INTERNATIONAL STANDARD

ISO 3183-3

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Petroleum and natural gas industries — Steel pipe for pipelines — Technical delivery conditions —

Part 3:
Pipes of requirement class C

Industries du pétrole et du gaz naturel — Tubes en acier pour le transport des fluides combustibles — Conditions techniques de livraison —

Partie 3: Tubes de la classe de prescription C

Reference number
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Contents

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 3183 was prepared by Technical Committee ISO/TC 67, *Materials and equipment for petroleum and natural gas industries*, Subcommittee SC 1, *Line pipe*.

Together with the other parts, this part of ISO 3183 cancels and replaces ISO 3183:1980, which has been technically revised.

ISO 3183 consists of the following parts, under the general title *Petroleum and natural gas industries — Steel pipe for pipelines — Technical delivery conditions*:

— *Part 1: Pipes of requirement class A*

— *Part 2: Pipes of requirement class B*

— *Part 3: Pipes of requirement class C*

Annexes B, C and D form a normative part of this part of ISO 3183. Annex A is for information only.

Introduction

In the preparation of ISO 3183, the committee responsible was unanimous in seeking to avoid specifying the quality level of line pipe to be used for a particular application. However, the committee recognized that there are several broad quality levels commonly used, and has differentiated between these quality levels as follows.

Firstly, the need was recognized to provide a basic quality level which corresponds to that specified in ANSI/API 5L [2]. This is designated requirement class A and is considered in ISO 3183-1.

Secondly, many purchasers impose requirements different from or additional to the basic standard, for instance concerning toughness and non-destructive testing. This approach is common, for example, for transmission pipelines. Such overall enhanced requirements are addressed in requirement class B and are considered in ISO 3183-2.

Thirdly, there are certain particularly demanding applications, such as sour service, offshore service, and low-temperature service, where very stringent requirements are imposed. Such requirements are reflected in requirement class C and are considered in this part of ISO 3183.

For toughness properties, ISO 3183-3 offers a choice of requirement modules which correspond to concepts for avoidance of either brittle fracture or long-running shear fracture. The drop-weight tear test is part of those requirement modules which are considered typical for gas lines.

The Charpy energy requirements to avoid long-running shear fracture have been derived from established data in accordance with EPRG recommendations [3] for pipelines transporting lean, dry natural gas. It is recognized that rich gas or two-phase fluids may require enhanced toughness properties which can only be determined case by case.

It is the responsibility of the designer to select the appropriate toughness requirement module and to decide whether the specified energy requirements suffice for the intended application or whether the use of pipe with enhanced toughness properties and/or the use of mechanical crack arrestors is necessary.

For pipes of this requirement class C, a weld efficiency factor of 1,0 may be used in pipeline design calculations because of the conditions specified for the manufacture of the pipes and for the testing of the seam welds.

The selection of the requirement class depends on many factors. The properties of the fluid to be conveyed, the service conditions, the design code and any statutory requirements should all be taken into consideration. It is therefore the ultimate responsibility of the user to select the appropriate requirement class for the intended application.

NOTE This part of ISO 3183 combines a wide range of product types, dimensions and technical restrictions. In some areas of application, the absence of a single international pipeline design standard has resulted in differing national regulations imposing conflicting requirements on users, thus making technical harmonization difficult. Consequently, it may be necessary to amend certain requirements of this part of ISO 3183 to satisfy various national design codes. However, this part of ISO 3183 remains the basic reference document and such amendments should be specified at the time of enquiry and order. (See for example the note to 8.2.3.3.1.)

The steel names used in this part of ISO 3183 do not comply with the regulations given in ISO/TR 4949 [1] for the formation of steel names. They have been established using the principle agreed between ISO/TC 67/SC 1 and ECISS/TC 29/SC 2 for the International Standard ISO 3183, and for the European Standard EN 10208, in order to avoid misunderstandings which could arise from different steel names for the same grade.

Petroleum and natural gas industries — Steel pipe for pipelines — Technical delivery conditions —

Part 3:
Pipes of requirement class C

1 Scope

This part of ISO 3183 specifies the technical delivery conditions for unalloyed and alloyed (except stainless) seamless and welded steel pipes. It includes requirements overall more stringent than those specified in ISO 3183-1 and ISO 3183-2 [4]. This part of ISO 3183 applies to pipes that are normally used for the transmission of combustible fluids under particularly arduous conditions, such as offshore service, low temperature service and/or sour service (see 3.5).

This part of ISO 3183 is not suitable for cast steel pipes.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 3183 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 148:1983, *Steel — Charpy impact test (V-notch).*

ISO 377:1997, *Steel and steel products — Location and preparation of samples and test pieces for mechanical testing.*

ISO 404:1992, *Steel and steel products — General technical delivery requirements.*

ISO 1027:1983, *Radiographic image quality indicators for non-destructive testing — Principles and identification.*

ISO 2566-1:1984, *Steel — Conversion of elongation values — Part 1: Carbon and low alloy steels.*

ISO 3183-1:1996, *Petroleum and natural gas industries — Steel pipe for pipelines — Technical delivery conditions — Part 1: Pipes of requirement class A.*

ISO 4885:1996, *Ferrous products — Heat treatments — Vocabulary.*

ISO 4948-1:1982, *Steels — Classification — Part 1: Classification of steels into unalloyed and alloy steels based on chemical composition.*

ISO 4948-2:1982, *Steels — Classification — Part 2: Classification of steels into unalloyed and alloy steels according to main quality classes and main property or application characteristics.*

ISO 6507-1:1982, *Metallic materials — Hardness test — Vickers test — Part 1: HV 5 to HV 10.*

ISO 6508:1986, *Metallic materials — Hardness test — Rockwell test (scales A-B-C-D-E-F-G-H-K).*

ISO 6892:1984, *Metallic materials — Tensile testing.*

ISO 6929:1987, *Steel products — Definitions and classification.*

ISO 7438:1985, *Metallic materials — Bend test.*

ISO 7539-2:1989, *Corrosion of metals and alloys — Stress corrosion testing — Part 2: Preparation and use of bent-beam specimens.*

ISO 8492:1986, *Metallic materials — Tube — Flattening test.*

ISO 8501-1:1988, *Preparation of steel substrates before application of paints and related products — Visual assessment of surface cleanliness — Part 1: Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings.*

ISO 9303:1989, *Seamless and welded (except submerged arc-welded) steel tubes for pressure purposes — Full peripheral ultrasonic testing for the detection of longitudinal imperfections.*

ISO 9304:1989, *Seamless and welded (except submerged arc-welded) steel tubes for pressure purposes — Eddy current testing for the detection of imperfections.*

ISO 9305:1989, *Seamless steel tubes for pressure purposes — Full peripheral ultrasonic testing for the detection of transverse imperfections.*

ISO 9402:1989, *Seamless and welded (except submerged arc-welded) steel tubes for pressure purposes — Full peripheral magnetic transducer/flux leakage testing of ferromagnetic steel tubes for the detection of longitudinal imperfections.*

ISO 9598:1989, *Seamless steel tubes for pressure purposes — Full peripheral magnetic transducer/flux leakage testing of seamless ferromagnetic steel tubes for the detection of transverse imperfections.*

ISO 9764:1989, *Electric resistance and induction welded steel tubes for pressure purposes — Ultrasonic testing of the weld seam for the detection of longitudinal imperfections.*

ISO 9765:1990, *Submerged arc-welded steel tubes for pressure purposes — Ultrasonic testing of the weld seam for the detection of longitudinal and/or transverse imperfections.*

ISO 10124:1994, *Seamless and welded (except submerged arc-welded) steel tubes for pressure purposes — Ultrasonic testing for the detection of laminar imperfections.*

ISO 10543:1993, *Seamless and hot stretch-reduced welded steel tubes for pressure purposes — Full peripheral ultrasonic thickness testing.*

ISO 10474:1991, *Steel and steel products — Inspection documents.*

ISO 11484:1994, *Steel tubes for pressure purposes — Qualification and certification of non-destructive testing (NDT) personnel.*

ISO 11496:1993, *Seamless and welded steel tubes for pressure purposes — Ultrasonic testing of tube ends for the detection of laminar imperfections.*

ISO 12094:1994, *Welded steel tubes for pressure purposes — Ultrasonic testing for the detection of laminar imperfections in strip/plates used in the manufacture of welded tubes.*

ISO 12096:1996, *Submerged arc-welded steel tubes for pressure purposes — Radiographic testing of longitudinal and spiral welds for the detection of imperfections.*

ISO 12135:1996, *Metallic materials — Unified method of test for the determination of quasistatic fracture toughness.*

ISO 13663:1995, *Welded steel tubes for pressure purposes — Ultrasonic testing of the area adjacent to the weld seam for the detection of laminar imperfections.*

ISO 13664:1997, *Magnetic particle inspection of tube ends of seamless and welded ferromagnetic steel tubes for the detection of laminar imperfections.*

ISO 13665:1997, *Magnetic particle inspection of the tube body of seamless and welded ferromagnetic steel tubes for the detection of surface imperfections.*

ISO 14284:1996, *Steel and iron — Sampling and preparation of samples for the determination of chemical composition.*

ANSI/ API RP 5L3:1996, *Recommended practice for conducting drop-weight tear tests on line pipe.*

ASME Sect. IX:1995, *ASME Boiler and pressure vessel code — Section IX: Qualification standard for welding and brazing procedures, welders, brazers, and welding and brazing operators.*

ASTM A 370-96 (1996), *Standard test methods and definitions for mechanical testing of steel products.*

EN 288-3:1992, *Specification and approval of procedures for welding metallic materials — Part 3: Welding procedure tests for the arc welding of steel.*

NACE TM0177-96 (1996), *Standard test method — Laboratory testing of metals for resistance to specific forms of environmental cracking in H_2S environments.*

NACE TM0284-96 (1996), *Standard test method — Evaluation of pipeline steels and pressure vessel steels for resistance to hydrogen-induced cracking.*

3 Terms and definitions

3.1 General

For the purposes of this part of ISO 3183, the terms and definitions apply for the

— classification of steels in ISO 4948-1 and ISO 4948-2;

— definition of steel products in ISO 6929;

— heat treatment in ISO 4885 and for

— types of sampling procedures, inspection and inspection documents in ISO 377, ISO 404 and ISO 10474.

The terms and definitions in 3.2 to 3.6 apply when complementary to or different from those given in the above.

3.2 Types of pipes and welds

3.2.1
seamless pipe
S pipe
tubular product manufactured in a hot forming process

NOTE The forming process may be followed by cold sizing (see 6.5) or cold finishing (see 3.3.5) to produce the desired dimensions.

3.2.2
high-frequency welded pipe
HFW pipe
tubular product, manufactured by forming from strip and welding the abutting edges without addition of filler metal, in which the longitudinal seam is generated by high-frequency (at least 100 kHz) current applied by induction or conduction

3.2.3
submerged arc-welded pipe
SAW pipe
tubular product, manufactured by forming from strip or plate and welding the abutting edges by addition of filler metal, in which the longitudinal (SAWL) or helical (SAWH) seam is produced by the automatic submerged-arc welding process

cf. 6.3.

NOTE At least one pass is made on the inside and at least one pass on the outside of the pipe. A single pass tack weld prior to the deposition of the submerged arc-weld metal is permitted (see 6.3.3).

3.2.4
strip [plate] end weld
weld that joins strip [plate] ends together

3.2.5
jointer
two pieces of pipe joined together by a circumferential weld

3.2.6
pipe body
⟨welded pipe⟩ the entire pipe excluding the weld(s) and heat-affected zone(s)

3.2.7
pipe body
⟨seamless pipe⟩ the entire pipe

3.3 Treatment condition

3.3.1
normalizing forming
forming process in which the final deformation is carried out in a certain temperature range leading to a material condition equivalent to that obtained after normalizing

NOTE 1 With normalizing forming, the specified values of the mechanical properties are retained even after normalizing.

NOTE 2 The abbreviated form of this delivery condition is N.

3.3.2
thermomechanical forming
forming process in which the final deformation is carried out in a certain temperature range, leading to a material condition with certain properties which cannot be achieved or repeated by heat treatment alone

NOTE 1 Subsequent heating above 580 °C may lower the strength values.

NOTE 2 The abbreviated form of this delivery condition is M.

NOTE 3 Thermomechanical forming leading to the delivery condition M may include processes of increased cooling rates without or with tempering, including self-tempering but excluding definitively direct quenching and quenching and tempering.

3.3.3
quenching and tempering
heat treatment consisting of quench hardening followed by tempering

NOTE 1 Quench hardening implies austenitization followed by cooling, under conditions such that austenite transforms more or less completely into martensite and possibly into bainite.

NOTE 2 Tempering implies heating to a specific temperature below the lower transformation temperature (Ac_1) one or more times or holding this temperature, followed by cooling at an appropriate rate so that the structure is modified and the specified properties are achieved.

NOTE 3 The abbreviated form of this delivery condition is Q.

3.3.4
cold forming
process by which a flat product is formed to a pipe without heating

3.3.5
cold finishing
cold working operation (normally cold drawing) with a permanent strain greater than 1,5 %

NOTE The level of permanent strain differentiates it from cold sizing operations specified in 6.5.

3.4 Imperfections and defects

3.4.1
imperfection
irregularity in the wall or on the pipe surface detectable by methods described in this part of ISO 3183

NOTE Imperfections with a size and/or population density that are within the acceptance criteria defined in this part of ISO 3183 are considered to have no practical implication on the intended use of the product.

3.4.2
defect
imperfection of a size and/or population density greater than the acceptance criteria defined in this part of ISO 3183

NOTE Defects are considered to adversely affect or limit the intended use of the product.

3.5
service conditions
conditions of use which depend on the design of the pipeline as specified by the purchaser in relationship with the intended application

NOTE Within this part of ISO 3183, the terms “sour service”, “offshore service” and “low-temperature service” indicate service conditions.

3.6
by agreement
unless otherwise indicated, agreed between manufacturer and purchaser at the time of enquiry and order

3.7 Margin symbols

The following symbols are used in the margin of pages or tables to indicate options for delivery conditions:

M Mandatory agreement [see 5.2 a)]

U Unless otherwise agreed, left to the discretion of the manufacturer [see 5.2 b)]

O Optional agreement [see 5.2 c)]

4 Classification and designation

4.1 Classification

The steels specified in this part of ISO 3183 are non-alloy or alloy special steels. Their classification in accordance with ISO 4948-1 and ISO 4948-2 is indicated in Table 1.

4.2 Designation

The steels specified in this part of ISO 3183 are designated with steel names given in Table 1.

NOTE A comparison of the basic steel names with those specified in ANSI/API 5L [2] using the basis of specified minimum yield strength is given in annex A.

Table 1 — Classification and designation of steels

Heat treatment condition	Steel class in accordance with ISO 4948-1 and ISO 4948-2	Steel name [a]
Normalized or normalizing formed	Non-alloy special steel	L245NC
		L290NC
		L360NC
Quenched and tempered	Non-alloy special steel	L290QC
	Alloy special steel	L360QC
		L415QC
		L450QC
		L485QC
		L555QC
Thermomechanically formed	Non-alloy special steel	L290MC
		L360MC
		L415MC
	Alloy special steel	L450MC
		L485MC
		L555MC

[a] In the steel name designations N, Q and M refer to the treatment condition given in 3.3, where:
N = Normalized or normalizing formed;
Q = Quenched and tempered;
M = Thermomechanically formed.

The additional letter S shall be added as a suffix to the steel name for sour service material to distinguish it from non-sour service material.

EXAMPLE: L450QCS

5 Information to be supplied by the purchaser

5.1 Mandatory information

The purchaser shall state in his enquiry and order the following minimum information:

a) quantity ordered (e.g. total mass or total length of pipe);

b) product form (i.e. pipe);

c) type of pipe (see Table 2, column 1);

d) number of this part of ISO 3183;

e) steel name (see Table 1) including service condition non-sour or sour (see Tables 3 and 4);

f) toughness requirements to be met (see 7.3.1);

g) pipe outside diameter and wall thickness, in millimetres (see 7.6.1.1);

h) offshore service, if applicable (see Table 11, footnotes e and f and 7.6.3.4.2);

i) for other than offshore pipe, the random length group or, if an exact length is required, the length in metres (see 7.6.3.4 and Table 13);

j) design temperature, if applicable [see 7.3.1 a) and 7.3.1 b) and 8.2.3.5];

k) type of inspection document required (see 8.1);

l) information on the type of intended subsequent coating, if applicable;

m) intended use as a mother pipe for factory bends, if applicable.

5.2 Other information

This part of ISO 3183 offers to the purchaser and manufacturer the possibility to agree upon additional information (see 7.3.1, note 1) or other conditions, in addition to the normally applicable delivery conditions, in accordance with items a) to c) as follows. The need for additional information or the options required shall be clearly indicated at the enquiry stage and stated in the order and in the confirmation of the order.

NOTE The parts of clauses or tables covering items listed in 5.2 are marked by the symbols M, U, O defined in 3.7.

a) **Mandatory agreement: option which shall be agreed if applicable (M)**

1) chemical composition of pipes with wall thicknesses > 25 mm (see Tables 3 and 4, text preceding footnotes);

2) mechanical properties of pipes with wall thicknesses > 25 mm (see Table 5, footnote a);

3) supply of information on hoop stress when option c). 6) is specified [see 7.3.1 c)];

4) impact and DWT test requirements for pipes with outside diameters > 1 430 mm and/or wall thicknesses > 25 mm (see Table 8, footnote a and Table 9, text preceding note);

5) diameter tolerances for the ends of seamless pipe with wall thicknesses > 25 mm (see Table 11, footnote b);

6) diameter tolerances for pipes with outside diameter > 1 430 mm (see Table 11);

7) out-of-roundness requirement for offshore pipe with $D/T > 75$ (see Table 11);

8) party to issue inspection document 3.2 (see 8.1);

9) marking of pipe intended for subsequent coating (see 9.1.4);

10) frequency and amount of testing for the manufacturing procedure qualification [see B.3 a)].

b) **Unless otherwise agreed, left to the discretion of the manufacturer (U)**

1) method to verify dimensional and geometrical requirements (see 8.2.3.14.4);

2) timing of NDT of seamless pipe (see D.2.2);

3) radiographic inspection for the detection of longitudinal imperfections [see D.5.4 a)].

c) **Optional agreement: option which may be agreed (O)**

1) alternative casting method for material for welded pipe (see 6.3.3);

2) manufacture of SAWL pipes with two longitudinal seams (see 6.3.3);

3) renunciation of cold expansion of SAWL pipe (see 6.5);

4) supply of SAWH containing plate end welds (see 6.6);

5) copper and/or molybdenum content (see Table 4, footnotes c and i);

6) specification of calculated impact energy values (see 7.3.1);

7) impact test temperature and, if applicable, DWT test temperature other than the standard test temperature shown in Tables 6, 8 and 9 (see 7.3.1, 8.2.3.3.1 and 8.2.3.4);

8) restricted yield strength range (see Table 5, footnote b);

9) increased $R_{t0,5}/R_m$ ratios (see Table 5, footnote c);

10) weldability data or weld tests (see 7.4.2);

11) application of the diameter tolerance to the inside diameter (see Table 11, footnote c);

12) application of the diameter tolerance to the outside diameter (see Table 11, footnote d);

13) length other than that specified in 7.6.3.4.1 and 7.6.3.4.2 (see 7.6.3.4.3);

14) special bevel configuration or end preparation (see 7.6.4.2);

15) trimming of the outside weld bead of SAW pipes (see 7.6.5.2.2);

16) transverse tensile test for seamless pipe (see Table 20, footnote b);

17) additional longitudinal tensile testing for deep water pipelay (see Table 20, footnote f);

18) use of round test pieces (see 8.2.2.3);

19) use of flattened and heat-treated test coupons (see 8.2.2.3);

20) use of alternative transverse impact test pieces (see 8.2.2.4);

21) use of hydraulic ring expansion test for transverse yield determination (see 8.2.3.2.3);

22) substitution of the macrographic alignment examination by an alternative test method (see 8.2.3.8.1);

23) hardness test during production and maximum hardness value for seam-heat-treated HFW pipe (see 8.2.3.8.2);

24) photomicrographs of reportable HIC cracks (see 8.2.3.9);

25) other SSC test methods and associated acceptance criteria for manufacturing procedure qualification (see 8.2.3.10);

26) hydrostatic test pressures and/or hoop stress greater than the standardized limit (see 8.2.3.12.1);

27) hydrostatic test pressure in accordance with ISO 3183-1 (see 8.2.3.12.3);

28) use of special devices for measuring the pipe diameter (see 8.2.3.14.1);

29) use of (cold) die stamping or vibro etching (see 9.1.3);

30) special marking (see 9.2);

31) temporary protection, including coating, lining, mill varnish or other temporary protection (see clause 10);

32) bead on pipe test for manufacturing procedure qualification [see B.3 d)];

33) SSC test for manufacturing procedure qualification [see B.3 e)];

34) CTOD test for manufacturing procedure qualification [see B.3 f)];

35) testing for laminar imperfections within extended length of 100 mm at pipe ends and/or in the bevel (see D.2.4);

36) testing for laminar imperfections of non-sour seamless pipe [see D.3.3 b)];

37) increase of coverage for wall thickness check (see D.3.4);

38) application of supplementary requirements (seamless pipes) (see D.3.5);

39) limitation of individual lamination size to 100 mm^2 (see Table D.2);

40) acceptance level L2/C (L2) for NDT of HFW pipe (see D.4.2);

41) application of supplementary operations (HFW pipe) (see D.4.5);

42) use of fixed depth notches for equipment calibration [see D.5.2.1.d)];

43) use of hole penetrometers instead of ISO Wire Penetrometer [see D.5.5.1.a)];

44) application of supplementary operations (SAW pipe) (see D.5.6).

5.3 Examples for ordering

Information for ordering should preferably be given as indicated in the following examples:

a) 32 000 m pipe SAWL ISO 3183-3 L415MC 610 × 12,5 r2 toughness requirement: subclause 7.3.1 b) TD: –10 °C inspection document ISO 10474-3.1.C.

   For information: Pipe is designated for subsequent external three-layer extruded polyethylene-based coating.

b) 20 000 m pipe S ISO 3183-3 L450QC 219,1 × 12,5 toughness requirement: subclause 7.3.1 b) TD: – 10 °C offshore service, inspection document ISO 10474-3.1.B.

c) 2 000 m pipe S ISO 3183-3 L360NC 88,9 × 14,2 r2 toughness requirement: subclause 7.3.1 a) inspection document ISO 10474-3.1.C.

   For information: Pipe is designated for subsequent external fusion-bonded epoxy coating.

Any optional agreements or supplementary requirements (see 5.2) should also be included.

6 Manufacturing

6.1 General

6.1.1 All pipes shall be manufactured in accordance with an appropriate manufacturing procedure which shall be subject to approval by the purchaser.

Verification of the manufacturing procedure may be by the provision of available data or by qualification in accordance with annex B.

6.1.2 All non-destructive testing (NDT) operations referred to in this part of ISO 3183 shall be conducted by NDT personnel qualified and certificated in accordance with ISO 11484 or equivalent.

6.2 Steelmaking

6.2.1 The steels covered by this part of ISO 3183 shall be made using the basic oxygen process or the electric furnace process.

6.2.2 The steels shall be fully killed and be made according to a fine grain, clean steel practice. For sour-service material, vacuum degassing or alternative processes should be applied. The material may be treated for inclusion shape control to increase resistance to hydrogen-induced (blistering and stepwise) cracking (HIC).

6.3 Pipe manufacturing

6.3.1 General

Acceptable types of pipe are described in 3.2 and listed in Table 2. The type of pipe and the type of heat treatment as given in the steel name shall be specified by the purchaser.

6.3.2 Seamless pipe manufacture

Seamless pipe shall be manufactured from continuously cast or ingot steel. Where the process of cold finishing is used, this shall be stated in the inspection document.

6.3.3 Manufacture of welded pipe

All plate or strip for the manufacture of SAWL, SAWH, and HFW pipe shall be rolled from continuously cast or pressure cast slabs and shall be in the appropriate condition listed as "starting material" in Table 2.

O Alternative casting methods when proposed shall be subject to agreement.

Where HFW pipe for sour service is produced from strip, the abutting edges should be milled or machined before welding.

Plates shall be visually examined after rolling and shall be examined ultrasonically for laminar imperfections in accordance with annex D. The timing of this ultrasonic examination may be either before or after cutting the plate, at the manufacturer's discretion. Strips used for SAWL pipe manufacture shall be treated in the same way.

Strip used for the manufacture of HFW and SAWH pipe shall be examined visually and ultrasonically for laminar imperfections in accordance with annex D at an appropriate stage, either before or during the pipe-making process. Alternatively, if the pipe manufacturer of HFW and SAWH pipe is able to carry out full-body inspection of the completed pipe body, including the ultrasonic test, the testing may be deferred to that stage.

Strip used for the manufacture of SAWH pipe shall be of width not less than 0,8 times nor more than 3,0 times the pipe outside diameter.

O By agreement, SAWL pipe may be manufactured with two seams.

In the manufacture of SAWL and SAWH pipe, any lubricant which contaminates the weld bevel or the surrounding area shall be removed before welding begins.

Intermittent tack welding of the SAWL groove shall not be permitted, unless the manufacturer furnishes data to demonstrate for the approval of the purchaser that the specified properties are obtained at both the tack weld and intermediate positions.

6.4 Delivery condition

The pipes shall be delivered in one of the forming and heat-treatment conditions given in Table 2.

Table 2 — Type of pipe, starting material, pipe forming and heat treatment conditions

Type of pipe	Starting material	Pipe forming[b]	Pipe heat treatment	Symbol for the heat treatment
Seamless (S)	Ingot or billet	Normalizing forming	—	N
		Hot forming	Normalizing	N
			Quenching and tempering	Q
		Hot forming and cold finishing	Normalizing	N
			Quenching and tempering	Q
High-frequency welded (HFW)	Normalizing rolled strip	Cold forming	Normalizing weld area	N
	Thermomechanically rolled strip		Heat treating weld area	M
			Heat treating weld area and stress relieving (entire pipe)	M
	Hot rolled or normalizing rolled strip		Normalizing (entire pipe)	N
			Quenching and tempering (entire pipe)	Q
		Cold forming and hot stretch reducing under controlled temperature resulting in a normalized condition	—	N
		Cold forming and thermomechanical processing (entire pipe)	—	M
Submerged-arc welded (SAW) — longitudinal seam (SAWL) — helical seam (SAWH)	Normalized or normalizing rolled plate or strip	Cold forming	—	N
	Thermomechanically rolled plate or strip			M
	Quenched and tempered plate		—	Q
	As rolled, normalized or normalizing rolled plate or strip		Quenching and tempering (entire pipe)	Q
	As rolled plate or strip	Normalizing forming	—	N
	Normalized or normalizing rolled plate or strip			

[b] See 3.3.4

6.5 Cold expansion and cold sizing

O Unless otherwise agreed, SAWL pipe shall be cold-expanded by a mechanical process.

The expansion shall be

$$0{,}003 < s_r \leqslant 0{,}015$$

where s_r is the sizing ratio.

Other types of pipe may be sized to their final dimensions by expanding or reducing. This shall not produce excessive permanent strain. In cases where no further heat treatment or only a heat treatment of the weld area is carried out, the sizing ratio s_r shall not exceed 0,015.

s_r shall be calculated according to the formula:

$$s_r = \frac{|D_a - D_b|}{D}$$

where

D_a is the outside diameter after sizing;

D_b is the outside diameter before sizing;

D is the specified outside diameter.

6.6 Strip/plate end welds

Strip end welds are not permitted in the delivered pipe.

O By agreement, for helically welded pipe made from plate, it is permissible to deliver pipes containing plate end welds [see Figure 3 c)] providing such welds are located at least 200 mm from the pipe end. However, the plate end weld shall be subject to the same non-destructive testing required for plate edges and welds in accordance with D.5.1.

6.7 Jointers

The delivery of jointers is not permitted.

7 Requirements

7.1 General

The requirements specified in this part of ISO 3183 apply on condition that the relevant specifications for test piece selection, test piece preparation and test methods given in 8.2.2 and 8.2.3 are met.

NOTE Table 19 gives a survey of the tables and clauses covering requirements and on the specifications for testing.

In addition to the requirements of this part of ISO 3183, the general technical delivery requirements specified in ISO 404 apply.

7.2 Chemical composition

7.2.1 Chemical composition shall be based on product analysis. The manufacturer's aim-cast chemistry and range shall be stated in the manufacturing procedure (see 6.1.1).

7.2.2 Product analysis shall be limited to that given in Table 3 for non-sour service applications, or Table 4 for sour service applications.

Table 3 — Chemical composition (product analysis) for non-sour service applications

Steel name	Maximum content, % C[a]	Si	Mn[a]	P	S	V	Nb	Ti	Other[b]	CEV[c] max.	P_{cm}[d,e] max.
Steels for seamless and welded pipes											
L245NC	0,14	0,40	1,35	0,020	0,010				f	0,36	0,19
L290NC	0,14	0,40	1,35	0,020	0,010	0,05	0,05	0,04	f	0,36	0,19
L360NC	0,16	0,45	1,65	0,020	0,010	0,10	0,05	0,04	g,h	0,43	0,22
Steels for seamless and welded pipes											
L290QC	0,14	0,40	1,35	0,020	0,010	0,04	0,04	0,04	f	0,34	0,19
L360QC	0,16	0.45	1,65	0,020	0,010	0,07	0,05	0,04	g,h	0,39	0,20
L415QC	0,16	0,45	1,65	0,020	0,010	0,08	0,05	0,04	g,h	0,41	0,22
L450QC	0,16	0,45	1,65	0,020	0,010	0,09	0,05	0,06	g,h	0,42	0,22
L485QC	0,17	0,45	1,75	0,020	0,010	0,10	0,05	0,06	g,h	0,42	0,23
L555QC	0,17	0,45	1,85	0,020	0,010	0,10	0,06	0,06	By agreement		
Steels for welded pipes											
L290MC	0,12	0,40	1,35	0,020	0,010	0,04	0,04	0,04	f	0,34	0,19
L360MC	0,12	0,45	1,65	0,020	0,010	0,05	0,05	0,04	h	0,37	0,20
L415MC	0,12	0,45	1,65	0,020	0,010	0,08	0,06	0,06	g,h	0,38	0,21
L450MC	0,12	0,45	1,65	0,020	0,010	0,10	0,06	0,06	g,h	0,39	0,22
L485MC	0,12	0,45	1,75	0,020	0,010	0,10	0,06	0,06	g,h	0,41	0,23
L555MC	0,14	0,45	1,85	0,020	0,010	0,10	0,06	0,06	By agreement		

M

Chemical composition applies for wall thicknesses up to 25 mm and shall be agreed for larger wall thicknesses. Elements not mentioned in this table shall not be added intentionally without purchaser's approval except for elements that may be added for deoxidation and finishing of the heat (see footnote b).

a For each reduction of 0,01 % below the maximum carbon content, an increase of 0,05 % manganese above the specified maximum values is permitted, with a maximum increase of 0,2 %.

b $Al_{total} \leqslant 0{,}060$; $N \leqslant 0{,}012$; Al:N ⩾ 2:1 (not applicable to titanium-killed steels).

c Carbon equivalent $CEV = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Cu + Ni}{15}$

d Parameter crack measurement $P_{cm} = C + \frac{V}{10} + \frac{Mo}{15} + \frac{Cr + Mn + Cu}{20} + \frac{Si}{30} + \frac{Ni}{60} + 5B$

e For seamless pipe, P_{cm} values 0,03 higher than the tabulated values are permitted, up to a maximum of 0,25.

f $Cu \leqslant 0{,}35$; $Ni \leqslant 0{,}30$; $Cr \leqslant 0{,}30$; $Mo \leqslant 0{,}10$; $B \leqslant 0{,}0005$

g The sum of V, Nb, Ti shall not exceed 0,15 %.

h $Cu \leqslant 0{,}50$; $Ni \leqslant 0{,}50$; $Cr \leqslant 0{,}50$; $Mo \leqslant 0{,}5$; $B \leqslant 0{,}0005$

Table 4 — Chemical composition (product analysis) for sour service applications

Steel name	Maximum content, %									CEV[e] max.	P_{cm}[f,g] max.
	C[a]	Si	Mn[a]	P	S[b]	V	Nb	Ti	Other[c,d]		
Steels for seamless and welded pipes											
L245NCS	0,14	0,40	1,35	0,020	0,003					0,36	0,19
L290NCS	0,14	0,40	1,35	0,020	0,003	0,05	0,05	0,04		0,36	0,19
L360NCS	0,16	0,45	1,65	0,020	0,003	0,10	0,05	0,04	h	0,43	0,22
Steels for seamless and welded pipes											
L290QCS	0,14	0,40	1,35	0,020	0,003	0,04	0,04	0,04		0,34	0,19
L360QCS	0,16	0,45	1,65	0,020	0,003	0,07	0,05	0,04	h	0,39	0,20
L415QCS	0,16	0,45	1,65	0,020	0,003	0,08	0,05	0,04	h,i	0,41	0,22
L450QCS	0,16	0,45	1,65	0,020	0,003	0,09	0,05	0,06	h,i	0,42	0,22
Steels for welded pipes											
L290MCS	0,10	0,40	1,25	0,020	0,002	0,04	0,04	0,04		0,34	0,19
L360MCS	0,10	0,45	1,45	0,020	0,002	0,05	0,05	0,04		0,37	0,20
L415MCS	0,10	0,45	1,45	0,020	0,002	0,08	0,06	0,06	h	0,38	0,21
L450MCS, L485MCS	0,10	0,45	1,55	0,020	0,002	0,10	0,06	0,06	h,i	0,39	0,22

M Chemical composition applies for wall thicknesses up to 25 mm and shall be agreed for larger wall thicknesses.

Elements not mentioned in this table shall not be added intentionally without purchaser's approval except for elements that may be added for deoxidation and finishing of the heat (see footnotes c and d).

a For each reduction of 0,01 % below the maximum carbon content, an increase of 0,05 % manganese above the specified maximum values is permitted with a maximum increase of 0,2 %.

b For seamless pipe, sulfur content up to 0,008 % is permitted.

O c $Al_{total} \leqslant 0{,}060$; $N \leqslant 0{,}012$; Al:N $\geqslant$ 2:1 (not applicable to titanium killed steel); $Cu \leqslant 0{,}35$ (by agreement $\leqslant 0{,}10$); $Ni \leqslant 0{,}30$;
$Cr \leqslant 0{,}30$; $Mo \leqslant 0{,}10$; $B \leqslant 0{,}0005$.

d For welded pipe where calcium is intentionally added, Ca/S shall be $\geqslant 1{,}5$ when $S > 0{,}0015$ %. For all types of pipe (seamless and welded) Ca shall be restricted to 0,006 %.

e Carbon equivalent $CEV = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Cu + Ni}{15}$

f Parameter crack measurement $P_{cm} = C + \frac{V}{10} + \frac{Mo}{15} + \frac{Cr + Mn + Cu}{20} + \frac{Si}{30} + \frac{Ni}{60} + 5B$

g For seamless pipe, P_{cm} values 0,03 higher than the tabulated values are permitted, up to a maximum of 0,25.

h The sum of V, Nb, Ti shall not exceed 0,15 %.

O i For these steel grades, a molybdenum content up to 0,35 % may be agreed.

7.3 Mechanical and technological properties

7.3.1 General requirements

The pipe shall conform with the requirements given in Table 5.

For toughness properties, the pipe shall conform with one of the following requirements as specified by the purchaser at the time of enquiry and order (see 5.1):

a) Table 7 (test temperature according to Table 6) [typically for liquid-conveying lines];

b) Table 7 (test temperature according to Table 6) and DWT requirements of Table 8 [typically for offshore gas-conveying lines];

c) For the base material, Table 8 (comprising DWT and Charpy requirements).

For the weld area, 40 J (minimum average value for three tests; with a minimum individual value of 30 J) at the same test temperature as the base material (typically for onshore gas-conveying lines).

O By agreement, the tabulated impact energy values for the base material in Table 8 may be replaced with values calculated by the relevant formula in Table 9. In this case,

M the purchaser shall provide information on hoop stress values.

NOTE 1 In the case of hot forming and/or subsequent field heat treatment of pipes delivered in the quenched and tempered or thermomechanically rolled condition, adverse change of mechanical properties can occur (see for example 3.3.2). Where appropriate, the purchaser should contact the manufacturer for more detailed information.

NOTE 2 The impact requirements in Table 8 have been determined using a safety factor of 1,4. The test temperature in Tables 6, 8 and 9 recognizes the stringent applications of level C material.

7.3.2 Special requirements for sour service

7.3.2.1 The test for evaluation of resistance to hydrogen-induced cracking (HIC) shall meet the following acceptance criteria as defined in NACE TM0284-96, the maximum figures below being the average values of three sections per specimen:

Crack sensitivity ratio (CSR) $\leqslant$ 2 %

Crack length ratio (CLR) $\leqslant$ 15 %

Crack thickness ratio (CTR) $\leqslant$ 5 %

7.3.2.2 Hardness testing shall be performed. The maximum hardness at any location [pipe body, heat-affected zone (HAZ) and weld] shall not exceed 250 HV10 (22 HRC).

The Rockwell hardness test shall only be used on parent material and not in the HAZ or weld metal. In case of dispute, the Vickers method shall apply (see 8.2.3.11.1).

7.3.2.3 The sulfide stress-cracking test, where specified for manufacturing procedure qualification, shall meet the following acceptance criterion:

The sample shall show no visible cracking that exceeds 0,1 mm in the through-thickness direction.

7.4 Weldability

7.4.1 In view of the processes for the manufacture of the pipes and of pipe lines, the requirements for the chemical composition of the steels and, in particular, the limiting values of CEV and P_{cm} (see Tables 3 and 4) have been selected to ensure that the steels delivered in accordance with this part of ISO 3183 are weldable.

However, account should be taken of the fact that the behaviour of the steel during and after welding is dependent not only on the steel, but also on the welding consumables used and on the conditions of preparing for, and carrying out welding.

O **7.4.2** By agreement, the manufacturer shall supply weldability data for the type of steel concerned or perform weld tests. In the case of weld tests, the details for carrying out the tests and the acceptance criteria shall also be agreed.

Table 5 — Requirements for the results of tensile and bend tests, and for the hydrostatic test

Steel name	Pipe body[a] (seamless and welded pipe)				Weld seam[a]		Entire pipe
					HFW, SAW	SAW	
	Yield strength[b] $R_{t0,5}$ N/mm²	Tensile strength R_m N/mm² min.	Ratio $R_{t0,5}/R_m$[c,d] max.	Elongation[e] $\left(L_0 = 5{,}65\sqrt{S_0}\right)$ A % min.	Tensile strength R_m N/mm² min.	Diameter of the mandrel for bend test[f] (see 8.2.3.6)	Hydrostatic test (see 8.2.3.12)
L245NC L245NCS	245 to 440	415	0,90	22	The same values as for the pipe body apply	3*T*	Each length of pipe shall withstand the test without showing leakage or visible deformation in excess of the specified tolerances
L290NC, L290NCS L290QC, L290QCS L290MC, L290MCS	290 to 440	415	0,90	21		3*T*	
L360NC, L360NCS L360QC, L360QCS L360MC, L360MCS	360 to 510	460	0,90	20		4*T*	
L415QC, L415QCS L415MC, L415MCS	415 to 565	520	0,92	18		5*T*	
L450QC, L450QCS L450MC, L450MCS	450 to 570	535	0,92	18		6*T*	
L485QC L485MC, L485MCS	485 to 605	570	0,92	18		6*T*	
L555QC L555MC	555 to 675	625	0,92	18		6*T*	

M a Mechanical properties apply for wall thicknesses up to 25 mm and shall be agreed for larger wall thicknesses.

O b A restricted yield strength range may be agreed at the time of enquiry and order.

O c The values for the yield strength ratio apply to the product "pipe". They cannot be required for the starting material. For grades L415MCS, L450MCS and L485MCS, the ratio may be increased by agreement to 0,93. For seamless pipe manufactured by a process of quenching and tempering, $R_{t0,5}/R_m$ ratios greater than the tabulated values may be agreed.

d The $R_{t0,5}/R_m$ ratio for M grades applies to transverse test pieces only.

e These values apply to transverse test pieces taken from the pipe body. If longitudinal test pieces are tested (see Table 20), the values of elongation shall be 2 units higher.

f *T*: specified wall thickness of the pipe.

Table 6 — Charpy V-notch test temperature for avoidance of brittle fracture

Specified wall thickness, T mm	Test temperature[a,b] °C
$T \leqslant 20$	TD – 10
$20 < T \leqslant 30$	TD – 20
$T > 30$	TD – 30

a TD: Design temperature as stated in the enquiry and order.

O b Other temperatures may be agreed (see 7.3.1, note 2).

Table 7 — Charpy V-notch impact energy requirements for avoidance of brittle fracture

Grade	Average of three test pieces J	Minimum individual value J
L245	27	22
L290	30	24
L360	36	30
L415	42	35
L450	45	38
L485	50	40
L555	56	45
Test shall be performed at temperatures in accordance with Table 6. Impact energy values apply to transverse full size test pieces, see 8.2.3.3.2 for sub-size test pieces and reporting of results. The specified impact values shall be multiplied by a factor of 1,5 for longitudinal test pieces.		

Table 8 — Charpy V-notch impact and drop-weight tear (DWT) test requirements for base material for the avoidance of long-running shear fracture

Steel name	Charpy V-notch impact test Minimum impact energy[a], *KV* J									DWT test[c] Shear fracture area in % (See also 8.2.3.4)
	Pipe body (pipe outside diameter *D*, mm)									Pipe body (*D*, mm)
	⩽ 510	> 510 ⩽ 610	> 610 ⩽ 720	> 720 ⩽ 820	> 820 ⩽ 920	> 920 ⩽ 1 020	> 1 020 ⩽ 1 120	> 1 120 ⩽ 1 220	> 1 220 ⩽ 1 430	500 < *D* ⩽ 1 430
	transverse to the pipe axis (longitudinal to the pipe axis in angular brackets)[b]									
L245NC, L245NCS L290NC, L290NCS L290QC, L290QCS L290MC, L290MCS L360NC, L360NCS L360QC, L360QCS L360MC, L360MCS	40 (30) [60 (45)]								42 (32)	(see [c])
L415QC, L245QCS L415MC, L245MCS				40 (30)	41 (31)	44 (33)	46 (35)	48 (36)	51 (38)	85[d]
L450QC, L450QCS L450MC, L450MCS			41 (31) [62 (47)]	43 (32)	46 (35)	48 (36)	51 (38)	53 (40)	57 (43)	
L485QC L485MC, L485MCS	46 (35) [69 (52)]	50 (38) [75 (56)]	55 (41) [83 (62)]	58 (44)	62 (47)	65 (49)	68 (51)	71 (53)	77 (58)	
L555QC L555MC	61 (46) [92 (69)]	68 (51) [102 (77)]	76 (57) [114 (86)]	83 (62)	90 (68)	96 (72)	102 (77)	108 (81)	120 (90)	

O Test temperature shall be minus 10 °C, or a lower temperature by agreement (see also 7.3.1, note 2).

a The values apply for outside diameters ⩽ 1 430 mm and wall thicknesses ⩽ 25 mm for full-size test pieces. For subsize test pieces see 8.2.3.3.2. The specified values without brackets are the minimum average values for three tests; minimum individual values (75 % of the average values) are indicated in round brackets. For outside diameters > 1 430 mm and/or wall thicknesses > 25 mm values shall be agreed. M

b The test pieces shall be taken transverse to the pipe axis as long as minimum subsize test pieces with a width of ⩾ 5 mm are still obtainable without straightening (see Table 21).

c Only applicable for pipe designated for gas lines with an outside diameter > 500 mm, a wall thickness > 8 mm and a specified minimum yield strength > 360 N/mm^2.

d Average value of two tests.

Table 9 — Minimum Charpy V-notch impact energy values of base material for avoidance of long-running shear fracture

Steel name	Minimum impact energy[a], KV J
L245... to L450...	$KV = 2{,}67 \times 10^{-4} \sigma_{hp}^{1,5} D^{0,5}$ (with a minimum of 40 J)
L485QC, L485MC, L485MCS	$KV = 3{,}21 \times 10^{-4} \sigma_{hp}^{1,5} D^{0,5}$
L555QC, L555MC	$KV = 3{,}57 \times 10^{-5} \sigma_{hp} \left(\frac{D}{2}\right)^{1/3} T^{1/3}$
O	Test temperature shall be −10 °C or a lower temperature by agreement. The calculated values apply for outside diameters ⩽ 1 430 mm and wall thicknesses ⩽ 25 mm for full-size transverse test pieces. For subsize test pieces, see 8.2.3.3.2. The calculated value is the minimum average value for a set of three test pieces. Minimum individual values may be below the required average provided that they are not less than 75 % of that value. For orientation of test pieces, see Table 21. Minimum impact energy values for longitudinal test pieces shall be 50 % higher than for transverse test pieces.
M	For outside diameters > 1 430 mm and wall thicknesses > 25 mm, values shall be agreed. NOTE These formulae are identical with formulae used in ISO 13623 [7] except that ISO 13623 utilizes other terms and symbols for specified outside diameter and specified wall thickness.
	a σ_{hp}: hoop stress in N/mm^2; D: specified outside diameter; T: specified wall thickness.

7.5 Surface conditions, imperfections and defects

7.5.1 The manufacturer shall take adequate precautions to prevent pipe damage and minimize the presence of imperfections.

7.5.2 The surface finish produced by the manufacturing process shall be such that surface defects can be detected by visual inspection.

7.5.3 Surface imperfections evident by visual inspection shall be investigated, classified and treated as follows (see annex C):

a) imperfections with a depth equal to or less than 5 % of the specified wall thickness, and which do not encroach upon the specified minimum wall thickness, shall be classified as acceptable imperfections and treated in accordance with C.1;

NOTE The purchaser may impose special requirements for disposition of surface imperfections if the pipe is subsequently to be coated.

b) imperfections with a depth greater than 5 % of the specified wall thickness, and which do not encroach upon the specified minimum wall thickness, shall be classified as defects and shall either be removed by grinding in accordance with C.2 or treated in accordance with C.3 as appropriate;

c) imperfections which encroach upon the specified minimum wall thickness shall be classified as defects and treated in accordance with C.3;

d) Arc burns which are localized points of surface melting caused by arcing between electrode or ground and pipe surface shall be considered as defects and shall be treated in accordance with C.2, C.3 b) or C.3 c).

7.5.4 For undercuts disclosed by visual inspection of SAW pipes, the acceptance criteria given in D.5.5.2 d) to D.5.5.2 f) apply.

7.5.5 The acceptance criteria for imperfections detected by non-destructive testing, as required by 8.2.3.16, are specified in annex D.

7.5.6 All pipes shall be free from defects (see 3.4.2).

7.5.7 Deviations from the normal cylindrical contour of the pipe which occur as a result of the pipe-forming process or manufacturing operations (e.g. dents, flat spots, peaks) shall not exceed the following limits:

— 3 mm for flat spots, peaks and cold-formed dents with sharp bottom gouges;

— 6 mm for other dents.

These limits refer to the gap between the extreme point of the deviation and the prolongation of the normal contour of the pipe.

For the measurement of flat spots and peaks, see 8.2.3.14.3. For dents, the length in any direction shall not exceed one quarter of the pipe outside diameter.

7.5.8 Any hard spot exceeding 50 mm in any direction shall have a hardness value less than 35 HRC (345 HV10) for non-sour service applications.

For sour service applications, any hard spot exceeding 22 HRC (250 HV10) on the internal surface of the pipe, or 27 HRC (275 HV10) on the external surface shall not be permitted.

7.6 Dimensions, masses and tolerances

7.6.1 Dimensions

7.6.1.1 The pipes shall be delivered to the dimensions specified in the enquiry and order, within the tolerances given in 7.6.3 to 7.6.6. The outside diameters and wall thicknesses given in Table 10 are selected from ISO 4200 [5] and should preferably be ordered, also other dimensions may be specified.

7.6.1.2 For the length of the pipes see 7.6.3.4, and for the finish of the pipe ends see 7.6.4.

7.6.2 Mass

The linear mass M, expressed in kilograms per metre, shall be calculated using the following formula:

$$M = (D - T) \times T \times 0{,}024\ 661\ 5$$

where

D is the specified outside diameter, in mm;

T is the specified wall thickness, in mm.

The formula is based on a density equal to 7,85 kg/dm^3.

Table 10 — Preferred outside diameters and wall thicknesses
(indicated by the marked field)

Outside diameter	Wall thickness mm																										
mm	2,3	2,6	2,9	3,2	3,6	4	4,5	5	5,6	6,3	7,1	8	8,8	10	11	12,5	14,2	16	17,5	20	22,2	25	28	30	32	36	40
33,7	■	■	■	■	■	■	■	■	■	■	■	■	■	■													
42,4	■	■	■	■	■	■	■	■	■	■	■	■	■	■													
48,3	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■											
60,3	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■										
88,9	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■							
114,3	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■							
141,3			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■					
168,3			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
219,1				■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
273					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
323,9						■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
355,6							■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
406,4							■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
457								■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
508									■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
559									■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
610									■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
660										■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
711										■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
762										■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
813											■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
864										■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
914										■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
965												■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
1 016												■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
1 067												■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
1 118													■	■	■	■	■	■	■	■	■	■	■	■	■	■	
1 168													■	■	■	■	■	■	■	■	■	■	■	■	■	■	
1 219													■	■	■	■	■	■	■	■	■	■	■	■	■	■	
1 321													■	■	■	■	■	■	■	■	■	■	■	■	■	■	
1 422													■	■	■	■	■	■	■	■	■	■	■	■	■	■	
1 524													■	■	■	■	■	■	■	■	■	■	■	■	■	■	
1 626													■	■	■	■	■	■	■	■	■	■	■	■	■	■	

7.6.3 Tolerances on the pipe

7.6.3.1 Diameter

The outside diameter, as measured in accordance with 8.2.3.14, shall be within the tolerances given in Table 11.

7.6.3.2 Out-of-roundness

The out-of-roundness shall be as specified in Table 11.

Table 11 — Tolerance on diameter and out-of-roundness

Outside diameter D mm	Diameter				Out-of-roundness[e]	
	Pipe except the end[a]		Pipe end[a,b]			
	Seamless pipe	Welded pipe	Seamless pipe	Welded pipe	Pipe except the end[a]	Pipe end[a,b,f]
$D \leqslant 60$	± 0,5 mm or ± 0,75 % D (whichever is greater)	± 0,5 mm or ± 0,75 % D (whichever is greater), but max. ± 3 mm	± 0,5 mm or ± 0,5 % D[c] (whichever is greater), but max. ± 1,6 mm		included in the diameter tolerance	
$60 < D \leqslant 610$					2,0 % (1,5%)	1,5 % (1,0%)
$610 < D \leqslant 1\,430$	± 1 % D	± 0,5 % D but max. ± 4 mm	± 2,0 mm[d]	± 1,6 mm[d]	1,5 % but max. 15 mm (1%, but max. 5 mm) for $\frac{D}{T} \leqslant 75$, 2,0 % for $\frac{D}{T} > 75$, (by agreement)	1,0 % for $\frac{D}{T} \leqslant 75$, (0,75%) 1,5 % for $\frac{D}{T} > 75$, (by agreement)
M $D > 1\,430$	by agreement		by agreement[d]			by agreement[d]

[a] The pipe end shall be considered to include a length of 100 mm at the pipe extremities.

M [b] For seamless pipes, the values apply for wall thicknesses ⩽ 25 mm; for greater thicknesses, by agreement.

O [c] Subject to agreement, the tolerance may be related to the inside diameter for specified outside diameters > 168,3 mm.

O [d] Unless otherwise agreed, the diameter tolerance relates to the inside diameter.

[e] For offshore pipelay, the requirements in brackets apply.

[f] When the diameter tolerance is related to the inside diameter, the inside diameter shall also be the basis for the out-of-roundness requirements. For offshore pipe, the out-of-roundness of pipe ends shall be related to the
— pipe outside diameter for $D \leqslant 168{,}3$ mm;
— pipe inside diameter for $D > 168{,}3$ mm.

7.6.3.3 Wall thickness

The wall thickness at any location shall be within the tolerances specified in Table 12, except that the weld area shall not be limited by the plus tolerance.

Table 12 — Tolerances on wall thickness

Wall thickness, T mm	Tolerance
Seamless pipe	
$T < 4$	+ 0,6 mm/– 0,5 mm
$4 \leqslant T < 10$	+ 15 %/– 12,5 %
$10 \leqslant T < 25$	+ 12,5 %/– 12,5 %[a,b]
$T \geqslant 25$	+ 3,75 mm or *+ 10 % – 3,0 mm or * – 10 % * (whichever is greater)
HFW pipe	
$T \leqslant 6$	± 0,4 mm
$6 < T \leqslant 15$	± 0,75 mm
$T > 15$	± 1,00 mm
SAW pipe	
$T \leqslant 6$	± 0,5 mm
$6 < T \leqslant 15$	± 0,75 mm
$15 < T \leqslant 20$	± 1,00 mm
$T > 20$	+ 1,50 mm – 1,00 mm

[a] For outside diameters ⩾ 273 mm and $D/T > 20$, the tolerance is + 15 %/– 12,5 %.

[b] Where diameters other than those shown in Table 10 are ordered, e.g. for seamless pipe ordered to an internal diameter, the wall thickness tolerance shall be + 15 %/– 12,5 %.

7.6.3.4 Length

7.6.3.4.1 Random lengths shall be delivered in accordance with the requirements of the specified length groups (see Table 13).

Exact lengths shall be delivered with a tolerance of $^{+100}_{0}$ mm .

Table 13 — Requirements for random length groups

Length group	Length range for 90 % of order item[a] m	Minimum average length of order item m	Shortest length of order item m
r1	6 to 11	8	4
r2	9 to 14	11	6
r3	10 to 16	13	7
r4	11 to 19	15	8

[a] The upper limit is the maximum value for the length of each individual pipe.

7.6.3.4.2 For offshore service, the minimum average length of pipe shall be 12,1 m. Where requested by the purchaser, the pipe manufacturer shall confirm the maximum average length of pipe to be supplied per order item. The actual length of each pipe (end face to end face) shall lie within the range 11,70 m to 12,70 m.

NOTE 1 (to 7.6.3.4.1 and 7.6.3.4.2): Subject to approval by the purchaser, the pipes from which the test samples are prepared may be delivered as short lengths.

NOTE 2 (to 7.6.3.4.2): The minimum average length of 12,1 m for offshore pipelay is based on the optimum lengths for handling on several 'S-lay' barges in operation at the time of preparing this part of ISO 3183. This may change in the course of time. A minimum average length of 12,1 m may not be optimum for deepwater 'J-lay' practice, of which there is little current experience and for which the purchaser should agree the length range with the manufacturer.

O **7.6.3.4.3** Lengths other than those specified in 7.6.3.4.1 and 7.6.3.4.2 may be agreed.

7.6.3.5 Straightness

The total deviation from a straight line shall be ⩽ 0,15 % of the whole pipe length. Any local deviation in straightness shall be < 3 mm/m.

7.6.4 Finish of pipe ends

7.6.4.1 All pipe ends shall be cut square and free from harmful burrs.

The out-of-squareness (see Figure 1) shall not exceed

— 1 mm for outside diameters less than or equal to 220 mm and

— 0,005 *D*, but max. 1,6 mm, for outside diameters greater than 220 mm.

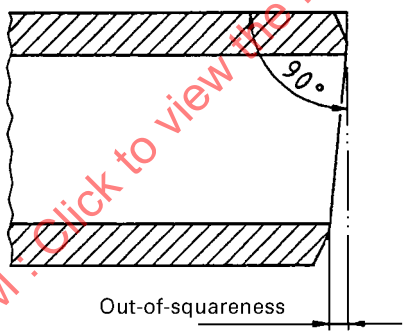


Figure 1 — Out-of-squareness

7.6.4.2 Unless otherwise specified, the end faces of pipes with a wall thickness greater than 3,2 mm shall be bevelled for welding. The angle of the bevel measured from a line drawn perpendicular to the axis of the pipe shall be 30° with a tolerance of $^{+5^\circ}_{0}$. The width of the root face of the bevel shall be 1,6 mm with a tolerance of ± 0,8 mm.

O Other end preparations may be agreed.

Where internal machining or grinding is carried out, the angle of the internal taper, measured from the longitudinal axis, shall be not greater than

— for seamless pipe: as given in Table 14;

— for welded pipe greater than 114,3 mm outside diameter: 7°.

Table 14 — Maximum angle of internal taper for seamless pipe

Specified wall thickness *T* mm	**Maximum angle of taper** degrees
$T < 10,5$	7
$10,5 \leqslant T < 14$	9,5
$14 \leqslant T < 17$	11
$T \geqslant 17$	14

7.6.5 Tolerances of the weld seam

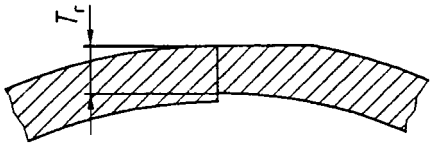
7.6.5.1 Radial offset of plate or strip edges

7.6.5.1.1 In the case of HFW pipes, the radial offset of strip edges shall not cause the remaining wall thickness T_r at the weld to be less than the specified minimum wall thickness [see Figure 2 a)].

7.6.5.1.2 In the case of SAW pipes, the maximum radial offset [see o_o and o_i in Figure 2 b)] of the plate/strip edges shall be as given in Table 15.

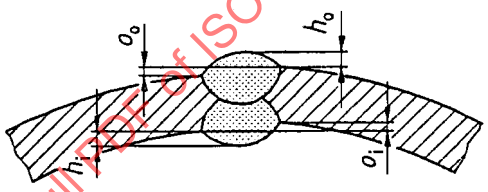
Table 15 — Maximum radial offset of SAW pipe

Specified wall thickness, T mm	Maximum radial offset mm
$T \leqslant 10$	1,0
$10 < T \leqslant 20$	0,1 T
$T > 20$	2,0



T_r: remaining wall thickness caused by radial offset

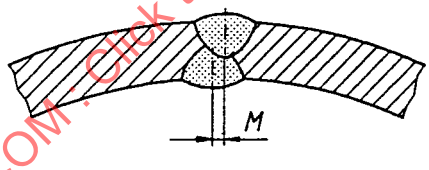
a) Radial offset of strip edges (HFW pipe)



o_o, o_i: outside/inside radial offset

h_o, h_i: outside/inside height of the weld beads

b) Radial offset and height of the weld beads of strip/plate edges (SAW pipe)



c) Misalignment *M* of the weld beads (SAW pipe)

Figure 2 — Dimensional deviations of the seam weld

7.6.5.2 Height of the flash or weld bead (weld reinforcement)

7.6.5.2.1 The outside flash of HFW pipe shall be trimmed to an essentially flush condition. The inside flash shall not extend above the contour of the pipe by more than 0,3 mm + 0,05T, where T is the specified wall thickness. When trimming, the wall thickness shall not be reduced below the minimum specified.

The depth of groove resulting from trimming the internal flash of HFW pipe shall not undercut the contour of the pipe by more than that given in Table 16.

Table 16 — Maximum depth of groove of HFW pipe

Specified wall thickness, T mm	Maximum depth of groove mm
$T \leqslant 4,0$	0,1 T
$4,0 < T \leqslant 8$	0,4
$T > 8$	0,05 T

7.6.5.2.2 The inside weld bead of SAW pipes shall be ground flush with a tolerance of $^{+0,5}_{0}$ mm for a distance of 100 mm from each pipe end [see h_i in Figure 2 b].

The height of the weld bead of the remainder of the pipe shall not exceed the values given in Table 17.

O In order to permit the use of particular field-welding processing, trimming of the outside weld bead of SAW pipes may be agreed for a distance up to 150 mm from each pipe end. In this case, the tolerance of the outside weld bead shall be $^{+0,5}_{0}$ mm.

Table 17 — Maximum height of the weld beads of SAW pipe
(except for the pipe ends)

Specified wall thickness, T mm	**Maximum height of the weld beads**	
	Inside h_i mm	Outside h_o mm
$T \leqslant 15$	3	3
$T > 15$	3	4

7.6.5.2.3 The weld beads shall blend in smoothly with the parent metal and, for SAW pipe, shall not intrude into the contour of the pipe, except that dressing out of undercuts is permitted [see D.5.5.2 d)].

7.6.5.3 Misalignment of the weld bead

Any misalignment of the weld beads of SAW pipe [see Figure 2 c)] shall not exceed the values given in Table 18.

Table 18 — Maximum misalignment of the weld beads of SAW pipe

Specified wall thickness, T mm	**Maximum misalignment of the weld beads** mm
$T \leqslant 20$	3
$T > 20$	4

7.6.6 Mass tolerance

The mass of any individual pipe shall not deviate from the nominal mass determined in accordance with 7.6.2 by more than + 10 % or – 3,5 %.

8 Inspection

8.1 Types of inspection and inspection documents

The compliance with the requirements of the order shall be checked by specific inspection for products manufactured in accordance with this part of ISO 3183.

The purchaser shall, taking into consideration the note below, state which of the following types of inspection document is required:

— ISO 10474-3.1.A

— ISO 10474-3.1.B

— ISO 10474-3.1.C

— ISO 10474-3.2.

NOTE When making the choice the purchaser should, where necessary, take into account the relevant requirements of standards or legal regulations for pipelines.

M If an inspection document 3.1.A, 3.1.C or 3.2 is ordered, the purchaser should also indicate in the order the address of the organization or person nominated to carry out the inspection and to issue and validate the inspection document, except that for document 3.2 it shall be agreed which party shall issue the document.

8.2 Specific inspection

8.2.1 Type and frequency of tests

The tests to be carried out on the various types of pipe are given in Table 19, columns 2, 3 and 4. The frequency of testing is given in Table 19, column 5.

Table 19 — Survey on tests and requirements

1	2				3	4	5		6	7	8
	The specifications in columns 3 to 8 apply for[a]				Type of test or requirements	Test status[b]	Frequency of testing		Sampling conditions	Test method	Requirements
	S	HFW	SAW						see	see	see
			lgt.	hel.							
	pipes		pipes								
a	x	x	x	x	Product analysis	m	1 analysis/cast		8.2.2.1	8.2.3.1	Table 3 and Table 4
b1	x	x	x	x	Tensile test[c] — on the pipe body	m	Except for plate end weld testing, the test units shall consist only of pipes of	Test pieces per sample 1	8.2.2.3 and Table 20	8.2.3.2	Table 5
b2		x	x	x	— on the weld seam (D ⩾ 210 mm)	m	— the same cast — the same heat treatment condition	1			
b3				x	— on the plate end weld seam (D ⩾ 210 mm)	m[g]	— the same dimension and a) in the case of outside diameters < 508 mm not more than 100 pipes; b) otherwise not more than 50 pipes.	1			
c1	x	x	x	x	Charpy V-notch impact test (for T ⩾ 5 mm) — on the pipe body[d]	m		3	8.2.2.4 and Table 20	8.2.3.3	7.3.1
c2		x	x	x	— on the weld seam[e]	m	For testing plate end welds, the test unit shall consist of not more than 50 such pipes per order item.	3			
c3				x	— on the plate end weld seam[e]	m[g]		3			
c4			x	x	— HAZ of the weld seam	m[e]		3			
d	x	x	x	x	Drop-weight tear test on the pipe body[f]	m	One sample shall be taken per test unit.	2	8.2.2.5 and Table 20	8.2.3.4	
e1			x	x	Bend test — on the weld seam	m		2	8.2.2.7 and Table 20	8.2.3.6	Figure 6, Table 5 and 8.2.3.6.2
e2				x	— on the plate end weld seam	m[g]		2			
f		x			Flattening test	m	4 tests per coil; plus 2 tests in the case of the weld stop.		Fig. 4 and 8.2.2.8	8.2.3.7	Figure 4 and 8.2.3.7.2

1	2				3	4	5	6	7	8
	The specifications in columns 3 to 8 apply for[a]				Type of test or requirements	Test status[b]	Frequency of testing	Sampling conditions	Test method	Requirements
	S	HFW	SAW					see	see	see
			lgt.	hel.						
	pipes		pipes							
g1			x	x	Macro- and metallographic examination — Macrographic	m	Once per shift or when pipe size is changed	8.2.2.9	8.2.3.8.1	7.6.5.3
g2		x			— Metallographic	m	Once per shift or when size or steel grade of the pipe is changed		8.2.3.8.2	8.2.3.8.2
h1		x	x	x	Hardness test	m	Hard spots (see 7.5.8) shall be examined	—	—	7.5.8
h2		x				o	To be carried out by agreement for seam-heat-treated HFW pipes.	8.2.2.12	—	8.2.3.8.2
h3	x	x	x	x		m	1 per test unit for sour service applications	8.2.2.12	8.2.3.11	7.3.2.2
i	x	x	x	x	Hydrostatic testing	m	Each pipe shall be tested	—	8.2.3.12	8.2.3.12 and Table 5
j	x	x	x	x	Visual examination	m	Each pipe shall be examined.		8.2.3.13	7.5
k1	x	x	x	x	Dimensional testing — outside or inside diameter of pipe ends and out-of-roundness of pipe ends	m	1 pipe of 100 pipes for ⩽ 168,3 mm outside diameter; 1 pipe of 20 pipes for > 168,3 mm outside diameter	—	8.2.3.14.1 8.2.3.14.2	7.6.3.1, 7.6.3.2 and Table 11
k2	x	x	x	x	— wall thickness of pipe ends		Each pipe shall be examined.		8.2.3.14.4	7.6.3.3 and Table 12
k3	x	x	x	x	— other dimensional characteristics excluding the seam		At random testing. The details are left to the discretion of the inspection representative		8.2.3.14.3 8.2.3.14.4	7.6.3.4, 7.6.3.5, 7.6.4
k4		x	x	x	— weld seam					7.6.5
l	x	x	x	x	Weighing	m	Each pipe or lot shall be weighed		8.2.3.15	7.6.6
m	x	x	x	x	Non-destructive testing	See Table D.1				
n	x	x	x	x	Hydrogen-induced cracking test	m	All sour service applications (first 3 casts, then every 10th)	8.2.2.10	8.2.3.9	7.3.2.1
o	x	x	x	x	Bead on pipe test	o	Manufacturing procedure qualification only	—	B.2 d	
p	x	x	x	x	Sulfide stress-cracking test	o	Manufacturing procedure qualification only; 3 test pieces to be taken per sample pipe.	8.2.2.11	8.2.3.10	7.3.2.3
q		x	x	x	Crack tip opening displacement test	o	Manufacturing procedure qualification only	8.2.2.6	8.2.3.5	For information only

a S = seamless; HFW = High-frequency welded; SAW = Submerged-arc welded; lgt. = longitudinal seam; hel. = helical seam

b m = mandatory; o = optional

c D = outside diameter

d To be carried out for the relevant pipe sizes in Table 21.

e To be carried out for the pipe sizes where transverse test pieces may be prepared (see Table 21).

f Only applicable for pipe designated for gas lines with an outside diameter > 500 mm, a wall thickness > 8 mm and a specified minimum yield strength > 360 N/mm^2.

g If plate end welds are permitted (see 6.3).

8.2.2 Selection and preparation of samples and test pieces

8.2.2.1 Samples and test pieces for the product analysis

The samples shall be taken and the test pieces prepared in accordance with ISO 14284. At the discretion of the pipe manufacturer, they shall be taken either from plate/strip or pipe.

8.2.2.2 Samples and test pieces for the mechanical and metallurgical tests

Samples for the following tests shall be taken and the corresponding test pieces prepared in accordance with the general conditions of ISO 377, as far as applicable:

— tensile test,

— Charpy V-notch impact test,

— drop-weight tear test,

— bend test,

— flattening test,

— hardness test,

— hydrogen-induced cracking test,

— bead on pipe test,

— sulfide stress-cracking test and

— crack tip opening displacement test.

Samples for the various types of tests shall be taken from pipe ends in accordance with Figures 3, 4, 5 and 6 and Table 20, taking into account the supplementary details specified in 8.2.2.3 to 8.2.2.12.

8.2.2.3 Tensile test pieces

Rectangular test pieces representing the full wall thickness of the pipe shall be taken in accordance with ISO 6892 and Figure 3. Transverse test pieces shall be flattened.

O Round test pieces machined from an unflattened sample may be used by agreement.

At the manufacturer's discretion, for testing the pipe body of pipes with $D \leqslant 210$ mm, a full pipe test piece may be used.

Weld beads shall be ground flush, local imperfections may be removed, but mill scale should not be removed from the test pieces.

O If the pipes are to be heat treated, by agreement test coupons may be taken and flattened before the heat treatment. The flattened test coupon shall then undergo the same heat treatment as the pipe.

8.2.2.4 Charpy V-notch impact test pieces

Unless otherwise agreed, the test pieces shall be prepared in accordance with ISO 148 [see also Figure 5 a) (position 1) and Figure 5 b)].

O By agreement, alternative transverse test pieces in accordance with Figures 5 a), position 2, and 5 c) containing portions of the original outside surface may be used.

Flattening of samples for test piece preparation shall not be permitted. The axis of the notch shall be perpendicular to the pipe surface. For test pieces taken on welds, the position of the axis of the notch shall be along the weld centreline. For test pieces taken on the heat-affected zone (HAZ) of SAW pipe, the position of the axis of the notch shall be dependent on the results of the manufacturing procedure qualification tests [see B.3 c)].

The orientation and size of the test piece shall be as follows:

— A transverse test piece with the greatest obtainable width between 10 mm and 5 mm shall be machined.

— If the smallest permitted transverse test piece cannot be obtained, a longitudinal test piece with the greatest obtainable width between 10 mm and 5 mm shall be machined.

Wall thickness limits for the preparation of transverse or longitudinal impact test pieces are given in Table 21 where a minimum machining allowance of 0,5 mm is taken into consideration.

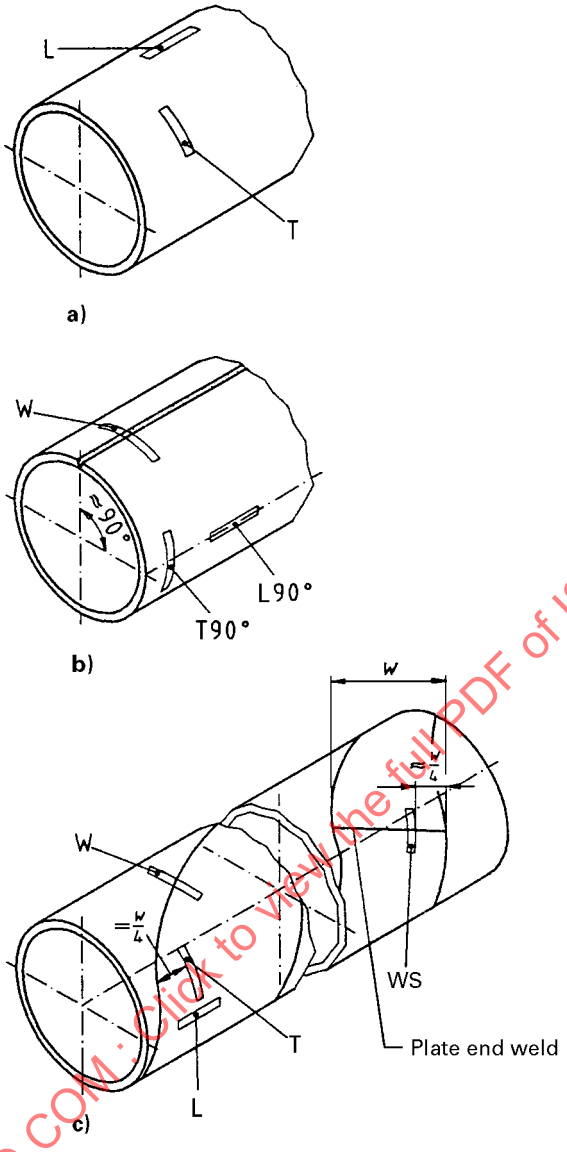
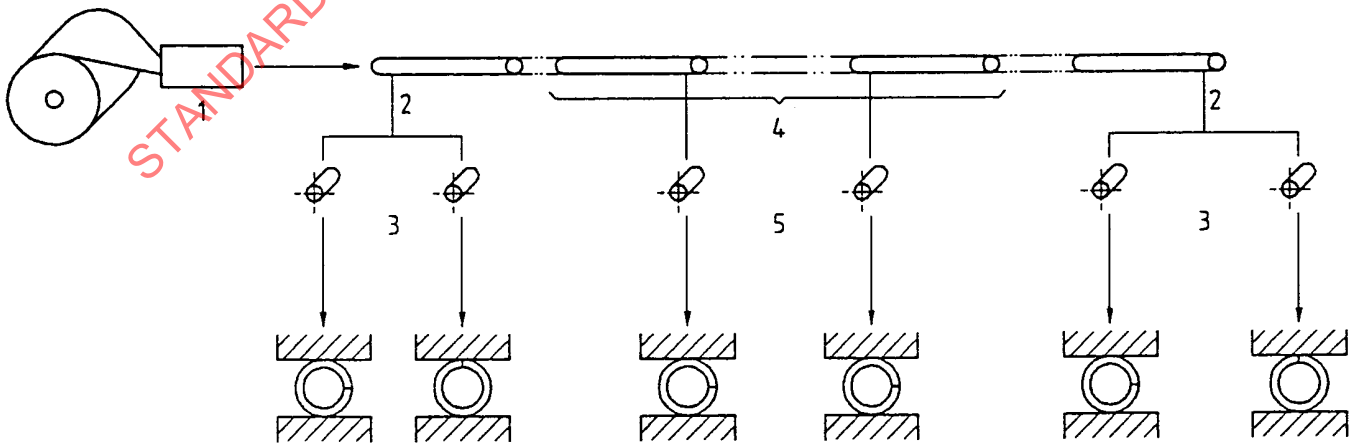


Figure 3 — Sample position and explanation of symbols applied in Table 20 for specifying test piece direction and position

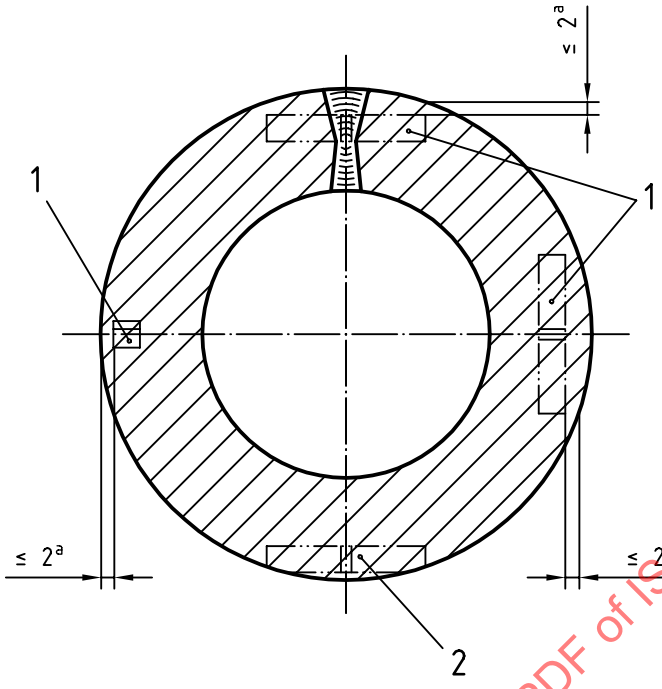


Key

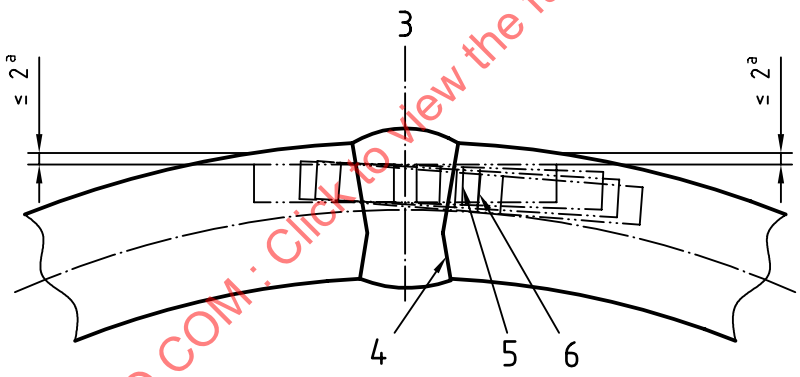
1 Welding
2 End of coil
3 Crop end, two samples
4 Weld stop
5 Two samples, one from each side of a weld stop

Figure 4 — Flattening test — Sampling and testing (schematic) (see further details in 8.2.3.7.)

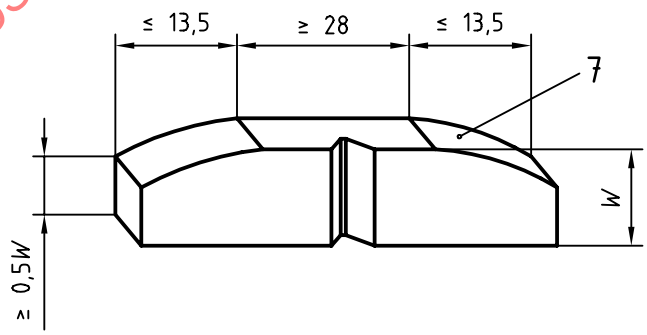
Dimensions in millimetres



a) Positions of test pieces



b) Positions of notch in SAWL and SAWH seam weld and heat-affected zone (HAZ) [see also B.3 c)]



c) Dimensions of alternative test pieces

Key

1 Standard test piece
2 Alternative test piece
3 Weld centreline
4 Fusion line
5 Fusion line + 2 mm (HAZ)
6 Fusion line + 5 mm (HAZ)
7 Original pipe outside curvature

a A minimum machining allowance of 0,5 mm shall be observed.

Figure 5 — Position of impact test pieces

Table 20 — Type, number, direction and location of the test pieces to be taken per sample for the mechanical tests

Type of pipe[a]		Test		Test pieces to be taken from	Outside diameter mm			For further information see
					< 210	⩾ 210 < 500	⩾ 500	
					Number, direction and location of test pieces (see explanation of symbols in Figures 3 and 5)			
Seamless (see Figure 3 a)		Tensile		Pipe body	1L	1L[b]	1L[b]	8.2.2.3
		Charpy V-notch			3T	3T	3T	8.2.2.4
		Drop-weight tear [c]			—	—	2T	8.2.2.5
		Hardness			1T	1T	1T	8.2.2.12
Longitudinal seam [see Figure 3 b)]	HFW, SAW	Tensile		Pipe body	1L90	1T90[f]	1T90[f]	8.2.2.3
		Charpy V-notch			3T90	3T90	3T90	8.2.2.4
		Drop-weight tear [c]			—	—	2T90	8.2.2.5
		Tensile		Seam[d]	—	1W	1W	8.2.2.3
		Charpy V-notch	HFW		3W	3W	3W	8.2.2.4
			SAW[e]		3W/3HAZ[g]	3W/3HAZ	3W/3HAZ	8.2.2.4
		Hardness			1W	1W	1W	8.2.2.12
	SAW	Bend		Seam[d]	2W	2W	2W	8.2.2.7
	HFW	Flattening		See Figure 4				8.2.2.8
Helical seam (see Figure 3 c)	SAW	Tensile		Pipe body	1L, w/4	1T, w/4	1T, w/4	8.2.2.3
		Charpy V-notch			3T, w/4	3T, w/4	3T, w/4	8.2.2.4
		Drop-weight tear [c]			—	—	2T, w/4	8.2.2.5
		Tensile		Seam	—	1W	1W	8.2.2.3
		Charpy V-notch[e]			3W/3HAZ	3W/3HAZ	3W/3HAZ	8.2.2.4
		Bend			2W	2W	2W	8.2.2.7
		Hardness			1W	1W	1W	8.2.2.12
		Tensile		Plate end weld	—	1WS	1WS	8.2.2.3
		Charpy V-notch[e]			3WS/3HAZ	3WS/3HAZ	3WS/3HAZ	8.2.2.4
		Bend			2WS	2WS	2WS	8.2.2.7
		Hardness			1WS	1WS	1WS	8.2.2.12

a HFW: High-frequency welded; SAW: Submerged-arc-welded.

O b By agreement, 1 T instead of 1 L.

c See Table 8, footnote c.

d If, by agreement (see 6.3.3), pipes with two seams are delivered, both seams are to be subjected to the tests.

e For notch position, see Figure 5 b) and 5 c) and B.3 c).

O f For deep water pipelay application, additional longitudinal tests may be specified, requirements and testing frequency to be agreed.

g HAZ: Heat-affected zone.

Table 21 — Orientation of impact test pieces

Specified outside diameter mm	Specified wall thickness[a] mm		
	Transverse test pieces		Longitudinal test pieces
	Standard	Alternative	Standard[b]
⩽ 33,6	n.p.	n.p.	⩾ 7,0
33,7 to 42,1	n.p.	n.p.	⩾ 6,8
42,2 to 48,2	n.p.	n.p.	⩾ 6,6
48,3 to 60,2	n.p.	n.p.	⩾ 6,6
60,3 to 88,8	⩾ 23,8	⩾ 20,8	6,5 to 23,7 (20,7)
88,9 to 114,2	⩾ 18,5	⩾ 12,5	6,3 to 18,4 (12,4)
114,3 to 168,2	⩾ 15,5	⩾ 10,1	6,2 to 15,4 (10,0)
168,3 to 219,0	⩾ 13,1	⩾ 7,6	6,2 to 13,0 (7,5)
219,1 to 272,9	⩾ 10,6	⩾ 6,5	6,1 to 10,5 (6,4)
273,0 to 323,8	⩾ 8,8	⩾ 6,2	6,1 to 8,7 (6,1)
323,9 to 355,5	⩾ 8,4	⩾ 6,1	6,1 to 8,3
355,6 to 406,3	⩾ 8,2	⩾ 6,1	6,1 to 8,1
406,4 to 456,9	⩾ 7,9	⩾ 6,0	6,1 to 7,8
457,0 to 507,9	⩾ 7,7	⩾ 6,0	6,1 to 7,6
508,0 to 558,9	⩾ 7,5	⩾ 6,0	6,1 to 7,4
559,0 to 609,9	⩾ 7,4	⩾ 6,0	6,1 to 7,3
610,0 to 659,9	⩾ 7,3	⩾ 6,0	6,1 to 7,2
660,0 to 710,9	⩾ 7,2	⩾ 6,0	6,1 to 7,1
711,0 to 761,9	⩾ 7,1	⩾ 6,0	6,1 to 7,0
762,0 to 812,9	⩾ 7,0	⩾ 6,0	6,1 to 6,9
813,0 to 863,9	⩾ 7,0	⩾ 6,0	6,1 to 6,9
864,0 to 913,9	⩾ 6,9	⩾ 6,0	6,0 to 6,8
914,0 to 964,9	⩾ 6,9	⩾ 6,0	6,0 to 6,8
965,0 to 1015,9	⩾ 6,8	⩾ 6,0	6,0 to 6,7
1016,0 to 1066,9	⩾ 6,8	⩾ 6,0	6,0 to 6,7
1067,0 to 1117,9	⩾ 6,7	⩾ 6,0	6,0 to 6,6
1118,0 to 1167,9	⩾ 6,7	⩾ 6,0	6,0 to 6,6
1168,0 to 1218,9	⩾ 6,7	⩾ 6,0	6,0 to 6,6
1219,0 to 1320,9	⩾ 6,7	⩾ 6,0	6,0 to 6,6
1321,0 to 1421,9	⩾ 6,6	⩾ 6,0	6,0 to 6,5
1422,0 to 1523,9	⩾ 6,6	⩾ 6,0	6,0 to 6,5
1524,0 to 1625,9	⩾ 6,5	⩾ 6,0	6,0 to 6,4
⩾ 1626,0	⩾ 6,5	⩾ 6,0	6,0 to 6,4

Impact testing is not required if the specified wall thickness is smaller than the applicable tabulated value.

[a] Standard: test pieces in accordance with ISO 148, including subsize test pieces of at least 5 mm width.
Alternative: test pieces in accordance with Figure 5 c), with a width of at least 5 mm.
n.p.: preparation of test pieces not possible.

[b] If alternative transverse test pieces are agreed, the following apply.
- The values in brackets indicate the wall thickness limit below which transverse test pieces are not obtainable.
- Where for $D > 60,3$ mm no values in brackets are given, alternative transverse test pieces shall be used.

8.2.2.5 Test pieces for the drop-weight tear (DWT) test

The test pieces shall be taken and prepared in accordance with ANSI/API RP 5L3.

8.2.2.6 Test pieces for crack tip opening displacement (CTOD) test

The test pieces shall be taken from the weld metal and the heat affected zone as well as from the base metal and shall be prepared in accordance with ISO 12135. The sampling procedure shall be agreed between purchaser and manufacturer.

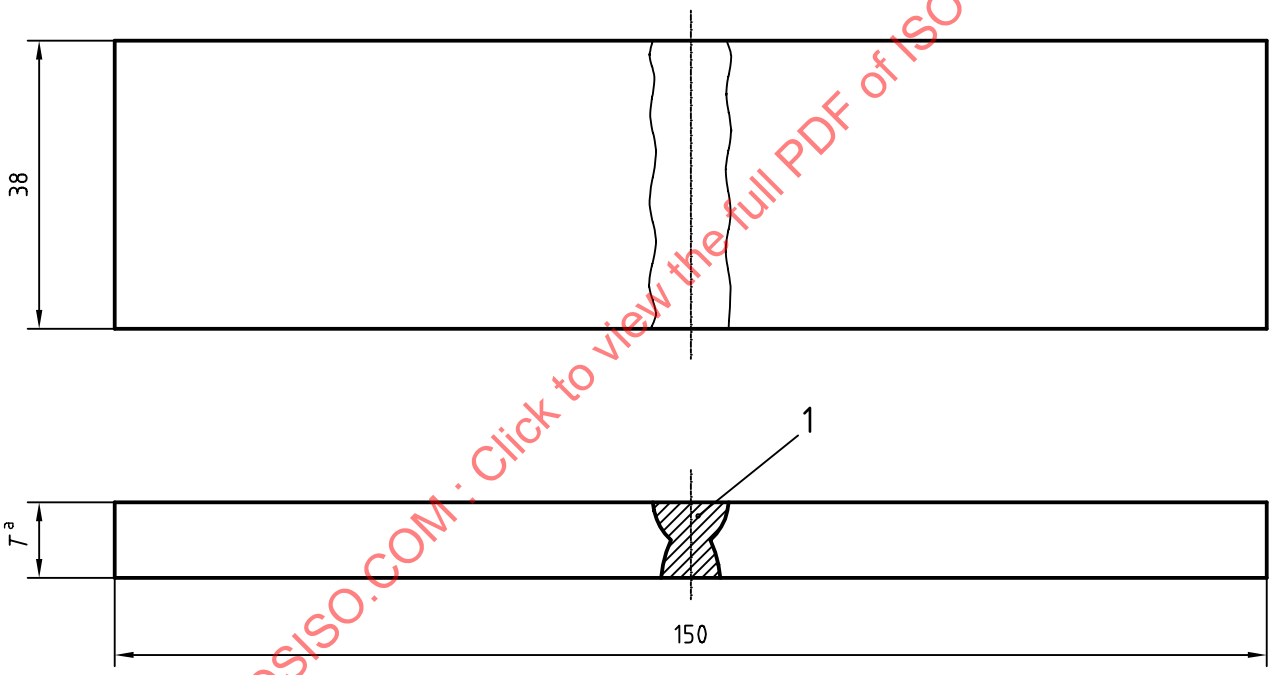
8.2.2.7 Test pieces for the bend test

The test pieces shall be taken in accordance with ISO 7438 and Figure 6. For pipes with a wall thickness > 20 mm, the test pieces may be machined to provide a rectangular cross-section having a thickness of 19 mm.

Full wall thickness curved-section test pieces are mandatory for pipe with wall thicknesses ⩽ 20 mm.

The weld reinforcement shall be removed from both faces.

Dimensions in millimetres



Key

1 Weld

a Unless machined test pieces are used.

Figure 6 — Test piece for the bend test

8.2.2.8 Test pieces for the flattening test

The test pieces shall be taken in accordance with ISO 8492. Minor surface imperfections may be removed by grinding.

8.2.2.9 Samples for macrographic and metallographic tests

The samples including the weld cross-section shall be taken and prepared in accordance with ISO 377 as far as applicable.

8.2.2.10 Samples for hydrogen-induced cracking (HIC) tests

Samples for HIC testing shall be taken in accordance with NACE TM0284-96.

8.2.2.11 Samples for sulfide stress cracking test

One sample shall be taken from each test pipe provided for the manufacturing procedure qualification; three test pieces shall be taken from each sample.

Each test piece shall be 115 mm long × 15 mm wide × 5 mm thick and shall, for welded pipe, contain a section of the longitudinal or helical seam weld at its centre. Samples may be flattened prior to machining test pieces from the inside surface of the pipe.

8.2.2.12 Samples for the hardness test

Samples for hardness testing shall be taken from the end of selected pipes and, for welded pipe, shall contain a section of the longitudinal or helical seam at its centre (see Figure 7). Preparation for testing shall be performed in accordance with ISO 377 as far as applicable.

8.2.3 Test methods

8.2.3.1 Chemical analysis (product analysis)

The elements shall be determined in accordance with the methods considered in the corresponding International Standards. Spectrographic analysis is permitted.

In cases of dispute, the method to be used for product analysis shall be agreed.

NOTE ISO/TR 9769 [6] covers a list of available International Standards providing chemical analysis methods, with information on the application and precision of the various methods.

8.2.3.2 Tensile test

8.2.3.2.1 The tensile test shall be carried out in accordance with ISO 6892.

The tensile strength (R_m), the yield strength for 0,5 % total elongation ($R_{t0,5}$) and the percentage elongation after fracture (A) shall be determined on the pipe body.

The percentage elongation after fracture shall be reported with reference to a gauge length of 5,65 $\sqrt{S_0}$, where S_0 is the initial cross-section of the gauge length. If other gauge lengths are used, the elongation referred to a gauge length of 5,65 $\sqrt{S_0}$ shall be determined in accordance with ISO 2566-1.

NOTE The $R_{t0,5}$ value is considered to be approximately equivalent to the R_{eH} or $R_{p0,2}$ value within the normal scatter band of test results.

8.2.3.2.2 For the tensile test transverse to the weld, only the tensile strength (R_m) shall be determined.

O 8.2.3.2.3 By agreement, the yield strength may be determined by hydraulic ring expansion tests in accordance with ASTM A 370.

8.2.3.3 Impact test

8.2.3.3.1 The impact test shall be carried out in accordance with ISO 148. Test temperature shall be as given in Tables 6, 8 and 9.

O NOTE As long as existing national design codes specify testing temperatures for the impact and drop-weight tear (DWT) tests that are different from those specified in this part of ISO 3183, the necessary deviations may be agreed (see the note in Introduction).

8.2.3.3.2 Where test pieces with a width < 10 mm are used, the measured impact energy (KV_p) and the test piece cross-section measured under the notch in mm^2 (S_p) shall be reported. For comparison with the values in 7.3.1 c) or in Table 7, 8 or 9 respectively, the measured energy shall be converted to the impact energy (KV) in joules (J) using the formula

$$KV = \frac{8 \times 10 \times KV_p}{S_p} .$$

8.2.3.4 Drop-weight tear (DWT) test

O The DWT test shall be carried out in accordance with ANSI/API RP 5L3. The test temperature shall be −10 °C or a lower operating temperature by agreement (see also 8.2.3.3.1, note).

8.2.3.5 Crack tip opening displacement (CTOD) test

The CTOD test shall be carried out in accordance with ISO 12135. The test temperature shall be the minimum design temperature stated in the enquiry and order.

8.2.3.6 Bend test

8.2.3.6.1 The bend test shall be carried out in accordance with ISO 7438. The mandrel dimension shall be as indicated in Table 5 for the relevant steel grade. Both test pieces shall be bent through approximately 180°, one with the root of the weld, the other with the face of the weld, directly under the mandrel.

8.2.3.6.2 The specimens shall not

a) fracture completely, nor

b) reveal any crack or rupture in the weld metal greater than 3 mm in length regardless of depth, nor

c) reveal any crack or rupture in the parent metal, the heat-affected zone or the fusion line longer than 3 mm and deeper than 12,5 % of the specified wall thickness.

Cracks that occur at the edges of the specimen and are less than 6 mm in length shall not be cause for rejection in b) or c) regardless of depth.

If a fracture or crack in a test piece is caused by a defect or flaw, the test piece may be discarded and a new test piece substituted.

8.2.3.7 Flattening test

8.2.3.7.1 The flattening test shall be carried out in accordance with ISO 8492. As indicated in Figure 4, one of the two test pieces taken from both end-of-coil locations shall be tested with the weld at the 12 o'clock position, whilst the remaining two test pieces shall be tested with the weld at the 3 o'clock position. Test pieces taken from crop ends in the case of a weld stop shall be tested with the weld at the 3 o'clock position only.

8.2.3.7.2 The flattening test shall be carried out in three steps, with the following acceptance criteria:

— Flatten to 2/3 of the original outside diameter; no weld opening shall occur.

— Flatten to 1/3 of the original outside diameter; no crack or break shall occur other than in the weld.

— Flatten until opposite walls of the pipe meet.

The presence of laminar imperfections or burnt metal shall not become apparent during the entire test.

8.2.3.8 Macrographic and metallographic examination

8.2.3.8.1 For SAW pipes, the alignment of internal and external seam welds [see Figure 2 c)] shall be verified by macrographic examination.

O Alternative methods, such as ultrasonic inspection, may be used by agreement. The ability of such equipment to detect misalignment shall be demonstrated. Where alternative methods are used, macrographic inspection shall be carried out at the beginning of the production of each pipe size (diameter and wall thickness).

8.2.3.8.2 For HFW pipe being delivered with seam heat-treatment, it shall be verified by metallographic examination that the entire heat-affected zone has been heat-treated over the full wall thickness.

O In addition, a hardness test and maximum hardness may be agreed.

8.2.3.9 Hydrogen-induced cracking (HIC) test

Hydrogen-induced cracking tests shall be performed and reported in accordance with NACE TM0284-96. Test solution A shall be used. Values of crack length ratio (CLR), crack thickness ratio (CTR) and crack sensitivity ratio (CSR) shall be reported.

O By agreement, photomicrographs of any reportable crack shall be provided with the report.

8.2.3.10 Sulfide stress cracking (SSC) test

Sulfide stress cracking tests shall be performed in accordance with NACE TM0177-96, Section 6, test solution A. A four-point bend test piece in accordance with ISO 7539-2 shall be used, and the test duration shall be 720 h.

The test pieces shall be stressed to 0,72 of the specified minimum yield strength.

O Other appropriate test methods and associated acceptance criteria may be agreed.

8.2.3.11 Hardness test

8.2.3.11.1 Hardness surveys for sour-service material shall be performed at the locations specified in 8.2.3.11.2 for seamless pipe, and in 8.2.3.11.3 for welded pipes.

Hardness testing on parent metal shall be performed in accordance with ISO 6507-1 (Vickers test) or ISO 6508 (Rockwell test) at the manufacturer's discretion. In the case of dispute, the Vickers method shall apply.

Hardness testing on the heat-affected zone (HAZ) and weld shall be carried out in accordance with ISO 6507-1.

Individual hardness readings exceeding the value permitted by this part of ISO 3183 may be considered acceptable if the average of several additional readings taken within close proximity does not exceed the value permitted and no such individual reading is greater than 10 HV10 units or 2 HRC units respectively, above the acceptable value.

8.2.3.11.2 Hardness locations on seamless pipe shall be as shown in Figure 7 a), except that for wall thickness $T < 4$ mm only the mid-thickness traverse need be performed, and for wall thickness 4 mm $\leqslant T < 6$ mm only the inside and outside surface traverse need be performed.

8.2.3.11.3 Hardness locations for welded pipes shall include the weld cross-section. Indentations shall be made in the parent metal, visible HAZ and at the weld centreline, as shown in Figure 7 b) and c). The wall thickness restrictions stated in 8.2.3.11.2 for seamless pipe shall also apply to welded pipes.

8.2.3.12 Hydrostatic test

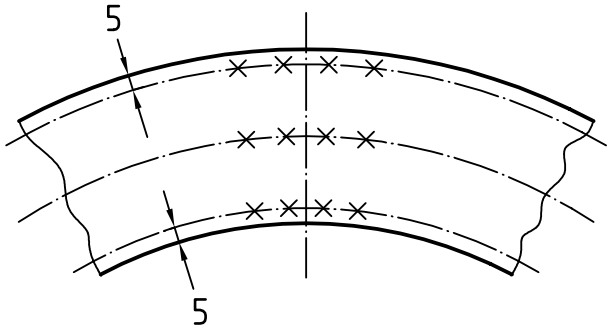
O **8.2.3.12.1** Except as allowed by 8.2.3.12.3, the hydrostatic test pressure shall be calculated in accordance with 8.2.3.12.2 so that, referred to the specified minimum wall thickness of the pipe, a hoop stress of 95 % of the specified minimum yield strength for the appropriate steel grade (see Table 5) is reached, but, unless otherwise agreed, the hydrostatic test pressure shall in no case be greater than

— 500 bar for outside diameter $\leqslant$ 406,4 mm;

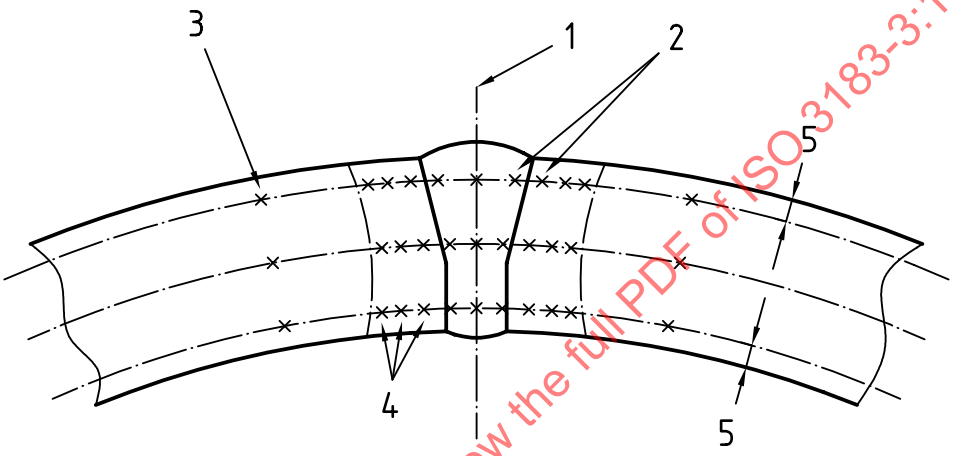
— 250 bar for outside diameter $>$ 406,4 mm.

O NOTE A higher hoop stress up to 100 % of the specified minimum yield strength may be agreed. However, plastic deformations may occur in such cases.

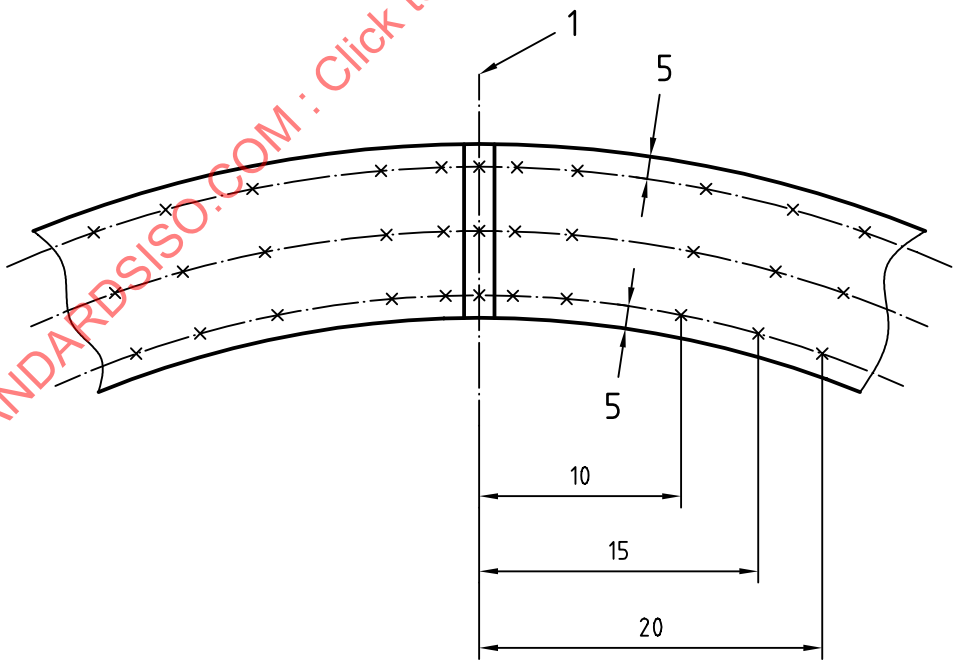
Dimensions in millimetres



a) Seamless pipe



b) SAW pipe



c) HFW pipe

Key

1 Weld centreline
2 0,75 mm from fusion line
3 1 T from fusion line, where T = specified wall thickness
4 1,0 mm spacings in visible HAZ
5 1,5 mm ± 0,5 mm from inside and outside surfaces

Figure 7 — Location of hardness measurements (readings)

8.2.3.12.2 The method of calculation for determining the hydrostatic test pressure necessary to reach a hoop stress of 95 % of the specified minimum yield strength depends on the equipment.

Consequently, the manufacturer shall state in the inspection document which of the following methods (A or B) has been used.

a) **Method A**

In cases where the seal is made on the outside or inside diameter of the pipe, the following formula shall apply:

$$p = \frac{20 \times S \times T_{min}}{D} \quad ,$$

where

p is the hydrostatic test pressure, in bar;

D is the specified outside diameter, in mm;

S is the stress, in N/mm^2, equal to 95 % of the specified minimum yield strength of the steel grade concerned (see note in 8.2.3.12.1);

T_{min} is the specified minimum wall thickness, in mm.

b) **Method B**

In the case of sealing against the end face of the pipe by means of a ram, a compressive longitudinal stress is produced. To take this into account, the following formula shall apply:

$$p_1 = \frac{10\,S - \frac{p_R \cdot A_R}{A_p}}{\frac{D}{2T_{min}} - \frac{A_1}{A_p}} \quad ,$$

where

p_1 is the hydrostatic test pressure, in bar;

A_1 is the internal cross-sectional area of pipe, in mm^2;

A_p is the cross-sectional area of pipe wall, in mm^2;

A_R is the cross-sectional area of ram, in mm^2;

D is the specified outside diameter, in mm;

p_R is the internal pressure on end sealing ram, in bar;

S is the stress in N/mm^2, equal to 95 % of the specified minimum yield strength of the steel grade concerned (see also note in 8.2.3.12.1);

T_{min} is the specified minimum wall thickness, in mm.

O 8.2.3.12.3 By agreement, the test pressures as given in ISO 3183-1, the calculation of which is based on the specified wall thickness, may be used.

8.2.3.12.4 The test pressure shall be held for not less than 10 s, and the pressure versus time shall be recorded for pipes with diameters equal to or greater than 114,3 mm. This record shall be available for examination by the inspection representative.

8.2.3.13 Visual examination

Each pipe shall be visually examined over the entire external surface. The internal surface shall be visually examined

— from each end, for pipe outside diameters less than 610 mm;

— over the entire internal surface, for pipe outside diameters equal to or greater than 610 mm.

The examination shall be carried out under sufficient lighting conditions, typically of the order of 300 lx, by trained personnel with satisfactory visual acuity to verify the conformity of the pipes with the requirements of 7.5.

The surface of cold-formed welded pipe shall be examined to detect deviations in the contour of the pipe. When this examination fails to disclose mechanical damage as the cause of the irregular surface, but indicates that the irregular surface may be attributed to a hard spot, the dimensions of the area and, where necessary (see 7.5.8), the hardness shall be determined in accordance with ISO 6507-1 or ISO 6508. The choice of the test method is left to the discretion of the manufacturer. If the acceptance criteria given in 7.5.8 are not met, the hard spot shall be removed.

8.2.3.14 Dimensional testing

8.2.3.14.1 The diameter of pipes shall be measured. At the discretion of the manufacturer, a circumferential tape or caliper/micrometer gauge may be used.

O By agreement, other approved measuring devices may be used.

8.2.3.14.2 The out-of-roundness (O) shall be calculated, in percent, by the formula

$$O = 100 \times \frac{D_{max} - D_{min}}{D}$$

where

D_{max} is the greatest outside (or inside) diameter;

D_{min} is the smallest outside (or inside) diameter;

D is the specified outside diameter (or inside diameter calculated from the specified outside diameter and wall thickness).

To calculate the out-of-roundness in accordance with the requirements of Table 11, the greatest and smallest outside or inside diameter shall be measured in the same cross-sectional plane of the pipe body and pipe ends, respectively.

8.2.3.14.3 The greatest distance of flat spots or peaks from the normal contour of the pipe shall be measured

— in the case of longitudinally welded pipe, with a template located transverse to the pipe axis,

— in the case of helically welded pipe, with a template parallel to the pipe axis.

The templates shall have a length of a quarter of the specified outside diameter, but max. 200 mm.

8.2.3.14.4 For the verification of other dimensional and geometrical requirements specified in 7.6, adequate methods shall be applied.

U The methods to be used are left to the discretion of the manufacturer, unless otherwise agreed.

8.2.3.15 Weighing

Each length of pipe with outside diameter equal to or greater than 141,3 mm shall be weighed separately. Lengths of pipe with outside diameters smaller than 141,3 mm shall be weighed either individually or in convenient lots at the discretion of the manufacturer.

8.2.3.16 Non-destructive testing

For non-destructive testing, see 6.3.3 and annex D.

8.2.4 Retests, sorting and reprocessing

For retests, sorting and reprocessing, the requirements of ISO 404 apply.

9 Marking of the pipes

9.1 General marking

9.1.1 Pipe marking shall include the following minimum information:

a) the name or mark of the manufacturer of the pipe (X);

b) the number of this part of ISO 3183;

c) specified outside diameter and wall thickness;

d) the steel name;

e) the type of pipe (S or W);

f) the mark of the inspection representative (Y);

g) an identification number that permits the correlation of the product or delivery unit with the related inspection document (Z).

EXAMPLE: X 3183-3 508 × 10 L36OMCS W Y Z

9.1.2 Unless die stamping is agreed (see 9.1.3), the mandatory markings given in 9.1.1 shall be applied indelibly as follows.

a) For pipe outside diameters smaller than or equal to 48,3 mm: marked on a tag fixed to the bundle or painted on the straps or banding clips used to tie the bundle. Alternatively, at the discretion of the manufacturer, each pipe may be paint-stencilled on one end.

b) For seamless pipe in all other sizes and welded pipe smaller than 406,4 mm outside diameter: paint-stencilled on the outside surface starting at a point between 450 and 750 mm from one end of the pipe.

c) For welded pipe equal to or greater than 406,4 mm outside diameter: paint-stencilled on the inside surface starting at a point not less than 150 mm from one end of the pipe.

O **9.1.3** Low-stress die stamping or vibro etching of the pipe surface may be used by agreement within 150 mm from the pipe end and for welded pipe at least 25 mm from the weld. Alternatively, die stamping of the bevel may be applied, for welded pipe, at a position at least 25 mm from the weld.

O Cold-die stamping (at temperatures lower than 100 °C) of plate/strip or pipe not subsequently heat-treated is only permitted if especially agreed and shall in this case be done with a rounded or blunt die.

M **9.1.4** For pipe intended for subsequent coating, marking may be applied either at the pipe mill or at the coater's, subject to agreement between purchaser and manufacturer. In such cases, traceability shall be assured, e.g. by application of a unique number (by individual pipe or cast).

9.1.5 If an external coating is applied, external markings are to remain readable or be transferred to the coating.

9.2 Special marking

O Any requirements for additional marking or for special locations or methods of marking are subject to agreement.

10 Coatings for temporary protection

O Unless otherwise specified, the pipe shall be delivered without temporary protection.

Annex A
(informative)

Correspondence with API steel grades

Table A.1 gives the correspondence between the grades defined by this part of ISO 3183 and similar grades in ANSI/API 5L (40th Edition) [2], based on a comparison of the specified minimum yield strength. However, the grades shown as comparable may differ in other respects.

Table A.1 — Correspondence between steel grades

Steel grade in accordance with ISO 3183-3	Steel grade in accordance with ANSI/API 5L
L245...	B
L290...	X42
L360...	X52
L415...	X60
L450...	X65
L485..	X70
L555...	X80

Annex B
(normative)

Manufacturing procedure qualification

B.1 Introductory note

Where acceptable data from previous production are not available, e.g. in the case of new grades, new processing routes or sizes significantly different from previous production, the purchaser and manufacturer may agree qualification in accordance with B.2 and/or B.3.

B.2 Characteristics of the manufacturing procedure

Before production commences, the manufacturer shall supply the purchaser with information on the main characteristics of the manufacturing procedure. This information shall include the following:

a) **for all pipe**

- steel maker;
- steel making and casting techniques;
- aim cast chemistry and range;
- hydrostatic test procedure;
- non-destructive testing procedure for the pipe.

b) **for welded pipe**

- plate or strip manufacturing method including heat treatment method;
- non-destructive testing procedures for the plate or strip;
- pipe forming procedures, including preparation of edges, control of alignment and shape;
- pipe heat-treatment procedure, where applicable, including in-line heat treatment of the weld seam;
- specification of the seam welding, including repair welding, procedure to be used together with previous qualification records for this procedure. This shall include sufficient information of the following kind:

  1) **for HFW pipe**

  - mechanical test results from seam heat-treated pipes made from thermomechanically rolled strip (including hardness tests on the heat-affected zone);
  - metallography.

  2) **for SAW pipe**

  - mechanical test results (including hardness test results on the heat-affected zone);
  - metallography;
  - deposited weld metal analysis.