

Recommended Practice for Source Inspection and Quality Surveillance of Fixed Equipment

API RECOMMENDED PRACTICE 588
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Contents

	Page
1 Scope/Purpose	1
2 Introduction.....	1
3 Normative References.....	2
4 Definitions, Abbreviations, and Acronyms	2
5 Training and Certification.....	11
5.1 General.....	11
5.2 Levels of Training and Experience	12
6 Source Inspection Management Program.....	13
6.1 General.....	13
6.2 Activities	13
6.3 Other References	13
7 Project-specific Source Inspection Planning Activities	14
7.1 General.....	14
7.2 Equipment Risk Assessment.....	15
7.3 Development of a Source Inspection Project Plan	16
7.4 Development of Inspection and Test Plans	16
7.5 Selection of an Inspector.....	18
7.6 Coordination of Inspection Events.....	18
7.7 Report Review	18
8 Source Inspection Performance	18
8.1 Inspector Conduct and Safety	18
9 Review of Project Documents	18
9.1 General.....	18
9.2 Contractual Agreements.....	19
9.3 Performing the Source Inspection	25
9.4 Source Inspection Work Process Scheduled Planning Events	26
9.5 Report Writing.....	27
9.6 Nonconformances/Deviations	27
9.7 Source Inspection Project Continuous Improvement	30
9.8 Source Inspector Continuous Improvement	30
10 Examination Methods, Tools, and Equipment	30
10.1 General.....	30
10.2 Review and Confirmation of Materials of Construction	31
10.3 Dimensional Inspections	32
10.4 Visual Inspections.....	32
10.5 Nondestructive Examination (NDE) Techniques.....	32
10.6 Destructive Testing	33
10.7 Pressure/Leak Testing	33
10.8 Performance/Functional Testing	34
10.9 Surface Preparation/Coatings Inspections	34
10.10 Final Acceptance	35

Contents

	Page
11 Manufacturing and Fabrication Processes	36
11.1 General.....	36
11.2 Welding Processes and Welding Defects.....	37
11.3 Casting	37
11.4 Forging	38
11.5 Machining	38
11.6 Assembly	39
11.7 Metallurgy Issues Associated with Manufacturing and Fabrication Processes	39
12 Pressure Vessels.....	40
12.1 General.....	40
12.2 Vessel Methods of Construction	41
12.3 Vessel Materials of Construction	41
12.4 Vessel Internal Components	42
12.5 Vessel Design and Construction Standards	42
12.6 Dimensional Check of Pressure Vessels.....	43
12.7 Heat Exchangers	44
13 Piping	45
13.1 General.....	45
13.2 Valves	45
13.3 Flanges.....	46
13.4 Fittings	47
14 Structural Components.....	48
Annex A (informative) Most Common Types of ASME and NB Code Symbol Stamps.....	50
Annex B (informative) Types of Tools for Use by the Source Inspector	51
Annex C (informative) Different Types of Bolted Flange Connections	57
Annex D (informative) Chemical Symbols	59
Annex E (informative) Websites Useful to the Source Inspector.....	60

Figures

1 Work Process	1
A.1 ASME and NB Code Symbol Stamps	50
B.1 Source Inspection Tools (1).....	51
B.2 Source Inspection Tools (2).....	52
B.3 Source Inspection Tools (3).....	53
B.4 Source Inspection Tools (4).....	54
B.5 Source Inspection Tools (5).....	55
B.6 Source Inspection Tools (6).....	56
C.1 Different Types of Flange Faces (Sealing Surfaces)	57
C.2 Different Flange Types	58

Contents

	Page
Tables	
D.1 Chemical Symbols.....	59
E.1 Useful Websites.....	60

Introduction

This recommended practice has been developed to provide information for source inspectors (SI) for the purpose of providing a consistent method of supplier/vendor (S/V) quality surveillance for the oil, petrochemical, and gas industries. It is intended as a resource for individuals studying to take the API Source Inspector Certification examination. Other references contained herein and in the published body of knowledge (BOK) will also be necessary for individuals to become familiar with to pass the examination and to perform satisfactorily in the source inspection.

Recommended Practice for Source Inspection and Quality Surveillance of Fixed Equipment

1 Scope/Purpose

This recommended practice (RP) covers the process of specifying the necessary quality surveillance of materials, equipment, and fabrications being supplied for use in the oil, petrochemical, and gas Industry, including upstream, midstream, and downstream segments. This RP may be used as the basis for providing a systematic approach to risk-based source inspection to provide confidence that materials and equipment being purchased meet the minimum requirements as specified in the project documents and contractual agreements. The activities outlined in this RP *are not* intended to replace the manufacturer's/fabricator's own quality systems, but rather are meant to guide SIs acting on behalf of the purchaser to determine whether manufacturer's/fabricator's own quality systems have functioned appropriately, such that the purchased equipment and materials will meet contractual agreements.

This RP focuses primarily on pressure-containing and structural equipment (fixed equipment), including but not limited to vessels, columns/towers, heat exchangers, piping, valves, pressure-relief devices, tubulars, and supporting structural fabrications. The principles of the document can be applied to other equipment disciplines. This document assumes that suppliers/vendors (S/V) have been pre-qualified by a systematic quality review process of their facilities and quality processes to determine if the facility has the ability to meet the requirements of the contractual agreements. That process generally leads to a list of pre-approved S/Vs deemed acceptable to the supply chain management of the purchaser who are capable of meeting the requirements of the contract prior to it being placed. S/Vs on such a list will normally have an acceptable quality process already in place that meets the requirements of the contract. An approved S/V list may also indicate that S/Vs have the technical skills and can meet the SCM commercial terms and conditions. The purpose of source inspection in such a case is simply to verify that the S/V quality processes are working as they should and to verify that certain critical steps in the inspection and test plan (ITP) have been satisfactorily accomplished prior to fabrication completion and/or shipping.

The primary purpose of this RP is to summarize the basic body of knowledge that the source inspector typically needs to know to perform as a source inspector for fixed equipment. A secondary purpose is to assist candidates intending to take the API Source Inspection Examination to become certified source inspectors. This RP outlines the fundamentals of source inspection and may be useful to all personnel conducting such activities to perform their jobs in a competent and ethical manner. For more information on how to apply for Source Inspection Certification, please visit the API website at www.api.org/si and follow the work process shown in Figure 1.

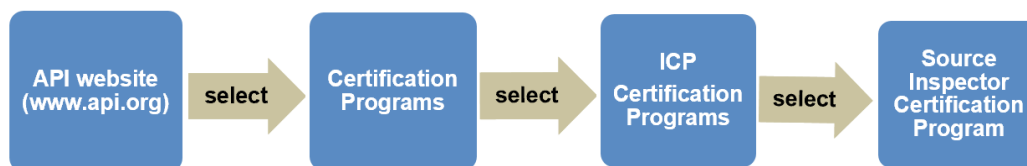


Figure 1—Work Process

2 Introduction

The source inspection work process follows the Plan–Do–Check–Act circular process first popularized in the 1950s by Edward Deming. The “Plan” part of source inspection is covered in Sections 6 and 7 of this RP and involves the source inspection management systems, source inspection project plan, and the inspection and test plan (ITP). The “Do” part is covered in Sections 8, 9, and 10, and involves implementing the ITP, participating in scheduled source inspection work process events, filing nonconformance reports (NCRs), and source inspection report writing. The “Check” part, covered in Section 9.7, involves reviewing all the source inspection activities that occurred in the “Plan” and “Do” parts to see what went well and what should be improved based on the results of that review. Finally, the “Act” part (sometimes called the “Adjust” part), covered in Section 9.8, involves

implementing all the needed improvements in the “Plan” and “Do” parts before they are implemented on the next source inspection project.

3 Normative References

The most recent editions of these codes, standards, or other recommended practices are referenced in this RP and are the documents from which the SI exam has been developed.

API 510, *Pressure Vessel Inspection Code: In-Service Inspection, Rating, Repair, and Alteration*

API Recommended Practice 572, *Inspection Practices for Pressure Vessels*

API Recommended Practice 577, *Welding Inspection and Metallurgy*

API Recommended Practice 578, *Guidelines for a Material Verification Program (MVP) for New and Existing Assets*

API Standard 598, *Valve Inspection and Testing*

ASME¹ Boiler and Pressure Vessel Code (BPVC), Section II—*Materials*, Parts A, B, C, and D

ASME Boiler and Pressure Vessel Code (BPVC), Section V—*Nondestructive Examination*

ASME Boiler and Pressure Vessel Code (BPVC), Section VIII—*Rules for Construction of Pressure Vessels*, Divisions 1 and 2

ASME Boiler and Pressure Vessel Code (BPVC), Section IX—*Welding and Brazing Qualifications*

ASME B31.1, *Power Piping*

ASME B31.3, *Process Piping*

ASME B16.5, *Pipe Flanges and Flanged Fittings*

ASNT²CP-189, *Standard for Qualification and Certification of Nondestructive Testing Personnel*

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

AWS³D1.1, *Structural Welding Code*

AWS Committee on Methods of Inspection., *Welding Inspector Handbook*

SSPC,⁴ PA 2, *Procedure for Determining Conformance to Dry Coating Thickness Requirements*

SSPC., *Surface Preparation Guide*

4 Definitions, Abbreviations, and Acronyms

For the purposes of this RP, the following definitions, abbreviations, and acronyms apply. Additional definitions that the source inspector needs to know and understand are included in the following documents:

¹ American Society of Mechanical Engineers, 2 Park Avenue, New York City, New York, 10016, www.asme.org.

² American Society for Nondestructive Testing, 1711 Arlingate Lane, Columbus, Ohio, 43228, www.asnt.org.

³ American Welding Society, 8669 NW 36th Street, #130, Miami, Florida, 33166, www.aws.org.

⁴ Society for Protective Coatings, 800 Trumbull Drive, Pittsburgh, Pennsylvania, www.sspc.org.

- API Recommended Practice 577, Section 3
- API Recommended Practice 578, Section 3
- ASME B31.3, 300.2
- ASME BPVC Section VIII, Division 1, Appendix 3
- ASME BPVC Section V, Subsection A, Article 1, Appendix 1
- ASME BPVC Section V, Subsection B, Article 30, SE-1316
- AWS D1.1, Annex K

4.1

AARH

Arithmetic average roughness height (a measure of surface roughness).

4.2

annealing heat treatment

Heating an object to and then holding it at a specified temperature, then cooling it at a suitable rate for such purposes as reducing hardness, improving machinability, facilitating cold working, producing a desired microstructure, or obtaining desired mechanical properties.

4.3

ANSI

American National Standards Institute.

4.4

API

American Petroleum Institute.

4.5

ASM

ASM International.

4.6

ASME

ASME International (formerly known as the American Society of Mechanical Engineers).

4.7

ASNT

American Society of Nondestructive Testing.

4.8

ASTM

ASTM International (formerly known as the American Society for Testing and Materials).

4.9

AI

Authorized inspector: the inspector responsible for confirmation to the recognized code.

4.10

BOK

Body of knowledge (in this case, the BOK for the SI examination).

4.11**BPVC**

Boiler and Pressure Vessel Code (published by ASME).

4.12**causal analysis**

A generic term for all types of investigative processes—from as simple as a 5-Why analysis to a full root cause analysis.

4.13**certification**

Documented and signed testimony of qualification. Certification generally refers to the confirmation of certain, specified characteristics of a product or confirmation of a person meeting requirements for a specific qualification.

4.14**calibration**

A comparison between measurements—one of known magnitude or correctness (the standard) compared with the measuring device under test to establish the accuracy of a measuring device.

4.15**cladding**

A metal integrally bonded onto another metal (e.g. plate), under high pressure and temperature, whose properties are better suited to resist damage from the process fluids than the underlying base metal.

4.16**cold working**

Plastic deformation (forming, rolling, forging, etc.) of metals below the recrystallization temperature of the metal.

4.17**continuity log**

A document detailing the continuous history of a welder, the types of welds made, and that there has been no gap (i.e. no more than six months) in performing these processes.

4.18**critical equipment**

Equipment that has been risk assessed and determined that, if it were to fail in service, it would have an unacceptable impact on process safety, environment, or business needs, and therefore deserves a higher level of source inspection attention to make sure the equipment being delivered is exactly as specified.

4.19**destructive testing**

Various tests that are performed on metals for the purposes of determining mechanical properties and that involve testing (usually breaking) of sample coupons. Examples include tensile testing, bend testing, and Charpy impact testing. A destructive-testing work process involves extracting samples/coupons from components and testing for characteristics that cannot otherwise be determined by nondestructive testing. The work process involves breaking and/or testing coupons/samples to failure, and usually renders the component from which the samples were extracted unfit for continued service.

4.20**deviation**

A departure from requirements in the contractual agreements or its referenced purchase order (PO), engineering design, specified codes, standards, or procedures.

4.21**DFT**

Dry film thickness (of paint and coatings) that is measured by a DFT gauge.

4.22**elevation**

The height of any point on a vessel as shown on a vessel drawing, e.g. nozzle, manway, or longitudinal weld, as measured from a base plate or other reference line, such as the bottom head tangent line.

4.23**employer**

The corporate, public, or private entity that employs personnel for wages, salaries, fees, or other considerations, e.g. the employer of the source inspector.

4.24**engineered equipment**

Equipment that is custom designed and engineered by the purchaser and/or EPC to perform a project-specific function. Engineered equipment will typically require more source inspection than non-engineered equipment.

4.25**EPC**

Engineering/procurement/construction contractor.

4.26**examiner**

A person who performs specified nondestructive examination (NDE) on components and evaluates the results to the applicable acceptance criteria to assess the quality of the component. Typically, NDE examiners (sometimes called NDE technicians) are qualified to ASNT NDE personnel qualification practices, e.g. SNT-TC-IA or CP-189.

4.27**ferrous materials**

Alloys that are iron-based, including stainless steels.

4.28**HAZ**

Heat affected zone: the thin base metal area next to the weld that has had its metal structure affected by the heat of welding.

4.29**hot working**

Plastic deformation (forming, rolling, forging, etc.) of metals at a temperature above the metal recrystallization temperature.

4.30**ICP**

Individual Certification Program (of API) under which the SI certification program is administered.

4.31**inspection**

The evaluation of a component or equipment for compliance with a specific product specification, code, drawing, and/or standard specified in the contractual requirements, that may include the measuring, testing, or gauging of one or more characteristics specified for the product to determine conformity.

4.32**inspection agency**

An entity employed to provide competent, qualified, and certified source inspection personnel for the purpose of performing source inspection. For example, an inspection agency can be an EPC company, an owner-user, or an inspection service company.

4.33**inspection coordinator**

Individual who is responsible for the development of the source inspection strategy, coordination of the source inspection visits, and implementation of the source inspection activities on a project.

4.34**inspection waiver**

Permission to proceed with production/shipment without having a purchaser source inspection representative present for a specific activity.

4.35**ITP**

Inspection and test plan: a plan that summarizes minimum inspection, testing, and quality control requirements for a defined scope of work.

4.36**lamination**

A type of discontinuity with separation or weakness generally aligned parallel to the worked surface of a plate material. In a forging, it can rise to the surface or occur internally; it is generally associated with forging at too low of a temperature or, in plate material, may be caused by the tramp elements that have congregated in the center of the plate during rolling.

4.37**levelness**

The position of a surface of a component or structure that is horizontal (within tolerances) with the base plate and at 90 degrees to the vertical plumb line. Nozzle and attachment levelness tolerances are not addressed in ASME BPVC Section VIII, Division 1; however, in the pressure vessel handbook, a $\frac{1}{2}^\circ$ tolerance is permissible. For levelness checking of a nozzle on a vessel, a level gauge is used. If the bubble is in the middle of the designated lines, the nozzle is level. A level gauge would be used for verification and measurement that the angle of a hillside (tangential) nozzle is properly installed relative to the vessel centerline.

4.38**management process**

Management processes are the methods that aid the structuring, investigation, analysis, decision-making and communication of business issues.

4.39**MAWP**

Maximum allowable working pressure: the maximum gauge pressure at the top of a pressure vessel allowed by code calculations for a designated temperature.

4.40**M&F**

Manufacturing and fabrication: Refers to the various material working processes that are commonly used to produce a product, such as welding, joining, heat treatment, casting, forming, forging, bending, machining, assembly, etc.

4.41**manufacturer's record book**

A document after completion of fixed equipment that contains all engineering documents outlined in the contractual agreement that confirms the FE met the engineering design. It contains all approved documents that confirm every inspection activity was satisfactorily completed.

4.42**MOC**

Management of change.

4.43**MSS**

Manufacturers Standardization Society.

4.44**MT**

magnetic particle testing (examination).

4.45**MTR**

Material test report or mill test report: a quality assurance document used in the steelmaking industry that certifies a material's compliance with appropriate standards, including physical and chemical specifications, and applicable dimensions. The MTR also includes a date of production and testing and may include notation about method of fabrication. A mill test report is also known as a certified mill test report, certified material test report, mill test certificate (MTC), inspection certificate, certificate of test, and other names.

4.46**NB**

National Board of Boiler and Pressure Vessel Inspectors.

4.47**NDE**

Nondestructive examination (the preferred terminology): a quality process that involves the examination, testing, and evaluation of materials, components, or assemblies without affecting their functionality, e.g. VT, PT, MT, UT, RT.

4.48**NDT**

Nondestructive testing: Means the same as NDE, which is now the preferred terminology.

4.49**nonconformance report**

Also called an NCR. A form on which the non-conformance is recorded and registered for further handling and follow-up.

4.50**non-engineered equipment**

Equipment that is designed and fabricated by S/Vs, that includes off-the-shelf items such as valves, fittings, some skid units, instruments, pumps, and electrical gear. Such equipment is usually purchased by catalog model numbers, etc. Non-engineered equipment will typically require less source inspection than engineered equipment.

4.51**nonferrous materials**

Alloys that are not iron-based, e.g. nickel- and copper-based alloys.

4.52**normalizing heat treatment**

A heat-treating process in which a ferrous material or alloy is heated to a specified temperature above the transformation range of the metal and subsequently cooled in still air at room temperature. Typically, normalizing heat treatments will refine the grain size and improve the impact properties of steels.

4.53**NPS**

Nominal pipe size: a standard for designating pipe sizes (inches) and associated wall thickness (schedule); for example, the nominal pipe size for a four-inch pipe is normally shown as NPS 4.

4.54**orientation**

The orientation of a nozzle or attachment is the number of degrees off from a vertical centerline (a circumferential degree line) of the attachment or nozzle on the plan view of a vessel. For example, orientation of a nozzle or attachment can be checked with a protractor or smart level.

4.55**out-of-roundness**

A deviation from perfect roundness, e.g. ovality in a vessel circumference. ASME BPVC Section VIII, Division 1, UG 80 deals with out-of-roundness of a vessel shell. The maximum permitted ovality tolerance ($D_{\max} - D_{\min}$) shall not exceed 1 % of the nominal diameter of the vessel.

4.56**PDCA**

Plan–Do–Check–Act (PDCA) cycle. Also known as the Deming cycle, Shewhart cycle, ISO 9001 Process approach.

4.57**PQR**

Procedure qualification record per ASME BPVC Section IX, QW 200.2: a record of the welding data and variables used to weld a test coupon, and the test results used to qualify the welding procedure.

4.58**pressure vessel**

A container designed to withstand a specified amount of internal or external pressure generally above 15 psig. This definition includes heat exchangers, air coolers, columns, towers, unfired steam generators (boilers), and other vapor-generating vessels.

4.59**procedure**

A document detailing how a work process is to be performed, e.g. a welding procedure.

4.60**project quality plan**

The plan for the project as a whole. Plans prepared by contractors or suppliers may be termed contractor or supplier quality plans.

4.61**protractor**

An instrument for measuring angles, typically in the form of a flat semicircle marked with degrees along the curved edge.

4.62**PRV/PRD/PSV**

Pressure relief valve/pressure relief device/pressure safety valve.

4.63**PT**

Penetrant testing (examination).

4.64**QA**

Quality assurance: a proactive quality process that aims to prevent defects and refers to a program of planned, systematic, and preventative activities implemented in a quality system that is intended to provide a degree of confidence that a product will consistently meet specifications. It includes systematic measurement, comparison with a standard, monitoring of processes, and an associated feedback loop that is intended to avoid deviations from specification.

4.65**QC**

Quality control: the specific steps in a QA process that aim to find potential defects in a product before it is released for delivery, e.g. VT, PT, RT, UT, dimensional verification, etc. The QA process will specify the particular QC steps necessary during manufacture/fabrication of a product.

4.66**qualification**

Demonstrated skill, demonstrated knowledge, documented training, and documented experience required for personnel to perform the duties of a specific job, e.g. a certified source inspector.

4.67**quality surveillance**

The process of monitoring or observing the inspection activities associated with materials, equipment, and/or components for adherence to the specific procedure, product specification, code, or standard specified in the contractual requirements. For the purposes of this RP, quality surveillance and source inspection mean the same thing (see “source inspection” definition).

4.68**quenching**

Rapid cooling of a heated metal for the purpose of affecting mechanical and/or physical properties.

4.69**RMS**

Root mean square: a measure of surface finish on flanges.

4.70**RT**

Radiographic testing (examination).

4.71**rust bloom**

The term used to describe surface discoloration that occurs on the surface of steel that has been previously blasted, e.g. near-white or white metal in preparation for coating. When rust bloom is found, the surface should generally be re-cleaned before coating using the same blast-cleaning process.

4.72**SDO**

Standards development organization, e.g. API, ASME, ASTM, NACE, MSS, TEMA, ISO, etc.

4.73**SI**

Source inspector: the person responsible for confirming the work conforms to the contractual requirements.

4.74**SME**

Subject-matter expert.

4.75**solution anneal heat treatment**

Heating an alloy to a specified temperature, holding at the temperature long enough for one or more elements to reenter into solid solution, then cooling rapidly enough to hold those elements in solid solution.

4.76**SOR**

Supplier observation reports: documents filled out by the SI indicating concerns or other factual descriptions of what was noticed during the course of product surveillance, but not necessarily issues that may be considered defects or that require NCRs.

4.77**source inspection**

The process of providing quality surveillance of materials, fabrications, and equipment being supplied by supplier/vendor (S/V) or manufacturer/fabricator (M/F), including their subcontractors, for use in the oil, petrochemical, and gas industry, including upstream, midstream, and downstream segments. Source inspection largely consists of verifying that the S/V's own quality assurance process is functioning as it should to produce quality products that meet contractual agreements.

4.78**source inspector**

Individual responsible for performing the actual source inspection activities at the S/V facilities in accordance with the applicable inspection and test plan (ITP).

4.79**source inspectors plan**

A document specifying the requirements that the purchaser deems necessary for the SI to ensure adherence.

4.80**specification**

A document that contains the requirements for the M&F of specific types of equipment and components.

4.81**SSPC**

Society for Protective Coatings.

4.82**S/V**

Supplier/vendor: the entity that is responsible for the actual manufacturing and fabrication (M&F) of the material, equipment, or components and that is responsible for meeting the contractual requirements.

4.83**surveillance**

Monitoring of engineering, fabrication, and construction activities. Surveillance would increase or decrease based on observations of the work quality. A deliverable from surveillance would be a surveillance report or other document that identifies activities conducted and any corrective action needed.

4.84**traceability**

Capability to show/prove the chain of custody or manufacturing of an asset until it is placed in service.

4.85**TEMA**

Tubular Exchanger Manufacturers Association.

4.86**tempering**

Reheating a hardened metal to a temperature below the transformation range to improve the toughness.

4.87**tolerance**

The limit (or limits) of specified dimensions, physical properties, or other measured values of a component.

4.88**training**

An organized program developed to impart the skills and knowledge necessary for qualification as a SI. May be formal or informal, i.e. OTJ.

4.89**UT**

Ultrasonic testing (examination): generally used to find component flaws or measuring thicknesses.

4.90**VT**

Visual testing (examination).

4.91**weld management process**

A disciplined, controlled process that requires adherence to established weld processes to provide for a consistent and reliable outcome.

4.92**weld map**

Set of construction drawings amended with the WPS reference used for each weld performed, the welder's ID reference, and the NDE reports reference for the welds subject to NDE.

4.93**weld mismatch**

The deviation from perfect alignment between two pieces of metal welded together. ASME BPVC Section VIII, Division 1 specified tolerances for weld mismatch are in UW-33. It is important for the SI to measure weld mismatch with a welding gauge and to know that the limit for weld mismatch is stringent for a Category A weld (longitudinal joint and circumferential shell to hemispherical head). The concept behind this is that the longitudinal joint bears double the amount of stress, and inspectors should precisely check these joints.

4.94**weld reinforcement**

The height of the weld cap. The longitudinal joint weld reinforcement limit is more stringent than that for circumferential joints. This is because the longitudinal joint bears double stress, and it is required that the stress concentration be minimized. Maximum weld reinforcement is specified in ASME BPVC Section VIII, Division 1.

4.95**WPQ**

Welding performance qualification record per ASME BPVC Section IX, QW 301.4

4.96**WPS**

A document that serves as a guide for the effective creation of a weld that meets all applicable code requirements and production standards

5 Training and Certification

5.1 General

Employers/inspection agencies providing inspection coordination and/or source inspection personnel or services should have an adequate training program for source inspection. The training should take into consideration the level of experience needed for the individuals performing the source inspection tasks. For instance, depending on the complexity and quality risks associated with any particular equipment, the purchaser may determine the requirement for a more- or less-experienced source inspector be appropriate for the job.

5.2 Levels of Training and Experience

5.2.1 General

Examples of different levels of training and experience for source inspectors include the following.

5.2.2 SI Level 1 (Entry/Awareness Level)

- a) The inspector would be exposed to source inspection methods and technology on an initial introductory level and may act as a SI trainee following other more experienced SIs to learn on the job. Entry-level classroom training may also be provided.
- b) The SI gains an awareness of the broad scope of SI activities, procedures, project documents, SI records, manufacturing processes, applicable codes and standards, etc. that they will eventually need to know and understand in greater detail as they become more experienced.

5.2.3 SI Level 2 (Basic Level)

- a) The new SI would have been on the job full-time for about a year. They would have completed most of the awareness/entry level training, as well as on-the-job exposure, and should be competent to perform some basic SI duties on their own with adequate supervision.
- b) The new SI should have passed the API SI entry-level exam and be gaining more knowledge and experience with a variety of SI issues and procedures.
- c) The SI may start to become exposed to more complex and different types of SI issues and equipment.

5.2.4 SI Level 3 (Stand-alone Level)

- a) The more experienced SI will have been on the job full-time for at least two to four years, have a good knowledge of all aspects of SI included in this document, as well as company procedures, and be able to perform most SI tasks competently with minimal supervision.
- b) The experienced SI will have more detailed knowledge of applicable industry codes and standards, have a much better understanding of quality issues and risks, and be able to correctly handle different types of nonconformances and deviations without much direct supervision. Additionally, the stand-alone SI should be able to competently train less-experienced SIs.
- c) The experienced SI will be able to handle more and different types of SI issues and equipment, including complex mechanical fixed equipment, packaged equipment, shop-fabricated piping, etc. The SI may also be competent with rotating equipment packages and electrical equipment depending on their area of expertise.
- d) The experienced SI should be starting to obtain different types of certifications that will assist him/her in the performance of their job, and should be becoming a “go to” person for less-experienced SIs. Those certifications might include:
 - 1) API Welding Inspector Certification.
 - 2) NACE Coatings Inspector Certification.
 - 3) Positive material identification (PMI) training/certification.
 - 4) AWS Certified Welding Inspection (or equal).
 - 5) AWS Senior Certified Welding Inspector (or equal).
 - 6) API 510 for pressure vessels.