



## **BODY OF KNOWLEDGE**

### **API-570 AUTHORIZED PIPING INSPECTOR**

#### **CERTIFICATION EXAMINATION**

**June 2007 (Replaces May 2005)**

API Authorized Piping Inspectors must have a broad knowledge base relating to maintenance, inspection, alteration and repair of in-service metallic piping systems. The API Authorized Piping Inspector Certification Examination is designed to determine if applicants have such knowledge.

The examination consists of two parts. The closed book part tests the candidate on knowledge and tasks requiring everyday working knowledge of API Standard 570 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:**

##### **A. API Publications:**

API Standard 570 – Inspection, Repair, Alteration, and Rerating of In-Service Piping Systems

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

API Recommended Practice 574 – Inspection Practices for Piping System Components

API RP 577, Welding Inspection and Metallurgy

API Recommended Practice 578 – Material Verification Program for New and Existing Alloy Piping Systems

##### **B. ASME (American Society of Mechanical Engineers) Publications:**

###### **Boiler and Pressure Vessel Code:**

Section V, Nondestructive Examination, and

Section IX, Welding and brazing Qualifications

B16.5, Pipe Flanges and Flanged Fittings

B31.3, Process Piping

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

The following is the list of specific topics in which an API certified Piping Inspector should be knowledgeable.

## **I. CALCULATIONS FOR EVALUATING THICKNESS MEASUREMENTS, INSPECTION INTERVALS, AND PIPING INTEGRITY**

A. Code calculation questions will be oriented toward existing in-service piping, not new piping. API Authorized Piping Inspectors should be able to check and perform calculations relative to in-service deterioration, repairs, rerates, or alterations, such as those included in the following eight categories.

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.

### **1. CORROSION RATES AND INSPECTION INTERVALS**

The Inspector should be able to understand inspection data and determine the thickness measurement and visual external inspection intervals.

The Inspector must be able to calculate:

- a) Corrosion Rates (API-570, Par. 7.1)
- b) Remaining Service Life (API-570, Par., 7.1)
- c) Inspection Interval (API-570, Par., 6.3 & Table 6-1)

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

### **2. WELD JOINT QUALITY FACTORS AND CASTING QUALITY FACTORS**

The inspector should be able to determine the weld joint quality factor "Ej" of a longitudinal pipe weld joint. The inspector should be able to determine:

- a) Casting Quality factor, Ec from B31.3, 312.3 and A-1A
- b) Weld Joint Quality factors from ASME B31.3 302.3.4 and A-1B;
- c) Increased Joint Quality Factors by performing supplemental NDE from ASME B31.3 Table 302.3.4;

Determining weld joint quality factor may be part of an internal pressure problem since the joint factor Ej is used in the formulas for determining required thickness or internal design pressure.

### **3. INTERNAL PRESSURE / MINIMUM THICKNESS OF PIPE**

The inspector should be able to determine:

- a) The minimum required thickness or pressure design thickness of a straight pipe section for a internal pressure only (ASME B31.3 Section 304.1.1 and 304.1.2);
- b) The minimum required thickness of a permanent blank for a given design pressure (ASME B31.3 Section 304.5.3);
- c) The "MAWP" of corroded pipe, compensating for expected corrosion loss at the next inspection (API 570, Par., 7.2)

The inspector should also be able to compensate for the corrosion allowance. (Add or subtract based on requirements from the exam problem).

### **4. PRESSURE TESTING**

The inspector should be able to:

- a) Demonstrate knowledge concerning hydrostatic leak testing (ASME B31.3 Section 345.4)
- b) Demonstrate knowledge concerning pneumatic leak testing (ASME B31.3 Section 345.5)
- c) Calculate a hydrostatic or pneumatic leak test pressure (ASME B31.3 Sections 345.4, 345.5)

## 5. IMPACT TESTING

The inspector should be able to:

- a) Determine the minimum metal temperature of a material, which is exempt from impact testing (ASME B31.3, Section 323.2.2, Figure 323.2.2A & Table A-1).
- b) Determine the minimum required charpy V-notch impact values of a given material. (ASME B31.3, Section 323.3, Table 323.3.5)

## 6. PREHEATING AND HEAT TREATMENT REQUIREMENTS

The inspector should be able to determine which weld sizes require preheating and/or heat treatment. The inspector also should be able to:

- a) Determine what is the required or recommended preheat temperature (ASME B31.3, Section 330 & Table 330.1.1).
- b) Determine the governing thickness, holding time, holding temperature, and maximum Brinell hardness for heat treatment applications (ASME B31.3, Section 331 & Table 331.1.1).

## 7. THERMAL EXPANSION

The inspector should be able to determine the total thermal expansion of a material between temperatures (ASME B31.3, Appendix C, Table C-1).

## 8. MINIMUM WALL THICKNESS & WORKING PRESSURES FOR FLANGES

The inspector should be able to determine the minimum wall thickness and working pressure requirements for flanges.

The inspector should also be able to:

- a) Determine the working pressure and minimum/maximum system hydrostatic test pressure for a flange of specified material and temperature (ASME B16.5, Par. 2.5 & Table 1A & Tables 2-1.1 through 2-3.17).
- b) Determine the minimum dimensions of a given flange (ASME B16.5 Tables 7 through 28).
- c) Determine maximum working pressure of a flange when given the design temperature, flange material and flange class.
- d) Determine maximum temperature of a flange when given the design pressure, flange material and flange class.
- e) Determine most cost effective flange when given the design pressure, design temperature, and flange material.

**B. The following are the ASME B31.3 code engineering requirements that are excluded from the examination and that the API Authorized Piping Inspectors will NOT be expected to know for the purposes of certification testing.**

1. 302 Design criteria –(All except for 302.3.3 Casting Quality factor, Ec, and 302.3.4, Weld Joint Quality Factor Ej )
2. 304.1.3 Straight Pipe Under External Pressure
3. 304.2 Curved and Mitered Segments of Metallic Piping
4. 304.3 Branch Connections in Metallic Piping
5. 304.4 Closures in Metallic Piping
6. 304.5 Pressure Design of Metallic Flanges & Blanks (All except 304.5.3, Blanks)
7. 304.6 Metallic Reducers
8. 304.7 Pressure Design of Other Metallic Components
9. 315 Flared, Flareless and Compression Joints for Tubing
10. 316 Caulked Joints
11. 317 Soldered and Brazed Joints in Metallic Piping
12. 318 Special Joints
13. 319.4 Flexibility Analysis, Metallic Piping
14. 319.5 Reactions, Metallic Piping
15. 319.6 Calculation of Movements, Metallic Piping
16. 319.7 Means of Increasing Flexibility, Metallic Piping
17. 322.3 Instrument Piping
18. Chap. VII Nonmetallic Piping and Piping Lined With Nonmetals
19. Chap. VIII Piping for Category M Fluid Service
20. Chap. IX High Pressure Piping
21. App.B Stress Tables and Allowable Pressure Tables for Nonmetals
22. App. D Flexibility and Stress Intensification Factors
23. App.E Reference Standards
24. App. G Safeguarding
25. App. H Sample Calculations for Branch Reinforcement
26. App. J Nomenclature
27. App. K Allowable Stresses for High Pressure Piping
28. App. X Metallic Bellows Expansion Joints
29. App. Z Preparation of Technical Inquiries; Code Cases & Interpretations

## II. WELDING PROCEDURE AND QUALIFICATION EVALUATION

### A. ASME BOILER AND PRESSURE VESSEL CODE, SECTION IX

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-570. The weld procedure review will include:
  - One Weld Procedure Specification (WPS); and
  - One Procedure Qualification Record (PQR).
- a) 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)
- b) 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<sup>0</sup>F and the upper transformation temperature will be 1600<sup>0</sup>F.

### B. ASME B31.3

The inspector should be familiar with and understand the general rules for welding in ASME B31.3, Chapter V such as:

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

### C. API Standard 570

The inspector should be familiar with and understand any rules for welding in API-570. Any rules for welding given in API-570 shall take precedence over those covering the same areas in ASME, B31.3.

Note: "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 Authorized Piping Inspector should know that the PQR must be signed and dated.

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

### III. NONDESTRUCTIVE EXAMINATION

#### 1. 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;

- a) The Scope of Section V,
- b) Rules for use of Section V as a referenced Code,
- c) Responsibilities of the Owner / User, and of subcontractors,
- d) Calibration,
- e) Definitions of "inspection" and examination"
- f) Record keeping requirements,

##### B. Article 2, Radiographic Examination:

The inspector should be familiar with and understand;

- a) The Scope of Article 2 and general requirements,
- b) The rules for radiography as typically applied on butt welded seams such as, but not limited to:
  - Required marking
  - Type, selection, number, and placement of IQI's,
  - Allowable density and density ranges
  - Control of backscatter radiation
- c) Records

##### C. Article 6, Liquid Penetrant Examination (Including mandatory appendices II and III):

The inspector should be familiar with and understand the general rules for applying and using the liquid penetrant method, including but not limited to the following:

- a) The Scope of Article 6,
- b) General requirements such as but not limited to:
  - Procedures
  - Contaminants
  - Techniques
  - Examination
  - Interpretation
  - Documentation and record keeping

##### E. 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 including, but not limited to the following:

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

##### F. Article 9, Visual Examination:

The inspector should be familiar with and understand the general rules for applying and using the visual examination method including, but not limited to the following:

- a) The scope of Article 9,
- b) General requirements such as but not limited to:
  - Procedures
  - Physical requirements
  - Procedure/technique
  - Evaluation
- c) Documentation and record keeping

G. Article 10, Leak Testing (Including Mandatory appendix I Bubble Test –Direct Pressure Technique):

The inspector should be familiar with and understand the general rules for applying and using the leak testing method including, but not limited to the following:

- a) The scope of Article 10,
- b) General requirements such as but not limited to :
  - Procedures
  - Equipment
  - Calibration
  - Test
  - Evaluation
- c) Documentation and record keeping

H. 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.

2. ASME B31.3 and API-570: General nondestructive examination requirements:

ASME B31.3: The inspector should be familiar with and understand the general rules for NDE (Chapter VI).  
API Standard 570

The inspector should be familiar with and understand the general rules for NDE in API-570.

#### **IV. PRACTICAL KNOWLEDGE - GENERAL**

A. The following topics may be covered:

1. Organization and Certification Requirements.
2. Types and Definitions of Maintenance Inspections.
3. Welding on Piping
4. Corrosion and Minimum Thickness Evaluation.
5. Estimated Remaining Life.
6. Inspection Interval Determination and Issues Affecting Intervals.
7. Maintenance Inspection Safety Practices.
8. Inspection Records and Reports.
9. Repairs/Alterations/Reratings to Piping.
10. Rerating Piping.
11. Pressure Testing After Repairs, Alterations, or Rerating
12. Pressure Temperature Ratings
13. Markings
14. Materials
15. Dimensions
16. Test
17. Limiting Dimensions of Gaskets
18. Methods for Establishing Pressure-Temperature Ratings
19. Methods of performing positive material identification and related record keeping.

More information relative to each of the categories is contained in section "V. PRACTICAL KNOWLEDGE - SPECIFIC" where each reference publication applicable for study for the examination has been listed with relevant topics that may be covered on the examination.

## V. PRACTICAL KNOWLEDGE - SPECIFIC

### API-570, Inspection, Repair, Alteration, and Rerating of In-Service Piping Systems

#### 1. Organization and Certification Requirements

- a) Certification for API Authorized Piping Inspectors (API-570, Section 4.2 and Appendix A).
- b) Authorized Inspection Agencies (API-570, Section 3.4)
- c) Piping Repair Organizations (API-570, Section 3.38)
- d) Responsibilities (API 570, 4.3)

#### 2. Types and Definitions of Maintenance Inspection

- a) Thickness Measurement Inspection (API 570, 5.4.2)
- b) Inspection of Flanged Joints (API-570, 5.11)
- c) Inspection of Valves (API-570, 5.9)
- d) Inspection of Buried Piping (API 570, 9.0)
- e) Inspection for Specific Types of Corrosion and Cracking (API-570, 5.3)
- f) Visual External Inspection (API-570, 5.4.3 & 6.4)
- g) Thickness Measurements (API-570, 5.5 & 5.6)
- h) Nondestructive Examination (API-570, 5.10 & 8.2.5)
- i) Risk Based Inspection (API 570, 5.1)

#### 3. Welding on Piping

- a) Welding Inspection Requirements (API-570, 5.10)

#### 4. Corrosion and Minimum Thickness Evaluation

Note: 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 570, 7.1)
- b) Maximum Allowable Working Pressure Determination (API 570, 7.2)
- c) Minimum Required Thickness Determination (API 570, 7.3)

#### 5. Calculation of Estimated Remaining Life (API 570, 7.1.1)

#### 6. Inspection Interval Determination and Issues Affecting Intervals

- a) Thickness Measurement and Visual External Inspection Intervals (API 570, 6.3 & Table 6-1)
- b) Piping service Classes (API 570, 6.2)
- c) Extent of thickness measurement Inspection (API 570, 6.5)
- d) Extent of Small Bore, Auxiliary Piping, and Threaded Connection Inspections (API 570, 6.6)
- e) Extent of Visual External and CUI Inspections (API 570, 6.4)

#### 7. Maintenance Inspection Safety Practices

- a) Piping Inspection (API-570, 5.2)

## 8. Inspection Records and Reports

- a) Permanent and Progressive Inspection Records (API-570, 7.6)

## 9. Repairs and Alterations to Piping

- a) Authorization (API 570, 8.1.1)
- b) Approval (API 570, 8.1.2)
- c) Design Requirements (API 570, 8.2.3)
- d) Materials Requirements (API 570, 8.2.4)
- e) Welding Repairs (API 570, 8.1.3, 8.2 & Appendix C)
- f) Nonwelding Repairs (8.1.4)
- g) Hot Tapping (8.2)
- h) Heat Treating Requirements, including
  - Preheating (API 570, 8.2.2.1)
  - Post weld Heat Treating (API 570, 8.2.2.2)
- i) Rerating of Piping (API 570, 8.3)
- j) Pressure Testing After Repairs, Alterations or Rerating (API-570, 8.2.6)

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

ATTN: Examination questions will be based on the following sections only:

- Par. 3 – Definitions ( included as a frame of reference only)
  - 4.2.7 – Brittle Fracture
  - 4.2.9 – Thermal Fatigue
  - 4.2.14 – Erosion/Erosion Corrosion
  - 4.2.16 – Mechanical Fatigue
  - 4.2.17 – Vibration-Induced Fatigue
  - 4.3.2 – Atmospheric Corrosion
  - 4.3.3 – Corrosion Under Insulation (CUI)
  - 4.3.5 – Boiler Water Condensate Corrosion
  - 4.3.7 – Flue Gas Dew Point Corrosion
  - 4.3.8 – Microbiological Induced Corrosion (MIC)
  - 4.3.9 – Soil Corrosion
  - 4.4.2 – Sulfidation
  - 4.5.1 – Chloride Stress Corrosion Cracking (Cl'SCC)
  - 4.5.3 – Caustic Stress corrosion Cracking (Caustic Embrittlement)
    - 5.1.3.1 – High Temperature Hydrogen Attack (HTTA)

## **API RP-574, Inspection of Piping, Tubing, Valves, and Fittings**

### 1. Types and Definitions of Maintenance Inspections

- a) Piping Components (API RP-574, Section 4)
- b) Reasons for Inspection (API RP-574, Section 5)
- c) Inspecting for Deterioration in Piping (API RP-574, Section 6)
- d) Frequency and Time of Inspection (API RP-574, Section 7)
- e) Inspection, Tools (API RP-574, Section 9)
- f) Inspection Procedures (API-RP-574, Section 10)
- g) Determination of Retirement Thickness (API RP-574, Section 11)

### 2. Maintenance Inspection Safety Practices

- a. Piping Inspection (API RP-574, Section 8)

### 3. Inspection Records and Reports (API RP-574, Section 12)

#### **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

#### **API Recommended Practice 578 – Material Verification program for New and Existing Alloy piping Systems**

1. Types & Definitions of activities related to PMI
  - a) Materials and systems covered
  - b) Substitutions of alloy material in carbon steel systems
  - c) Organizations and specific responsibilities
  - d) Verify proper base metal materials are used in new construction and in repairs and alterations and that proper documentation is supplied
  - e) Verify proper welding filler metal materials are used in new construction and in repairs and alterations and that proper documentation is supplied
  - f) Verify incoming materials using PMI methods, mark and keep records to assure control of materials
  - g) Develop and implement a PMI program for existing systems
  - h) Integrate PMI in maintenance activities
  - i) Perform or audit PMI inspections and examinations to assure proper procedures and calibrated equipment are used and implemented by qualified personnel
  - j) Maintain or audit PMI record keeping system to assure accuracy

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

- a) Scope
- b) Pressure Temperature Ratings
- c) Markings
- d) Materials
- e) Dimensions
- f) Test
- g) Limiting Dimensions of Gaskets
- h) Methods for Establishing Pressure-Temperature Ratings

