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American Petroleum Institute

Individual Certification Programs: ICP™



API 510 PRESSURE VESSEL INSPECTOR

CERTIFICATION EXAM

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 (BOK) 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.

Questions may be taken from anywhere within each document in this BOK, unless specifically excluded herein. If specific sections of a document are listed as excluded– all other sections within that document are included. In some cases, specific paragraphs, or sections, such as the example shown below, are included as an aid to the candidate. This is not intended to exclude other paragraphs.

For example: In the “Corrosion Rate and Inspection Intervals” section of this BOK (Section A, sub-section 1), it states:

The Inspector must be able to calculate:

- a) Metal Loss (including corrosion averaging) (API 510, 7.4)

This means that the metal loss calculation will be found in 7.4. It does not mean that other paragraphs in that section are excluded.

The exam consists of two parts. The closed-book part tests the candidate on knowledge and tasks requiring everyday working knowledge of API 510 and the applicable reference documents. The open-book portion of the exam 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. During the exam, applicants will be expected to choose the best answer from the options provided.

REFERENCE PUBLICATIONS:

A. API Publications:

API 510, *Pressure Vessel Inspection Code: In-service Inspection, Rating, Repair, and Alteration*
API RP 571, *Damage Mechanisms Affecting Fixed Equipment in Refining Industry*
API RP 572, *Inspection Practices for Pressure Vessels*, including Annex B, (all other Annexes are excluded)
API RP 576, *Inspection of Pressure-relieving Devices*
API RP 577, *Welding Processes, Inspection, and Metallurgy*
API RP 578, *Guidelines for a Material Verification Program (MVP) for New and Existing Assets*

B. ASME Publications:

American Society of Mechanical Engineers (ASME) *Boiler and Pressure Vessel Code:*

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Section V, Nondestructive Examination

Section VIII, Division 1, Rules for Constructing Pressure Vessels

Section IX, Qualification Standard for Welding, Brazing and Fusion Procedures; Welders; Brazers; and Welding, Brazing and Fusing Operators

ASME PCC-2, Repair of Pressure Equipment and Piping

Note: Refer to the Publications Effectivity Sheet on the ICP Website (www.api.org/ICP) 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

(Note: Paragraph references for all formulas and calculations listed here should be checked for accuracy to the edition, addenda, or supplement for the exam you plan to take per the Publication Effectivity Sheet on the ICP website (www.api.org/ICP).)

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

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

- Metal Loss (including corrosion averaging) (API 510, 7.4)
- Corrosion Rates (API 510, 7.1)
- Remaining Corrosion Allowance (API 510, 7.1)

$$\text{Remaining Corrosion Allowance} = t_{\text{actual}} - t_{\text{required}}$$
- Remaining Service Life (API 510, 7.2)
- 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 exam.

2. JOINT EFFICIENCIES

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

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

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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:

- List the static head/pressure conversion factor (0.433 psi/ft);
- Know the difference between vessel MAWP and vessel part MAWP (ASME *BPVC* Section VIII, UG-98);
- Calculate static head pressure on any vessel part;
- Calculate total pressure (MAWP + static head) on any vessel part;
- 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 exam problem.

4. INTERNAL PRESSURE

The inspector should be able to determine:

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

The inspector should also be able to compensate for the corrosion allowance: add or subtract based on requirements of the exam 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 knowledgeable of the rules for design of shells and tubes under external pressure (UG-28). The inspector will not be required to perform external pressure calculations.

6. PRESSURE TESTING

The inspector should be able to:

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

7. IMPACT TESTING

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- a) The inspector should understand impact testing requirements and impact testing procedure (UG-84)
- b) The inspector should be able to 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 vice versa, using conversion factor (0.7); and
- b) Determine the required size of welds at opening (UW-16)

9. NOZZLE REINFORCEMENT

The inspector should understand the key concepts of reinforcement, such as replacement of strength removed and limits of reinforcement.

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

1. Required thickness calculations for wind, earthquake, and other secondary stress loadings;
2. Supplementary design formulas and calculations for non-cylindrical shell components;
3. External pressure calculations (but should understand the rules governing external pressure noted in Section 5);
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 (-45°C);
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, ULW, ULT, UHX and UIG;
20. Code Cases and interpretations;
21. Requirements for pressure vessels for human occupancy; and
22. Rules for natural resource vessels, API 510, Section 9.

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

(**Note:** Candidates should be familiar with the basic requirements for welding qualifications for procedures and welding personnel contained in ASME BPVC Section IX. Brazing is NOT covered on the exam.)

A. WELD PROCEDURE REVIEW

The inspector should have the knowledge and skills required to review a Procedure Qualification Record, a Welding Procedure Specification, and a Welder Performance Qualification to be able to determine the following:

- Determine if procedure and qualification records are in compliance with applicable ASME Boiler and Pressure Vessel Code and any additional requirements of API 510.
The weld procedure review will include:
 - Weld Procedure Specification (WPS)
 - Procedure Qualification Record (PQR)
 - Welder Performance Qualification (WPQ)
- Determine if all required essential and non-essential variables have been properly addressed. (Supplemental essential variables will not be a part of the WPS/PQR)
- Determine that the number and type of mechanical tests that are listed on PQR are the proper tests, and whether the results are acceptable.
- Determine that the welder is qualified to make a production weld according to the WPS

WELD PROCEDURE REVIEW WILL ONLY INCLUDE SMAW, GTAW, GMAW, OR SAW, WITH THE FOLLOWING LIMITATIONS:

- No more than one process will be included on a single WPS,PQR or WPQ and the WPS to be reviewed will be supported by a single PQR.
- Filler metals will be limited to one-per-process for SMAW, GTAW, GMAW, or SAW
- The PQR will be the supporting PQR for the WPS.
- The WPQ test coupon is to be welded in accordance with a qualified WPS.
- Base metals will be limited to P-No. 1, P-No. 3, P-No. 4, P-No. 5, and P-No. 8.
- Dissimilar base metal joints, and dissimilar thicknesses of base metals will be excluded.
- Special weld processes such as corrosion-resistant weld metal overlay, hard-facing overlay, and dissimilar metal welds with buttering of ferritic member will be excluded.
- For P-No. 1, P-No. 3, P-No. 4, and P-No. 5, for the purpose of the exam the lower transition temperature will be 1330°F (720°C) and the upper transformation temperature will be 1600°F (870°C).

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 *BPVC* Section VIII, Div. 1, Parts UW and UCS such as:

- Typical joints and definitions
- Weld sizes
- Restrictions on joints
- Maximum allowable reinforcement
- Inspection requirements
- Heat treatment

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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 *BPVC* 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 and WPQ 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

A. ASME *BPVC* Section V, Nondestructive Examination

Note: The exam 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:
 - Required marking
 - Type, selection, number, and placement of IQI's,
 - Allowable density
 - Control of backscatter radiation
 - 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

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- e) interpretation
- f) documentation
- 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
3. 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;

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

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

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)

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 exam. More information relative to each of the categories is contained in section.

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.

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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: In-service Inspection, Rating, Repair, and Alteration**
All of API 510 is applicable to the exam unless specifically excluded. For example: Section 9 and Appendix E are excluded.
- **API RP 571, Damage Mechanisms Affecting Fixed Equipment in the Refining Industry**

ATTN: Test questions will be based on the following portions of the document only:

Section 2 Terms and Definitions

- 3.3 Amine Stress Corrosion Cracking
- 3.8 Atmospheric Corrosion
- 3.11 Brittle Fracture
- 3.14 Caustic Corrosion
- 3.15 Caustic Stress Corrosion Cracking
- 3.17 Chloride Stress Corrosion Cracking
- 3.20 Cooling Water Corrosion
- 3.22 Corrosion Under Insulation (CUI)
- 3.27 Erosion/Erosion-Corrosion
- 3.36 High Temperature Hydrogen Attack
- 3.37 Hydrochloric Acid Corrosion
- 3.43 Mechanical Fatigue (including Vibration-induced Fatigue)
- 3.58 Sour Water Corrosion
- 3.61 Sulfidation
- 3.67 Wet H₂S Damage (Blistering/HIC/SOHIC/SCC)

- **API RP-572, Inspection Practices for Pressure Vessels** – Entire document is subject to testing, including Annex B. All other Annexes are not subject to testing.
- **API RP 576, Inspection of Pressure-relieving Devices** – Entire document is subject to testing except for annexes.
- **API RP 577, Welding Processes, Inspection, and Metallurgy** – Entire document is subject to testing
- **API RP 578, Guidelines for a Material Verification Program (MVP) for New and Existing Assets** – Entire document is subject to testing
- **ASME PCC-2, Repair of Pressure Equipment and Piping**
ATTN: The examination will cover each referenced Article and its Appendices.
Article 101: Scope, Organization, and Intent
Article 201: Butt-Welded Insert Plates in Pressure Components
Article 202: External Weld Buildup to Repair Internal Thinning
Article 209: Alternatives to Postweld Heat Treatment
Article 210: In-Service Welding Onto Carbon Steel Pressure Components or Pipelines

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Article 211: Weld Buildup, Weld Overlay, and Clad Restoration
Article 212: Fillet Welded Patches
Article 215: Repair Welding Considerations for Cr-Mo Steel Pressure Vessels
Article 216: Welded Hot Taps in Pressure Equipment or Pipelines
Article 304: Flaw Excavation and Weld Repair
Article 305: Flange Repair and Conversion
Article 312: Inspection and Repair of Shell and Tube Heat Exchangers
Article 501: Pressure and Tightness of Piping and Equipment
Article 502: Nondestructive Examination in Lieu of Pressure Testing for Repairs and Alternations