SCHEDULE 2 Regulations 2(2), 7(5), 8(5), 14, 16(1), 19, 20(7)(a)

(Annex I to the Pressure Equipment Directive)
ESSENTIAL SAFETY REQUIREMENTS

PRELIMINARY OBSERVATIONS

1. The obligations arising from the essential requirements listed in this Annex for pressure equipment also apply to assemblies where the corresponding hazard exists.

2. The essential requirements laid down in the Directive are compulsory. The obligations laid down in these essential requirements apply only if the corresponding hazard exists for the pressure equipment in question when it is used under conditions which are reasonably foreseeable by the manufacturer.

3. The manufacturer is under an obligation to analyse the hazards in order to identify those which apply to his equipment on account of pressure; he must then design and construct it taking account of his analysis.

4. The essential requirements are to be interpreted and applied in such a way as to take account of the state of the art and current practice at the time of design and manufacture as well as of technical and economic considerations which are consistent with a high degree of health and safety protection.

1 GENERAL

1

1.1. Pressure equipment must be designed, manufactured and checked, and if applicable equipped and installed, in such a way as to ensure its safety when put into service in accordance with the manufacturer's instructions, or in reasonably foreseeable conditions.

1.2. In choosing the most appropriate solutions, the manufacturer must apply the principles set out below in the following order:

— eliminate or reduce hazards as far as is reasonably practicable,

— apply appropriate protection measures against hazards which cannot be eliminated,

— where appropriate, inform users of residual hazards and indicate whether it is necessary to take appropriate special measures to reduce the risks at the time of installation and/or use.

1.3. Where the potential for misuse is known or can be clearly foreseen, the pressure equipment must be designed to prevent danger from such misuse or, if that is not possible, adequate warning given that the pressure equipment must not be used in that way.

2 DESIGN

2

2.1. General

The pressure equipment must be properly designed taking all relevant factors into account in order to ensure that the equipment will be safe throughout its intended life.

The design must incorporate appropriate safety coefficients using comprehensive methods which are known to incorporate adequate safety margins against all relevant failure modes in a consistent manner.

2.2. Design for adequate strength

(2.2.1) The pressure equipment must be designed for loadings appropriate to its intended use and other reasonably foreseeable operating conditions. In particular, the following factors must be taken into account:

— internal/external pressure,

— ambient and operational temperatures,

— static pressure and mass of contents in operating and test conditions,

— traffic, wind, earthquake loading,

— reaction forces and moments which result from the supports, attachments, piping, etc.,

— corrosion and erosion, fatigue, etc.,

— decomposition of unstable fluids.

Various loadings which can occur at the same time must be considered, taking into account the probability of their simultaneous occurrence.

(2.2.2) Design for adequate strength must be based on:

— as a general rule, a calculation method, as described in 2.2.3, and supplemented if necessary by an experimental design method as described in 2.2.4, or

— an experimental design method without calculation, as described in 2.2.4, when the product of the maximum allowable pressure PS and the volume V is less than 6 000 bar-L or the product PS-DN less than 3 000 bar.

(2.2.3) Calculation method

(a) Pressure containment and other loading aspects

The allowable stresses for pressure equipment must be limited having regard to reasonably foreseeable failure modes under operating conditions. To this end, safety factors must be applied to eliminate fully any uncertainty arising out of manufacture, actual operational conditions, stresses, calculation models and properties and behaviour of the material.

These calculation methods must provide sufficient safety margins consistent, where applicable, with the requirements of section 7.

The requirements set out above may be met by applying one of the following methods, as appropriate, if necessary as a supplement to or in combination with another method:

— design by formula,

— design by analysis,

— design by fracture mechanics;

(b) Resistance

Appropriate design calculations must be used to establish the resistance of the pressure equipment concerned.

In particular:

— the calculation pressures must not be less than the maximum allowable pressures and take into account static head and dynamic fluid pressures and the decomposition of unstable fluids. Where a vessel is separated into individual pressure-containing chambers, the partition wall must be designed on the basis of the highest possible chamber pressure relative to the lowest pressure possible in the adjoining chamber,

— the calculation temperatures must allow for appropriate safety margins,

- the design must take appropriate account of all possible combinations of temperature and pressure which might arise under reasonably foreseeable operating conditions for the equipment,
- the maximum stresses and peak stress concentrations must be kept within safe limits,
- the calculation for pressure containment must utilise the values appropriate to the properties of the material, based on documented data, having regard to the provisions set out in section 4 together with appropriate safety factors. Material characteristics to be considered, where applicable, include:

  yield strength, 0.2% or 1.0% proof strength as appropriate at calculation temperature,

  tensile strength,

  time-dependent strength, i.e. creep strength,

  fatigue data,

  Young's modulus (modulus of elasticity),

  appropriate amount of plastic strain,

  impact strength,

  fracture toughness,

  appropriate joint factors must be applied to the material properties depending, for example, on the type of non-destructive testing, the materials joined and the operating conditions envisaged,

  the design must take appropriate account of all reasonably foreseeable degradation mechanisms (e.g. corrosion, creep, fatigue) commensurate with the intended use of the equipment. Attention must be drawn, in the instructions referred to in section 3.4, to particular features of the design which are relevant to the life of the equipment, for example:

  for creep: design hours of operation at specified temperatures,

  for fatigue: design under number of cycles at specified stress levels,

  for corrosion: design corrosion allowance;

(c) Stability aspects

Where the calculated thickness does not allow for adequate structural stability, the necessary measures must be taken to remedy the situation taking into account the risks from transport and handling.

(2.2.4) Experimental design method

The design of the equipment may be validated, in all or in part, by an appropriate test programme carried out on a sample representative of the equipment or the category of equipment.

The test programme must be clearly defined prior to testing and accepted by the notified body responsible for the design conformity assessment module, where it exists.

This programme must define test conditions and criteria for acceptance or refusal. The actual values of the essential dimensions and characteristics of the materials which constitute the equipment tested shall be measured before the test.

Where appropriate, during tests, it must be possible to observe the critical zones of the pressure equipment with adequate instrumentation capable of registering strains and stresses with sufficient precision.

The test programme must include:

(a) A pressure strength test, the purpose of which is to check that, at a pressure with a defined safety margin in relation to the maximum allowable pressure, the equipment does not exhibit significant leaks or deformation exceeding a determined threshold.

The test pressure must be determined on the basis of the differences between the values of the geometrical and material characteristics measures under test conditions and the values used for design purposes; it must take into account the differences between the test and design temperatures;

(b) where the risk of creep or fatigue exists, appropriate tests determined on the basis of the service conditions laid down for the equipment, for instance hold time at specified temperatures, number of cycles at specified stress-levels, etc;

(c) where necessary, additional tests concerning other factors referred to in 2.2.1 such as corrosion, external damage, etc.

2.3. Provisions to ensure safe handling and operation

The method of operation specified for pressure equipment must be such as to preclude any reasonably foreseeable risk in operation of the equipment. Particular attention must be paid, where appropriate to:

— closures and openings,

— dangerous discharge of pressure relief blow-off,

— devices to prevent physical access whilst pressure or a vacuum exists,

— surface temperature taking into consideration the intended use,

— decomposition of unstable fluids.

In particular, pressure equipment fitted with an access door must be equipped with an automatic or manual device enabling the user easily to ascertain that the opening will not present any hazard.

Furthermore, where the opening can be operated quickly, the pressure equipment must be fitted with a device to prevent it being opened whenever the pressure of temperature of the fluid presents a hazard.

2.4. Means of examination

(a) Pressure equipment must be designed and constructed so that all necessary examinations to ensure safety can be carried out;

(b) Means of determining the internal condition of the equipment must be available, where it is necessary to ensure the continued safety of the equipment, such as access openings, allowing physical access to the inside of the pressure equipment so that appropriate examinations can be carried out safely and ergonomically;

(c) Other means of ensuring the safe condition of the pressure equipment may be applied:

— where it is too small for physical internal access, or

— where opening the pressure equipment would adversely affect the inside, or

— where the substance contained has been shown not to be harmful to the material from which the pressure equipment is made and no other internal degradation mechanisms are reasonably foreseeable.

2.5. Means of draining and venting

Adequate means must be provided for the draining and venting of pressure equipment where necessary:

— to avoid harmful effects such as water hammer, vacuum collapse, corrosion and uncontrolled chemical reactions. All stages of operation and testing, particularly pressure testing, must be considered,

— to permit cleaning, inspection and maintenance in a safe manner.

2.6. Corrosion or other chemical attack

Where necessary, adequate allowance or protection against corrosion or other chemical attack must be provided, taking due account of the intended and reasonably foreseeable use.

2.7. Wear

Where severe conditions of erosion or abrasion may arise, adequate measures must be taken to:

— minimise that effect by appropriate design, e.g. additional material thickness, or by the use of liners or cladding materials,

— permit replacement of parts which are most affected,

— draw attention, in the instructions referred to in 3.4, to measures necessary for continued safe use.

2.8. Assemblies

Assemblies must be so designed that:

— the components to be assembled together are suitable and reliable for their duty,

— all the components are properly integrated and assembled in an appropriate manner.

2.9. Provisions for filling and discharge

Where appropriate, the pressure equipment must be so designed and provided with accessories, or provision made for their fitting, as to ensure safe filling and discharge in particular with respect to hazards such as:

(a) on filling:

— overfilling or overpressurisation having regard in particular to the filling ratio and to vapour pressure at the reference temperature,

— instability of the pressure equipment;

(b) on discharge: the uncontrolled release of the pressurised fluid;

(c) on filling or discharge: unsafe connection and disconnection.

2.10. Protection against exceeding the allowable limits of pressure equipment

Where, under reasonably foreseeable conditions, the allowable limits could be exceeded, the pressure equipment must be fitted with, or provision made for the fitting of, suitable protective devices, unless the equipment is intended to be protected by other protective devices within an assembly.

The suitable device or combination of such devices must be determined on the basis of the particular characteristics of the equipment or assembly.

Suitable protective devices and combinations thereof comprise:

(a) safety accessories as defined in Article 1, section 2.1.3,

(b) where appropriate, adequate monitoring devices such as indicators and/or alarms which enable adequate action to be taken either automatically or manually to keep the pressure equipment within the allowable limits.

2.11. Safety accessories

(2.11.1) Safety accessories must:

— be so designed and constructed as to be reliable and suitable for their intended duty and take into account the maintenance and testing requirements of the devices, where applicable,

— be independent of other functions, unless their safety function cannot be affected by such other functions,

— comply with appropriate design principles in order to obtain suitable and reliable protection. These principles include, in particular, fail-safe modes, redundancy, diversity and self-diagnosis.

(2.11.2) Pressure limiting devices

These devices must be so designed that the pressure will not permanently exceed the maximum allowable pressure PS; however a short duration pressure surge in keeping with the specifications laid down in 7.3 is allowable, where appropriate.

(2.11.3) Temperature monitoring devices

These devices must have an adequate response time on safety grounds, consistent with the measurement function.

2.12. External fire

Where necessary, pressure equipment must be so designed and, where appropriate, fitted with suitable accessories, or provision made for their fitting, to meet damage-limitation requirements in the event of external fire, having particular regard to its intended use.

3 MANUFACTURING

3

3.1. Manufacturing procedures

The manufacturer must ensure the competent execution of the provisions set out at the design stage by applying the appropriate techniques and relevant procedures, especially with a view to the aspects set out below.

(3.1.1) Preparation of the component parts

Preparation of the component parts (e.g. forming and chamfering) must not give rise to defects or cracks or changes in the mechanical characteristics likely to be detrimental to the safety of the pressure equipment.

(3.1.2) Permanent joining

Permanent joints and adjacent zones must be free of any surface or internal defects detrimental to the safety of the equipment.

The properties of permanent joints must meet the minimum properties specified for the materials to be joined unless other relevant property values are specifically taken into account in the design calculations.

For pressure equipment, permanent joining of components which contribute to the pressure resistance of equipment and components which are directly attached to them must be carried out by suitably qualified personnel according to suitable operating procedures.

For pressure equipment in categories II, III and IV, operating procedures and personnel must be approved by a competent third party which, at the manufacturer’s discretion, may be:

— a notified body,

— a third-party organisation recognised by a Member State as provided for in Article 13.

To carry out these approvals the third party must perform examinations and tests as set out in the appropriate harmonised standards or equivalent examinations and tests or must have them performed.

(3.1.3) Non-destructive tests

For pressure equipment, non-destructive tests of permanent joints must be carried out by suitable qualified personnel. For pressure equipment of categories III and IV, the personnel must be approved by a third-party organisation recognised by a Member State pursuant to Article 13.

(3.1.4) Heat treatment

Where there is a risk that the manufacturing process will change the material properties to an extent which would impair the safety of the pressure equipment, suitable heat treatment must be applied at the appropriate stage of manufacture.

(3.1.5) Traceability

Suitable procedures must be established and maintained for identifying the material making up the components of the equipment which contribute to pressure resistance by suitable means from receipt, through production, up to the final test of the manufactured pressure equipment.

3.2. Final assessment

Pressure equipment must be subjected to final assessment as described below.

(3.2.1) Final inspection

Pressure equipment must undergo a final inspection to assess visually and by examination of the accompanying documents compliance with the requirements of the Directive. Test carried out during manufacture may be taken into account. As far as is necessary on safety grounds, the final inspection must be carried out internally and externally on every part of the equipment, where appropriate in the course of manufacture (e.g. where examination during the final inspection is no longer possible).

(3.2.2) Proof test

Final assessment of pressure equipment must include a test for the pressure containment aspect, which will normally take the form of a hydrostatic pressure test at a pressure at least equal, where appropriate, to the value laid down in 7.4.

For category 1 series-produced pressure equipment, this test may be performed on a statistical basis.

Where the hydrostatic pressure test is harmful or impractical, other tests of a recognised value may be carried out. For tests other than the hydrostatic pressure test, additional measures, such as non-destructive tests or other methods of equivalent validity, must be applied before those tests are carried out.

(3.2.3) Inspection of safety devices

For assemblies, the final assessment must also include a check of the safety devices intended to check full compliance with the requirements referred to in 2.10.

3.3. Marking and labelling

In addition to the CE marking referred to in Article 15, the following information must be provided:

(a) for all pressure equipment:

— the name and address or other means of identification of the manufacturer and, where appropriate, of his authorised representative established within the Community,

— the year of manufacture,

— identification of the pressure equipment according to its nature, such as type, series or batch identification and serial number,

— essential maximum/minimum allowable limits;

(b) depending on the type of pressure equipment, further information necessary for safe installation, operation or use and, where applicable, maintenance and periodic inspection such as:

— the volume V of the pressure equipment in L,

— the nominal size for piping DN,

— the test pressure PT applied in bar and date,

— safety device set pressure in bar,

— output of the pressure equipment in kW,

— supply voltage in V (volts),

— intended use,

— filling ratio kg/L,

— maximum filling mass in kg,

— tare mass in kg,

— the product group;

(c) where necessary, warnings fixed to the pressure equipment drawing attention to misuse which experience has shown might occur.

The CE marking and the required information must be given on the pressure equipment or on a dataplate firmly attached to it, with the following exceptions:

— where applicable, appropriate documentation may be used to avoid repetitive marking of individual parts such as piping components, intended for the same assembly. This applies to CE marking and other marking and labelling referred to in this Annex;

— where the pressure equipment is too small, e.g. accessories, the information referred to in (b) may be given on a label attached to that pressure equipment;

— labelling or other adequate means may be used for the mass to be filled and the warnings referred to in (c), provided it remains legible for the appropriate period of time.

3.4. Operating instructions

(a) When pressure equipment is placed on the market, it must be accompanied, as far as relevant, with instructions for the user, containing all the necessary safety information relating to:

— mounting including assembling of different pieces of pressure equipment,

— putting into service,

— use,

— maintenance including checks by the user;

(b) Instructions must cover information affixed to the pressure equipment in accordance with 3.3, with the exception of serial identification, and must be accompanied, where appropriate, by the technical documents, drawings and diagrams necessary for a full understanding of these instructions;

(c) If appropriate, these instructions must also refer to hazards arising from misuse in accordance with 1.3 and particular features of the design in accordance with 2.2.3.

4 MATERIALS

4

Materials used for the manufacture of pressure equipment must be suitable for such application during the scheduled lifetime unless replacement is foreseen.

Welding consumables and other joining materials need fulfil only the relevant requirements of 4.1, 4.2(a) and the first paragraph of 4.3, in an appropriate way, both individually and in a joined structure.

4.1 Materials for pressurised parts must:

(a) have appropriate properties for all operating conditions which are reasonably foreseeable and for all test conditions, and in particular they should be sufficiently ductile and tough. Where appropriate, the characteristics of the materials must comply with the requirements of 7.5. Moreover, due care should be exercised in particular in selecting materials in order to prevent brittle-type fracture where necessary; where for specific reasons brittle material has to be used appropriate measures must be taken;

(b) be sufficiently chemically resistant to the fluid contained in the pressure equipment; the chemical and physical properties necessary for operational safety must not be significantly affected within the scheduled lifetime of the equipment;

(c) not be significantly affected by ageing;

(d) be suitable for the intended processing procedures;

(e) be selected in order to avoid significant undesirable effects when the various materials are put together.

(a) (a) The pressure equipment manufacturer must define in an appropriate manner the values necessary for the design calculations referred to in 2.2.3 and the essential characteristics of the materials and their treatment referred to in 4.1;

(b) the manufacturer must provide in his technical documentation elements relating to compliance with the materials specification of the Directive in one of the following forms:

— by using materials which comply with harmonised standards,

— by using materials covered by a European approval of pressure equipment materials in accordance with Article 11,

— by a particular material appraisal;

(c) for pressure equipment in categories III and IV, particular appraisal as referred to in the third indent of (b) must be performed by the notified body in charge of conformity assessment procedures for the pressure equipment.

4.3. The equipment manufacturer must take appropriate measures to ensure that the material used conforms with the required specification. In particular, documentation prepared by the material manufacturer affirming compliance with a specification must be obtained for all materials.

For the main pressure-bearing parts of equipment in categories II, III and IV, this must take the form of a certificate of specific product control.

Where a material manufacturer has an appropriate quality-assurance system, certified by a competent body established within the Community and having undergone a specific assessment for materials, certificates issued by the manufacturer are presumed to certify conformity with the relevant requirements of this section.

SPECIFIC PRESSURE EQUIPMENT REQUIREMENTS

In addition to the applicable requirements of sections 1 to 4, the following requirements apply to the pressure equipment covered by sections 5 and 6.

5 FIRED OR OTHERWISE HEATED PRESSURE EQUIPMENT WITH A RISK OF OVERHEATING AS REFERRED TO IN ARTICLE 3(1)

5

This pressure equipment includes:

— steam and hot-water generators as referred to in Article 3, section 1.2, such as fired steam and hot-water boilers, superheaters and reheaters, waste-heat boilers, waste incineration boilers, electrode or immersion-type electrically heated boilers, pressure cookers, together with their accessories and where applicable their systems for treatment of feedwater and for fuel supply, and

— process-heating equipment for other than steam and hot water generation falling under Article 3, section 1.1, such as heaters for chemical and other similar processes and pressurised food-processing equipment.

This pressure equipment must be calculated, designed and constructed so as to avoid to minimise risks of a significant loss of containment from overheating. In particular it must be ensured, where applicable, that:

(a) appropriate means of protection are provided to restrict operating parameters such as heat input, heat take-off and, where applicable, fluid level so as to avoid any risk of local and general overheating,

(b) sampling points are provided where required to allow evaluation of the properties of the fluid so as to avoid risks related to deposits and/or corrosion,

(c) adequate provisions are made to eliminate risks of damage from deposits,

(d) means of safe removal of residual heat after shutdown are provided,

(e) steps are taken to avoid a dangerous accumulation of ignitable mixtures of combustible substances and air, or flame blowback.

6 PIPING AS REFERRED TO IN ARTICLE 3, SECTION 1.3

6

Design and construction must ensure:

(a) that the risk of overstressing from inadmissible free movement or excessive forces being produced, e.g. on flanges, connections, bellows or hoses, is adequately controlled by means such as support, constraint, anchoring, alignment and pre-tension;

(b) that where there is a possibility of condensation occurring inside pipes for gaseous fluids, means are provided for drainage and removal of deposits from low areas to avoid damage from water hammer or corrosion;

(c) that due consideration is given to the potential damage from turbulence and formation of vortices; the relevant parts of 2.7 are applicable;

(d) that due consideration is given to the risk of fatigue due to vibrations in pipes;

(e) that, where fluids of Group 1 are contained in the piping, appropriate means are provided to isolate `take-off' pipes the size of which represents a significant risk;

(f) that the risk of inadvertent discharge is minimised; the take-off points must be clearly marked on the permanent side, indicating the fluid contained;

(g) that the position and route of underground piping is at least recorded in the technical documentation to facilitate safe maintenance, inspection or repair.

7 SPECIFIC QUANTITATIVE REQUIREMENTS FOR CERTAIN PRESSURE EQUIPMENT

7

The following provisions apply as a general rule. However, where they are not applied, including in cases where materials are not specifically referred to and no harmonised standards are applied, the manufacturer must demonstrate that appropriate measures have been taken to achieve an equivalent overall level of safety.

This section is an integral part of Annex 1. The provisions laid down in this section supplement the essential requirements of sections 1 to 6 for the pressure equipment to which they apply.

7.1. Allowable stresses

(7.1.1) Symbols

Re/t, yield limit, indicates the value at the calculation temperature of:

— the upper flow limit for a material presenting upper and lower flow limits,

— the 1.0% proof strength of austenitic steel and non-alloyed aluminium,

— the 0.2% proof strength in other cases.

Rm/20 indicates the minimum value of the ultimate strength 20°C.

Rm/t designates the ultimate strength at the calculation temperature.

(7.1.2) The permissible general membrane stress for predominantly static loads and for temperatures outside the range in which creep is significant must not exceed the smaller of the following values, according to the material used:

— in the case of ferric steel including normalised (normalised rolled) steel and excluding fine-grained steel and specially heat-treated steel, 2/3 of Re/t and 5/12 of Rm/20

— in the case of austenitic steel:

  — if its elongation after rupture exceeds 30%, 2/3 of Re/t

  — or, alternatively, and if its elongation after rupture exceeds 35%, 5/6 of Re/t and 1/3 of Rm/t;

— in the case of non-alloy or low-alloy cast steel, 10/19 Re/t and 1/3 of Rm/20;

— in the case of aluminium, 2/3 of Re/t;

— in the case of aluminium alloys excluding precipitation hardening alloys 2/3 of Re/t and 5/12 of Rm/20.

7.2. Joint coefficients

For welded joints, the joint coefficient must not exceed the following values:

— for equipment subject to destructive and non-destructive tests which confirm that the whole series of joints show no significant defects: 1,

— for equipment subject to random non-destructive testing: 0.85,

— for equipment not subject to non-destructive testing other than visual inspection: 0.7.

If necessary, the type of stress and the mechanical and technological properties of the joint must also be taken into account.

7.3. Pressure limiting devices, particularly for pressure vessels

The momentary pressure surge referred to in 2.11.2 must be kept to 10% of the maximum allowable pressure.

7.4. Hydrostatic test pressure

For pressure vessels, the hydrostatic test pressure referred to in 3.2.2 must be no less than:

- that corresponding to the maximum loading to which the pressure equipment may be subject in service taking into account its maximum allowable pressure and its maximum allowable temperature, multiplied by the coefficient 1.25 or
- the maximum allowable pressure multiplied by the coefficient 1.43, whichever is the greater.

7.5. Material characteristics

Unless other values are required in accordance with other criteria that must be taken into account, a steel is considered as sufficiently ductile to satisfy 4.1(a) if, in a tensile test carried out by a standard procedure, its elongation after rupture is no less than 14% and its bending rupture energy measured on an ISO IV test-piece is no less than 27 J, at a temperature not greater than 20°C but not higher than the lowest scheduled operating temperature.