Fitness-For-Service

API 579-1/ASME FFS-1, JUNE 5, 2007
(API 579 SECOND EDITION)

The American Society of
Mechanical Engineers

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API 579-1/ASME FFS-1 2007 Fitness-For-Service

FOREWORD

This standard is based on and supercedes the American Petroleum Institute's Recommended Practice 579, Fitness-For-Service.

In contrast to the straightforward and conservative calculations that are typically found in design codes, more sophisticated assessment of metallurgical conditions and analyses of local stresses and strains can more precisely indicate whether operating equipment is fit for its intended service or whether particular fabrication defects or in-service deterioration threaten its integrity. Such analyses offer a sound basis for decisions to continue to run as is or to alter, repair, monitor, retire or replace the equipment.

The publication of the American Petroleum Institute's Recommended Practice 579, Fitness-For-Service, in January 2000 provided the refining and petrochemical industry with a compendium of consensus methods for reliable assessment of the structural integrity of equipment containing identified flaws or damage. API RP 579 was written to be used in conjunction with the refining and petrochemical industry's existing codes for pressure vessels, piping and aboveground storage tanks (API 510, API 570 and API 653). The standardized Fitness-For-Service assessment procedures presented in API RP 579 provide technically sound consensus approaches that ensure the safety of plant personnel and the public while aging equipment continues to operate, and can be used to optimize maintenance and operation practices, maintain availability and enhance the long-term economic performance of plant equipment.

Recommended Practice 579 was prepared by a committee of the American Petroleum Institute with representatives of the Chemical Manufacturers Association, as well as some individuals associated with related industries. It grew out of a resource document developed by a Joint Industry Program on Fitness-For-Service administered by The Materials Properties Council. Although it incorporated the best practices known to the committee members, it was written as a Recommended Practice rather than as a mandatory standard or code.

While API was developing Fitness-For-Service methodology for the refining and petrochemical industry, ASME also began to address post-construction integrity issues. Realizing the possibility of overlap, duplication and conflict in parallel standards, ASME and API formed the Fitness-For-Service Joint Committee in 2001 to develop and maintain a Fitness-For-Service standard for equipment operated in a wide range of process, manufacturing and power generation industries. It was intended that this collaboration would promote the widespread adoption of these practices by regulatory bodies. The Joint Committee included the original members of the API Committee that wrote Recommended Practice 579, complemented by a similar number of ASME members representing similar areas of expertise in other industries such as chemicals, power generation and pulp and paper. In addition to owner representatives, it included substantial international participation and subject matter experts from universities and consulting firms.

This publication is written as a standard. Its words *shall* and *must* indicate explicit requirements that are essential for an assessment procedure to be correct. The word *should* indicates recommendations that are good practice but not essential. The word *may* indicates recommendations that are optional.

Most of the technology that underlies this standard was developed by the Joint Industry Program on Fitness-For-Service, administered by The Materials Properties Council. The sponsorship of the member companies of this research consortium and the voluntary efforts of their company representatives are acknowledged with gratitude.

The committee encourages the broad use of the state-of-the-art methods presented here for evaluating all types of pressure vessels, boiler components, piping and tanks. The committee intends to continuously improve this standard as improved methodology is developed and as user feedback is received. All users are encouraged to inform the committee if they discover areas in which these procedures should be corrected, revised or expanded. Suggestions should be submitted to the Secretary, API/ASME Fitness-For-Service Joint Committee, The American Society of Mechanical Engineers, Three Park Avenue, New York, NY 10016, or SecretaryFFS@asme.org.

This standard is under the jurisdiction of the ASME Board on Pressure Technology Codes and Standards and the API CRE Committee and is the direct responsibility of the API/ASME Fitness-For-Service Joint Committee. The American National Standards Institute approved API 579-1/ASME FFS-1 2007 on June 5, 2007.

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Classified areas may vary depending on the location, conditions, equipment, and substances involved in any given situation. Users of this Standard should consult with the appropriate authorities having jurisdiction.

Work sites and equipment operations may differ. Users are solely responsible for assessing their specific equipment and premises in determining the appropriateness of applying the Instructions. At all times users should employ sound business, scientific, engineering, and judgment safety when using this Standard.

Users of this Standard should not rely exclusively on the information contained in this document. Sound business, scientific, engineering, and safety judgment should be used in employing the information contained herein.

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Information concerning safety and health risks and proper precautions with respect to particular materials and conditions should be obtained from the employer, the manufacturer or supplier of that material, or the material safety data sheet.

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PART 1

INTRODUCTION

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1.1 Introduction

1.1.1 The ASME and API new construction codes and standards for pressurized equipment provide rules for the design, fabrication, inspection and testing of new pressure vessels, piping systems, and storage tanks. These codes do not provide rules to evaluate equipment that degrades while in-service and deficiencies due to degradation or from original fabrication that may be found during subsequent inspections. API 510, API 570, API 653, and NB-23 Codes/Standards for the inspection, repair, alteration, and rerating of in-service pressure vessels, piping systems, and storage tanks do address the fact that equipment degrades while in service.

1.1.2 Fitness-For-Service (*FFS*) assessments are quantitative engineering evaluations that are performed to demonstrate the structural integrity of an in-service component that may contain a flaw or damage. This Standard provides guidance for conducting *FFS* assessments using methodologies specifically prepared for pressurized equipment. The guidelines provided in this Standard can be used to make run-repair-replace decisions to help determine if pressurized equipment containing flaws that have been identified by inspection can continue to operate safely for some period of time. These *FFS* assessments are currently recognized and referenced by the API Codes and Standards (510, 570, & 653), and by NB-23 as suitable means for evaluating the structural integrity of pressure vessels, piping systems and storage tanks where inspection has revealed degradation and flaws in the equipment.

1.2 Scope

1.2.1 The methods and procedures in this Standard are intended to supplement and augment the requirements in API 510, API 570, API 653, and other post construction codes that reference *FFS* evaluations such as NB-23.

1.2.2 The assessment procedures in this Standard can be used for Fitness-For-Service assessments and/or rerating of equipment designed and constructed to the following codes

a) ASME B&PV Code, Section VIII, Division 1

b) ASME B&PV Code, Section VIII, Division 2

c) ASME B&PV Code, Section I

d) ASME B31.1 Piping Code

e) ASME B31.3 Piping Code

f) API 650

g) API 620

1.2.3 The assessment procedures in this Standard may also be applied to pressure containing equipment constructed to other recognized codes and standards, including international and internal corporate standards. This Standard has broad application since the assessment procedures are based on allowable stress methods and plastic collapse loads for non-crack-like flaws, and the Failure Assessment Diagram (FAD) Approach for crack-like flaws (see Part 2 , paragraph 2.4.2).

a) If the procedures of this Standard are applied to pressure containing equipment not constructed to the codes listed in paragraph 1.2.2, then the user is advised to first review the validation discussion in Annex H. The information in Annex H, along with knowledge of the differences in design codes, should enable the user to factor, scale, or adjust the acceptance limits of this Standard such that equivalent FFS in-service margins can be attained for equipment not constructed to these codes. When evaluating other codes and standards the following attributes of the ASME and API design codes should be considered:

   1) Material specifications
   2) Upper and/or lower temperature limits for specific materials
   3) Material strength properties and the design allowable stress basis
   4) Material fracture toughness requirements
   5) Design rules for shell sections
   6) Design rules for shell discontinuities such as nozzles and conical transitions
   7) Design requirements for cyclic loads
   8) Design requirements for operation in the creep range
   9) Weld joint efficiency or quality factors
   10) Fabrication details and quality of workmanship
   11) Inspection requirements, particularly for welded joints

b) As an alternative, users may elect to correlate the pressure-containing component's material specification to an equivalent ASME or API listed material specification to determine a comparable allowable stress. This approach provides an entry point into the ASME or API codes (refer also to Annex A) wherein the pressure-containing component is reconciled or generally made equivalent to the design bases assumed for this Standard. Hence, general equivalence is established and the user may then directly apply the acceptance limits of the Fitness-For-Service procedures contained in this Standard. Equivalent ASME and ASTM material specifications provide a satisfactory means for initiating reconciliation between the ASME and API design codes and other codes and standards. However, the user is cautioned to also consider the effects of fabrication and inspection requirements on the design basis (e.g., joint efficiency with respect to minimum thickness calculation).

1.2.4 The Fitness-For-Service assessment procedures in this Standard cover both the present integrity of the component given a current state of damage and the projected remaining life. Assessment techniques are included to evaluate flaws including: general and localized corrosion, widespread and localized pitting, blisters and hydrogen damage, weld misalignment and shell distortions, crack-like flaws including environmental cracking, laminations, dents and gouges, and remaining life assessment procedures for components operating in the creep range. In addition, evaluation techniques are provided for condition assessment of equipment including resistance to brittle fracture, long-term creep damage, and fire damage.

1.2.5 Analytical procedures, material properties including environmental effects, NDE guidelines and documentation requirements are included in the Fitness-For-Service assessment procedures in this Standard. In addition, both qualitative and quantitative guidance for establishing remaining life and in-service margins for continued operation of equipment are provided in regards to future operating conditions and environmental compatibility.

1.2.6 The Fitness-For-Service assessment procedures in this Standard can be used to evaluate flaws commonly encountered in pressure vessels, piping and tankage. The procedures are not intended to provide a definitive guideline for every possible situation that may be encountered. However, flexibility is provided to the user in the form of an advanced assessment level to handle uncommon situations that may require a more detailed analysis.

1.3 Organization and Use

The organization, applicability and limitations, required information, analysis techniques and documentation requirements are described in Part 2 of this Standard. In addition, an overview of the acceptance criteria utilized to qualify a component with a flaw is provided. First time users of the Fitness-For-Service assessment technology in this Standard should carefully review Part 2 prior to starting an analysis.

1.4 Responsibilities

1.4.1 Owner-User

The Owner-User of pressurized equipment shall have overall responsibility for Fitness-For-Service assessments completed using the procedures in this Standard, including compliance with appropriate jurisdictional and insurance requirements. The Owner-User shall ensure that the results of the assessment are documented and filed with the appropriate permanent equipment records. Many of the Owner-User responsibilities are given to the Plant Engineer (see paragraph 1.4.3.3).

1.4.2 Inspector

The Inspector, working in conjunction with the NDE engineer, shall be responsible to the Owner-User for determining that the requirements for inspection and testing are met. In addition, the Inspector shall provide all necessary inspection data required for a Fitness-For-Service assessment in accordance with the appropriate part of this Standard, and be responsible for controlling the overall accuracy of the flaw detection and sizing activities. In some instances, as determined by the Owner-User, the Inspector may also be responsible for the Fitness-For-Service assessment (Level 1 Assessment, see Part 2 , paragraph 2.4).

1.4.3 Engineer

1.4.3.1 The Engineer is responsible to the Owner-User for most types of Fitness-For-Service assessments, documentation, and resulting recommendations. The exception is that a Level 1 Assessment (see Part 2, paragraph 2.4) may be performed by an Inspector or other non-degreed specialist; however, in these cases the Engineer should review the analysis.

1.4.3.2 In the context of this Standard, the term Engineer applies to the combination of the following disciplines unless a specific discipline is cited directly. A Fitness-For-Service assessment may require input from multiple engineering disciplines as described below.

a) *Materials or Metallurgical Engineering* – Identification of the material damage mechanisms, establishment of corrosion/erosion rates, determination of material properties including strength parameters and crack-like flaw growth parameters, development of suitable remediation methods and monitoring programs, and documentation.

b) *Mechanical or Structural Engineering* – Computations of the minimum required thickness and/or $MAWP$ (MFH) for a component, performance of any required thermal and stress analysis, and knowledge in the design of and the practices relating to pressure containing equipment including pressure vessel, piping, and tankage codes and standards.

c) *Inspection Engineering* – Establishment of an inspection plan that is capable of detecting, characterizing, sizing flaws or damage, and selection and execution of examination procedures in conjunction with available NDE expertise.

d) *Fracture Mechanics Engineering* – Assessment of crack-like flaws using the principles of fracture mechanics.

e) *Non-Destructive Examination (NDE) Engineering* – Selection and development of methods to detect, characterize, and size flaws or quantify the amount of damage, and the analysis and interpretation of inspection data.

f) *Process Engineering* – Documentation of past and future operating conditions, including normal and upset conditions, and identification of the contained fluid and its contaminant levels that may affect degradation of the component being evaluated.