Designation: E2905/E2905M – 13

Standard Practice for Examination of Mill and Kiln Girth Gear Teeth—Electromagnetic Methods[1]

This standard is issued under the fixed designation E2905/E2905M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This practice describes a two-part procedure for electromagnetic evaluation on gear teeth on mill and kiln gear drives and pinions. The first part of this practice details the ability to detect 100 % of surface-breaking discontinuities only in the addendum, dedendum, and root area on both the drive side and non-drive side of the gear tooth using an eddy current array. The second part of the examination is to size or measure accurately the length and depth of any cracks found in these areas using electromagnetic methods. No other practice addresses the use of electromagnetic methods for the detection and sizing of surface-breaking discontinuities on mill and kiln ring gear teeth.

1.2 This practice is used only for crack detection, alignment issues, wear patterns, and early signs of macro-pitting. It will not illustrate a full gear tooth analysis. Visual examination by an experienced gear technician is the only way to analyze fully gear teeth wear patterns and potential failure.

1.3 Two technicians, or one technician and a technical assistant, are typically required for this practice. One technical assistant guides the probe and the technician operates the computer/software and analyzes the gear teeth condition.

1.4 It is important that the appropriate method standards, such as Guide E709 and Practice E2261, if the alternating current field measurement approach is used for crack sizing, accompany the technician when performing the examination.

1.5 It is recommended that the technician reviews the appendixes in this practice in advance of starting the job.

1.6 A clean gear is recommended for a complete gear analysis. Depending on the lubrication used, the technician, in discussion with the client, shall determine the appropriate cleaning procedure, if cleaning is required. If an oil bath lubrication system is used, ensure the gear teeth surface is clean. If an asphaltic-based or synthetic-based lubricant is used, refer to the annexes and appendices in this practice.

1.7 *Units*—The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with the standard.

1.8 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E709 Guide for Magnetic Particle Testing
E1316 Terminology for Nondestructive Examinations
E2261 Practice for Examination of Welds Using the Alternating Current Field Measurement Technique
E2884 Guide for Eddy Current Testing of Electrically Conducting Materials Using Conformable Sensor Arrays

2.2 *AIA Standard:*[3]

NAS 410 Certification and Qualification of Nondestructive Test Personnel

2.3 *ANSI/AGMA Standards:*[4]

AGMA 912-A04 Mechanisms of Gear Tooth Failures—Information Sheet
ANSI/AGMA 1010 E-95 Standard for Appearance of Gear Teeth—Terminology of Wear and Failure
ANSI/AGMA 1012 G-05 Gear Nomenclature, Definition of Terms

[1] This test method is under the jurisdiction of ASTM Committee E07 on Nondestructive Testing and is the direct responsibility of Subcommittee E07.07 on Electromagnetic Method.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from Aerospace Industries Association of America, Inc. (AIA), 1000 Wilson Blvd., Suite 1700, Arlington, VA 22209-3928, http://www.aia-aerospace.org.

[4] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

***A Summary of Changes section appears at the end of this standard**

2.4 *ANSI/ASNT Standards:*[4]
ANSI/ASNT-CP-189 Qualification and Certification of Nondestructive Testing Personnel
SNT-TC-1A Recommended Practice for Personnel Qualification and Certification in Nondestructive Testing

3. Terminology

3.1 *Definitions*—For definitions of terms relating to this guide refer to Terminology E1316, Practice E2261, and Guide E2884. For definitions of general terms relating to gear examinations refer to Guide E709, ANSI/AGMA 1012 G-05, and ANSI/AGMA 1010 E-95.

NOTE 1—Different equipment manufacturers may use slightly different terminology. Reference should be made to the equipment manufacturer's documentation for clarification.

3.2 *Eddy Current Array Method:*

3.2.1 *basic concepts of eddy current array, ECA, n*—eddy current array (ECA) technology provides the ability to measure electronically multiple eddy current sensing coils placed side by side in the same probe assembly. Example eddy current arrays have distinct drive coils associated with each sense coil or a drive coil with a linear conductor that is parallel to a linear array of sense coils. Depending upon the instrumentation, the response for each sense element can be measured in parallel or a multiplexer can be used to switch between one or more of the sense coils. Typically, a multiplexer is used when the number of sense coils is greater than the number of data acquisition channels for impedance measurement. When using eddy current sensor arrays with multiple drive coils and multiple sensing coils, undesired coupling between the individual coils is likely to take place. It may be necessary to use a multiplexer with a special multiplexing pattern to avoid such undesired coupling. Most conventional eddy current flaw detection techniques can be reproduced with an ECA examination. With the benefits of single-pass coverage, and enhanced imaging capabilities, ECA technology provides a remarkably powerful tool and significant time savings during inspections compared to raster scanning with a single coil probe. (See Fig. 1.)

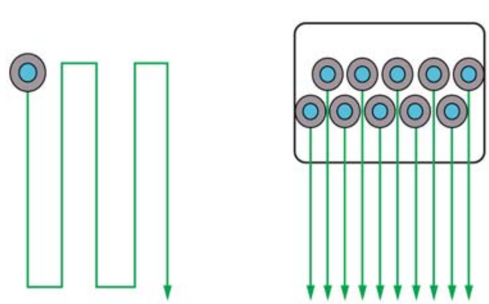

FIG. 1 Eddy Current Single Coil Probe Compared to Eddy Current Array Probe Coils

3.2.1.1 *Discussion*—In this standard, the use of the eddy current array is for crack detection, early signs of macro-pitting alignment issues, and wear patterns. Although ECA will show wear patterns, the proper method for interpreting contact and wear patterns should be used. Refer to AGMA 912-A04, section 3.3.3.2. Limitations—The eddy current array will not reveal backlash problems, lubrication issues, tip to root interface, and so forth. Visual interpretation is the typical method used to analyze these conditions. It is also very important that the technician has an education in gear analysis. Basic eddy current experience does not provide the knowledge required to interpret gear teeth issues or the understanding of ECA. The knowledge of the defect type helps in determining the root causes and the potential solutions, resulting in a higher standard of examination.

3.2.2 *eddy current array probes, n*—probes can be designed to detect a specific type of discontinuity and to conform to the shape of the part under examination (see Fig. 2).

3.2.2.1 *Discussion*—Probes can be designed to detect a specific type of discontinuity and conform to the shape of the gear tooth under examination. Also notice that the center of the root would actually be scanned twice. In this examination, there is no saturation performed. Surface probes are made with coils designed to be driven at relatively high frequencies (typically 50 to 500 kHz). Using higher frequencies results in less penetration of the eddy current field into the test part allowing full coverage of any surface-breaking discontinuities of the component to be examined. In addition, the higher frequencies provide a higher resolution for the detection of smaller defects. For this practice, a surface array probe, with the ability of detecting all surface discontinuities—including cracks, is required for a successful examination.

3.2.3 *reference standard, n*—shall contain at least one long reference indicator to standardize all the channels of the array at once and also representative defects for flaw characterization during the examination.

3.2.4 *set screws, n*—conformable and substantially nonconducting set screws on the probe that are used to allow small lift-off adjustments or excursions on surface response.

3.2.5 *system performance verification, n*—use of a measurement of one or more response values, typically physical property values for a reference standard to confirm that the response values are within specified tolerances to validate the system standardization and verify proper instrument operation.

3.2.5.1 *Discussion—Probe quality*—Probe life varies depending on the environmental conditions within the work area. Some of these environmental factors are temperature, moisture, cleanliness, and the main factor being surface roughness.

4. Summary of Practice

4.1 *Gear-Cleaning Procedure*—Typically, mill operations does the cleaning or supervises the cleaning. Mill maintenance removes the guards for access to the gear. Nondestructive evaluation (NDE) mill girth gear examinations are provided for maintenance. Visual interpretation is also a common method used to analyze gear teeth condition, such as contact patterns and wear patterns. For visual inspection, a cleaned gear is mandatory. Another reason for a cleaned gear tooth is that it is very hard for the ECA probe to maintain the geometry of a gear tooth that is covered with lubricant, especially if the lubricant is asphaltic-based or synthetic. If asphaltic or sythetic lubrication is used, refer to Appendix X2 for cleaning procedures.

4.1.1 *ECA*—ECA is used for nondestructively locating and characterizing surface-breaking discontinuities in conducting

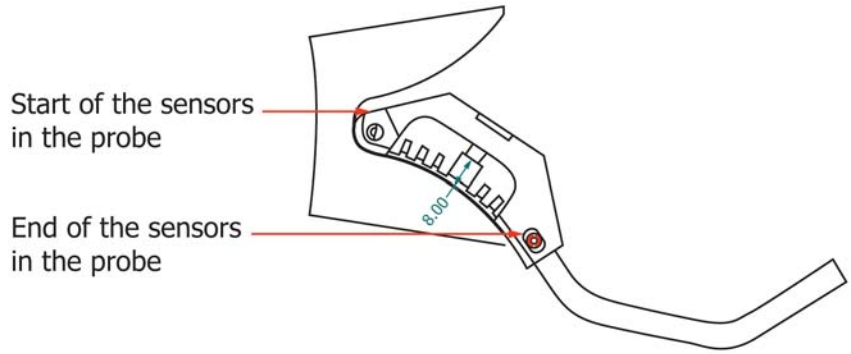

FIG. 2 Coverage of a Flexible Probe—Root, Dedendum, and Addendum

FIG. 3 Two cracks on a tooth just above the root that were only observed visually after being revealed by the ECA examination. In this example, the cracks were not apparent visually until MT was performed.

materials to electrically conductive materials. For use in this practice, the properly designed ECA probe has proven to detect all surface-breaking discontinuities from 0.76 mm (0.03 in.) and larger on the addendum, dedendum, and root of girth gear teeth. The examination is performed by scanning a conformable eddy current sensor array over the surface of the addendum, dedendum, and root of the gear tooth being examined in one pass. The drive side of the tooth is referred to as the A side and the nondrive side of the tooth is referred to as the B side of the tooth. The measured responses and location information are then used, typically in the form of a displayed image (C-scan), to determine the presence and characteristics of discontinuities.

4.1.2 *Alternating Current Field Measurement Method*—Alternating current field measurement is used if a crack is found. Alternative electromagnetic methods can also be used for sizing cracks.

4.1.3 *Alternating Current Field Measurement for Nondestructive Testing Detection and Sizing of Surface-Breaking Cracks*—It works on all metals, ferrous or nonferrous. A sensor probe is placed on the surface to be examined and an alternating current is induced into the surface. When no defects are present the alternating current produces a uniform magnetic field above the surface. Any defect present will perturb the current, forcing it to flow around and underneath the defect; this causes the magnetic field to become non-uniform and sensors in the alternating current field measurement probe measure these field variations. Two components of this magnetic field are measured—one provides information about the depth or aspect ratio of the defect(s) and the other shows the positions of the defects' ends. The two signals are used to confirm the presence of a defect and, together with a sizing algorithm, measure its length and depth. The main advantages of alternating current field measurement for this practice are the speed of sizing cracks and that it provides both depth and length information. Defects up to 25 mm (1 in.) in depth can be sized accurately.

4.1.4 *Magnetic Particle Examination*—Magnetic particle is used when a crack is found. It is used to illustrate the crack for the picture in the report. (See Fig. 3.) It is also used when excessive lift-off prevents the ECA probe from receiving a signal.

5. Significance and Use

5.1 Visual interpretation of gear teeth condition is different from examining for cracks or early signs of macro-pitting. Visual interpretation is referred to ANSI/AGMA 1010 E-95.

5.1.1 The purpose of using an eddy current array for mill girth gear teeth examination is it drastically reduces the examination time; covers a large area in one single pass; provides real-time cartography of the examined region, facilitating data interpretation; and improves reliability and probability of detection (POD). One tooth can be examined in less than 30 seconds.

NOTE 2—In this standard, ECA is used as a discontinuity finding tool (see Fig. 3) and a presentation aid as support once problems are discovered and photographed. Colors and three-dimensional (3D) images (see Fig. 4) that help with visualization are invaluable in such circumstances.

5.1.2 The purpose of using alternating current field measurement is to size surface-breaking cracks electronically.

5.1.3 This practice is a useful tool for a condition-based monitoring program.

5.2 The examination results may then be used by qualified personnel or organizations to assess remaining service life or other engineering characteristics (beyond the scope of this practice). This practice is not intended for the examination of non-surface-breaking discontinuities.

6. Basis of Application

6.1 The following item is subject to contractual agreement between the parties using or referencing this practice.

6.1.1 *Personnel Qualification*—If specified in the contractual agreement, personnel performing examinations to this practice shall be qualified in accordance with a nationally or internationally recognized NDT personnel qualification practice or standard such as ANSI/ASNT-CP-189, SNT-TC-1A, NAS-410, or a similar document and certified by the employer or certifying agency, as applicable. The practice or standard used and its applicable revision shall be identified in the contractual agreement between the using parties.

7. Interferences—ECA

7.1 *Curvature of Examination Surface*—For helical gears with a helix angle of 1° or more, a flexible probe is required and needs to be flexible enough to adjust its curvature to the various helix angles. System performance verification tests should be run to verify lift-off sensitivity by adjusting the set screws in the face of the array probe.

7.2 *Surface Conditions*—Micropitting, macropitting, spalling, and so forth of gear teeth surfaces can be readily scanned with the ECA probe by adjusting the set screws allowing for lift-off. Gear teeth surfaces shall be clean and free of any asphaltic or synthetic lubricant that could interfere with sliding of the ECA probe along the gear tooth surface.

7.3 *Pressure of the Probe against Surface under Examination*—Sliding the probe across the gear tooth is all the pressure that is required.

NOTE 3—The array probe has two set screws that allow for adjusting lift-off.

7.4 *Temperature*—Eddy current measurements are generally affected by temperature variations of the material under examination. For this practice, once the gear has been cleaned, the temperature of the gear teeth is ready for examination.

7.5 *Scanning Speed*—The length of the C-scan image may depend upon how fast a gear tooth is scanned if a position encoder is not used. This means that the number of acquisition points in the images may vary with the scan speed. As the technician applies a filter with a given number of points on the C-scan, this filter could cut or modify some indications. Scanning speed should be at the same speed that is set in the scan parameters.

7.6 *Residual Magnetism*—In magnetic materials, residual magnetism may affect the measurement and appear as a local property change. In this application, eddy current is induced in the material by the applied alternating magnetic field. With a probe configuration as in this application, the magnetism is very weak. Residual magnetism would be detected if the gear was previously examined using magnetic particle. Gears of this nature are usually examined every year or two, so any residual magnetism would be minimal. This application reduces the noise level by an optimal probe configuration.

8. Apparatus—ECA

8.1 *Instrumentation*—The electronic instrumentation shall be capable of energizing the eddy current surface array with alternating current of one or more suitable frequencies and shall be capable of measuring changes in the impedance of each element in the surface array. The equipment shall include a capability to correlate the impedance variations with physical property changes for the material under examination.

8.2 *Eddy Current Surface Array*—The eddy current surface array shall be capable of inducing currents in the material

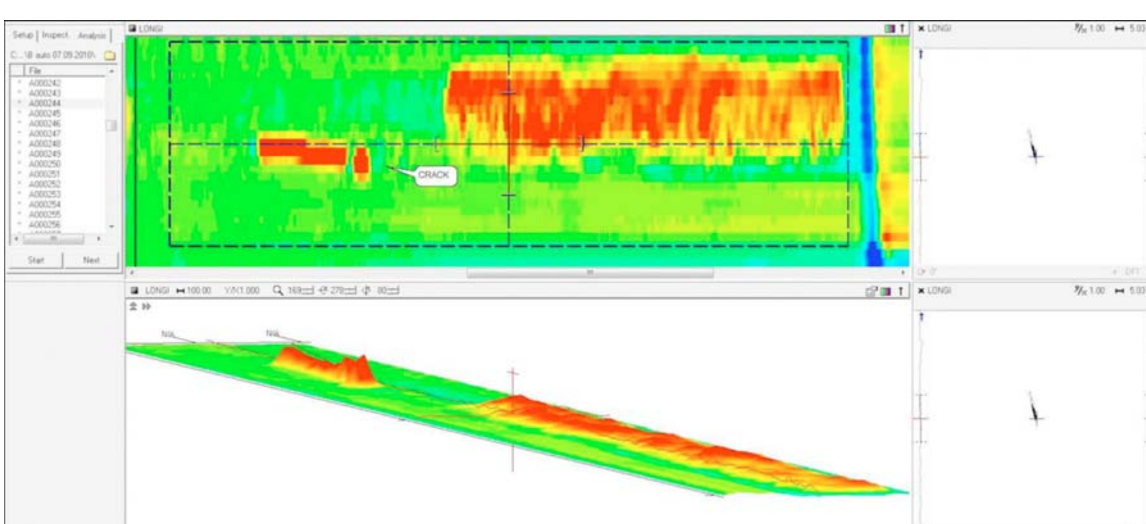

FIG. 4 Two- and Three-Dimensional View

under examination and sensing changes in the physical characteristics of the material under examination. Eddy current array (ECA) technology provides the ability to measure electronically multiple eddy current coils placed side by side in the same probe assembly. The surface probe array shall have at least two rows of coils offset by one-half coil and covering the entire length of the surface to be examined. Such coils configuration, whichever the exciting mode (absolute, transmit-receive, differential, and so forth), will allow good coverage all along the array and also to avoid dead zones. The ECA data responses can be displayed as an image spanning the surface of the examined region of the gear or as individual coil channels for analysis after examination.

8.2.1 Depending upon the instrumentation, the response for each sense element can be measured in parallel or a multiplexer can be used to switch between one or more of the sensing coils. Typically, a multiplexer is used when the number of sense elements is greater than the number of data acquisition channels for impedance measurement. When using eddy current sensor arrays with multiple drive coils and multiple sensing coils, undesired coupling between the individual coils is likely to take place. It may be necessary to use a multiplexer with a special multiplexing pattern to avoid such undesired coupling. An undesirable effect known as mutual inductance (magnetic coupling between coils in close proximity) can be minimized with the use of an internal multiplexing system to program carefully the exact time that each coil is excited to transmit its eddy current signal. The signals are then reassembled before being displayed.

8.2.2 To achieve the best results for examination performance, there are several important parameters to consider when designing an effective ECA probe. Key factors include examination coverage, sensitivity, frequency, and, of course, cost. To optimize performance, it is important to balance the various probe parameters carefully. For example, high-sensitivity probes require small, high-frequency coils (providing less coverage); probes capable of greater coverage require larger, lower-frequency coils (resulting in decreased sensitivity to small defects). As is the case with conventional eddy current examinations, choosing the correct probe characteristics is essential to a successful examination. The array can be in contact with the material being tested or offset by an intended lift-off distance (for noncontact scanning) with two set screws in the face of the array probe.

8.3 An important consideration affecting the choice of instrumentation, eddy current array, and operational parameters is the depth of penetration of the sensor fields into the material under examination. The eddy current density does not remain constant with depth into the material. The eddy current density is greatest at the surface and decreases exponentially with depth (i.e., the "skin effect"). The standard depth of penetration decreases with increasing frequency, electrical conductivity, or magnetic permeability of the material. For a material that is both thick and uniform, the standard depth of penetration is the depth at which the eddy current density is 37 % of the material surface value. To detect shallow defects in a material, relatively high frequencies are used. Refer to E2884 for additional information.

9. Standardization—ECA

9.1 The eddy current unit is a precision instrument and should be calibrated annually or at periodic intervals after a repair or when a malfunction is suspected.

9.1.1 *Standardization*—Standardization is performed to adjust the sensitivity for an ECA probe. To do this, the operator scans a reference standard containing a reference notch to generate the same eddy current signal for each channel. To do this, the operator needs to adjust signal amplitude and phase for each channel to achieve it. After the standardization, other defects can be scanned, such as three different long transversal notches at depths from 1 to 3 to 5 mm (0.04 to 0.1 to 0.2 in.) long to 30 mm (1.2 in.) long. Also six holes ranging from 0.76 to 6 mm (0.03 to 0.24 in.) in diameter can be used for characterization purposes. Using the reference standard, the operator adjusts the gain and rotation of each channel so that the same phase and amplitude response is obtained for all channels. To validate the standardization, a system performance verification should be performed.

9.1.2 *System Performance Verification*—System performance verification refers to measurements on a reference standard to confirm that the measured responses are within specified tolerances for the application. This serves to validate the standardization and verify proper instrument operation.

9.1.3 *Discontinuity System Performance Verification*—A discontinuity system performance verification uses measurements on a discontinuity containing reference standard to verify instrument operation. The reference standard should contain one or more reference indicators that are representative of the discontinuities to be found in the examination. The response variation as a result of the discontinuity as well as the background variation associated with discontinuity-free regions of the reference standard is to be within specified tolerances. When possible, the discontinuity reference standard should have the same shape as the part being examined.

10. Procedure

10.1 *Preparing the Gear before Examination*—Ensure the addendum, dedendum, and root on both the drive side and the non-drive side of the gear teeth are clean. If the lubrication used is an oil bath type, then the probe will glide along the gear tooth surface with ease and additional cleaning may not be required. If an asphaltic-based or synthetic lubricant is used, refer to Appendix X2.

NOTE 4—The gear teeth surface does not have to be wiped clean to remove all residues as in magnetic particle or liquid penetrant examination techniques.

NOTE 5—If the teeth are not already prestamped with numbers, use a stamp to mark every 25th tooth on the top land. Confirmation with the technical assistant should be made every 25 teeth to ensure accuracy.

10.2 *ECA Method*—Operate and setup the instrument and software in accordance with the manufacturer's instructions.

10.2.1 Ensure that the ECA probe is compatible with the eddy current instrument.

10.2.2 The instrument should be assembled, turned on, and allowed sufficient time to stabilize in accordance with the manufacturer's instructions before use. The instrument should be standardized on a reference standard. Standardization should be repeated at intervals established based on experience for a given application, including performance verification.

10.2.3 Once the equipment is set up and secured, the technical assistant will position himself or herself safely close to the girth gear so access to the gear teeth is unobstructed. The technician will position himself or herself safely where they have complete access to the notebook computer or whatever device the technician is using to store the acquisition software.

10.2.4 Once both people are in position, the technician will give the command for the assistant to run the probe across the gear tooth face (A side) of the tooth on the girth gear. The assistant will run the probe partially off the edge of the tooth from the farthest side of the gear tooth and pull it towards him until the probe has passed over the entire surface of the tooth face and off the edge. The technician will then give the command to start on the B side tooth face. This process will continue until all the gear teeth surfaces are scanned.

10.2.5 During the scanning, discontinuities may present themselves (see Fig. 4). If discontinuities are present, the technician will decide if further investigation is required. If so, the technician will take a picture of this with the tooth number marked on the gear tooth. If the discontinuity is a crack, the technician will use alternating current field measurement technique to size the crack accurately. The crack will be identified with the tooth number marked on the tooth and using magnetic particle method allowing the crack to present itself for a picture. If the discontinuity warrants contacting the maintenance supervisor to inform him of the discontinuity, the maintenance supervisor is responsible for making a decision, if any, on the repair procedure to remedy the situation.

10.2.6 Once the girth gear examination is completed, the team will then move themselves into position to examine the pinion. This part of the examination process will use the ECA flexible probe. The same process as A1.1-A1.4 will apply here.

10.2.7 Once all the data are collected, the technicians will gather all the equipment, clean up their work area, and clear the area. The technician and maintenance supervisor responsible for the examination will discuss the best course of action for presentation of the findings from the gear examination.

10.2.8 Finally, a formal hard copy of the report will be sent to the client.

11. Report

11.1 An examination report should contain the following information:

11.1.1 Date and name of operator;

11.1.2 Instrument, probe, and sensor identification;

11.1.3 Identification of components or location or both of examination;

11.1.4 Material(s) of the component;

11.1.5 Date of last instrument calibration and type and frequency of standardization;

11.1.6 Frequencies used;

11.1.7 A scope of work;

11.1.8 A summary of work performed identifying critical areas of concern;

11.1.9 An analysis report of the gear teeth examined;

11.1.10 Pictures of the critical areas of concern, including cracks highlighted by magnetic particle;

11.1.11 Pictures of gear teeth that show no surface breaking discontinuities. This would illustrate how the average scan would look on unaffected areas of the gear teeth; and

11.1.12 For performance verification and standardization, either the reference standard identification or a description of the discontinuity-free regions of the component should be provided.

11.2 All information should be archived whether or not it is required in the report.

12. Keywords

12.1 alternating current field measurement; crack; eddy current; eddy current array; electromagnetic examination; gear; gear examination; gear teeth; girth gear; kiln gear; macro-pitting; micro-pitting; mill gear; nondestructive examination; open gear; pitting

ANNEX

(Mandatory Information)

A1. PREPARATION OF THE GEAR BEFORE EXAMINATION

A1.1 It is critical to confirm with the client if cleaning is necessary and who will be cleaning the gear before examination. Will the client clean the gear before examination or will gear examination technicians do it? Ensure only approved gear-cleaning products are used. When cleaning a mill gear, no more than a 30 % charge or load of ore should be in the mill before starting the cleaning procedure to reduce stresses on the gear teeth.

A1.2 If the gear is lubricated with asphaltic or synthetic-based lubricants, acceptable cleaning methods include spraying the gear and manual scraping. A description of the spray method is found in Appendix X2. Manual scraping of the gear tooth flank and root can be performed with a stiff putty knife. Care must be taken to ensure that the scraping does not damage the gear tooth. However, a uniform surface is important to ensure that the probe fits the geometry of the addendum, dedendum, and root of the gear tooth. In addition, the lubricant thickness must be less than 2 mm (0.08 in.) on the gear tooth flank or root so that excessive lift-off is not encountered during the examination.

A1.3 If the gear examination team is cleaning the gear, a discussion with the client is needed as to how the spent lubricant and gear-cleaning chemical, if used during the cleaning, will be contained. As the gear is being cleaned, the spent lubrication and cleaning chemical will fall to the bottom of the gear guard. It is imperative that there is a drain in the bottom of the gear guard. If allowed to collect there, it will build up to a point at which the gear, when back in operation, the gear teeth will be immersing into the built-up sludge. This will result in contaminants coating the gear teeth. Proper cleaning of spent lubricant and gear-cleaning chemical into a tote or barrel eases disposal and reduces environmental concerns.

NOTE A1.1—If scraping the lubricant off of the gear tooth, it is recommended to use fresh lubricant after the examination. It is not recommended to reuse the lubricant scraped off of the gear tooth as it may be contaminated.

A1.4 *Verification of Contractual Requirements*—This process should happen 30 days in advance of the examination.

A1.5 Information Exchange between Gear Examination Team and Client

A1.5.1 A complete understanding shall be made to ensure the objectives are accomplished to the client's expectations. Before calling, research prior examinations on the gear and review details to update yourself on the background of the gear.

A1.5.2 Call for confirmation of gear specifications; any changes in schedule; safety requirements; directions to the plant and gate (that is, contractors, main); power source or special adapters or both; outside/inside/weather conditions; shift duration; and how is our work impacting other maintenance personnel? Is there an inching drive for the mill or kiln onsite? A gear examination information sheet can be used as a guide to cover the areas of information in the conversations with the client. Access to the gear is important (see Fig. A1.1). If the gear guard or portion of the gear guard is not removed and examination is only permitted through the examination door, this will create unnecessary extended examination period as only five to six teeth can be examined at one time. The technician and other maintenance personnel would have to remove their locks to inch the mill or kiln 0.9 m (3 ft) and then put their locks back on. This is very unproductive.

A1.6 Guide E709 should be referred to when required.

A1.7 Practice E2261 is referred to in this practice. Practice E2261 is used for examination of welds with the ability to size surface-breaking discontinuities. As long as the location and orientation of the discontinuity is known, so that the alternating current field measurement probe can be scanned along its length, this same practice is acceptable for sizing cracks found on ring gear teeth.

FIG. A1.1 Cleaned Girth Gear Ready for Examination

APPENDIXES

(Nonmandatory Information)

X1. PROBE

X1.1 *Probe Size*—Choosing a compatible probe size is important. For example, calculate the size of the gear tooth area to be examined. This includes the addendum, dedendum, and root.

X1.2 *Probe Types—Flat or Curved Probes*—Flat probes are usually for mill girth gears or spur gears; and curved probes are strictly for the pinions or helical gears.

X1.3 A good quality camera is required for pictures of affected gear teeth.

X2. CLEANING ASPHALTIC-BASED AND SYNTHETIC LUBRICANTS OFF GEAR TEETH ONLY

X2.1 *Necessary Equipment*—Mid-pressure variable pressure sprayer (approximately 2758-10 342 kPa (400-1500 psi)); spray wand with a stop installed to keep the end of the wand 15 cm (6 in.) from the gear to prevent touching the gear or spray bar with extensions to within 15 cm (6 in.) of the gear.

X2.2 *Setup Procedure*—Direct all basement water that can be affected by the spent gear cleaning chemical and lubricant to tailings. Ensure the spent gear-cleaning chemical and lubricant cannot find its way into the flotation circuit. This can be achieved by diverting sump pumps and diking and directing the solution and water to the tailings lines or impoundments. If the solution reaches the flotation circuits, shut off the frothier to the circuit and increase the collector until the circuit returns to normal. Set up the spray bar just before the initial spray to keep the ends from possibly getting clogged with lubricant that could be flung off of the gear. As in A1.3, another method of containing the spent gear-cleaning chemical and lubricant is if there is a drain on the bottom of the gear guards, ensure that the spent gear cleaning chemical and lubricate can freely flow through the drain hole into a container (tote/drum). You do not want the spent gear-cleaning chemical and lubricate to collect in the bottom of the gear guard.

X2.2.1 *Step 1*—Shut off the Farval or lube system 6 to 8 h before the cleaning is to commence.

X2.2.2 *Step 2*—Discuss with the supervisor to determine the operating load in the semi-autogenous grinding (SAG) mill only if work inside the mill is going to coincide with the gear examination. This is done by doing a load check 6 h or so before the final cleaning is to start.

X2.2.3 *Step 3*—These times are related to that shutdown time and can be adjusted according to your own schedule so 4 h before the shutdown spray the gear for 30 s (if a spray bar is installed on both sides of the mill use them both, if it is installed on only one side install it on the side that allows the cleaner to travel over the top of the mill). If a wand is used, spray for 5 s at each of four or five locations across the face of the gear angling the ones on either side of the gear towards the edges.

X2.2.4 *Step 4*—For the first few gear cleanings, or until you feel comfortable with the procedure, set up a check sheet listing times sprayed and the temperature across the face of the gear and the temperature of the pinion also across the face. You should take a temperature at the outboard edge, the center, and the inboard edge. The cleaner has a lubricant in it and the temperature is very stable even sometimes going lower than the operating temperature. The temperature of the gear cannot rise more than -9.4 to -6.6 °C (15 to 20 °F).

X2.2.5 *Step 5*—At 1-h intervals, after the initial spray, increase the times sprayed by 30 s each time, with the last short spray before the shutdown being 1 min 30 s. Using the heat gun, record the temperatures of the gear and the pinion. The strobe light can be used to see how the lube is coming off of the gear and if it is starting to clean out of the root of the gear.

X2.2.6 *Step 6*—With the feed still on the mill, start spraying the gear steadily 20 to 30 min before the mill is scheduled to go down, monitoring the temperatures and using a strobe light on the gear periodically to monitor the lubricant removal.

X2.2.7 *Step 7*—The control room operator does a normal controlled shut down of the mill, which normally takes about 5 min from the time that the feed is shut off. Keep spraying the mill until it is down.

X2.2.8 *Step 8*—After the mill is shut down, the gear can be checked for cleanliness and, if more cleaning is required, the mill can be inched around, with the guard still in place, with the spray running for one or two revolutions of the mill.

X2.2.9 *Step 9*—Remove the guard and provide access for the examination.

X2.2.10 *Step 10*—Evaluate the cleanliness of the gear. This determines the quality of the examination and the time it takes to do the examination.

NOTE X2.1—For a secondary grinding mill or a ball mill, use Steps 1-5. Start spraying the gear on the secondary or ball mill after the auto or primary mill is down for the last 20 min or so before the desired grind out of the mill is achieved, then proceed to Step 8.

X2.2.11 *Step 11*—Mark the starting point and tooth number of the gear being examined. Depending on what other work is being done on the mill, talk to the supervisor to determine which way the mill will be turned.

SUMMARY OF CHANGES

Committee E07 has identified the location of selected changes to this standard since the last issue (E2905–12) that may impact the use of this standard. (Approved December 1, 2013.)

(1) Sections 1.1, 1.3, 1.4, 10.2.5, and Note 2 clarified description of the basic examination procedure.
(2) Sections 1.6, 4.1, 10.1, and Appendix X1 were revised to clarify the necessity for cleaning and acceptable cleaning methods for asphaltic-bsed or synthetic lubricants.
(3) Section 2.1 was updated.
(4) Section 3 was revised so that the references to other standards was consistent. Sections 3.2.7, 3.3, and 3.4 were deleted since they are redundant with Section 3.
(5) Section 3.7.6.2 was deleted because it is redundant with Note 2.
(6) Sections 3.2, 7.6, and 8.1 clarified descriptions of the eddy current arrays and the use of multiplexing.
(7) Sections 3.2.5, 9.1.2, 9.1.3, and 11.1.12, were revised to be consistent with the new guide on the use of eddy current arrays.
(8) Editorial changes throughout the document to ensure that the terms “lift-off” and “eddy current” are used consistently.