



Pressure equipment—Hazard levels



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Australian Standard[®]

Pressure equipment—Hazard levels

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PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee ME-001, Pressure Equipment, to supersede AS 4343—2005.

After consultation with stakeholders in both countries, Standards Australia and Standards New Zealand decided to develop this Standard as an Australian Standard rather than an Australian/New Zealand Standard.

The objective of this revision is to include improvements suggested by users of this Standard.

Significant changes are as follows:

- (a) Adoption of the numerical method of calculating hazard level. This has been done to remove the inconsistencies that arise when calculating modified PV values and remove the unneeded conservatism in the hazard level.
- (b) Clarification of parameters used to calculate hazard levels—removal of some inconsistency between design and operating parameters.
- (c) Revision of fluid criteria to remove anomalies and remove contradictory requirements in the Standard.
- (d) Identifying the role of purchasers and owners in determining hazard levels.

In determining and allocating the hazard level values, input has been received from regulatory authorities and users, and the practices adopted in industrialized countries and those in the European Union Pressure Equipment Directive have been taken into account.

The impact of this revision is expected to be negligible, except to resolve a number of issues raised in the use of the Standard, and to facilitate its use. Specifically, the adoption of the calculation method for determining hazard level simplifies and enhances the automation of hazard level calculation.

The basis for hazard level in this Standard is the maximum amount of stored energy that could be released in 5–10 seconds and the level of exposure. For boilers and pressure vessels, calculation involves pressure and volume, while for piping, pressure and diameter are used similarly to that in EU-PED for ease of use.

Changes introduced in this edition do not require alteration to hazard level of existing pressure equipment determined in accordance with the previous edition of AS 4343.

The use (or implementation) of this Standard is subject to the requirements of the applicable regulator, for example, in some States and Territories the superseded Standard may apply until regulations are amended.

The term ‘normative’ has been used in this Standard to define the application of the appendix to which it applies. A ‘normative’ appendix is an integral part of a Standard.

Statements expressed in mandatory terms in Notes to Tables are deemed to be requirements of this Standard.

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STANDARDS AUSTRALIA

Australian Standard

Pressure equipment—Hazard levels

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE

This Standard specifies criteria for determining the hazard levels of various types of pressure equipment to AS/NZS 1200. It also classifies fluids for use with pressure equipment.

1.2 OBJECTIVE

This Standard is intended to provide a uniform, practical, generic system for assessing the level of hazard associated with various pressure equipment, that is, the potential to harm people, or damage property and the environment, as a consequence of pressure equipment loss of containment by rupture, serious leakage or collapse.

These hazard levels may be used for a number of purposes, including—

- (a) selecting the appropriate levels of control for safety purposes and risk management;
- (b) providing a basis for registration of boilers and pressure vessels and their design with authorities; and
- (c) providing a basis for in-service inspection of pressure equipment.

1.3 APPLICATION

This Standard is intended to be used in the design, manufacture, inspection, conformity assessment, use and ultimate disposal of pressure equipment.

This Standard is not intended to apply to gas cylinders. For further information, see AS 2030 series and ADG Code.

The controls at each of the above phases should be proportionate to the hazard that the equipment presents to provide an overall acceptable level of risk to the community.

This Standard uses the main characteristics of pressure equipment hazards to determine the hazard level. In certain cases, the hazard levels determined by this Standard might need to be increased based on sound engineering rationale.

NOTE: State and Territory regulations usually reference this Standard and may require design registration for boilers and pressure vessels of hazard levels A, B, C and D and item registration of such equipment with hazard levels A, B or C (see relevant State and Territory regulations for pressure equipment).

The hazard level should be recorded on the equipment and the associated documentation.

The purchaser shall supply the necessary information so as to allow the appropriate hazard level to be determined.

Where there is a fundamental change in design condition, such as the design pressure or the location of the pressure equipment, the hazard level shall be reviewed and the classification shall either be reaffirmed or changed accordingly.

1.4 REFERENCED DOCUMENTS

The documents referred to in this Standard are listed in Appendix A.

1.5 DEFINITIONS

For the purposes of this Standard, the definitions given in AS 4942 and the following apply.

1.5.1 Hazard level

Categorization of pressure equipment into one of five groups (A, B, C, D, E) that have similar potentials to cause harm to persons, property and the environment, based on fluid contents, design parameters and working environment.

1.5.2 Pressure equipment

Boilers, pressure vessels and pressure piping as defined in AS/NZS 1200.

SECTION 2 HAZARD LEVELS OF PRESSURE EQUIPMENT

2.1 HAZARD LEVELS

2.1.1 Typical hazard levels

Typical examples of hazard levels A, B, C, D and E are as follows:

- (a) Hazard level A (high hazard)—applies to large vessels, (e.g. 4000 tonne ethane vessels, 7000 tonne butane or propane vessels, 25 000 tonne ammonia vessels, 200 tonne chlorine vessels and large power boilers) and also some vessels containing quantities above the threshold quantities for major hazard facilities as listed in Table 3.1.
- (b) Hazard level B (medium hazard)—applies to most shop fabricated boilers and pressure vessels.
- (c) Hazard levels C and D (low and extra low hazards, respectively)—apply to small pressure equipment or equipment with low hazard contents (e.g. small air receivers).
- (d) Hazard level E (negligible hazard)—covers all negligible-hazard pressure equipment not classified in hazard levels A, B, C and D. This equipment is usually exempt from special regulatory control but is covered by general plant safety regulations.

2.1.2 Determining hazard level

The hazard levels A, B, C, D and E of various types of pressure equipment shall be determined from Equation 2.1 or Appendix B using the following procedure or equivalent:

- (a) Identify the values of—
 - (i) P —the design pressure, in megapascals;
 - (ii) V —(for all equipment except piping) the volume, in litres; and
 - (iii) D —(for piping only) the nominal pipe diameter, in millimetres.

NOTE: D is used to calculate PD , see Clauses 2.2.5 and 2.2.6.
- (b) Identify the contents of the equipment, and whether they will be gas or liquid (see Clauses 2.2.2, 2.2.3 and 3.2). Use this information to determine compressibility and mass factor (F_c) in Equation 2.1.
- (c) Determine the fluid type of the contents using Section 3 and Table 3.1. Use this information to determine contents factor (F_f) in Equation 2.1.
- (d) Review Clauses 2.2.6 to 2.2.9 and 2.2.11 to 2.2.13 to determine any location or service level factor (F_s) applicable.

For pressure vessels and boilers the preferred method for determining hazard levels is the numerical method using Equation 2.1.

For pressure piping and a conservative method for determining hazard levels of other pressure equipment, the tabular method provided in Appendix B may be used.

2.2 NUMERICAL METHOD OF DETERMINING HAZARD LEVELS

2.2.1 Method

The hazard level value (H) shall be calculated from Equation 2.1 (see Clause 2.1.2) and using relevant clauses from Clause 2.2.2 to 2.2.6.

$$H = PVF_c F_f F_s \quad \dots 2.1$$

where

- H = hazard level value, in megapascal litres
- P = design pressure, in megapascals
- V = volume (see Clause 2.2.4), in litres
- F_c = compressibility and mass factor (see Clause 2.2.2)
 - = 0.1 for vacuum
 - = 1 for liquid
 - = 10 for gas
- F_f = contents (fluid) factor (see Clause 2.2.2)
 - = $\frac{1}{3}$ for non-harmful liquids (except as provided in Clause 2.2.6)
 - = 1.0 for non-harmful gas
 - = 3 for harmful liquid or gas
 - = 10 for very harmful liquid or gas
 - = 1000 for lethal liquid or gas
- F_s = location or service factor
 - = 1 unless one of the following conditions apply
 - = 3 for one of the conditions in Clause 2.2.5(a)
 - = 10 for more than one of the conditions in Clause 2.2.5(a)
 - = 30 for $P > 50$ MPa [see Clause 2.2.5(b)]
 - = $\frac{1}{3}$ for one of the conditions in Clause 2.2.5(c)
 - = 1/10 for more than one of the conditions in Clause 2.2.5(c)
 - = 3 for human occupancy vessels [see Clause 2.2.5(a)]

2.2.2 Terms relating to contents

The classification of contents into the four groups in this Clause (2.2.2) applies specifically for this Standard and is based on the ADG Code (for dangerous goods), Model Work Health and Safety Regulations, Safe Work Australia and NOHSC:1008. Terms used by these references are shown in *italics*. The expected concentrations referenced as follows are for the contents of the pressure equipment:

- (a) *Lethal contents (LG/LL)*—containing a very toxic substance or highly radioactive substance which, under design concentration and operating conditions, is capable on leakage of causing death or serious irreversible harm to persons from a single short-term exposure to a very small amount of the substance by inhalation or contact, even when prompt restorative measures are taken. Examples of such substances are acrolein, chloropicrin, and other substances with an exposure limit usually ≤ 0.1 ppm by volume (or equivalent) to NOHSC:1003 or other relevant Standard.
- (b) *Very harmful contents (VHG/VHL)*—containing a substance which, under design concentration and operating conditions, is classified as extremely or highly flammable, very toxic, toxic, harmful, oxidizing, explosive, self-reactive, corrosive, or harmful to human tissue, but excluding lethal contents.

- (c) *Harmful contents (HG/HL)*—containing a substance which, under design concentration and operating conditions, is classified as a combustible liquid or fluid irritant to humans, or is harmful to the environment, the contents above 90°C, or below –30°C, but excluding lethal or very harmful fluids.
- (d) *Non-harmful contents (NHG/NHL)*—containing substances which are not covered by lethal, very harmful or harmful, that is normally not harmful, except for pressure effects and concentration effects (e.g. oxygen depletion).

For mixed contents, the harmfulness of the mixture may be determined from the criteria specified in NOHSC:1008 (e.g. a mixture of 5% cyanide in water would not be classified as lethal).

2.2.3 Terms relating to fluids

Where a substance meets more than one of the following descriptions, it shall be treated as that resulting in the most severe requirement:

- (a) *Substance*—includes gas, liquid, solid or mixture. A fluid is a gas, liquid or mixture; it may contain entrained solids, e.g. slurries and fluidized solids.
- (b) *Harmful to human tissue*—describes a substance which is capable of harming the skin, eyes or exposed mucous membrane so that irreversible damage may be done unless prompt restorative measures are taken, including flushing with water, use of antidotes or medicines. It includes oxidizing, radioactive and corrosive fluids.
- (c) *Flammable gas*—dangerous goods of Class 2.1 of the ADG Code (i.e. a gas capable of being ignited and burned in air at atmospheric pressure).
- (d) *Flammable liquid*—dangerous goods of Class 3 of the ADG Code (i.e. generally with a flashpoint not greater than 61°C, or a liquid at a service temperature at or above its flashpoint).
- (e) *Combustible liquid*—a liquid capable of burning but with a flashpoint above 61°C or at a service temperature below its flashpoint.
- (f) *Gas*—see Clause 3.2.4.
- (g) *Liquid*—see Clause 3.2.5.
- (h) *Oxidizing substance*—dangerous goods of Class 5 of the ADG Code.
- (i) *Irritant*—substance capable or likely to cause temporary discomfort, but unlikely to cause permanent injury or illness. This includes Class 2 or 6.1 substances at concentrations which are not hazardous to humans, and also skin sensitizing substances.
- (j) *Toxic (or poisonous) substance*—dangerous goods of Class 2.3 or 6 of the ADG Code (e.g. chlorine, anhydrous ammonia or infectious substances). Also includes some carcinogenic, mutagenic and teratogenic substances in accordance with NOHSC:1008.
- (k) *Very toxic substance*—a toxic substance classified by NOHSC:1008 as very toxic.
- (l) *Radioactive substance*—dangerous goods of Class 7 of the ADG Code.
- (m) *Corrosive substance*—dangerous goods of Class 8 of the ADG Code.

2.2.4 Volume to be used in PV calculations

The volume (V) to be used in calculating PV values shall be net internal volume, in litres, as follows:

- (a) *General vessels*—use volume of vessel (i.e. volume which can be filled with fluid under pressure).
- (b) *Multi-chamber vessels*—
 - (i) chambers normally open to each other, treat as one vessel, i.e. use total volume; or
 - (ii) chambers normally isolated, treat as separate vessels.
- (c) *Vessel containing fluid in more than one phase (e.g. gas and liquid)*—assume the vessel is full of gas if liquid is above its atmospheric pressure boiling point, otherwise select greater hazard based on maximum volume of liquid or gas.
- (d) *Open container with pressurized jacket*—use volume of jacket.
- (e) *Coil or similar type heater/cooler*—use the total volume or, if desired, the tubular portion may be regarded as a pipe with diameter equal to the tube diameter.
- (f) *Boilers*—use the volume of pressurized fluid in the shell or largest drum. If the boiler has no shell or drum, use the diameter D of the largest tube to determine hazard level as for a pipe.
- (g) *Shell and tube heat exchangers*—calculate the volumes (and relevant hazard levels) of the shell and tube/plenums separately.
- (h) *Refrigeration and air conditioning systems*—treat each vessel and tubing separately as in Item (f) above.

2.2.5 Modifications to values of PV or PD for special conditions

The calculated value of PV or PD shall be multiplied as follows:

- (a) By a factor of 3 when one of the following conditions apply, or by a factor of 10 when two or more of the conditions apply (for piping the factors are 1.5 and 2, respectively):
 - (i) Fired equipment heated by the products of combustion, electric heating and highly focussed solar heating (e.g. pressurized hot water heater, fired oil heater) but not equipment heated by steam, air, hot water or microwave.
Factor is not required when using Table B1 to calculate the hazard level as it is already incorporated in the tabular values.
 - (ii) Equipment fitted with quick-actuating closures or doors, except for vacuum vessels.
 - (iii) Equipment sited in a facility which comes under the control of the major hazard facility legislation, except where a risk assessment establishes that a higher hazard level should be adopted for the equipment.
 - (iv) Road tankers and transportable vessels when transporting their contents under pressure with volumes greater than 200 L. Conditions (a)(i) to (iii) are not intended to apply additionally.
 - (v) For pressure vessels intended for human occupancy and with a design pressure in excess of 0.01 MPa, and non-harmful gas. Conditions (a)(i) to (iii) are not intended to apply additionally.
- (b) By a factor of 30 for pressure vessels (5 for piping) with design pressure exceeding 50 MPa.

- (c) By a factor of 1/3 when one of the following conditions (i) to (iii) apply, or by a factor of 1/10 when two or more items apply (these factors do not apply to fired boilers), and for piping the factors are 1/1.5 and 1/2 respectively:
- (i) Equipment is located in an area where employees are not permanently stationed but may periodically visit for servicing and the like, and which is remote from other buildings, processes or persons.
 - (ii) Piping is buried or is covered in trenches, or pressure vessels are sufficiently safeguarded (e.g. purpose built bunkers).
 - (iii) Maximum membrane stress for vessels and piping based on corroded thickness does not exceed 50 MPa, 20% of specified minimum yield stress at design temperature, or 50% of permissible design strength (f), whichever is less.

NOTE: Suppliers, owners or users (as the case may be) of pressure equipment installed on major hazard facility sites should ensure that the relevant modification factor has been applied by the designer. A retrospective application of this factor may necessitate the registration of plant design and/or registration of item of plant of the particular equipment be completed with the relevant WHS authority.

2.2.6 *PV* and *PD* limits

Pressure equipment with $PV < 100\,000$ MPa.L or $PD < 2300$ MPa.mm (before multiplying factors are applied) with non-harmful liquid at a temperature above 0°C but not exceeding 65°C shall be classified as hazard level E.

2.2.7 Combined conditions

All three conditions of volume or diameter, pressure and the product PV or PD shall be met before a hazard level is determined except for the conditions given in Clauses 2.2.10, 2.2.11 and 2.2.12.

2.2.8 Hazard level *PV* and *PD* limits

If the product $P \times V$ or $P \times D$ equals the value of boundary between two categories, then the lower category shall apply.

2.2.9 Multiple hazard levels

Where pressure equipment can be classified into more than one hazard level (e.g. multi-chamber vessels, shell and tube heat exchangers), the higher hazard level shall be selected.

2.2.10 Applicability

All pressure vessels which fall above the application curves in AS 1210, should be classified in accordance with this Standard. The hazard level for pressure vessels having a design pressure not exceeding 0.05 MPa (or 0.05 MPa vacuum for vacuum vessels), but which have a pressure–diameter relationship above the application curves in AS 1210 shall be determined using a PV value equal to 0.3 times (0.1 times for vacuum vessels) the actual PV of the vessel).

2.2.11 Lethal gas

For pressure vessels with lethal gas (Item 1.1 of Table B1, Appendix B) hazard level D shall apply where $PV \leq 0.1$ MPa.L.

2.2.12 Pressure piping

For pressure piping, where $D \leq$ the nominal size in Column 3, Items 5.1 to 5.4 of Table B1, Appendix B and $P > 10$ MPa, then the hazard level shall be selected for the appropriate contents and value of PD .

Piping from pressure equipment up to their first point of flange or point of isolation from the outside diameter of pressure equipment (whichever is the lesser) shall take the most severe hazard level of the pressure equipment or the piping.

Where two items of pressure equipment are designed to different design Standards (e.g. pressure vessels and attached piping), the change of hazard level shall occur at the change of scope of the design Standard.

2.2.13 Determine hazard level from hazard level value

The hazard level shall be determined from the hazard level value (see Equation 2.1) as given in Table 2.1.

TABLE 2.1
HAZARD LEVEL

Hazard level value (H)	Hazard level
$<10^{2.5}$	E
$\geq 10^{2.5}$ to $<10^3$	D
$\geq 10^3$ to $<10^4$	C
$\geq 10^4$ to $<10^{8.5}$	B
$>10^{8.5}$	A

NOTE: One hazard level (H) is approximately equal to 1 kJ equivalent energy or 0.001 kg of TNT.

SECTION 3 FLUID TYPES AND CLASSES

3.1 GENERAL

Table 3.1 lists the fluid types from this Standard and the fluid class from the ADG Code, for various fluids conveyed or contained in pressure equipment.

This information is intended to assist designers, manufacturers, users and others in calculating hazard levels and using the following documents:

- (a) AS 1210, AS 1228, AS 3059, AS 4041, AS 4458, AS/NZS 3788 and AS 3920, that specify design, fabrication and test requirements for different fluid types.
- (b) State and Territory regulations for pressure equipment, which may adopt hazard levels of this Standard.
- (c) ADG Code, which specifies requirements for land transport of dangerous goods and classifies these goods.
- (d) Model Work Health and Safety Regulations, Safe Work Australia and NOHSC:2007.
- (e) NOHSC:1014 and NOHSC:2016.

NOTE: If a fluid is not listed in Table 3.1, see Table 3.2 and relevant material safety data sheet (MSDS) to determine fluid type.

3.2 USE OF TABLE 3.1

3.2.1 Column 1

Column 1 identifies the fluid by the United Nation number (UN) listed in the ADG Code.

3.2.2 Column 2

Column 2 alphabetically lists the name of gases and liquids as in the ADG Code and also some substances piped as solutions or fluidized substances (e.g. slurries in liquids or powder in air or other gases).

3.2.3 Columns 3 and 4

Columns 3 and 4 identify type and class (see Table 3.2 for basis).

3.2.4 Gas

For this Standard, gas is any Class 2 dangerous good as specified in ADG Code, (i.e. completely gaseous at 20°C and 101.3 kPa absolute or at 50°C has a vapour pressure greater than 300 kPa absolute). Gas includes the following:

- (a) Compressed gas which is entirely gaseous at 20°C and 101.3 kPa absolute.
- (b) Liquefied gas which is partially liquid at 20°C.
- (c) Refrigerated liquefied gas which is partially liquid because of its low temperature.
- (d) Gas in solution which is a compressed gas dissolved in a solvent.
- (e) Any liquid when it is above its atmospheric pressure boiling point, e.g. pressurized high-temperature water which flashes to steam on release of pressure.
- (f) Fluidized liquids or solids in compressed air or other gas.

3.2.5 Liquid

For this Standard, liquid is any substance at a temperature below its atmospheric pressure boiling point (e.g. water $<100^{\circ}\text{C}$). Liquid also includes solids fluidized in liquids (e.g. slurries). For the ADG Code, liquid is any substance with melting point $\leq 20^{\circ}\text{C}$ at 101.3 kPa absolute and which is not a gas.

3.2.6 Change of fluid type for design temperature

For this Standard, the fluid type changes depending on the design temperature as follows:

- (a) Above 90°C or below -30°C , the fluid type listed in Table 3.1 is changed from non-harmful gas to harmful gas, and from non-harmful liquid to harmful liquid. Air is an exception to the above, and this range is increased to 120°C as a result of the cooling provided by the Joule-Thompson effect, reducing temperature hazard to personnel.
- (b) Above their atmospheric pressure boiling point, liquids are treated as gas.
- (c) Above their flashpoint, liquids are treated as flammable gas.

3.2.7 Change of fluid type for mixture and different concentrations

For change of fluid type for mixture and different concentrations at the time and location of release from pipe or equipment, see ADG Code or Hazardous Substances Information System, Safe Work Australia.

3.2.8 Change of fluid type for pressure

For non-toxic, non-flammable gas (ADG Code Class 2.2) at pressure ≤ 300 kPa treat as non-harmful gas.

3.3 BASIS OF FLUID TYPES

Fluids in Table 3.1 have been allocated a 'fluid type' number or letters on the following basis:

- (a) Assumes 100% concentration unless noted otherwise.
- (b) Alignment with the class system of the ADG Code, except where temperature, concentration, or pressure necessitate modification (see Clauses 3.2.6, 3.2.7 and 3.2.8).
- (c) Alignment with NOHSC:1003, NOHSC:1008 and Hazardous Substances Information System, Safe Work Australia.

This classification is intended to assist in determining hazards affecting—

- (i) health and safety of persons by inhalation, ingestion, skin or eye contact, primarily with short-term exposure; and
- (ii) person, property and environment by blast, flammability, corrosion, contamination and the like.

NOTE: Corrosion effect on pressure equipment material is assumed minor, as design is required to cater for these effects.