SCHEDULE 1 Regulation 4

ESSENTIAL SAFETY REQUIREMENTS

PART 1

MATERIALS

1. Materials must be selected according to the intended use of the vessels and in accordance with the following provisions of this Part.

Pressurised components

2. The non-alloy quality steel, non-alloy aluminium or non-age hardening aluminimum alloy used to manufacture the pressurised components must:

— be capable of being welded;

— be ductile and tough, so that a rupture at the minimum working temperature does not give rise to either fragmentation or brittle-type fracture; and

— not be adversely affected by ageing.

— For steel vessels, the materials must in addition meet the requirements set out in paragraph 3 below and, for aluminium or aluminium alloy vessels, those set out in paragraph 4 below. They must be accompanied by an inspection slip.

Steel vessels

3. Non-alloy quality steels must meet the following requirements:

(a) they must be non-effervescent and be supplied after normalisation treatment, or in an equivalent state;

(b) the content per product of carbon must be less than 0.25% and that of sulphur and phosphorus must each be less than 0.05%; and

(c) they must have the following mechanical properties per product:

— the maximum tensile strength must be less than 580 Newtons per square millimetre (N/mm

— the elongation after rupture must be:

• if the test piece is taken parallel to the direction of rolling:

thickness – 3mm: A – 22%

thickness A – 17%

• if the test piece is taken perpendicular to the direction of rolling:

thickness – 3mm: A – 20%

thickness A – 15%; and

— the average rupture energy for three longitudinal test pieces at the minimum working temperature must not be less than 35 Joules per square centimetre (J/cm Not more than one of the three figures may be less than 35 J/cm with a minimum of 25 J/cm

In the case of steels used to manufacture vessels whose minimum working temperature is lower than minus 10° C and whose wall thickness exceeds 5 millimetres, the average rupture energy must be checked.

Aluminium vessels

4. Non-alloy aluminium must have an aluminium content of at least 99.5% and non-age hardening aluminium alloys must display adequate resistance to intercrystalline corrosion at the maximum working temperature. Moreover these materials must meet the following requirements:

(a) they must be supplied in an annealed state; and

(b) they must have the following mechanical properties per product:

— the maximum tensile strength must be no more than 350 N/mm and

— the elongation after rupture must be:

— A – 16% if the test piece is taken parallel to the direction of rolling

— A – 14% if the test piece is taken perpendicular to the direction of rolling.

Welding materials

5. The welding materials used to make the welds on or of the vessel must be appropriate to and compatible with the materials to be welded.

Accessories contributing to the strength of the vessel

6. These accessories (bolts, nuts etc) must be made either of a material specified in paragraphs 2 to 4 above or of another kind of steel, aluminium or aluminium alloy which:

— is appropriate to and compatible with the materials used to manufacture the pressurised components; and

— at the minimum working temperature has an appropriate elongation after rupture and toughness.

Non-pressurised components

7. All welded non-pressurised components must be of a material which is compatible with that of the parts to which they are welded.

PART 2

VESSEL DESIGN

8. The manufacturer must, when designing the vessel, define the use to which it will be put, and select:

— the minimum working temperature;

— the maximum working temperature; and

— the maximum working pressure.

— However, should a minimum working temperature higher than minus 10° C be selected, the properties required of the materials must be satisfied at minus 10° C.The manufacturer must also take account of the following requirements:

— it must be possible to inspect the inside of the vessels;

— it must be possible to drain the vessels;

— the mechanical qualities must be maintained throughout the period of use of the vessel for its intended purpose;

— the vessels must, bearing in mind their envisaged use, be adequately protected against corrosion,

— and of the fact that under the conditions of use envisaged:

— the vessels will not be subjected to stresses likely to impair their safety in use; and

— the internal pressure will not permanently exceed the maximum working pressure; however, it may momentarily do so by up to 10%.Circular and longitudinal seams must be made using full penetration welds or welds of equivalent effectiveness. Dished ends other than hemispherical ones must have a cylindrical edge.

Wall thickness

9. In the case of vessels of Category A.2 or A.3 whose maximum working temperature does not exceed 100° C, the manufacturer must select either the calculation method or the experimental method, as defined below, for determining vessel wall thickness.

In the case of vessels in Category A.1 or vessels in Category A.2 or A.3 whose maximum working temperature exceeds 100° C, the calculation method must be used.

However, the actual wall thickness of the cylindrical component and ends must in any case be not less than 2 millimetres in the case of steel vessels, and not less than 3 millimetres in the case of aluminium or aluminium alloy vessels.

Calculation method:

The minimum thickness of the pressurised components must be calculated having regard to the intensity of the stresses and to the following requirements:

- the calculation pressure to be taken into account must not be less than the maximum working pressure; and
- the permissible general membrane stress must not exceed 0.6 times the yield strength at the maximum working temperature(R or 0.3 times the tensile strength (R whichever value is the lower. The manufacturer must use the minimum values of R and R guaranteed by the producer of the materials in order to determine the permissible stress.

However, where the cylindrical component of the vessel has one or more longitudinal welds made using a non-automatic welding technique, the thickness calculated as above must be multiplied by the coefficient 1.15.

Experimental method:

Wall thickness must be so determined as to enable the vessels to resist at ambient temperature a pressure equal to at least 5 times the maximum working pressure, with a maximum permanent circumferential deformation factor of 1%.

PART 3

MANUFACTURING PROCESSES

10. Vessels must be constructed and checked in accordance with the design and manufacturing schedule referred to in Schedule 3.

Preparation of the component parts

11. The preparation of the component parts (eg forming and chamfering) must not give rise to surface defects, cracks or changes in the mechanical properties of those parts likely to be detrimental to the safety of the vessels.

Welds on pressurised components

12. The characteristics of welds and adjacent zones must be similar to those of the welded materials and must be free of any surface or internal defects detrimental to the safety of the vessels.Welds must be made by appropriately qualified welders or operators in accordance with approved welding techniques. "Qualified" means qualified by means of tests carried out by an approved body; and "approved" means approved by such a body.The manufacturer must also, during manufacture, ensure consistent weld quality by conducting appropriate tests using adequate procedures. These tests must be the subject of a written report.

PART 4

DEFINITIONS AND SYMBOLS

Definitions

13. In this Schedule–

(a) "minimum working temperature" means the lowest stabilised temperature in the wall of the vessel under normal conditions of use;

(b) "inspection slip" means the document by which the producer of the materials certifies that the materials delivered to the manufacturer meet the requirements set by the manufacturer, and in which the producer sets out the results of the routine inspection tests carried out during the production of those materials (or of materials produced by the same process but not being the materials delivered to the manufacturer) in particular as to their chemical composition and mechanical properties;

(c) "maximum working temperature" means the highest stabilised temperature in the wall of the vessel under normal conditions of use;

(d) "maximum working pressure" means the maximum gauge pressure which may be exerted under normal conditions of use; and

(e) "yield strength at the maximum working temperature" means:

— the upper yield point for a material with both a lower and an upper yield point; or

— the proof stress at 0.2%; or

— the proof stress at 1.0% in the case of non-alloy aluminium.

Symbols

14. In this Schedule–

(a) "A" means the percentage elongation after rupture (L N S where L is the gauge length expressed in millimetres and S is the cross-sectional area of the test section expressed in square millimetres; and

(b) "A_{80mm}" means the percentage elongation after rupture (L_o = 80mm).