# INTERNATIONAL STANDARD

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# Plastics piping systems for the supply of gaseous fuels for maximum operating pressures up to and including 2 MPa (20 bar) — Polyamide (PA) —

## Part 2: **Pipes**

*Systèmes de canalisations en matières plastiques pour la distribution de combustibles gazeux pour des pressions maximales de service inférieures ou égales à 2 MPa (20 bar) — Polyamide (PA) —*

*Partie 2: Tubes*

Reference number
ISO 22621-2:2007(E)

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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 2.

The main task of technical committees is to prepare International Standards. 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.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 22621-2 was prepared by Technical Committee ISO/TC 138, *Plastics pipes, fittings and valves for the transport of fluids*, Subcommittee SC 4, *Plastics pipes and fittings for the supply of gaseous fuels*.

ISO 22621 consists of the following parts, under the general title *Plastics piping systems for the supply of gaseous fuels for maximum operating pressures up to and including 2 MPa (20 bar) — Polyamide (PA)*:

— *Part 1: General*

— *Part 2: Pipes*

— *Part 3: Fittings*

Fitness for purpose of the system is to form the subject of a future part 5.

# Introduction

As polyamide material is used for piping systems for the supply of gaseous fuels both at low and high pressure, ISO/TC 138/SC 4 experts decided to split the standardization programme into two series of International Standards, with one series covering low pressures up to 0,4 MPa (4 bar), and ISO 22621 high pressures up to 2 MPa (20 bar).

Thin wall thickness pipes and solvent cement joints are used typically for pressures up to 0,4 MPa (4 bar), while thicker wall thickness pipes and butt fusion, electrofusion and mechanical joints are typically used for pressures up to 2 MPa (20 bar). For technical and safety reasons, it is not possible to mix the components of the two types of piping system (thin wall thickness pipes cannot be jointed by butt fusion or mechanical joints and vice versa). In particular, solvent cement joints must not be used for jointing for high pressure piping systems.

# Plastics piping systems for the supply of gaseous fuels for maximum operating pressures up to and including 2 MPa (20 bar) — Polyamide (PA) —

## Part 2: **Pipes**

## 1 Scope

This part of ISO 22621 specifies the physical and mechanical properties of pipes made from polyamide (PA) in accordance with ISO 22621-1, intended to be buried and used for the supply of gaseous fuels at maximum operating pressures (MOP) up to and including 20 bar [1)].

It also specifies the test parameters for the test methods to which it refers.

In addition, it lays down dimensional characteristics and requirements for the marking of pipes.

Pipes conforming to this part of ISO 22621 are jointed typically by using mechanical, electrofusion or butt fusion (see Annex A) techniques, but not by solvent cement jointing.

## 2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 161-1, *Thermoplastics pipes for the conveyance of fluids — Nominal outside diameters and nominal pressures — Part 1: Metric series*

ISO 291, *Plastics — Standard atmospheres for conditioning and testing*

ISO 307, *Plastics — Polyamides — Determination of viscosity number*

ISO 1133:2005, *Plastics — Determination of the melt mass-flow rate (MFR) and the melt volume-flow rate (MVR) of thermoplastics*

ISO 1167-1, *Thermoplastics pipes, fittings and assemblies for the conveyance of fluids — Determination of the resistance to internal pressure — Part 1: General method*

ISO 1167-2, *Thermoplastics pipes, fittings and assemblies for the conveyance of fluids — Determination of the resistance to internal pressure — Part 2: Preparation of pipe test pieces*

ISO 2505, *Thermoplastics pipes — Longitudinal reversion — Test method and parameters*

1) 1 bar = 0,1 MPa = $10^5$ Pa; 1 MPa = 1 N/mm$^2$

ISO 3126, *Plastics piping systems — Plastics components — Determination of dimensions*

ISO 4065, *Thermoplastics pipes — Universal wall thickness table*

ISO 6259-1, *Thermoplastics pipes — Determination of tensile properties — Part 1: General test method*

ISO 6259-3, *Thermoplastics pipes — Determination of tensile properties — Part 3: Polyolefin pipes*

ISO 11922-1:1997, *Thermoplastics pipes for the conveyance of fluids — Dimensions and tolerances — Part 1: Metric series*

ISO 13477, *Thermoplastics pipes for the conveyance of fluids — Determination of resistance to rapid crack propagation (RCP) — Small-scale steady-state test (S4 test)*

ISO 13479, *Polyolefin pipes for the conveyance of fluids — Determination of resistance to crack propagation — Test method for slow crack growth on notched pipes (notch test)*

ISO 22621-1, *Plastics piping systems for the supply of gaseous fuels for maximum operating pressures up to and including 2 MPa (20 bar) — Polyamide (PA) — Part 1: General*

## 3 Terms, definitions, symbols and abbreviated terms

For the purposes of this document, the terms, definitions, symbols and abbreviated terms given in ISO 22621-1 apply.

## 4 Compound

The pipes shall be made from virgin material. Rework material shall not be used.

The compound from which the pipes are made shall be in accordance with ISO 22621-1.

## 5 Appearance

When viewed without magnification, the internal and external surfaces of pipes shall be smooth, clean and free from scoring, cavities and other surface defects which can affect pipe performance. The pipe ends shall be cut cleanly and square to the axis of the pipe.

## 6 Geometrical characteristics

### 6.1 Measurement of dimensions

Dimensions shall be measured in accordance with ISO 3126 at (23 ± 2) °C, after being conditioned for at least 4 h. The measurement shall not be made less than 24 h after manufacture.

### 6.2 Mean outside diameters, out-of-roundness and their tolerances

The mean outside diameter of the pipe, $d_{em}$, and the out-of-roundness and their tolerances shall be in accordance with Table 1.

For maximum mean outside diameter grade B tolerances, ISO 11922-1 shall apply.

**Table 1 — Mean outside diameters and out-of-roundness**

Dimensions in millimetres

| Nominal outside diameter | Mean outside diameter | | Maximum of absolute out-of-roundness [a] | |
|---|---|---|---|---|
| $d_n$ | $d_{em,min}$ | $d_{em,max}$ | Grade K [b] | Grade N |
| 16 | 16,0 | 16,3 | 1,2 | 1,2 |
| 20 | 20,0 | 20,3 | 1,2 | 1,2 |
| 25 | 25,0 | 25,3 | 1,5 | 1,2 |
| 32 | 32,0 | 32,3 | 2,0 | 1,3 |
| 40 | 40,0 | 40,4 | 2,4 | 1,4 |
| 50 | 50,0 | 50,4 | 3,0 | 1,4 |
| 63 | 63,0 | 63,4 | 3,8 | 1,5 |
| 75 | 75,0 | 75,5 | — | 1,6 |
| 90 | 90,0 | 90,6 | — | 1,8 |
| 110 | 110,0 | 110,7 | — | 2,2 |
| 125 | 125,0 | 125,8 | — | 2,5 |
| 140 | 140,0 | 140,9 | — | 2,8 |
| 160 | 160,0 | 161,0 | — | 3,2 |
| 180 | 180,0 | 181,1 | — | 3,6 |
| 200 | 200,0 | 201,2 | — | 4,0 |
| 225 | 225,0 | 226,4 | — | 4,5 |
| 250 | 250,0 | 251,5 | — | 5,0 |

[a] Measurement of out-of-roundness shall be made at the point of manufacture according to ISO 3126.

[b] For coiled pipe with $d_n \leqslant 63$ mm, grade K applies; for pipe with $d_n \geqslant 75$ mm, the maximum out-of roundness shall be specified by agreement.

## 6.3 Wall thicknesses and tolerances

### 6.3.1 Minimum wall thickness

The minimum wall thickness, $e_{min}$, shall be in accordance with Table 2. Small diameter pipes are characterized by wall thickness. Large diameter pipes are characterized by their standard dimension ratio (SDR).

The use of any SDR derived from the pipe series S given according to ISO 4065 and ISO 161-1 is permitted.

NOTE In order to minimize the possibility of damage to small-diameter gas pipes by external influences, the use of pipes having a wall thickness of not less than 3,0 mm — even if higher than the minimal SDR value — can be considered.

**Table 2 — Minimum wall thickness**

Dimensions in millimetres

| Nominal outside diameter $d_n$ | Minimum wall thickness $e_{min}$ | | | | | | |
|---|---|---|---|---|---|---|---|
| | SDR 7,4 | SDR 9 | SDR 11 | SDR 13,6 | SDR 17 | SDR 21 | SDR 26 |
| 16 | 2,2 | — | — | — | — | — | — |
| 20 | 2,8 | 2,3 | — | — | — | — | — |
| 25 | 3,5 | 2,8 | 2,3 | — | — | — | — |
| 32 | 4,4 | 3,6 | 2,9 | 2,4 | — | — | — |
| 40 | 5,5 | 4,5 | 3,7 | 3,0 | 2,4 | 2,0 | — |
| 50 | 6,9 | 5,6 | 4,6 | 3,7 | 3,0 | 2,4 | 2,0 |
| 63 | 8,6 | 7,1 | 5,8 | 4,7 | 3,8 | 3,0 | 2,5 |
| 75 | 10,3 | 8,4 | 6,8 | 5,6 | 4,5 | 3,6 | 2,9 |
| 90 | 12,3 | 10,1 | 8,2 | 6,7 | 5,4 | 4,3 | 3,9 |
| 110 | 15,1 | 12,3 | 10,0 | 8,1 | 6,6 | 5,3 | 4,2 |
| 125 | 17,1 | 14,0 | 11,4 | 9,2 | 7,4 | 6,0 | 4,8 |
| 140 | 19,2 | 15,7 | 12,7 | 10,3 | 8,3 | 6,7 | 5,4 |
| 160 | 21,9 | 17,9 | 14,6 | 11,8 | 9,5 | 7,7 | 6,2 |
| 180 | 24,6 | 20,1 | 16,4 | 13,3 | 10,7 | 8,6 | 6,9 |
| 200 | 27,4 | 22,4 | 18,2 | 14,7 | 11,9 | 9,6 | 7,7 |
| 225 | 30,8 | 25,2 | 20,5 | 16,6 | 13,4 | 10,8 | 8,6 |
| 250 | 34,2 | 27,9 | 22,7 | 18,4 | 14,9 | 12,0 | 9,6 |

### 6.3.2 Tolerances on wall thickness at any point

The tolerances on the wall thickness at any point shall be in accordance with ISO 11922-1:1997, Grade V. The maximum permissible variation between the nominal wall thickness, $e_n$, and the wall thickness at any point, $e$, shall be in accordance with Table 3.

**Table 3 — Tolerances on wall thickness at any point**

Dimensions in millimetres

| Minimum wall thickness $e_{min}$ | | Permitted positive deviation | Minimum wall thickness $e_{min}$ | | Permitted positive deviation |
|---|---|---|---|---|---|
| > | ⩽ | | > | ⩽ | |
| 2,0 | 3,0 | 0,4 | 18,0 | 19,0 | 2,0 |
| 3,0 | 4,0 | 0,5 | 19,0 | 20,0 | 2,1 |
| 4,0 | 5,0 | 0,6 | 20,0 | 21,0 | 2,2 |
| 5,0 | 6,0 | 0,7 | 21,0 | 22,0 | 2,3 |
| 6,0 | 7,0 | 0,8 | 22,0 | 23,0 | 2,4 |
| 7,0 | 8,0 | 0,9 | 23,0 | 24,0 | 2,5 |
| 8,0 | 9,0 | 1,0 | 24,0 | 25,0 | 2,6 |
| 9,0 | 10,0 | 1,1 | 25,0 | 26,0 | 2,7 |
| 10,0 | 11,0 | 1,2 | 26,0 | 27,0 | 2,8 |
| 11,0 | 12,0 | 1,3 | 27,0 | 28,0 | 2,9 |
| 12,0 | 13,0 | 1,4 | 28,0 | 29,0 | 3,0 |
| 13,0 | 14,0 | 1,5 | 29,0 | 30,0 | 3,1 |
| 14,0 | 15,0 | 1,6 | 30,0 | 31,0 | 3,2 |
| 15,0 | 16,0 | 1,7 | 31,0 | 32,0 | 3,3 |
| 16,0 | 17,0 | 1,8 | 32,0 | 33,0 | 3,4 |
| 17,0 | 18,0 | 1,9 | 33,0 | 34,0 | 3,5 |
| | | | 34,0 | 35,0 | 3,6 |
| | | | 35,0 | 36,0 | 3,7 |

# 7 Mechanical characteristics

## 7.1 Conditioning

Unless otherwise specified by the applicable test method, the test pieces shall be conditioned for at least 16 h at 23 °C and 50 % relative humidity in accordance with ISO 291 before testing in accordance with Table 4.

## 7.2 Requirements

The test pieces shall be tested in accordance with Table 4. When tested using the test method and parameters specified therein, the pipe shall have mechanical characteristics conforming to the requirements of Table 4.

**Table 4 — Mechanical characteristics**

| Characteristic | Requirement | Test parameters — Parameter | Test parameters — Value | Test method(s) |
|---|---|---|---|---|
| Hydrostatic strength at 20 °C for 1 000 h | No failure of any test piece during test period | End caps<br>Orientation<br>Conditioning period<br>Type of test<br>Test temperature<br>Test period<br>Circumferential (hoop) stress:<br>PA 11 160 and PA 12 160 [a]<br>PA 11 180 and PA 12 180 [a] | Type a)<br>Free<br>6 h<br>Water-in-water<br>20 °C<br>1 000 h<br><br>19,0 MPa<br>20,0 MPa | ISO 1167-1<br>ISO 1167-2 |
| Hydrostatic strength at 80 °C for 165 h | No failure of any test piece during test period | End caps<br>Orientation<br>Conditioning period<br>Type of test<br>Test temperature<br>Test period<br>Circumferential (hoop) stress:<br>PA 11 160 and PA 12 160 [a]<br>PA 11 180 and PA 12 180 [a] | Type a)<br>Free<br>6 h<br>Water-in-water<br>80 °C<br>165 h<br><br>10,0 MPa<br>11,5 MPa | ISO 1167-1<br>ISO 1167-2 |
| Elongation at break | ⩾ 200 % | Test speed | 25 mm/min | ISO 6259-1<br>ISO 6259-3 |
| Melt volume rate (MVR) [b] | < 25 $cm^3$/10 min<br>or<br>as recommended by the material supplier<br>— whichever is the lower for PA 11 and PA 12 compounds | Temperature<br>Load | 235 °C<br>10 kg | ISO 1133 |
| Resistance to slow crack growth for $e > 5$ mm (notch test) | No failure during the test period | Test temperature<br>SDR<br>Type of test<br>Test period<br>Test pressure:<br>PA 11 160 and PA 12 160 [a]<br>PA 11 180 and PA 12 180 [a] | 80 °C<br>11<br>Water-in-water<br>500 h<br><br>18 bar [c]<br>20 bar [c] | ISO 13479 |
| Resistance to rapid crack propagation (critical pressure, $p_c$) [d] | $p_c \geqslant 1{,}5$ MOP<br>with $p_c = 7{,}8\, p_{c,S4} + 6{,}8$ [e] | Test temperature | 0 °C | ISO 13477 |

[a] For material classification and designation, see ISO 22621-1:2007, 5.4.

[b] It is essential that the water content of the sample be < 0,1 %, because PA resin is sensitive to hydrolyses. Therefore, the test sample shall be dried prior to testing at 80 °C in a dry air or vacuum dryer for 3 h, or as recommended by the PA resin producer.

[c] Test pressure levels for other SDR are given in Table 5.

[d] Testing is only required when the wall thickness of the pipe is greater than that of the pipe used in the RCP test to qualify the compound (see ISO 22621-1:2007, Table 2). For severe conditions (e.g. sub-zero temperatures), RCP testing is also recommended for establishing the critical pressure of the working temperature.

[e] Alternatively, the full-scale test (FST) method according to see ISO 22621-1:2007, Annex C may be used. The relation between the FST and the S4 test is defined by the formula $p_{C,FS} + p_{atm} = 7{,}8\,(p_{C,S4} + p_{atm})$. In this case, $p_C = p_{C,FS}$. In case of dispute, the FST shall be decisive.

**Table 5 — Test pressure levels**

| SDR | Test pressure bar [b] | |
|---|---|---|
| | **PA 11 160 and PA 12 160 [a]** | **PA 11 180 and PA 12 180 [a]** |
| 7,4 | 28,12 | 31,25 |
| 9 | 22,5 | 25 |
| 11 | 18,0 | 20 |
| 13,6 | 14,28 | 15,87 |
| 17 | 11,25 | 12,5 |
| 21 | 9,0 | 10 |
| 26 | 7,2 | 8 |

These pressure levels are calculated to give nominal pipe hydrostatic levels of either 9 MPa (in PA 11 160 and PA12 160 materials) [a] or 10 MPa (in PA 11 180 and PA 12 180 materials), [a] using the following equation:

$$p = \frac{20\sigma}{\text{SDR} - 1}$$

where

$\sigma$ is the hydrostatic stress, in megapascals;

SDR is the standard dimension ratio.

[a] For material classification and designation, see ISO 22621-1:2007, 5.4.

[b] 1 bar = 0,1 MPa = $10^5$ Pa; 1 MPa = 1 N/mm$^2$.

# 8 Physical characteristics

## 8.1 Conditioning

Unless otherwise specified by the applicable test method, the test pieces shall be conditioned at normal atmosphere 23/50 according to ISO 291 before testing.

## 8.2 Requirements

The test pieces shall be tested in accordance with Table 6. When tested using the test method and parameters specified therein, the pipe shall have physical characteristics conforming to the requirements of Table 6.

**Table 6 — Physical characteristics**

| Characteristic | Requirement | Test parameters | | Test method(s) |
|---|---|---|---|---|
| | | **Parameter** | **Value** | |
| Viscosity number | ⩾ 180 ml/g | Solvent | m-Cresol | ISO 307 |
| Longitudinal reversion | ⩽ 3 %<br>The pipe shall retain its original appearance. | Heating fluid | Air | ISO 2505 |
| | | Test temperature | 150 °C | |
| | | Length of test piece | 200 mm | |
| | | Duration of exposure | According to ISO 2505 | |

## 9 Marking

All pipes shall be permanently and legibly marked with the minimum information specified in Table 7 so that the marking does not initiate cracks or other types of failure or weaken the pipe, and so that normal storage, weathering, handling, installation or use does not affect the legibility of the marking.

The length of coiled pipes may be indicated on the coil.

If printing is used, the colour of the printed information shall differ from the basic colour of the product. The frequency of the printing shall be at intervals not greater than 1 m.

The quality and size of the marking shall be so that it is easily legible without magnification.

**Table 7 — Minimum information for marking**

| Information | Marking or symbol |
|---|---|
| Manufacturer or trademark | Name or symbol |
| Internal fluid | Gas |
| Dimensions | e.g. $d_n \times e_n$ |
| SDR (for $d_n \geqslant 40$ mm) | e.g. SDR 17 |
| Material and designation | e.g. PA11 160 [a] |
| Production period | Date, code |
| Reference to this part of ISO 22621 | ISO 22621-2 |

[a] For material classification and designation, see ISO 22621-1:2007, 5.4

# Annex A
(informative)

# Butt fusion procedure for jointing PA pipes

## A.1 General

The following butt fusion procedure is intended to be used for jointing PA pipes. Critical parameters in the butt fusion process are heater iron surface temperature, heat soak time and interfacial pressure during the initial contact of the molten pipe ends and during cooling and cooling time. The heat soak time and cooling time parameters vary as a function of pipe size and wall thickness. As a general guideline, the heat soak time for $d_n \leqslant 50$ mm should be sufficiently long to produce a melt bead of approximately 1,5 mm. For $d_n \geqslant 110$ mm, the melt bead width should be approximately 3 mm to 5 mm. The pipe should be held under pressure until cool to the touch.

## A.2 Butt fusion procedure parameters

The following parameters should be used:

— interface pressure range of from 4 bar to 6 bar;

— heater surface temperature range of from 255 °C to 260 °C.

## A.3 Butt fusion procedure

### A.3.1 Principle

The principle of the heat fusion is to heat two surfaces to a designated temperature, then fuse them together by application of a sufficient force. This force causes the melted materials to flow and mix, thereby resulting in fusion. When fused according to the proper procedures, the joint area becomes as strong as, or stronger than, the pipe itself in both tensile and pressure properties.

Field-site butt fusions may be carried out readily by trained operators using butt fusion machines that secure and precisely align the pipe ends for the fusion process.

The seven steps involved in performing a butt fusion joint are the following:

a) clean the pipe ends;

b) securely fasten the components to be joined;

c) face the pipe ends;

d) align the pipe profile;

e) melt the pipe interfaces without pressure;

f) join the two profiles together;

g) hold under pressure until cooling.

### A.3.2 Clean the pipe ends

Clean the inside and outside of the pipe to be joined by wiping with a clean lint-free cloth. Remove all foreign matter.

### A.3.3 Securely fasten the components

Clamp the components in the machine. Check alignment of the ends and adjust as needed.

### A.3.4 Face the pipe ends

Face the pipe ends to establish clean, parallel mating surfaces. Most, if not all, equipment manufacturers incorporate the rotating planer block design in their facers to accomplish this goal. Continue the facing until a minimal distance exists between the fixed and movable jaws of the machine and the facer is locked firmly and squarely between the jaw bushings. This operation provides for a perfectly square face, perpendicular to the pipe centreline on each pipe end and with no detectable gap.

### A.3.5 Align the pipe profile

Remove any pipe chips from the facing operation and any foreign matter with a clean, untreated, lint-free cotton cloth. Round and align the pipe profiles with each other to minimize mismatch (high-low) of the pipe walls. This can be accomplished by adjusting clamping jaws until the outside diameters of the pipe ends match. Avoid loosening of the jaws or the pipe may slip during fusion.

### A.3.6 Melt the pipe interfaces without pressure

Heating tools that simultaneously heat both pipe ends are used to accomplish this operation. These heating tools are normally furnished with thermometers to measure internal heater temperature so the operator can monitor the temperature before each joint is made. However, the thermometer can be used only as a general indicator because there is some heat loss from internal to external surfaces, depending on factors such as ambient temperatures and wind conditions. A pyrometer or other surface temperature measuring device should be used periodically to ensure proper temperature of the heating tool face.

Additionally, heating tools are usually equipped with suspension and alignment guides that centre them on the pipe ends. The heater faces that come into contact with the pipe should be clean, oil-free and coated with a nonstick coating as recommended by the manufacturer to prevent molten plastic from sticking to the heater surfaces. Remaining molten plastic can interfere with fusion quality and must be removed according to the tool manufacturer's instructions.

Plug in the heater and bring the surface temperatures up to the temperature range (255 °C to 260 °C). Install the heater in the butt fusion machine and bring the pipe ends into full contact with the heater. To ensure that full and proper contact is made between the pipe ends and the heater, the initial contact should be under moderate pressure. After holding the pressure very briefly, it should be released without breaking contact. Continue to hold the components in place, without force, while a bead of molten PA develops between the heater and the pipe ends. When the proper bead size is formed against the heater surfaces, the heater should be removed. The bead size is dependent on the pipe size. For $d_n \leqslant 50$ mm, a bead size of approximately 1,5 mm should be present and for $d_n > 50$ mm, a bead size of 3 mm to 5 mm should be present before removing the heater.

### A.3.7 Join the two profiles together

After the pipe ends have been heated for the proper time, remove the heater tool and bring the molten pipe ends together with sufficient force to form a bead against the pipe wall. Determine the fusion force by multiplying the interfacial pressure, 4 bar to 6 bar, by the pipe area.

For manually operated fusion machines, a torque wrench may be used to accurately apply the proper force. For manual machines without force reading capability of a torque wrench, the correct fusion joining force is the force required to form a homogeneous bead during joining. For hydraulically operated fusion machines, divide the fusion force by the total effective piston area of the carriage cylinders to give a hydraulic gauge reading in bar. The gauge reading is theoretical; the internal and external drags need to be added to this figure to obtain the actual fusion pressure required by the machine.

### A.3.8 Hold under pressure until cooling

Hold the molten joint immobile under pressure until cooled adequately to develop strength. Allowing proper times under pressure for cooling prior to removal from the clamps of the machine is important in achieving joint integrity. The fusion force should be held between the pipe ends until the surface of the bead is cool to the touch. Pulling, installation or rough handling of the pipe should be avoided until the joint cools to ambient temperature (roughly an additional 30 min).

ICS 75.200; 83.140.30

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