भारतीय मानक
Indian Standard

IS 302-2-21 : 2018

घरेलू और समान विद्युत साधित्रों की सुरक्षा

भाग 2 विशेष अपेक्षाएँ

अनुभाग 21 भण्डार किस्म के बिजली के वाटरहीटर

(*दूसरा पुनरीक्षण*)

Safety of Household and Similar Electrical Appliances

Part 2 Particular Requirements

Section 21 Stationary Storage Type Electric Water Heaters

(Second Revision)

ICS 91.140.65;13.120

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भारतीय मानक ब्यूरो

B U R E A U O F I N D I A N S T A N D A R D S

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October 2018   **Price Group 9**

Electrical Appliances Sectional Committee, ETD 32

FOREWORD

This Indian Standard (Part 2/Sec 21) (Second Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Electrical Appliances Sectional Committee had been approved by the Electrotechnical Division Council.

This standard was first published in 1992, and revised in 2011. This revision has been undertaken primarily to align the existing standard with the latest International Standard.

This standard covers the safety requirements of stationary storage type electric water heaters. This standard however does not cover the performance requirements which are covered under IS 2082 'Stationary storage type electric water heater'.

It has been assumed in the formulation of this standard that the execution of its provisions is entrusted to appropriately qualified and experienced persons.

This standard recognizes the internationally accepted level of protection against hazards such as electrical, mechanical, thermal, fire and radiation of appliances when operated as in normal use taking into account the manufacturer's instructions. It also covers abnormal situations that can be expected in practice and takes into account the way in which electromagnetic phenomena can affect the safe operation of appliances.

This standard takes into account the requirements of IS 732 : 2018 'Code of practice for Electrical Wiring Installations (*fourth revision*), as far as possible so that there is compatibility with the wiring rules when the appliance is connected to the supply mains. However, in case of any deviation, wiring rules take precedence.

If an appliance within the scope of this standard also incorporates functions that are covered by another Part 2 of IS 302, the relevant Part 2 is applied to each function separately, as far as is reasonable. If applicable, the influence of one function on the other is taken into account.

When a Part 2 standard does not include additional requirements to cover hazards dealt with in Part 1, Part 1 applies.

NOTE — This means that in such a case, it has been decided that for the Part 2 standards that it is not necessary to specify particular requirements for the appliance in question over and above the general requirements.

This standard is a product family standard dealing with the safety of appliances and takes precedence over horizontal and generic standards covering the same subject.

NOTE — Horizontal and generic standards covering a hazard are not applicable since they have been taken into consideration when developing the general and particular requirements for the IS 302 series of standards.

An appliance that complies with the text of this standard will not necessarily be considered to comply with the safety principles of the standard if, when examined and tested, it is found to have other features which impair the level of safety covered by these requirements.

An appliance employing materials or having forms of construction differing from those detailed in the requirements of this standard may be examined and tested according to the intent of the requirements and, if found to be substantially equivalent, may be considered to comply with the standard.

This standard is to be read in conjunction with the latest edition of IS 302-1 'Safety of household and similar electrical appliances : Part 1 General Requirements' and its amendments.

NOTE — When Part 1 is mentioned in this standard, it refers to IS 302-1.

This Part 2 supplements or modifies the corresponding clauses in IS 302-1, so as to convert that standard into the Indian standard: Particular requirements for Stationary Storage Type Electric Water Heaters .

Indian Standard

SAFETY OF HOUSEHOLD AND SIMILAR ELECTRICAL APPLIANCES

PART 2 PARTICULAR REQUIREMENTS

Section 21 Stationary Storage Type Electric Water Heaters

(Second Revision)

1 SCOPE

This clause of Part 1 is replaced by the following.

This Indian standard deals with the safety of electric storage water heaters for household and similar purposes and intended for heating water below boiling temperature, their rated voltage being not more than 250 V for single-phase appliances and 480 V for other appliances.

Appliances not intended for normal household use but which nevertheless may be a source of danger to the public, such as appliances intended to be used by laymen in shops, in light industry and on farms, are within the scope of this standard.

This standard is also applicable to immersion heater units intended to be retrofitted in a heat exchange closed water heater having provision for retrofitting. Such a unit shall comply with the requirements in Annex AA.

> NOTE — Australia, Netherlands and New Zealand do not allow immersion heater units intended to be retrofitted in a heat exchange closed water heater unless;
>
> a) the immersion heater unit has been tested with the tank models and brands listed in the instructions of the immersion heater unit; and
>
> b) the tank models and brands list the models of the immersion heater units that can be retrofitted.

As far as is practicable, this standard deals with the common hazards presented by appliances that are encountered by all persons in and around the home. However, in general, it does not take into account,

a) persons (including children) whose

1. physical, sensory or mental capabilities; or

2. lack of experience and knowledge prevents them from using the appliance safely without supervision or instruction;

b) children playing with the appliance,

NOTE 101 Attention is drawn to the fact that

a) for appliances intended to be used in vehicles or on board ships or aircraft, additional requirements may be necessary;

b) in many countries additional requirements are specified by the national health authorities, the national authorities responsible for the protection of labour and similar authorities;

c) in many countries regulations exist for the installation of equipment connected to the water mains.

NOTE 102 — This standard does not apply to

a) appliances for boiling water (IS 302-2-15);

b) instantaneous water heaters (IS 302-2-35);

c) commercial dispensing appliances and vending machines (IS 302-2-75 (under preparation));

d) appliances intended exclusively for industrial purposes;

e) appliances intended to be used in locations where special conditions prevail, such as the presence of a corrosive or explosive atmosphere (dust, vapour or gas).

2 REFERENCES

This clause of Part 1 is applicable except as follows:

Addition

IS No.	Title
191 : 2007	Copper (*fourth revision*)
1570 (Part 5) : 1985	Schedule for wrought steels: Part 5 Stainless and heat resisting steels (*second revision*)
302-1 (Part 1) : 2008	Safety of household and similar electrical appliances: Part 1 General requirements.
IS/IEC 60730-1 : 1999	Automatic electric controls for household and similar use: Part 1 General requirements.
IS/IEC 61508-7 : 2000	Functional safety of electrical/ electronic/programmable electronics safety released systems : Part 7 Overview of techniques & measures.
3972 (Part 2/ Sec 2) : 1985	Methods of test for vitreous enamelware: Part 2 Test methods, Section 2 Low and high voltage tests for detecting and locating defects (*first revision*)
13273 : 1991	Vitreous enamelled inner tanks for storage water heaters

3 TERM AND DEFINITIONS

This clause of Part 1 is applicable except as follows.

3.1.9 *Replacement:*

normal operation

operation of the appliance after installation in accordance with the instructions and filled with cold water

3.101 storage water heater

stationary appliance for heating and storing water in a container and incorporating devices to control the water temperature

3.102 closed water heater

unvented storage water heater intended to operate at the pressure of the water system, the flow of water being controlled by one or more valves in the outlet system

NOTES

1 A closed water heater is shown in Figure 101a.

2 The operating pressure may be the output pressure of a reducing or boosting device.

3.103 cistern-fed water heater

storage water heater that is vented to atmosphere and intended to be supplied by water under gravity from a separate cistern, the flow of water being controlled by one or more valves in the outlet system

NOTES

1 A cistern-fed water heater is shown in Figure 101d.

2 The water heater may be installed so that the expanded water returns to the cistern.

3 In a cistern-fed water heater, the pressure in the container results from the column of water in the cistern.

3.104 cistern-type water heater

storage water heater having a container supplied by water under gravity from a cistern incorporated in the appliance.

NOTES

1 The expanded water can return to the cistern, the flow of water being controlled by one or more valves in the outlet system

2 A cistern-type water heater is shown in Figure 101c.

3 In a cistern-type water heater, the surface of the water is always at atmospheric pressure.

3.105 open-outlet water heater

storage water heater in which the flow of water is only controlled by a valve in the inlet pipe and in which the expanded or displaced water flows through the outlet

NOTES

1 An open-outlet water heater is shown in Figure 101b.

2 In an open-outlet water heater, the static pressure at the outlet is always at atmospheric pressure.

3.106 low-pressure water heater

storage water heater that is vented to atmosphere and intended to be connected to the water mains through a pressure reducing valve, the flow of water being controlled by one or more valves in the outlet system

NOTE — **A low-pressure water heater** is shown in Figure 101e.

3.107 rated pressure

water pressure assigned to the appliance by the manufacturer

3.108 heat exchange water heater

storage water heater in which heated water is fed into a heat exchanger, such as a coiled tube or similar device, which is itself immersed in a container with the water to be heated.

NOTES

1 The heated water fed into the heat exchanger is heated from a primary heat source such as a solar panel or heat pump.

2 A heat exchange water heater is shown in Figure 101f.

4 GENERAL REQUIRMENTS

This clause of Part 1 is applicable.

5 GENERAL CONDITIONS FOR THE TESTS

This clause of Part 1 is applicable except as follows.

5.2 *Addition*:

NOTE 101 Additional appliances can be required if damage occurs during the tests of **19.2** or **19.3**.

5.3 *Addition:*

When the tests are carried out on a single appliance, the tests of **22.47**, **22.102**, **22.103**, and **24.102** are carried out before the tests of **19**.

6 CLASSIFICATION

This clause of Part 1 is applicable except as follows.

6.1 Modification*:*

Water heaters shall be class I, class II or class III.

6.2 Addition*:*

Water heaters for installation outdoors shall be at least IPX4. Other water heaters shall be at least IPX1.

7 MARKING AND INSTRUCTIONS

This clause of Part 1 is applicable except as follows.

7.1 Addition:

Appliances, other than cistern-type water heaters, shall be marked with the rated pressure in pascals.

Appliances shall be marked with the rated capacity in litres.

Closed water heaters shall be marked with a statement that a pressure-relief device is to be fitted in the installation, unless it is incorporated in the appliance.

Closed water heaters having a rated pressure less than 0.6 MPa and low-pressure water heaters shall be

marked with a statement that a pressure reducing valve is to be fitted in the installation.

Open-outlet water heaters shall be marked, close to the outlet connection or on a tag attached to the appliance, with the substance of the following:

> WARNING: This outlet acts as a vent and must only be connected to a fitting recommended by the manufacturer. It must not be connected to a tap.

7.12 Addition:

The instructions for closed water heaters shall state the substance of the following:

a) the water may drip from the discharge pipe of the pressure-relief device and that this pipe must be left open to the atmosphere;

b) the pressure-relief device is to be operated regularly to remove lime deposits and to verify that it is not blocked;

c) how the water heater can be drained.

7.12.1 *Addition:*

The installation instructions shall state the substance of the following:

a) the type or characteristics of the pressure-relief device and how to connect it, unless it is incorporated in the appliance;

b) a discharge pipe connected to the pressure-relief device is to be installed in a continuously downward direction and in a frost-free environment;

c) the type or characteristics of a pressure reducing valve and the installation details (for appliances having a rated pressure less than 0.6 MPa).

The instructions for closed water heaters incorporating a heat exchanger shall give details on the installation of control devices and the temperature settings that are necessary to prevent operation of the thermal cut-out caused by the heat from the exchanger.

The instructions for cistern-fed water heaters and low-pressure water heaters shall contain the substance of the following:

> WARNING: Do not connect any pressure-relief device to the vent pipe of this water heater.

7.101 The water inlet and the water outlet shall be identified. This identification shall not be on detachable parts. If colours are used, blue shall be used for the inlet and red for the outlet. An alternative means of identification may be by means of arrows showing the direction of the water flow.

Compliance is checked by inspection.

8 PROTECTION AGAINST ACCESS TO LIVE PARTS

This clause of Part 1 is applicable.

9 STARTING OF MOTOR OPERATED APPLIANCES

This clause of Part 1 is not applicable.

10 POWER INPUT AND CURRENT

This clause of Part 1 is applicable.

11 HEATING

This clause of Part 1 is applicable except as follows.

11.7 Replacement:

The appliance is operated until steady conditions are established or until the thermostat interrupts the current for the first time after 16 h, whichever is shorter.

12 VOID

13 LEAKAGE CURRENT AND ELECTRIC STRENGTH AT OPERATING TEMPRETURE

This clause of Part 1 is applicable.

14 TRANSIENT OVER VOLTAGES

This clause of Part 1 is applicable.

15 MOISTURE RESISTANCE

This clause of Part 1 is applicable except as follows.

15.2 Addition:

The test is only applicable to cistern-type water heaters.

15.3 Addition:

NOTE 101— If the appliance is too large for the humidity cabinet, the test can be carried out on those parts that contain electrical components.

16 LEAKAGE CURRENT AND ELECTRIC STRENGTH

This clause of Part 1 is applicable.

17 OVERLOAD PROTECTION OF TRANSFORMEFS AND ASSOCIATED CIRCUITS

This clause of Part 1 is applicable.

18 ENDURANCE

This clause of Part 1 is not applicable.

19 ABNORMAL OPERATION

This clause of Part 1 is applicable except as follows.

19.1 Modification:

Instead of the tests specified for appliances incorporating heating elements, the following applies.

For closed water heaters, low-pressure water heaters and open-outlet water heaters, compliance is checked by the tests of **19.2, 19.3 and 19.4** if applicable. However, **19.101** applies instead for appliances not liable to be emptied in normal use and having all four of the following features:

a) An outer enclosure of metal or a water container of metal and an outer enclosure of non-metallic material;

NOTE 101 — Non-metallic covers can be used for the supply terminals and controls.

b) Non-combustible thermal insulation;

NOTE 102 — Insulation withstanding the needle flame test of Annex E is considered to be non-combustible.

1) a capacity exceeding 30 l;

2) a rated power input not exceeding 6 kW.

NOTE 103 Appliances are not considered liable to be emptied in normal use if emptying through the inlet is prevented by a check valve, a pipe interrupter or an air gap. These devices can be fitted in the inlet pipe in accordance with the instructions. Emptying through openings provided for servicing purposes only is not considered to be normal use.

NOTE 104— Cistern-fed water heaters and cistern-type water heaters are not subjected to the tests.

19.2 Addition:

The appliance is operated empty, any thermal control that operates during the test of **11** being short-circuited.

NOTE 101— If the appliance is provided with more than one thermal control, these are short-circuited in turn.

19.3 Addition:

NOTE 101— If the water heater has been damaged during the previous test, a new appliance is used.

19.4 Replacement*:*

For open-outlet water heaters, the test of **19.2** is repeated but with the container filled with water to a level at least 10 mm above the highest point of the heating element. The appliance is operated at 1.15 times rated power input under normal operation.

NOTE 101— If the water heater has been damaged during previous tests, a new appliance is used.

19.13 *Addition:*

There shall be no leakage from the container during the tests.

19.101 The appliance is tested for 24 h under the conditions specified in **11** but with the container empty.

20 STABILITY AND MECHANICAL HAZARDS

This clause of Part 1 is applicable.

21 MECHANICAL STRENGTH

This clause of Part 1 is applicable.

22 CONSTRUCTION

This clause of Part 1 is applicable except as follows.

22.6 Addition:

The enclosure shall have a drain hole positioned so that the water can drain without impairing electrical insulation, unless condensed water cannot accumulate within the enclosure in normal use. The hole shall be at least 5 mm in diameter or 20 mm^2 in area with a width of at least 3 mm.

Compliance is checked by inspection and measurement.

22.20 Addition:

Thermal insulation shall not be used for basic insulation of internal wiring.

22.47 Replacement:

Appliances shall withstand the water pressure occurring in normal use.

Compliance is checked by subjecting the appliance to a water pressure of,

a) twice the rated pressure, for closed water heaters. If the water heater is supplied through a pressure reducing valve, the container is subjected to twice the working pressure instead;

NOTES

1 The pressure reducing valve can be incorporated in the water-inlet pipe.

2 The working pressure is the maximum pressure in the container measured during the test of **11**.

b) 1.5 times rated pressure, for cistern-fed water heaters and low-pressure water heaters;

c) 0.15 MPa, for open-outlet water heaters;

d) 0.03 MPa, for cistern-type water heaters.

Pressure-relief devices are rendered inoperative. The pressure is raised at a rate of 0.13 MPa/s to the specified value and is maintained at that value for 15 min.

Water shall not leak from the appliance and there shall be no permanent deformation to such an extent that compliance with this standard is impaired.

NOTE 3 — Heat exchangers incorporated in an appliance are subjected to a pressure test based on their working pressure.

NOTE 4 — Damage to a protective coating on the inside of containers is not considered to be a hazard.

22.101 The rated pressure of closed water heaters intended for direct connection to the water main shall be at least 0.6 MPa.

The rated pressure of closed water heaters and low-pressure water heaters, intended to be supplied by a

pressure reducing valve that is not incorporated in the appliance, shall be at least 0.1 MPa.

The rated pressure of cistern-fed water heaters shall not exceed 0.2 MPa.

NOTE — The rated pressure of open-outlet water heaters is 0 Pa.

Compliance is checked by inspection.

22.102 Closed water heaters shall be constructed so that repeated drawing off does not cause the water to boil.

Compliance is checked by the following test.

The appliance is operated as specified in **11**.

When the thermostat has operated for the first time, water is drawn off at a rate of approximately 2 l/min or 10 percent of the capacity of the appliance per minute, whichever is less, until the thermostat switches on again.

When the thermostat next operates, water is drawn off again at the same rate until the thermostat switches on, this sequence being repeated until steady conditions are established.

The temperature of the water, measured by means of a thermocouple at the outlet, shall not exceed 98°C.

22.103 Pressure-relief devices of closed water heaters shall prevent the pressure in the container from exceeding the rated pressure by more than 0.1 MPa.

Compliance is checked by subjecting the container to a slowly increasing water pressure.

NOTE —The pressure-relief device can be fitted during installation.

22.104 The outlet of open-outlet water heaters shall be constructed so that the water flow is not limited to such an extent that the container is subjected to a significant pressure.

NOTE — This requirement is considered to be met if the cross-sectional area of the water outlet is not less than that of the inlet.

The vent pipe of low pressure water heaters shall have an internal diameter of at least 20 mm.

Compliance is checked by inspection and measurement.

22.105 Cistern-type water heaters shall be constructed so that the container is always at atmospheric pressure by means of a vent having an area of at least 30 mm^2 and a minimum dimension of at least 3 mm.

Compliance is checked by inspection and by measurement.

22.106 Water heaters shall incorporate a thermal cut-out providing all-pole disconnection and which operates independently from the thermostat. However, for appliances intended to be connected to fixed wiring,

the neutral conductor need not be disconnected.

Compliance is checked by inspection.

22.107 Heating elements and thermal control sensors in contact with the outer surface of the container shall be held in position securely.

Compliance is checked by inspection.

22.108 Appliances for wall mounting shall have reliable provision for fixing to a wall, independent of the connection to the water mains.

Compliance is checked by inspection.

22.109 Appliances having a capacity of more than 15 l that cannot be emptied through a drain fitted in the water pipes shall incorporate means for draining that requires a tool for its operation.

Compliance is checked by inspection and by manual test.

NOTES
1 Residual water in the container below the end of the inlet pipe is disregarded.
2 The means for draining can be combined with a pressure-relief valve.

22.110 Closed water heaters incorporating a heat exchanger shall be constructed so that during normal use the thermal cut-out does not operate due to heat from the exchanger.

Thermostatic valves, by-pass valves and similar controlling devices used for this purpose shall be supplied with the appliance.

Compliance is checked by inspection.

The material of the inner container in water heaters other than open outlet water heaters and feed cistern in cistern type shall be of copper of purity not less than 99.8 percent as per IS 191. In addition the inner container can be made of stainless steel. Stainless steel of Grades 304, 304L, 316, 316L of IS 1570 (Part 5) is recommended for this purpose. The apparatus plates and all bosses for screwed connection shall be, made of gunmetal, brass of brazing quality or stainless steel. All pipes shall be of copper, brass or stainless steel.

The vitreous enamelled inner tank conforming to IS 13273 may also be used. However, the cathodic protection shall be provided for enamel inner container if complete coverage of enamel is not ensured within the limits of relevant Indian Standard. In case, cathodic protection is not provided in that case, inner container shall be subjected to high voltage test as laid down in IS 3972 (Part 2/Sec 2).

22.111 Water heaters shall be resistant to vacuum impulses which may occur in normal use. Compliance is checked by subjecting containers to a vacuum of

66 kPa (0.66 bar) for 1 min. After the test, the container shall show no deformation which might result in hazard. Anti vacuum valves, if any, are not rendered inoperative.

NOTE — The test may be made on a separate container.

23 INTERNAL WIRING

This clause of Part 1 is applicable.

24 COMPONENTS

This clause of Part 1 is applicable except as follows.

24.1.4 Addition:

Thermal cut-outs incorporated in closed water heaters shall comply with the requirements for Type 2.B controls in **13**, **15**, **16**, **17** and **20** of IS/IEC 60730-1, unless they are tested with the appliance.

24.101 Thermal cut-outs shall be non-self-resetting. They shall have a trip-free switching mechanism or be located so that they can only be reset after removal of a non-detachable cover.

Compliance is checked by inspection.

24.102 The operating temperature of the thermal cut-out of a closed water heater shall ensure that the water temperature cannot exceed 99°C or that the thermal cut-out operates before its temperature exceeds 130°C.

Compliance is checked by the test of **24.102.1** for water temperatures not exceeding 99°C or by the test of **24.102.2** for thermal cut-outs having an operating temperature up to 130°C.

24.102.1 The appliance is operated under the conditions specified in **11** until the thermostat operates for the first time. A quantity of water equal to 25 per cent of the capacity of the container is then drawn off so that it is replaced by cold water.

Immediately after the thermostat operates for the second time, it is short-circuited. The test is continued until the thermal cut-out operates. The outlet valve is then opened and the temperature of the water measured at the outlet.

The temperature shall not exceed 99°C.

If compliance relies on the operation of an electronic circuit, the test is repeated under the following conditions applied separately:

the fault conditions a) to f) of **19.11.2** of Part 1 applied one at a time to the electronic circuit;

the electromagnetic phenomena tests of **19.11.4.1** to **19.11.4.7** of Part 1 applied to the appliance.

The temperature of the water at the outlet shall not

exceed 99°C during or after each of the tests.

If the electronic circuit is programmable, the software shall contain measures to control the fault/ errorconditions specified in Table R.1 and is evaluated in accordance with the relevant requirements of Annex R.

24.102.2 The operating temperature of the thermal cut-out is measured by means of a thermocouple positioned on its sensing element or as close as possible to it.

The water temperature for appliances having vertically oriented metallic water containers is measured by a thermocouple attached to the outer surface of the upper dome. If the water container is horizontally oriented, two thermocouples are attached to the outer surface. The position of the thermocouple is shown in Fig. 102a.

The water temperature for appliances having non-metallic water containers is measured at the most unfavourable position by a thermocouple positioned 50 mm below the upper inner surface of the container, as shown in one of the diagrams of Fig. 102b. This method may also be used to measure the water temperature of appliances having metallic containers.

The appliance is operated at 1.15 times rated power input under normal operation with the outlet valve closed and thermostats short-circuited. The test is continued until the thermal cut-out operates.

The thermal cut-out shall operate before its temperature exceeds 110°C. The water temperature shall not exceed 20 K of the maximum permitted operating temperature of the thermal cut-out.

If compliance relies on the operation of an electronic circuit, the test is repeated under the following conditions applied separately:

the fault conditions a) to f) of **19.11.2** of Part 1 applied one at a time to the electronic circuit;

the electromagnetic phenomena tests of **19.11.4.2** and **19.11.4.5** Part 1 applied to the appliance.

The temperature of the water at the outlet shall not exceed 110 °C during or after each of the tests.

25 SUPPLY CONNECTION AND EXTERNAL FLEXIBLE CORDS

This clause of Part 1 is applicable except as follows.

25.1 Modification:

Appliances shall not incorporate an appliance inlet.

26 TREMINALS FOR EXTERNAL CONDUCTORS

This clause of Part 1 is applicable.

a

b

c

d

e

f

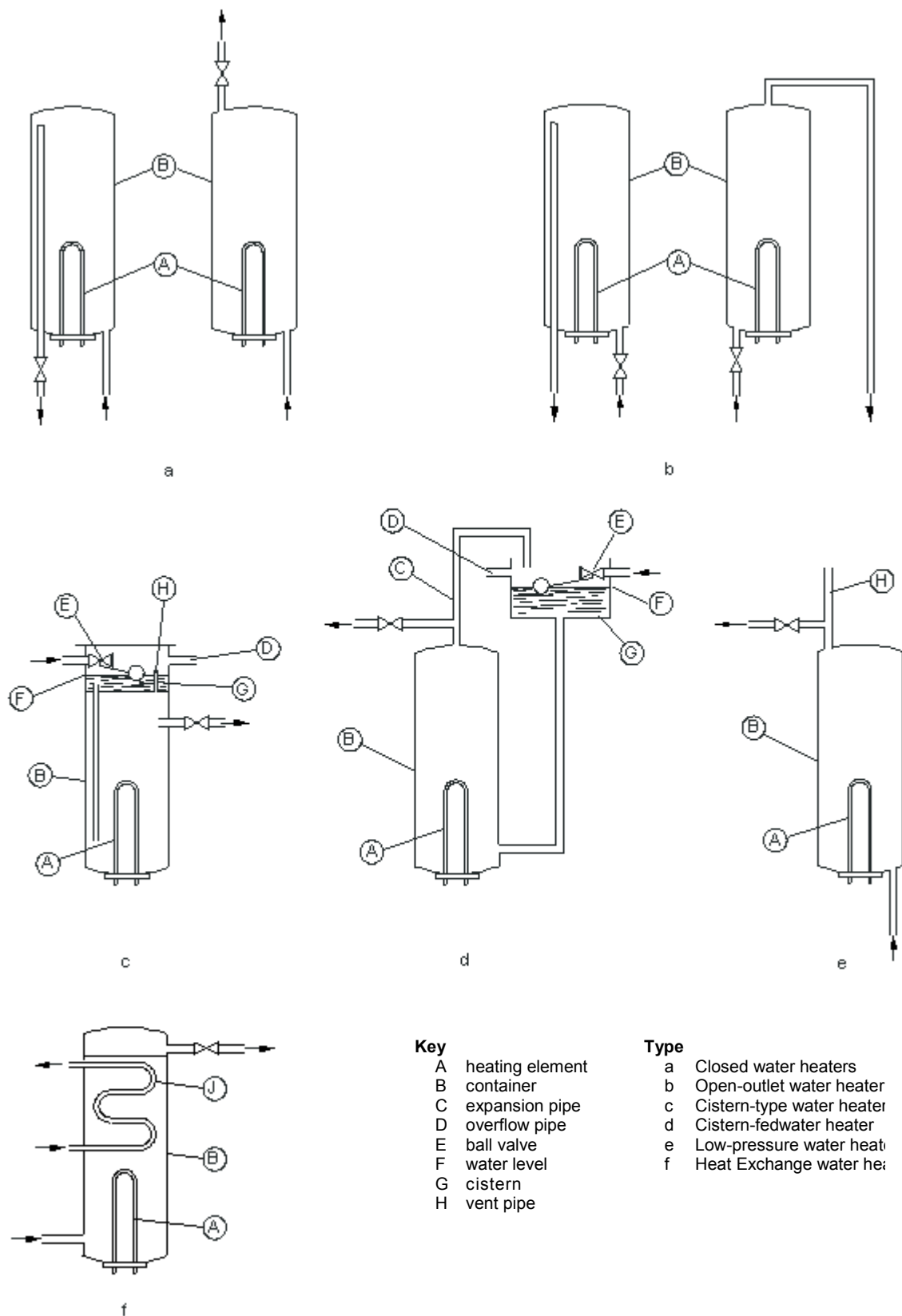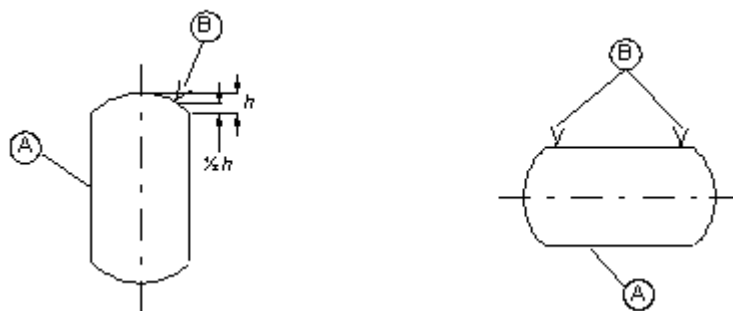| Key		Type	
A	heating element	a	Closed water heaters
B	container	b	Open-outlet water heater
C	expansion pipe	c	Cistern-type water heater
D	overflow pipe	d	Cistern-fedwater heater
E	ball valve	e	Low-pressure water heater
F	water level	f	Heat Exchange water heater
G	cistern		
H	vent pipe		

FIG. 101 EXAMPLE OF TYPES OF STORAGE WATER HEATERS

7

Key
A container
B external thermocouple

FIG. 102A POSITION OF THERMOCOUPLES FOR METALLIC WATER CONTAINERS
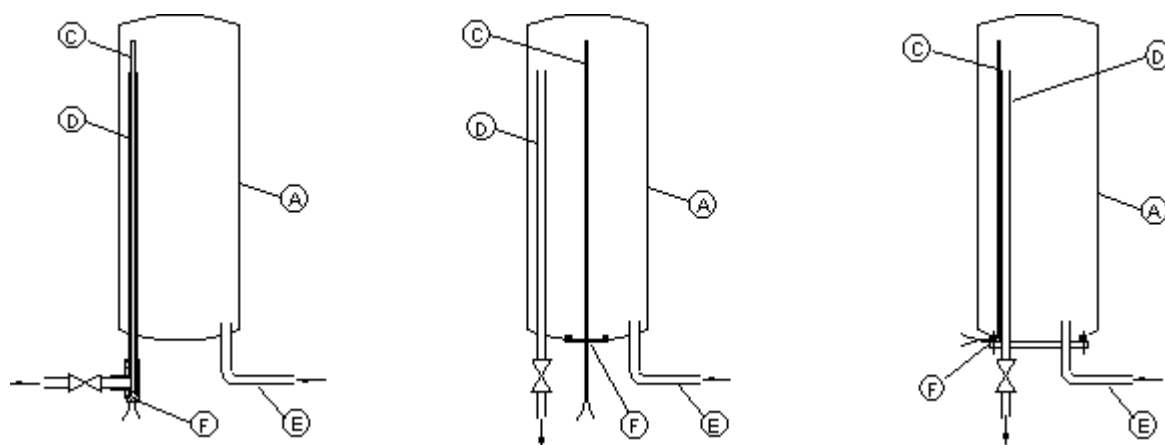
The thermocouple in a tube is inserted in the outlet pipe through a sealed entry

The thermocouple in a tube is inserted through a sealed entry

Insulated thermocouple wire are inserted through a sealed entry and attached to the outlet pipe

FIG. 102B POSITION OF THERMOCOUPLES FOR VERTICALLY ORIENTED WATER CONTAINERS

Key
A container
B External thermocouple
C Internal thermocouple
D Outlet pipe
E Inlet pipe
F Sealed entry

FIG. 102 EXAMPLE OF POSITIONS OF THE THERMOCOUPLES

27 PROVISION FOR EARTHING

This clause of Part 1 is applicable except as follows.

27.1 Addition:

For Class I water heaters, the sheath of the heating element shall be permanently and reliably connected to the earthing terminal unless,

a) the container is provided with inlet and outlet pipes of metal that are permanently and reliably connected to the earthing terminal; and

b) other accessible metal parts of the container in contact with the water are permanently and reliably connected to the earthing terminal.

28 SCREWS AND CONNECTIONS

This clause of Part 1 is applicable.

29 CLEARANCES, CREEPAGE, DISTANCES AND SOLID INSULATION

This clause of Part 1 is applicable.

30 RESISTANCE TO HEAT AND FIRE

This clause of Part 1 is applicable except as follows.

8

30.1 Addition:

The temperature rises occurring during the tests of **19.2, 19.3 and 19.101** are not taken into account.

30.2.2 *Not applicable.*

31 RESISTANCE TO RUSTING

This clause of Part 1 is applicable.

32 RADIATION TOXICITY AND SIMILAR HAZARDS

This clause of Part 1 is applicable.

101 TESTS

101.1 Type Tests

The tests specified in Table 101 shall constitute the type tests and shall be carried out on a sample selected preferably at random from regular production lot *(see* 5.3). Before commencement of the tests, the water heater shall be visually examined and inspected of components, parts and their assembly, constructions, mechanical hazards, marking provision of suitable terminals for supply connections, earthing and the effectiveness screws and connection. The external surface finish shall be even and free from finishing defects.

101.1.1 *Criteria of Acceptance*

Sample shall successfully pass all the type tests for proving conformity with the requirements of the

Table 101 Schedule of Type Tests
(*Clause* 101.1)

Sl No.	Tests	Ref to Clause
(1)	(2)	(3)
i)	Protection against access to live parts	8
ii)	Power input and current	10
iii)	Heating	11
iv)	Leakage current and electric strength at operating temperature	13
v)	Transient overvoltages	14
vi)	Moisture resistance	15
vii)	Leakage current and electric strength	16
viii)	Abnormal operation	19
ix)	Stability and mechanical hazards	20
x)	Mechanical Strength	21
xi)	Construction	22
xii)	Internal wiring	23
xiii)	Components	24
xiv)	Supply connection and external flexible cords	25
xv)	Terminals for external conductors	26
xvi)	Provision for earthing	27
xvii)	Screw and connections	28
xviii)	Clearances, creepage distances and solid insulation	29
xix)	Resistance to heat and fire	30
xx)	Resistance to rusting	31
xxi)	Radiation, toxicity and similar hazards	32

standard. If the sample fails in any of the type tests, the testing authority at its discretion, may call for fresh samples not exceeding twice the original number and subject them again to all tests or to the test (s) in which failure (s) had occurred. No failure should be permitted in the repeat test (s).

ANNEXES

The annexes of Part 1 are applicable except as follows.

ANNEX A

(*Informative*)

ROUTINE TESTS

A-101 PRESSURE TEST

The water container is subjected to a pressure test using a fluid.

When a liquid is used, the pressure is,

a)   for closed water heaters, 0.7 MPa for those having a rated pressure not greater than 0.6 MPa, and 1.1 times rated pressure for others;

b)   for cistern-fed water heaters and low-pressure water heaters, 1.1 times rated pressure;

c)   for open-outlet water heaters, 0.05 MPa;and

d)   for cistern-type water heaters, 0.03 MPa.

When gas is used, these pressures may be reduced but are to be sufficient to reveal leakage.

Leakage of the fluid is not to occur during the test.

ANNEX R

(*Normative*)

SOFTWARE EVALUATION

Programmable **electronic circuits** requiring software incorporating measures to control the fault/error conditions specified in Table R.1 or Table R.2 shall be validated in accordance with the requirements in this annex.

> NOTE — Tables R.1 and R.2 are based on Table H.11.12.7 of IEC 60730-1 that is, for the purpose of this annex, divided in two tables, Table R.1 for general fault/error conditions and Table R.2 for specific fault/error conditions.

R-1 PROGRAMMABLE ELECTRONIC CIRCUITS USING SOFTWARE

Programmable **electronic circuits** requiring software incorporating measures to control the fault/error conditions specified in Table R.1 or Table R.2 shall be constructed so that the software does not impair compliance with the requirements of this standard.

Compliance is checked by the inspections and tests, according to the requirements of this annex, and by examination of the documentation as required by this annex.

R-2 REQUIREMENTS FOR THE ARCHITECTURE

R-2.1 General

Programmable electronic circuits requiring software incorporating measures to control the fault/error conditions specified in Table R.1 or Table R.2 shall use measures to control and avoid software-related faults/errors in safety-related data and safety-related segments of the software.

Compliance is checked by the inspections and tests in R-2.2 to R-3.3.3 inclusive.

R.2.1.1 Programmable electronic circuits requiring software incorporating measures to control the fault/error conditions specified in Table R.2 shall have one of the following structures:

– single channel with periodic self-test and monitoring (see IS/IEC 60730-1, H.2.16.7);
– dual channel (homogenous) with comparison (see IS/IEC 60730-1, H.2.16.3);
– dual channel (diverse) with comparison (see IS/IEC 60730-1, H.2.16.2).

NOTE 1 Comparison between dual channel structures may be performed by:

• use of a comparator (see IS/IEC 60730-1 H.2.18.3), or
• reciprocal comparison (see IS/IEC 60730-1 H.2.18.15).

Programmable **electronic circuits** requiring software incorporating measures to control the fault/error conditions specified in Table R.1 shall have one of the following structures:

– single channel with functional test (see IS/IEC 60730-1, H.2.16.5);
– single channel with periodic self-test (see IS/IEC 60730-1, H.2.16.6);
– dual channel without comparison (see IS/IEC 60730-1, H.2.16.1).

> NOTE 2 — Software structures incorporating measures to control the fault/error conditions specified in Table R.2 are also acceptable for programmable **electronic circuits** with functions requiring software measures to control the fault/error conditions specified in Table R.1.

Compliance is checked by the inspections and tests of the software architecture in **R.3.2.2**.

R-2.2 Measures to control faults/errors

R-2.2.1 When redundant memory with comparison is provided on two areas of the same component, the data in one area shall be stored in a different format from that in the other area (see software diversity, IS/IEC 60730-1 H.2.18.19).

Compliance is checked by inspection of the source code.

R-2.2.2 Programmable **electronic circuits** with functions requiring software incorporating measures to control the fault/error conditions specified in Table R.2 and that use dual channel structures with comparison shall have additional fault/error detection means (such as periodic functional tests, periodic self tests, or independent monitoring) for any fault/errors not detected by the comparison.

R-2.2.3 For programmable electronic circuits with functions requiring software incorporating measures to control the fault/error conditions specified in Table R.1 or Table R.2, means shall be provided for the recognition and control of errors in transmissions to external safety-related data paths. Such means shall take into account errors in data, addressing, transmission timing and sequence of protocol.

Compliance is checked by inspection of the source code.

R-2.2.4 For programmable electronic circuits with functions requiring software incorporating measures to

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control the fault/error conditions specified in Table R.1 or Table R.2, the programmable electronic circuits shall incorporate measures to address the fault/errors in safety-related segments and data indicated in Table R.1 or Table R.2 as appropriate.

Compliance is checked by inspection of the source code.

R-2.2.5 For programmable electronic circuits with functions requiring software incorporating measures to

Table R.1[e] General fault/error conditions

Component [a]	Fault/error	Acceptable measures [b, c]	Definitions See IEC 60730-1
1 **Central processing unit (CPU)**			
1.1 **Registers**	Stuck at	Functional test, or periodic self-test using either: – static memory test, or – word protection with single bit redundancy	H.2.16.5 H.2.16.6 H.2.19.6 H.2.19.8.2
1.2 VOID			
1.3 **Programme counter**	Stuck at	Functional test, or periodic self-test, or independent time-slot monitoring, or logical monitoring of the programme sequence	H.2.16.5 H.2.16.6 H.2.18.10.4 H.2.18.10.2
2 **Interrupt handling and execution**	No interrupt or too frequent interrupt	Functional test, or time-slot monitoring	H.2.16.5 H.2.18.10.4
3 **Clock**	Wrong frequency (for quartz synchronized clock: harmonics/ sub-harmonics only)	Frequency monitoring, or time slot monitoring	H.2.18.10.1 H.2.18.10.4
4 **Memory**			
4.1 **Invariable memory**	All single bit faults	Periodic modified checksum, or multiple checksum, or word protection with single bit redundancy	H.2.19.3.1 H.2.19.3.2 H.2.19.8.2

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Table R.1 — (*Continued*)[e]

Component [a]	Fault/error	Acceptable measures [b, c]	Definitions See IEC 60730-1
4.2 **Variable memory**	DC fault	Periodic static memory test, or word protection with single bit redundancy	H.2.19.6 H.2.19.8.2
4.3 **Addressing (relevant to variable and invariable memory)**	Stuck at	Word protection with single bit redundancy including the address	H.2.19.8.2
5 **Internal data path**	Stuck at	Word protection with single bit redundancy	H.2.19.8.2
5.1 VOID			
5.2 Addressing	Wrong address	Word protection with single bit redundancy including the address	H.2.19.8.2
6 **External communication**	Hamming distance 3	Word protection with multi-bit redundancy, or CRC – single word , or transfer redundancy, or protocol test	H.2.19.8.1 H.2.19.4.1 H.2.18.2.2 H.2.18.14
6.1 VOID			
6.2 VOID			
6.3 **Timing**	Wrong point in time	Time-slot monitoring, or scheduled transmission Time-slot and logical monitoring, or comparison of redundant communication channels by either: – reciprocal comparison – independent hardware comparator	H.2.18.10.4 H.2.18.18 H.2.18.10.3 H.2.18.15 H.2.18.3
	Wrong sequence	Logical monitoring, or time-slot monitoring, or scheduled transmission	H.2.18.10.2 H.2.18.10.4 H.2.18.18
7 **Input/output periphery**	Fault conditions specified in 19.11.2	Plausibility check	H.2.18.13

Table R.1 — (*Concluded*)[e]

Component [a]	Fault/error	Acceptable measures [b, c]	Definitions See IEC 60730-1
7.1 VOID			
7.2 **Analog I/O**			
7.2.1 A/D- and D/A- convertor	Fault conditions specified in 19.11.2	Plausibility check	H.2.18.13
7.2.2 Analog multiplexer	Wrong addressing	Plausibility check	H.2.18.13
8 VOID			
9 **Custom chips [d]** **e.g. ASIC, GAL, gate array**	Any output outside the static and dynamic functional specification	Periodic self test	H.2.16.6

NOTE — A Stuck-at fault model denotes a fault model representing an open circuit or a non-varying signal level. A DC fault model denotes a stuck-at fault model incorporating short circuits between signal lines.

[a] For fault/error assessment, some components are divided into their sub-functions.

[b] For each sub-function in the table, the Table R.2 measure will cover the software fault/error.

[c] Where more than one measure is given for a sub-function, these are alternatives.

[d] To be divided as necessary by the manufacturer into sub-functions.

[e] Table R.1 is applied according to the requirements of R.1 to R.2.2.9 inclusive.

Table R.2[e] — Specific fault/error conditions

Component [a]	Fault/error	Acceptable measures [b, c]	Definitions See IEC 60730-1
1 Central Processing Unit (CPU) **1.1 Registers**	DC fault	Comparison of redundant CPUs by either: – reciprocal comparison – independent hardware comparator, or internal error detection, or redundant memory with comparison, or periodic self-tests using either – walkpat memory test – Abraham test – transparent GALPAT test; or word protection with multi-bit redundancy, or static memory test and word protection with single bit redundancy	H.2.18.15 H.2.18.3 H.2.18.9 H.2.19.5 H.2.19.7 H.2.19.1 H.2.19.2.1 H.2.19.8.1 H.2.19.6 H.2.19.8.2
1.2 Instruction decoding and execution	Wrong decoding and execution	Comparison of redundant CPUs by either: – reciprocal comparison – independent hardware comparator, or internal error detection, or periodic self-test using equivalence class test	H.2.18.15 H.2.18.3 H.2.18.9 H.2.18.5
1.3 Programme counter	DC fault	Periodic self-test and monitoring using either: – independent time-slot and logical monitoring – internal error detection, or comparison of redundant functional channels by either: – reciprocal comparison – independent hardware comparator	H.2.16.7 H.2.18.10.3 H.2.18.9 H.2.18.15 H.2.18.3
1.4 Addressing	DC fault	Comparison of redundant CPUs by either: – reciprocal comparison – independent hardware comparator; or internal error detection; or periodic self-test using – a testing pattern of the address lines; or – a full bus redundancy – a multi bus parity including the address	H.2.18.15 H.2.18.3 H.2.18.9 H.2.16.7 H.2.18.22 H.2.18.1.1 H.2.18.1.2
1.5 Data paths instruction decoding	DC fault and execution	Comparison of redundant CPUs by either: – reciprocal comparison, or – independent hardware comparator, or – internal error detection, or – periodic self-test using a testing pattern, or – data redundancy, or – multi-bit bus parity	H.2.18.15 H.2.18.3 H.2.18.9 H.2.16.7 H.2.18.2.1 H.2.18.1.2

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Table R.2 — (*Continued*)[e]

Component [a]	Fault/error	Acceptable measures [b, c]	Definitions See IEC 60730-1
2 **Interrupt handling and execution**	No interrupt or too frequent interrupt related to different sources	Comparison of redundant functional channels by either – reciprocal comparison, – independent hardware comparator, or – independent time-slot and logical monitoring	 H.2.18.15 H.2.18.3 H.2.18.10.3
3 **Clock**	Wrong frequency (for quartz synchronized clock: harmonics/ subharmonics only)	Frequency monitoring, or time-slot monitoring, or comparison of redundant functional channels by either: – reciprocal comparison – independent hardware comparator	H.2.18.10.1 H.2.18.10.4 H.2.18.15 H.2.18.3
4. Memory			
4.1 **Invariable memory**	99,6 % coverage of all information errors	Comparison of redundant CPUs by either: – reciprocal comparison – independent hardware comparator, or redundant memory with comparison, or periodic cyclic redundancy check, either – single word – double word, or word protection with multi-bit redundancy	 H.2.18.15 H.2.18.3 H.2.19.5 H.2.19.4.1 H.2.19.4.2 H.2.19.8.1
4.2 **Variable memory**	DC fault and dynamic cross links	Comparison of redundant CPUs by either: – reciprocal comparison – independent hardware comparator, or redundant memory with comparison, or periodic self tests using either: – walkpat memory test – Abraham test – transparent GALPAT test, or word protection with multi-bit redundancy	 H.2.18.15 H.2.18.3 H.2.19.5 H.2.19.7 H.2.19.1 H.2.19.2.1 H.2.19.8.1
4.3 **Addressing (relevant to variable and invariable memory)**	DC fault	Comparison of redundant CPUs by either: – reciprocal comparison, or – independent hardware comparator, or full bus redundancy testing pattern, or periodic cyclic redundancy check, either: – single word – double word, or word protection with multi-bit redundancy including the address	 H.2.18.15 H.2.18.3 H.2.18.1.1 H.2.18.22 H.2.19.4.1 H.2.19.4.2 H.2.19.8.1

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Table R.2 — (*Continued*)[e]

Component [a]	Fault/error	Acceptable measures [b, c]	Definitions See IEC 60730-1
5 **Internal data path**			
5.1 Data	DC fault	Comparison of redundant CPUs by either – reciprocal comparison – independent hardware comparator, or word protection with multi-bit redundancy including the address, or data redundancy, or testing pattern, or protocol test	 H.2.18.15 H.2.18.3 H.2.19.8.1 H.2.18.2.1 H.2.18.22 H.2.18.14
5.2 Addressing	Wrong address and multiple addressing	Comparison of redundant CPUs by: – reciprocal comparison – independent hardware comparator, or word protection with multi-bit redundancy, including the address, or full bus redundancy; or testing pattern including the address	 H.2.18.15 H.2.18.3 H.2.19.8.1 H.2.18.1.1 H.2.18.22
6 **External communication**			
6.1 **Data**	Hamming distance 4	CRC – double word, or data redundancy or comparison of redundant functional channels by either: – reciprocal comparison – independent hardware comparator	H.2.19.4.2 H.2.18.2.1 H.2.18.15 H.2.18.3
6.2 **Addressing**	Wrong address	Word protection with multi-bit redundancy, including the address, or CRC single word including the addresses, or transfer redundancy or protocol test	H.2.19.8.1 H.2.19.4.1 H.2.18.2.2 H.2.18.14
	Wrong and multiple addressing	CRC – double word, including the address, or full bus redundancy of data and address, or comparison of redundant communication channels by either: – reciprocal comparison – independent hardware comparator	H.2.19.4.2 H.2.18.1.1 H.2.18.15 H.2.18.3
6.3 **Timing**	Wrong point in time	Time-slot monitoring, or scheduled transmission	H.2.18.10.4 H.2.18.18
7 **Input/output periphery**			

Table R.2 — (*Concluded*)[e]

Component [a]	Fault/error	Acceptable measures [b, c]	Definitions See IEC 60730-1
7.1 **Digital I/O**	Fault conditions specified in 19.11.2	Comparison of redundant CPUs by either: – reciprocal comparison – independent hardware comparator, or input comparison, or multiple parallel outputs, or output verification, or testing pattern, or code safety	H.2.18.15 H.2.18.3 H.2.18.8 H.2.18.11 H.2.18.12 H.2.18.22 H.2.18.2
7.2 **Analog I/O**			
7.2.1 A/D- and D/A- convertor	Fault conditions specified in 19.11.2	Comparison of redundant CPUs by either: – reciprocal comparison – independent hardware comparator, or input comparison, or multiple parallel outputs, or output verification, or testing pattern	H.2.18.15 H.2.18.3 H.2.18.8 H.2.18.11 H.2.18.12 H.2.18.22
7.2.2 Analog multiplexer	Wrong addressing	Comparison of redundant CPUs by either: – reciprocal comparison – independent hardware comparator, or input comparison or testing pattern	H.2.18.15 H.2.18.3 H.2.18.8 H.2.18.22
8 **Monitoring devices and comparators**	Any output outside the static and dynamic functional specification	Tested monitoring, or redundant monitoring and comparison, or error recognizing means	H.2.18.21 H.2.18.17 H.2.18.6
9 **Custom chips [d]** **e.g. ASIC, GAL, gate array**	Any output outside the static and dynamic functional specification	Periodic self-test and monitoring, or dual channel (diverse) with comparison, or error recognizing means	H.2.16.7 H.2.16.2 H.2.18.6
NOTE — A DC fault model denotes a stuck-at fault model incorporating short circuits between signal lines.			

[a] For fault/error assessment, some components are divided into their sub-functions.

[b] For each sub-function in the table, the software measure will cover the Table R.1 fault/error.

[c] Where more than one measure is given for a sub-function, these are alternatives.

[d] To be divided as necessary by the manufacturer into sub-functions.

[e] Table R.2 is applied according to the requirements of R.1 to R.2.2.9 inclusive, only if required by a part 2.

control the fault/error conditions specified in Table R.1 or Table R.2, detection of a fault/error shall occur before compliance with **19** and **24.102.1** is impaired.

R-2.2.6 The software and safety-related hardware under its control shall be initialized and shall terminate before compliance with Clause **19**, **22.105 and 22.108** is impaired.

R-2.2.7 Where labels are used for memory locations, these labels shall be unique.

Compliance is checked by inspection of the source code.

R-2.2.8 The software shall be protected from user alteration of safety-related segments and data.

Compliance is checked by inspection of the source code.

R-2.2.9 The software and safety-related hardware under its control shall be initialized and shall terminate before compliance with **19** and **24.102.1** is impaired.

Compliance is checked by testing of the source code.

R-3 MEASURES TO AVOID ERRORS

R-3.1 General

For programmable **electronic circuits** with functions requiring software incorporating measures to control the fault/error conditions specified in Table R.1 or Table R.2, the following measures to avoid systematic faults in the software shall be applied.

Software that incorporates measures used to control the fault/error conditions specified in Table R.2 is inherently acceptable for software required to control the fault/error conditions specified in Table R.1.

NOTE — The content of these requirements is extracted from IEC 61508-3 and adapted to the needs of this Standard.

R-3.2 Specification

R-3.2.1 Software safety requirements

The specification of the software safety requirements shall include:

– a description of each safety related function to be implemented, including its response time(s):

• functions related to the application including their related software faults required to be controlled;

• functions related to the detection, annunciation and management of software or hardware faults;

– a description of interfaces between software and hardware;

– a description of interfaces between any safety

and non-safety related functions;

– a description of any compiler used to generate the object code from the source code, including details of any compiler switch settings used such as library function options, memory model, optimization, SRAM details, clock rate and chip details;

– a description of any linker used to link the object code to executable library routines.

Compliance is checked by inspection of the documentation and as specified in R-3.2.2.2.

NOTE — Examples of some techniques/measures to meet these requirements can be found in Table R.3.

Table R-3 — Semi-formal methods

Technique / Measure	Informative references
Semi-formal methods	
Logical/functional block diagrams	
Sequence diagrams	
Finite state machines/state transition diagrams	IS/IEC 61508-7, B.2.3.2
Decision/truth tables	IS/IEC 61508-7, C.6.1

R-3.2.2 Software architecture

R-3.2.2.1 The specification of the software architecture shall include the following aspects:

– techniques and measures to control software faults/errors (refer to R-2.2);

– interactions between hardware and software;

– partitioning into modules and their allocation to the specified safety functions;

– hierarchy and call structure of the modules (control flow);

– interrupt handling;

– data flow and restrictions on data access;

– architecture and storage of data;

– time-based dependencies of sequences and data.

Compliance is checked by inspection of the documentation and as specified in R-3.2.2.2.

NOTE — Examples of some techniques/measures to meet these requirements can be found in Table R.4.

R-3.2.2.2 *The architecture specification shall be validated against the specification of the software safety requirements by static analysis.*

NOTE Example methods for static analysis are:
• control flow analysis; (IS/IEC 61508-7, C.5.9);
• data flow analysis; (IS/IEC 61508-7, C.5.10);
• walk-throughs/design reviews. (IS/IEC 61508-7, C.5.16).

R-3.2.3 Module design and coding

R-3.2.3.1 Based on the architecture design, software

shall be suitably refined into modules. Software module design and coding shall be implemented in a way that is traceable to the software architecture and requirements.

Compliance is checked by R-3.2.3.3 and by inspection of the documentation.

NOTE 1 — The use of computer aided design tools is accepted.

NOTE 2 — Defensive programming (IEC 61508-7, Subclause C.2.5) is recommended (e.g. range checks, check for division by 0, plausibility checks).

NOTE 3 — The module design shall specify:

- function(s),
- interfaces to other modules,
- data.

NOTE 4 Examples of some techniques/measures to meet these requirements can be found in Table R.5.

R-3.2.3.2 Software code shall be structured.

Compliance is checked by R-3.2.3.3 and by inspection of the documentation.

NOTE 1 Structural complexity can be minimized by applying the following principles:

- keep the number of possible paths through a software module small, and the relation between the input and output parameters as simple as possible;
- avoid complicated branching and, in particular, avoid unconditional jumps (GOTO) in higher level languages;
- where possible, relate loop constraints and branching to input parameters;

- avoid using complex calculations as the basis of branching and loop decisions.

NOTE 2 — Examples of some techniques/measures to meet these requirements can be found in Table R.6.

R-3.2.3.3 Coded software shall be validated against the module specification by static analysis. The module specification shall be validated against the architecture specification by static analysis.

R-3.3.3 Software validation

The software shall be validated with reference to the requirements of the software safety requirements specification.

NOTE 1 — Validation is confirmation by examination and provision of objective evidence that the particular requirements for a specific intended use are fulfilled. Therefore, for example, software validation means confirming by examination and provision of objective evidence that the software satisfies the software safety requirements specification.

Compliance is checked by simulation of

- input signals present during normal operation,
- anticipated occurrences,
- undesired conditions requiring system action.

Test cases, test data and test results shall be reported.

NOTE 2 — Examples of some techniques/measures to meet these requirements can be found in Table R.7.

Table R.4 — Software architecture specification

Technique / Measure	Informative references
Fault detection and diagnosis	IS/IEC 61508-7, C.3.1
Semi-formal methods: • Logic/function block diagrams • Sequence diagrams • Finite state machines / state transition diagrams • Data flow diagrams	IS/IEC 61508-7, B.2.3.2 IS/IEC 61508-7, C.2.2

Table R.5 — Module design specification

Technique / Measure	Informative references
Limited size of software modules	IS/IEC 61508-7, C.2.9
Information hiding / encapsulation	IS/IEC 61508-7, C.2.8
One entry / one exit point in subroutines and functions	IS/IEC 61508-7, C.2.9
Fully defined interface	IS/IEC 61508-7, C.2.9
Semi-formal methods: • Logic/function block diagrams • Sequence diagrams • Finite state machines / state transition diagrams • Data flow diagrams	IS/IEC 61508-7, B.2.3.2 IS/IEC 61508-7, C.2.2

Table R.6 — Design and coding standards

Technique / Measure	Informative references
Use of coding standard (see NOTE)	IS/IEC 61508-7, C.2.6.2
No use of dynamic objects and variables (see NOTE)	IS/IEC 61508-7, C.2.6.3
Limited use of interrupts	IS/IEC 61508-7, C.2.6.5
Limited use of pointers	IS/IEC 61508-7, C.2.6.6
Limited use of recursion	IS/IEC 61508-7, C.2.6.7
No unconditional jumps in programs in higher level languages	IS/IEC 61508-7, C.2.6.2
NOTE — Dynamic objects and/or variables are allowed if a compiler is used which ensures that sufficient memory for all dynamic objects and/or variables will be allocated before runtime, or which inserts runtime checks for the correct online allocation of memory.	

Table R.7 — Software safety validation

Technique / Measure	Informative references
Functional and black-box testing: • Boundary value analysis • Process simulation	IS/IEC 61508-7, B.5.1, B.5.2 IS/IEC 61508-7, C.5.4 IS/IEC 61508-7, C.5.18
Simulation, modelling: • Finite state machines • Performance modelling	 IS/IEC 61508-7, B.2.3.2 IS/IEC 61508-7, C.5.20

NOTE 3 — Testing should be the main validation method for software; modelling may be used to supplement the validation activities.

ANNEX AA

(*Normative*)

ADDITIONAL REQUIREMENT FOR IMMERSION HEATER UNITS INTENDED FOR THE INSTALLATION IN HEAT EXCHANGE CLOSED WATER HEATERS

The following requirements of this standard are for immersion heater units intended for the installation in a heat exchange closed water heater. Other subclauses of this standard not mentioned in this annex are applicable. Where 'water heater' is written, the requirement applies for 'immersion heater units' of this annex.

NOTE — Water storage tanks without an integrated heat exchanger can be retrofitted with an immersion heater unit if the retrofitting is allowed by the manufacturer of the container. In this case, the manufacturer needs to specify the acceptable immersion heater units in the instruction for installation of the water storage tank.

AA.3 TERMS AND DEFINITIONS

AA.3.1.9 *Replacement*:

normal operation

operation of the immersion heater unit after installation in accordance with the instructions in the smallest tank specified, the tank being thermally insulated and filled with water

NOTE 101— Accessible parts of the immersion heater unit are not thermally insulated.

AA.3.201 Immersion Heater Unit

appliance consisting of heating element and controls in a single unit to control the temperature in both normal and abnormal conditions and intended to be retrofitted to a heat exchange closed water heater

AA-5 GENERAL CONDITIONS FOR THE TESTS

AA.5.2 *Addition*:

Additional immersion heater units may be required for the tests of **19** and **22.102.**

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AA.5.3 *Addition*:

The test is to be carried out in a water tank according to the instructions of the manufacturer of the immersion heater unit.

> NOTE — Several tests for different mounting positions (vertically from the top or bottom, horizontally) can be required.

AA.7 MARKING AND INSTRUCTIONS

AA.7.1 *Replacement*:

Immersion heater units for multiple supply shall be marked with their rated power input for each supply circuit.

Immersion heater units shall be marked with the rated pressure. The rated pressure shall not be lower than 0.6 MPa.

AA.7.12.1 Replacement:

The installation instruction shall include the following:

a) type, the volume or volume range, and dimensions of the tank in which the immersion heater unit can be installed;

b) the positioning of the immersion heater unit within the tank;

c) a statement that the installer must check that there is water in the tank before the immersion heater unit is switched on the first time;

d) that a pressure-relief device is to be installed in the installation, unless it is not already part of the water tank installation;

e) the type and properties of the pressure-relief device and how to install it;

f) that a discharge pipe connected to the pressure relief device shall be installed with a steady downward inclination in a frost-free environment.

The instructions for immersion heater units for water tanks with an incorporated heat exchanger shall include instructions for the installation of thermal controls and their temperature setting in order to prevent the thermal cut-out from operating due to the heat of the heat exchanger.

AA.19 ABNORMAL OPERATION

AA.19.1 Addition:

For immersion heater units, the tests of **19.2** and **19.3** are applicable.

AA.19.13 Addition:

During the test, the immersion heater unit shall not show any leakage.

AA.22 CONSTRUCTION

AA.22.47 Replacement:

The immersion heater units shall withstand the water pressure occurring in normal use.

Compliance is checked by the following: The immersion heater units are exposed to a water pressure which is twice as high as the rated pressure.

The pressure is raised to the specified value at a rate of 0.13 MPa/s and maintained at this value for 5 min.

No water is allowed to leak and no permanent deformation of the parts of the immersion heater unit intended to withstand the water pressure is allowed to an extent which would impair conformity to this standard.

AA.22.101 Replacement:

The rated pressure of immersion heater units intended to be exposed directly to the water main shall be at least 0.6 MPa.

AA.22.111 Replacement:

Void.

AA.22.112 Immersion heater units shall be supplied with a seal or similar means to ensure that there is no leakage from the tank after installation.

Compliance is checked by inspection during the test of **11**.

AA.22.113 The immersion heater unit shall not be able to be removed from the tank without the aid of a tool.

Compliance is checked by inspection.

The cover of the compartment containing the supply terminals shall be prevented from rotating by more than 180° with respect to the fixed part of the immersion heater unit.

Compliance is checked by inspection.

AA.24 COMPONENTS

AA.24.102 Replacement:

The thermal cut-out shall operate before the water temperature exceeds 99 °C and the water temperature shall not exceed the opening temperature of the thermal cut-out by more than 20 K.

Compliance is checked by the following test.

The operating temperature of the thermal cut-out is measured with a thermo element that is attached to the sensor element or arranged in its close vicinity.

If the tank is in a horizontal position, the water temperature is measured at the most unfavourable position by a thermocouple positioned 50 mm below the upper inner surface of the container.

The immersion heater unit is operated at 1.15 times its rated power input with the thermostat short-circuited but under normal operation conditions and with the output valve of the tank closed.

The test is continued until the thermal cut-out operates.

(*Continued from second cover*)

When a particular subclause of Part 1 is not mentioned in this Part 2, that subclause applies as far as is reasonable. When this standard states 'addition', 'modification' or 'replacement', the relevant text in Part 1 is to be adapted accordingly.

NOTES The following numbering system is used:

a) Subclauses, tables and figures that are numbered starting from 101 are additional to those in Part 1;

b) Unless notes are in a new subclause or involve notes in Part 1, they are numbered starting from 101, including those in a replaced clause or subclause;

c) Additional annexes are lettered AA, BB, etc.

This standard is based on IEC 60335-2-21 : 2012 Household & similar electrical appliances-safety — Part 2-21 : Particular requirements for storage water heaters. As this standard refers to IS 302-1, the differences of IS 302-1 from IEC 60335-1 shall apply.

The principal change in this revision is as follows (minor changes are not listed):

added requirements for immersion heater units (fixed immersion heaters).

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This Indian Standard has been developed from Doc No.: ETD 32 (6764).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

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