Fitness-For-Service

API 579-1/ASME FFS-1, June, 2016

The American Society of Mechanical Engineers

AMERICAN PETROLEUM INSTITUTE

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Foreword

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, the American Society of Mechanical Engineers (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.

In June 2007, the Fitness-For-Service Joint Committee published the first edition of API 579-1/ASME FFS-1 Fitness-For-Service.

The 2016 publication of API 579-1/ASME FFS-1 includes a number of modifications and technical improvements. Some of the more significant changes are the following:

- Reorganized the standard to facilitate use and updates.
- Expanded equipment design code coverage.
- Added Annex for establishing an allowable Remaining Strength Factor (RSF).
- Simplified Level 1 criterion for the circumferential extent of a Local Thin Area (LTA) through the modification of the Type A Component definition and subdivision of Type B Components into Class 1 or Class 2.
- Updated crack-like flaw interaction rules.
- Re-wrote weld residual stress solution Annex for use in the assessment of crack-like flaws.

- Updated guidance on material toughness predictions for use in the assessment of crack-like flaws.
- Updated evaluation procedures for the assessment of creep damage.
- Added Annex covering metallurgical investigation and evaluation of mechanical properties in a fire damage assessment.
- Developed new Part 14 covering the assessment of fatigue damage.

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 indicate 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, Two Park Avenue, New York, NY 10016, or SecretaryFFS@asme.org.

There is an option available to receive an e-mail notification when errata are posted to a particular code or standard. This option can be found on the Committee Web at http://go.asme.org/ffscommittee after selecting “errata” in the “Publication Information” section.

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 2016 in June, 2016.

Special Notes

This international code or standard was developed under ASME/API Joint Committee on Fitness-For-Service Policies and Procedures which were approved by ANSI and accredited as meeting the criteria for American National Standards and it is an American National Standard. The Standards Committee that approved the code or standard was balanced to assure that individuals from competent and concerned interests have had an opportunity to participate. The proposed code or standard was made available for public review and comment that provides an opportunity for additional public input from industry, academia, regulatory agencies, and the public-at-large.

This document addresses problems of a general nature. With respect to particular circumstances, local, state, and federal laws and regulations should be reviewed.

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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.

API and ASME are not undertaking to meet the duties of employers, manufacturers, or suppliers to warn and properly train and equip their employees, and others exposed, concerning health and safety risks and precautions, nor undertaking their obligations to comply with authorities having jurisdiction.

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 Construction Codes and Fitness-For-Service

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 typically do not provide rules to evaluate equipment that degrades while in-service and deficiencies caused by 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 Definition

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, or that may be operating under a specific condition that might cause a failure. 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 components in 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 Supplement to In-Service Inspection Codes

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 Application Construction Codes

The assessment procedures in this Standard can be used for FFS 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) ASME B31.4 Piping Code

g) ASME B31.8 Piping Code

h) ASME B31.12 Piping Code

i) API Std 650

j) API Std 620

k) API Std 530

1.2.3 Other Recognized Codes and Standards

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 applications 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 Annexes 3A through 13A. The information in these Annexes, 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 wherein the pressure-containing component is reconciled or generally made equivalent to the design bases assumed for this Standard (see Annex 2C, paragraph 2C.2). Hence, general equivalence is established and the user may then directly apply the acceptance limits of the FFS 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 Remaining Life

The FFS assessment procedures in this Standard cover both the present integrity of the component given a current state of damage and the projected remaining life. 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.

1.2.5 Assessment Methods for Flaw Types and Damage Conditions

Assessment methods as well as material properties, Nondestructive Examination (NDE) guidelines, and documentation requirements 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. In addition, evaluation techniques are provided for condition assessment of equipment including resistance to brittle fracture, creep damage, and fire damage.

1.2.6 Special Cases

The FFS 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 FFS 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 FFS 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 1.4.4).

1.4.2 Inspector

The Inspector, working in conjunction with the Nondestructive Examination (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 FFS 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 FFS assessment, i.e. a 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 FFS assessments, documentation, and resulting recommendations. The exception is that a Level 1 Assessment may be performed by an Inspector or other non-degreed specialist (see Part 2, paragraph 2.4). 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 FFS 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