

Corrosion and Equipment Integrity

Why each internal and external factor matters, from first principles, and how it changes a fitness-for-service assessment

ATS Fitness-for-Service · Industrial Inspection & Radiological Services · Kuwait

Document control	
Document	TG-01 Corrosion and Equipment Integrity
Revision	Rev 0, 19 October 2026: issued for publication (drafts A, B and C, 18–19 October 2026)
Status	Issued
Prepared by	ATS Technical team
Reviewed by	S. Surya Prakash, 19 October 2026
Approved for issue by	S. Surya Prakash, 19 October 2026
Applies to	Carbon and low-alloy steel, stainless steel and common alloys in oil, gas, petrochemical, power and water service

This guide explains principles. It does not replace the governing codes and standards, a damage-mechanism review by a qualified corrosion engineer, or a fitness-for-service assessment of a specific component. Values quoted for illustration are typical or indicative; for design or assessment use the current edition of the cited standard and site-specific data.

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1 Introduction

1.1 Why this guide exists

Most pressure equipment, piping, tanks and steel structures do not fail because they were designed badly. They fail because the metal that was there on the first day is no longer there, or is no longer as strong, and nobody measured how quickly that was happening. Corrosion is the commonest reason that a component which once met its design code no longer does.

A fitness-for-service (FFS) assessment answers a narrow but important question: *given the damage that has been measured, is this component safe to keep operating, under what conditions, and for how long?* The answer depends on two things:

1. **The damage now.** What thickness remains, how the loss is distributed, and whether there are pits, grooves, blisters or cracks.
2. **The damage to come.** How quickly the damage will grow between now and the next inspection, or the end of the planned life.

Inspection measures the first. The second can only be judged by understanding *why* the metal is corroding: which chemical and physical factors drive the attack, and what would make it faster or slower. A corrosion rate is not a property of the steel. It belongs to the steel in a particular environment, at a particular temperature, flow and chemistry. When any of these changes, the rate changes, and so does the answer to the FFS question.

1.2 What this guide covers

The guide works through each major factor in turn and, for each one, explains:

- **The mechanism:** the fundamental chemistry or physics, with the governing equations.
- **The effect on the rate or form of damage:** what makes it worse and what makes it better.
- **Why it matters for fitness-for-service:** how the factor changes the inputs and the outcome of an assessment to API 579-1/ASME FFS-1.

Section 2 sets out the chain from corrosion to an FFS result. Sections 3 and 4 give the two foundations, thermodynamics (*will it corrode?*) and kinetics (*how fast?*). Section 5 covers internal factors on the process side, Section 6 covers external factors, and Section 7 covers high-temperature damage. Section 8 shows with numbers how the factors feed an assessment. Section 9 maps damage mechanisms to the relevant parts of API 579-1, and Section 10 lists the records an owner should keep so that an assessment can be done well.

1.3 Who it is for

The guide is written for plant engineers, inspection supervisors and integrity managers who commission or use FFS assessments. It is also for anyone who has to decide whether a corrosion finding is “just cosmetic” or the start of a problem. A working knowledge of school chemistry is enough. The equations are there to show *why* each factor behaves as it does. You do not need to evaluate them to follow the argument.

1.4 How corrosion and FFS meet: the short version

Every factor in this guide acts through one or more of three channels. It changes **how fast** metal is lost (the corrosion rate), it changes **where and in what shape** metal is lost (general, local, pitting, cracking), or it changes **what the remaining metal can carry** (hydrogen damage, embrittlement, stress-corrosion). An FFS assessment is sensitive to all three. The rate sets the future corrosion allowance and the remaining life. The shape decides which assessment procedure applies and how conservative it is. The strength of the remaining metal decides whether a thickness-based assessment is valid at all.

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