. (b) When analog to digital or digital to analog converters are used, the frequency response of the analog element outputs shall be constant within 5% of the input value from dc to Fmax, where Fmax (Hz) is equal to 10 Hz-sec/in. (0.4 Hz-s/mm) times maximum probe travel speed.	
II-840 REQUIREMENTS II-840.1 Recording and Sensitivity Level. (a) The eddy current signal data from all test frequencies shall be recorded on the recording media as the probe traverses the tube. (b) The sensitivity for the differential bobbin coil technique shall be sufficient to produce a response from the through-wall hole(s) with a minimum vertical amplitude of 50% of the full Lissajous display height. II-840.2 Probe Traverse Speed. The traverse speed shall not exceed that which provides adequate frequency response and sensitivity to the applicable calibration discontinuities. Minimum digitization rates must be maintained at all times.	

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II-840 REQUIREMENTS II-840.3 Fixture Location Verification. (a) The ability of the fixture to locate specific tubes shall be verified visually and recorded upon installation of the fixture and before relocating or removing the fixture. Independent position verification, e.g., specific landmark location, shall be performed and recorded at the beginning and end of each unit of data storage of the recording media. (b) When the performance of fixture location reveals that an error has occurred in the recording of probe verification location, the tubes examined since the previous location verification shall be reexamined. II-840.4 Automated Data Screening System. When automated eddy current data screening systems are used, each system shall be qualified in accordance with a written procedure.	
II-860 CALIBRATION II-860.1 Equipment Calibration. II-860.1.1 Analog Equipment. The following shall be verified by annual calibration: (a) the oscillator output frequency to the drive coil shall be within 5% of its indicated frequency (b) the vertical and horizontal linearity of the cathode ray tube (CRT) display shall be within 10% of the deflection of the input voltage (c) the CRT vertical and horizontal trace alignment shall be within 2 deg of parallel to the graticule lines (d) the ratio of the output voltage from the tape recorder shall be within 5% of the input voltage for each channel of the tape recorder (e) the chart speed from the strip chart recorder shall be within 5% of the indicated value (f) amplification for all channels of the eddy current instrument shall be within 5% of the mean value, at all sensitivity settings, at any single frequency (g) the two output channels of the eddy current instrument shall be orthogonal within 3 deg at the examination frequency II-860.1.2 Digital Equipment. Analog elements of digital equipment shall be calibrated in accordance with II-860.1.1. Digital elements need not be calibrated.	VIII-860 CALIBRATION VIII-861 EQUIPMENT CALIBRATION VIII-861.1 Analog Equipment. The following shall be verified by annual calibration: (a) the oscillator output frequency to the drive coil shall be within 5% of its indicated frequency (b) the vertical and horizontal linearity of the cathode ray tube (CRT) display shall be within 10% of the deflection of the input voltage (c) the ratio of the output voltage from the tape recorder shall be within 5% of the input voltage for each channel of the tape recorder (d) the chart speed from the strip chart recorder shall be within 5% of the indicated value (e) amplification for all channels of the eddy current instrument shall be within 5% of the mean value, at all sensitivity settings, at any single frequency VIII-861.2 Digital Equipment. Digital equipment shall be calibrated after repairs which may change the instrument’s accuracy are made.

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	VIII-860 CALIBRATION VIII-861 EQUIPMENT CALIBRATION VIII-861.1 Analog Equipment. The following shall be verified by annual calibration: (a) the oscillator output frequency to the drive coil shall be within 5% of its indicated frequency (b) the vertical and horizontal linearity of the cathode ray tube (CRT) display shall be within 10% of the deflection of the input voltage (c) the ratio of the output voltage from the tape recorder shall be within 5% of the input voltage for each channel of the tape recorder (d) the chart speed from the strip chart recorder shall be within 5% of the indicated value (e) amplification for all channels of the eddy current instrument shall be within 5% of the mean value, at all sensitivity settings, at any single frequency VIII-861.2 Digital Equipment. Digital equipment shall be calibrated after repairs which may change the instrument's accuracy are made.
II-860.2 Calibration Reference Standards. II-860.2.1 Calibration Reference Standard Requirements. Calibration reference standards shall conform to the following: (a) Calibration reference standards shall be manufactured from tube(s) of the same material specification and nominal size as that to be examined in the vessel. (b) Tubing calibration reference standard materials heat treated differently from the tubing to be examined may be used when signal responses from the discontinuities described in II-860.2.2 are demonstrated to the Inspector to be equivalent in both the calibration reference standard and tubing of the same heat treatment as the tubing to be examined. (c) As an alternative to (a) and (b), calibration reference standards fabricated from UNS Alloy N06600 shall be manufactured from a length of tubing of the same material specification and same nominal size as that to be examined in the vessel. (d) Artificial discontinuities in calibration reference standards shall be spaced axially so they can be differentiated from each other and from the ends of the tube. The as-built dimensions of the discontinuities and the applicable eddy current equipment response shall become part of the permanent record of the calibration reference standard. (e) Each calibration reference standard shall be permanently identified with a serial number.	VIII-862 CALIBRATION REFERENCE STANDARDS VIII-862.1 Calibration Reference Standard Requirements. Calibration reference standards shall conform to the following: (a) Calibration reference standards shall be manufactured from tube(s) of the same material specification, temper, and nominal size as that to be examined in the vessel. (b) The resistivity of the reference standard shall be within 2 μohm/cm of the resistivity of the tubing to be examined to ensure good results. When the resistivity of the reference standard differs from the tubes being tested, the resistivity of the reference standard shall be compared to that of the tubes being tested with a button probe at a frequency of at least 5 times greater than f90. (c) Artificial discontinuities in calibration reference standards shall be spaced axially so they can be individually evaluated and their eddy current response scan be differentiated from each other and from the ends of the tube. The as-built dimensions of the discontinuities shall become part of the permanent record of the calibration referenced specimen. (d) Each calibration reference standard shall be permanently identified with a serial number.

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II-860.2.2 Calibration Reference Standards for Differential and Absolute Bobbin Coils. (a) Calibration reference standards shall contain the following artificial discontinuities: (1) One or four through-wall holes as follows: (-a) A 0.052 in. (1.3 mm) diameter hole for tubing with diameters of 0.750 in. (19 mm) and less, or a 0.067in.(1.70mm) hole for tubing with diameters greater than 0.750 in. (19 mm). (-b) Four holes spaced 90 deg apart in a single plane around the tube circumference, 0.026 in. (0.65 mm) diameter for tubing with diameters of 0.750 in. (19 mm) and less and 0.033 in. (0.83 mm) diameter for tubing with diameters greater than 0.750 in. (19 mm). (2) A flat-bottom hole 0.109 in. (2.7 mm) diameter, 60% through the tube wall from the outer surface. (3) Four flat-bottom holes 0.187 in. (5 mm) diameter, spaced 90 deg apart in a single plane around the tube circumference, 20% through the tube wall from the outer surface. (b) The depth of the artificial discontinuities, at their center, shall be within 20% of the specified depth or 0.003 in. (0.08 mm), whichever is less. All other dimensions shall be within 0.003 in. (0.08 mm). (c) All artificial discontinuities shall be sufficiently separated to avoid interference between signals, except for the holes specified in (a)(1)(-b) and (a)(3).	VIII-862.2 Calibration Reference Standards for Differential and Absolute Bobbin Coils. Calibration reference standards shall contain the following artificial discontinuities that are located on either the inner or outer surface of the tube specimen: (a) One 1/16 in. (1.6 mm) wide, 360 deg circumferential groove 10% through from the tube inner surface. (b) One 1/8 in. (3.2 mm) wide, 360 deg groove 10% through from the tube outer surface. (c) One hole drilled 100% through the tube wall 1/16 in. (1.6 mm) diameter. (d) A sufficient number of artificial defects, such as EDM manufactured inner surface originated cylindrical rounded bottom pits, 180 deg outer surface originated wear scars, and inner surface originated 360 deg grooves to aid in developing a calibration relationship for sizing tube degradation. (1) There shall be a minimum of three sizing discontinuities of each type having depths equal to 20%, 40%, and 60% of the nominal tube wall. As-built depths within 5% are sufficient. (2) The length of sizing defects shall be selected to simulate the expected degradation mechanism. When general inside or outside originated wall loss is possible, the minimum length shall be 5/8 in. (16 mm). (3) Simulated internal pitting defects shall have a diameter that simulates the size pitting which may be encountered. The 1/16 in. (1.6 mm) diameter 100% through-wall hole specified in (c) is intended to identify the appropriate relationship between inside and outside originated wall loss and should not be used to generate linear calibration curves for pit sizing.
	VIII-863 BASE FREQUENCY The base frequency shall bebetween f90 and2.1 ×f90 as defined by the following equations: (a) Minimum Base Frequency: $f90=4{,}8\rho/t2\mu r$ (b) Maximum Base Frequency: $2{,}1xf90=10\rho/t2\mu r$ where f90 = the frequency which generates a 90 deg phase separation between a shallow inside originated defect and a shallow outside originated defect ρ = tube material resistivity ($\mu\Omega\cdot$cm) t = tube wall thickness [in. or (mm/25)] μr = relative magnetic permeability (μr = 1.0 for nonmagnetic materials)

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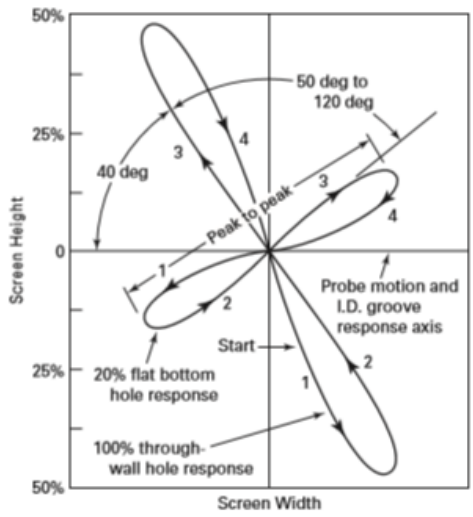
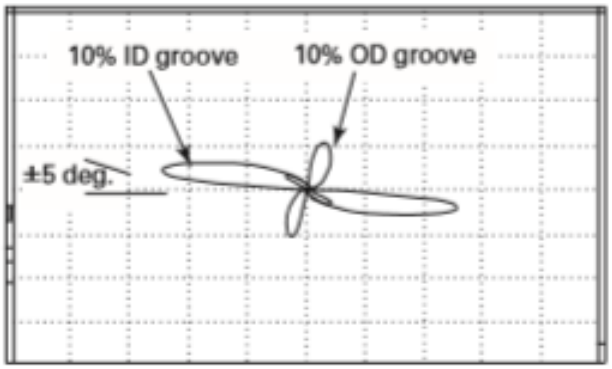
II-860.3 Analog System Set-up and Adjustment. II-860.3.1 Differential Bobbin Coil Technique. (a) The sensitivity shall be adjusted to produce a minimum peak-to-peak signal of 4 V from the four 20% flatbottom holes or 6 V from the four through-wall drilled holes. (b) The phase or rotation control shall be adjusted so the signal response due to the through-wall hole forms down and to the right first as the probe is withdrawn from the calibration reference standard holding the signal response from the probe motion horizontal. See Figure II-860.3.1. (c) Withdraw the probe through the calibration reference standard at the nominal examination speed. Record the responses of the applicable calibration reference standard discontinuities. The responses shall be clearly indicated by the instrument and shall be distinguishable from each other as well as from probe motion signals. **Figure II-860.3.1** **Differential Technique Response From Calibration Reference Standard**  	VIII-864 SET-UP AND ADJUSTMENT VIII-864.1 Differential Bobbin Coil Technique (a) The sensitivity shall be adjusted to produce Lissajous and/or strip chart signals which clearly display the smallest defect expected to be measured by the differential signal. (b) The phase rotation shall be adjusted so the signal response due to the 10% inside originated groove is within 5 deg of the horizontal axis (max rate). The response due to the through-wall hole forms either up and to the left or down and to the right first as the probe is withdrawn from the calibration reference standard. (c) Withdraw the probe through the calibration reference standard at the nominal examination speed. Record the responses of the applicable calibration reference standard discontinuities. The responses shall be clearly indicated by the instrument and shall be distinguishable from each other as well as from probe motion signals. (d) The f90 frequency should be verified by a 90 deg phase separation between the inside and outside originated 10% deep grooves. See example in Figure VIII-864.1. **Figure VIII-864.1** **Differential Technique Response From Calibration Reference** 

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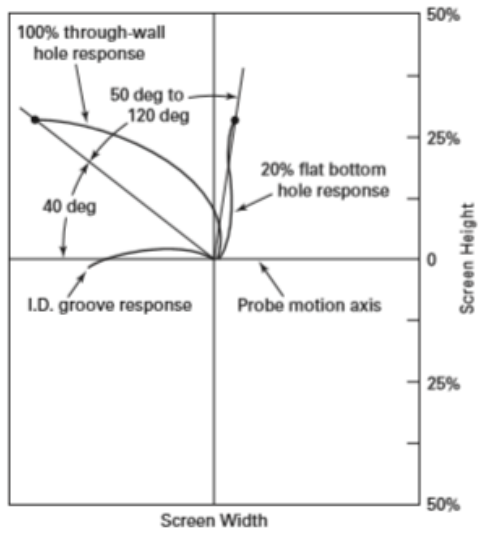
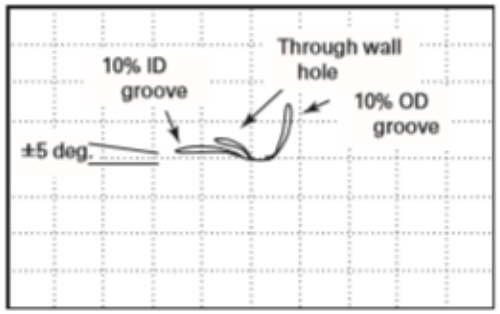
II-860.3.2 Absolute Bobbin Coil Technique. (a) The sensitivity shall be adjusted to produce a minimum origin-to-peak signal of 2 V from the four 20% flatbottom holes or 3 V from the four through-wall drilled holes. (b) Adjust the phase or rotation control so that the signal response due to the through-wall hole forms up and to the left as the probe is withdrawn from the calibration reference standard holding the signal response from the probe motion horizontal. See Figure II-860.3.2. (c) Withdraw the probe through the calibration reference standard at the nominal examination speed. Record the responses of the applicable calibration reference standard discontinuities. The responses shall be clearly indicated by the instrument and shall be distinguishable from each other as well as from probe motion signals. **Figure II-860.3.2** **Absolute Technique Response From Calibration Reference Standard**  	VIII-864.2 Absolute Bobbin Coil Technique (a) The sensitivity shall be adjusted to produce Lissajous and strip chart signals that clearly display the smallest defect to be measured with the absolute signal. (b) The phase rotation control shall be adjusted so the signal response due to the 10% inside originated groove is within 5 deg (peak-to-peak) of the horizontal axis. The signal response due to the through-wall hole can be formed up and to the left or down and to the right as the probe is withdrawn from the calibration reference standard. (c) Withdraw the probe through the calibration reference standard at the nominal examination speed. Record the responses of the applicable calibration reference standard discontinuities. The responses shall be clearly indicated by the instrument and shall be distinguishable from each other as well as from probe motion signals. (d) The f90 frequency should be verified by a 90 deg phase separation between the inside and outside originated 10% deep grooves. See example in Figure VIII-864.2. **Figure VIII-864.2** **Absolute Technique From Calibration Reference Standard** 
II-860.4 Digital System Off-Line Calibration. The eddy current examination data is digitized and recorded during scanning for off-line analysis and interpretation. The system set-up of phase and amplitude settings shall be performed off-line by the data analyst. Phase and amplitude settings shall be such that the personnel acquiring the data can clearly discern that the eddy current instrument is working properly.	VIII-864.3 Digital System Off-Line Calibration. The eddy current examination data is digitized and recorded during scanning for off-line analysis and interpretation. The system set-up of phase and amplitude settings shall be performed off-line by the data analyst. Phase and amplitude settings shall be such that the personnel acquiring the data can clearly discern that the eddy current instrument is working properly.

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II-860.4.1 System Calibration Verification. (a) Calibration shall include the complete eddy current examination system. Any change of probe, extension cables, eddy current instrument, recording instruments, or any other partsof the eddycurrent examination system hardware shall require recalibration. (b) System calibration verification shall be performed and recorded at the beginning and end of each unit of data storage of the recording media. (c) Should the system be found to be out of calibration (as defined in II-860.3), the equipment shall be recalibrated. The recalibration shall be noted on the recording. All tubes examined since the last valid calibration shall be reexamined.	VIII-864.4 System Calibration Verification. (a) Calibration shall include the complete eddy current examination system. Changes of any probe, extension cables, eddy current instrument, recording instruments, or any other parts (essential variables) of the eddy current examination system hardware shall require recalibration. (b) System calibration verification shall be performed and recorded at the beginning and end of each unit of data storage of the recording media and every 2 hr. (c) Should the system be found to be out of calibration (as defined in VIII-864.2), the equipment shall be recalibrated. The recalibration shall be noted on the recording. All tubes examined since the last valid calibration shall be reexamined.
II-870 EXAMINATION Data shall be recorded as the probe traverses the tube. II-880 EVALUATION II-880.1 Data Evaluation. Data shall be evaluated in accordance with the requirements of this Appendix. II-880.2 Means of Determining Indication Depth. For indication types that must be reported in terms of depth, a means of correlating the indication depth with the signal amplitude or phase shall be established. The means of correlating the signal amplitude or phase with the indication depth shall be based on the basic calibration standard or other representative standards that have been qualified. This shall be accomplished by using curves, tables, or software. Figure II-880 illustrates the relationship of phase angle versus flaw depth for a nonferromagnetic thinwalled tube examined at a frequency selected to optimize flaw resolution. II-880.3 Frequencies Used for Data Evaluation. All indications shall be evaluated. Indication types, which must be reported, shall be characterized using the frequencies or frequency mixes that were qualified.	VIII-870 EXAMINATION The maximum probe travel speed used for examination shall not exceed that used for calibration. Data shall be recorded as the probe traverses the tube. VIII-880 EVALUATION VIII-880.1 Data Evaluation. Data shall be evaluated in accordance with the requirements of this Appendix. VIII-880.2 Means of Determining Indication Depth. For indication types that must be reported in terms of depth, a means of correlating the indication depth with the signal amplitude or phase shall be established. The means of correlating the signal amplitude or phase with the indication depth shall be based on the basic calibration standard or other representative standards that have been qualified. This shall be accomplished by using curves, tables, or equations and aided by software. VIII-880.2 Frequencies Used for Data Evaluation. All indications shall be evaluated. Indication types, which must be reported, shall be characterized using the frequencies or frequency mixes that were qualified.

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II-890 DOCUMENTATION II-890.1 Reporting. II-890.1.1 Criteria. Indications reported in accordance with the requirements of this Appendix shall be described in terms of the following information, as a minimum: (a) location along the length of the tube and with respect to the support members (b) depth of the indication through the tube wall, when required by this Appendix (c) signal amplitude (d) frequency or frequency mix from which the indication was evaluated. II-890.1.2 Depth. The maximum evaluated depth of flaws shall be reported in terms of percentage of tube wall loss. When the loss of tube wall is determined by the analyst to be less than 20%, the exact percentage of tube wall loss need not be recorded, i.e., the indication may be reported as being less than 20%. II-890.1.3 Non-Quantifiable Indications. A non-quantifiable indication is a reportable indication that cannot be characterized. The indication shall be considered a flaw until otherwise resolved.	VIII-890 DOCUMENTATION VIII-890.1 REPORTING VIII-890.1.1 Criteria. Indications reported in accordance with the requirements of this Appendix shall be described in terms of the following information, as a minimum: (a) location along the length of the tube and with respect to the support members, when the indication identification is relevant to a specific location (i.e., fretting @ baffle 2) (b) depth of the indication through the tube wall (c) frequency or frequency mix from which the indication was evaluated VIII-890.1.2 Depth. The maximum evaluated depth of flaws shall be reported in terms of percentage of tube wall loss. When the loss of tube wall is determined by the analyst to be less than 20%, the exact percentage of tube wall loss need not be recorded, i.e., the indication may be reported as being less than 20%. VIII-890.1.3 Non-quantifiable Indications. A non-quantifiable indication is a reportable indication that cannot be characterized. The indication shall be considered a flaw until otherwise resolved.
II-890.1.4 Support Members. II-890.1.4.1 Location of Support Members. The location of support members used as reference points for the eddy current examination shall be verified by fabrication drawings or the use of a measurement technique.	VIII-890.2 SUPPORT MEMBERS VIII-890.2.1 Location of Support. The location of support members used as reference points for the eddy current examination shall be verified by fabrication drawings or the use of a measurement technique.

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II-890.2 Records. II-890.2.1 Record Identification. The recording media shall contain the following information within each unit of data storage: (a) Owner (b) plant site and unit (c) heat exchanger identification (d) data storage unit number (e) date of examination (f) serial number of the calibration standard (g) operator's identification and certification level (h) examination frequency or frequencies (i) mode of operation including instrument sample rate, drive voltage, and gain settings (j) lengths of probe and probe extension cables (k) size and type of probes (l) probe manufacturer's name and manufacturer's part number or probe description and serial number (m) eddy current instrument serial number (n) probe scan direction during data acquisition (o) application side — inlet or outlet (p) slip ring serial number, as applicable (q) procedure identification and revision	VIII-890.3 RECORDS VIII-890.3.1 Record Identification. The recording media shall contain the following information within each unit of data storage: (a) Owner (b) plant site and unit (c) heat exchanger identification (d) data storage unit number (e) date of examination (f) serial number of the calibration standard (g) operator's identification and certification level (h) examination frequency or frequencies (i) mode of operation including instrument sample rate, drive voltage, and gain settings (j) lengths of probe and probe extension cables (k) size and type of probes (l) probe manufacturer's name and manufacturer's part number or probe description and serial number (m) eddy current instrument model and serial number (n) probe scan direction during data acquisition (o) application side — inlet or outlet (p) slip ring serial number, as applicable (q) procedure identification and revision
II-890.2.2 Tube Identification. (a) Each tube examined shall be identified on the applicable unit of data storage and (b) The method of recording the tube identification shall correlate tube identification with corresponding recorded tube data.	VIII-890.3.2 Tube Identification. (a) Each tube examined shall be identified on the applicable unit of data storage and should be consistent with the manufacturer's as-built drawings and previous inspection. (b) The method of recording the tube identification shall correlate tube identification with corresponding recorded tube data.
II-890.2.3 Reporting. (a) The Owner or his agent shall prepare a report of the examinations performed. The report shall be prepared, filed, and maintained in accordance with the referencing Code Section. Procedures and equipment used shall be identified sufficiently to permit comparison of the examination results with new examination results run at a later date. This shall include initial calibration data for each eddy current examination system or part thereof. (b) The report shall include a record indicating the tubes examined (this may be marked on a tube sheet sketch or drawing), any scanning limitations, the location and depth of each reported flaw, and the identification and certification level of the operators and data evaluators that conducted each examination or part thereof. (c) Tubes that are to be repaired or removed from service, based on eddy current examination data, shall be identified.	VIII-890.3.3 Reporting. (a) The Owner or his agent shall prepare a report of the examinations performed. The report shall be prepared, filed, and maintained in accordance with the referencing Code Section. Procedures and equipment used shall be identified sufficiently to permit comparison of the examination results with new examination results run at a later date. This shall include initial calibration data for each eddy current examination system or part thereof. (b) The report shall include a record indicating the tubes examined (this may be marked on a tube sheet sketch or drawing), any scanning limitations, the location and depth of each reported flaw, and the identification and certification level of the operators and data evaluators that conducted each examination or part thereof. (c) Tubes that are to be repaired or removed from service, based on eddy current examination data, shall be identified.

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II-890.2.4 Record Retention. Records shall be maintained in accordance with requirements of the referencing Code Section.	VIII-890.3.4 Record Retention. Records shall be maintained in accordance with requirements of the referencing Code Section.