INTERNATIONAL STANDARD

ISO 2531

Fourth edition
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Ductile iron pipes, fittings and accessories for pressure pipelines

Tuyaux, raccords et pièces accessoires en fonte ductile pour canalisations avec pression

Reference number
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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.

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 2531 was prepared by Technical Committee ISO/TC 5, *Ferrous metal pipes and metallic fittings*, Sub-Committee SC 2, *Cast iron pipes, fittings and their joints*.

This fourth edition cancels and replaces the third edition (ISO 2531 : 1986), of which it constitutes a technical revision. In particular, the scope has been extended to cover loose flanges.

Introduction

Ductile iron, also called nodular iron or spheroidal graphite iron, is characterized by the presence of spheroidal graphite in the resultant castings.

It differs from flake graphite iron in that it has a higher tensile strength, a high proof stress and high elongation.

These characteristics ensure the suitability of ductile iron pipes and fittings for a majority of pipeline applications.

This International Standard defines dimensions for castings having adequate strength for the majority of conditions of use. However, various methods of strengthening are authorized, particularly where high working pressures could lead to localized areas of high stress.

The value adopted for the density of ductile iron is 7 050 kg/m^3. This value is a compromise between the values measured in various manufacturing countries and provides a reasonably acceptable agreement between the calculated masses and actual masses.

Ductile iron pipes, fittings and accessories for pressure pipelines

Section 1: General

1.1 Scope

This International Standard establishes general specifications completed by specific requirements applicable to

a) ductile iron pipes manufactured by any one of the following four processes:

1) centrifugal casting in lined or unlined metal moulds;

2) centrifugal casting in sand[1] moulds;

3) casting in sand[1] moulds;

4) casting in metal moulds;

b) ductile iron fittings and accessories manufactured by either of the following two processes:

1) casting in sand[1] moulds;

2) casting in metal moulds.

It is applicable to pipes, fittings and accessories for pressure pipelines for water, other liquids, or gas.

Pipes, fittings and accessories may be provided with fixed or loose flanges. It is the responsibility of the manufacturer to define the type of flanges he normally produces and to specify this in his catalogues.

The range of diameters extends from nominal size DN 40 to nominal size DN 2 600 inclusive. DN 60, which is shown in parentheses in the tables, exists in national standards in certain countries. However, it is recommended that whenever possible it be replaced by DN 65.

1.2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 13 : 1978, *Grey iron pipes, special castings and grey iron parts for pressure main lines.*

ISO 6506 : 1981, *Metallic materials — Hardness test — Brinell test.*

ISO 6708 : 1980, *Pipe components — Definition of nominal size.*

1.3 Definition

For the purposes of this International Standard, the definition of nominal size (DN) given in ISO 6708 applies.

1) "Sand" refers to sand or mineral-based materials used in the foundry trade irrespective of the type of bonding agent.

Section 2: General specification

2.1 Types of joints

The pipes and fittings may be supplied with various types of joint.

The specification mainly concerns pipes, fittings with sockets for gasket joints with elastomer packings and flanged fittings.

It may also be used for pipes and fittings having other types of joint — for example, lead-caulked joints, which are still used in certain countries. Castings with these various joints retain the same overall dimensions, making it easier for manufacturers to use interchangeable patterns.

NOTE — The standard external diameter of the spigot end of pipes and fittings remains the same for all types of joint. Furthermore, this external diameter is the same in the common range of nominal sizes as that of the spigot end of grey iron castings (see ISO 13), which makes it easier to joint the new ductile iron pipes or fittings to existing grey iron pipelines.

2.2 Standard iron thickness of pipes and fittings

The standard iron thickness of pipes and fittings is calculated as a function of the nominal size using the formula

$$e = k\,(0{,}5 + 0{,}001\,DN)$$

where

e is the standard wall thickness, in millimetres;

DN is the nominal size;

k is the coefficient selected from a series of whole numbers . . . 8, 9, 10, 11, 12 . . . as laid down in the specific requirements of sections 3, 5 and 6 of this International Standard:

$k = 9$ for the pipes in table 10,

$k = 9$; 12; 14 for the flanged pipes in table 28,

$k = 9$; 10; 12 for the flanged pipes in table 29,

$k = 12$ for the fittings in tables 32 to 38, 44, 45 and 54 to 57,

$k = 14$ for the fittings in tables 39 to 43 and 58 to 63.

If necessary, each particular specification shall give an additional formula applicable to small size castings.

The external diameter of the pipes, expressed in millimetres, is fixed as a function of the nominal size and independently of the pipe wall thickness. Increases or decreases in the pipe wall thickness shall be obtained by modification of the actual internal diameter.

The wall thickness of the fittings may be adjusted to the forces acting at each point of the castings, particularly to the mechanical stresses induced by internal pressure. In bends, for example, the wall thickness at the inner radius may be greater than that at the outer radius.

Increases or decreases in the wall thickness of fittings may be obtained by modifications to either the internal or the external diameter of the fittings.

The thickness e indicated in each table and on the drawings of the fittings shall be a mean thickness corresponding to the mass of each casting. The actual thickness at any particular point may be varied to meet local stresses, depending on the shape of the casting.

2.3 Marking

Each pipe, fitting or accessory shall bear at least the following indications:

a) the mark of the manufacturer;

b) an indication that the casting is of ductile iron;

c) an indication of its nominal size (DN).

If necessary, each fitting shall bear an indication of its main characteristics. Pipes, fittings and accessories with a nominal size greater than DN 300 shall also bear the year of manufacture.

The marks may be cast on, painted or cold stamped.

2.4 Quality of pipes, fittings and accessories

After casting, ductile iron pipes, fittings and accessories may be subjected, when necessary, to a suitable heat treatment in order to give them the required mechanical characteristics.

Pipes, fittings and accessories shall not have any defects likely to be detrimental to their use.

Pipes, fittings and accessories showing small imperfections inseparable from the method of manufacture and in no way affecting their use, shall not be rejected. On his own responsibility the manufacturer may remedy slight surface imperfections in a suitable manner.

With the previous agreement of the purchaser or his representative, certain defects may be repaired by any proven process such as welding. In such cases, the purchaser may require one of the tests described below to be carried out.

The pipes shall be such that they can be cut, drilled or machined; in case of dispute they shall be considered as acceptable provided that the superficial hardness does not exceed 230 HB. The superficial hardness of fittings and accessories shall not exceed 250 HB.[1)]

2.5 Tolerances on joints

To ensure interchangeability between supplies from different origins, the plus tolerance on the external diameters of spigot ends of pipes and fittings, as measured circumferentially in the jointing area, shall not be greater than 1 mm.

The tolerances on joints depend on the characteristics peculiar to each type of joint, and shall be as specified in the national standards, or, when not so specified, in the manufacturers' catalogues for the type of joint and the nominal size considered.

NOTE — As a general rule, the tolerances on the sockets are more restricted than the tolerances on the barrel because of the greater thickness and the greater rigidity of the sockets.

2.6 Tolerances on thickness

The tolerances on wall thickness are given in table 1, where DN is the nominal size.

Table 1

Tolerances in millimetres

Type of casting	Tolerance
Pipes centrifugally cast	$-(1{,}3 + 0{,}001\ DN)$ *)
Pipes, fittings and accessories not centrifugally cast	$-(2{,}3 + 0{,}001\ DN)$ *)
*) No limit for the plus tolerance has been set.	

2.7 Manufacturing lengths

2.7.1 Spigot and socket pipes

The standard working lengths of spigot and socket pipes are as shown in section 3.

Of the total number of spigot and socket pipes to be supplied in each diameter, the manufacturer may supply up to 10 % in lengths shorter than the standard working length specified, the maximum reduction in length allowed being as given in table 2.

Table 2

Dimensions in metres

Specified length, L	Maximum reduction in length
$L \leqslant 4$	1
$4 < L \leqslant 6$	2
$6 < L$	3

2.7.2 Flanged pipes

The manufacturing working lengths of flanged pipes shall be those specified in national standards or in the manufacturers' catalogues.

2.7.3 Fittings

The standard working lengths of fittings are indicated in section 6.

2.8 Deviations and tolerances on length

This International Standard specifies permissible deviations from the standard working lengths.

These deviations have been selected generously and they allow individual manufacturers to produce castings of differing manufacturing working lengths to accommodate the use of various foundry tackle systems and joint designs.

The manufacturing working lengths shall be those given in manufacturers' catalogues.

This International Standard also specifies where appropriate (see clauses 3.3, 5.2 and 6.3) manufacturing tolerances which shall apply to the manufacturing working lengths.

2.9 Tolerances on the straightness of centrifugally cast pipes

When the pipes are rolled along two gantries separated by approximately two-thirds of the length L of the pipe to be checked, the maximum deviation f_m, in millimetres, shall not be greater than 1,25 times the length L, in metres, of this pipe, i.e.

$$f_m \leqslant 1{,}25\ L$$

1) In the case where pipes or fittings are manufactured from welded elements, a higher hardness is permitted locally at the welds.

2.10 Tolerances on flanges

The dimensional tolerances of flanges are specified in section 4.

2.11 Tolerances on masses

The values of the masses of the sockets given in the tables of this International Standard are approximate.

The masses of pipes and fittings corresponding to each type of joint shall be those specified in the national standards or, when not so specified, in the manufacturers' catalogues; these shall have been calculated by taking the density of cast iron as 7 050 kg/m^3.

The mass of the pipes for each working length, and the mass of the fittings shown in the tables, have been calculated taking into account in each case a socket mass fixed by a linear formula corresponding to average socket masses as manufactured in practice in various countries.

The values indicated for the mass per metre of pipe and the masses of the sockets are rounded off to the nearest 0,1 kg.

The values indicated for the masses of accessories are rounded off

- to the nearest 0,1 kg for masses less than 20 kg;
- to the nearest 0,5 kg for masses between 20 kg and 100 kg;
- to the nearest kilogram for masses above 100 kg.

The tolerances on the standard masses are given in table 3.

NOTES

1 Castings of a greater mass than the maximum should be accepted provided that they comply in every other respect with the requirements of this International Standard.

2 Pipes and fittings below DN 150 need not be weighed individually unless specified by the purchaser in his enquiry or order.

Table 3

Type of casting	Tolerance on standard mass %
Pipes centrifugally cast { up to DN 200 inclusive	± 8
Pipes centrifugally cast { above DN 200	± 5
Pipes not centrifugally cast Standard fittings except as stated below }	± 8
Bends, fittings with branches and non-standard fittings	± 12

2.12 Tensile tests — Test bars

2.12.1 Pipes centrifugally cast

The machined test bar for the tensile test shall be taken from the spigot end of the pipe, at approximately mid-thickness of the wall.

The manufacturer may opt to take the test bar perpendicular or parallel to the axis of the pipe. In case of dispute the test bar shall be taken parallel to the axis of the pipe.

The test bar shall include a cylindrical part, the gauge length of which shall be at least five times its diameter; the diameter of the test bar shall be determined from table 4 according to the thickness of the pipe, e.

Table 4

Dimensions in millimetres

Thickness of pipe, e	Diameter of test bar
$e < 6$	2,5
$6 \leqslant e < 8$	3,5
$8 \leqslant e < 12$	5
$12 \leqslant e$	6

2.12.2 Pipes, fittings and accessories not centrifugally cast

The machined test bar for the tensile test may, at the manufacturer's option, be taken either from a sample attached to the casting or from a sample cast separately. In the latter case it shall be cast from the same iron as that used for the casting. If the casting is subjected to heat treatment, the sample shall be subjected to the same heat treatment. The choice of the method used for casting the sample shall be left to the manufacturer with a view to obtaining soundly cast test bars. The thickness of the sample and the diameter of the test bar are given in table 5 as a function of the mean thickness of the casting.

Table 5

Dimensions in millimetres

Mean thickness of casting	Thickness of sample	Diameter of test bar
< 12	12,5	6
⩾ 12	25	12

The gauge length of the machined test bar shall be at least five times its diameter.

In all cases, the ends of the test bars shall be such that they will fit the testing machine.

2.13 Tensile tests — Method and results

The manufacturer's mechanical tests shall be carried out during manufacture.

The mechanical acceptance tests shall be carried out on castings grouped in batches as follows.

a) **Pipes centrifugally cast**

Each batch shall be made up of pipes cast successively as follows:

- DN 40 to DN 300: 200 pipes
- DN 350 to DN 600: 100 pipes
- DN 700 to DN 1 000: 50 pipes
- DN 1 200 to DN 2 600: 25 pipes

b) **Pipes, fittings and accessories not centrifugally cast**

Castings made from iron of substantially the same composition and, if necessary, having been subjected to the same heat treatment, shall be considered as one batch. The size of such batches shall be limited to 4 t of crude castings, excluding the mass of the risers.

A single casting is considered as one batch if its mass is equal to or greater than 4 t.

The manufacturer shall take a test bar which shall satisfy the requirements of table 6 from one pipe of each batch [see item a)] or from one sample of each batch [see item b)].

If the results of this test are below the specified minimum values, two other test bars shall be taken from the same pipe, or from the same sample in the case of fittings and accessories, and these shall satisfy the same specified requirements.

Pipes from which test bars have been cut shall be included in the supply, along with pipes from which test bars have not been cut.

NOTE — The provisions made for dividing the pipes and fittings into batches and for the heat treatment of the castings, together with the specifying of different diameters of a test bar according to the thickness and type of the casting, contribute towards the accuracy of this test.

2.14 Brinell hardness test

The Brinell hardness value HB, specified in clause 2.4, shall be checked by means of a test carried out on the outer surface of the castings after slight grinding.

The Brinell hardness test shall be carried out in accordance with ISO 6506, with a steel ball of 10 mm, 5 mm or 2,5 mm diameter.

2.15 Maximum working pressure and internal pressure proof test

2.15.1 Maximum working pressure

The maximum working pressures for these pipes, fittings and accessories shall be determined according to the regulations in operation in each country as a function of the works proof test pressure and the anticipated working conditions, i.e. the type of liquid transported, static and transitory overloads, etc.

2.15.2 Internal pressure proof test

2.15.2.1 Pipes centrifugallly cast

Centrifugally cast pipes shall be subjected to a works hydrostatic test for a duration of at least 10 s at a minimum pressure defined by the corresponding specific requirements.

It is recommended that this pressure p, expressed in bars[1] as a function of the coefficient k (clause 2.2), be calculated using the following formulae:

- DN 40 to DN 300: $p = 0{,}5\ (k + 1)^2$
- DN 350 to DN 600: $p = 0{,}5\ k^2$
- DN 700 to DN 1 000: $p = 0{,}5\ (k - 1)^2$
- DN 1 200 to DN 2 000: $p = 0{,}5\ (k - 2)^2$
- DN 2 200 to DN 2 600: $p = 0{,}5\ (k - 3)^2$

Table 6

Type of casting	Tensile strength R_m min. N/mm²	0,2 % proof stress*) (non-proportional elongation) $R_{p0,2}$ min. N/mm²	Percentage elongation after fracture A min.	
	DN 40 to DN 2 600	DN 40 to DN 2 600	DN 40 to DN 1 000	DN 1 200 to DN 2 600
Pipes centrifugally cast	420	300**)	10	7
Pipes, fittings and accessories not centrifugally cast	400	300	5	5

*) The proof stress shall be measured only by special agreement between the manufacturer and the purchaser and under conditions which shall be specified in the order.

**) Values of $R_{p0,2}$ between 270 N/mm² and 300 N/mm² are allowed when the elongation after fracture is greater than or equal to 12 % for pipes of DN 40 to DN 1 000 or 10 % for pipes of DN 1 200 to DN 2 600.

1) 1 bar = 10^5 Pa

The actual test pressures shall not exceed the following values:

- DN 40 to DN 300: p = 100 bar
- DN 350 to DN 600: p = 80 bar
- DN 700 to DN 1 000: p = 60 bar
- DN 1 200 to DN 2 000: p = 40 bar
- DN 2 200 to DN 2 600: p = 25 bar

2.15.2.2 Pipes, fittings and accessories not centrifugally cast

Pipes, fittings and accessories not centrifugally cast shall be subjected to a leak-tightness test carried out with water or air, under the conditions indicated by the relevant specific requirements.

2.15.2.3 Acceptance criteria

After completion of the test there shall be no visible signs of leakage, sweating or other fault of any kind.

NOTE — Because of their great mechanical strength, ductile iron pipes and fittings may be used for a very wide range of working conditions. The hydrostatic test or leak-tightness test pressures are therefore indicated in the specific requirements applicable to each type of casting. For pipes and fittings used for the conveyance of gas, air pressure or other appropriate tests should be carried out.

2.16 Coating

Except when otherwise specified, all pipes, fittings and accessories shall be coated inside and outside.

The coatings shall dry rapidly with good adherence, and shall not scale off.

The inside coating shall not contain constituants soluble in water or ingredients liable to impart any taste or smell to the water after suitable washing of the mains. For pipelines carrying potable water, or alimentary fluids, the inside coating shall not contain any toxic constituant.

NOTE — The requirements concerning the coating of the various castings are based on similar requirements to those given in ISO 13 for grey iron pipes and fittings. Technical specifications concerning cement mortar internal linings for pipes are the subject of ISO 4179 : 1985, *Ductile iron pipes for pressure and non-pressure pipelines — Centrifugal cement mortar lining — General requirements,* and ISO 6600 : 1980, *Ductile iron pipes — Centrifugal cement mortar lining — Composition controls of freshly applied mortar.* Other specifications regarding external protection are under study.

2.17 Inspection

If the purchaser wishes to inspect the pipes, fittings and accessories, such inspection shall be undertaken at the works of the manufacturer. The equipment and labour necessary for the carrying out of the inspection shall be provided by the manufacturer.

The inspector appointed by the purchaser and accredited to the manufacturer shall be advised previously of the time at which the inspection operations will take place.

The inspector may witness the sampling, the preparation and testing of the test pieces, the checking of dimensions, the weighing and the hydraulic tests.

The inspection and weighing of the pipes, fittings and accessories may be carried out after coating.

Should the purchaser or his representative not be present when these operations are carried out at the time agreed upon, the manufacturer shall be entitled to proceed with the inspection without the purchaser or his representative being present.

NOTE — The requirements concerning inspection of the various castings are based on similar requirements to those given in ISO 13 for grey iron pipes and fittings.

Section 3: Spigot and socket pipes

3.1 General — Pipes

This section defines (see table 10) a range of ductile iron pipes which satisfy most normal needs, particularly in the conveyance and distribution of water or gas under pressure.

The thickness of the pipes is defined as a function of their diameter by linear formulae, as given in ISO 13 for grey iron pipes.

In case of particular needs, other pipe ranges, having smaller or greater wall thicknesses, may be envisaged.

Table 10 deals with ductile iron spigot and socket pipes used for the transportation and distribution of water, other liquids, or gas under pressure. It applies equally to double spigot pipes.

Their iron thickness e (see figure 1) has been calculated as a function of the nominal size DN, using the formula given in clause 2.2, with 9 as the value for k, thus

$$e = 4{,}5 + 0{,}009\ DN$$

However, for pipes DN 40 to DN 200, the thickness is given by the additional formula

$$e = 5{,}8 + 0{,}003\ DN$$

with a minimum of 6 mm.

In these formulae

e is the standard wall thickness, in millimetres;

DN is the nominal size of the pipe.

3.2 Standard working length

The standard working lengths of spigot and socket pipes are given in table 7.

Table 7

Nominal size DN	Standard working lengths m
40 ⩽ DN ⩽ 65	2—3—4—5—5,5—6
80 ⩽ DN ⩽ 500	4—5—5,5—6
600 ⩽ DN ⩽ 2 600	4—5—5,5—6—7—8—9
NOTE — Not all the standard working lengths are available in all countries and consequently they cannot be required.	

3.3 Deviations and tolerances on length

The deviation on standard working lengths and the tolerance on manufacturing working lengths are given in table 8.

They are applied irrespective of nominal size DN and length.

Table 8

Values in millimetres

Deviation on standard working length	± 250
Tolerance on manufacturing working length	± 30

3.4 Works test pressure

The hydrostatic works test pressure for the pipes shown in table 10 is indicated in table 9.

Table 9

Nominal size DN	Hydrostatic works test pressure bar
40 ⩽ DN ⩽ 300	50
350 ⩽ DN ⩽ 600	40
700 ⩽ DN ⩽ 1 000	32
1 200 ⩽ DN ⩽ 2 000	25
2 200 ⩽ DN ⩽ 2 600	18

3.5 Dimensions and masses — Class $k = 9$

See figure 1 and table 10.

$$e = \begin{cases} 5{,}8 + 0{,}003\ DN, \text{ with a minimum value of 6 mm, for DN 40 to DN 200} \\ 4{,}5 + 0{,}009\ DN, \text{ for DN 250 to DN 2 600} \end{cases}$$

Symbol:

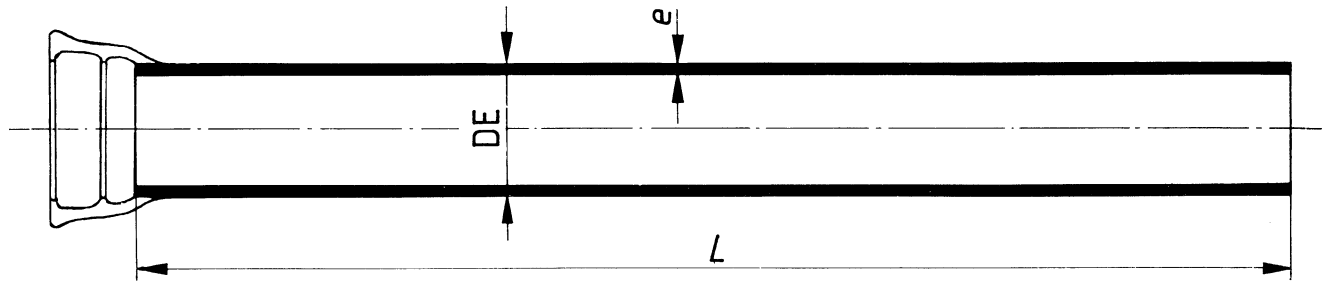

Figure 1

Table 10

Dimensions in millimetres — Masses in kilograms

Nominal size DN	Barrel			Socket mass (approximate)	Total mass (approximate) for one working length L of								
	DE	e	Mass per metre (approximate)		2 m	3 m	4 m	5 m	5,5 m	6 m	7 m	8 m	9 m
40	56	6	6,6	1,7	15	21,5	28	34,5	38	41,5	—	—	—
50	66	6	8	2,1	18	26	34	42	46	50	—	—	—
(60)	77	6	9,4	2,5	21,5	30,5	40	49,5	54	59	—	—	—
65	82	6	10,1	2,7	23	33	43	53	58,5	63,5	—	—	—
80	98	6	12,2	3,4	—	—	52	64,5	70,5	76,5	—	—	—
100	118	6,1	15,1	4,3	—	—	64,5	80	87,5	95	—	—	—
125	144	6,2	18,9	5,7	—	—	81,5	100	110	119	—	—	—
150	170	6,3	22,8	7,1	—	—	98,5	121	133	144	—	—	—
200	222	6,4	30,6	10,3	—	—	133	163	179	194	—	—	—
250	274	6,8	40,2	14,2	—	—	175	215	235	255	—	—	—
300	326	7,2	50,8	18,6	—	—	222	273	298	323	—	—	—
350	378	7,7	63,2	23,7	—	—	277	340	371	403	—	—	—
400	429	8,1	75,5	29,3	—	—	331	407	445	482	—	—	—
500	532	9	104,3	42,8	—	—	460	564	616	669	—	—	—
600	635	9,9	137,3	59,3	—	—	608	745	813	882	1 019	1 156	1 293
700	738	10,8	173,9	79,1	—	—	775	949	1 036	1 123	1 296	1 470	1 644
800	842	11,7	215,2	102,6	—	—	963	1 179	1 286	1 394	1 609	1 824	2 039
900	945	12,6	260,2	129,9	—	—	1 171	1 431	1 561	1 691	1 951	2 212	2 472
1 000	1 048	13,5	309,3	161,3	—	—	1 399	1 708	1 862	2 017	2 326	2 636	2 945
1 200	1 255	15,3	420,1	237,7	—	—	1 918	2 338	2 548	2 758	3 178	3 599	4 019
1 400	1 462	17,1	547,2	279,3	—	—	2 468	3 015	3 289	3 563	4 110	4 657	5 204
1 600	1 668	18,9	690,3	375,4	—	—	3 137	3 827	4 172	4 517	5 208	5 898	6 588
1 800	1 875	20,7	850,1	490,6	—	—	3 891	4 741	5 166	5 591	6 441	7 291	8 142
2 000	2 082	22,5	1 026,3	626,4	—	—	4 732	5 758	6 271	6 784	7 811	8 837	9 863
2 200	2 288	24,3	1 218,3	784,2	—	—	5 657	6 876	7 485	8 094	9 312	10 531	11 749
2 400	2 495	26,1	1 427,2	966,2	—	—	6 675	8 102	8 816	9 529	10 957	12 384	13 811
2 600	2 702	27,9	1 652,4	1 173,7	—	—	7 783	9 436	10 262	11 088	12 741	14 393	16 045

Section 4: Flanges

4.1 General — Flanges

In ISO 13, only one type of flange has been adopted for grey iron pipelines. The increase in pressures permissible in ductile iron pipelines, and the extension of the range of uses to which they may be put, have led to the inclusion of four types of flange corresponding to the nominal pressures PN 10, PN 16, PN 25 and PN 40 respectively.

Because they have identical drilling details, it has been possible to adopt a single design for flanges DN 40 and DN 50 for nominal pressures PN 10, PN 16, PN 25 and PN 40, and, for DN 60 and DN 65, a common design for nominal pressures PN 10 and PN 16 on the one hand and PN 25 and PN 40 on the other.

Moreover, since a degree of rationalization of flange dimensions and/or drilling details already exists for DN 80 to DN 200, for the above nominal pressures, and since this rationalization of flange dimensions has been extended to include DN 250 and DN 300 for nominal pressures PN 10 and PN 16, the multiplicity of designs has been reduced as shown in table 11.

Table 11

Nominal size DN	Identical flange dimensions for nominal pressures PN	Identical drilling details for nominal pressures PN
40 and **50**	10—16—25—40	10—16—25—40
60 and **65**	10—16—25—40	10—16 / 25—40
80	10—16—25—40	10—16—25—40
100	10—16 / 25—40	10—16 / 25—40
125 and **150**	10—16	10—16 / 25—40
200 to **300**	10—16	

As specified in ISO 13, PN 10 flanges (see tables 16 and 17) may be used on socket pipelines up to pressures of approximately 15 bar.

The flanges may have a machined raised face and drilled holes; they may also be supplied as cast where particularly accurate moulding processes are used, while respecting the dimensional requirements shown in tables 16 to 27 hereafter for a selected nominal size and nominal pressure.

Flanges can be cast integral with the corresponding casting or cast separately and attached by any known means, such as screwing and welding.

They can also be fixed or removable. The latter arrangement makes casting mounting and PN change easier. Loose flanges can be used under the same service conditions as fixed flanges.

A loose flange is comprised of a ring, in one or several parts bolted together, which bears on an end joint collar. The ring can be freely rotated around the pipe axis and can thus be positioned for alignment with the bolt holes. The external diameter and the drilling details are the same for fixed and loose flanges.

It should be noted that the diameters of bolt holes of the various types of flange are 1 mm larger than those envisaged for pipelines not laid in the ground. This increase makes it easier to assemble the castings, which is sometimes difficult in the case of underground pipelines.

The diameter of the holes has been fixed according to the nominal diameter of the bolts in accordance with the following rule:

- for a bolt $\leqslant$ M20: nominal diameter of the bolt + 3 mm;
- for a bolt $>$ M20 but $\leqslant$ M52: nominal diameter of the bolt + 4 mm;
- for a bolt $>$ M52: nominal diameter of the bolt + 6 mm.