Damage Mechanisms Affecting Fixed Equipment in the Refining Industry

API RECOMMENDED PRACTICE 571
SECOND EDITION, APRIL 2011

AMERICAN PETROLEUM INSTITUTE

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Downstream Segment

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TABLE OF CONTENTS

SECTION 1

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 579-1/ASME FFS-1 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 an 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 an 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

This recommended practice provides general guidance as to the most likely damage mechanisms affecting common alloys used in the refining and petrochemical industry and is intended to introduce the concepts of service-induced deterioration and failure modes. These guidelines provide information that can be utilized by plant inspection personnel to assist in identifying likely causes of damage; to assist with the development of inspection strategies; to help identify monitoring programs to ensure equipment integrity.

The summary provided for each damage mechanism provides the fundamental information required for an FFS assessment performed in accordance with API 579-1/ASME FFS-1 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.