Recommended Practice for Field Inspection of New Line Pipe

API RECOMMENDED PRACTICE 5L8
SECOND EDITION, DECEMBER 1996

REAFFIRMED, MAY 2015

AMERICAN PETROLEUM INSTITUTE

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Upstream Segment

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FOREWORD

This recommended practice is under the jurisdiction of the API Subcommittee on Standardization of Tubular Goods.

Included in this practice are the recommended procedures for field inspection and testing of new plain-end line pipe. This recommended practice has been prepared specifically to address the practices and technology used in field inspection of line pipe, and certain parts are not suitable or appropriate for mill inspections.

The recommended practices established within this document are intended as an inspection and/or testing guide, and nothing in this guide shall be interpreted to prohibit the agency or owner from using personal judgment, supplementing the inspection with other techniques, extending existing techniques, or reinspecting certain lengths.

This recommended practice covers the qualification of inspection personnel, a description of inspection methods, apparatus calibration, and standardization procedures for various inspection methods. The evaluation of imperfections and marking of inspected new line pipe are included.

This document shall be used as a guide applicable to the methods for field inspection and shall not be used as a basis for acceptance or rejection. Acceptance or rejection of new API monogrammed line pipe shall be based on conformance with API Specification 5L.

This practice shall become effective on the date printed on the cover but may be used voluntarily from the date of distribution.

Suggested revisions are invited and should be submitted to the director of the Exploration and Production Department, American Petroleum Institute, 1220 L Street, N.W., Washington, D.C. 20005.

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1 Scope and Application

1.1 BASIS FOR INSPECTION

This document contains practices recommended for use in the inspection of new line pipe subsequent to production by the manufacturer. Appendix A contains ordering information for owners desiring to order inspection of new pipe per this document. The basis for performing an inspection may have its origin either in API Specification 5L or in a supplemental specification or contract prepared by the owner. The inspections represented by the practices may be placed in one of three categories as follows:

a. Inspections specified in API Specification 5L.
b. Inspections specified as one of several options in API Specification 5L.
c. Inspections not specified in API Specification 5L.

1.2 APPLICABILITY OF INSPECTIONS

1.2.1 Some of the practices contained in this recommended practice are applicable to pipe regardless of size or type. Other practices typically may have limited applicability. Table 1 indicates those inspections that are available in the field and covered by this recommended practice in relation to pipe type. It is the owner's responsibility to specify which inspections are to be used when completing the ordering information (see Appendix A) to accompany an inspection contract.

1.3 REPEATABILITY OF RESULTS

1.3.1 Sources of Variation

Every inspection and measurement process is characterized by an inherent variability of results. The nondestructive inspections and measurements included in this recommended practice are characterized by additional inherent variability attributable to the following factors:

a. API Specification 5L permits options in the selection of practices to be used in the inspection for specific attributes.
b. Within a single practice, API Specification 5L permits options in the selection of calibration standards.
c. Each manufacturer of nondestructive inspection systems uses different mechanical and electronic designs.
d. Certain practices in this recommended practice are based on operation of the system at high, and even maximum, sensitivity without the use of the reference standards specified in API Specification 5L.
e. Within the performance capability of a single nondestructive inspection system installation, there will not be perfect repeatability of results.
f. API Specification 5L contains provisions for a number of uses of radiological inspection of double submerged arc welds (DSAW) pipe, which are neither contained nor specifically referenced in this recommended practice. The possibility exists that material classified as rejected using practices in this recommended practice may have been inspected and classified prime by the manufacturer using radiological inspection or reinspection procedures in compliance with API Specification 5L.

Table 1—Field Inspections Available

Inspection (see Note 1 below)	Pipe Type (see Notes 2 and 3 below)			
	CW	SMLS	EW	AW
FLVI	All	All	All	All
DBE	All	All	All	All
Hardness	All	All	All	All
FLMPIW	N	N.A.	All	All
FLMPOW	N	N.A.	All	All
FLMPI	N	All	All	All
FLMPO	N	All	All	All
EAI	All	All	All	N
EMI	EQ	EQ	EQ	N
Residual magnetism	All	All	All	All
Gamma wall thickness	N	All	All	N
Grade comparison	N	All	All	N
UTBL	N	All	All	N
UTBLTO	N	EQ	EQ	N
UTW	N	N.A.	All	All
UTLE	N	All	All	All
Hand-held UT gauging	All	All	All	All

Note 1: Key to inspection abbreviations:

DBE	Diameter and bevel check, pipe ends
EAI	End area inspection
EMI	Electromagnetic inspection
FLMPI	Full-length magnetic particle, inside surface
FLMPIW	Full-length magnetic particle, inside weld
FLMPO	Full-length magnetic particle, outside surface
FLMPOW	Full-length magnetic particle, outside weld
FLVI	Full-length visual inspection
UTBL	Ultrasonic body laminations and wall thickness
UTBLTO	Ultrasonic body longitudinal, transverse, oblique
UTLE	Ultrasonic lamination check, pipe ends
UTW	Ultrasonic inspection, weld only

Note 2: Key to pipe types:

AW	Arc-welded pipe
CW	Continuous-welded pipe (butt-welded)
EW	Electric-welded pipe
SMLS	Seamless pipe

Note 3: Key to applicability of inspections:

All	Inspection may be applicable throughout the diameter range.
EQ	Inspection may be applicable throughout the diameter range subject to equipment limitations.
N	Inspection usually is not applicable for this type pipe.
N.A.	Not applicable because there are no welds in seamless pipe.

1.4 CONSEQUENCES OF VARIABILITY

1.4.1 Disposition

For any of the reasons given in 1.3.1, the results of field inspection may not duplicate corresponding inspections performed during manufacture. Variability within and among the results of practices contained in the recommended practice is to be expected. When field inspection results in the classification of pipe as other than prime, it shall not be presumed that the material is defective until an evaluation has been performed in accordance with Section 16, to establish final disposition.

1.4.2 Responsibility For Rejections

In some cases, a pipe inspected using practices described in this recommended practice may be classified as a reject, even though it was inspected in conformance with API Specification 5L and classified as an acceptable pipe in conformance with API Specification 5L by the manufacturer. Responsibility for a rejection shall be based on the acceptance criteria contained in API Specification 5L or on an additional or more restrictive criteria previously negotiated with the manufacturer. Under no circumstances will the results of field nondestructive inspection stand alone as a basis for rejection without corroborating evidence that the material is properly classified as defective based on the appropriate evaluation(s) performed in accordance with Section 16 of this recommended practice. In case disposition is disputed between the purchaser and the manufacturer, the provisions of H.4 of API Specification 5L shall apply.

2 References

This recommended practice includes by reference, either in total or in part, other API, industry standards listed below. The latest edition of these standards should be used unless otherwise noted below:

API

Spec 5L	*Line Pipe*
Bull 5T1	*Imperfection Terminology*

ASNT[1]

SNT-TC-1A	*Personnel Qualification and Certification in Nondestructive Testing*

ASTM[2]

E 110	*Indentation Hardness of Metallic Materials by Portable Hardness Testers*

[1]American Society for Nondestructive Testing, 4153 Arlingate Plaza, Columbus, Ohio 43228-0518.
[2]American Society of Testing and Materials, 100 Bar Harbor Drive, West Conshohocken, Pennsylvania 19428.

3 Definition of Terms

The following terms are frequently used in the field inspection of new line pipe:

3.1 AC field: The active magnetic field produced by the use of alternating current.

3.2 agency: The entity contracted to inspect new line pipe using the methods and criteria specified.

3.3 alternating current (AC): Current that reverses its direction of flow at regular intervals.

3.4 ampere (A or amp): A unit of electrical current.

3.5 ampere-turns (A-t): The product of the number of turns in a coil and the number of amperes of current flowing through it. This is a measure of the magnetizing strength of the coil. For example: 800 amperes in a 6-turn coil = 4800 A-t.

3.6 angle beam: A term used to describe an angle of incidence or refraction other than normal to the surface of the test object. This includes shear waves and longitudinal (compression) waves.

3.7 API: American Petroleum Institute.

3.8 arcing: Current flow through a gap, often accompanied by intense heat and light.

3.9 artificial discontinuity: See *reference reflector.*

3.10 ASNT: American Society for Nondestructive Testing.

3.11 ASTM: American Society for Testing and Materials.

3.12 back reflection: In ultrasonic testing, the signal received from the back surface of the pipe wall.

3.13 backscatter: Secondary radiations resulting from the interaction between the primary gamma radiations from the source and the pipe wall.

3.14 bevel: On plain-end line pipe, the angle (excluding a right angle) to which the end is finished, measured from a line drawn perpendicular to the axis of the pipe.

3.15 bevel gauge: The term applied to any instrument which may be used to measure the pipe and bevel angle. Bevel gauges may be template-type gauges with fixed angles or adjustable protractor-type gauges.

3.16 black light: A colloquial expression used to describe long wave ultraviolet light (UV-A). See *ultraviolet light.*

3.17 borescope: A long optical instrument with an illuminating lamp for inspecting the inside surface of a pipe.

3.18 butt-weld pipe: See *continuous weld pipe.*

3.19 calibration: The adjustment of instruments, prior to use, to a known basic reference often traceable to the National Institute of Standards and Technology.

3.20 cathode ray tube (CRT): A vacuum tube with a luminescent screen often used for viewing ultrasonic echo signals or for video readouts of computer stored data.

3.21 central conductor (shooting rod): A conductor that is passed through the pipe, for the purpose of creating a circular or circumferential magnetic field in the pipe. This term does not imply that the current rod must be centered in the pipe.

3.22 chock: Block or wedge used beneath a length of pipe so that it cannot roll.

3.23 circular (circumferential) magnetic field: The magnetic field in or surrounding a current-carrying conductor or pipe with an interior current-carrying rod.

3.24 circular (circumferential) magnetization: Circular magnetization is the production of a magnetic field in a pipe wall such that the magnetic field is oriented circumferentially.

3.25 circumferential magnetization: See *circular magnetization.*

3.26 classification: The action taken to categorize a length of new line pipe based on conformance with the contracted inspection requirements.

3.27 coating: A nonmetallic material bonded to the external or internal surface of the pipe. External coatings are normally applied for corrosion protection purposes while internal coatings are usually applied for corrosion protection or to improve flow efficiency. Pipe may have a chemical conversion coating that is used to retard rust during storage or shipment.

3.28 coil method: A method of magnetizing in which pipe is encircled by a current-carrying coil.

3.29 coil shot: A short pulse of magnetizing current passed through a coil surrounding a pipe for the purpose of longitudinal magnetization.

3.30 cold expanded pipe: Pipe in which the final diameter is attained by either internal mechanical or hydraulic expansion of the pipe.

3.31 color code: Paint band identification of pipe classification in accordance with appropriate specifications.

3.32 contact method (current flow method): A method of magnetizing pipe by passing a current through its wall via prods or hand-held contacts.

3.33 continuous method: A method of searching for flaws while the magnetizing current is being applied.

3.34 continuous weld pipe: Pipe having one longitudinal seam formed by mechanical pressure to make the welded junction, the edges being furnace heated to the welding temperature prior to welding.

3.35 contour (verb)**:** The gradual tapering by filing or grinding to prevent abrupt changes in the wall thickness.

3.36 contract: The documented agreement that specifies the terms of the inspections to be performed.

3.37 controlled area: A defined area in which the occupational exposure of personnel to radiation or to radioactive material is under the supervision of an individual in charge of radiation protection. (This implies that a controlled area is one that requires control of access, occupancy, and working conditions for radiation protection purposes.)

3.38 couplant: A material (usually a liquid) used between an ultrasonic transducer and the test specimen to conduct ultrasonic energy between them.

3.39 CRT: See *cathode ray tube.*

3.40 DC field: Either a residual magnetic field or an active magnetic field produced through the use of direct current.

3.41 dead zone (ultrasonic): The distance from the front surface of the pipe to the nearest inspectable depth.

3.42 defect: An imperfection of sufficient magnitude or properties to warrant rejection of the pipe, based on the stipulations of the latest edition of the applicable specification(s).

3.43 demagnetization: The process of removing part or all of the existing residual magnetism from the pipe.

3.44 detect: The act of locating a flaw or imperfection.

3.45 detector or detector shoe: A scanning shoe carrying one or more transducers. It is used to protect transducers from mechanical damage from the pipe surface, and so forth.

3.46 diameter tape: A measuring device consisting of a thin, flexible, metallic tape that can be wrapped around the circumference of the pipe and is graduated such that pipe diameter can be directly read from the scale. A diameter tape is also referred to as pi tape.

3.47 differential wiring: Coils electrically connected in opposed series such that the output of one coil effectively opposes the other coil. In search coils, the differential wiring results in equal and opposite voltages being developed when the magnetic field changes equally in each coil. Thus, no net voltage output is produced.

3.48 diffuse indications (magnetic particle): Indications that are not clearly defined as, for example, indications of subsurface imperfections.

3.49 direct current (DC): Refers to an electric current flowing continually in one direction only through a conductor.

3.50 discontinuity: An irregularity in the pipe such as laps, seams, pits, and laminations. Also called a flaw or imperfection.

3.51 disposition: The action taken in conformance with API Specification 5L with regard to a defect in a length of new line pipe. The defect may be removed, weld repaired, cut off or rejected. See 9.7.5.4 of API Specification 5L for restrictions.

3.52 dose rate: The amount of ionizing radiation energy absorbed per unit of mass and time of irradiated material. Measured in reps, rem, or rad.

3.53 dosimeter: A device that measures radiation dose, such as a film badge or ionization chamber.

3.54 double extra strong: A schedule of wall thicknesses for different sizes of pipe. It is abbreviated as XXS.

3.55 double random length (DRL): A term denoting the length of a pipe. In a shipment of pipe of double random lengths, the minimum average length for each order item is 35 feet.

3.56 double seam arc welded pipe: Pipe having two longitudinal seams formed by the submerged arc welding process or the gas metal arc-welding process or a combination of both processes. Location of seams are approximately 180 degrees apart.

3.57 DRL: Abbreviation for double random length.

3.58 DSAW: Abbreviation for double submerged arc weld (single seam).

3.59 dry method: A magnetic particle inspection method in which the particles employed are in dry powder form.

3.60 dual transducer: An ultrasonic probe containing two piezoelectric crystals, one for transmitting and one for receiving.

3.61 eddy current: Circulating current caused to flow in the pipe by varying magnetic fields.

3.62 electric-weld pipe: Pipe having one longitudinal seam formed by electric resistance welding (ERW) or electric induction welding without the addition of extraneous (filler) metal.

3.63 electromagnet (EM): When ferromagnetic material is surrounded by a current carrying coil, it becomes magnetized and is called an electromagnet.

3.64 electromagnetic inspection: A general term including primarily the eddy current and flux leakage methods for the detection of imperfections. Field electromagnetic inspection systems may include equipment for performing additional inspections or services.

3.65 encircling coil: A coil surrounding the pipe being tested.

3.66 end effect: The reduction in magnetization near the ends of a length of magnetized pipe due to the demagnetizing effect of the poles at the pipe ends.

3.67 ERW: An abbreviation for electric resistance welding.

3.68 evaluation: Process of determining the severity of an imperfection which leads to determining whether the pipe is acceptable or rejectable under the appropriate specification.

3.69 extra strong: A schedule of wall thicknesses for different sizes of pipe. It is abbreviated as XS.

3.70 false indication: An indication that may be interpreted erroneously as an imperfection or defect. An irrelevant indication. Sometimes called artifact.

3.71 ferromagnetic: A term applied to materials that can be magnetized or strongly attracted by a magnetic field.

3.72 film badge: A package of photographic film worn like a badge by some workers in the inspection industry to measure exposure to ionizing radiation. The absorbed dose can be calculated by the degree of film-darkening caused by the irradiation.

3.73 fluorescence: The emission of visible radiation by a substance as the result of the absorption of ultraviolet light radiation.

3.74 fluorescent magnetic particle inspection: The magnetic particle inspection process employing a finely divided fluorescent ferromagnetic inspection medium that fluoresces when activated by ultraviolet light (3200 to 4000 angstroms).

3.75 flux density: The strength of a magnetic field expressed in flux lines per unit area, that is, gauss, kilogauss.

3.76 flux leakage: This is the magnetic field forced out into the air by a distortion of the field within the pipe caused by the presence of a discontinuity.

3.77 flux lines: Imaginary magnetic lines used as a means of explaining the behavior of magnetic fields. The conception of flux lines is based on the pattern of lines produced when iron filings are sprinkled on a piece of paper laid over a magnet. Synonymous with magnetic lines of force.

3.78 frequency (Hz): Number of complete cycles of a wave motion per second of time. Unit of measure is called hertz.

3.79 full body: This term refers to inspection coverage of the entire surface area of the pipe within the limitations of the inspection equipment used. For example, EMI equipment normally does not provide coverage of 6 to 12 inches on each pipe end.

3.80 furring: Buildup or bristling of magnetic particles at the ends of a longitudinal magnetized pipe, that is, at its poles.

3.81 gain control: A sensitivity adjustment on an amplifier or circuit.

3.82 gamma rays: High-energy, short-wave-length electromagnetic radiation emitted by a nucleus. Energies of gamma rays are usually between 0.010 and 10 Mev. Gamma rays are penetrating and are best attenuated by dense material like lead or tungsten.

3.83 gas metal-arc welded pipe: Pipe having one longitudinal seam formed by continuous gas-metal arc welding. At least one pass is made inside the pipe and at least one pass is made from the outside of the pipe.

3.84 gauss (G): This is the unit of flux density or induction. Numerically, one gauss is one line of flux per square centimeter of area.

3.85 gaussmeter: See magnetometer.

3.86 grind, probe: An exploratory grind made to determine the depth of an imperfection.

3.87 grind, radius: Grinding performed to remove sharp edges and/or abrupt changes in the wall thickness around exploratory grinds or imperfections.

3.88 grind, removal: A grind made to remove a questionable imperfection and to make the product comply with the appropriate specification (see API Specification 5L, 9.7.5.4).

3.89 grinding: Removing material from a pipe surface by abrading, for example, by grinding wheel or file.

3.90 handling damage: Cuts, gouges, and dents that occurred during handling (loading, unloading, shifts in transit, and so forth).

3.91 hardness: A measure of the hardness of a metal, as determined by pressing a hard steel ball or diamond penetrator into a smooth surface under standard conditions. Results are often expressed in terms of Rockwell hardness number (HRB or HRC) or Brinell hardness number (BHN). Refer to ASTM E10, ASTM E18, and ASTM E110 for added information.

3.92 hardness value (hardness testing): The average of the valid readings taken in the test area.

3.93 ID: Inside diameter.

3.94 imperfection: A discontinuity or irregularity in the product, sometimes called a flaw. For exact definitions and illustrations of specific imperfections, see API Bulletin 5T1.

3.95 indication: A response from nondestructive inspection that requires interpretation in order to determine its significance, (for example, a blip on the log or a powder buildup on the pipe).

3.96 indicator (or readout): A device for displaying a condition, current, or potential. Typical ones used on inspection instruments are galvanometers, De Arsenval (dial) or digital meters, CRTs, or warning lights.

3.97 induction: The magnetism induced in a ferromagnetic body by an outside magnetizing force.

3.98 inspection: The process of examining materials and pipes for possible defects or for deviation from established standards.

3.99 inspection job: The inspection of one or more lots of pipe by an agency subject to a single contract or subcontract as appropriate.

3.100 inspector: An employee of an agency qualified and responsible for one or more of the inspections or tests specified in the contract.

3.101 interpretation: The process of determining the nature of an indication.

3.102 ionization chamber: An instrument that detects and measures ionizing radiation by observing the electrical current created when radiation ionizes gas in the chamber, making it a conductor of electricity.

3.103 jointer: A length of pipe made up of two shorter pieces of pipe.

3.104 land: See *root face*.

3.105 leakage field: The magnetic field forced out of the material into the air by distortion of the field within the material caused by the presence of a discontinuity.

3.106 length: A complete section of pipe (colloquial term is *joint*).

3.107 licensed material: Radiation source material possessed, used, or transferred under license issued by the appropriate government agency.

3.108 lift-off: The perpendicular distance between detector shoe and pipe surface: sometimes called *standoff*.

3.109 line pipe: Pipe used for conveyance in the oil, chemical, and natural gas industries.

3.110 log: The strip chart record or readout of the detected imperfections in the pipe being inspected by EMI or other electronic inspection equipment.

3.111 longitudinal magnetic field: Magnetization of a material in such a way that the magnetic flux runs substantially parallel to the axis of the pipe.

3.112 longitudinal imperfection: An imperfection that has its principal direction or dimension approximately in the longitudinal direction.

3.113 loss of back reflection (ultrasonic): Absence of, or a significant reduction in, an indication from the back surface of the article being inspected.

3.114 magnetic field: The space around a magnet within which ferromagnetic materials are attracted.

3.115 magnetic particle field indicator: A device containing artificial flaws that is used to verify the adequacy or direction, or both, of a magnetic field.

3.116 magnetic particles: Finely divided ferromagnetic material capable of being individually magnetized and attracted to distortions in a magnetic field.

3.117 magnetic poles: The area on a magnetized pipe where the magnetic field is "leaving or returning," usually at its end when longitudinally magnetized.

3.118 magnetism: The ability of a magnet to attract or repel another magnet. Also recognized as a force-field surrounding conductors carrying electric current.

3.119 magnetizing force: The total force tending to set up a magnetic field in a magnetic circuit divided by its length. It is usually designated by the letter H and the unit is the oersted.

3.120 magnetometer: Either a mechanical or electronic instrument for measuring magnetic field strength. An electronic magnetometer is also known as a gaussmeter.

3.121 magnetomotive force (mmf): The product of the current and the number of turns in a current carrying coil.

3.122 manufacturer: The entity last responsible for manufacturing compliance with API Specification 5L and for selling the pipe to the purchaser.

3.123 marking: The assorted marks on tubular products. Includes inspection markings made with paint sticks and stencils and ball-point paint tubes.

3.124 may: A term used to indicate that a provision is optional.

3.125 mill grind: An area of the pipe surface removed by grinding during the manufacturing process.

3.126 mill scale: An oxide of iron that forms on the surface of hot steel.

3.127 monitoring radiation: Periodic or continuous determination of the amount of ionizing radiation present in a region.

3.128 MPI: Abbreviation for magnetic particle inspection.

3.129 nondestructive evaluation (NDE): Same as nondestructive testing.

3.130 nondestructive testing (NDT): Inspection to detect internal, surface, and concealed defects or imperfections in materials using techniques that do not damage or destroy the items being tested.

3.131 normal beam: A vibrating pulse wave train traveling normal to the test surface.

3.132 notch: See *reference reflector.*

3.133 oblique imperfection: An imperfection at an angle other than longitudinal or transverse.

3.134 OD: Outside diameter. Often used as an abbreviation for outside surface.

3.135 owner: The entity who has ownership of the new line pipe at the time inspection is contracted, specifies the type of inspection or testing to be conducted and authorizes its performance. The owner may be the purchaser.

3.136 penetrometer (radiography): In radiography, a device used to determine the sensitivity of a radiographic image. There are many types of penetrometers in radiography ranging from thin wires to step wedges, but the usual form consists of a flat strip (preferably of the same material as the specimen), with its thickness a fixed percentage of the specimen thickness and with small holes whose diameter bear fixed ratios to the penetrometer thickness.

3.137 permeability: (1) The ease with which material can become magnetized; (2) the ratio of flux density produced to magnetizing force, that is, B/H.

3.138 permanent magnet: A magnet or body that retains a strong residual magnetic field.

3.139 personnel monitoring equipment: Device designed to be worn or carried by an individual for the purpose of measuring the radiation dose received (for example, film badges, pocket dosimeters, film rings, and so forth).

3.140 pipe: In this document, refers to line pipe.

3.141 plain-end: For line pipe, this term refers to the preparation on each end of the pipe and, depending on the pipe size and type or how the purchaser specifies, can be either square cut or with a bevel.

3.142 planar: This term refers to an imperfection in one geometric plane that is normally parallel to, and within, the outer and inner pipe surfaces.

3.143 pole: The area of a magnetized pipe where a magnetic field is leaving or returning.

3.144 pole piece: The ferromagnetic portion of a magnetic circuit attached to the core used to shape and direct the magnetic field through the air gaps into the wall of the pipe being inspected.

3.145 powder dry: A pipe surface that is sufficiently dry to allow any type of powder, applied to the surface, to be blown from the surface without a remaining residue.

3.146 precision caliper: A measuring device, usually with two legs or jaws, that can be adjusted to determine the thickness, diameter, and distance between surfaces. The device may be equipped with a vernier or dial.

3.147 precision ruler: A smooth-edged strip (usually of wood or metal) that is marked off in units, usually to 1/100 of an inch, and is used for measuring.

3.148 prime pipe: Pipe meeting all of the specified inspection and testing requirements.

3.149 probe: Transducer or search unit.

3.150 process capability: The ability of a process or NDT method to repeatedly detect a defect under normal conditions of variability. Sometimes related to confidence level.

3.151 prod magnetization: Magnetization of the pipe by direct contact, that is, passing current through the pipe wall with prods.

3.152 prods: Hand-held electrodes attached to cables to transmit the magnetizing current from the source to the pipe under inspection.

3.153 protractor: A device or instrument used to measure an angle.

3.154 pulse: A wave of short duration.

3.155 pulse-echo method: An ultrasonic test method that both generates ultrasonic pulses and receives the return echo.

3.156 pulser: Electronic device and probe for generating a controlled magnitude magnetic pulse for standardizing transducers.

3.157 pulse length (or pulse duration): The time between the points when the instantaneous value of current exceeds 10 percent of the maximum pulse current. Measured in milliseconds.

3.158 purchaser: The entity that has purchased directly from the manufacturer the new line pipe being inspected. The purchaser may be the owner.

3.159 radiation safety officer: An individual engaged in the practice of providing radiation protection. The officer is the representative appointed by the licensee for liaison with the Nuclear Regulatory Commission and with agreement states radiation control branches.

3.160 radiography: The process of making a photographic record of an object produced by the passage of X rays or gamma rays through the object into a film.

3.161 reading (hardness testing): The number that is obtained from the instrument dial from a single penetration of the indenter into the pipe wall.

3.162 readout: A device that visually indicates a condition, voltage, or current. Typical devices used in inspection requirements are galvanometers and CRTs.

3.163 recommended practice (RP): A standard to facilitate the broad availability of proven sound engineering and operating practices.

3.164 reference reflector: Real or artificial discontinuities in a reference standard that provide reproducible sensitivity levels for inspection equipment. Artificial reflectors may be holes, notches, grooves, or slots.

3.165 reference standard: A pipe, or pipe section, containing one or more reference reflectors used as a base for comparison or for inspection equipment standardization.

3.166 reflection: The characteristic of a surface to change the direction of propagating acoustic waves; the return of sound waves from surfaces.

3.167 reject level (to be evaluated): The value that is established as a baseline test signal and is used to determine whether specimens that are above or below the baseline may be rejectable, or otherwise distinguished from the remaining specimens.

3.168 relevant indication: An indication resulting from a discontinuity in the pipe.

3.169 residual field: The remaining magnetic field retained by ferromagnetic materials after they have been exposed to a magnetic force.

3.170 residual method: Inspection utilizing the residual magnetic field remaining in the pipe after magnetization for obtaining indications.

3.171 resolving power (ultrasonics): The measure of the capability of an ultrasonic system to separate in time two discontinuities at slightly different distances.

3.172 ring gauge: A hand-held device usually consisting of a fabricated circular piece of flat steel plate with a bored hole of specified diameter. The device is applied over the pipe ends to check the pipe outside diameter.

3.173 root face: On plain end line pipe, beveled for welding, the root face is the surface that is perpendicular to the pipe axis between the bevel and the inside surface of the pipe. Also referred to as land or root land.

3.174 root land: See root face.

3.175 scanner: A detector assembly carrying one or more transducers for detecting flaws in pipe. (See detector unit.) Often the scanner is equipped with a magnetizer and is a part of it.

3.176 scatter: Secondary radiation that is emitted in all directions.

3.177 seamless pipe: A wrought steel tubular product made without a welded seam. It is manufactured by hot working steel, or if necessary, by subsequently cold finishing the hot-worked tubular product to produce the desired shape, dimensions, and properties.

3.178 search coil: Small coil or coils mounted in a transducer shoe.

3.179 search probe: A small coil or coil assembly that is placed on or near the pipe surface for detecting flaws and defects.

3.180 sensitivity: The size of the smallest discontinuity detectable by a nondestructive test method with a reasonable signal-to-noise level.

3.181 sensitivity, percentage: A ratio of the smallest flaw detectable divided by the wall thickness of the pipe being examined.

3.182 shall: Used to indicate that a provision is mandatory.

3.183 shallow flaw or discontinuity: A discontinuity that has little depth in proportion to wall thickness.

3.184 shield: A layer or mass of material used to reduce the passage of ionizing radiation.

3.185 shoe: See detector shoe.

3.186 shoot: Pass a short-time pulse of high current through a conductor.

3.187 shot: Short-time pulse of current.

3.188 shot field: Residual magnetic field induced by a short impulse of magnetizing current. Often it is generated using a battery or capacitor discharge magnetizer.

3.189 should: Used to indicate that a provision is not mandatory but recommended as good practice.

3.190 signal: A response of electronic NDT equipment to a pipe imperfection or defect.

3.191 signal-to-noise ratio: The ratio of the signal from a significant flaw or defect to signals generated from surface noise.

3.192 single random length: A term denoting the length of a pipe. In a shipment of pipe of single random lengths, the minimum average length for the entire shipment is 17.5 feet.

3.193 skelp: A coil or strip of metal produced to a certain thickness, width, and edge configuration from which welded pipe is made.

3.194 SOP: An abbreviation for standard operating procedures.

3.195 source: The origin of radiation, an X ray tube, or a radioisotope.

3.196 spiral weld pipe: Pipe having a helical seam produced by automatic submerged arc welding. At least one pass is made on the inside and at least one pass on the outside.

3.197 SRL: Abbreviation for single random length.

3.198 standardization: The adjustment of instruments, prior to use, to an arbitrary reference value.

3.199 standardization check: A check of the standardization adjustments to ensure that they remain correct.

3.200 standard weight: A schedule of wall thicknesses for different sizes of pipe. It is abbreviated STD.

3.201 STD: See standard weight.

3.202 straightness: The degree to which the longitudinal axis of a pipe parallels a straight line.

3.203 stress: The load per unit area.

3.204 submerged-arc welded pipe: Pipe having one longitudinal seam formed by automatic submerged arc welding. At least one pass is made from inside the pipe and at least one pass is made from the outside.

3.205 subsurface discontinuity or imperfection: Any discontinuity that does not open onto the surface (either ID or OD).

3.206 surface speed: Velocity of the transducer shoe over the surface of the pipe.

3.207 survey: An evaluation of the radiation levels incident to the presence and use of radioactive materials.

3.208 survey meter: A portable instrument that measures dose rate exposure of radiation intensity.

3.209 tally: The individual length of line pipe normally measured to the nearest $^{1}/_{10}$ of a foot. Also a record of the overall total length of a line pipe order or a batch of line pipe.

3.210 test (hardness testing): Two or more valid readings that have been made in the same test area. Readings are usable when they are within two Rockwell C numbers (HRC) of one another or four Rockwell B numbers (HRB) of one another.

3.211 test area (hardness testing): An area on the pipe that has been ground or filed smooth and flat to remove the decarburized surface material.

3.212 test block: Special precision made blocks used as standards to facilitate rapid calibration of an inspection instrument.

3.213 third party inspector: See agency or inspector.

3.214 tolerance: The permissible deviation from the specified value.

3.215 transducer: Devices used for converting a pipe condition into an electrical signal. This is a term which includes all ultrasonic probes, search coils, eddy current probes and most other detectors.

3.216 transverse: Literally means *across*, usually signifying circumferential or substantially circumferential in direction.

3.217 ultrasonic testing (UT): A nondestructive method of inspecting materials by the use of high-frequency sound waves.

3.218 ultrasonic: Relating to frequencies above the audible range, that is, in excess of 20 kilohertz (kHz).

3.219 ultraviolet light (W): Light in the ultraviolet wavelengths of 3200 to 4000 angstrom, just shorter than visible light.

3.220 velocity, ultrasonic: The speed at which sound waves travel through a medium.

3.221 voltage (V): The unit of potential causing the flow of current.

3.222 welded jointer: Two pieces of pipe welded together to make up a standard length.

3.223 wet method: The magnetic particle inspection method employing ferromagnetic particles suspended in a liquid bath.

3.224 wetting agent: A substance that lowers the surface tension of a liquid.

3.225 XS: See extra strong.

3.226 XXS: See double extra strong.

3.227 yoke: A U-shaped piece of soft magnetic material, either solid or laminated, around which is wound a coil carrying the magnetizing current.

3.228 yoke magnetization: A magnetic field induced in a pipe, or in an area of a pipe, by means of an external electromagnet shaped like a yoke.

3.229 zero: The act of setting a dial indicating depth gauge for zero depth. Past tense is *zeroed*.

Note: For definitions of specific types of defects and imperfections, refer to API Bulletin 5T1.

4 Quality Assurance

4.1 The agency performing field inspection shall have a quality program consistent with the provisions of API Specification Q1, or ISO 9001.

4.1.1 The agency's quality program shall be documented and shall include written procedures for all inspections performed.

4.1.2 The agency's quality program shall include documented procedures for the calibration and verification of the accuracy of all measuring, testing, and inspection equipment and materials.

4.1.3 The agency's quality program shall include provisions for the education, training, and qualification of personnel performing inspections in accordance with this recommended practice.

5 Qualification of Inspection Personnel

5.1 SCOPE

This section sets forth the minimum requirements for qualification and certification (where applicable) of personnel performing field inspection of new, plain end line pipe.

5.2 WRITTEN PROCEDURE

5.2.1 Agencies performing inspection of new line pipe in accordance with this recommended practice shall have a written procedure for education, training, and qualification of personnel.

5.2.2 The written procedure shall:

a. Establish administrative duties and responsibilities for execution of the written procedure.
b. Establish personnel qualification requirements.
c. Require documentation verifying all qualifications.

5.3 QUALIFICATION OF INSPECTION PERSONNEL

5.3.1 The qualification requirements and qualification of inspection personnel shall be the responsibility of the agency.

5.3.2 The requirements shall include as a minimum:

a. Training and experience commensurate with the inspector's level of qualification.
b. Written and practical examinations with acceptable grades.
c. A vision examination.
d. Knowledge of the applicable sections in API documents: Specification 5L, Bulletin 5T1 and this document.

5.4 TRAINING PROGRAMS

All qualified personnel shall have completed a documented training program designed for that level of qualification.

Training may be given by the agency or an outside agent. The *program shall include:*

a. Principles of each inspection method.
b. Procedures for each inspection method, including calibration and operation of inspection equipment.
c. Related sections of the applicable API standards.

5.5 EXAMINATIONS

All candidates for qualification shall have successfully completed the following examinations given by the agency or an outside agent:

a. Written examinations addressing the general and specific principles of the inspection method, the inspection procedures, and the applicable API standards.
b. A hands-on or operating examination that includes apparatus assembly, calibration, inspection techniques, operating procedures, interpretation of results for appropriate levels, and related report preparation.
c. Natural or corrected vision to read J-2 letters on a Jaeger number 2 test chart at a distance of 12 to 15 inches. Equivalent tests such as the ability to perceive a Titmus number 8 target, a Snellen fraction 20/25, or vision examinations with optical apparatus administered by physicians are also acceptable.

5.6 EXPERIENCE

All candidates for qualification shall have the experience required by the written procedure.

5.7 REQUALIFICATION

5.7.1 Requalification requirements shall be defined in the written procedures.

5.7.2 Requalification is required at least every five years for all personnel.

5.7.3 Requalification also is required for personnel who have not performed defined functions within the previous 12 months or who have changed employers.

5.7.4 As a minimum requirement for requalification, all personnel shall achieve an acceptable grade on a written examination addressing the current tubular inspection procedures and the applicable API documents.

5.8 DOCUMENTATION

Record retention and documentation are required for all qualification programs. The following are minimum requirements:

a. All qualified personnel shall receive a certificate stating their level of qualification.
b. The records showing training program completion, experience, and examinations for all qualified personnel shall be maintained by the agency and made available for review upon request.
c. All qualifications and related documents shall be approved by authorized agency personnel.

5.9 NDT PERSONNEL CERTIFICATION

5.9.1 A program for certification of NDT personnel shall be developed by the agency. The latest edition of the American Society for Nondestructive Testing Recommended Practice No. SNT-TC-1A may be used as a guideline.

5.9.2 The administration of the NDT personnel certification program shall be the responsibility of the agency.

5.9.3 The API is neither responsible for administering the NDT certification program nor acting as a certifying agent in the program.

6 General Inspection Procedures

6.1 SCOPE

This section covers general procedures applicable to all inspection methods contained in this recommended practice.

6.1.1 Reference Documents

The following API documents are relevant to this recommended practice:

a. API Specification 5L.
b. API Bulletin 5T1.

6.1.2 Documents at Jobsite

The following inspection-related documents shall be available at the jobsite:

a. API Specification 5L.
b. API Bulletin 5T1.
c. All applicable agency inspection procedure documents.
d. The field inspection contract or agency inspection order based on the contract.

6.2 PRE-INSPECTION PROCEDURES

6.2.1 Each inspection job shall start with the correct equipment available and in good working condition.

6.2.2 A copy of the current applicable API standards shall be on the jobsite at all times while inspection and evaluation of imperfections are being performed.

6.2.3 Prior to equipment setup, the agency shall ensure that the pipe to be inspected is the pipe that the owner has ordered inspected by comparing the information on the job order with the pipe markings, that is, size, weight, grade, manufacturer, and whether seamless or welded.

6.2.4 All line pipe inspection should begin by uniquely numbering or renumbering each length with a paint marker. If the line pipe is 8⅝ inches or larger, place the sequence number 8 to 18 inches from each end, on the inside surface. On line pipe smaller than 8⅝ inches, place the sequence number on the outside surface approximately 2 feet from each end. Do not place numbers over mill paint stencils. During line pipe inspection, if a defect is found and marked, continue to inspect the entire length so that the disposition of the pipe can be accurately determined.

6.3 RECORDS AND NOTIFICATION

As inspection progresses, maintain a record of the classification of the pipe inspected. If at any time after 50 lengths have been inspected or tested the reject rate exceeds 10 percent of the pipe inspected, notify the owner or the owner's representative. When appropriate, it is suggested that the manufacturer, or the manufacturer's representative, be notified in turn through the purchaser.

6.4 POST-INSPECTION PROCEDURES

6.4.1 Pipe Classification

Classify each length of pipe into one of the categories listed below (see Section 17 for details):

a. Prime pipe, including repaired pipe.
b. Pipe with defects that have not been conditioned.
c. Pipe containing imperfections whose depth cannot be determined.
d. Pipe that contains nonconditionable defects.

6.4.2 Pipe Marking

Mark the classification of each length with paint markings as described in Section 17.

6.4.3 Tally and Count Lengths

Tally and count the lengths in each of the classification categories. Be sure to verify the length count totals after the initial count.

6.4.4 Bevel Protector

Check the protectors to ensure they have been properly installed.

6.4.5 Jobsite Checklist

Before leaving the jobsite, the agency shall ensure that the following items have been completed:

a. Pipe racking. The agency shall ensure that each row of pipe has been properly secured (with chocks) for safety, and that no loose or unsecured pipe is left free to roll or fall from the racks. No pipe shall be left on the ground.
b. Debris removal. The jobsite shall be left neatly arranged and clean of all job-related debris.
c. Solvent disposal. Cleaning solvents used at the jobsite should be disposed of properly.

6.4.6 Documentation

A field copy of the completed inspection report and supporting documents should be delivered to the customer or specified representative upon completion of the job. Defect terminology shall comply with API Bulletin 5T1, where applicable.

7 Acceptance Criteria, Disposition, and Responsibility

7.1 SCOPE

This section sets forth the principles for determining acceptance criteria, disposition, and responsibility for pipe inspected in accordance with this recommended practice.

7.2 BASIS FOR ACCEPTANCE

The latest edition of API Specification 5L shall constitute the basis for acceptance of pipe inspected in accordance with this recommended practice, except that additional or more restrictive criteria may be contracted between the owner and the agency.

7.3 RESPONSIBILITY FOR REJECTIONS

For the purpose of this paragraph, a rejection is any pipe not classified as prime as the result of field inspection.

7.3.1 The manufacturer shall be responsible for rejects which, after evaluation, are demonstrated to be nonconforming to the requirements of API Specification 5L. Manufacturer responsibility for defects attributable to handling or shipping shall be limited to those conditions reported to the manufacturer at or prior to delivery to the purchaser. Rejection shall not be based solely on unevaluated imperfections or indications (see 7.3.3).

7.3.2 In an identical manner to 7.3.1, the manufacturer shall be responsible for rejects which, after evaluation, are demonstrated to be conforming to the requirements of API Spec 5L, but nonconforming to additional or more restrictive criteria for which the manufacturer is contractually liable (see 7.3.3).

7.3.3 In the event the manufacturer may be responsible for the rejection, but the purchaser and manufacturer are unable to agree that the pipe is defective, a destructive test of the pipe may be performed. If a destructive test is performed, the purchaser shall pay for the material that meets the specification but shall not pay for any material that fails to meet the specification, as provided by H.4, API Specification 5L.

7.3.4 Disposition of defects shall be in compliance with 9.7.5.4 of API Specification 5L. Dispositions shall be recorded and shall be traceable to pipe inspection number (see 6.2.4).

8 Visual and Dimensional Inspection

8.1 SCOPE

This section provides descriptions, mechanical equipment requirements, and procedures for visual and dimensional inspection of line pipe.

8.2 APPLICATION

The inspections described in this section are applicable to all sizes and all types of new plain-end line pipe.

8.3 EQUIPMENT (INCLUDING CALIBRATION)

The items listed in 8.3.1 through 8.3.4 are mechanical equipment required for dimensional inspection of the ends of line pipe.

8.3.1 Ring Gauge

8.3.1.1 The inside diameter and roundness of the gauge should be measured with a vernier caliper or a micrometer with rounded contacts of ½-inch radius or less. The instrument used should be calibrated using a known precision setting standard at least once every 4 months. Accuracy of ring gauges should be within plus 0.005 inch, minus 0.000 inch.

8.3.1.2 As an alternative, the ring gauge may be checked on a precision cylinder of a diameter specified by agreement between the owner and inspecting company. The accuracy of the precision cylinder is verified with a micrometer or vernier caliper with flat contacts.

8.3.2 Bevel Gauge

The angle(s) of template-type gauges should be checked for accuracy with a precision protractor or an optical comparator at least once every 4 months. Accuracy should be within ±1 degree.

8.3.3 Diameter Tape

Accuracy should be verified with precision cylinders or lengths, covering the range of measurements done by the diameter tape, at least once every four months. The diameter tape should measure the reference diameter or lengths with an accuracy of ±1/64 inch.

8.3.4 Precision Calipers (micrometer, vernier, or dial)

The instrument should be calibrated using a known precision setting standard at least once every four months. The calibration check shall be recorded on the caliper or in a log book.

8.4 EXTERNAL SURFACE ILLUMINATION

8.4.1 Direct daylight conditions do not require a check of surface illumination.

8.4.2 Enclosed Facility Lighting

8.4.2.1 The diffused light level at the surfaces being inspected should be a minimum of 32.5 foot-candles.

8.4.2.2 Illumination should be checked once every month. The check should be recorded in a log book with the date, the reading, and the initials of the person who performed the check. This record should be available on site.

8.4.2.3 Illumination should be checked whenever lighting fixtures change position or intensity, relative to surfaces being inspected.

8.4.3 Night Lighting With Portable Equipment

8.4.3.1 The diffused light level at the surfaces being inspected should be a minimum of 32.5 foot-candles.

8.4.3.2 Proper illumination should be verified at the beginning of the job to ensure that portable lighting is directed effectively for pipe surfaces being inspected.

8.4.3.3 Illumination should be checked during the job whenever lighting fixtures change position or intensity, relative to surfaces being inspected.

8.4.4 Light meters used to verify illumination should be calibrated at least once a year. The calibration date should be recorded on the meter. A calibration log or certificate file should be maintained to provide descriptive evidence of calibration.

8.5 INTERNAL SURFACE ILLUMINATION

8.5.1 Mirrors For Illumination

The reflecting surface should be a nontinted mirror that provides a nondistorted image. The reflecting surface also should be flat and clean.

8.5.2 Spotlights

A spotlight may be used for illumination of inside surfaces. The lens of the light source shall be kept clean.

8.5.3 Borescope Equipment

8.5.3.1 For pipe inside diameters less than 1 inch, the borescope lamp should be 10 watts or more.

8.5.3.2 For pipe inside diameters from 1 to 3 inches, the borescope lamp should be 30 watts or more.

8.5.3.3 For pipe inside diameters greater than 3 inches but not greater than 5 inches, the borescope lamp should be 100 watts or more.

8.5.3.4 For pipe inside diameters greater than 5 inches, the borescope lamp should be 250 watts or more.

8.5.3.5 The resolution of the borescope should be checked at the start of a job and whenever all or part of the scope is assembled or reassembled during a job. The date on a coin, or as an alternative Jaeger J4 letters, placed within 4 inches of the objective lens should be readable through the assembled borescope.

8.6 FULL-LENGTH VISUAL INSPECTION OF LINE PIPE (FLVI)

8.6.1 Description

A full-length, inspection including the bevel and root face, shall be conducted to detect gouges, cuts, flats, dents, grinds, mechanical damage, lack of straightness, and other visually detectable imperfections. Special attention is given to the weld line for undercut, off-seam weld, and other visually detectable imperfections. Rolling each length and viewing the entire external surface is required. The entire inside surface is inspected using a high-intensity light source.

8.6.2 External Visual Inspection Procedures

8.6.2.1 If the line pipe is to receive an external coating, the ideal time to perform this inspection is after sand or shot blasting and before coating. Inspectors shall be careful not to contaminate the pipe at this point.

8.6.2.2 Lengths are inspected in groups by first rolling them together. Observe the pipe while rolling to detect straightness problems. Evaluate bent or bowed pipe according to Section 16.

8.6.2.3 Identify the upper one-third of each length with a chalk mark.

8.6.2.4 Examine the bevels and then examine the pipe surface by walking the length of the pipe from one end to the other. With 12¾ inch OD and larger pipe, two lengths can be covered with one pass. With smaller pipe, more lengths may be inspected per pass.

8.6.2.5 After the top ⅓ of this group has been inspected, roll each length ⅓ of a turn.

8.6.2.6 As each imperfection is found, it should be evaluated according to Section 16. If found to be a reject, the pipe shall be properly marked immediately in accordance with Section 17.

8.6.2.7 Repeat the operations described in 8.6.2.2, 8.6.2.3, 8.6.2.4, 8.6.2.5, and 8.6.2.6 until the entire outside surface of the pipe is covered by this technique.

Note: When an imperfection is found and marked, continue inspection until the entire length is inspected so that the disposition of the pipe can be accurately determined.

8.6.3 Internal Visual Inspection Procedures

Inspect the entire inside surface, including the weld area where applicable, for imperfections.

8.6.3.1 Line pipe 22 inches OD and larger may be visually inspected by a person moving through the pipe on a special creeper rigged with a bright light.

8.6.3.2 Pipe with 10¾ inches through 20 inches OD should be visually examined from each end using a very-high-intensity lamp.

8.6.3.3 For pipes smaller than 10¾ inches OD, the best quality inspections are done with a borescope. See 8.5.3 for illumination head recommendations on these pipe sizes.

8.7 DIAMETER AND BEVEL CHECK ON PIPE ENDS

8.7.1 Description

The diameter of each end is checked for a distance of 4 inches to ensure compliance with API Specification 5L. Also, the bevel and root face are visually examined for damage. The geometry of the bevel and root face should be checked with a template, protractor, or other applicable method.

8.7.2 Diameter Checks

8.7.2.1 Ring Gauging

A ring gauge of appropriate diameter is passed over each end of the pipe for a distance of 4 inches. For specified outside diameters of 10¾ inches or smaller, the specified bore of the ring gauge is 1/16 inch larger than the specified pipe OD For specified outside diameters of 12¾ inches to 20 inches, the specified bore of the ring gauge is 3/32 inch larger than the specified pipe OD.

8.7.2.2 Diameter Tape Measurements

For specified outside diameters of 20 inches or smaller, the diameter within 4 inches from each end may be measured with a diameter tape to ensure that it meets the allowable minimum. For line pipe larger than 20 inches, the diameter within 4 inches from each end should be measured with a diameter tape.

8.7.2.3 Out-of-Roundness Measurements

For specified pipe diameters larger than 20 inches, the minimum and maximum diameter within 4 inches of each pipe end should be measured with a bar gauge, caliper, or other acceptable device.

8.7.2.4 Ring gauge or out-of-roundness measurements should be made with skid or pipe support no closer than 2 diameters to the pipe end.

8.7.3 Bevel Checks

8.7.3.1 Visually examine the full circumference of each end of each length of pipe for mechanical damage. At the same time, examine the bevel, root face, and inside taper for out of tolerance condition.

8.7.3.2 Apply a protractor or template to the outside bevel on each end of each length, the inside taper on seamless pipe, and any locations that appear out of tolerance. The bevel angle shall be measured from a line projected perpendicular to the pipe axis. The taper angle shall be measured from a line parallel to the pipe axis.

8.7.3.3 Apply a steel scale or template to the root face on each end of each length and at any locations that appear out of tolerance.

8.7.3.4 As an option, by agreement between owner and agency, an end-cut squareness check may be included with end-finish examinations. A square, or similar device, is applied such that one of its straight edges is along the pipe OD surface and parallel to the pipe axis; and its other straight edge is across the end of the pipe coincident with a diameter of the pipe end. As the straight edge (across the pipe end) contacts one point of the root face, a gap between the straight edge and root face 180 degrees away represents the amount of deviation from square. The straight edge should be positioned at different locations around the pipe to obtain the maximum gap. Apply a steel scale, template, or feeler gauge to the location where the maximum gap appears out of tolerance. Alternative methods may be used.

9 Hardness Testing

9.1 SCOPE

This section covers methods for hardness testing under field conditions. The purpose of the test may be to evaluate hard spots or to determine compliance with contractual hardness specifications.

9.2 APPLICATION

9.2.1 API Spec 5L contains no direct provision for hardness testing. Paragraph 7.8.7 of API Specification 5L contains provisions regarding the size and maximum hardness of acceptable hard spots.

Note: The API grade cannot be reliably determined by hardness testing alone.

9.3 EQUIPMENT

A wide variety of portable hardness testing equipment is available. Some types of hardness testers are good for general information only and vary in accuracy (see 1.1, Note 2 in ASTM E110). Other types of hardness testers, as described in ASTM E110 may be employed.

9.4 CALIBRATION AND STANDARDIZATION

9.4.1 Annual Calibration

Hardness testers shall be calibrated at least once a year and after each repair. The calibration shall be conducted by a certified agency issuing a certificate showing traceability to a statutory authority. The certificate shall identify the date of the check, the specified values of each certified hardness test block, the mean value of the tester readings on each block, and the initials of the person performing the check.

9.4.2 Quarterly Verification

The accuracy of hardness testers used during any three-month period shall be verified at the end of that three-month period. Verification is done by taking five readings on each of two certified hardness test blocks of different hardness values on the scale to be used. For the tester to be acceptable for use, the mean of the five readings on any certified hardness test block shall be within 2 hardness numbers of the specified mean of that block. Certified hardness test blocks are never to be used on both sides. One of the test blocks should be within ±5 hardness numbers at the low end of the range of values established for the pipe being tested. The other test block should be within ±5 hardness numbers at the high end of the established range of values for the pipe being tested. Each HRC-certified hardness test block shall not have a mean value less than HRC 20. Each HRB-certified hardness test block shall not have a mean value more than HRB 100.

9.4.3 Standardization

The hardness tester instructions supplied by the manufacturer shall be followed. For all types of testers, the procedure for checking the tester prior to performing a test is the same, except for attaching the tester to the pipe or certified hardness test block.

9.4.3.1 The penetrant must be examined prior to use. If it is chipped, spalled, distorted, or deformed, it is defective and requires replacement.

9.4.3.2 The hardness-testing equipment shall be checked to determine if the proper load cell has been installed and if the correct penetrator is being used for the hardness range specified.

9.4.3.3 A hardness test block shall be placed onto the anvil with the calibration (penetrated) side up. If both sides of the test block show use, the test block is not suitable for use.

9.4.3.4 Indentations shall be spaced no closer than $2^1/_2$ diameters from its center to the edge of the test block or 3 diameters from another indentation, measured center to center.

9.4.3.5 Contact surfaces and/or shoulders of a hardness test block, anvil, or penetrator shall be clean and free from oil film.

9.5 PROCEDURES

9.5.1 The tester shall be periodically checked on a certified hardness test block, per 9.4.3. The test block shall have a hardness within the expected range of the pipe to be tested. The tester shall be checked at the following times:

a. At the start of each inspection job and/or when the grade of pipe changes.
b. After every 100 readings.
c. Whenever the hardness tester is subjected to abnormal mechanical shock.
d. At the end of the inspection job.
e. Prior to rejection of a tested length of pipe.

9.5.2 Three readings shall be made on the certified hardness test block. The average of these readings shall be within two Rockwell numbers of the test block. Any single reading shall not vary more than two Rockwell numbers from the average of the readings.

9.5.3 The acceptable hardness range, number of readings made on each prepared test area, and the location of the test areas are by agreement between the owner of the pipe and the agency. Unless otherwise specified, grind or file the pipe surface approximately 0.010-inch deep, for a length of approximately 2 inches, to remove the decarburized layer. Before grinding or filing, the wall thickness should be determined to prevent reducing the wall thickness below that allowable. If the wall thickness is at or close to the allowable minimum, an alternative location should be selected. Ensure that the area is smooth and flat so that accurate readings can be obtained. Caution should be taken during grinding to avoid overheating the test area. Contact surfaces of the test area and the penetrator shall be clean and free from oil film.

9.5.4 Attach the tester to the pipe and test the pipe, according to the instrument operating procedures as specified by the hardness tester manufacturer.

9.5.5 A test shall consist of two or more valid readings that have been made in the same test area. Readings are usable when they are within two HRC numbers of one another or four HRB numbers of one another. The hardness value shall be recorded on the pipe surface adjacent to the test area using chalk or paint.

9.5.6 The hardness value shall be the average of the valid readings taken in the test area. The readings shall be recorded to the nearest whole number on the appropriate report form.

9.5.7 All pipe that has been tested between the last acceptable periodic check and an unacceptable check should be retested.

9.5.8 Rockwell readings that are below HRC 20 may require that the readings be made again using the Rockwell B scale.

9.5.9 Rockwell readings above HRB 100 may require that the readings be made again using the Rockwell C scale.

10 Magnetic Particle Inspection (MPI)

10.1 SCOPE

This section provides equipment requirements, material requirements, descriptions, and procedures for wet fluorescent or dry magnetic particle inspection of ferromagnetic line pipe.

10.1.1 Pipe subjected to MPI may retain significant residual magnetism. See Section 12 regarding measurement of residual magnetism and demagnetization.

10.1.2 The magnetization of pipe may be accomplished in a number of ways that may limit the application of the method.

10.2 APPLICATION

10.2.1 API Specification 5L provides for magnetic particle inspection only as a supplementary requirement (SR-4) for the inspection of seamless pipe and as an option for the reinspection of pipe ends (Section 9.7.4.5 and 9.7.5 of API Specification 5L) of cold-expanded pipe nondestructively inspected prior to cold expansion.

10.2.2 Full-length magnetic particle inspection (FLMPI) utilizes a transverse-oriented magnetic field for the inspection of the inside and outside weld and pipe body surfaces for imperfections principally oriented parallel to the pipe axis. This method also includes locating visible imperfections. It is applicable for line pipe of most diameters.

10.2.3 End areas may also be inspected utilizing magnetic particle methods. This is normally done to supplement a full-length EMI or full-length ultrasonic inspection. The inspection utilizes both transverse and longitudinal magnetic fields.

10.2.4 Section 16 of this recommended practice describes the use of MPI for evaluation of imperfections.

10.3 EQUIPMENT, MATERIALS, AND GENERAL PROCEDURES

10.3.1 Central Conductors

A central conductor is placed inside a pipe to generate a circumferential magnetic field for the detection of imperfections oriented principally parallel to the axis of the pipe.

10.3.1.1 The circumferential magnetic field is induced in the pipe by inserting the insulated central conductor inside the pipe, clamping the connectors, and energizing the current to the values given in 10.4.2. An audible or visible annunciator may be used to indicate inadequate current.

10.3.1.2 The conductor or current rod placed in the pipe shall be insulated from the pipe surface to prevent electrical contact or arcing.

10.3.1.3 For large-diameter pipe, it may be necessary to locate the conductor near the pipe wall and magnetize the pipe at more than one location around the circumference.

10.3.2 Coils

A coil is placed around the circumference of pipe ends to generate a longitudinal magnetic field for the detection of imperfections oriented principally transverse to the pipe axis.

10.3.2.1 When the coil is passed over the pipe end, the applied current shall not vary more than 10 percent of the selected value in 10.4.2. An audible or visible annunciator may be used to indicate inadequate current.

10.3.2.2 The number of turns of the coil should be clearly marked on the coil.

10.3.2.3 Flexible coils made up of conductor cable shall be tied or taped to keep the turns close together.

10.3.3 Yokes

Yokes are hand-held magnetizing devices. Because they are small and hand-held, they can be applied to virtually any pipe to detect imperfections in virtually any orientation on the same surface to which the yoke is applied.

10.3.3.1 Yokes have either fixed or articulated legs and may be energized by either AC, rectified AC, or DC current. For some applications, adjustable legs are preferred for pipe inspection because the legs can be adjusted to position the flat bottom portions on the inspection surface, regardless of contour.

10.3.3.2 The yoke is energized while magnetic particles are sprinkled or dusted over the part surface between the legs. This is repeated until the entire area is examined.

10.3.4 Magnetic Particle Field Indicators

10.3.4.1 Acceptable field indicators should be able to hold magnetic particles in a residual field of 5 gauss.

10.3.4.2 To verify longitudinal magnetic fields, the indicator should be positioned on the outside pipe surface with the artificial imperfections aligned in the transverse direction.

10.3.4.3 To verify circumferential or transverse magnetic fields, the indicator should be positioned on the outside pipe surface with the artificial imperfection aligned in the longitudinal direction.

Note: Magnetometers may also be used to indicate the relative strength of a magnetic field and are covered in 12.3.2.

10.3.5 Magnetic Particles

Magnetic particles are used to indicate imperfections that cause magnetic flux leakage. Particles may be applied either dry or in suspension (wet).

10.3.5.1 Dry Magnetic Particles

The procedure for dry magnetic particle inspection is listed in the following:

a. Dry magnetic particles should contrast with the product surface. Grey, yellow, and white magnetic particles are acceptable for inspection. A particle color should be chosen to provide adequate contrast.
b. The mixture should consist of different size particles with at least 75 percent by weight being finer than 120 ASTM sieve size and a minimum of 15 percent by weight finer than 325 ASTM sieve size.
c. The particle mixture should not contain undesirable fillers such as moisture, dirt, and sand.
d. As a supplementary practice, there may be a batch or lot check of particles for high permeability and low retentivity.
e. Dry particles should be applied with a blower, bulb, or suitable sprinkler to provide a light uniform distribution over the surface.
f. Dry magnetic particles shall not be reused.

Note: Wind or other inclement weather may be detrimental to the uniform application of magnetic particles to the pipe surface. Dry magnetic particle inspection should not be attempted when uniform application of the magnetic particles over the pipe surface is not possible. Dampness of the pipe surface reduces the mobility of the magnetic particles and is detrimental to accurate inspection.

10.3.5.2 Wet Fluorescent Magnetic Particles

Wet fluorescent magnetic particles are used for inspection as follows:

a. Fluorescent magnetic particles are suspended in a solution to enhance sensitivity. The particles should glow when exposed to ultraviolet light.
b. Wet fluorescent particles should be applied, with low velocity flow on the surface, by using pumps in recirculating systems or manually by using spray containers to obtain complete and uniform coverage.

10.3.5.3 Pipe Surface

The pipe surface shall be clean, and free from all dirt, oil, grease, loose scale, or other substances that have detrimental effects on particle mobility. It should be free of coatings that are sticky or have a thickness that hinders the effectiveness of the inspection. The surface shall be dry for dry particle inspections.

10.3.5.4 After inspection, the magnetic particles (either dry or suspended in solution) shall be removed from the surfaces with pressurized air, water flush, or other suitable means that will not damage the pipe.

10.3.6 Illumination Equipment and Optical Aids

These devices are used to provide illumination and visual aid for surface examination of line pipe.

10.3.6.1 White light for inspection may be provided by devices such as fluorescent, incandescent, mercury vapor bulbs, and so forth. White light meters should be used to measure light intensity.

10.3.6.2 Mirrors should be nontinted, flat, and clean to produce a nondistorted image and adequate light reflection.

10.3.6.3 Ultraviolet light (UV) is used to illuminate the accumulation of fluorescent-dyed magnetic particles. Consideration should be given to the following:

a. UV light should be provided by an appropriately filtered mercury arc lamp with a minimum value of 100 watts.
b. UV meters should be used to measure UV intensity.
c. UV meters should be capable of measuring the wave length of the UV light source.

10.3.6.4 Borescopes are optical aids that may be used to view the ID surfaces of pipe beyond the end area. Borescope lamps should have the following values:

a. A minimum of 10 watts for inside diameters less than 1 inch.
b. A minimum of 30 watts for inside diameters from 1 to 3 inches.
c. A minimum of 100 watts for inside diameters larger than 3 inches but not over 5 inches.
d. A minimum of 250 watts should be used for inside diameters over 5 inches.

10.3.7 Residual Magnetic Fields

When using a residual magnetic field for inspection, magnetize only enough lengths to maintain the workload for the current workday. Any lengths not inspected on the day that they are magnetized must be remagnetized prior to any future inspection.

10.3.8 Magnetic Particle Indications

All imperfections that accumulate magnetic particles shall be evaluated and dispositioned as described in Sections 16 and 7, respectively.

10.4 CALIBRATION AND STANDARDIZATION

10.4.1 Calibration

10.4.1.1 Ammeters

Ammeters shall be calibrated for accuracy at least once every four months, after repair or replacement, and whenever erratic response is indicated. The date and initials of the person who performed the calibration shall be recorded on the meter and in a log book.

10.4.1.2 Light Meters

a. The meters shall be calibrated annually.
b. The date and initials of the person who performed the calibration should be recorded on the meter and in a log book.

10.4.1.3 Yokes

a. AC yokes should be capable of lifting 10 pounds at the maximum pole spacing that would be used for inspection.
b. DC yokes should be capable of lifting 40 pounds for the maximum pole spacing that would be used for inspection.
c. Every four months, yokes should be tested for lifting power using a steel bar or plate of the appropriate weight or a calibrated magnetic weight lift test bar. The test date and initials of the person that performed the test should be recorded on the yoke and in a log book.

10.4.2 Standardization and Periodic Checks

10.4.2.1 Central Conductor Systems

A minimum magnetizing current of 400 amperes per inch of pipe diameter should be used when the energy source is a capacitor discharge unit and 300 amperes per inch when a battery power supply is used.

10.4.2.2 Coils

The number of coil turns and current required are imprecise, but shall be adequate to cause a clearly defined particle accumulation on imperfections without furring.

10.4.2.3 Periodic Checks

The following periodic checks shall be made at the start of each day, after meal breaks, whenever an element of the inspection equipment is repaired or replaced, and after every 50 lengths of pipe are inspected, or at least once in every 4 hours of continuous operations:

a. All electrical connections carrying magnetizing current should be checked for tightness.
b. Rod-to-cable contactors shall be clean.
c. The power supply providing magnetizing current should be checked for internal shorts.

d. Ammeters indicating magnetizing current should be observed with each application of current. The current shall be in compliance with 10.3.2.1, 10.4.2.1, and 10.4.2.2.
e. Strength and direction of magnetic fields should be confirmed with equipment as described in 10.3.4.

10.4.2.4 Illumination for (Visible) Dry Magnetic Particles

a. The diffused light intensity shall be a minimum of 32.5 foot-candles at the surface being inspected.
b. Direct daylight conditions do not require a check of surface illumination.
c. For facility (white) lighting, illumination should be checked once every month. The check should be recorded in a log book with the date, the reading, and the initials of the person who performed the check. This record should be available on site.
d. For portable (white) light equipment, proper illumination should be verified at the beginning of the job to ensure that stationary portable lighting is directed effectively for pipe surfaces being inspected.
e. Illumination should be checked during the job whenever stationary lighting fixtures change position or intensity relative to surfaces being inspected.
f. The resolution of the borescope should be checked at the start of a job or whenever all or part of the scope is assembled or reassembled during the job. Borescopes should be capable of displaying the date on a penny or dime (coin) or Jaeger J4 letters when placed within 4 inches of the objective lens.

10.4.2.5 Wet Fluorescent Magnetic Particle and Illumination

a. The particle solution shall be mixed according to the manufacturer's instructions and agitated either continuously or periodically.
b. The concentration of the solution shall be checked prior to use.
c. The concentration of the solution in recirculating systems shall be verified at least once during each working period.
d. The blacklight intensity level at the product surface should be a minimum of 800 microwatts per centimeter.

10.5 PROCEDURES FOR INSPECTION OF LONGITUDINAL WELDS, INSIDE AND OUTSIDE SURFACE (FLMPIW, FLMPOW)

This inspection is performed to detect cracks, undercuts, arc burns, dents, and other imperfections. The owner may specify that the inspection be performed only from one pipe surface or from both surfaces.

10.5.1 Induce a circular magnetic field in the pipe in accordance with 10.3.1. Alternatively, an AC or DC yoke may be used when examining all outside welds or inside welds in pipe 22 inches or larger in OD. The yoke is placed across the weld to provide a transverse magnetic field.

10.5.2 An area encompassing the weld and 1 inch on either side of the weld is covered uniformly with magnetic particles on the outside and/or inside surfaces along the entire length, in the presence of the appropriate magnetic field.

10.5.3 The weld should be positioned for effective inspection. As an example, for outside weld inspection, position the weld of SAW pipe at 12 o'clock and other types of welds at a position offset from 12 o'clock.

10.5.4 A borescope should be used when examining a weld on the ID, except that for outside diameters of 22 inches or larger, a weld may be examined by an inspector passing through the pipe on a creeper using a high-intensity light.

10.6 FULL-BODY INSPECTION OF INSIDE AND OUTSIDE SURFACES (FLMPI, FLMPO)

This inspection is performed to detect cracks, laps, seams, rolled-in slugs, mechanical damage, and other imperfections in the pipe body as well as the weld imperfections described in 10.5. The owner may specify that the inspections be performed only from one pipe surface or from both surfaces.

10.6.1 Induce a circular magnetic field in the pipe in accordance with 10.3.1.

10.6.2 The following procedures should be used when inspecting an inside surface full length:

a. Distribute magnetic particles on pipe interiors with sufficient volume to distribute completely around the pipe inside surface (360 degrees) when the pipe is rolled. Roll the pipe a minimum of one-and-one-half turns to distribute particles evenly.
b. Examine pipe smaller than 10¾ inches in OD with a borescope.
c. A high-intensity light may be used to inspect pipe with outside diameters of 10¾ inches to 20 inches.
d. Pipe of 22 inches or more in OD may be inspected by passing through the pipe on a creeper using a high-intensity light.
e. If an abnormal amount of particle accumulation exists on the inside bottom of the pipe, the pipe shall be rolled sufficiently to expose the area previously covered with particles and shall be reinspected as outlined above.

10.6.3 The following procedures should be used when inspecting an outside surface full length:

a. Mark the top side of each magnetized length with chalk.
b. The entire outside surface should be examined by rotating in one-third increments of the circumference and by marking the top side of each length after each rotation.

c. Apply magnetic particles to three distinct areas that are inspected on each length of pipe to ensure overlap and a complete surface coverage.

10.7 END AREA INSPECTION (EAI)

EAI is a dry or wet magnetic particle inspection of each end area outside surface for both transverse and longitudinal imperfections, excluding the bevel and root face. The inspection is performed to supplement EMI or UT inspection of new line pipe and may be conducted before or after either method. The EAI is performed to detect seams, laps, cracks, pits, rolled-in slugs, weld imperfections, and mechanical damage. By agreement between the owner and the agency, this inspection shall include MPI of the inside surface for a distance of 18 inches.

10.7.1 Inspect the outside surface of each end for 18 inches, using MPI techniques for detecting longitudinal and transverse imperfections as follows:

a. Either an AC or a DC yoke may be used to induce transverse and longitudinal magnetic fields for the inspection. Full coverage of the pipe circumference requires multiple positioning of the yoke legs.
b. As alternatives, a circular magnetic field may be induced according to 10.3.1, and a longitudinal magnetic field may be induced according to 10.3.2.
c. Distribute magnetic particles evenly over the outside surface in the presence of each appropriate magnetic field.

10.7.2 Visually inspect the inside surface of each end for a distance of 18 inches with a high-intensity light.

11 Electromagnetic Inspection (EMI)

11.1 SCOPE

This section describes the equipment and methods for detecting longitudinal and transverse imperfections in the tube body (excluding the ends) of ferromagnetic line pipe.

Pipe subjected to EMI inspection may retain significant residual magnetism. See Section 12 regarding residual magnetism and demagnetization.

11.2 APPLICATION

11.2.1 API Specification 5L provides EMI as one of two alternate methods for the inspection of the weld seam (See API Specification 5L). Inspection of the weld seam is required only for electric resistance welded pipe (See API Specification 5L). All other EMI inspections performed in accordance with this recommended practice are beyond the inspection requirements of API Specification 5L.

11.2.2 EMI systems may be used for the inspection of all sizes of pipe within the size range of the equipment and for all types of pipe except submerged arc welded (SAW).

Note: Most field EMI inspection systems contain electromagnetic scanners for the detection of longitudinal, transverse, and volumetric imperfections; a gamma-ray (or ultrasonic) scanner for wall thickness and eccentricity measurement; and may also contain equipment for making a grade comparison. Typically, these systems incorporate these four inspection stages in one field-portable unit. This section will address only the electromagnetic inspection portion of EMI systems. Equipment and procedures for wall thickness and grade comparison portions of EMI systems are addressed in Sections 13 and 14, respectively.

11.2.3 Longitudinal imperfections are detected by passing the magnetized pipe through a rotating scanner. A combination of the longitudinal velocity of the pipe and the rotating speed of the scanner and/or pipe shall result in overlapping coverage of paths of adjacent detector shoes.

11.2.4 Transverse imperfections are detected by passing the magnetized pipe through a fixed encircling scanner.

11.2.5 Volumetric imperfections may be detected by using either longitudinal or transverse scanners.

11.3 EQUIPMENT

EMI systems may be of the flux leakage or eddy current type.

11.3.1 In flux leakage equipment, a strong magnetic field is applied to the region of the pipe under the sensors. The sensors detect magnetic flux fields which leak from the pipe at the location of imperfections.

11.3.2 In eddy current equipment, an electric field is induced in the pipe by one or more exciter coils. One or more sensor coils detect a change in the normal flow of currents due to the presence of imperfections.

11.3.3 Flux leakage is the most commonly used technique in field applications, therefore the balance of this section does not address eddy current systems.

11.4 CALIBRATION AND STANDARDIZATION

This section includes the minimum requirements necessary to ensure that inspection equipment is operating to its intended capability. Practices should be stipulated by agreement between the owner and the agency prior to commencement of the inspection service.

11.4.1 General Standardization and Periodic Checks

General standardization of electromagnetic inspection equipment shall be performed at the beginning of each job. Periodic checks on standardization shall be performed as follows:

a. At the beginning of each inspection shift and after meal break.

b. At least once every 4 hours of continuous operation or every 50 lengths inspected, whichever occurs first.
c. After any power interruption.
d. Prior to equipment shutdown during a job.
e. Prior to resuming operation after repair or change to a system component that would affect system performance.

Note: All pipe that has been inspected between the last acceptable periodic standardization check and an unacceptable check shall be reinspected.

11.4.2 Equipment Calibration

11.4.2.1 Active Field Systems

Ammeters (reading magnetizing current) should be calibrated whenever they fail to respond smoothly and repeatedly with increasing values, at least once every four months, and after any repairs or changes. The calibration is to be recorded on the meter or power supply and in a log book, and should include the date of the calibration and the initials of the person performing the calibration.

For dual coil systems, the polarity of the magnetizing coils shall be the same (that is, nonopposing). This should be checked with a compass or magnetometer at least once every four months and after any repairs are performed on the assembly or magnetizing circuit.

11.4.2.2 Residual Field Systems (Central Conductor Method for EMI)

Ammeters should be calibrated at least once every four months, whenever they fail to respond smoothly and repeatedly, and after any repairs. The calibration is to be recorded on the meter or power supply as well as in a log book, and should specify the date of the calibration and the initials of the person performing the calibration.

11.4.3 Standardization

The agency shall select one or more of the following techniques for standardizing the EMI equipment in order to detect suspect pipe for further evaluation.

11.4.3.1 The adjustment of gains and/or threshold settings should be done to provide discernible defect signals or a suitable signal-to-noise ratio for the material being inspected.

For at least the first five lengths inspected, a gain should be chosen that produces background noise amplitudes of no more than about one-eighth of fullscale. Use maximum gain if necessary. If investigation of signals above the background noise indicates excessive gain, the gain can be reduced until minor (less than 5 percent of specified pipe wall thickness) imperfection signals are no more than one-eighth of fullscale.

For adjustable threshold readouts, the first five lengths shall be used to determine the optimum setting, which will keep background noise amplitudes less than one-fourth fullscale.

11.4.3.2 Detector sensitivity may be standardized during its manufacture by passing a changing flux density through the transducer element. The signal output level should be within ±10 percent of a standard level. This provides a uniformity from element to element.

11.4.3.3 A magnetic pulser may be used for standardizing flux leakage inspection equipment. The pulser shall produce reproducible and controllable pulses. The output signal from this pulser shall be calibrated every six months.

The magnetic pulser head is placed adjacent to each transducer element in each detector shoe. The overall system gain of each readout channel is then standardized to produce optimum system performance.

11.4.3.4 A reference standard may be used in the following manner:

a. A length of pipe of the same diameter, wall thickness, grade and, if possible, manufacture as the order of the pipe being inspected should be utilized. This pipe shall be furnished by the owner.
b. Reference reflector(s) should be selected by agreement between the owner and the agency. The reflector(s) should not be used as reject criteria, but rather to establish equipment sensitivity.
c. By agreement between the owner of the pipe and the agency, location of reference reflector(s)—that is, OD, ID, and weld—shall be clearly defined prior to commencement of inspection. Their depth and placement should be such that they can be removed by grinding without reducing the remaining wall of the reference standard to less than the minimum allowable thickness. Alternatively, the section containing the reflector(s) may be cut off.
d. Reflector(s) should be separated such that resulting indications are distinct and separate from each other and from other pipe anomalies or end effects.
e. A longitudinal notch similar to the N-10 or SR-4 described in API Specification 5L, with a maximum notch width of 0.040 inch (typically 0.010 inch or less) and a depth no less than 0.012 inch, should be placed on the reference standard.
f. The longitudinal notch should be placed under each appropriate transducer of each longitudinal flaw detection shoe. The instrumentation should be adjusted to produce an indication having an amplitude equal to or greater than 25 percent of fullscale, and clearly identifiable above background noise. This adjustment would apply to the inside surface notch when both inside and outside surface notches are used. Dynamic periodic checks require the same signal height minimum.
g. When requested by the owner, the reference standard may contain a drilled hole as described in API Specification 5L. The instrumentation should be adjusted to produce an indication having an amplitude equal to or greater than 25 percent of fullscale and clearly identifiable above background noise.

A reference standard that contains a drilled hole will be clearly identified as a reject. Alternatively the section containing the hole may be cut off.

11.4.3.5 By agreement between the owner and the agency, the following supplementary procedure may be used:

a. The reference standard shall be a length of pipe of the same diameter, wall thickness, grade, and if possible, manufacture as the order of pipe being inspected. This pipe is to be furnished by the owner.
b. By agreement between the owner and the agency, location and orientation of reference notches (that is, OD, ID, weld, longitudinal, and transverse) shall be clearly defined prior to commencement of inspection. Notch depth and placement should be such that they can be removed by grinding without reducing the remaining wall of the standard to less than the minimum allowable thickness. Alternatively, the notched section may be cut off.
c. A longitudinal notch similar to the N-10 or SR-4 described in API Specification 5L, with a maximum notch width no greater than 0.040 inch (typically 0.010 inch or less) and a depth no less than 0.012 inch, shall be placed on the standard.
d. A transverse notch shall be placed on the outside surface of the standard. Its depth should be 10 percent (for N-10) or 12½ percent (for SR-4) of the specified wall thickness of the pipe being inspected.
e. Notches shall be separated such that the indication from each is distinct and separate from another and from other pipe anomalies or end effects.
f. When requested by the owner, the standard may contain drilled holes (not less than 1/16 inch in diameter) and/or thin wall sections (at least 10 percent less than specified wall thickness). A standard that contains one or more drilled holes shall be clearly identified as a reject. Alternatively, the section containing the holes may be cut off.
g. The standard shall be passed through the inspection system four times at production speed, once with a notch or hole at each of the following positions: 12 o'clock, 3 o'clock, 6 o'clock, and 9 o'clock. Height of the principal indication from each notch or hole shall not vary more than 30 percent from its average indication level. Each indication shall be clearly identified above background noise and no less than 25 percent of fullscale.

11.4.4 Equipment Requirements and Periodic Checks

The following periodic checks shall be made at the same frequency as stated in 11.4.1, unless otherwise specified:

11.4.4.1 Central conductor (residual circular magnetization):

a. The conductor (current rod) placed in the pipe shall be completely insulated from the pipe surface so that no arcing to the pipe surface is possible.
b. The connections of the conductor or current rod shall be tight.
c. Rod-to-cable contactors shall be clean.
d. The magnetizing system shall be free of internal shorts.
e. An ammeter indicating the magnetizing current shall be employed and observed with each application of current. Alternatively, an ammeter indicating the magnetizing current may be employed in conjunction with a low current indicator and alarm.
f. The magnetizing current shall not be less than the minimum value stated in the inspection company's SOP.

11.4.4.2 Active field type magnetizer:

a. The magnetizing coils should be checked to ensure that the proper current or magnetizing force is used and that no magnetizing coils are open or shorted.
b. The current or magnetizing force should be checked to ensure that it is within 10 percent of the correct value for the equipment being used.

11.4.4.3 Manual and/or automatic circuit checks shall be employed to ensure search coil or magnetic transducer continuity. Continuity checks should be made with a device that produces a change in flux density or generates a current in each transducer element, providing reliable detection of an open circuit.

11.4.4.4 Periodic checks shall be made throughout the inspection job to ensure that the shoes carrying the EMI transducers are riding smoothly on the pipe surface, since substantial impairment of imperfection sensitivity accompanies liftoff of these shoes.

11.4.4.5 All electronic inspection equipment systems shall be standardized, calibrated, or adjusted to proper sensitivity levels as described in 11.4.2 and 11.4.3.

11.5 INSPECTION PROCEDURES

11.5.1 Pass each length of pipe through the EMI inspection unit. The various scanners shall perform their respective function effectively and without detrimental interaction with each other. Minimum throughput speed shall be in accordance with that specified in the agency SOP.

11.5.2 A readout of imperfection indications detected, and a record of the inspection is made and identified. These documents should be retained by the agency for a minimum of six months.

11.5.3 To confirm the electronic readout indications, mark the area of the suspected imperfections on the pipe surface for further evaluation. Locate and outline the full extent of the imperfection using supplementary nondestructive inspection techniques.

11.5.4 The first length inspected and one of each 25 lengths thereafter shall be verified as being demagnetized in accordance with Section 12. If greater than 30 gauss, then the demagnetizing current may need adjusting prior to continuing.

12 Residual Magnetism and Demagnetization

12.1 SCOPE

This section describes the equipment and methods used for the measurement of residual magnetic fields and for demagnetization.

12.1.1 Magnetic particle inspection (MPI) and electromagnetic inspection (EMI) are accomplished by inducing a magnetic field into the pipe. Care must be taken to ensure that the residual magnetic field is less than a defined acceptance level after inspection.

12.1.2 API Specification 5L contains no criteria regarding residual magnetism.

12.2 APPLICATION

API Specification 5L contains references neither to residual magnetism nor to demagnetization. Restrictions regarding residual magnetism normally are applied only to pipe that has been subjected to MPI or EMI procedures.

12.3 DEMAGNETIZATION SERVICES

This service is performed on line pipe to reduce the longitudinal magnetic field to 30 gauss or less to alleviate possible difficulty during the circumferential welding process. Circumferential magnetic fields do not cause welding problems and are not addressed in this service.

12.3.1 Measuring Flux Density

Measurements are made on the pipe ends using a magnetometer in contact with the root face of the pipe. The pipe being checked should be separated from other pipe in all directions. When using an electronic magnetometer (gaussmeter), pipe which shows a residual field of more than 30 gauss should be demagnetized. When using a mechanical magnetometer, the residual field measurement should not exceed 8 gauss.

12.3.2 Flux Density Measuring Equipment Including Calibration

12.3.2.1 Electronic magnetometers (gaussmeters) shall be calibrated at least once a year and after repair. Calibration shall be recorded on the instrument as well as in a log book and shall include the calibration date and the initials of the person performing the calibration.

12.3.2.2 If a reference magnet is used to adjust gaussmeters, the reference magnet shall be calibrated at least once a year. Calibration should be recorded on the magnet and in a log book and should include the calibration date and the initials of the person performing the calibration.

12.3.2.3 Mechanical magnetometers shall be checked for accuracy at least once every four months and when the zero position deviates more than 10 percent of the full-scale value. The accuracy should be within 10 percent of a calibrated variable reference magnetizing force over the entire range of the readout. The accuracy check shall be recorded on the instrument or in a log book and shall include the date of the acceptable check and the initials of the person performing the check.

12.3.3 Demagnetization Methods

12.3.3.1 Line pipe up to 5 inches in diameter may be demagnetized longitudinally by inducing a circular magnetic field into the pipe. This is done with an insulated central conductor and capacitive discharge or battery-powered magnetizer. Generally a current of 3000 or more amperes applied once or twice should reduce the longitudinal field to the acceptable level.

12.3.3.2 Line pipe in diameters larger than 5 inches may be demagnetized longitudinally in the same manner, except the amount of amperes used will have to be increased (5000 or more amperes) in proportion to the increase in pipe diameter. The grade of pipe, its wall thickness, and the type of magnetizer used have an effect on the amount of current necessary. Multiple shots may be necessary when using pulse times less than ¼ second.

12.3.3.3 Line pipe may also be demagnetized by passing it through a circular coil energized with AC. As in other methods, the larger the pipe, the more current required. Approximately 6000 to 10,000 ampere-turns should demagnetize pipe up to 10 inches in diameter. Larger sizes may require more current, depending on the demagnetizing system.

12.3.3.4 Many EMI systems contain a demagnetizing coil as part of the inspection system. If the pipe is to be EMI inspected, proper adjustment and monitoring of the demagnetizing unit can reduce the residual field in the inspected pipe to the acceptable level. If this system is used, a periodic check of the gauss level remaining in the pipe should be performed after every 25 lengths are inspected.

13 Gamma Ray Wall Thickness Measurement

13.1 SCOPE

This section describes the gamma ray equipment and procedures used for the measurement of pipe wall thickness. When available, this equipment typically is an integral component of an EMI inspection system and may not be available as a separate, stand-alone inspection.

Other nondestructive methods (for example, ultrasonics) may also be available for automated wall thickness measurement.

13.2 APPLICATION

API Specification 5L contains no provision for the measurement of wall thickness using gamma ray methods. This method is applicable to seamless and welded pipe, except submerged arc welded (SAW) pipe. It is applicable to all diameter pipe within the size range of the inspection equipment.

13.3 EQUIPMENT

The equipment typically consists of a gamma ray source, a sensor, and a readout. Measurements are normally made on a helical path along the length of the pipe. Surface coverage is typically not 100 percent. Rotation of the pipe, the source, the sensor, or any combination thereof, may be used to accomplish this scan.

13.4 CALIBRATION AND STANDARDIZATION

This section includes the minimum requirements necessary to ensure that inspection equipment is operating to its intended capability. Practices should be stipulated by agreement between the owner and the agency prior to commencement of the inspection service.

13.4.1 General standardization of inspection equipment shall be performed at the beginning of each job. Periodic checks on standardization shall be performed as follows:

a. At the beginning of each inspection shift and after meal break.
b. At least once every 4 hours of continuous operation or every 50 lengths inspected, whichever occurs first.
c. After any power interruption.
d. Prior to equipment shutdown during a job.
e. Prior to resuming operation after repair or change to a system component that would affect system performance.

Note: All pipe that has been inspected between the last acceptable periodic standardization check and an unacceptable check shall be reinspected.

13.4.2 Standardization Procedure

The gamma ray system shall be standardized using one or more of the following methods:

13.4.2.1 The gain of the system is adjusted so that the readout corresponds with the known thickness of a reference standard.

13.4.2.2 The gain of the system is adjusted so that the readout corresponds with the measured thickness values on a selected circumferential ring of the pipe reference standard. On the ring, a minimum and maximum thickness shall be determined using a micrometer or properly calibrated ultrasonic thickness gauge. The minimum thickness value shown on the readout should be adjusted to be within ±0.010 inch of the minimum thickness selected on the standard. The maximum thickness of the standard should be clearly distinguishable on the readout.

13.4.2.3 If the standard is not available, a minimum wall thickness reading for at least one of every 50 lengths inspected should be verified with micrometers or a calibrated ultrasonic gauge.

13.5 INSPECTION PROCEDURE

Each length of pipe shall be passed through the system. The readout of the wall thickness measuring system shall provide a specific scale or reject level on recording. To confirm the readout indications, mark the area of the suspected wall variation on the pipe surface for further evaluation. Using supplementary nondestructive inspection techniques (see 16.8), determine the wall thickness in the suspect area.

14 Electromagnetic Grade Comparison

14.1 SCOPE

This section describes grade comparison equipment and procedures using principles based on differences in the electromagnetic characteristics of grades of pipe. When available, this equipment typically is an integral component of an EMI inspection system and may not be available as a separate stand-alone inspection.

Note: Grade comparators may not be capable of distinguishing between line pipe grades that have similar properties.

14.2 APPLICATION

API Specification 5L does not provide for grade comparison based on pipe electromagnetic characteristics. This method is applicable to all types and diameters of pipe within the size range of the inspection equipment.

14.3 EQUIPMENT

Grade comparators, which categorize pipe based on the pipe's electromagnetic characteristics, consist of two types—Comparator Bridge System and Transformer System. A grade comparator, when used, should be equipped with a visible or audible alarm, or should otherwise signal the operator when a coil circuit opens.

14.4 CALIBRATION AND STANDARDIZATION

With either type equipment, there is no absolute calibration possible. A comparison may be made between a known standard and each length inspected.

14.4.1 General standardization of inspection equipment shall be performed at the beginning of each job. Periodic checks on standardization shall be performed as follows:

a. At the beginning of each inspection shift and after meal break.
b. At least once every 4 hours of continuous operation or every 50 lengths inspected, whichever occurs first.
c. After any power interruption.
d. Prior to equipment shutdown during a job.
e. Prior to resuming operation after repair or change to a system component that would affect system performance.

Note: All pipe that has been inspected between the last acceptable periodic standardization check and an unacceptable check shall be reinspected.

14.4.2 Standardization Procedure

The standardization procedure depends on the type of system being used, as follows.

14.4.2.1 Comparator Bridge System

The grade of the first length of pipe to be inspected is confirmed by visual examination of the pipe markings and placed in the comparator coil in the inspection line. The bridge is balanced and the gain control set at a selected position. After several lengths are inspected, the gain control is readjusted to an optimum level based on the normal variations in the pipe being inspected.

14.4.2.2 Transformer System

The first five lengths of pipe to be inspected are confirmed to be the same grade by visual examination of the pipe markings. Each of the first five lengths is run through the inspection line, and the readout voltage is recorded. An average voltage is determined, and upper and lower warning limits are set.

14.4.2.3 Supplementary Performance Test

A reference signal from a secondary reference standard of different magnetic or conductive properties than the pipe being inspected may be used to verify the sorting capability of the system.

14.5 INSPECTION PROCEDURE

Each length of pipe shall be passed through the inspection system. The readout of the grade comparison equipment shall provide a distinct indication, level, or threshold to indicate pipe with properties dissimilar to that being inspected. When a significant grade comparator indication is detected, the proper weight, grade and manufacture of the length of pipe should be investigated prior to its disposition. This investigation should include a review of the mill markings and pipe dimensions.

15 Ultrasonic Inspection

15.1 SCOPE

This section describes the equipment and procedures used to perform ultrasonic inspection in five categories. The categories are as follows:

a. Inspection of the pipe weld.
b. Inspection of the pipe body for wall thickness and planar imperfections.
c. Inspection of the pipe body for longitudinal, transverse and oblique imperfections.
d. Inspection of the pipe ends for laminations.
e. Manual ultrasonic thickness gauging.

15.2 APPLICATION

Of the categories of ultrasonic inspection in 15.1.b, only inspection and reinspection of the pipe weld and inspection of seamless pipe for longitudinal imperfections as a supplementary requirement (Appendix E, SR-4) are included in API Specification 5L.

In principle, ultrasonic inspection in all five categories can be performed using either manual or mechanized equipment. In practice, inspection of the pipe body (see 15.1.b and 15.1.c) typically is performed only using mechanized equipment and, therefore, is limited to the size range that can be processed through the equipment. Normally pipe body inspection is not performed on large-diameter pipe.

15.3 GENERAL PROCEDURES FOR CALIBRATION, STANDARDIZATION, AND INSPECTION

The following recommendations apply to all categories of ultrasonic inspection except as noted.

15.3.1 The horizontal and vertical linearity of the CRT display should be calibrated after any repairs to related circuitry or at least once every six months. If a recorder display is used, the linearity of its scale should also be calibrated once every six months. The vertical linearity between 25 and 75 percent of fullscale of either display should be within ±5 percent of its fullscale value. The calibration should be recorded on the CRT instrument or recorder and in a log book, and should include the date of calibration and the initials of the person performing the calibration.

15.3.2 Standardization of ultrasonic inspection equipment shall be performed at the beginning of each job. A reference standard of the same specified thickness and curvature as the pipe being inspected should be used. The standard's material should have ultrasonic velocity and attenuation properties that are similar to those of the pipe being inspected. If the standard is to be a piece of the material to be inspected, it should be provided by the owner. Checks of standardization shall be performed as follows:

a. At the beginning of each inspection shift.
b. At least once every 4 hours of continuous operation or every 50 lengths inspected, whichever occurs first.
c. After any power interruption.
d. Prior to equipment shutdown during a job.
e. Prior to resuming operation after repair or change to a system component that would affect system performance.

15.3.3 All pipe surfaces shall be clean and free of loose scale, dirt, grease, or any other material that may interfere with the sensitivity of the inspection or the interpretation of the readout.

15.3.4 A liquid couplant that is free of suspended particles and air bubbles shall be used to wet the surface of the pipe and provide transmission of ultrasound from the transducers into the pipe being tested. Rust inhibitors, water softeners, glycerine, antifreeze, or wetting agents may be added to the couplant, provided they are not detrimental to the pipe surface.

15.3.5 All ultrasonic inspection systems shall be standardized, calibrated, or adjusted to proper sensitivity levels as described in 15.3.2. All pipe that has been inspected between the last acceptable periodic calibration check and an unacceptable check shall be reinspected.

15.3.6 Mechanized ultrasonic inspection systems may be configured to perform more than one category of inspection in the same operation.

15.4 ULTRASONIC INSPECTION OF PIPE WELDS (UTW)

15.4.1 Equipment

The longitudinal weld area is automatically or manually scanned along its entire length for imperfections. Angled (refracted) sound beams are propagated through the weld in opposing circumferential directions for detection of weld imperfections such as, but not limited to, lack of fusion, pin holes, lack of penetration, longitudinal cracks, porosity, and inclusions. A means of monitoring effective acoustic coupling should also be used. An audible alarm should be used to respond when a detectable imperfection is encountered. A readout of imperfection indications detected should be made and retained by the agency for a minimum of six months.

15.4.2 Calibration and Standardization for Weld Inspection

15.4.2.1 Basic Standardization Procedure

The basic standardization procedure includes the following:

a. Longitudinal notches shall be placed on the outside and inside surfaces of the reference standard. Normal practice includes the use of a reference notch similar to the N-10 or N-5 notches described in Section 9 of API Specification 5L. As an alternate, an API Specification 5L-drilled hole may be used. Equipment should be capable of inspecting $^1/_{16}$ inch on either side of the weld line through the entire thickness of the weld.
b. Notches or holes should be separated such that the indication from each is distinct and separate from each other and from other pipe anomalies or end effects.
c. Transducers, instrument gain, and thresholds should be chosen for optimum signal-to-noise ratios. Distance amplitude compensation may be used when it is required to detect and gauge reflectors over a significant distance.
d. Reference signal amplitudes should be produced by simulation of the scanning method on the pipe to be inspected. Reference reflector signal amplitude should be adjusted to at least 50 percent of fullscale of the readout for each transducer. The reference notch responses from each transducer shall be of sufficient amplitude to activate threshold alarms. Coverage of scanning on both sides of the center line of the weld may be verified by demonstrating signal amplitude from a reflector positioned offset from the reference line for the weld.
e. Non-API types of reference reflectors may be used by agreement between the owner and the agency. This must include agreement on non-API acceptance/rejection criteria.

15.4.2.2 Supplementary Practice A

By agreement between the owner and the agency, specific reference standards and reference reflectors may be used to:

a. Check each transducer angle.
b. Check proper adjustment of gates and inspection coverage by the equipment. This includes the use of multiple ID surface and OD surface reflectors and a longitudinally drilled hole at midwall of the pipe. Longitudinal notches (or radial holes) are separated by a transverse distance of $^1/_{16}$ inch on both sides of the reference line, and the longitudinal hole is placed along a line midway between them. In addition, a radial hole through the reference line may be used for setting the reference signal amplitude (See Figure 1). The offset reflectors, as well as the longitudinal hole, are used to verify sensitivity of coverage on both sides of the center line of the weld and through the thickness of the weld. By agreement between the owner and the agency, the reference line may coincide with the weld line. Signal repeatability should be the same as stated in 15.4.2.1.d above.

15.4.2.3 Supplementary Practice B

By agreement between the owner and the agency, the effect of the shape and radial direction of a reference reflector (on signal amplitude) may be verified. This is done by comparing the peak amplitudes from both sides of the reflector. If one

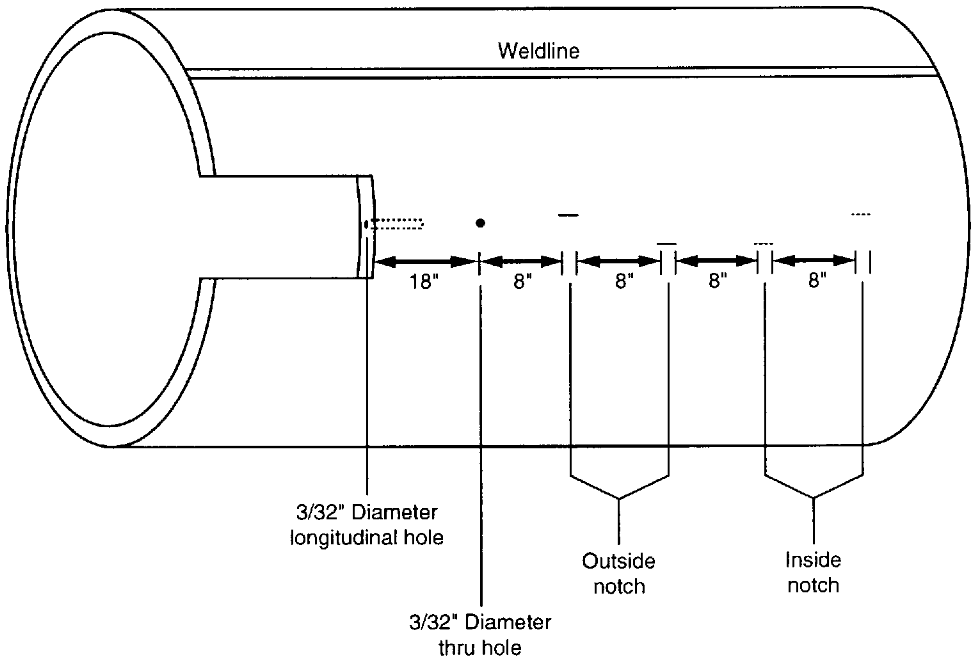


Figure 1—Ultrasonic Reference Standard Example for Supplementary Practice 15.4.2.2.b

amplitude is less than 70 percent of the other, the use of the reference reflector for calibration sensitivity is questionable.

15.4.3 Procedure for Ultrasonic Inspection of Pipe Welds

The transducer assembly is propelled along the weld at a scanning speed to provide both a reliable recording and reliable operation of the flaw detection alarm(s). A method of tracking the weld in a consistent manner must be employed. The operation of the equipment shall provide a beam inspection $\frac{1}{16}$ inch on either side of the weld through the entire thickness. The inspection shall cover the entire length, from bevel to bevel. Inspection for thin wall and planar imperfections may be included by agreement between the owner and the agency. Then, the operation of the equipment would include a normal beam inspection along the edge of the weld for the full length of the weld in accordance with Section 15.5.

Proceed as follows:

a. Properly position the weld.
b. Clean the weld area as required.
c. If the weld is not visible full length on the outside pipe surface, mark the position of the weld line full length with a chalk line or by equivalent means.
d. Place the transducer assembly on the pipe so that one angle beam transducer is examining the weld just behind the bevel and at the full wall thickness.
e. Initiate movement between the transducer assembly and the pipe to begin inspection and continue until the length is fully examined. The speed shall be compatible with the electronic equipment being used.
f. To confirm the electronic readout indications, mark the area of the suspected imperfections on the pipe surface for further evaluation. Locate and outline the full extent of the imperfection using supplementary nondestructive inspection techniques.
g. Continue UT examination of the weld in each length until the job is complete.

15.5 INSPECTION OF THE PIPE BODY FOR WALL THINNING AND PLANAR IMPERFECTIONS (UTBL)

15.5.1 Equipment

The entire surface shall be scanned. Sound beams, propagated normal to the pipe's surface, are used to measure wall thickness throughout the length of the tube and may include inspection for planar imperfections. The combination of linear and rotational speed of the pipe and/or scanner shall produce full pipe body coverage without gaps. The pipe may be pre-wet or submerged in part or in total for scanning. Couplant shall provide an effective acoustic contact between the transducer beams and the pipe surface. A means of monitoring effective acoustic coupling should also be used. A readout of imperfection indications and a record of the inspection are made and identified.

These documents are retained by the agency for a minimum of six months.

15.5.2 Calibration and Standardization

15.5.2.1 Basic Standardization Procedure

Basic standardization procedure is as follows:

a. The standard should contain at least two thicknesses that will allow adjustment of the readout over an appropriate range of thickness values for the pipe being inspected. The reference thicknesses should be verified by measurement with a micrometer or a calibrated ultrasonic thickness gauge (see 15.8). One thickness shall be greater than the specified wall thickness of the pipe being inspected. The other thickness shall be less than the specified thickness. The difference in the thicknesses shall be equal to or greater than 10 percent of the specified wall thickness of the pipe being inspected.
b. The equipment's readout of wall thickness should be adjusted to read the reference thickness nearest the minimum allowable thickness of the pipe being inspected within 0.010 inch or 2 percent of the specified pipe wall thickness, whichever is the smaller. These adjustments are to be done for each transducer used for wall thickness measurements.

15.5.2.2 Supplementary Practice A

By agreement between the owner and the agency, the thinnest reference thickness used in 15.5.2.1.a above may be equal to or less than the minimum allowable thickness for the pipe being inspected. This standard is to be provided by the owner. Equipment adjustment is the same as described in 15.5.2.1.b.

15.5.2.3 Supplementary Practice B

This option may be performed when wall thickness inspection coverage is to be verified or when planar imperfection detection sensitivity is to be standardized for normal beam transducers.

The following procedures should be followed:

a. By agreement between the owner and the agency, a standard provided by the owner may be used to adjust gate widths, alarm threshold, and signal height of the equipment's readout. The standard shall be of sufficient length to permit dynamic standardization and to have the same diameter, wall thickness, and ultrasonic properties as the pipe being inspected.
b. The standard should contain a ¼-inch diameter flat-bottom hole placed on the ID surface at a depth equal to or greater than the maximum allowable wall reduction for the pipe being inspected.
c. The gate width for each applicable transducer should be adjusted to allow detection of planar imperfections between 0.100 inch or less from the outside surface and the minimum allowable wall thickness for the pipe being inspected. The signal height for the reference reflector should be adjusted to ensure detection. For periodic checks, tolerances on signal height should be by agreement between the owner and the agency.

15.5.3 Procedure for Measurement of Wall Thickness and Detection of Planar Imperfections

15.5.3.1 The pipe to be inspected and the search unit assembly may have a rotating motion and longitudinal axis movement relative to each other to ensure that the scan covers the entire surface. The relative speed of rotation and the longitudinal movement will be maintained within a consistent range not to vary more than 10 percent. The scanning speed shall be such as to provide both reliable recording and operation of the threshold alarms. Other methods for obtaining complete coverage of the pipe surface may be used.

The inspection procedures are as follows:

a. Inspect each length of pipe using the ultrasonic inspection unit.
b. A minimum wall thickness reading for at least one length out of every 50 inspected should be verified using a precision deep-throated caliper or a properly calibrated ultrasonic thickness gauge.
c. To confirm the electronic readout indications, mark the area of the suspected imperfections on the pipe surface for further evaluation. Locate and outline the full extent of the imperfection using supplementary nondestructive inspection techniques.

15.6 INSPECTION OF THE PIPE BODY FOR LONGITUDINAL, TRANSVERSE, AND OBLIQUE IMPERFECTIONS (UTBLTO)

15.6.1 Equipment

The entire surface shall be scanned. Multiple sound beams should be used to transverse, longitudinal, and oblique imperfections. The combination of linear and rotational speed of the pipe and/or scanner shall produce full pipe body coverage without gaps. The pipe may be pre-wet or submerged partially or totally for scanning. Couplant shall provide an effective acoustic contact between the transducer beams and the pipe surface. A means of monitoring effective acoustic coupling should also be used. A readout of imperfection indications and a record of the inspection should be made and identified. These documents are to be retained by the agency for a minimum of six months.

15.6.1.1 Inspection for Longitudinal Imperfections

Angled sound beams are propagated clockwise (cw) and counterclockwise (ccw) by two or more transducers. Each group (cw and ccw) shall have sufficient coverage so that there are no gaps between the active portions of the transducers. The sensitivity of the system shall enable it to detect, display, and record imperfections oriented parallel to the pipe's major axis such as, but not limited to, seams, laps and cracks.

15.6.1.2 Inspection for Transverse Imperfections

Angled sound beams are propagated in each longitudinal direction to provide for the detection of imperfections oriented transverse to the pipe's major axis. The transducer scan path shall have sufficient overlap to produce complete coverage of the pipe wall in each longitudinal direction. The sensitivity of the system shall enable it to detect, display, and record transversely oriented and three-dimensional imperfections such as, but not limited to, cracks, cuts, rolled-in slugs, and pits.

15.6.1.3 Inspection for Oblique or Angular Imperfections

Angled sound beams propagating at various angles to the pipe's longitudinal axis are used to detect imperfections such as seams, cracks, laps, rolled-in slugs, pits, and mechanically induced cuts, gouges, and so forth. The number and placement of the transducers shall be sufficient for 100 percent coverage at the dedicated angles. The sensitivity of the system shall enable it to detect, display, and record obliquely oriented imperfections.

15.6.2 Calibration and Standardization

15.6.2.1 A length of pipe of the same diameter, wall thickness and of similar ultrasonic properties as the pipe being inspected should be utilized as a reference standard. This reference standard should be of a length sufficient for dynamic periodic checks and should be provided by the owner.

15.6.2.2 For the inspection, reference notches should be placed on the outside surface of the reference standard. The length and orientation should be as required to provide a comparable peak amplitude from both sides of the reference reflector, using the same transducer and gain control settings. The depth should be 5 to 10 percent of the specified wall thickness of the pipe to be inspected. By agreement between the owner and the agency, similar notches may be placed on the inside surface of the reference standard. As an alternate to the above notches, a drilled hole (see API Spec 5L) may be used.

15.6.2.3 Reference notches should be placed so they can be removed by grinding without reducing the wall thickness to less than the minimum allowable thickness. Alternatively, the notched section may be cut off. A reference standard that contains a drilled hole will be clearly identified as a reject. Drilled holes should be placed so that the section containing them may be cut off with minimal loss of acceptable pipe.

15.6.2.4 Notches or holes should be separated such that each indication is distinct and separate from each other and from other pipe anomalies or end effects. Equipment gain and threshold adjustments should be set for a minimum signal to noise ratio (S:N) of 3:1.

15.6.2.5 Instrumentation should be adjusted to produce reference signal amplitudes of at least 50 percent of full-scale of the readout for each transducer. The reference notch response from each transducer must be of sufficient amplitude to activate threshold alarms.

15.6.3 Procedure for the Detection of Longitudinal, Transverse, and Oblique Imperfections

The combination of linear and rotational speeds of the pipe and/or scanner shall produce full pipe body coverage without gaps. The scanning speed shall be such as to provide both reliable recording and operation of the threshold alarms. Other methods for obtaining complete coverage of the pipe surface may be used.

The inspection procedures are as follows:

a. Inspect each length of pipe using the ultrasonic inspection unit.
b. To confirm the electronic readout indications, mark the area of the suspected imperfections on the pipe surface for further evaluation. Locate and outline the full extent of the imperfection using supplementary nondestructive inspection techniques.

15.7 INSPECTION OF PIPE ENDS FOR LAMINATIONS (UTLE)

15.7.1 Equipment

A standard pulse-echo ultrasonic instrument normally is used in conjunction with a search unit of appropriate size, shape, and sensitivity.

15.7.2 Calibration and Standardization

15.7.2.1 A ¼-inch diameter flat-bottom hole, or a ¼-inch wide longitudinal notch, that penetrates to 50 percent of the specified pipe wall thickness should be placed on the opposite surface from the sound entry. The location of this reference reflector (on the standard) is by agreement between the owner and the agency.

15.7.2.2 Reference reflector signal height should be adjusted to be at least 50 percent of fullscale of the readout and be of sufficient amplitude to activate threshold alarms.

15.7.3 Procedure

This inspection uses normal beam ultrasonics to detect laminations that exceed allowable dimensions in the ends of pipe. The end areas for the complete circumference of the pipe are scanned in a 1-inch path adjacent to the intersection of the bevel and OD surface. After detection of a lamination, detailed examination shall be done to determine whether it exceeds the applicable specification.

15.7.3.1 After calibration, inspection can be started. Place the transducer on the pipe surface and, when the coupling is established, move the transducer slightly more than 360 degrees around the pipe. This scan may be automatic or manual, but in either case, the scanning speed should be compatible with the electronic equipment being used.

15.7.3.2 Perform the test described in 15.7.3.1 on each end of each length.

15.7.3.3 To confirm the electronic readout indications, mark the area of the suspected imperfections on the pipe surface for further evaluation. Locate and outline the full extent of the imperfection using supplementary nondestructive inspection techniques.

15.7.3.4 Ends with damage that prevents effective scanning shall be identified.

15.8 MANUAL ULTRASONIC THICKNESS GAUGING

15.8.1 Equipment

The ultrasonic thickness gauge is used to measure pipe wall thickness from the outside surface. The gauge typically consists of an ultrasonic transducer, a connecting cable, and a battery-powered instrument packaged with a digital scope or meter readout. It shall be capable of reading the thickness of a parallel surface test block within ±0.002 inch of the actual thickness.

15.8.2 Calibration and Standardization

15.8.2.1 All standards used for calibration should have velocity and attenuation properties similar to the pipe being inspected. Prior to use, and to minimize error due to temperature differences, the standards should be exposed to the same ambient temperature as the pipe for 30 minutes or longer. Placement of the standard on the pipe surface and maximizing its contact area with the pipe may shorten the exposure time to 10 minutes.

15.8.2.2 Calibrate the gauge according to the gauge manufacturer's instructions on a standard thickness that is at least 0.050 inch less than the specified wall thickness and on a second standard thickness that is at least 0.050 inch greater than the specified wall thickness of the pipe being inspected. The thickness should be verified by micrometer measurement. The gauge accuracy should be within ±0.002 inch of the standard's thickness.

15.8.2.3 The standards used in 15.8.2.2 should have the same outside surface curvature as the outside diameter of the pipe being measured, except a flat standard may be used when pipe larger than 3½ inch OD is being inspected with a transducer no larger than ⅜ inch (0.375 inch) diameter.

15.8.2.4 When practical, a micrometer measurement of a properly prepared area of the pipe to be inspected (or a piece of material of the same OD, wall thickness, and grade) should be used for the final calibration of the gauge. Adjustments should be made with the gauge's controls to match the micrometer reading. A properly prepared external surface, includes removal of varnish, paint, and loose material. A properly prepared internal surface at the same point, includes removal of loose material and varnish to allow proper contact of the micrometer anvil. If it is not practical to access the pipe reference thickness, a section of pipe of the same diameter, weight, and grade may be used to measure calibration during the job.

15.8.2.5 Frequency of Calibration Checks

In addition to the requirements stated in 15.3.2 of this recommended practice, the following should be done:

a. Perform the procedures in 15.8.2.4 (or 15.8.2.2 and 15.8.2.3, if 15.8.2.4 is not possible) for every 25 areas measured in continuous operation, whenever a reject reading is encountered, or whenever a reading within 0.005 inch of the permissible thickness is encountered.
b. Perform all of the procedures in 15.8.2 whenever the gauge operator (inspector) changes.
c. In 15.8.2.5.a, the gauge reading during a calibration check should be readjusted when there is a variance of more than 0.002 inch from the original set-up value.

15.8.2.6 Sensitivity Check

If the UT gauge is used to evaluate an imperfection on the inside surface of the pipe, the gauge should be able to detect a 1/16-inch flat-bottom hole ⅜ inch from the front surface of a parallel surface test block. The remaining wall thickness measurement accuracy should be ±0.005 inch and should be checked after any repair of the instrument and at least once every six months.

15.8.2.7 Gauge Linearity

The linearity of the gauge's readout should be calibrated over an interval of 0.100 inch to 2.000 inches after any repair of the instrument, or at least once every six months. The calibration is to be recorded on the instrument and in a log book, and should include the date of the calibration and the initials of the person who performed it.

15.8.3 Procedure

15.8.3.1 Calibration

When the UT gauge is turned on (if battery powered), and the instrument indicates that the battery is low, the battery must be recharged or replaced before proceeding. The appropriate scale is then selected for the pipe wall to be measured, and the UT gauge shall be calibrated as described in 15.8.2.

15.8.3.2 Measurement

When measuring the wall thickness, remove all dirt and loose material from the pipe surface and apply a couplant to the area to be gauged. This couplant shall not injure the material being inspected. Avoid using an oil-based couplant on line pipe that is to be coated. Press the transducer firmly onto the surface.

The measurement procedures are as follows:

a. When a twin-element transducer is employed, the parting line between the sending and receiving transducers should be either perpendicular or parallel to the pipe axis, but should be used in the same manner as on the reference standard.
b. Allow the reading to stabilize, then compare the reading with the minimum allowable wall thickness. A stable reading is one that maintains the same value (±0.001 inch) for at least three seconds.
c. When a reading is made that would classify the pipe as a reject, scrape all surface coating and loose scale to clean the surface without removing any base metal. Verify the gauge accuracy on the test block, and recheck the pipe thickness measurement.
d. When searching for or evaluating an inside imperfection, the previously outlined steps are used, except that the transducer is moved back and forth over the pipe in a scanning mode, searching for the thinnest wall reading.
e. When using a highly sensitive gauge, care must be taken to ensure that detection of an inclusion or lamination is not interpreted as a reduction in wall thickness. Refer to Section 16 for details of imperfection evaluation.

15.8.3.3 Ultrasonic Probe Wear

When a significant amount of scanning is being performed, visually examine the ultrasonic probe face periodically for wear. When a worn probe face results in inaccurate readings, it should be either remachined or replaced. Recalibration of the UT gauge is required in either case.

15.8.3.4 Gauge Function

If the readout does not remain stable when the transducer is being held firmly on a test block, the gauge may be malfunctioning. It should be repaired or replaced and then calibrated before proceeding.

15.8.3.5 Gauge Accuracy

Achieving the accuracy on calibration thicknesses as described in 15.8.2.2 does not necessarily ensure the same accuracy for pipe wall thickness measurements. The pipe's surface conditions (both entry and back wall reflection surfaces) are not necessarily the same as a test block.

16 Evaluation of Imperfections and Deviations

16.1 SCOPE

This section describes the procedures for the evaluation of imperfections and deviations detected using the methods contained in this recommended practice. Acceptance and rejection principles are contained in Section 7.

16.2 APPLICATION

The evaluation procedures contained in this section are applicable to all pipe except those classified as prime as the result of inspection in accordance with this recommended practice.

16.3 EQUIPMENT

Equipment used in conjunction with evaluation procedures includes, but is not limited to, the following:

a. Depth gauges.
b. Wall thickness calipers.
c. Straight edges.
d. Rules, rigid and flexible.
e. Hardness testing equipment.
f. Portable ultrasonic inspection equipment.
g. Magnetic particle inspection equipment.
h. Dye penetrant materials.

16.4 CALIBRATION AND STANDARDIZATION PROCEDURES

All equipment and materials used to evaluate imperfections shall be calibrated on a regular basis in accordance with the provisions of the agency's quality assurance program. In addition, the following calibrations shall be performed:

16.4.1 Depth Gauges

The following conditions and checks apply to gauges used for imperfection evaluation:

a. Zero the gauge on a flat surface.
b. Check measuring accuracy of the gauge over a range of standard depths, at least once every four months and after repair or replacement.
c. Accuracy should be within 0.001 inch of actual depths of standard.
d. The accuracy check shall be recorded on the gauge and in a log book with the date of the accuracy check and the initials of the person who performed the check.

16.4.2 Wall Thickness Calipers

a. Set the gauge to read *zero* or a specified thickness when the contact points touch or when a standard thickness is placed between the contacts.
b. Check the measuring accuracy of the gauge over a range of standard thicknesses different from 16.4.2.a above, at least once every four months and after repair.
c. Accuracy of differential readings should be within 2 percent of the actual wall thickness of the thickest standard used.
d. The Accuracy check shall be recorded on the gauge and in a log book with the date of the accuracy check and the initials of the person who performed the check.

16.4.3 Shear Wave Ultrasonic Equipment

Refer to 15.3.1 and 15.3.2 of this recommended practice for calibration procedure.

16.5 PROCEDURE FOR EVALUATING PIPE BODY IMPERFECTIONS

These guidelines shall be used when evaluating surface imperfections, excluding dents, hard spots, and arc burns, detected in locations other than the weld region in new line pipe (Evaluation of weld imperfections is covered in 16.6).

16.5.1 Procedure for Evaluating Outside Surface Imperfections

16.5.1.1 Exploration

When imperfections such as seams or laps are found in a length of pipe, the following procedure applies. Explore the region with a file or grinder. Exploratory grinding should be conducted carefully to avoid creating a defect by overgrinding and to include intermittent wall thickness measurements. Traces of imperfections determined to be rejectable should be left for verification by the manufacturer or the manufacturer's representative. A small hammer and chisel may be used for exploring laps and rolled-in slugs. Pits, cuts, and gouges usually do not require grinding for depth measurement, but should be cleaned of foreign matter before measuring. When no imperfection is readily identified, refer to 16.5.2 for further evaluation.

16.5.1.2 Measurement of Imperfection

Adjust the depth gauge to *zero* on a flat surface. Measure the depth of the imperfection using the depth gauge. Verify the measurement by scraping away the varnish and loose scale and by removing metal protrusions with a flat file. Do not remove steel from the pipe surface during cleaning, as this may result in an inaccurate evaluation.

Read the depth of the imperfection directly from the dial. Whenever a rejectable reading is obtained, the *zero point* of the gauge shall be reconfirmed. When an imperfection is contained within a dent or irregular surface, the depth gauge should be zeroed immediately adjacent to the imperfection, with the major axis of the anvil parallel to the longitudinal axis of the pipe. This practice ensures measurement of the imperfection, excluding deformation of the pipe surface.

16.5.1.3 Disposition

If the pipe has a defect as defined in 7.8 of the latest edition of API Specification 5L, the pipe shall be rejected unless the defect is removed by contour grinding and the remaining wall thickness is equal to or greater than the minimum allowed in accordance with Table 9 of the latest edition of Specification 5L. The measured wall thickness shall be verified after complete removal of the defect. Removal of defects by grinding is performed only by agreement between the owner and the agency.

If agreed upon between the owner of the pipe and the manufacturer, the section of pipe containing the defect may be cut off within the limits of requirements on length or may be weld repaired, according to B.3 and B.4 of the latest edition of API Specification 5L.

16.5.2 Procedures for Evaluating Inside Surface Imperfections

When pipe diameter permits, an attempt shall be made to explore by grinding and/or measuring the depth of an imperfection on the inside surface.

16.5.2.1 Further Exploration

When an electromagnetic or ultrasonic inspection signal is displayed and/or a magnetic powder buildup exists, but no imperfection is readily identifiable, supplementary tools and techniques shall be used to evaluate these imperfections as either acceptable or rejectable. Tools and techniques that may be used are as follows:

a. Removing a few thousandths of an inch of outside surface metal, applying a strong circular magnetic field, and reinspecting using MPI on the outside surface of the suspected area.
b. Inspecting the inside surface using a high-intensity light source or a borescope.
c. Scanning the surface using an ultrasonic thickness gauge.
d. Magnetizing the pipe using a circular magnetic field and inspecting the inside surface using MPI in the suspected area.

16.5.2.2 If the imperfection exceeds the requirements of the latest edition of Specification 5L, then the length will be identified with a red paint band.

If after application of two or more of the previously mentioned methods, an inside surface breaking imperfection is verified to be present by any one of the methods, but cannot be measured, the following procedure shall apply.

a. Linear imperfections shall be evaluated by the procedure in 16.5.2.3.
b. Round-bottomed imperfections shall be evaluated using an ultrasonic thickness gauge.

16.5.2.3 Alternative Procedure

As an alternative to the methods described in 16.5.2.1, a shear wave ultrasonic unit shall be used by an inspector qualified in accordance with Section 5 of this recommended practice to evaluate the imperfection. The unit is calibrated with a reference standard containing outside and/or inside notches, as agreed between the owner and the agency. A procedure shall be agreed upon between the owner and the agency. It is recommended that this procedure not rely on signal amplitude alone to classify an imperfection as a defect.

16.5.2.4 If agreed upon between the owner of the pipe and the manufacturer, the section of pipe containing the defect may be cut off within the limits of requirements on length or may be weld repaired according to B.3 and B.4 of the latest edition of API Specification 5L.

16.5.2.5 If the severity of the imperfection cannot be determined, the length shall be identified with the appropriate blue band for further evaluation and disposition by the owner and manufacturer.

16.5.3 Nonsurface Breaking Imperfections

Nonsurface breaking imperfections should be evaluated by using the procedure in 16.5.2.3.

16.5.4 Radius Grinds

Contour all field exploratory grinds and chisel marks when the measured wall is equal to or greater than the minimum allowed, in accordance with Table 9 of the latest edition of Specification 5L. All grinds in acceptable pipe should be coated with a rust inhibitor, unless the pipe was ordered bare and/or will be subsequently coated with a service corrosion control coating.

16.6 PROCEDURE FOR EVALUATING WELDS

These guidelines are to be used when evaluating surface imperfections or dimensional variations detected in the weld area of new line pipe manufactured using a welding process.

16.6.1 Surface Penetrating Imperfections

Except for visible cracks, narrow imperfections that will not accept the contact point of a depth gauge should be explored with a file or grinder. Exploratory grinding shall be round bottomed. In the case of submerged-arc welds, filing or grinding (on the weld) should not extend below a prologation of the surface of the pipe. Exploration grinding should be conducted carefully to avoid creating a defect caused by overgrinding and include intermittent wall thickness measurements. Traces of imperfections, determined to be rejectable in accordance with 16.5.1.3, should be left for verification by the manufacturer or the manufacturer's representative. Imperfections such as pits, undercutting, or excessive trim usually do not require grinding for depth measurement, but should be cleaned of foreign matter before measuring.

16.6.2 Measurement of Surface Penetrating Imperfections

Adjust the depth gauge to *zero* on a flat surface. Measure the depth of the imperfection using the depth gauge aligned parallel to the longitudinal axis of the weld seam. Read the depth of the imperfection directly from the dial. Whenever a rejectable reading is obtained, the *zero point* of the gauge shall be reconfirmed.

16.6.3 Disposition

16.6.3.1 Cracks

All cracks are considered defects in accordance with 7.8.8 of the latest edition of API Specification 5L. The pipe shall be rejected unless the defect can be removed in accordance with the dispositions shown in 9.7.5.4 of the latest edition of API Specification 5L.

16.6.3.2 Undercutting

Undercutting that exceeds the depth, length, or distribution requirements of 7.8.11 of the latest edition of API Specification 5L is considered a defect. The pipe shall be rejected unless the defect can be removed in accordance with dispositions shown in 9.7.5.4 of the latest edition of API Specification 5L.

16.6.3.3 Excessive Trim in Electric Welded Line Pipe

Excessive trim in electric-welded pipe is considered a defect if the depth of the groove exceeds the limits described in 7.8.6 of API Specification 5L. The depth of the groove is determined by the difference between wall thickness measurements taken approximately 1 inch away from the groove and in the groove in the same transverse plane.

16.6.3.4 Other Surface Imperfections

A surface imperfection other than those described in 16.6.3.1 through 16.6.3.3 above, having a depth exceeding those described in 7.8.12 of the latest edition of API Specification 5L shall be considered a defect. The pipe shall be rejected unless the defect can be removed by contour grinding, and the measured wall thickness is not less than the minimum allowed in accordance with Table 9 of the latest edition of API Specification 5L. Refer to 16.5.4 for additional requirements concerning removal by grinding.

16.6.3.5 Weld Geometry

The pipe is considered defective if the weld geometry exhibits an offset of plate edges, weld bead height, or flash height in excess of the limits described in 7.8.2, 7.8.4, or 7.8.5 of the latest edition of API Specification 5L. The pipe shall be rejected unless the defect can be removed in accordance with the dispositions shown in 9.7.5.4 of the latest edition of API Specification 5L.

16.6.3.6 If agreed upon between the owner of the pipe and the manufacturer, the section of pipe containing a defect may be cut off within limits of requirements on length or may be weld-repaired according to B.3.2 of the latest edition of API Specification 5L.

16.6.4 Radius Grinds

Contour all field exploratory grinds and chisel marks with generous radii when the measured wall is equal to or greater than the appropriate values specified in Table 9 in the latest edition of API Specification 5L. All grinds in acceptable pipe should be coated with a rust inhibitor, unless the pipe was ordered bare and/or will be subsequently coated with a service corrosion control coating.

16.7 PROCEDURE FOR EVALUATING MILL GRINDS

When evidence of defect removal by the manufacturer (mill grind) is found, the following paragraphs apply.

16.7.1 MPI Inspection

Inspect the area using magnetic particle or dye penetrant to ensure imperfection is completely removed. If the imperfection is not completely removed, use a file or grinder to explore to the full depth of the imperfection.

16.7.2 Wall Thickness Measurement

If no further imperfection is found in accordance with 16.8.1, measure the wall thickness in several places in the grind area to ensure that the wall thickness is equal to or greater than the minimum allowed in accordance with Table 9 in the latest edition of API Specification 5L.

16.7.3 Contouring

If the remaining wall (measured wall thickness, minus the exploratory depth) is greater than the minimum allowed in accordance with Table 9 in the latest edition of API Specification 5L, the exploratory indentation shall be contoured in order to make the length acceptable.

16.7.4 Disposition

If the area is determined to be defective as described in Section 7.8 of the latest edition of API Specification 5L, the length shall be rejected. If agreed upon between the owner of the pipe and the manufacturer, the section of pipe containing the defect may be cut off within the limits of requirements on length or may be weld repaired according to B.3 and B.4 of the latest edition of API Specification 5L.

16.8 PROCEDURE FOR EVALUATING WALL REDUCTION

When wall reduction, or thinning, is evident due to eccentricity or other conditions, the following procedure applies:

16.8.1 Wall Thickness Measurement

Confirm the wall thickness using an acceptable device such as an ultrasonic wall thickness gauge or pipe-wall micrometer.

16.8.1.1 When using a pipe-wall micrometer, it shall meet the construction requirements in 7.3 of the latest edition of API Specification 5L.

16.8.1.2 When using an ultrasonic thickness gauge, if the minimum reading is borderline on the minimum allowed in accordance with Table 9 in the latest edition of API Specification 5L, multiple readings should be taken to determine the lowest measured wall thickness. The measured wall thickness is defined as the average of at least three ultrasonic readings within approximately a ¼-inch-diameter surface area. Each reading shall be no closer than ⅛ inch to another. Readings are usable for averaging when they are within 0.010 inch of each other. No single ultrasonic reading shall be the basis for rejection of wall thickness. In the case of dispute, the measurement determined by use of a mechanical caliper (or pipe-wall micrometer) shall govern.

16.8.2 Disposition

Pipe that has a measured wall thickness equal to or greater than the appropriate value specified in Table 9 in the latest edition of API Specification 5L is acceptable. If the "measured" wall thickness is less than the minimum allowed in accordance with Table 9 in the latest edition of API Specification 5L, the pipe shall be rejected unless the defective area can be cut off in accordance with 9.7.5.4 of the latest edition of API Specification 5L.

16.9 PROCEDURE FOR EVALUATING SUBSURFACE IMPERFECTIONS IN WELDS

This procedure is to be used when imperfections such as slag inclusions, porosity, lack of fusion, lack of penetration, cracks, and so forth, are detected, which do not break the surface and cannot be evaluated as described in Section 16.6.

16.9.1 Evaluation

Imperfections that do not penetrate the surfaces of the weld area, and that produce a signal greater than the appropriate limit given in Table 20 of the latest edition of API Specification 5L, require further evaluation with a shear wave ultrasonic unit. The operator of the equipment shall be qualified in accordance with Section 5. The shear wave ultrasonic unit shall be calibrated on the same type reference reflector used to standardize the scanning system that detected the imperfection being evaluated. If the imperfection produces a signal greater in height than the appropriate acceptance limit given in Table 20 of the latest edition of API Specification 5L, it shall be considered a defect unless it can be demonstrated that the imperfection does not exceed the provisions of 7.8 of the latest edition of API Specification 5L.

16.9.1.1 Defects found in submerged-arc welds may be reinspected by radiological methods in accordance with 9.7.3.1 through 9.7.3.12 of the latest edition of API Specification 5L.

16.9.1.2 For gas metal-arc welds, imperfections greater than 1 inch in length, regardless of signal height but discernible above background noise, shall be considered defects and may be reinspected by radiological methods in accordance with 9.7.3.1 through 9.7.3.12 of the latest edition of API Specification 5L or other techniques as agreed upon between the owner of the pipe and the manufacturer.

16.9.2 Disposition

Disposition of defects shall be in accordance with 9.7.5.4 of the latest edition of API Specification 5L.

16.10 PROCEDURE FOR EVALUATING DENTS

When a dent is detected during an inspection process, its severity shall be evaluated as follows:

16.10.1 Exploration

The gap between the bottom of the dent and the prolongation of the original pipe surface shall be measured with a depth gauge or straightedge and precision ruler.

16.10.2 Gap Measurement

Adjust the depth gauge to *zero* on a flat surface. Measure the gap resulting from the dent. Whenever a rejectable reading is obtained, the zero point of the gauge shall be reconfirmed. Alternatively, the straightedge shall be placed across the dent, parallel to the longitudinal axis of the pipe. The gap between the lowest point of the dent and the prolongation of the original contour of the pipe shall then be measured with a precision ruler.

16.10.3 Dent Length Measurement

If the gap measurement is acceptable, the maximum distance across the dent in any direction shall be measured with a precision ruler.

16.10.4 Disposition.

If the pipe has a defect as described in 7.8.1 of the latest edition of API Specification 5L, it is a reject, unless the defect can be cut off in accordance with the dispositions shown in 9.7.5.4 of the latest edition of API Specification 5L.

16.11 PROCEDURE FOR EVALUATING HARD SPOTS

16.11.1 Procedure

When pipe surface irregularities are visually detected and fail to disclose mechanical damage as the cause, the hardness of the suspect area should be evaluated as follows:

a. The hardness testing procedures provided in Section 9 shall be followed.
b. Several hardness tests may be required to define the perimeter of the hard spot.

16.11.2 Disposition

If the dimensions and hardness of the hard spot exceed those limits specified in 7.8.7 of the latest edition of API Specification 5L, then by agreement between the manufacturer and the owner of the pipe, the defect region may be cut out as a cylinder, within the limits of requirements on pipe length. Otherwise, the length shall be rejected or given disposition in accordance with the requirements of the latest edition of API Specification 5L, 9.7.5.4.

16.12 PROCEDURE FOR EVALUATING ARC BURNS

Arc burns are considered defects in accordance with 7.8.10 of the latest edition of API Specification 5L. However, contact marks on electric-weld pipe are not considered defects.

16.12.1 Disposition

Pipe containing arc burns shall be rejected or the defect may be removed in accordance with 7.8.10.a of the latest edition of API Specification 5L.

16.13 PROCEDURE FOR EVALUATING LAMINATIONS AND INCLUSIONS

When imperfections such as laminations or inclusions, which extend into either the face or the bevel of the pipe, are detected, a substantial effort shall be made to evaluate such imperfections by means of magnetic particle inspection using a hand-held AC yoke. As an alternative, dye-penetrant inspection may be performed.

16.13.1 Disposition

Imperfections exceeding the provisions of 7.8.9 of the latest edition of API Specification 5L shall be considered defects and the pipe rejected or given one of the dispositions in 9.7.5.4 of the latest edition of API Specification 5L. Grinding to remove defects on the bevel or face of pipe is not permitted.

16.14 PROCEDURE FOR EVALUATING BENT PIPE

When visual examination discloses that a length of pipe is not reasonably straight, the following procedures apply.

16.14.1 Measurement of Straightness

On pipe grades A25, A, and B with OD less than 4½ inches, if the length is not reasonably straight, it shall be considered a reject and given one of the dispositions in 9.7.5.4 of the latest edition of API Specification 5L. On all other pipe, the deviation shall be measured with a precision ruler. The reference straight line is a taut string or wire placed from end to end along the side of the pipe providing the greatest gap. If the measurement of the gap exceeds the requirements of 7.6 of the latest edition of API Specification 5L, the pipe shall be considered defective.

16.14.2 Disposition

Pipe containing deviations from straightness greater than the provision of 7.6 of API Specification 5L shall be considered defective and given one of the dispositions of 9.7.5.4 of the latest edition of API Specification 5L.

16.15 PROCEDURE FOR EVALUATING DIAMETER

When a deviation from specified nominal diameter is evident due to out-of-roundness or incorrect diameter, the following procedure applies.

16.15.1 Measurement of Diameter

The deviation from the specified diameter shall be measured in accordance with 8.6.2. Ring gauges and diameter tapes so employed shall meet the construction requirements of 7.2 in the latest edition of API Specification 5L.

16.15.2 Disposition

If the pipe has a diameter or out-of-roundness condition exceeding the tolerances of Tables 7 and 8 in the latest edition of API Specification 5L, it shall be rejected unless the defect can be removed in accordance with the dispositions shown in 9.7.5.4 of that specification. By agreement between the owner and the manufacturer, pipe with out-of-roundness conditions may be repaired.

16.16 PROCEDURE FOR EVALUATING BEVEL, FACE, TAPER, AND SQUARENESS

When mechanical damage or a deviation from a specified dimension is evident, the appropriate procedure applies as follows:

16.16.1 A bevel angle, root face width, or internal taper angle exceeding the tolerances given in 7.9.3 of the latest edition of API Specification 5L is a defect and the pipe shall be rejected.

16.16.2 An internal burr is a defect and the pipe shall be rejected. Alternatively, the defect may be removed by filing or grinding if the resulting taper angle and root face width complies with the tolerances given in 7.9.3 of the latest edition of API Specification 5L.

16.16.3 When end squareness exceeds the tolerance specified in 7.9.3 of the latest edition of API Specification 5L, it is a defect and the pipe shall be rejected. In the case of dispute, the referee measurement method shall be by agreement between the owner and the manufacturer of the pipe.

16.16.4 Alternative disposition: A defect may be removed in accordance with the applicable disposition in 9.7.5.4 of the latest edition of API Specification 5L.

17 Marking

17.1 SCOPE

This section sets forth the recommended practice for the uniform inspection marking of new line pipe after field inspection.

17.2 AUTHORITY

The classification of each inspected length shall be performed only by a qualified inspector. However, any crew member may be directed to paint the length with appropriate descriptions and paint bands.

17.3 GENERAL GUIDELINES

17.3.1 Legibility

No inspection markings shall be placed over the mill markings that reduce the legibility of the manufacturer's markings, unless an imperfection exists under such a marking.

17.3.2 Paint Bands

All paint bands or stripes (see Table 2) shall be approximately 1-inch wide and placed neatly on or in the pipe as close as possible to the identified end of the pipe (but not on the pipe bevels).

17.3.3 Exploratory Areas

All exploratory marks and grinds, except those on rejected lengths, should be covered with a rust-inhibiting coating if the pipe is intended for storage. If pipe is received uncoated, coating of grinds is unnecessary.

17.3.4 Sequence Number

Each length of inspected pipe shall have a unique number printed in white paint in accordance with 6.2.4.

17.3.5 Marking

For 2⅜-inches and larger pipe, white paint markings shall be placed on or in the pipe adjacent to the inspection paint band or stripe, or following the mill markings. These markings shall identify the agency, the work order number, the type of inspection, and the date (month and year) of the inspection. On each reject length, the type and depth (if applicable) of defect shall be printed in white paint, and the word REJECT shall be printed after the type of inspection in white paint.

The format illustrated in Figure 2 is presented as an example only. On small-diameter pipe, it may be necessary to place the markings in a single line along the longitudinal axis of the pipe. On pipe smaller than 2⅜ inches, an alternate marking method (such as tags) may be used by agreement between the owner and the agency.

Inspection techniques shall be indicated using either descriptive wording or the following abbreviations. (By agreement between the owner and the agency, a trade name may be substituted for a specific inspection.)

a. EMI: electro-magnetic inspection.
b. EAI: end area inspection.
c. FLVI: full-length visual inspection.
d. FLMPIW: full-length magnetic particle inside weld.
e. FLMPOW: full-length magnetic particle outside weld.
f. FMLPI: full-length magnetic particle inside surface.
g. FLMPO: full-length magnetic particle outside surface.
h. UTBL: ultrasonic body wall thinning and planar imperfections.
i. UTBLTO: ultrasonic body longitudinal, transverse, oblique.
j. UTW: ultrasonic inspection weld only.
k. UTLE: ultrasonic lamination check on pipe ends.
l. DBE: diameter and bevel check on pipe ends.

Table 2—Summary of New Line Pipe Inspection Identification Bands

Classification	Band Color
Prime pipe	White
Acceptable conditioned pipe	White
Pipe with imperfections of undetermined depth	Blue
Pipe requiring conditioning	Yellow
Nonconditionable pipe (reject)	Red
Pipe failing special owner-specified tests	Green

17.4 MARKING OF PRIME LINE PIPE

17.4.1 Requirements

Each length of pipe that meets API Specification 5L for the specific inspections being performed is classified as prime pipe.

17.4.2 Markings

Markings for prime pipe include the following:

a. One white paint band or white stripe placed on or in the pipe as closely as possible to the identified end.
b. Other markings, as described in 17.3.5.

17.5 MARKING OF LINE PIPE WITH AN IMPERFECTION OF UNDETERMINED DEPTH

17.5.1 Requirements

Each length of inspected pipe that has an inside imperfection, whose magnitude cannot be determined, shall be classified as pipe with imperfections of undetermined depth.

17.5.2 Markings

Markings for pipe containing imperfections include the following:

a. One blue paint band around the pipe as close as possible to the identified end.
b. One blue paint band around the pipe at each end of the area where the imperfection occurs.
c. Blue paint outlining the total length and width of the imperfection on the outside surface of the pipe.

17.6 MARKING OF CONDITIONED LINE PIPE

17.6.1 Requirements

Each length of pipe that has a defect requiring conditioning according to API Specification 5L shall be classified as prime pipe after proper conditioning.

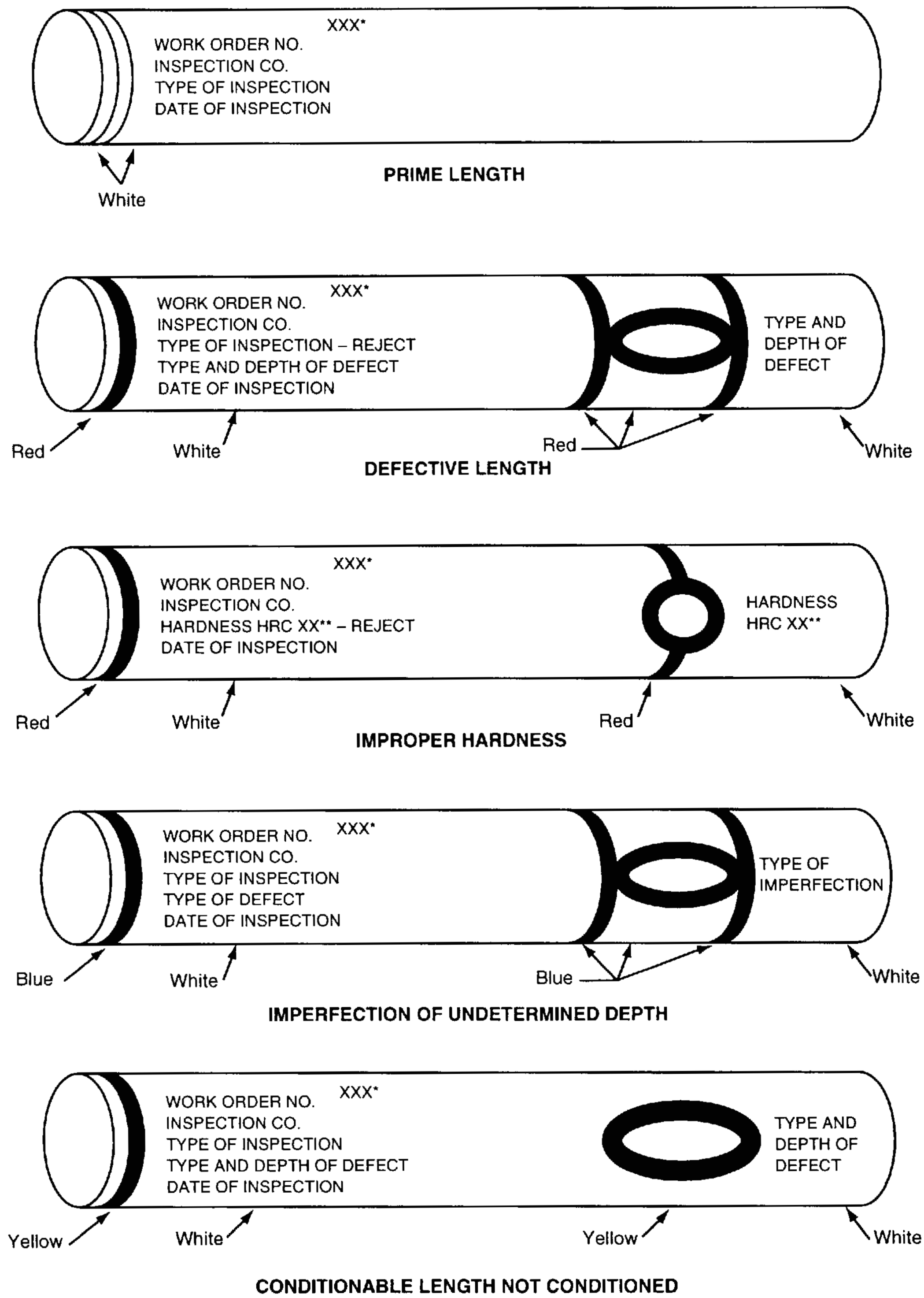
17.6.2 Markings

After the pipe has been properly conditioned, the length is considered prime and shall be identified as described in 17.3.5.

17.7 MARKING OF CONDITIONABLE LINE PIPE (TO BE CONDITIONED)

17.7.1 Requirements

Each length of pipe that has a defect requiring conditioning according to API Specification 5L and not conditioned shall be classified as a conditionable length.



Note:
*XXX = length number.
**HRC XX = hardness number on the Rockwell "C" scale.

Figure 2—Inspection Marking of New Line Pipe

17.7.2 Markings

Markings for conditionable line pipe include the following:

a. One yellow paint band around the pipe as close as possible to the identified end.
b. Yellow paint outlining the total length and width of the defect on the outside surface of the pipe.
c. Type and depth of the defect printed in white paint adjacent to the defect.
d. Other markings, as described in 17.3.5.

17.8 MARKING OF NONCONDITIONABLE LINE PIPE (REJECT)

17.8.1 Requirements

Each length of nonconditionable pipe containing a defect as defined in API Specification 5L shall be classified as a reject.

17.8.2 Markings

Nonconditionable pipe shall be marked as follows:

a. One red paint band around the pipe as close as possible to the identified end.
b. Red paint outlining the total length and width of the defect on the outside surface of the pipe.
c. One red paint band around the pipe at each end of the defect, except as noted in Figure 2 for improper hardness.
d. Type and depth of the defect printed in white paint adjacent to the defect.

Other markings as described in 17.3.5.

APPENDIX A—ORDERING INFORMATION

A.1 In specifying the application of this recommended practice to an order for the inspection of new line pipe, the owner should specify for each size and type of pipe the following ordering information:

a. The inspection(s) to be applied.
b. The frequency of sampling for inspection.
c. The reference standard, if applicable.
d. The acceptance criteria.
e. The permissible disposition of all classifications of pipe (Table 2).
f. The instructions for marking.

A.2 The applicability of methods and procedures contained in this recommended practice in accordance with API Specification 5L is indicated in the Applications paragraphs of Sections 8 through 15. Some procedures in this recommended practice are beyond the scope of the inspection requirements of API Specification 5L.

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