

AS 2593:2021



STANDARDS
Australia



Boilers — Safety management and supervision systems



AS 2593:2021

This Australian Standard® was prepared by ME-001, Pressure Equipment. It was approved on behalf of the Council of Standards Australia on 01 March 2021.

This Standard was published on 19 March 2021.

The following are represented on Committee ME-001:

- Australasian Institute of Engineer Surveyors
- Australian Aluminium Council
- Australian Industry Group
- Australian Institute for Non-Destructive Testing
- Australian Institute for the Certification of Inspection Personnel
- Australian Institute of Petroleum
- Bureau of Steel Manufacturers of Australia
- Compressed Air Association of Australasia
- Energy Networks Australia
- Engineers Australia
- Gas Energy Australia
- Insurance Council of Australia
- Materials Australia
- National Association of Testing Authorities Australia
- Office of Industrial Relations, Qld
- Better Regulation Division (Fair Trading, SafeWork NSW, TestSafe)
- SafeWork SA
- Weld Australia
- WorkSafe Division — Department of Mines, Industry Regulation and Safety (DMIRS), WA
- Victorian WorkCover Authority (WorkSafe Victoria)

This Standard was issued in draft form for comment as DR AS 2593:2019.

Keeping Standards up-to-date

Ensure you have the latest versions of our publications and keep up-to-date about Amendments, Rulings, Withdrawals, and new projects by visiting:

www.standards.org.au

ISBN 978 1 76113 242 1

Boilers — Safety management and supervision systems

Originated as AS 2593—1983 and part of AS 3653—1993.
Previous edition AS 2593—2004.
Sixth edition AS 2593:2021.

© Standards Australia Limited 2021

All rights are reserved. No part of this work may be reproduced or copied in any form or by any means, electronic or mechanical, including photocopying, without the written permission of the publisher, unless otherwise permitted under the Copyright Act 1968 (Cth).

Preface

This Standard was prepared by the Australian members of Standards Australia/Standards New Zealand Committee ME-001, Pressure Equipment to supersede AS 2593—2004, *Boilers — Safety management and supervision systems*.

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

The inclusion of roles and responsibilities in AS 2593:2021 was approved by the Standards Development and Accreditation Committee on 4 February 2021, as a one-off exemption to the directives of Standardisation Guide 009, Preparation of Standards for Legislative Adoption.

The objective of this Standard is to —

- (a) specify clear, safe, minimum requirements for the operation of all boilers and other devices;
- (b) assist all parties involved in the provision of safe boilers and other devices;
- (c) provide a basis for determination of the boiler attendance category with any supervision, checking, testing and maintenance with a view to support safety; and
- (d) specify emission requirements that will support an overall reduction in greenhouse gas emissions from boilers.

The major changes made in this revision include —

- (i) defining the criteria for different boiler attendance categories with limited attendance operation no longer being part of this Standard;
- (ii) specifying that devices connected to the boiler, such as any economizer or superheater or deaerator, are also to be treated as part of any boiler in the attendance category;
- (iii) defining the minimum safety requirements for any economizer or superheater or deaerator when connected to a boiler;
- (iv) defining the minimum safety requirements for boilers with greater than 500 kW power output with a boiler attendance category of “unattended”, to have only one flame safeguard of the continuous self-checking type equipped with a flame detector;
- (v) defining the minimum criteria for feedwater pumps and feedwater tanks in relation to any necessary consideration of capacity and net positive suction head (NPSH) requirement;
- (vi) defining the minimum criteria for feedwater tanks in relation to low-water safety devices fitted in the feed tank (or other feedwater storage device) for all boiler power outputs with a boiler attendance category of “unattended”;
- (vii) defining the requirements for automatic modulating water level control in all boilers exceeding 1 MW power output;
- (viii) defining installation requirements for vertical boiler types fitted with down-fired packaged burners that include sufficient head room and mechanical lifting equipment to allow for safe and complete burner removal, and to provide platforms, walkways, stairways, and ladders to enable all round access to the boiler for its safe operation, inspection, maintenance and complete burner removal; and
- (ix) specifying that the combustion equipment for all boilers is to be capable of effecting satisfactory combustion and provide for reduced greenhouse gas emissions.

Users of this Standard are reminded that it has no legal authority in its own right, but may acquire legal standing in one or more of the following circumstances:

- (A) Adoption by a government authority.
- (B) Adoption by a purchaser as a required standard of construction when placing a contract.
- (C) Adoption where a manufacturer states that a boiler and other devices are in accordance with this Standard.

The terms “normative” and “informative” are used in Standards to define the application of the appendices to which they apply. A “normative” appendix is an integral part of a Standard, whereas an “informative” appendix is for information and guidance only.

Contents

Preface	ii
Section 1 Scope and general	1
1.1 Scope	1
1.2 Application	1
1.3 Normative references	2
1.4 Terms and definitions	3
1.5 New designs, materials and construction methods	6
Section 2 Design and construction for all types of boilers and other devices	8
2.1 General requirements	8
2.1.1 Basic design	8
2.1.2 Tube diameter	8
2.1.3 Water level indicators	8
2.2 Steam boilers (other than electric boilers)	8
2.2.1 General	8
2.2.2 Water-tube steam boilers	8
2.2.3 Steam boilers other than water-tube or electric boilers	8
2.3 Hot water boilers	9
2.3.1 General	9
2.3.2 Hot water systems	9
2.4 Waste heat boilers	9
2.5 Electric boilers	10
2.6 Economizers	10
2.7 Superheaters	10
2.8 Deaerators	10
Section 3 Boiler management system for unattended boilers	11
3.1 General	11
3.2 Fail-safe techniques	11
3.3 Temperature suitability of components	11
3.4 Combustion management	11
3.4.1 General	11
3.4.2 Power-operated fuel valves	12
3.4.3 Flame detectors	12
3.5 Water management systems	12
3.5.1 Blowdown	12
3.5.2 Feedwater tanks	12
3.5.3 Steam boilers, other than coil-type forced circulation boilers and electric boilers	13
3.5.4 Water management systems for coil-type forced circulation boilers	15
3.5.5 Water management systems for hot water boilers	15
3.5.6 Water management systems for waste heat boilers	16
3.5.7 Water management systems for electric boilers	16
3.6 Electrical power isolation	17
3.7 Power failure and overheating protection	18
3.7.1 Design and construction	18
3.7.2 Hazard of overheating	18
3.8 Electrical control equipment	18
3.9 Alarms	18
3.10 Visual display for boilers up to and including a power output of 500 kW	19
3.10.1 General	19
3.10.2 Fuel-fired boilers	19
3.10.3 Water level security	19
3.11 Visual display for boilers exceeding a power output of 500 kW	20
3.11.1 General	20
3.11.2 Fuel-fired boilers	20

3.11.3	Water level security.....	20
3.12	Combustion equipment for fuel-fired boilers.....	21
3.12.1	General	21
3.12.2	Alternative firing of main fuels.....	21
3.12.3	Alternative firing of main fuels, fluidized bed combustion boilers.....	21
3.12.4	Supplementary fuel firing.....	21
3.12.5	Combustion characteristics.....	22
3.12.6	Secure mounting.....	22
3.12.7	Heat effects to combustion equipment.....	23
3.12.8	Visual flame-checking provisions	23
3.13	Multiple-burner installations	23
3.14	Air supply and control system	23
3.14.1	General	23
3.14.2	Start flame or pilot ignition	23
3.14.3	Ignition electrodes	23
3.14.4	High voltage components.....	23
3.14.5	Location and fixing.....	24
3.14.6	Start gas rate.....	24
3.15	Main fuel firing rate.....	24
3.15.1	Low-fire rate operation.....	24
3.15.2	Low-fire interlock	24
3.15.3	Main flame turn down and modulation	24
3.15.4	Main flame firing rate	25
Section 4	Additional requirements for oil-fired, gas-fired and solid-fuel-in-suspension-fired unattended boilers	26
4.1	Application.....	26
4.2	Operational requirements for oil, gas and solid-fuel-in-suspension management systems for boilers with a power output above 500 kW	26
4.2.1	Pre-start safety interlocks.....	26
4.2.2	Starting and operating sequence	26
4.2.3	Fault shutdown and lockout condition for other than forced circulation boilers.....	27
4.2.4	Fault complete shutdown and lockout condition for other than forced circulation boilers.....	28
4.2.5	Purging	28
4.2.6	Flame — Extraneous light.....	28
4.2.7	Fuel admission	28
4.2.8	Spark ignition period	28
4.2.9	Flame establishment period for spark ignition.....	28
4.2.10	Start flame proving.....	29
4.2.11	Main flame establishment period for start flame ignition.....	29
4.2.12	Ignition failure	29
4.2.13	Flame failure response	29
4.2.14	Controlled shutdown	29
4.3	Operational requirements for oil, gas and solid-fuel-in-suspension management systems for boilers up to and including a power output of 500 kW.....	29
4.3.1	Pre-start safety interlocks.....	29
4.3.2	Starting and operating sequence	30
4.3.3	Fault shutdown and lockout condition for other than forced circulation boilers.....	31
4.3.4	Flame — Extraneous light.....	31
4.3.5	Fuel admission	31
4.3.6	Spark ignition period	31
4.3.7	Flame establishment period for spark ignition.....	31
4.3.8	Start flame proving.....	31
4.3.9	Main flame establishment period for start flame ignition	31
4.3.10	Ignition failure	32
4.3.11	Flame failure response	32

4.3.12	Controlled shutdown	32
4.4	Specific requirements for oil-fired boilers.....	32
4.4.1	Oil fuel pre-treatment.....	32
4.4.2	Gas pilot.....	32
4.4.3	Controls and safety devices	32
4.4.4	Fuel bypass valve	33
4.4.5	Steam and air atomized burners.....	33
4.4.6	Fuel oil installation.....	33
4.5	Specific requirements for gas-fired boilers.....	33
4.6	Specific requirements for solid-fuel-in-suspension-fired boilers	33
4.6.1	General.....	33
4.6.2	Controls and safety devices	33
4.6.3	Valve and piping arrangement	34
4.6.4	Fuel quality	34
Section 5	Additional requirements for solid-fuel-fired (bed or grate) unattended boilers.....	35
5.1	Application.....	35
5.2	Operational requirements for solid fuel (bed or grate) management systems	35
5.2.1	Pre-start interlocks.....	35
5.2.2	Start-up	35
5.2.3	Controlled shutdown.....	36
5.2.4	Fault shutdown and lockout.....	36
5.2.5	Purging	36
5.3	Specific requirements for solid-fuel-fired (bed or grate) boilers	36
5.3.1	General.....	36
5.3.2	Fuel quality	36
5.3.3	Combustion equipment.....	36
5.3.4	Ignition of bed fuel	36
5.3.5	Controls and safety devices	37
5.3.6	Burn-back protection.....	37
5.3.7	Power failure protection	37
5.3.8	Solid fuel and residue handling plant	37
Section 6	Inspection, checking, testing and maintenance for unattended boilers	38
6.1	General.....	38
6.2	Periodic checking, testing and maintenance personnel.....	38
6.3	Checking, testing and maintenance procedures	38
6.3.1	Program and procedures	38
6.4	Checking and testing.....	38
6.4.1	Additional checking and testing — Unattended operation.....	38
6.4.2	Daily checking and testing — Unattended operation	39
6.4.3	Weekly checking and testing — Unattended operation.....	39
6.4.4	Periodic checking, testing and maintenance — Unattended operation	40
6.4.5	Changes to procedures.....	40
6.4.6	Log — Daily and weekly checking — Unattended operation.....	40
6.4.7	Records — Periodic checking, testing and maintenance.....	41
6.5	Yearly and required maintenance — Unattended operation.....	41
6.5.1	Required maintenance	41
6.5.2	Yearly inspection, testing and maintenance	41
6.5.3	Records — Yearly and required maintenance	42
6.6	Retention of records.....	42
6.7	Maintenance checklist/instructions	42
Section 7	Attended boilers.....	43
7.1	General.....	43
7.2	Electrical control equipment.....	43
7.3	Power failure and overheating protection.....	43
7.4	Management system	43
7.5	Manual operation	43
7.6	Automatic operation	43

7.6.1	General	43
7.6.2	Automatic water level management	44
7.6.3	Alarms	44
7.6.4	Controls and boiler mountings	44
7.7	Low-water cut-out and alarm	44
7.8	Water feed control	44
7.8.1	General	44
7.8.2	Modulating water control	45
7.9	Operational supervision	45
7.10	Testing and checking programs	45
7.10.1	General	45
7.10.2	Checks	45
7.10.3	Records — Checking Attended operation	45
Section 8	Water level management and security for all types of boilers	47
8.1	Water level devices and interlocks	47
8.1.1	General	47
8.1.2	Electrical requirements	47
8.2	Water level indicators	47
8.2.1	Number and type	47
8.2.2	Length of water level indicators on boilers	48
8.2.3	Glass diameter	48
8.2.4	Drains	48
8.2.5	Guards	48
8.2.6	Water level indicator connections and location	48
8.2.7	Connecting pipes for water level indicators	50
8.3	Feedwater systems	50
8.3.1	Design pressure	50
8.3.2	Design temperature	50
8.3.3	Feedwater arrangements	50
Section 9	Installation requirements of all types of boilers	53
9.1	General requirements	53
9.1.1	Gas installations	53
9.1.2	Fuel oil installations	53
9.1.3	Solid fuel installations	53
9.1.4	Electrical installations	53
9.2	Housing, access and security	53
9.3	Feedwater supply	53
9.4	Water treatment	53
9.5	Blowdown	53
9.6	Flues and chimneys	54
9.7	Electrical equipment	54
Section 10	Marking, instructions and statements for all types of boilers	55
10.1	Marking	55
10.2	Electrical data	55
10.3	Instructions	55
10.4	Language and units	55
10.5	Boiler attendance-category statement	55
Section 11	Energy input for all types of boilers	56
11.1	Combustion systems	56
11.1.1	Suitability	56
11.1.2	Emission requirements	56
11.1.3	Combustion heat flux limitation	56
11.1.4	Automatic oil and gas firing equipment	56
11.1.5	Other oil, gas or solid-fuel-in-suspension firing equipment	57
11.1.6	Solid-fuel firing systems	57
11.2	Waste heat energy recovery system	57

11.2.1	Input control.....	57
11.2.2	Input location	57
11.3	Electric energy input systems.....	58
11.3.1	General.....	58
11.3.2	Electricity supply.....	58
11.3.3	Load adjustment.....	58
11.3.4	Electrodes, elements and internal parts.....	58
11.3.5	Pressure and temperature control.....	59
11.3.6	Access.....	59
Section 12	Valves for all types of boilers.....	60
12.1	General.....	60
12.2	Valves and fittings for steam boilers.....	60
12.2.1	Minimum requisite fittings.....	60
12.2.2	Safety valves.....	60
12.2.3	Discharge capacity	61
12.2.4	Accumulation.....	62
12.2.5	Reseating pressure.....	62
12.2.6	Valve settings	62
12.2.7	Connections to the boiler	62
12.2.8	Expansion joints.....	63
12.2.9	Pilot pipes	63
12.2.10	Safety valve discharge system.....	63
12.2.11	Discharge restriction	63
12.2.12	Blowdown valves.....	63
12.2.13	Main steam isolating valve.....	64
12.2.14	Main feedwater isolating valve.....	64
12.2.15	Isolating valves.....	64
12.3	Valves and fittings for hot water boilers	64
12.3.1	Minimum requisite fittings.....	64
Section 13	Integral and boiler pressure piping for all types of boilers.....	65
13.1	General.....	65
13.2	Water-heating boiler system design.....	65
13.2.1	General.....	65
13.2.2	Expansion vessels.....	65
13.2.3	Piping system.....	66
13.2.4	Make-up water systems	66
13.2.5	Energy input interlock.....	66
Appendix A	(normative) Type test for a boiler subject to power failure.....	67
Appendix B	(informative) Typical oil or gas burner firing sequences.....	69
Appendix C	(informative) Typical oil supply and control systems.....	70
Appendix D	(informative) Typical boiler attendance-category statement.....	72
Appendix E	(informative) Example of steam boiler piping and other equipment covered by this Standard.....	73
Bibliography		75

Australian Standard®

Boilers — Safety management and supervision systems

Section 1 Scope and general

1.1 Scope

This Standard specifies the requirements for the operation of boilers and other devices including any connected economizer or superheater or deaerator. It includes the special features within the control, management and supervision systems, associated valves and fittings, housing, access and installation for those boilers and other devices operating in the unattended or attended modes. It also details the checking, testing, supervision and maintenance requirements for each category of attendance to support continued safety.

1.2 Application

This Standard is intended to be used in the design, manufacture, use (with and without attendance) and modification of new and existing boilers as follows:

- (a) Boilers for fixed land installations.
- (b) Boilers having a design pressure as shown in [Table 1](#).
- (c) Boilers having a power output within the capacities specified in [Table 1](#) for the boiler type and category.
- (d) Boilers in accordance with the checking, testing, supervision and maintenance requirements specified in [Table 1](#) for the boiler type and category.
- (e) Boilers for the generation of steam, or other vapour, for which the types of boilers permitted are —
 - (i) water-tube type or fire-tube type or combination of water-tube and fire-tube types or electric type or all boiler types up to 500 kW (see [Table 1](#)) for unattended operation; and
 - (ii) any type of boiler for attended operation (see [Table 1](#)).
- (f) Boilers for the heating of water or other liquids at a pressure above that of the atmosphere and to a temperature not less than the normal atmospheric boiling temperature of the liquid, for which application any type of boiler conforming to AS/NZS 1200 is permitted.
- (g) Boilers having any of the following sources of energy input:
 - (i) Gas fuel (mains or other gases).
 - (ii) Oil fuel with a closed flashpoint greater than 23 °C.
 - (iii) Solid fuels, including solid-fuel-in-suspension.
 - (iv) Waste heat fluids.
 - (v) Electric power.
 - (vi) Solar energy.

NOTE 1 This Standard may also be applied to boilers outside the limits specified in Items (a) to (g) where equivalent safety and reliability are required by the owner.

NOTE 2 This Standard is not intended to apply to miniature boilers in accordance with AMBSC Code Parts 1, 2, 3 and 4.

NOTE 3 Except for definitions in [Clause 1.4](#), other clauses in the Standard refer to steam and water only. The Standard may be applied to other fluids with attention by the owner to the owner's duty of care to the operational personnel and the general public.

This Standard may be applied at any time determined by the boiler owner or applicable regulatory authority.

Regulatory authorities may impose additional requirements, such as design registration, boiler gas supply arrangements, water and sewerage arrangements, electrical arrangements, attendance and supervision by operators and training of operators.

1.3 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document:

NOTE Documents for informative purposes are listed in the Bibliography.

AS ISO 1000, *The international system of units (SI) and its application*

AS 1210, *Pressure vessels*

AS 1228, *Pressure equipment—Boilers*

AS 1271, *Safety valves, other valves, liquid level gauges, and other fittings for boilers and unfired pressure vessels*

AS 1375, *Industrial fuel-fired appliances*

AS 1657, *Fixed platforms, walkways, stairways and ladders - Design, construction and installation*

AS 1940, *The storage and handling of flammable and combustible fluids*

AS 3814, *Industrial and commercial gas-fired appliances*

AS 3892, *Pressure equipment—Installation*

AS 4041, *Pressure piping*

AS 4625, *Electronic flame safeguards and flame detectors*

AS 4942, *Pressure equipment—Glossary of terms*

AS/NZS 1170.2, *Structural design actions, Part 2: Wind actions*

AS/NZS 1200, *Pressure equipment*

AS/NZS 1768, *Lightning protection*

AS/NZS 3000, *Electrical installations (known as the Australian/New Zealand Wiring Rules)*

AS/NZS 3788, *Pressure equipment—In-service inspection*

AS/NZS 5601.1, *Gas installations, Part 1: General installations*

ISO 22968, *Forced draught oil burners*

FCI 70-2, *Control valve seat leakage*

1.4 Terms and definitions

For the purpose of this Standard, the definitions given in AS 4942 and those below apply.

1.4.1

acceptable

acceptance

accepted

equipment or procedure conforms to the Australian Standard applicable to the equipment or procedure, or it can be shown to fulfil the performance requirements of this Standard if no such Standard exists

1.4.2

boilers

1.4.2.1

boiler

arrangement of vessels and interconnecting parts wherein steam, or other vapour is generated, or water or other liquid is heated at a pressure above that of the atmosphere by the application of fire or the products of combustion or process, or by electrical or solar means. It also includes valves, gauges, fittings and controls directly associated with the boiler and, where consistent with the requirements of this Standard, includes the boiler setting and associated equipment and other devices

Note 1 to entry: It does not include fully flooded systems or pressurized systems where the water or other liquid is heated to a temperature lower than the normal atmospheric boiling temperature of the liquid.

1.4.2.2

attended boiler

boiler which requires supervision by a licensed boiler operator ([1.4.12](#)) who has effective control of the boiler at all times while it is in use and is in a position to hear the alarms and to respond to them at the boiler immediately

1.4.2.3

unattended boiler

boiler intended to operate unattended that includes the addition of special features within the control, management and supervision systems, associated valves and fittings, housing and installation for those boilers together with other devices including the connection of an economizer or superheater or deaerator

1.4.2.4

combined water-tube – fire-tube steam boilers

boiler having a combination of design features as follows:

- (a) The fire-tube section only receives hot gases that have first passed through the water-tube section of the combination unit. The design of the water-tube section to be such that the temperature of these gases entering the fire-tube section does not exceed 800 °C.
- (b) The fire-tube section output does not exceed 60 % of the total energy output of the combined unit.
- (c) The fire-tube section has no furnace or any combustion taking place within its tubes.
- (d) The shell or tube plate of the fire-tube section is not subjected to any direct combustion or radiation.
- (e) The maximum temperature of the plate of a multi-pass fire-tube section is measured just below the low-water line, at entry of the second fire-tube pass of the flue gases. The design of this multi-pass fire-tube section to be such that the maximum temperature of the plate does not exceed the steam saturation temperature by more than 50 °C.

1.4.3**boiler management system**

system that controls the entire boiler and other device function including the energy input management system, the water level management system, the pressure controls, instruments and circuitry

1.4.4**chimney**

vertical duct or stack which finally conveys products of combustion from the boiler flue or flues or from the boiler direct to the atmosphere

1.4.5**competent person**

person who has acquired, through education, training, qualification or experience or a combination of these, the knowledge and skill enabling that person to perform the task required

1.4.6**complete shutdown**

condition in which the boiler is immediately and effectively isolated from energy sources to the combustion management, as well as shutting down of feedwater pumps, and the controls can only be reset at the boiler by hand manually

1.4.7**design lifetime**

lifetime specified by agreement between the manufacturer and the purchaser for each boiler component operating in the creep (high temperature) range and used in determining material design strength; it is expressed in hours service at specified conditions

Note 1 to entry: The design lifetime relates only to the creep performance of the relevant component and is not necessarily related to the life of the boiler.

1.4.8**energy input management system**

system for the management of the combustion or energy input equipment, including the operating controls, limit switches, safety interlocks, and flame safeguard devices

1.4.9**fail-safe**

feature which ensures that the absence or malfunction of any critical control or safety component, system, signal or function will not result in an unsafe condition

1.4.10**flue**

horizontal, inclined or vertical duct through which combustion products are discharged from the boiler, including any draught diverter, slip joint and associated duct, barometric device, fan or other components in the duct and the boiler chimney

1.4.11**human-machine interface****HMI**

human-machine interface (HMI) is the user interface that connects an operator to the safety controls and sequences for the boiler and other devices, which may include translation of data into human-readable visual representations

1.4.12**licensed boiler operator****High Risk Work Licence — Boiler Operator**

person who is the holder of a High Risk Work Licence (HRWL), issued by the relevant regulatory authority, to operate certain unattended boiler types and all attended boiler types and their included features

Note 1 to entry: The *Work Health and Safety Act 2011* (Cth) and associated *Model Work Health Safety Regulations* (Cth) specify boiler operations for boilers in certain categories are to be considered as “High Risk Work (HRW)” for which an operator is to hold a “High Risk Work Licence (HRWL)” to operate the boiler. Refer to Safe Work Australia for descriptions of high risk work licences and classes of high risk work.

Note 2 to entry: For boiler operation, the HRWL (the licence) is commonly known as a “Boiler Licence”. States and Territories may have different types/categories of Boiler Licences.

Note 3 to entry: The person holding the HRW licence (HRWL) for boiler operation is commonly known as a “Licensed Boiler Operator” by the Regulators and Pressure Equipment (PE) Industry as a whole.

1.4.13**owner**

body corporate, firm or person who has right of title to, or management of, or control over the boiler and any associated equipment or service and includes a person exercising such management or control as an agent of the owner

1.4.14**power output**

maximum continuous rated output of the boiler as specified by the manufacturer

1.4.15**proved**

relevant conditions have been sensed and registered as being correct

1.4.16**purging**

use of air or inert gas to remove and replace a potentially dangerous atmosphere

1.4.17**self-checking system**

sub-system within the boiler management system, designed and arranged to automatically and regularly test the integrity of the flame failure devices or water proving devices by dynamic testing of each and every component on which safe and correct operation is dependent, usually by creating a change of state

1.4.18**shutdown and lockout**

condition in which the boiler is immediately and effectively isolated from energy sources to the combustion management (or for a solid fuel boiler, from all sources of combustion air to the grate) and the controls can only be reset by hand at the boiler manually

Note 1 to entry: It is not intended for the safety control and sequence indicator system [human-machine interface (HMI)] and feedwater supply to be isolated.

Note 2 to entry: This will enable the feed pump/s to run after the boiler has shutdown with —

- (a) low-water level alarm condition;
- (b) fault in low-level water device;
- (c) failure of the system to go to a water self-checking or water self-monitoring sequence;
- (d) failure of the system during the self-checking or water self-monitoring function; and
- (e) failure of water self-checking device to return to a normal operating position.

1.4.19**trained person**

person who has received adequate instruction and training to be competent in the operation of certain unattended boiler types

Note 1 to entry: Different authorities may have varying requirements for training and competencies.

1.5 New designs, materials and construction methods

This Standard does not intend to prohibit the use of materials, methods of design or construction, which conform to AS/NZS 1200 and other relevant Standards referred to therein.

Table 1 — Criteria for type, power output, associated supervision and maintenance for unattended and attended boilers

Attendance category	Boiler type	Maximum power output and maximum design pressure	Supervision – Daily and weekly				Periodic checking, testing and maintenance			
			By	When	Checking and testing to be performed		By	How	Period	
					Clause 6.4.1	Clause 6.4.2				Clause 6.4.3
(a) Unattended operation	(i) Water-tube steam and hot-water boilers (excluding electrical elements)	(A) 10 MW 6 MPa	Trained person	24 h interval	Not applicable	Required appropriate to the boiler	Maintenance personnel as per this Standard	As per Clause 6.4.4	5 weeks maximum	
		(B) 20 MW 6 MPa	Licensed boiler operator	4 h interval	Required					Required appropriate to the boiler
	(ii) Forced circulation coil steam boilers	10 MW 10 MPa	Trained person	24 h interval	Not applicable	Required				12 months maximum
	(iii) Fire-tube hot water boilers	5 MW 2.5 MPa								
	(iv) Combined water-tube – fire-tube steam boilers	20 MW 2.5 MPa	Licensed boiler operator	4 h interval		5 weeks maximum				
	(v) All other types including fire-tube steam boilers	5 MW 2.5 MPa		12 h interval						
	(vi) Electrode or electric steam boilers (electric element fails on low-water)	No MW limit 2.5 MPa	Trained person	24 h interval	Not applicable	3 months maximum				
	(vii) Electric element steam boiler (electric element may not fail on low-water)	(A) 250 kW 2.5 MPa (B) 6 MW 2.5 MPa								
(viii) Boilers all types except for (vii)(A)	500 kW 1.2 MPa									
(b) Attended operation	All types	No limits	Licensed boiler operator			Refer to Clause 7.9 and AS/NZS 3788				

Section 2 Design and construction for all types of boilers and other devices

2.1 General requirements

2.1.1 Basic design

Each boiler or economizer or superheater or deaerator shall conform to the relevant pressure equipment Standard, e.g. AS/NZS 1200, AS 1228, AS 1210, and in addition shall be designed to —

- (a) incorporate a highly reliable management and control system with fail-safe features;
- (b) incorporate such construction features as are necessary to minimize the effect of any failure in the safety systems from creating a hazardous condition (see Note); and
- (c) conform to the relevant requirements specified in [Clauses 2.2 to 2.8](#) for unattended operation and [Clauses 2.2 to 2.5](#) for attended operation.

NOTE In order to minimize the operating water content and potential overheating effects in the event of a loss of water, unattended steam boilers are limited in [Table 1](#) to the construction types and capacities noted.

2.1.2 Tube diameter

The maximum outside diameter of any water tube exposed to combustion flame or furnace radiation shall be 80 mm.

NOTE This restriction on the maximum tube diameter is to limit the harmful discharge of energy from the furnace in the event of a tube rupture.

2.1.3 Water level indicators

Water level indicators and protective guards shall conform to AS 1271 and, if of the tubular glass type, shall be fitted with safety balls, to prevent the escape of both steam and water from a ruptured glass.

2.2 Steam boilers (other than electric boilers)

2.2.1 General

Each steam boiler, except electric boilers (see [Clause 2.5](#)), shall conform to [Clause 2.2.2](#) or [Clause 2.2.3](#), as applicable.

2.2.2 Water-tube steam boilers

Water-tube steam boilers of the natural circulation type or the forced circulation type shall conform to [Clause 2.1](#) and AS/NZS 1200.

The heat transfer surface shall be wholly composed of water tubes. Pressure vessels sections, such as drums or headers, other than for headers associated with attended solid fuel boilers, shall be protected from direct flame radiation.

2.2.3 Steam boilers other than water-tube or electric boilers

Steam boilers other than a water-tube or electric type shall conform to [Clause 2.1](#) and AS/NZS 1200.

The shell, tube plate and tube ends of a fire-tube boiler shall be protected from direct flame radiation, e.g. ensuring that combustion is complete within the combustion chamber.

2.3 Hot water boilers

2.3.1 General

Each hot water boiler shall conform to [Clause 2.1](#), AS/NZS 1200 and with the following:

- (a) Except as specified in Item (c), the boiler shall be part of a closed circulation hot water system.
- (b) For boilers other than water-tube types, the boiler shall be designed to remain in a fully flooded condition at all times.
- (c) Water-tube type boilers which are operated with steam space for expansion purposes shall be fitted with the controls required for steam boilers, refer to [Clause 2.2](#).
- (d) For fire-tube boilers, the water inlet and outlet shall be located at the top of the boiler and arranged so as to promote circulation in order to minimize both thermal shock and loss of water in the event of external pipe breakage.

2.3.2 Hot water systems

Each hot water system shall —

- (a) be a circulation system with no steam or water consumed during operation;
- (b) be designed and constructed so that loss of system water or loss of flow (circulation) cannot create a hazard in the boiler or system;
- (c) be equipped with the provision to expand, to accommodate the volume fluctuations in the system, with such an expansion vessel maintaining a positive system pressure at all times that the boiler is in operation, using compressed air, inert gas, steam, or liquid head for pressurization; and
- (d) have a temperature difference between the outflow temperature and the return flow temperature of the hot water at the boiler connections not exceeding the following:
 - (i) For fire-tube boilers — 25 °C.
 - (ii) For natural circulation water-tube boilers — 50 °C.
 - (iii) For forced circulation water-tube boilers — 80 °C.

Where the temperature difference between the outflow temperature and the temperature of the water returning to the boiler exceeds the temperature difference specified in Items (i), (ii) or (iii), as applicable, an external mixing device shall be fitted to raise the return flow temperature to a value that would conform to the specified maximum temperature difference at the boiler connections.

2.4 Waste heat boilers

Waste heat boilers shall conform to [Clause 2.2](#) or [Clause 2.3](#), as applicable, and with one of the following:

- (a) *Maximum temperature design* — The design strengths of all parts of the waste heat boiler shall be based on the strengths of the various materials at the maximum temperature attainable under any condition, including complete loss of water. As well, the heating medium shall not be capable of exceeding the maximum design temperature of the boiler. As such, no provision shall be necessary for input energy control or safety controls, or water level safety devices.
- (b) *Controlled input design* — The waste heat boiler shall have an input energy control system that regulates the flow of waste fluid automatically according to the output requirements and shall be interlocked with a water level management system in accordance with [Clauses 3.5.3, 3.5.4, 3.5.5](#) and [7.2](#), as applicable.

2.5 Electric boilers

Electrode boilers and element boilers can be used as steam boilers or hot water boilers or superheaters and shall be in accordance with [Clauses 2.1, 2.3](#) and [2.7](#), as applicable. If used in this way, they shall conform to AS/NZS 1200.

2.6 Economizers

Where an economizer is fitted to the unattended boiler also for unattended operation, the economizer shall be suitable for safe automatic start up and operation i.e. without manual supervision or operator control and shall conform to the following:

- (a) Have energy input management system of fully modulating type.
- (b) Have sustained water flowrate through the economizer at all times when the burner is operating.
- (c) Have the inclusion of devices or be designed to protect against overheating or overpressure of the economizer — The activation of any over temperature device shall cause shutdown unless the flue gases are isolated and diverted.

2.7 Superheaters

Where a superheater is fitted to the unattended boiler also for unattended operation, the superheater shall be suitable for safe automatic start-up and operation, i.e. without manual supervision or operator control.

Two devices shall be provided to protect against overheating of any tube circuit due to loss of flow or scale build-up. The action of any overheating protection device shall cause complete shutdown and require independent manual reset of that device.

2.8 Deaerators

Where a deaerator is fitted to the unattended boiler also for unattended operation, the deaerator shall be suitable for safe automatic start up and operation i.e. without manual supervision or operator control and shall conform to the following:

- (a) Have a suitable method to control corrosion levels associated with the oxygen rich environment, e.g. isolated deaeration chamber made from corrosion resistant materials, or internal surfaces protected using a suitable industrial coating.
- (b) Have a water level indicator.
- (c) Have the inclusion of one low-level water safety device fitted in the deaerator drum. The activation of any low-water device shall cause shutdown and lockout.
- (d) Have the inclusion of devices to protect against overpressure of the deaerator.

The position of the deaerator shall be at a sufficient height above the boiler feed pump/s suction inlet to give an adequate margin on the net positive suction head (NPSH) required for the pump.

The calculation for NPSH shall be in accordance with the requirements of [Clause 3.5.3.3](#), as appropriate.

Section 3 Boiler management system for unattended boilers

3.1 General

The boiler management system shall be suitable for fully automatic operation and adequate safety control of all the functions of the boiler and other devices, combustion or energy input, water level security and electric systems without the intervention of operating personnel, except for initial start-up or for restarting after complete shutdown or any shutdown and lockout.

Time clocks may be used for start-up and shutdown of unattended boilers provided that the main steam isolating valve or a powered-operated steam isolation valve is closed after shut-down and prior to start-up and the checking, testing and maintenance requirements of [Section 6](#) are carried out.

Under no circumstances shall the time clock or any other system initiate an automatic start following complete shutdown or any shutdown and lockout.

The boiler management system shall not have any provisions for the bypassing of safety features or controls except those to permit competent maintenance by maintenance personnel, for which acceptable security arrangements shall be incorporated.

The safety controls and sequence indicator system visual display panel (HMI) and feedwater supply cannot be isolated. The second feedwater pump where fitted, is energized to run, when the boiler water level activates the low-water level device. Both feedwater pumps remain running until normal water level is retained.

NOTE 1 Maintenance personnel capabilities are defined in [Clause 6.2](#).

NOTE 2 Where bypassing of electrical circuits is required for testing, it is recommended that suitable facilities and test equipment should be supplied. Such test equipment should be retained by the competent maintenance personnel.

3.2 Fail-safe techniques

The boiler management system should incorporate fail-safe components, circuits and techniques so that the loss or removal of a control signal will result in a shutdown and lockout or a resulting situation which is safe.

3.3 Temperature suitability of components

Each component of the boiler management system shall operate reliably and safely within the temperature and humidity limits specified by the manufacturer and shall conform to AS/NZS 3000.

3.4 Combustion management

3.4.1 General

The boiler management system of each oil-fired, gas-fired or solid-fuel-in-suspension-fired boiler shall include a combustion and flame safeguard system which shall provide the following facilities:

- (a) An automatically controlled starting and operating combustion sequence as required by [Section 4](#).
- (b) Supervision of the start flame and main flame during ignition and main flame operation by means of a flame detector.
- (c) For gas-fired boiler management systems the combustion and flame safeguard systems shall conform to the requirements of AS 3814 and AS 4625.

Boilers not exceeding 500 kW power output shall have one flame safeguard of the non-continuous self-checking type equipped with a flame detector in accordance with [Clause 3.4.3](#).

Boilers exceeding 500 kW power output shall have one flame safeguard of the continuous self-checking type equipped with a flame detector in accordance with [Clause 3.4.3](#).

If flame failure is detected by either flame safeguard type, shutdown and lockout shall occur.

3.4.2 Power-operated fuel valves

3.4.2.1 Fail-safe design

Any power-operated main fuel valve shall fail shut and vent valves in a double block and vent gas system shall fail open.

3.4.2.2 Closing time

One main fuel safety shut-off valve at least in a gas-fired system or an oil-fired system and the main diverter valve in a solid-fuel-in-suspension-fired system shall close in not more than 1 s after it has been de-energized. The combined time for the flame supervision system and its associated valves to shut off the fuel supply in the event of a flame failure at the point of supervision shall not exceed 3 s.

3.4.3 Flame detectors

Where flame detectors are required by [Clause 3.4.1](#), each detector shall be of an ultraviolet-sensing type or infrared sensing type or flame rod sensing type in accordance AS 4625. The flame detectors shall be as follows:

- (a) For a non-continuous self-checking flame safeguard installation, the flame detector shall be of a non-continuous self-checking type which provides a circuitry pre-check prior to any ignition attempt.
- (b) For a continuous self-checking flame safeguard installation, the flame detector shall be of a continuous self-checking type capable of self-checking.

NOTE Unless otherwise recommended by the flame safeguard original equipment manufacturer, all non-continuous self-checking flame safeguards operating on a continuous or permanent basis should undergo a controlled shutdown at least once every 24 h.

3.5 Water management systems

3.5.1 Blowdown

Each boiler shall be provided with blowdown facilities in accordance with AS 3892. In addition, each steam boiler intended for operation for a period in excess of 24 h without human supervision, shall be provided with an automatic device to control the level of the total dissolved solids during that period.

3.5.2 Feedwater tanks

All boilers shall be provided with the means to cause shutdown and lockout in the event of inadequate feedwater supply to the boiler feed pump/s suction inlet. Conformance to this requirement shall be achieved by a low-water safety device fitted in the feed tank (or other feedwater storage device) where the low-water device is activated once the minimum holding volume level is reached.

The feedwater supply minimum holding volume shall be calculated in accordance with AS 3892.

The position of the feed tank shall be at a sufficient height above the boiler feed pump/s suction inlet to give an adequate margin on the net positive suction head (NPSH) required for the pump.

The calculation for NPSH shall be in accordance with the requirements of [Clause 3.5.3.3](#), as appropriate.

3.5.3 Steam boilers, other than coil-type forced circulation boilers and electric boilers

3.5.3.1 General

The water management systems for steam boilers, other than coil-type forced circulation boilers and electric boilers, shall conform to this Standard, as applicable, and in addition shall be fitted with the equipment specified in [Clauses 3.5.2](#) and [3.5.3.2](#) to [3.5.3.4](#).

3.5.3.2 Water level controls and safety devices

3.5.3.2.1 Low-level water safety devices

For boilers not exceeding 500 kW power output, not less than one low-level water safety device shall be fitted directly into the boiler steam drum or shell.

For boilers exceeding 500 kW power output, not less than two low-level water safety devices, independent of each other, shall be fitted. The settings for the two devices shall be low-water level and extra-low-water level and shall be incorporated into an acceptable system comprising of either —

- (a) two low-level water safety devices with one of the devices being an acceptable self-checking type; or
- (b) two high integrity conductive probes.

The requirement for probes in this clause shall not include pump control devices.

Low-level water safety devices in accordance with Item (a) or (b) shall be fitted directly into the boiler steam drum or shell.

The extra-low-water level set point shall be no less than 50 mm above the level where the topmost heating surface would be exposed. This point should be at the lowest visible water level in the water level indicator when viewed from the operator level.

The low-water level set point shall be above the extra-low-water level set point.

The operation of low-water safety devices shall be in accordance with the fault shutdown requirements of [Clause 4.2.3](#) or [Clause 5.2.4](#), as appropriate.

The requirements for acceptable low-level water systems shall be as follows:

- (a) *Low-level water self-checking type* — Where a self-checking device is used a part of a low-level water system, the device shall conform to the following requirements:
 - (i) Operate on a time cycle so that the self-checking operation is performed at least once every 10 min. The duration of the self-checking bypass operation shall be no greater than 50 % of the time taken for the water level to drop from normal operating level to a level that would expose any uncooled heating surface to the products of combustion, with the boiler operating at its rated power output and the feedwater isolated, or 1.5 min, whichever is greater.
 - (ii) Operate as a normal low-level water device at all times except for the period of the self-checking bypass operation.
 - (iii) Have fail-safe circuitry and operating sequences.
 - (iv) Be actuated to a complete shutdown by any of the following:
 - (A) Lowering of the water surface below a pre-set level.

- (B) Malfunctioning of the level device.
 - (C) Failure to go into self-checking mode after the prescribed interval.
 - (D) Failure of the switch mechanism to operate during the changeover (self-check to operating).
 - (E) Failure of the low-level water device or switch mechanism to return to the normal position after the self-checking operation.
- (b) *Low-level water high-integrity conductive probe type* — Where high-integrity conductive probes are used a part of a low-level water system they shall be of a type that is self-monitoring, have a minimum of SIL 2 rating, and shall conform to the following requirements:
- (i) Be of fail-safe design so that a single fault in any related part shall not lead to a loss of the safety function.
 - (ii) Have screened cable directly connected from the controller to the probe such that a complete or partial short-circuit of the screen to earth or to the electrode, or a break in any of the wires in the cable is detected.
 - (iii) Be of a two-tip design, one tip to sense the water level, the second tip (comparator tip) used to ensure that correct water levels are sensed under all normal and abnormal operating conditions.
 - (iv) Perform a self-test within a 60 s interval that proves status of the probe, the probe cable and the operation of the controller.
 - (v) Continually monitor the water level.
 - (vi) Each conductive probe shall be located in separate locations on the boiler.

3.5.3.2.2 Automatic water level control

For boilers exceeding 1 MW power output, the water level control shall be of modulating type.

3.5.3.2.3 Externally fitted water level device other than water level indicators

Where an externally fitted water level device is fitted, there shall be no isolating valves between the chamber and the boiler, with the sole exception of a sequencing blowdown valve.

The sequencing blowdown valve shall be of a type that ensures that the following operations shall be carried out in the specified sequence and in a gradual manner:

- (a) Close the water connection to the chamber and simultaneously open the water connection direct to the drain.
- (b) Maintain closed the water connection to the chamber and the drain while simultaneously opening the chamber direct to the drain.
- (c) Open the water connection to the chamber and simultaneously close the drain (normal operating position).

3.5.3.3 Feedwater pumps

Each boiler shall be fitted with automatically controlled feedwater pump/s, each capable of supplying not less than 120 % of the mass of steam generated at the power output of the boiler and shall be provided with adequate margin on the net positive suction head (NPSH) for the pump.

Where feedwater is heated by steam injection or condensate return or by other means in an open vented feedwater tank the calculation of NPSH shall allow for the water temperature to be at 90 °C in all cases.

Where feedwater is heated by steam injection or condensate return or by other means in a closed pressurized tank such as a deaerator or hot well the calculation of NPSH shall allow for the maximum water temperature of that system being greater than 100 °C, as appropriate.

Each boiler exceeding 500 kW power output shall be fitted with two automatically controlled feedwater pumps, and boilers not exceeding 500 kW power output shall be fitted with one feedwater pump.

Where two feedwater pumps are fitted, the feedwater pump system shall be controlled so that after each automatic pump stop, the operating pump shuts down and the alternative pump is started. Where the pump operation is continuous, a pump changeover shall occur at a maximum period not exceeding seven days.

3.5.3.4 Assisted circulation

Each boiler fitted with a pump to assist natural circulation shall be interlocked to prevent operation of the combustion equipment unless water flow is established and maintained.

3.5.4 Water management systems for coil-type forced circulation boilers

3.5.4.1 General

Each coil-type forced circulation boiler shall conform to the requirements of AS 1228 for such boilers and shall be fitted with equipment specified in [Clauses 3.5.4.2 to 3.5.4.4](#).

3.5.4.2 Overheating interlock

Two devices shall be provided to protect against the overheating of any tube circuit due to loss of flow or scale build-up. The actuation of any overheating protection device shall cause complete shutdown and require independent manual reset at the boiler of that device.

3.5.4.3 Water circulation pump

Each boiler shall be fitted with a controlled circulating pump which shall be interlocked to prevent the operation of the combustion equipment unless water flow is established and maintained.

NOTE In some boilers, the circulating pump may be the feedwater pump.

3.5.4.4 Feedwater pumps for coil-type forced circulation boilers

Feedwater pumps shall conform to the requirements of [Clause 3.5.3.3](#), except that only one pump need be fitted for coil-type forced circulation boilers in accordance with the limitations applicable to boilers for which modified design and construction requirements are permitted in accordance with AS 1228.

3.5.5 Water management systems for hot water boilers

3.5.5.1 General

In addition to conforming to AS 1228 as appropriate, each boiler shall be fitted with the equipment specified in [Clauses 3.5.5.2 and 3.5.5.3](#).

3.5.5.2 Low-level water safety devices

Low-level water safety devices shall be provided in accordance with the following:

- (a) Power output not exceeding 500 kW, one device.
- (b) Power output exceeding 500 kW, two devices.

The lowering of the actual water level to a level such that will cause any low-water safety device to be actuated, shall cause complete shutdown.

Low-level water safety devices in accordance with Item (a) or (b) shall be fitted directly into the boiler water drum.

3.5.5.3 Safety high limit temperature device

Each boiler shall be fitted with an independent high limit temperature device, and the operation of that device shall cause complete shutdown of the boiler. The device shall be of a type that requires manual reset at the boiler.

Any high limit temperature device shall operate not higher than 6 °C above the boiling point temperature of the pressurized medium.

3.5.6 Water management systems for waste heat boilers

The water management system for a waste heat boiler shall conform to this Standard as applicable. In addition, each controlled input design type boiler (see [Clause 2.4\(b\)](#)) shall conform to [Clause 3.5.3](#), [3.5.4](#) or [3.5.5](#), as applicable.

3.5.7 Water management systems for electric boilers

3.5.7.1 General

For electrode type boilers containing water, no provision is necessary for input energy controls or safety controls or low-water level safety devices. A high-level safety device shall be fitted to each electrode boiler to protect the boiler electrode insulators. The device shall be self-checking or a high integrity conductive probe type. The rise of the actual water level to a level such as will cause the high-level safety device to be actuated shall cause complete shutdown.

Except as permitted by this clause electrode type steam boilers shall conform to [Clause 3.5.7.2](#) and electrode type hot water boilers shall conform to [Clause 3.5.5](#) or [Clause 3.5.7.2](#).

For electric element type boilers, the water management system shall conform to the following:

- (a) Steam boilers — with [Clause 3.5.7.2](#).
- (b) Hot water boilers — with [Clause 3.5.5](#) or [Clause 3.5.7.2](#), as applicable.

3.5.7.2 Water level controls and safety devices for electric element boilers

The following water level devices shall be fitted:

- (a) An effective and reliable automatic water level controller of the float or probe type shall be fitted. For boilers exceeding 1 MW power output, the water level controller shall be of the modulating type. The water level controller shall operate within the visible range of the water level indicator.
- (b) Water level safety devices shall conform to [Clause 3.5.3.2.1](#).
- (c) The extra-low-water level controller shall de-energize the heating circuit on a fall in the water level to a level not less than 50 mm above the level where the topmost heating section of the highest element would be exposed above water. De-energization shall be affected by the opening of the boiler mains contactor or circuit-breaker, which shall have high reliability and be protected to minimize tampering.
- (d) Where the second low-water safety device is in the form of independent water level control, it shall conform to the requirements of [Clause 3.5.3.1](#) with its physical attachment to the boiler shell and its electrical circuitry and operation independent of the primary level control system.

- (e) Where the second low-water safety device is in the form of over temperature protection, the over temperature safety devices or safety features used to protect the pressure-retaining parts against heating above their design temperature, shall be in accordance with Item (i) or Item (ii), as follows:
- (i) Where the boiler has electric elements, which will fail before any pressure-retaining part is heated above its design temperature (see Note 1), one over temperature safety device as minimum protection (see Note 2) shall be fitted.
 - (ii) Where the boiler has electric elements that cannot be ensured of failing before any pressure-retaining part is heated above its design temperature (see Note 1) —
 - (A) for boilers with a power output not exceeding 500 kW, two over temperature safety devices as minimum protection (see Note 2), completely independent and having different modes of operation, or one safety device at least incorporating acceptable self-checking features shall be fitted; or
 - (B) for boilers with a power output exceeding 500 kW, two over temperature safety devices (see Note 2), at least one of which incorporates acceptable self-checking features shall be fitted.

NOTE 1 For conformance to Item (e) (i), calculations or a proof test should be carried out to demonstrate the acceptability of the combination of element type, size, location and capacity with the pressure-retaining parts, dimensions and material properties. Where the voltage may fall below 90 % of rated voltage, an under-voltage shutdown and lockout device should be fitted.

NOTE 2 For conformance to Item (e) (i) or Item (e) (ii), one or more of the following safety devices may be used:

- (a) Where the device is an over temperature safety thermostat, this thermostat may make use of a thermocouple or capillary tube attached directly to the sheath of the element or of the change in electrical resistance of the element. The sensor of such over temperature safety device is to be fitted to the uppermost element. It is desirable that this element be the first energized and the last de-energized. Alternatively, where it is desired to have cyclic step control of elements, the sensor/s should be located and arranged to cause de-energizing of the operating element/s and complete shutdown and lockout in the event of low-water and overheating of any element.
- (b) Temperature sensors attached to the outer shell of the boiler in at least two areas where maximum temperature of the pressure-retaining parts would be expected under any failure condition.
- (c) Temperature relief safety valve located in the top space of the boiler. This relief safety valve should open to reduce pressure when the steam or water temperature exceeds the boiler design temperature.

Where the electric elements cannot be ensured of failing before the pressure retaining parts exceed their design temperature, an over temperature safety device/s shall be fitted. Each of the over temperature safety devices (except that in Note 2 Item (c)) is to be able to remove supply to the element/s by de-energizing the power supply, and each should cause complete shutdown. It is desirable that the first operating over temperature safety device de-energize the contactor coil and the other over temperature safety device trip the circuit-breaker.

3.5.7.3 Feedwater pumps for electric boilers

Feedwater pumps shall conform to the requirements of [Clause 3.5.3.3](#).

3.6 Electrical power isolation

A means of isolation of power to the boiler shall be located in a safe and readily accessible location and shall be clearly and prominently labelled.

The boiler power isolation device shall be located in the vicinity of the boiler to enable a visual inspection of the boiler system to be made, prior to reset, to establish that the operating condition that