

ANNEX I

ESSENTIAL SAFETY REQUIREMENTS

1. **Materials**

Materials shall be selected according to the intended use of the vessels and in accordance with points 1.1 to 1.4.

1.1. *Pressurised parts*

The materials used for manufacturing the pressurised parts of the vessels shall be:

- (a) capable of being welded;
- (b) ductile and tough, so that a rupture at minimum working temperature does not give rise to either fragmentation or brittle-type fracture;
- (c) not adversely affected by ageing.

For steel vessels, the materials shall in addition meet the requirements set out in point 1.1.1 and, for aluminium or aluminium alloy vessels, those set out in point 1.1.2.

They shall be accompanied by an inspection slip as defined in point (i) of point 3.1 of Annex III, drawn up by the producer of the materials.

1.1.1. *Steel vessels*

Non-alloy quality steels shall meet the following requirements:

- (a) they shall be non-effervescent and supplied after normalisation treatment, or in an equivalent state;
- (b) the content per product of carbon shall be less than 0,25 % and that of sulphur and phosphorus shall each be less than 0,05 %;
- (c) they shall have the following mechanical properties per product:
 - (i) the maximum tensile strength $R_{m,max}$ shall be less than 580 N/mm²;
 - (ii) the elongation after fracture shall be:

if test pieces are taken parallel to the direction of rolling:

thickness \geq 3 mm:	A	\geq 22 %,
thickness < 3 mm:	A _{80 mm}	\geq 17 %,

if test pieces are taken perpendicular to the direction of rolling:

thickness \geq 3 mm:	A	\geq 20 %,
thickness < 3 mm:	A _{80 mm}	\geq 15 %,

- (iii) the average bending rupture energy KCV for three longitudinal test pieces at minimum working temperature shall not be less than 35 J/cm². Not more than one of the three figures may be less than 35 J/cm², with a minimum of 25 J/cm². In the case of steels intended to be used in the manufacture of vessels

the minimum working temperature of which is lower than $-10\text{ }^{\circ}\text{C}$ and the wall thickness of which exceeds 5 mm, this property shall be checked.

1.1.2. *Aluminium vessels*

Non-alloy aluminium shall have an aluminium content of at least 99,5 % and the alloys referred to in point (b) of Article 1(1) shall display adequate resistance to intercrystalline corrosion at maximum working temperature.

Moreover, these materials shall satisfy the following requirements:

- (a) they shall be supplied in an annealed state;
- (b) they shall have the following mechanical characteristics per product:
 - the maximum tensile strength $R_{m,max}$ shall be no more than 350 N/mm^2 ,
 - the elongation after fracture shall be:
 - $A \geq 16\%$ if the test piece is taken parallel to the direction of rolling,
 - $A \geq 14\%$ if the test piece is taken perpendicular to the direction of rolling.

1.2. *Welding materials*

The welding materials used to manufacture the welds on or of the vessel shall be appropriate to and compatible with the materials to be welded.

1.3. *Accessories contributing to the strength of the vessel*

These accessories (for example bolts and nuts) shall be made of a material specified in point 1.1 or of other kinds of steel, aluminium or an appropriate aluminium alloy compatible with materials used for the manufacture of pressurised parts.

The latter materials shall at minimum working temperature have an appropriate elongation after fracture and bending rupture energy.

1.4. *Non-pressurised parts*

All unpressurised parts of welded vessels shall be of materials which are compatible with that of the components to which they are welded.

2. **Vessel design**

- (a) The manufacturer shall, when designing the vessel, define the use to which it will be put, and select:
 - (i) the minimum working temperature T_{min} ;
 - (ii) the maximum working temperature T_{max} ;
 - (iii) the maximum working pressure PS .

However, should a minimum working temperature exceeding $-10\text{ }^{\circ}\text{C}$ be selected, the qualities required of the materials shall be satisfied at $-10\text{ }^{\circ}\text{C}$.
- (b) The manufacturer shall also take account of the following provisions:
 - (i) it shall be possible to inspect the inside of vessels;
 - (ii) it shall be possible to drain the vessels;

- (iii) the mechanical qualities shall be maintained throughout the period of use of the vessel for the intended purpose;
 - (iv) the vessels shall, bearing in mind their prescribed use, be adequately protected against corrosion.
- (c) The manufacturer shall take account of the fact that under the conditions of use envisaged:
- (i) the vessels shall not be subjected to stresses likely to impair their safety in use;
 - (ii) internal pressure shall not permanently exceed the maximum working pressure PS. However, it may momentarily do so by up to 10 %.
- (d) Circumferential and longitudinal seams shall be made using full penetration welds or welds of equivalent effectiveness. Convex ends other than hemispherical ones shall have a cylindrical edge.

2.1. *Wall thickness*

If the product of $PS \times V$ is not more than 3 000 bar.L, the manufacturer shall select one of the methods described in points 2.1.1 and 2.1.2 for determining vessel wall thickness; if the product of $PS \times V$ is more than 3 000 bar.L, or if the maximum working temperature exceeds 100 °C, such thickness shall be determined by the method described in point 2.1.1.

The actual wall thickness of the cylindrical section and ends shall, however, be not less than 2 mm in the case of steel vessels and not less than 3 mm in the case of aluminium or aluminium alloy vessels.

2.1.1. *Calculation method*

The minimum thickness of pressurised parts shall be calculated having regard to the intensity of the stresses and to the following provisions:

- (a) the calculation pressure to be taken into account shall not be less than the maximum working pressure PS selected;
- (b) the permissible general membrane stress shall not exceed the lower of the values $0,6 R_{eT}$ or $0,3 R_m$. The manufacturer shall use the R_{eT} and R_m minimum values guaranteed by the producer of the material in order to determine the permissible stress.

However, where the cylindrical portion of the vessel has one or more longitudinal welds made using a non-automatic welding process, the thickness calculated as referred to in the first paragraph shall be multiplied by the coefficient 1,15.

2.1.2. *Experimental method*

Wall thickness shall be so determined as to enable the vessels to resist at ambient temperature a pressure equal to at least five times the maximum working pressure, with a permanent circumferential deformation factor of no more than 1 %.

3. **Manufacturing processes**

Vessels shall be constructed and subjected to production checks in accordance with points 2, 3 or 4 of Annex II.

3.1. *Preparation of the component parts*

Preparation of the component parts (for example forming and chamfering) shall not give rise to surface defects or cracks or changes in the mechanical characteristics likely to be detrimental to the safety of the vessels.

3.2. *Welds on pressurised parts*

The characteristics of welds and adjacent zones shall be similar to those of the welded materials and shall be free of any surface or internal defects detrimental to the safety of the vessels.

Welds shall be performed by qualified welders or operators possessing the appropriate level of competence, in accordance with approved welding processes. Such approval and qualification tests shall be carried out by notified bodies.

The manufacturer shall also, during manufacture, ensure consistent weld quality by conducting appropriate tests using adequate procedures. These tests shall be the subject of a report.

4. **Putting into service of the vessels**

Vessels shall be accompanied by the instructions drawn up by the manufacturer, as referred to in point 2 of Annex III.