



BODY OF KNOWLEDGE

API-510 PRESSURE VESSEL INSPECTOR

CERTIFICATION EXAMINATION

January 2009 (Replaces June 2007)

API Authorized Pressure Vessel Inspectors must have a broad knowledge base relating to maintenance, inspection, repair, and alteration of pressure vessels. The API Authorized Pressure Vessel Inspector Certification Examination is designed to determine if individuals have such knowledge. The following is a list of specific topics in which the API Authorized Pressure Vessel Inspector should be knowledgeable.

To determine whether the applicants have this broad base of inspection knowledge, a minimum of one question from each category listed within this Body of Knowledge will be included on the API certification examination. Only inspection information covered in one of the references outlined in this body of knowledge will be utilized for the examination questions.

The examination consists of two parts. The closed book part tests the candidate on knowledge and tasks requiring everyday working knowledge of API Standard 510 and the applicable reference documents. The open book portion of the examination requires the use of more detailed information that the inspector is expected to be able to find in the documents, but would not normally be committed to memory.

REFERENCE PUBLICATIONS:

API publications and ASME codebooks must be brought to the examination site to be used as reference materials for the open-book part of the examination.

A. API Publications:

- API 510, Pressure Vessel Inspection Code
- API RP 571, Damage Mechanisms Affecting Equipment in Refining Industry
- API RP 572, Inspection of Pressure Vessels (except Appendix B)
- API RP 576, Inspection of Pressure-Relieving Devices
- API RP 577, Welding Inspection and Metallurgy

B. ASME Publications:

- Section V, Nondestructive Examination
- Section VIII, Division 1, Rules for Constructing Pressure Vessels
- Section IX, Welding and Brazing Qualifications

Note: Refer to the Publications Effectivity Sheet in the application package for a list of specific editions, addenda, and supplements of the reference publications that are effective for your exam date.

I. THICKNESS MEASUREMENTS, INSPECTION INTERVALS AND VESSEL INTEGRITY

- A.** Code calculation questions will be oriented toward existing pressure vessels, not new pressure vessels. API Authorized Pressure Vessel Inspectors should be able to check and perform calculations relative to in-service deterioration, repairs, rerates, or alterations. Only internal and external pressure loadings will be considered for the API 510 examination.

Note: Candidates are expected to understand the SI units (metric system) and the US customary units (inches, feet, PSI, etc.) and to use both system formulas.

The following categories describe the minimum necessary knowledge and skills:

1. CORROSION RATES AND INSPECTION INTERVALS

The Inspector should be able to take inspection data and determine the internal and external inspection intervals.

The Inspector must be able to calculate:

- a. Metal Loss (including corrosion averaging) (API-510, Para 7.4)
- b. Corrosion Rates (API-510, Para 7.1)
- c. Remaining Corrosion Allowance (API-510, Para 7.1)
- d. Remaining Service Life (API-510, Para, 7.2)
- e. Inspection Interval (API-510, Section 6)

The formulas for performing the above calculations and rules for setting the inspection intervals may be "closed-book" during the examination.

2. JOINT EFFICIENCIES

The inspector must be able to determine the joint efficiency "E" of a vessel weld. Inspector should be able to determine:

- a. Weld Joint Categories (ASME Section VIII, UW-3);
- b. Type of radiography (full, spot, or none) performed basis the nameplate markings (RT-1, RT-2, etc.); (UW -11)
- c. Joint efficiency by reading Table UW-12;
- d. Joint efficiency for seamless heads and vessels Sections per UW-12 (d); and
- e. Joint efficiency for welded pipe and tubing per UW-12 (e).

Determining joint efficiency may be part of the internal pressure problem since joint efficiency "E" is used in the formulas for determining required thickness or Vessel Part MAWP.

3. STATIC HEAD

The inspector must be able to compensate for the pressure resulting from static head. All static head will be based upon a Specific Gravity of 1.0. The inspector should be able to:

- a) List the static head/pressure conversion factor (0.433 psi/ft);
- b) Know the difference between vessel MAWP and vessel part MAWP (UG-98);
- c) Calculate static head pressure on any vessel part;
- d) Calculate total pressure (MAWP + static head) on any vessel part;
- e) Calculate maximum vessel MAWP given vessel parts MAWP and elevations

Static head calculations may also be required during the internal pressure calculations if static head data is given in the examination problem.

4. INTERNAL PRESSURE

The inspector should be able to determine:

- a) The required thickness of a cylindrical shell based on circumferential stress given a pressure (UG-27(c)(1));
- b) The vessel part MAWP for a cylindrical shell based on circumferential stress given a metal thickness (UG-27(c)(1));
- c) The required thickness of a head (ellipsoidal, and hemispherical) given a pressure. (UG-32 (d), (e), (f) and (g))
- d) The vessel part MAWP for a head (ellipsoidal, and hemispherical) given a metal thickness. (UG-32 (d), (e), (f) and (g)).
- e) Whether a head (ellipsoidal, torispherical or hemispherical) meets Code requirements given both pressure and metal thickness (UG 32(d), (e), (f) and (g)).

The inspector should also be able to compensate for the corrosion allowance: add or subtract based on requirements of the examination problem. The Section VIII, Appendix 1 formula for cylinders, which is based on outside diameter, can be used. The Appendix 1 formulas for non-standard heads will not be required.

5. EXTERNAL PRESSURE

The inspector should be able to:

- a) Calculate the maximum allowable external pressure; and
- b) Calculate whether a cylindrical shell or tube meets Code design for external pressure given a wall thickness and a pressure (UG 28 (c)(1).

Note: Factors from the external pressure charts will be given in the wording of the question. Use of the actual charts is not required.

6. PRESSURE TESTING

The inspector should be able to:

- a) Calculate a test pressure compensating for temperature. (UG-99 & UG-100)
- b) Be familiar with the precautions associated with hydrostatic and pneumatic testing, such as minimum test temperatures, protection against overpressure etc.
- c) Be familiar with all steps in a hydrotest procedure (UG 99 and UG 100)
- d) Be familiar with all steps in a pneumatic test procedure (UG 100 and UG 102)

7. IMPACT TESTING

The inspector should be able to:

- a) Determine the minimum metal temperature of a material which is exempt from impact testing (UG-20 (f), UCS-66, UCS-68(c).)

8. WELD SIZE FOR ATTACHMENT WELDS AT OPENINGS

The inspector must be able to determine if weld sizes meet Code requirements. The inspector should be able to:

- a) Convert a fillet weld throat dimension to leg dimension or visa versa, using conversion factor (0.707); and
- b) Determine the required size of welds at openings (UW-16).

9. NOZZLE REINFORCEMENT

The inspector should:

- a) Understand the key concepts of reinforcement, such as replacement of strength removed and limits of reinforcement.
Credit can be taken for extra metal in shell and nozzle
- b) Be able to calculate the required areas for reinforcement or check to ensure that a designed pad is large enough. To simplify the problem:
 - All $f_r = 1.0$
 - All $F = 1.0$
 - All $E = 1.0$
 - All required thicknesses are given
- c) There will be no nozzle projecting inside the shell
- d) Be able to compensate for corrosion allowances.
- e) Weld strength calculations are excluded.

B. The following are typical ASME code engineering requirements that API certification candidates will NOT be expected to know for purposes of the certification examination.

- 1. Required thickness calculations for wind, earthquake, and other secondary stress loadings;
- 2. Supplementary design formulas and calculations for non-cylindrical shell components;
- 3. Most external pressure calculations;
- 4. Nozzle calculations for external loads;
- 5. Flange calculations;
- 6. Brazing requirements;
- 7. Ligament calculations;
- 8. Stayed flat heads and sizing of stays;
- 9. Tubesheet calculations (stayed or unstayed) and tube to tubesheet joints and loads;
- 10. Relief valve sizing;
- 11. Lifting lug and other structural type calculations;
- 12. Proof testing requirements;
- 13. Required inspections for new construction, except as they apply to alterations and repairs;
- 14. Zick analysis;
- 15. Integrally forged pressure components;
- 16. Cryogenic vessels (below -50 f);
- 17. Dimpled, embossed, jacketed, and non-metallic vessels and assemblies;
- 18. NDE requirements for acoustic emission, eddy current, and motion radiography;
- 19. ASME Sections UF, UB, UNF, UHA, UCI, UCL, UCD, UHT (except UHT-6), ULW, and ULT;
- 20. Code Cases and interpretations;
- 21. Welding process requirements other than shielded metal arc welding (SMAW), gas tungsten arc welding (GTAW), gas metal arc welding (GMAW), or submerged arc welding (SAW);
- 22. Requirements for pressure vessels for human occupancy; and
- 23. Rules for natural resource vessels, API-510, Section 9.

II. WELDING PROCEDURE AND QUALIFICATION EVALUATION BASED ON ASME BOILER AND PRESSURE VESSEL CODE, SECTION IX

A. WELD PROCEDURE REVIEW

1. The inspector should be able to determine if procedure and qualification records are in compliance with applicable ASME boiler and pressure vessel code and any additional requirements of API-510 (API-510 requirements will take precedence over any ASME requirements covering the same technical area).

The weld procedure review may include:

- a. Welding Procedure Specification (WPS); and
- b. Procedure Qualification Record (PQR).

The weld procedure review may include: SMAW, GTAW, GMAW, OR SAW, with the following limitations:

- a) No more than one process will be included on a single WPS or PQR, and the WPS to be reviewed will be supported by a single PQR.
- b) Filler metals limited to one-per-process for SMAW, GTAW, GMAW, or SAW.
- c) The PQR will be the supporting PQR for the WPS.

2. The inspector should be able to determine:

- a) Whether number and type of mechanical tests listed on PQR are appropriate
- b) Whether the results of the tests are acceptable
- c) Whether all required essential and non-essential variables have been properly addressed. (Supplemental essential variables will not be a part of the WPS). The following limitations or conditions will apply:
 - Base metals limited to P1, P3, P4, P5, and P8.
 - Dissimilar base metal joints, and dissimilar thicknesses of base metals are excluded.
 - Supplemental powdered filler metals and consumable inserts are excluded.
 - Special weld processes such as corrosion-resistant weld metal overlay, hard-facing overlay, and dissimilar metal are excluded
 - Welds with buttering of ferritic member are excluded.
 - For P1, P3, P4, and P5, for the purpose of the examination the lower transformation temperature will be 1333⁰F and the upper transformation temperature will be 1600⁰F.

B. ASME Section VIII, Div. 1 and API-510: GENERAL WELDING REQUIREMENTS:

1. ASME Section VIII, Div. 1

The inspector should be familiar with and understand the general rules for welding in ASME Section VIII, Div. 1, Parts UW and UCS such as:

- a) Typical joints and definitions
- b) Weld sizes
- c) Restrictions on joints
- d) Maximum allowable reinforcement
- e) Inspection requirements
- f) Heat treatment

2. API 510

The inspector should be familiar with and understand any rules for welding in API-510. Any rules for welding given in API-510 shall take precedence over those covering the same areas in ASME, Section VIII, Div. 1.

3. "Editorial" and non-technical requirements for the welding subject matter, the candidate is to be tested on, are excluded. This includes items such as the revision level of the WPS, company name, WPS number and date, and name of testing lab. However, the API 510 applicants shall know that the PQR must be certified by signing and dating.

C. The inspector shall be familiar with all the requirements of and information in API RP 577.

III. NONDESTRUCTIVE EXAMINATION

ASME Section V, Nondestructive Examination

NOTE: The examination will cover ONLY the main body of each referenced Article, except as noted

A. Article 1, General Requirements:

The inspector should be familiar with and understand;

1. The Scope of Section V,
2. Rules for use of Section V as a referenced Code,
3. Responsibilities of the Owner / User, and of subcontractors,
4. Calibration,
5. Definitions of "inspection" and examination",
6. Record keeping requirements.

B. Article 2, Radiographic Examination:

The inspector should be familiar with and understand;

1. The Scope of Article 2 and general requirements,
2. The rules for radiography as typically applied on pressure vessels such as, but not limited to:
 - a. Required marking
 - b. Type, selection, number, and placement of IQI's,
 - c. Allowable density
 - d. Control of backscatter radiation
 - e. Location markers
3. Records

C. Article 6, Liquid Penetrant Examination, including Mandatory Appendices II and III:

The inspector should be familiar with and understand:

1. The Scope of Article 6,
2. The general rules for applying and using the liquid penetrant method such as, but not limited to;
 - a) Procedures
 - b) Contaminants
 - c) Techniques
 - d) Examination
 - e) Interpretation
 - f) Documentation and
 - g) Record keeping

D. Article 7, Magnetic Particle Examination (Yoke and Prod techniques only):

The inspector should be familiar with and understand the general rules for applying and using the magnetic particle method such as, but not limited to;

1. The Scope of Article 7,
2. General requirements such as but not limited to requirements for:
 - a. Procedures
 - b. Techniques (Yoke and Prod only)
 - c. Calibration
 - d. Examination
 - e. Interpretation
 - f. Documentation and record keeping

E. Article 23, Ultrasonic Standards, **Section SE-797 only** – Standard practice for measuring thickness by manual ultrasonic pulse-echo contact method:

The inspector should be familiar with and understand;

- 1) The Scope of Article 23, Section SE-797,
- 2) The general rules for applying and using the Ultrasonic method
- 3) The specific procedures for Ultrasonic thickness measurement as contained in paragraph 7.

ASME Section VIII, Div. 1 and API-510. General nondestructive examination requirements:

1. ASME Section VIII, Div. 1:

The inspector should be familiar with and understand the general rules for NDE (UG, UW, Appendices 4, 6, 8, and 12)

2. API 510:

The inspector should be familiar with and understand the general rules for NDE in API-510.

IV. PRACTICAL KNOWLEDGE - GENERAL

The following topics may be covered in the examination. More information relative to each of the categories is contained in section V. PRACTICAL KNOWLEDGE - SPECIFIC

1. Organization and Certification Requirements.
2. Types and Definitions of Maintenance Inspections.
3. Types of Process Corrosion and Deterioration.
4. Modes of Mechanical, Thermal, and High Temperature Deterioration.
5. Pressure Vessel Materials and Fabrication Problems.
6. Welding on Pressure Vessels.
7. Nondestructive Examination (NDE) Methods.
8. Corrosion and Minimum Thickness Evaluation.
9. Estimated Remaining Life.
10. Inspection Interval Determination and Issues Affecting Intervals.
11. Relief Devices.
12. Maintenance Inspection Safety Practices.
13. Inspection Records and Reports.
14. Repairs/Alterations to Pressure Vessels.
15. Rerating Pressure Vessels.
16. Pressure Testing After Repairs, Alterations, or Rerating

V. PRACTICAL KNOWLEDGE - SPECIFIC

API-510, Pressure Vessel Inspection Code

NOTE: All of API 510 is applicable to the examination unless specifically excluded. For example: Section 9 and Appendix E are excluded.

1. Organization and Certification Requirements

- a) Certification for API Authorized Pressure Vessel Inspectors (API-510, Appendix B).
- b) Authorized Inspection Agencies (API-510, Section 3.6)
- c) Vessel Repair Organizations (API-510, Section 3.54)
- d) Relief Device Testing and Repair Organizations (API-510, Section 4.2.3 and 6.6)

2. Types and Definitions of Maintenance Inspection

- a) Internal Inspection (API 510, 5.5.2)
- b) Damage Inspection (API-510, 5.7)
- c) Inspection of Parts (API-510, 5.10, 5.11)
- d) External Inspection & Buried Vessels (API 510, 5.5.4)
- e) On-Stream Inspection (API-510, 3.43, 5.5.3 & 6.5.2)
- f) Thickness Measurements (API-510, 5.5.5, 5.7.2,)
- g) Nondestructive Examination (API-510, 5.7.1)
- h) Assessment of Inspection Findings (Section 7)
- i) Risk-based Inspection (API 510, 5.2)
- j) CUI Inspection (API 510, 5.5.6)

3. Welding on Pressure Vessels

- a) Welding Inspection Requirements (API-510, 5.10)

4. Corrosion and Minimum Thickness Evaluation

The inspector should have a general knowledge of the following principles, and may be required to make calculations using these principles.

- a) Corrosion Rate Determination (API 510, 7.1)
- b) Corrosion Averaging (API 510, 7.4.2)
- c) Widely Scattered Pitting (API 510, 7.4.3)
- d) Surfaces Remote from a Weld (API, 7.4.5.)
- e) Corrosion in Central Portion of Dished Heads (API 510, 7.4.6)

5. Estimated Remaining Life and Corrosion rate (API 510, 7.2)

6. Inspection Interval Determination and Issues Affecting Intervals

- a) Risk-based inspection (API 510, 6.3)
- b) Internal or On-Stream Inspection Intervals (API 510, 6.5)
- c) Internal and On-stream inspection Intervals for Estimated Life (API 510, 6.5)
- d) External Inspection Intervals ((API-510, 6.4)
- e) Deterioration Other Than Metal Loss (API 510, 5.4)
- f) Different Zones of a Vessel (API 510, 6.5.3)
- g) Change of Service Conditions (API 510, 6.2.2)
- h) Change in Location and Ownership (API 510,6.2.2)

7. Relief Devices

- a) Repair Organizations (API-510, Section 6.6)
- b) Minimum Requirements for Quality Control Systems (API 510, 6.6)
- c) Testing and Inspection Intervals (API-510, 6.6)

8. Maintenance Inspection Safety Practices

- a) Pressure Vessel Inspection (API-510, Section 5.3)

9. Inspection Records and Reports

- a) Permanent and Progressive Inspection Records (API-510, 7.8)

10. Repairs, Alterations and Rerating of Pressure Vessels

- a) Authorization (API 510, 8.1.1)
- b) Approval (API 510, 8.1.2)
- c) Design Requirements (API 510, 8.1.3)
- d) Materials Requirements (API 510, 8.1.4)
- e) Welding Requirements (API 510, 8.1.6)
- f) Heat Treating Requirements, including
 - Preheating (API 510, 8.1.6.4.2)
 - Post weld Heat Treating (API 510, 8.1.6.4)
 - Local Postweld Heat treatment (API 510, 8.1.6.4.1)
- g) Repairs to Stainless Steel Weld Overlay and Cladding (API 510, 8.1.5.4)
- h) Inspection (API 510, 8.1.7 & 8.1.8)
- i) Rerating of Pressure Vessels (API 510, 8.2)
- j) Pressure Testing After Repairs, Alterations or Rerating (API-510,5.8)
- k) Nondestructive Examination of Welds (API 510, 8.1.7)

API RP 571, Damage Mechanisms Affecting Fixed equipment in the Refining Industry

ATTN: Test questions will be based on the following mechanisms only:

- Par. 3. - Definitions (included as a frame of reference only)
 - 4.2.3 – Temper Embrittlement
 - 4.2.7 – Brittle Fracture
 - 4.2.9 – Thermal Fatigue
 - 4.2.14 – Erosion/Erosion-Corrosion
 - 4.2.16 – Mechanical Failure
 - 4.3.2 – Atmospheric Corrosion
 - 4.3.3 – Corrosion Under Insulation (CUI)
 - 4.3.4 – Cooling Water Corrosion
 - 4.3.5 – Boiler Water Condensate Corrosion
 - 4.4.2 – Sulfidation
 - 4.5.1 – Chloride Stress Corrosion Cracking (Cl SCC)
 - 4.5.2 – Corrosion Fatigue
 - 4.5.3 – Caustic Stress Corrosion Cracking (Caustic Embrittlement)
 - 5.1.2.3 – Wet H₂S Damage (Blistering/HIC/SOHIC/SCC)
 - 5.1.3.1 – High Temperature Hydrogen Attack (HTHA)

API RP-572, Inspection of Pressure Vessels – Entire document is subject to testing with the exception of Appendix B.

1. Types and Definitions of Maintenance Inspections
 - a) Types of Pressure Vessels (API RP-572, Section 4)
 - b) Construction Standards (API RP-572, Section 5)
 - c) Maintenance Inspection (API RP-572, Section 6)
 - d) Reasons for Inspection (API RP-572, Section 7)
 - e) Causes of Deterioration (API RP-572, 8.1 – 8.5)
 - f) Frequency and Time of Inspection (API RP-572, Section 9)
 - g) Internal Inspection (API RP-572, 10)
 - h) External Inspection, Typical Items Checked (API RP-572, 10.3)
 - i) Visual Examination (API-RP-572, Section 10)
 - j) Thickness Measurements and Limits (API RP-572, Section 10)
 - k) Nondestructive Examination (API RP-572, Section 10)
 - l) Repair Methods (API RP-572, Section 11)
2. Pressure Vessel Materials and Fabrication Problems
 - a) Material and Fabrication Problems (API RP-572, 8.4 & 8.5)
3. Maintenance Inspection Safety Practices
 - a) Pressure Vessel Inspection (API RP-572, 10.2)
4. Inspection Records and Reports (API RP-572, Section 12)

API RP 576, Inspection of Pressure-Relieving Devices (Entire document is subject to testing with the exception for appendices):

1. Relief Devices
 - a) Description of Types -- General Knowledge of Application and Limitations (API RP-576, Section 2)
 - b) Causes of Improper Performance (API RP-576, Section 4)
 - c) Reasons for Inspection and Frequency Determination (API RP 576, Sections 3 & 5)
 - d) Inspection and Test Service Procedures (API RP-576, Sections 6 and 7)
 - e) Maintenance Inspection Safety Practices (API RP 576, Section 6)
 - f) Inspection Records and Reports (API RP-576, Section 8)

API RP 577, Welding Inspection and Metallurgy

1. Definitions
2. Welding Inspection
3. Welding Processes
4. Welding procedure
5. Welding Materials
6. Welder qualifications
7. Non-destructive examination
8. Metallurgy
9. Refinery and Petrochemical Plant Welding Issues
10. Terminology and symbols
11. Actions to Address improperly made production welds
12. Welding procedure review
13. Guide to common filler metal selection
14. Example report of RT results