BODY OF KNOWLEDGE

API-510 PRESSURE VESSEL INSPECTOR

CERTIFICATION EXAMINATION

August 2010 (Replaces January 2009)

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: Dimensions, pressures and temperatures in exam items are supplied in SI units (metric) and the US customary units (inches, feet, psi, etc.) where applicable, to assist all candidates' understanding.

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, Para7.1)
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), and (f))
d) The vessel part MAWP for a head (ellipsoidal, and hemispherical) given a metal thickness. (UG-32 (d), and (f)).
e) Whether a head (ellipsoidal or hemispherical) meets Code requirements given both pressure and metal thickness (UG 32(d) 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

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 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 fr = 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 (except as shown in A.5, above);
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

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

a) 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:
- One Weld Procedure Specification (WPS); and
- One Procedure Qualification Record.

b) 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)
c) Determine that the number and type of mechanical tests that are listed on PQR are the proper tests, and whether the results are acceptable.

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 will be limited to one-per-process for SMAW, GTAW, GMAW, or SAW
c) The PQR will be the supporting PQR for the WPS.
d) Base metals will be limited to P1, P3, P4, P5, and P8.
e) Dissimilar base metal joints, and dissimilar thicknesses of base metals will be excluded.
f) 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.
g) For P1, P3, P4, and P5, for the purpose of the examination the lower transition temperature will be 1330^0F and the upper transformation temperature will be 1600^0F.

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

All of API 510 is applicable to the examination 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 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
- 4.3.10 – Caustic 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 H_2S 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.

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

API RP 577, Welding Inspection and Metallurgy – Entire document is subject to testing

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