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# Petroleum, petrochemical and natural gas industries — Test methods for quality control of microstructure of ferritic/austenitic (duplex) stainless steels

*Industries du pétrole, de la pétrochimie et du gaz naturel — Méthodes d'essai de contrôle de la qualité de la microstructure des aciers inoxydables (duplex) austénitiques/ferritiques*



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# Foreword

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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*.

# Introduction

The aim of this document is to establish common test methods for quality control of microstructure of ferritic/austenitic (duplex) stainless steels for the oil and gas industry, enabling the manufacturers to apply the same test procedures for their clients.

Duplex stainless steels have a dual phase microstructure consisting of ferrite and austenite. Ideally, these phases are present in equal proportions; although in alloys which are commercially available, the ferrite phase volume fraction can vary between 35 % and 65 % for products in the solution annealed condition. They are characterized by high-chromium (19 % to 33 %) and low-nickel contents compared with austenitic stainless steels.

Duplex stainless steels are prone to precipitation of intermetallic phases, carbides and/or nitrides possibly causing embrittlement and reduced corrosion resistance. The formation of intermetallic phases such as Sigma, σ, and Chi, χ, occurs depending on exposure time in the approximate temperature range 590 °C to 1 000 °C (1 094 °F to 1 832 °F) and decomposition of ferrite to Alpha Prime occurs in the range 300 °C to 540 °C (572 °F to 1 004 °F).

The microstructure of components or fabrication welds is affected by amongst others the thermal-mechanical history associated with hot working, solution annealing and with subsequent forming and welding. The destructive test methods with acceptance criteria specified herein are considered relevant to verify that exposure time at above stated temperature ranges have been within acceptable limits and to ensure that desired corrosion resistance and mechanical properties are obtained in final products.

# Petroleum, petrochemical and natural gas industries — Test methods for quality control of microstructure of ferritic/austenitic (duplex) stainless steels



## 1 Scope

This document specifies quality control testing methods and test conditions for the characterization of microstructure in relation to relevant properties in ferritic/austenitic (duplex) stainless steel components supplied in the solution annealed condition and fabrication welds in the as welded condition.

This document supplements the relevant product and fabrication standards with respect to destructive testing methods including sampling of test specimens, test conditions and test acceptance criteria to show freedom from deleterious intermetallic phases and precipitates in duplex stainless steels. In addition, this document specifies the documentation of testing and test results by the testing laboratory.

NOTE 1 This document is based upon experience with duplex stainless steels in offshore oil and gas industry applications including topside and subsea hydrocarbon service, sea water service, as well as structural use.

NOTE 2 The austenite spacing is relevant to the susceptibility of duplex stainless steels to hydrogen-induced stress cracking (HISC) in subsea applications where cathodic protection is applied. This falls outside the scope of this document. Reference is made to DNV/GL RP-F112[4].

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 148-1, *Metallic materials — Charpy pendulum impact test — Part 1: Test method*

ISO 15614-1[1)], *Specification and qualification of welding procedures for metallic materials — Welding procedure test — Part 1: Arc and gas welding of steels and arc welding of nickel and nickel alloys)*

ASTM A 370, *Standard test methods and definitions for mechanical testing of steel products*

ASTM A 1058, *Standard test methods and definitions for mechanical testing of steel products — Metric*

ASTM A 1084, *Standard test method for detecting detrimental phases in lean duplex austenitic/ferritic stainless steels*

ASTM E 3, *Standard practice for preparation of metallographic specimens*

ASTM E 562, *Standard test method for determining volume fraction by systematic manual point count*

ASTM E 1245, *Standard practice for determining the inclusion or second-phase constituent content of metals by automatic image analysis*

ASTM G 48, *Standard test methods for pitting and crevice corrosion resistance of stainless steels and related alloys by use of ferric chloride solution*

1) For the purpose of this document, the following documents are considered equivalent: ASME Boiler and pressure vessel code, section IX Welding and brazing qualifications[2].