Damage Mechanisms Affecting Fixed Equipment in the Refining Industry

RECOMMENDED PRACTICE 571
FIRST EDITION, DECEMBER 2003

American Petroleum Institute

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Downstream Segment

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FOREWORD

(December, 2003)

This publication is a result of a need for a document that describes damage mechanisms affecting equipment in the refining and petrochemical industries. A key first step in safely and reliably managing equipment is identifying and understanding the relevant damage mechanisms. Proper identification of damage mechanisms is important when implementing the API Inspection Codes (API 510, API 570, API 653) and in conducting risk based inspection per API 580 and API 581. When performing a fitness-for-service assessment using API 579, the damage mechanisms need to be understood and need to be considered when evaluating the remaining life.

This publication contains guidance for the combined considerations of:

- Practical information on damage mechanisms that can affect process equipment,
- Assistance regarding the type and extent of damage that can be expected, and
- How this knowledge can be applied to the selection of effective inspection methods to detect size and characterize damage.

The overall purpose of this document is to present information on equipment damage mechanisms in a set format to assist the reader in applying the information in the inspection and assessment of equipment from a safety and reliability standpoint.

This document reflects industry information, but it is not a mandatory standard or code. In this regard, the terms *shall* and *must* are only used to state mandatory requirements with respect to the assessment procedures which may not otherwise be correct unless followed explicitly. The term *should* is used to state that which is considered good practice and is recommended but is not absolutely mandatory. The term *may* is used to state that which is considered optional.

This publication was prepared by an API Task Group that included representatives of the American Petroleum Institute and the Pressure Vessel Research Council, as well as individuals associated with related industries.

It is the intent of the American Petroleum Institute to periodically revise this publication. All owners and operators of pressure vessels, piping, and tanks are invited to report their experiences in utilizing this document.

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Suggested revisions are invited and should be submitted to API, Standards department, 1220 L Street, NW, Washington, DC 20005.

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INTRODUCTION AND SCOPE

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1.1 Introduction

The ASME and API design 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 address equipment deterioration while in service and that deficiencies due to degradation or from original fabrication may be found during subsequent inspections. Fitness-For-Service (FFS) assessments are quantitative engineering evaluations that are performed to demonstrate the structural integrity of an in-service component containing a flaw or damage. The first step in a fitness-for-service assessment performed in accordance with API RP 579 is to identify the flaw type and the cause of damage. Proper identification of damage mechanisms for components containing flaws or other forms of deterioration is also the first step in performing a Risk-Based Inspection (RBI) in accordance with API RP 580.

When conducting a FFS assessment or RBI study, it is important to determine the cause(s) of the damage or deterioration observed, or anticipated, and the likelihood and degree of further damage that might occur in the future. Flaws and damage that are discovered during an in-service inspection can be the result of a pre-existing condition before the component entered service and/or could be service-induced. The root causes of deterioration could be due to inadequate design considerations including materials selection and design details, or the interaction with aggressive environments/conditions that the equipment is subjected to during normal service or during transient periods.

One factor that complicates a FFS assessment or RBI study for refining and petrochemical equipment is that material/environmental condition interactions are extremely varied. Refineries and chemical plants contain many different processing units, each having its own combination of aggressive process streams and temperature/pressure conditions. In general, the following types of damage are encountered in petrochemical equipment:

a) General and local metal loss due to corrosion and/or erosion

b) Surface connected cracking

c) Subsurface cracking

d) Microfissuring/microvoid formation

e) Metallurgical changes

Each of these general types of damage may be caused by a single or multiple damage mechanisms. In addition, each of the damage mechanisms occurs under very specific combinations of materials, process environments, and operating conditions.

1.2 Scope

General guidance as to the most likely damage mechanisms for common alloys used in the refining and petrochemical industry is provided in this recommended practice. These guidelines provide information that can be utilized by plant inspection personnel to assist in identifying likely causes of damage, and are intended to introduce the concepts of service-induced deterioration and failure modes.

The summary provided for each damage mechanism provides the fundamental information required for a FFS assessment performed in accordance with API RP 579 or an RBI study performed in accordance with API RP 580.

The damage mechanisms in this recommended practice cover situations encountered in the refining and petrochemical industry in pressure vessels, piping, and tankage. The damage mechanism descriptions are not intended to provide a definitive guideline for every possible situation that may be encountered, and the reader may need to consult with an engineer familiar with applicable degradation modes and failure mechanisms, particularly those that apply in special cases.