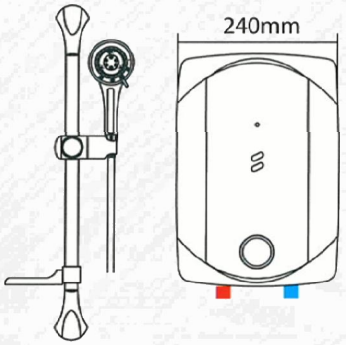
Suruhanjaya Tenaga
Energy Commission

NATIONAL CONFERENCE ON ELECTRICAL SAFETY 2015



Water Heater Safety

9th November 2015

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PRESENTATION OUTLINE

THIS PRESENTATION aims to provide an understanding of the safety (electrical) issues in the design and installation of domestic electric water heater with the following topical discussions:

(1) The water heater market

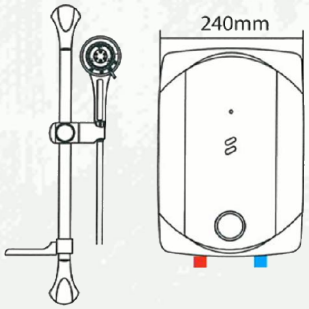
(2) Types of domestic water heater

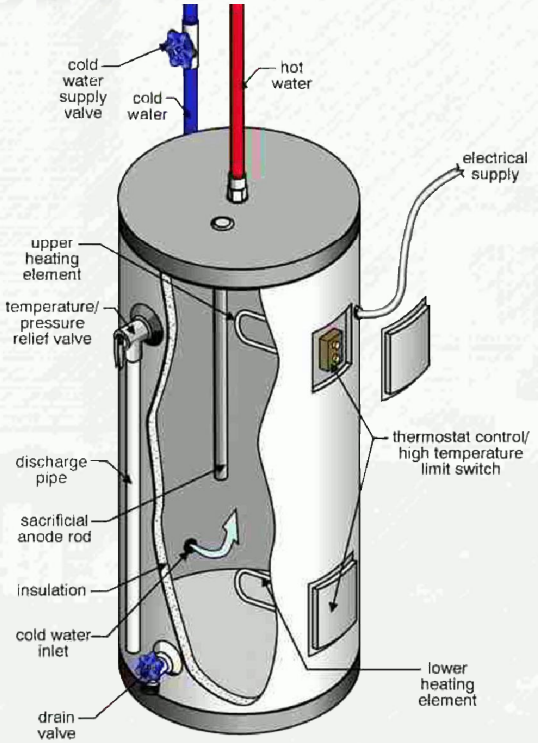
(3) IEC 60364 wiring configurations and part 701 (locations contain bath or showers)

(4) Installation Standards IEC 60364-7-701

(5) Design challenges water heater installations.

1 The Water Heater Market





4 Water Heater Failure (Thailand)

A Swedish couple have died after apparently being electrocuted while taking a shower together in a hotel room in Thailand.

Friend received electric shock when trying to revive victims.

2nd April 2011

Heating element in shower head. Substandard instant water heater.

5 Examples of WH Failure (Singapore)

18-year-old dies after getting electrocuted during shower at Hougang flat, Singapore. 1st September 2014

- ✓ Instant water heater newly bought to replaced the old WH which was not working.
- ✓ New water heater was connected to the plug point (outside the bath room. Note No RCD.

- ✓ Yell from bathroom, grandfather rushed to locked bathroom. Smoke coming out from socket outlet.
- ✓ By the time the socket outlet was switched off, victim was unconscious. Victim died in

6 Examples of WH Failure (Singapore)

18-year-old dies after getting electrocuted during shower at Hougang flat, Singapore. 1st September 2014

7 Examples of WH Failure (Malaysia)

September 2013 – Japanese man electrocuted while holding shower head of water heater. Wife electrocuted trying to save husband.

August 2014 – Pharmacist (lady) found electrocuted while still clutching shower head of water heater.

Since 2009; seven reported cases of death by electrocution (source WG on heated appliances, safety for electrical household appliances, SIRIM):

- ✓ Four cases involved water heaters
- ✓ Three cases involved storage water heaters
- ✓ Most cases RCCB (main) not working
- ✓ In one case earth and live cables melted (found to be undersized).
- ✓ In ALL cases, victim died while still holding onto metallic shower head.

8 2012 Electrical Appliances in Malaysia

	Appliances	Urban	Rural	Total
1.	Car	83.6%	62.7%	77.8%
2.	Motorcycle	61.5%	77.6%	66.0%
3.	Bicycle	28.6%	30.4%	29.1%
4.	Air Conditioner	46.8%	13.8%	37.6%
5.	Washing machine	93.5%	82.9%	90.5%
6.	Refrigerator	97.5%	93.0%	96.2%
7.	Gas Stove	95.5%	95.6%	95.5%
8.	Kerosene Stove	1.4%	4.0%	2.1%
9.	Wood/Charcoal Stove	1.6%	11.9%	4.5%
10.	Microwave oven	32.7%	14.7%	27.7%
11.	Personal computer	25.0%	10.8%	21.0%
12.	Television	98.2%	96.1%	97.7%

Table 2 – Penetration Rate of Appliances in Malaysian Households 2012 (Census data from Department of Statistics)

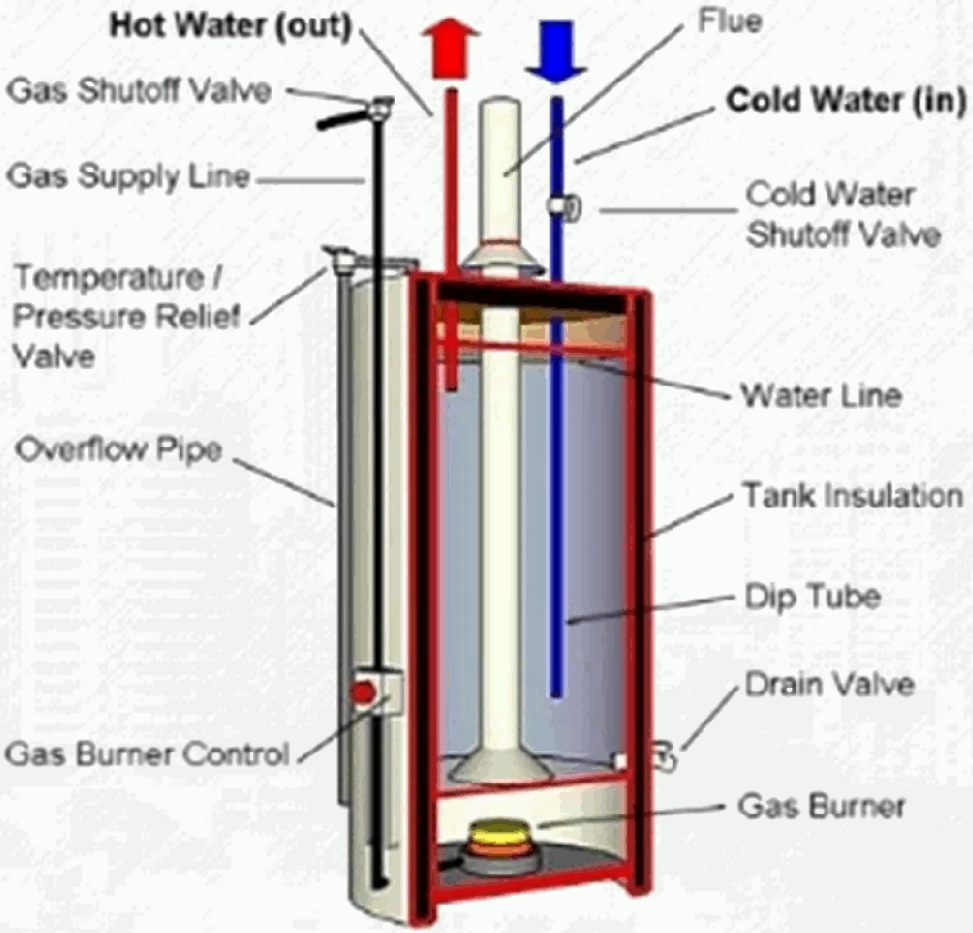
No statistics for water heater BUT can correlate water heater penetration to air conditioning units. Water heater may have penetration of at least 45% in urban area.

Total house holds approx. 6.5million, >70% in areas classified as Urban.

Types of Water Heater

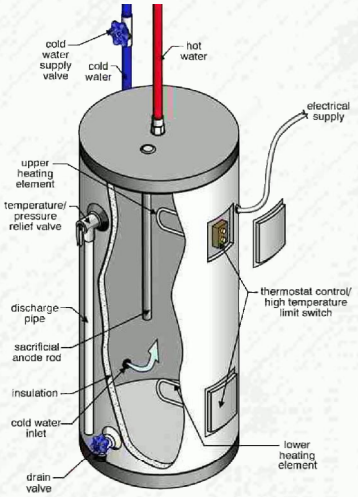
2

10 Types of Domestic Water Heater

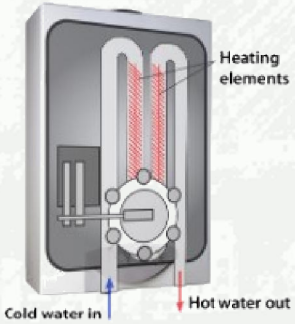


Gas water heater

Immersion water heater



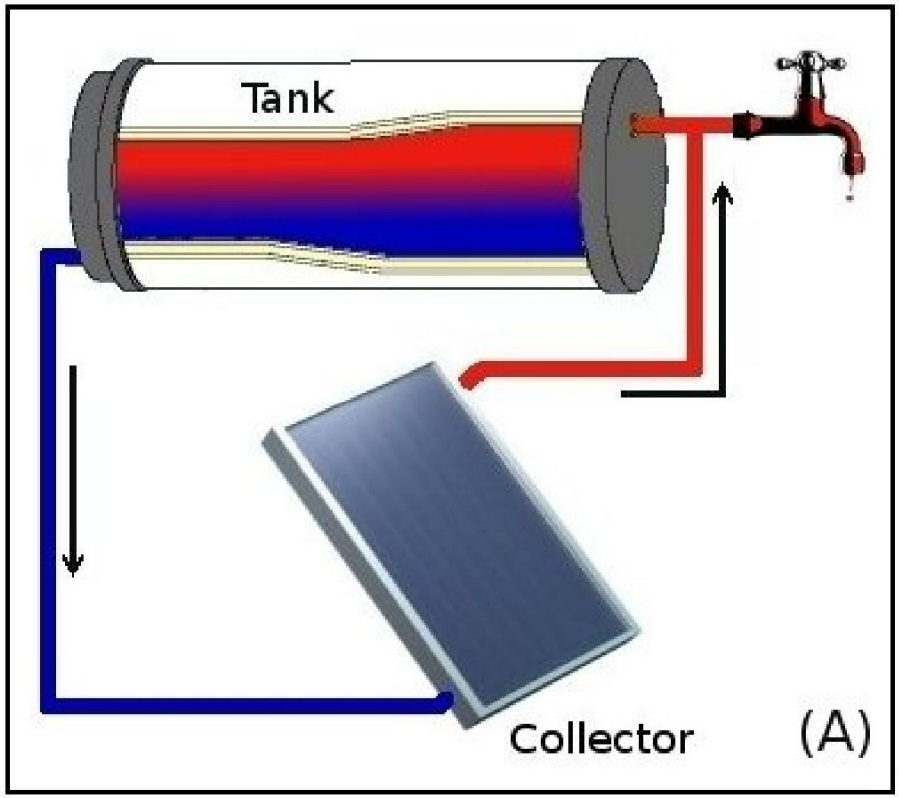
Storage water heater



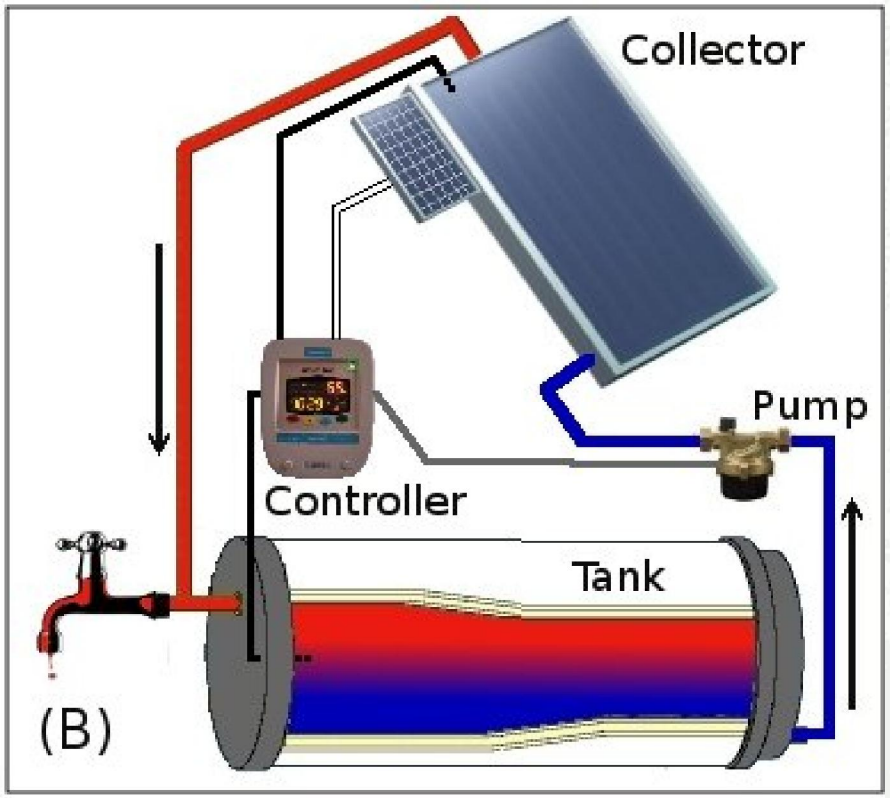
Instant water heater

Electric water heater

11 Types of Domestic Water Heater



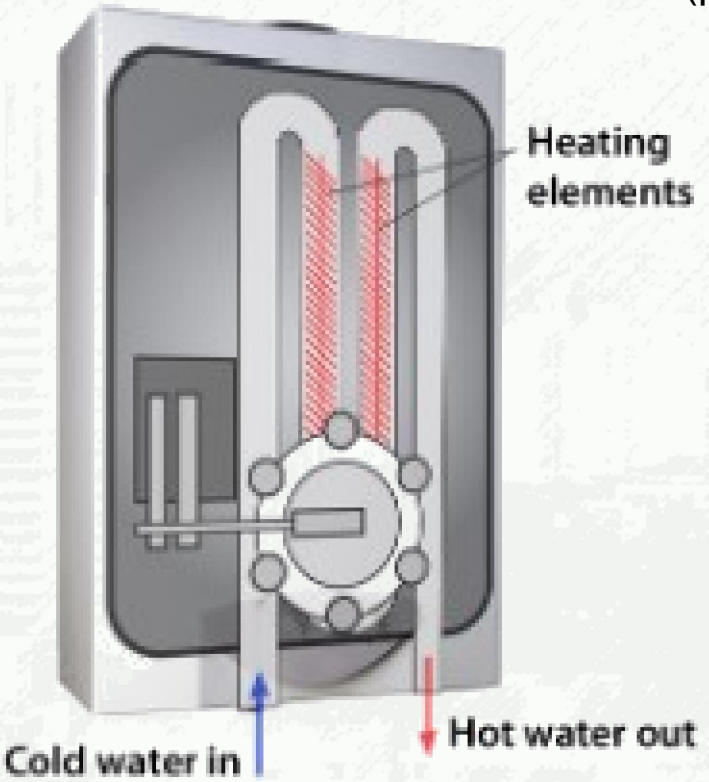
Passive solar collector



Active solar collector

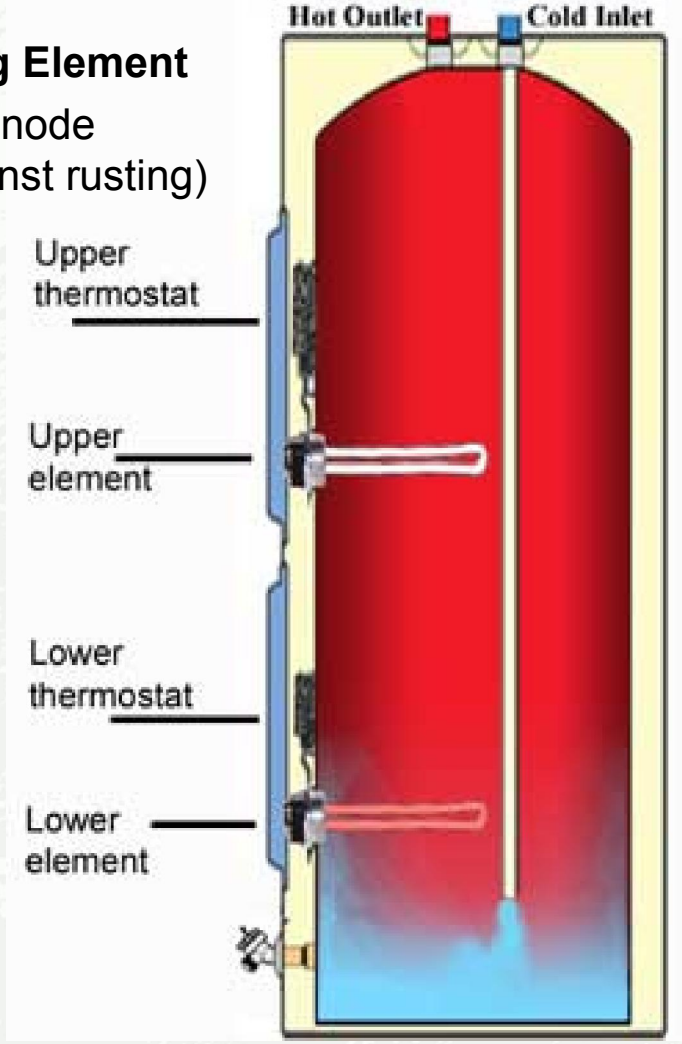
12 Types of Domestic Water Heater

Single Element

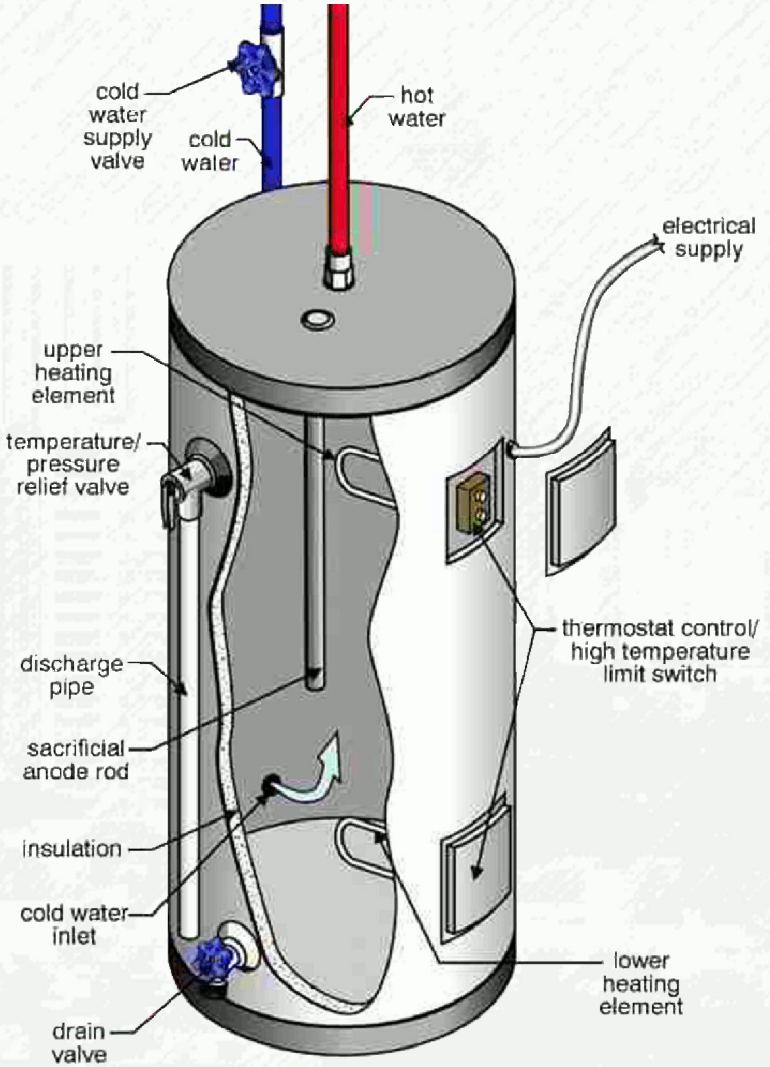


Double heating Element

with sacrificial anode
(protection against rusting)



13 Sizing Domestic Water Heater



Typical Hot Water Usage

Typical Hot Water Use	
Showers (normal)	10 L/min
Showers (water efficient, 5 ✓)	5 L/min
Standard bath (1/2 full)	75 – 100 L/min
Dish washer	35 – 50 L/min
Laundry – hot wash/warm rinse	115 L/min
Laundry – hot wash/cold rinse	75 L/min
Laundry – warm wash/cold rinse	35 – 45 L/min

14 Sizing Domestic Water Heater

Typical Hot Water Usage for showers; 5 – 10 L/min

Instant water heater flow rate from 1 – 2 gpm

Power outlets can therefore start from 15A to 30A, 240V

Electrical Loading	2.2 kW	10.0 A	220 Va.c.	50 / 60 Hz
	3.0 kW	13.0 A	230 Va.c.	50 / 60 Hz
	3.3 kW	15.0 A	220 Va.c.	50 / 60 Hz
	3.3 kW	13.8 A	240 Va.c.	50 / 60 Hz
	3.6 kW	16.0 A	230 Va.c.	50 / 60 Hz
	3.6 kW	15.0 A	240 Va.c.	50 / 60 Hz
	4.4 kW	20.0 A	220 Va.c.	50 / 60 Hz
	4.8 kW	21.0 A	230 Va.c.	50 / 60 Hz
	5.2 kW	24.0 A	220 Va.c.	50 / 60 Hz
Min. Water Pressure	10 kPa / 1.45 psi / 0.1 bar			
Max. Water Pressure	380 kPa / 55 psi / 3.8 bar			
Min. Water Flow	2 litres per minute			
Max. Water Flow	8 litres per minute			
Inlet / Outlet Connection	ø15mm (1/2" BSP) – Single Point System			
Dimensions	240 X 360 X 70 mm			
Weight	3.4 kg (i90P), 2.9 kg (i90e) & 2.7 kg (i90) 4.7 kg (i90P (RS)), 4.2 kg (i90e (RS)) & 4.0 kg (i90 (RS))			

15 Sizing Domestic Water Heater

Storage tank; 15 Litres to 100 Litres.

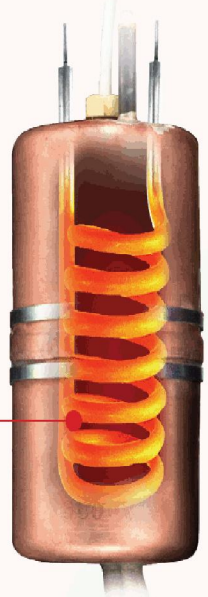
Electric power from 1kW to 3kW

Model	Tank Capacity Litres (Imp. Gals)	Time Taken (Min)[1]		Replacement Rate 43°C Rise
		3kW	1.5kW	
JH15	15 (3.3)	15	23	3kW Heating Element 63 Litres (14 Gals) per hour 1.5kW Heating Element 32 Litres (14 Gals) per hour
JH25	25 (5.5)	20	40	
JH35	35 (7.7)	30	60	
JH38	38 (8.4)	35	70	
JH50	50 (11.0)	45	90	
JH56	56 (12.3)	50	100	
JH68	68 (15.0)	60	120	
JH91	91 (20.0)	80	160	

[1] Approximate time taken to heat up to 70°C, inlet water temperature at 27°C

Safe, Reliable Design

Safety Features Hitachi is Particular About

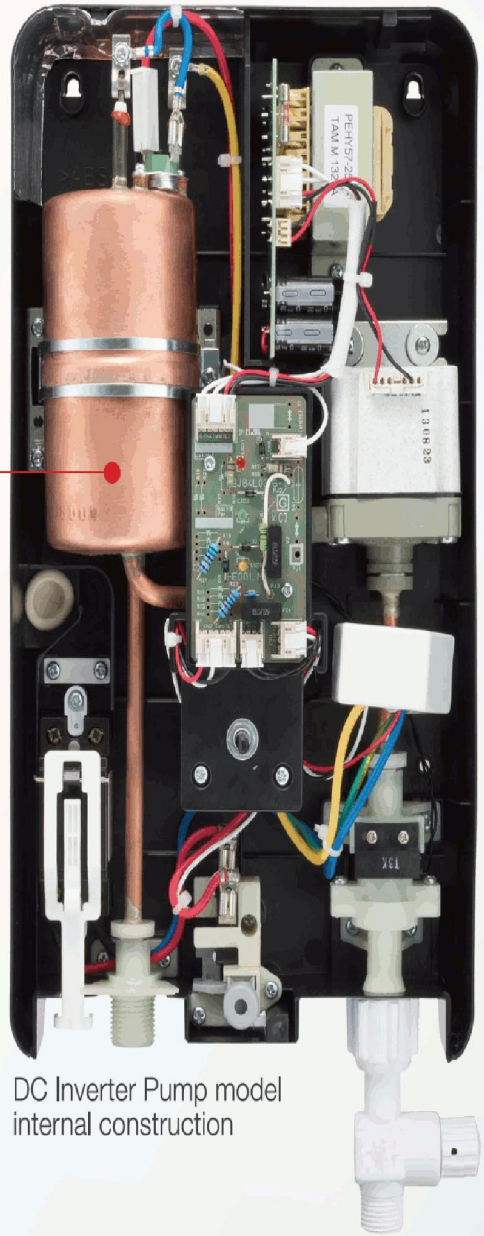


Incoloy Heater
(Incoloy is a stainless steel and nickel alloy)

This rust-free heater prevents the formation of sediment and withstands high temperatures.

Copper Heater Tank

The tank is made of copper and is highly resistant to heat and pressure.



DC Inverter Pump model internal construction

12 Advanced Safety Features

Detailed Consideration by Hitachi

All potential risk sites are thoroughly insulated and, of course, there's an earth leakage circuit breaker (ELCB) to further assure safe use.

ELCB
(Earth Leakage Circuit Breaker)

This breaker cuts off the power within 0.1 second when it detects an electrical leakage of 15mA or higher.

On-Off Switch

This is the master switch to control the operation of the system.

Insulation at Potential Risk Points

Rust-resistant Incoloy heater
Features a function to prevent water becoming too hot and causing scolding. For extra safety, UL 94-V0 flame-resistant material is also used.

Incoloy Heater

This rust-free heater prevents the formation of sediment and withstands high temperatures.

Thermostat with a Reset System

The system makes sure that the water temperature never goes any higher than 75°C.

Copper Heater Tank

The tank is made of copper and is highly resistant to heat and pressure.

PCB Cover

It protects the PCB unit from any damage from an outside source.

Non Flammable Cabinet

The cover is made of a special material and is certified with the UL 94-V0 standard.

IP25 water- and dust-resistant finish. Also features a water pressure regulation valve to prevent excessive water pressure on the heater.

Waterproof Structure

IP25 Grade

Water Pressure Sensor

This enables the machine to continue working normally even when the water pressure drops to as low as 4.9033 kPa. (Standard model: 15.6906 kPa)

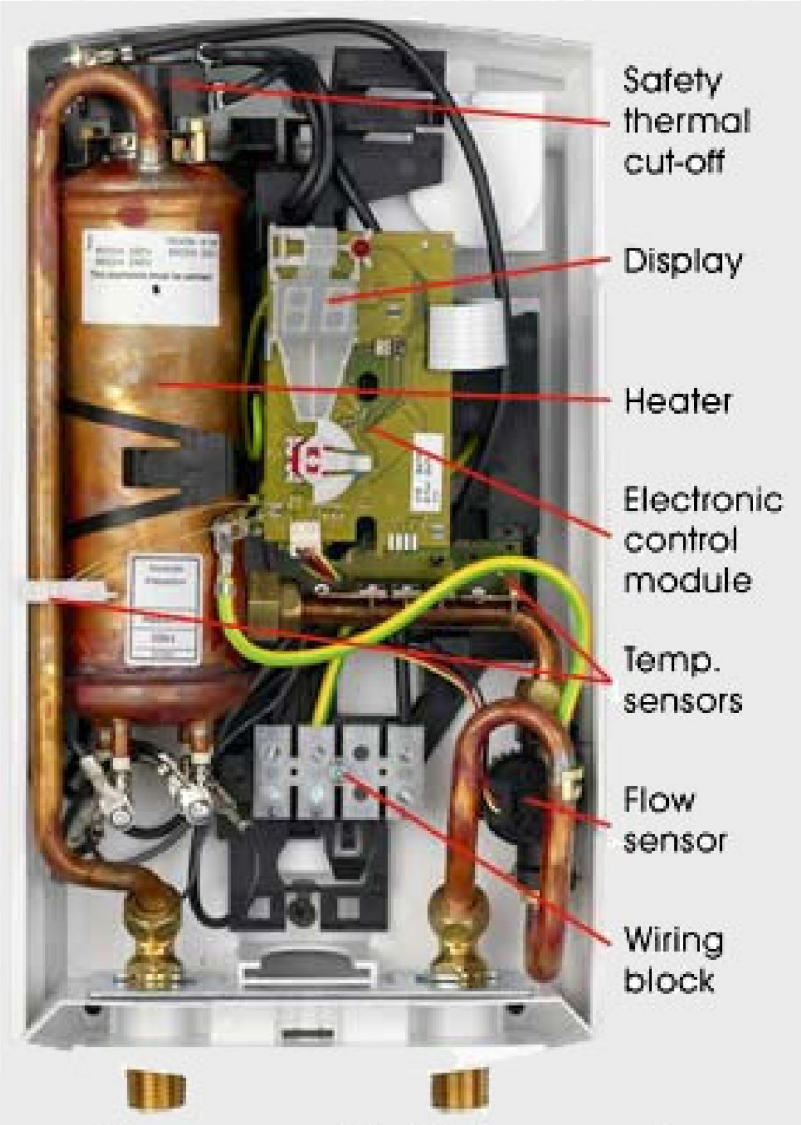
Water Pressure Controller

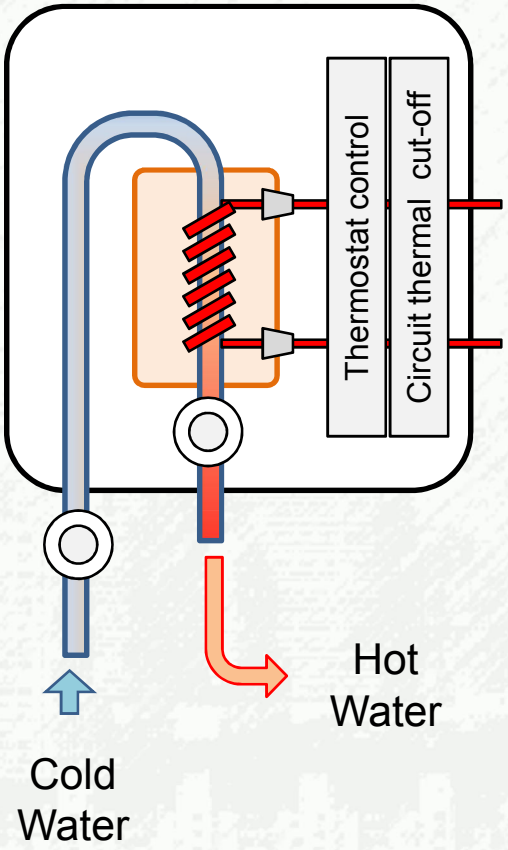
The valve ensures that water pressure does not exceed 980.665 kPa.

Water Filter

Prevents dirt entering at the valve.

17 Instant Water Heater (tankless)

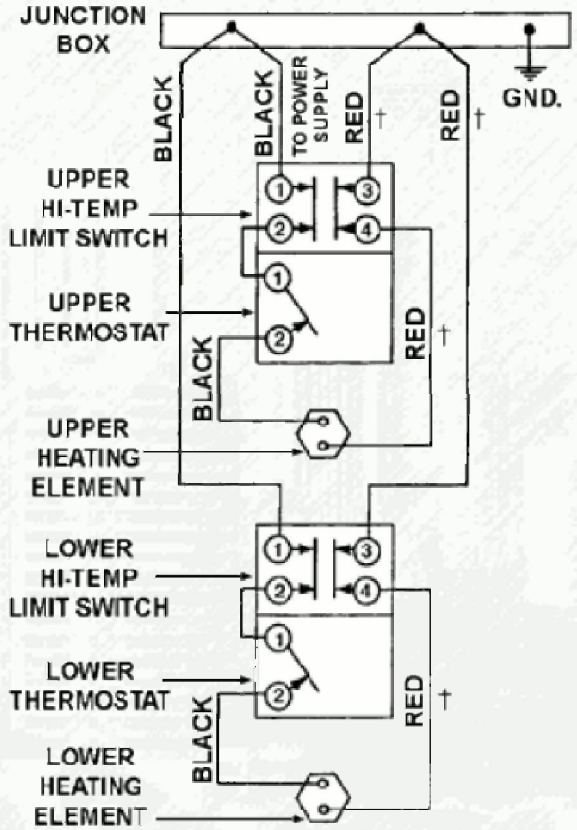




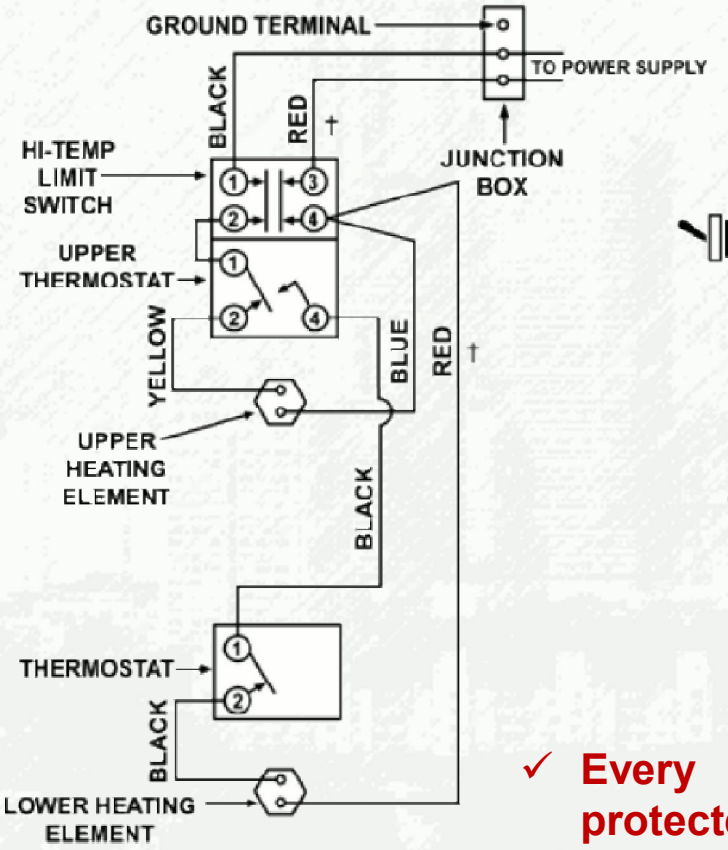
Cables In (Live, Neutral & Earth)

18 Water Heater (typical internal wirings)

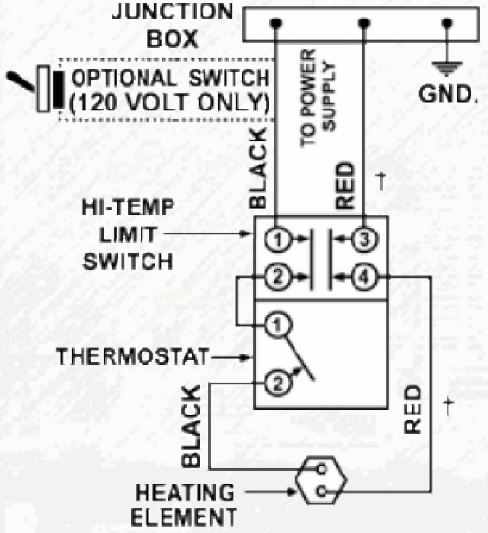
2 heating element



2 heating element



1 heating element



- ✓ **Every heating element is protected with a thermal overload.**
- ✓ **Thermostat control switches element ON/OFF.**

3 Technical Standards

20 Energy Commission Controlled Goods

34 categories of controlled goods for electrical & electronic equipment

Rationale for Regulation:

Ensure safety and Consumer protection

Legislative Framework

Electricity Supply Act 1990;-

Section 4 (l), Part III-

Section 37 (1), Part IX

Electricity Regulations 1994;-

Regulation 97 (1)

NRG = Not Regulated

IDT = Identical

MOD = Modified

NEQ = Not Equivalent

Suruhanjaya Tenaga
Energy Commission

21 Energy Commission Controlled Goods

Suruhanjaya Tenaga
Energy Commission

34 categories of controlled goods for electrical & electronic equipment

1. Plug top/Plug (15A and below)

3. SOCKET OUTLET (15A and below)

10. CIRCUIT BREAKER including AC CURRENT OPERATED EARTH LEAKAGE CIRCUIT BREAKER and MINIATURE CIRCUIT BREAKER

17. IMMERSION WATER HEATER

18. WATER HEATER including HEATING ELEMENTS IF SUPPLIED SEPARATELY

22 List of Technical Standards

Suruhanjaya Tenaga
Energy Commission

Suruhanjaya Tenaga – Certificate of Approval to Manufacture, Import, Display, Sell or Advertise for Electrical Equipment.

	MS	IEC
Instantaneous Water Heater	MS IEC 60335-1:2003 MS 1597-2-35:2003	IEC 60335-1:2001 IEC 60335-2-35:2002
Electric Storage Water Heater	MS IEC 60335-1:2003 MS 1597-2-21:2000	IEC 60335-1:2001 IEC 60335-2-21:1997
Electric Fixed Immersion Heater	MS IEC 60335-2-73:2003	IEC 60335-2-73:2002
Portable Immersion Heater	MS IEC 60335-2-74:1995	IEC 60335-2-74:1994

23 List of Technical Standards

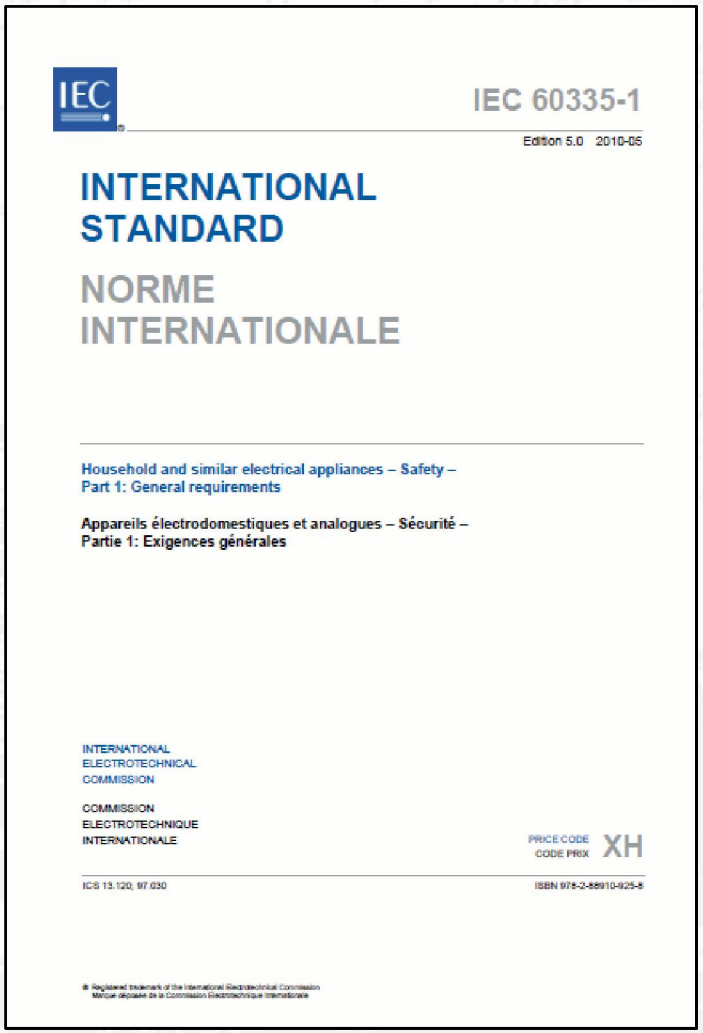
Suruhanjaya Tenaga – Circuit Breaker & RCCB

Item	Category	Detail of Equipment	Standards	
			Domestic	Relevant International
10	**CIRCUIT BREAKER including AC CURRENT OPERATED EARTH LEAKAGE CIRCUIT BREAKER and MINIATURE CIRCUIT BREAKER**	Residual Current Circuit Breaker (RCCB)	MS IEC 61008-1: 2007 MS IEC 61008-2-1: 2003 MS IEC 61008-2-2: 2003	IEC 61008-1: 2002 IEC 61008-2-1: 1990 IEC 61008-2-2: 1990
		Residual Current Breaker with Overcurrent Protection (RCBO)	MS IEC 61009-1: 2005 MS IEC 61009-2-1: 2003 MS IEC 61009-2-2: 2003	IEC 61009-1: 2003 IEC 61009-2-1: 1991 IEC 61009-2-2: 1991
		Miniature Circuit Breaker (MCB)for ac	MS IEC 60898-1: 2007	IEC 60898-1: 2003
		Miniature Circuit Breaker (MCB)for ac & dc	MS IEC 60898-2: 2007	IEC 60898-2: 2003
		Fuse Base & Carrier up to 32A	MS IEC 60269-1:2011 MS IEC 60296-2:2011	IEC 60269-1:2006 IEC 60269-2:2006
		Fuse/Fuse Link up to 63A	MS IEC 60269-2:2011 MS IEC 60269-3:2011	IEC 60269-2:2006 IEC 60269-3:2010
		Switch fuse up to 63A.	MS IEC 60947-1:2010 MS IEC 60947-3:2010	IEC 60947-1:2007 IEC 60947-3:2008

24 Installation Standards

Table 1.: Electrical Standard for Installation Equipment	
Consumer Unit	IEC 61439–3
Final distribution board	IEC 61439–3
*Miniature Circuit Breaker (MCB)	MS IEC 60898–1 & –2
Circuit breaker	MS IEC 60947–2
*Residual current device (RCD)	MS IEC 61008–1 & –2, MS IEC 62423
Wire and cable for fixed wiring	
450/750V PVC insulated cable	MS 2112–3/–4
600/1000 V PVC insulated cable	MS 2100/1/2/3
Cable trunking and ducting	MS 1777
Conduit	MS IEC 61386
Double pole switch (Up to 63A)	**MS IEC 60669 (Non – Electronic)
***13A plug and switched socket outlet	MS 589
***15A plug and socket outlet	MS 1577
Switches, Disconnectors	MS IEC 60947–3
Flexible wire and cable	MS 2112–5
*= MCB – RCD combinations such as RCBO are acceptable as replacement ** = Electronic switches are not permitted by MS IEC 60364 *** = Shall not be used for new installation and recommend to replace for existing installations	

25 Technical Standards – 60335-1



IEC 60335-1

Edition 5.0 2010-05

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Household and similar electrical appliances – Safety – Part 1: General requirements

Appareils électrodomestiques et analogues – Sécurité – Partie 1: Exigences générales

INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

PRICE CODE CODE PRIX XH

ICS 13.120; 97.030

ISBN 978-2-88910-925-5

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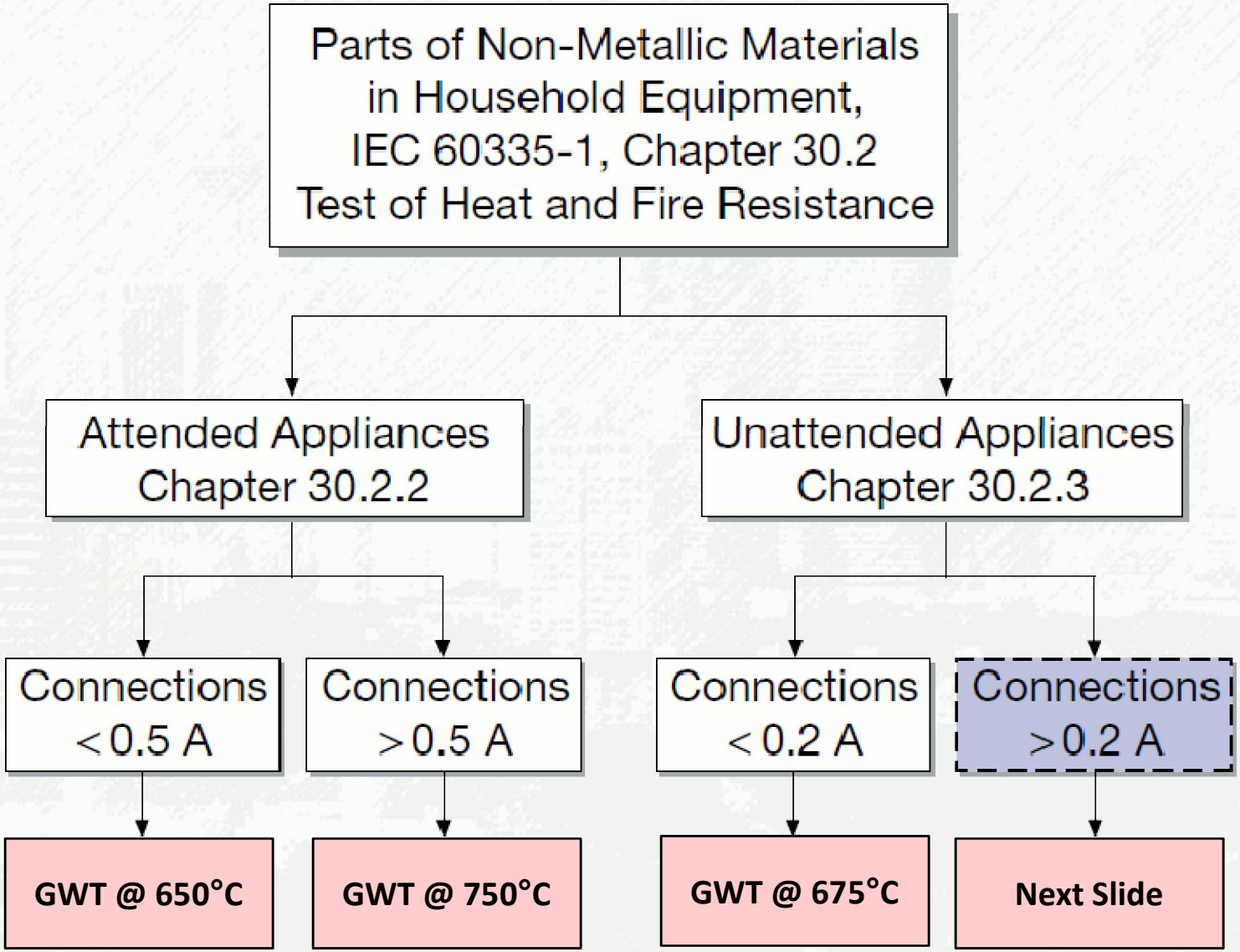
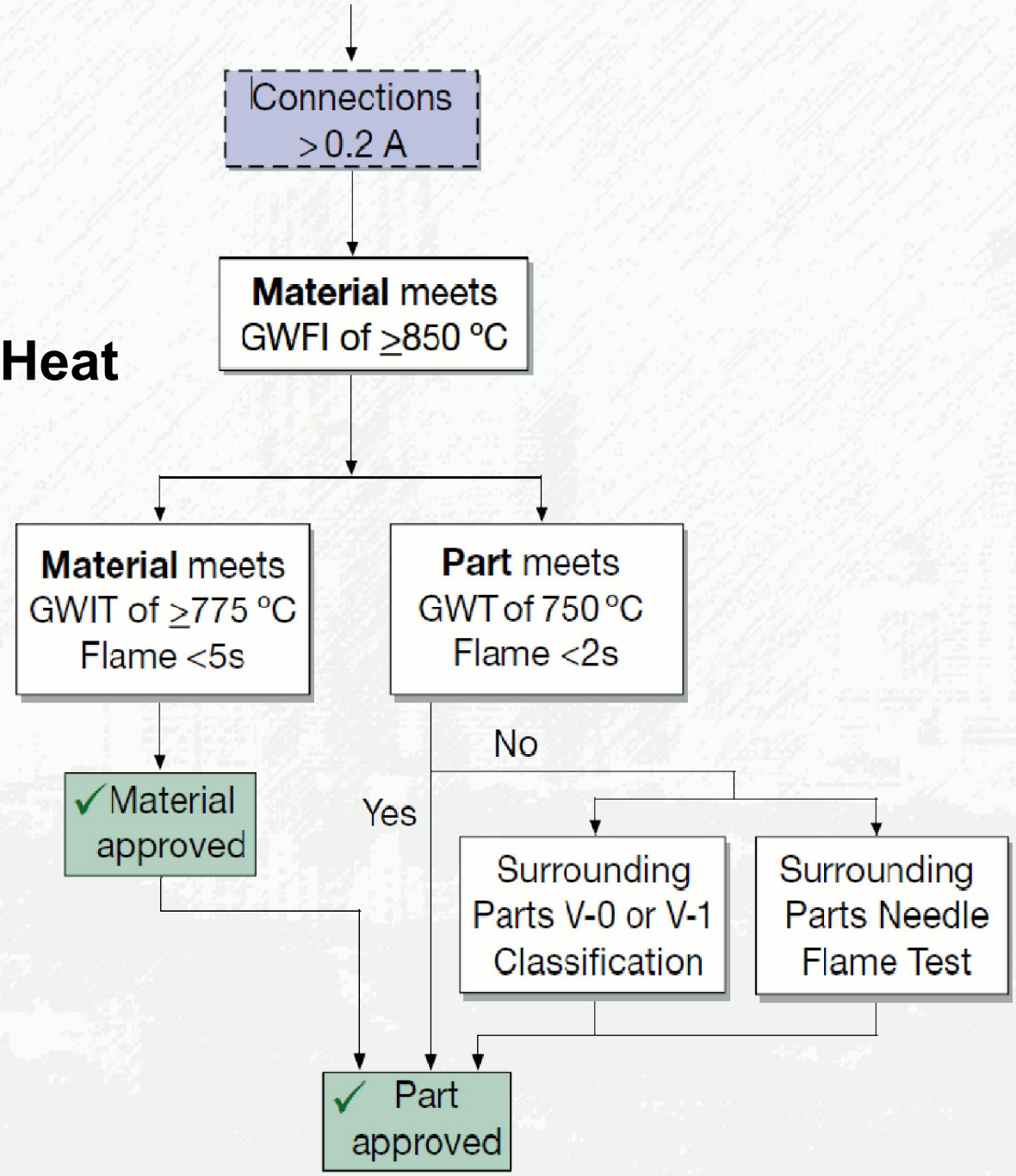
IEC 60335 – 1 (Edition 5: 2010) – Household and similar electrical appliances – Safety – Part 1: General Requirements.

- ✓ **Covers domestic appliances**
- ✓ **Prescribe electrical, mechanical, and thermal hazards, as well as fire and radiation hazards**
- ✓ **Takes into account hazards that may arise even if the appliance is used properly and in accordance with the operating instructions.**
- ✓ **This standard is a product-family standard that covers the safety of appliances and takes priority over any generic standards that may apply to the same item.**

26 60335 – 1 ; Clause 30 Heat and Fire Rating



IEC 60335 – 1;
Clause 30: Fire & Heat



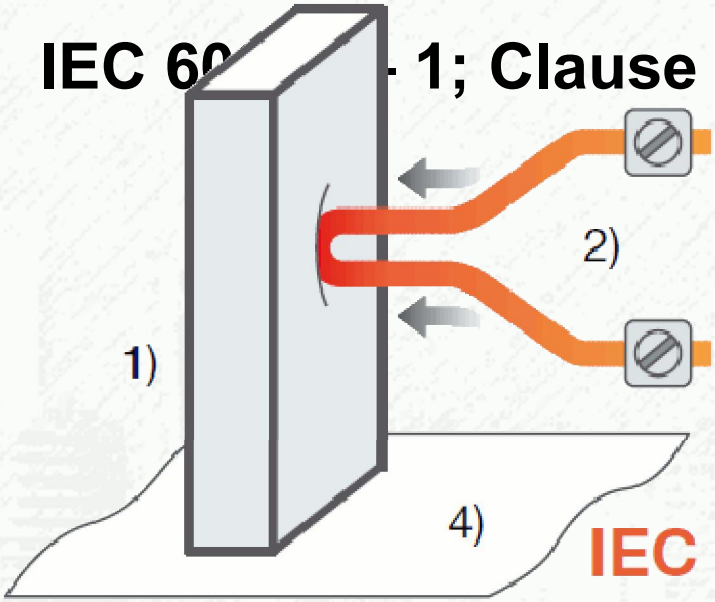
GWT = Glow Wire Test

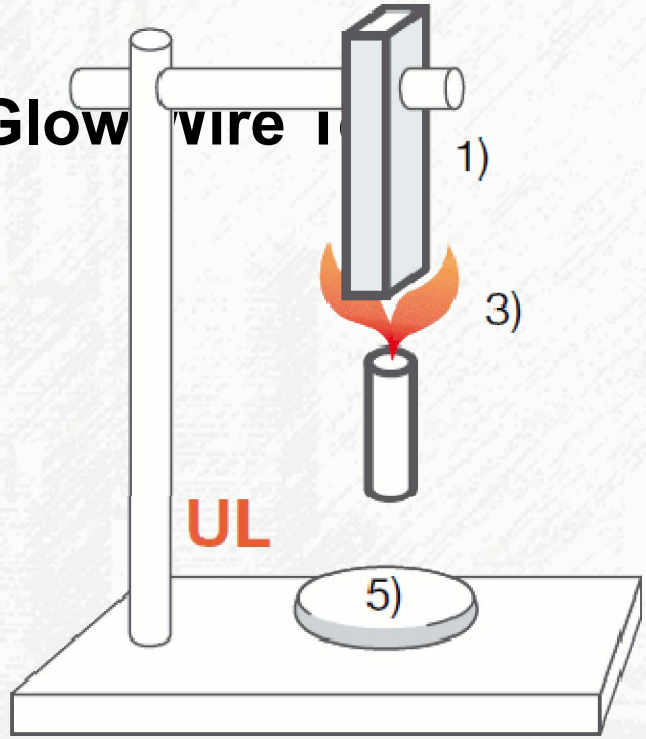
GWFI = Glow Wire Flammability Index

GWIT = Glow Wire Ignition Temperature

28 60335 – 1 ; Heat and Fire Rating

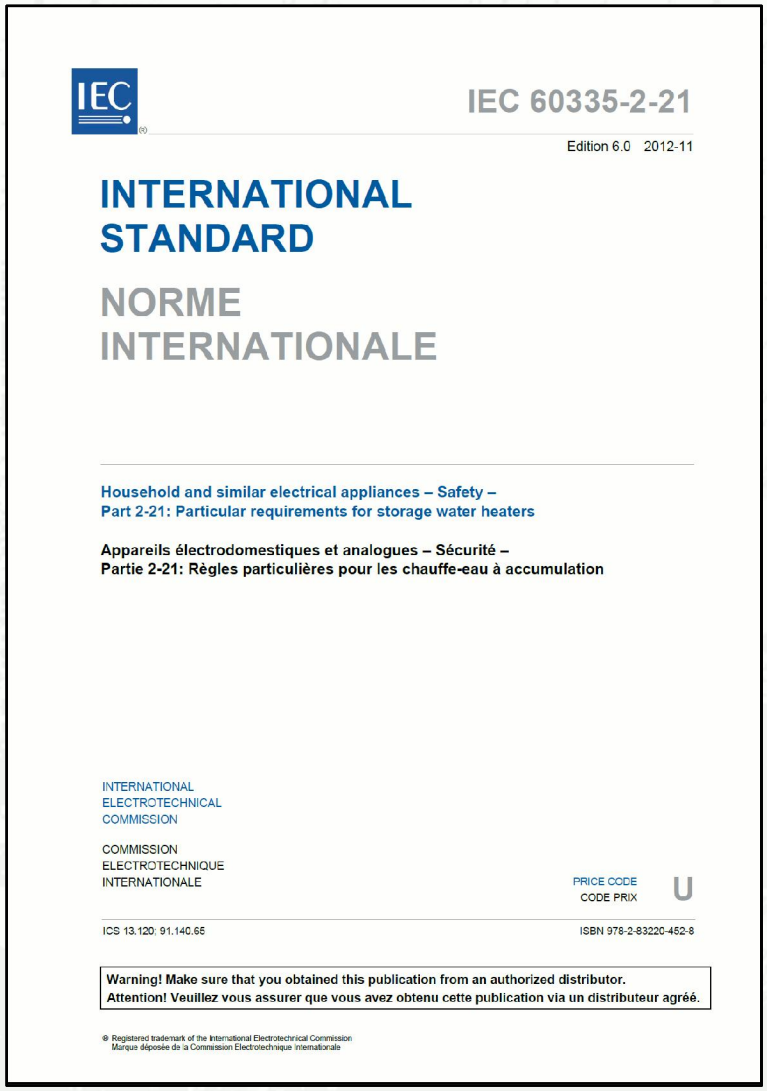
28 IEC 60[illegible] 1; Clause 30: Glow [illegible]wire [illegible]





(1) = Specimen
(2) = Glow Wire
(3) = Flame
(4) = Tissue
(5) = Cotton

29 IEC 60335-2-21 ; Storage Water Heater



IEC 60335-2-21

Edition 6.0 2012-11

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Household and similar electrical appliances – Safety –
Part 2-21: Particular requirements for storage water heaters

Appareils électrodomestiques et analogues – Sécurité –
Partie 2-21: Règles particulières pour les chauffe-eau à accumulation

INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

PRICE CODE
CODE PRIX U

ICS 13.120; 91.140.65

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IEC 60335–2–21 (Edition 6: 2011) – Household and similar electrical appliances – Safety – Part 2–21: Particular requirement for storage water heaters.

- ✓ **To be read in conjunction with Part 1**
- ✓ **Part 2 covers particular requirement for domestic appliances. Part 2-21 covers storage water heater.**

4 Installation Standards

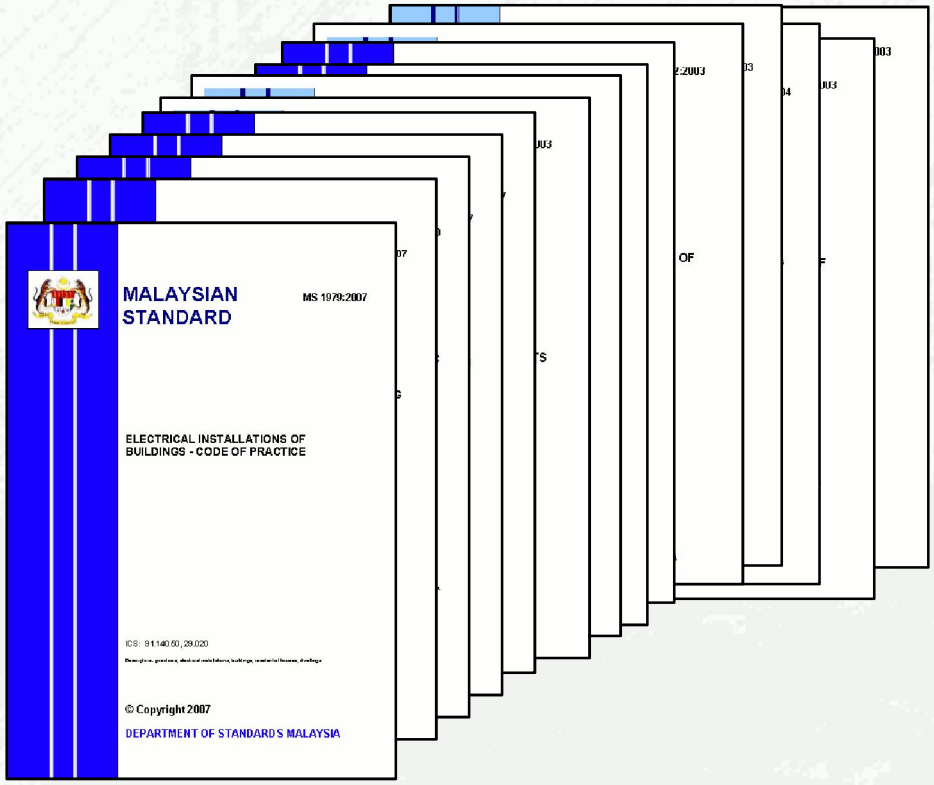
31 Malaysian Wiring Standards

ALL WIRING WORKS SHALL BE IN ACCORDANCE WITH MALAYSIAN WIRING STANDARDS:

(a) MS IEC 60364,

(b) MS 1979

(c) MS 1936



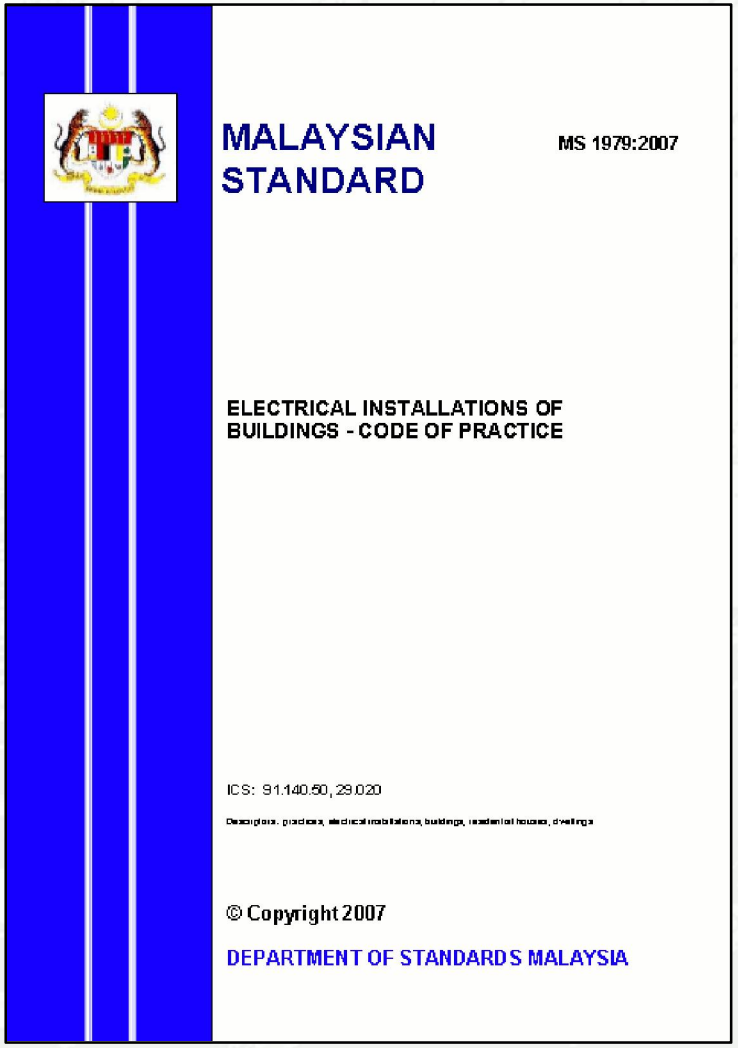
Part/Sections		Ed.	Year
1	**Fundamental principles, assessment of general characteristics, definitions**	**5th**	**2005**
4	**Protection for Safety**		
Section 41	Protection against electric shock	5th	2005
Section 42	Protection against thermal effects	3rd	2010
Section 43	Protection against overcurrent	3rd	2008
Section 44	Protection against voltage disturbances and electromagnetic disturbances	2nd	2007
5	Selection and erection of electrical equipment		
Section 51	Common rules	5th	2005
Section 52	Wiring systems	3rd	2009
Section 53	Isolation, switching and control	3rd	2002
Section 54	Earthing arrangements, protective conductors and protective bonding conductors	3rd	2010
Section 55	Other equipment	2nd	2011
Section 56	Safety services	2nd	2009
6	**Verification**	**1st**	**2006**

Part/Sections		Ed.	Year
7	Requirements for special installations or locations		
Section 701	Locations containing a bath or shower	2nd	2006
Section 702	Swimming pools and fountains	3rd	2010
Section 703	Locations containing sauna heaters	2nd	2004
Section 704	Construction and demolition site installations	2nd	2005
Section 705	Agricultural and horticultural premises	2nd	2006
Section 706	Conducting locations with restricted movement	2nd	2005
Section 707	Earthing requirements for the installation of data processing equipment **(withdrawn).**	1st	1984
Section 708	Caravan Parks, camping parks and other location	2nd	2007
Section 709	Marinas and similar locations	2nd	2012
Section 710	Medical Locations	1st	2002
Section 711	Exhibitions, shows and stands	1st	1998
Section 712	Solar photovoltaic (PV) power supply system	1st	2002
Section 713	Furniture	2nd	2013
Section 714	External lighting installations	2nd	2011
Section 715	Extra Low Voltage lighting installations	2nd	2011

Part/Sections		Ed.	Year
7	Requirements for special installations or locations		
Section 715	Extra Low Voltage lighting installations	2nd	2011
Section 717	Mobile or transportable units	2nd	2009
Section 718	Communal facilities and workplaces	1st	2011
Section 721	Electrical installations in caravans and motor caravans	1st	2007
Section 722	Supply of Electric vehicle **(still under development)**	1st	2014?
Section 729	Operating or maintenance gangways		2007
Section 740	Temporary electrical installations for st amusement devices and booths at fai amusement parks and circuses		00
	Malaysian Standards		
MS 1979	Electrical Installation of Building - Code of Practice	2nd	2014
MS 1936	Guide to MS IEC 60364 on Electrical Installations of Buildings	2nd	2014
MS 2356	Guidance on the application of MS IEC 60364-7-710 for group 2: Medical Locations	1st	2010

Mandatory Requirements

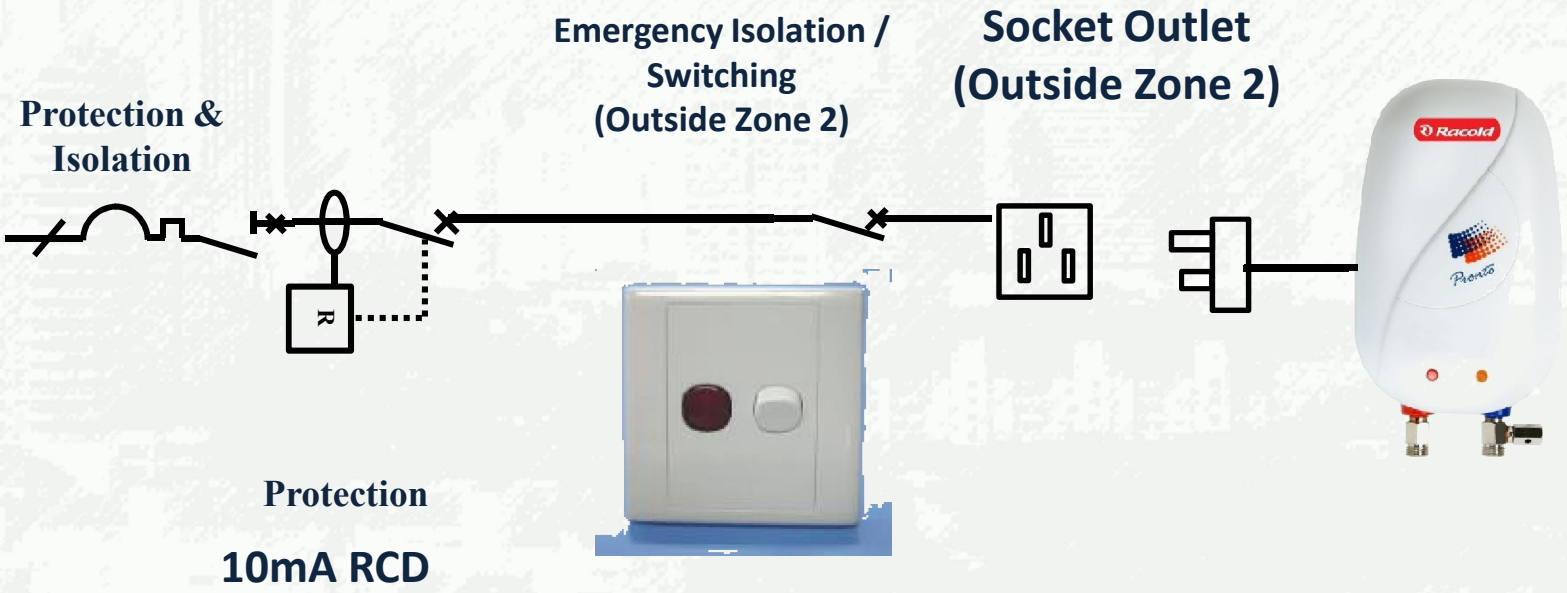
35 MS 1979 – Code of Practice



- ✓ **CoP31** – 2P switch and 10mA RCD protection for water heater
- ✓ **CoP35** – Size of Neutral same size as phase conductor
- ✓ **CoP36** – Reduced size of neutral only at the discretion of P.Eng
- ✓ **CoP39** – Cable size < 1.5mm² not allowed
- ✓ **CoP41** – Allowable voltage drop ≤ 4%
- ✓ **CoP42** – soldered cable connection and termination NOT ALLOWED
- ✓ **CoP44** – Cables for final sub circuit shall not be joined
- ✓ **CoP54** – RCD not exceeding 10mA shall be installed for special location (places of public entertainment; wet places; protection of electric water heaters)
- ✓ **CoP55** – RCD to be Regularly tested, at least twice a year

36 MS 1979 – CODE OF PRACTICE

COP31 – Water heater circuits shall have 2-pole switch installed at suitable location. At the vicinity of the heater a socket outlet is required (unswitched is acceptable). Every power circuit for wet-equipment shall be protected individually by a 10 mA rated residual operating current device



37 IEC 60364–7–701 LOCATIONS CONTAINING BATH OR SHOWER

HAZARD ZONES IN WET LOCATIONS

IEC 60364–7–701 Classification of **FOUR hazard zones** for wet locations

Zone O.
is the interior of the bathtub or the shower basin. In those cases where a shower has no basin, the zone extends 50mm above the floor and includes the volume within the vertical surface at a radius of 1.2m from the water outlet position of a demountable shower head, or at a radius of 0.6m from the position of a fixed shower head.

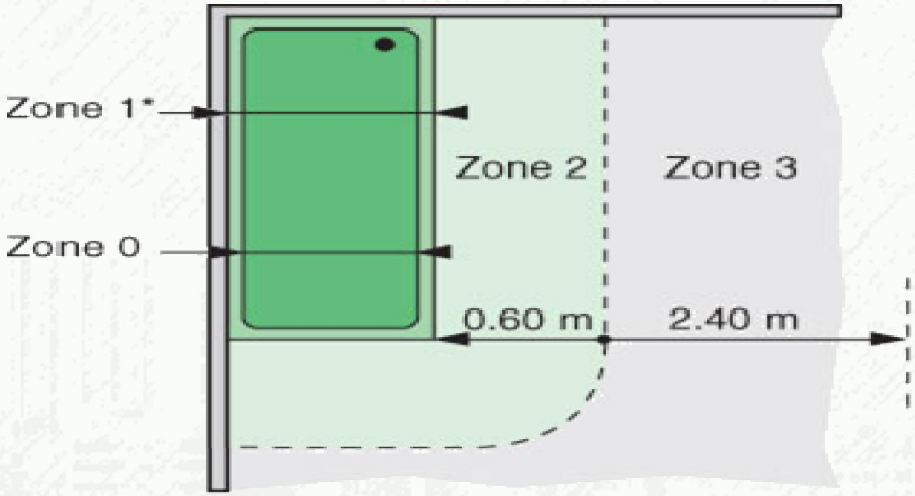
Zone 1.
extends from Zone 0 up to 2.25m above the floor, and outwards to the extent of the bath or basin, or the extent of Zone 0 as defined above where there is no shower basin. It includes the space below a bath or shower tub or basin where that space is accessible without the use of a tool.

Zone 2.
extends outside Zone 1 for 0.6m horizontally and up to a height of 2.25m. If the ceiling height is more than 2.25m, the space above Zone 1 up to 3m is also zone 2

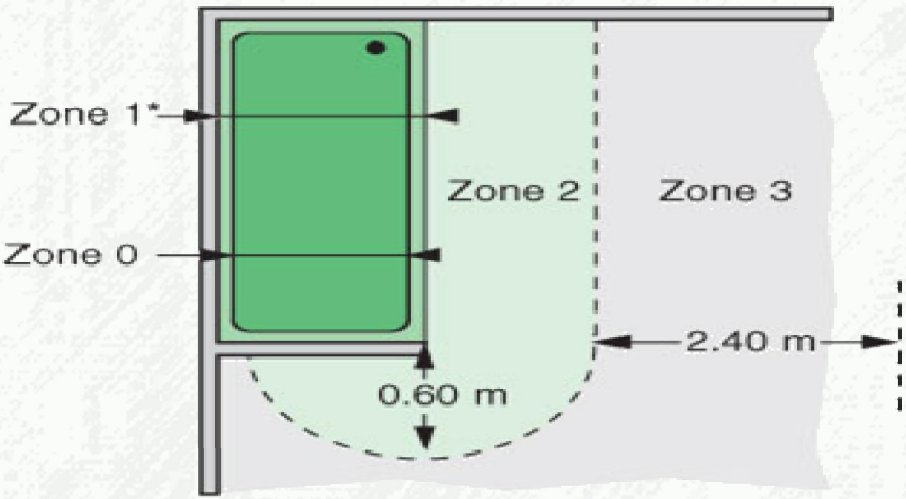
Zone 3.
extends outside Zone 2 for 2.4m horizontally and up to a height of 2.25m. If the ceiling height is more than 2.25m, the space above Zone 2 up to 3 m is also Zone 3

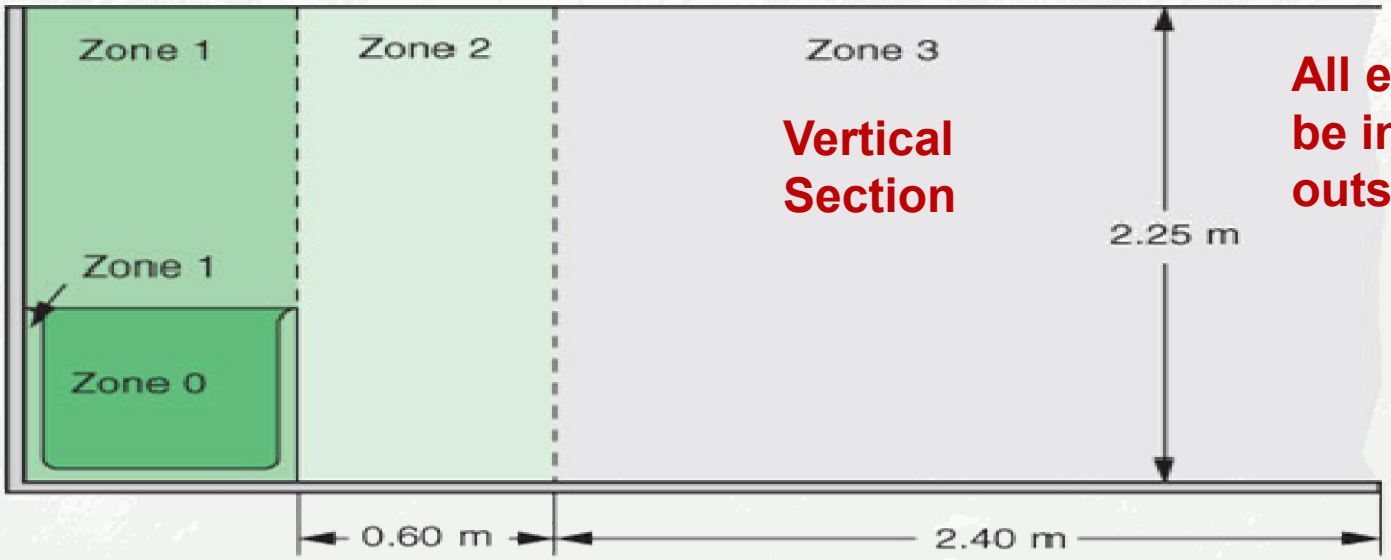
IEC 60364–7–701 LOCATIONS CONTAINING BATH OR SHOWER

Plan View – Bath Tub



Plan View – Bath Tub



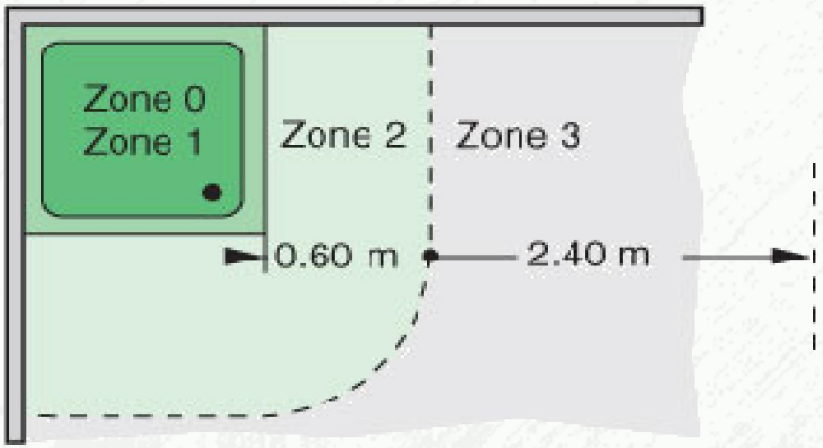


Vertical Section

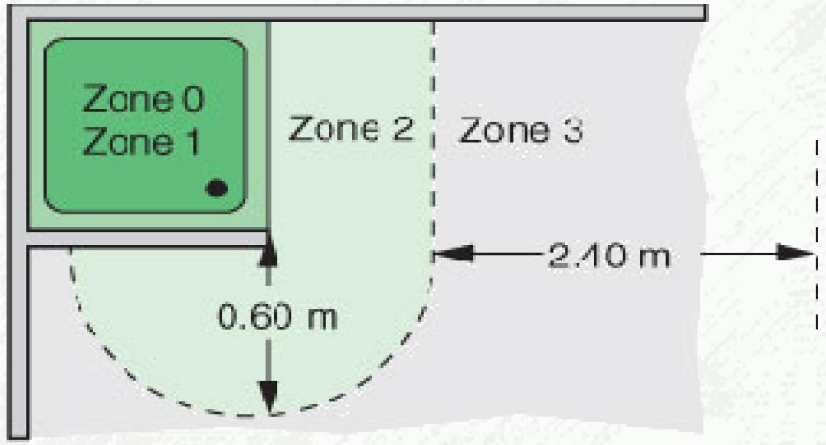
All equipment to be installed outside Zone 2.

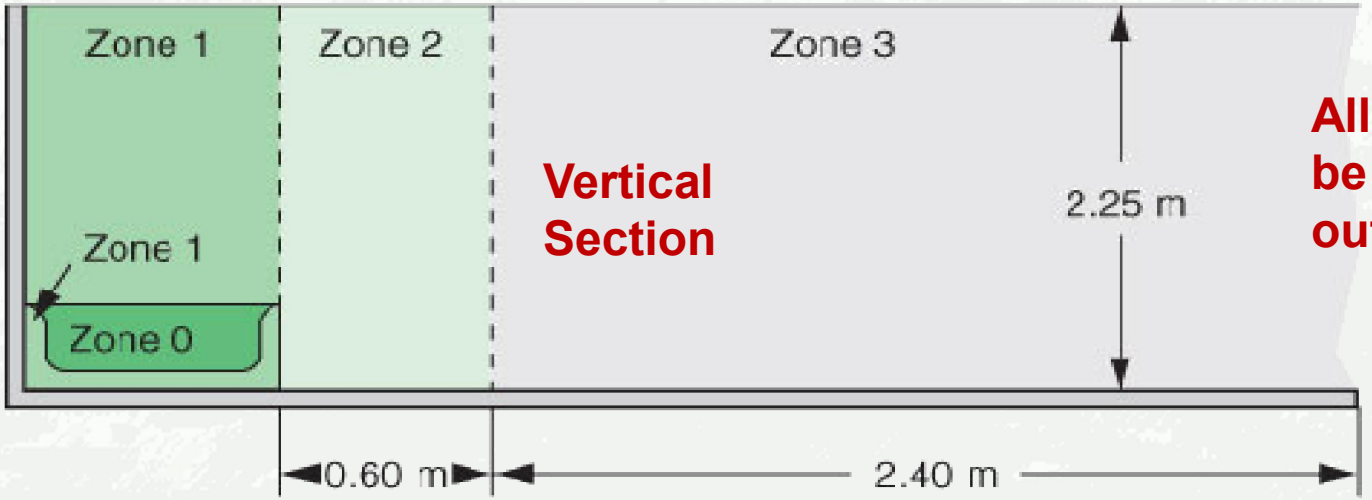
39 IEC 60364–7–701 LOCATIONS CONTAINING BATH OR SHOWER

Plan View – Shower with basin



Plan View – Shower with basin



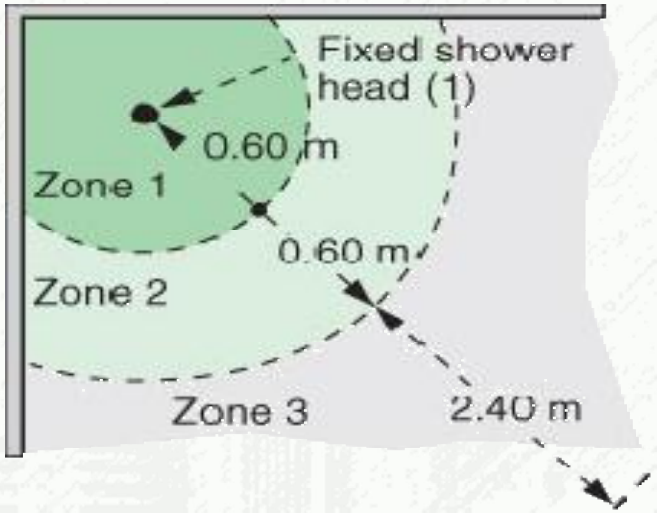


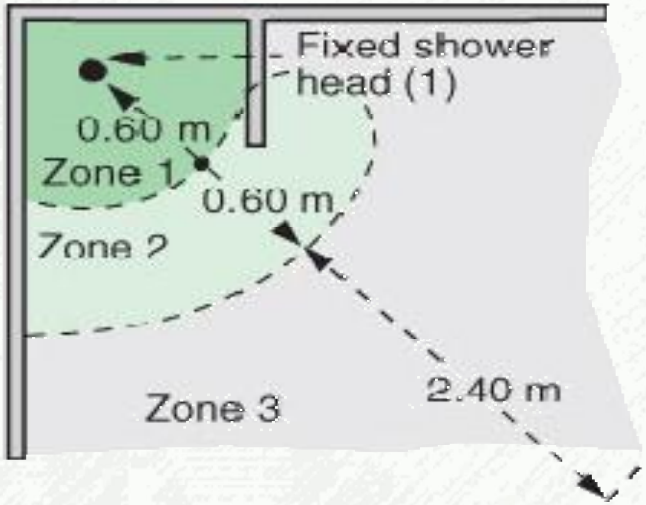
Vertical Section

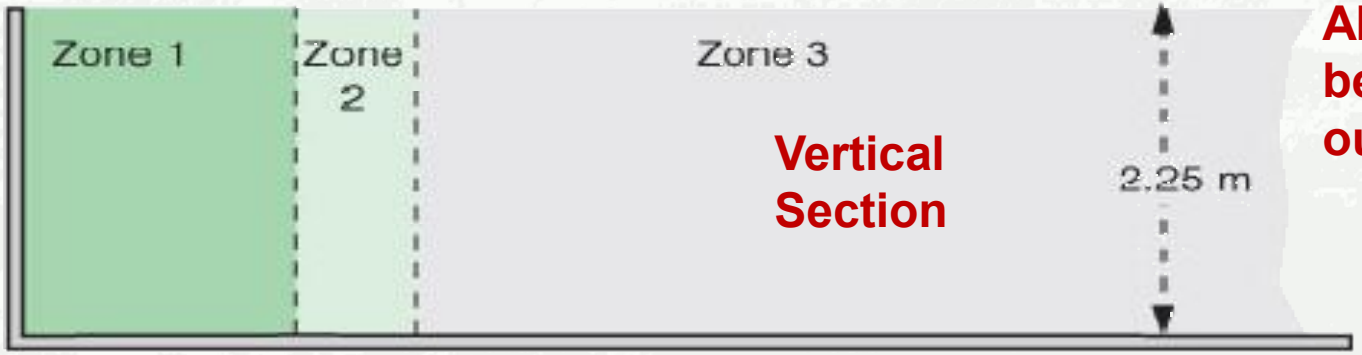
All equipment to be installed outside Zone 2.

IEC 60364–7–701 LOCATIONS CONTAINING BATH OR SHOWER

Plan View – Shower without basin







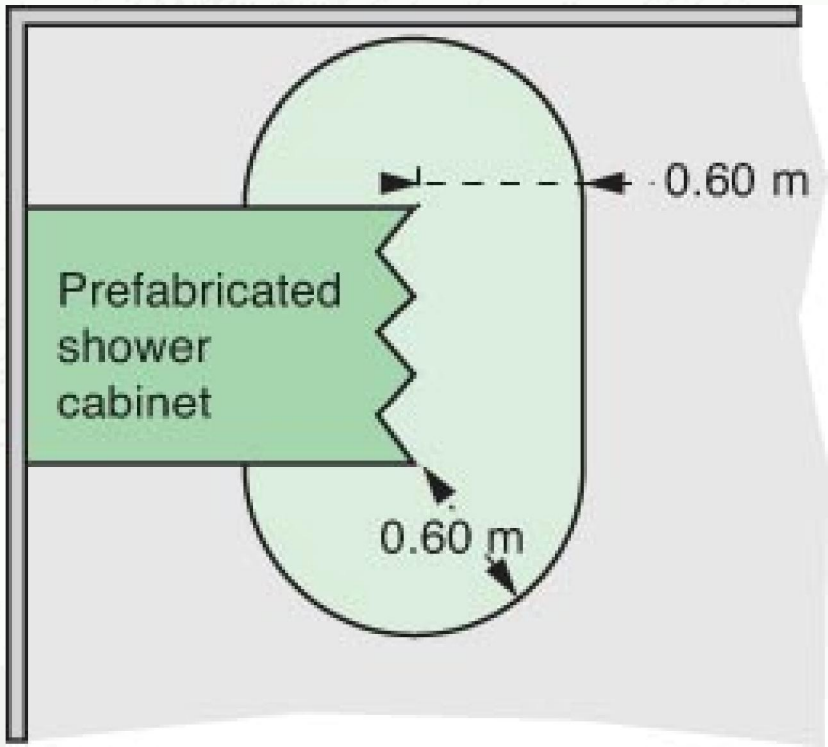
Vertical Section

All equipment to be installed outside Zone 2.

(1) When the shower head is at the end of a flexible tube, the vertical central a zone passes through the fixed end of the flexible tube

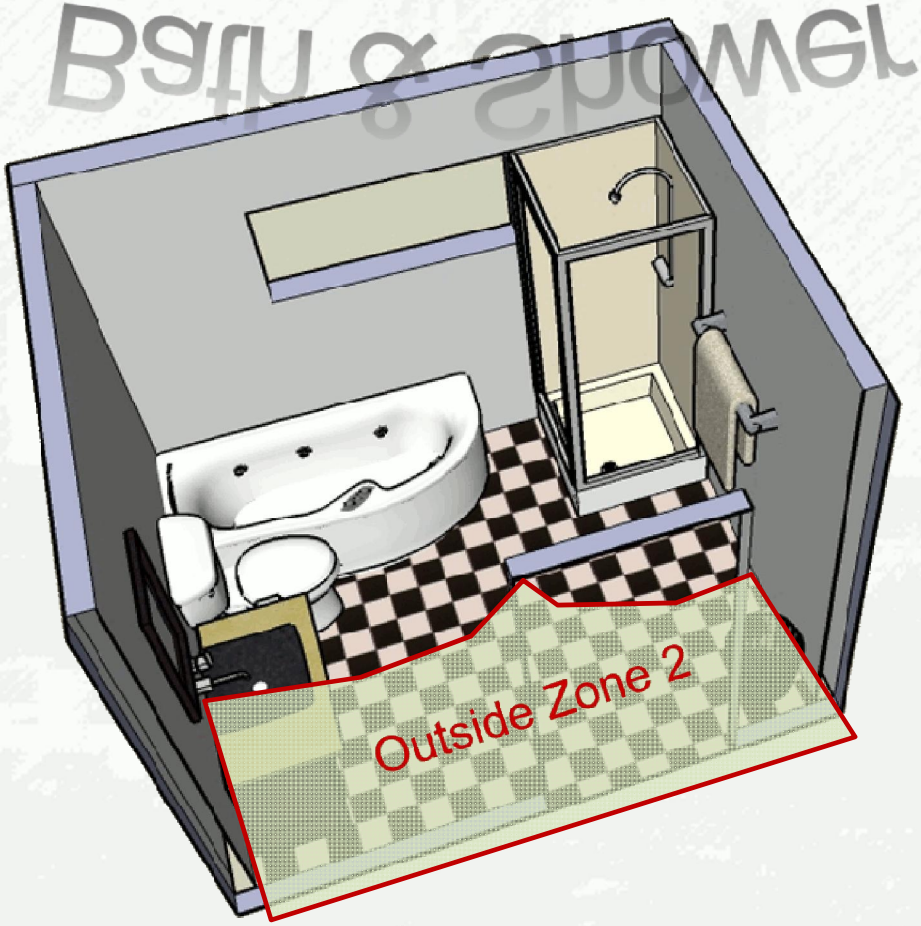
41 IEC 60364–7–701 LOCATIONS CONTAINING BATH OR SHOWER

No switch or socket outlet permitted within 0.60m of the door opening of a shower cabinet.



5

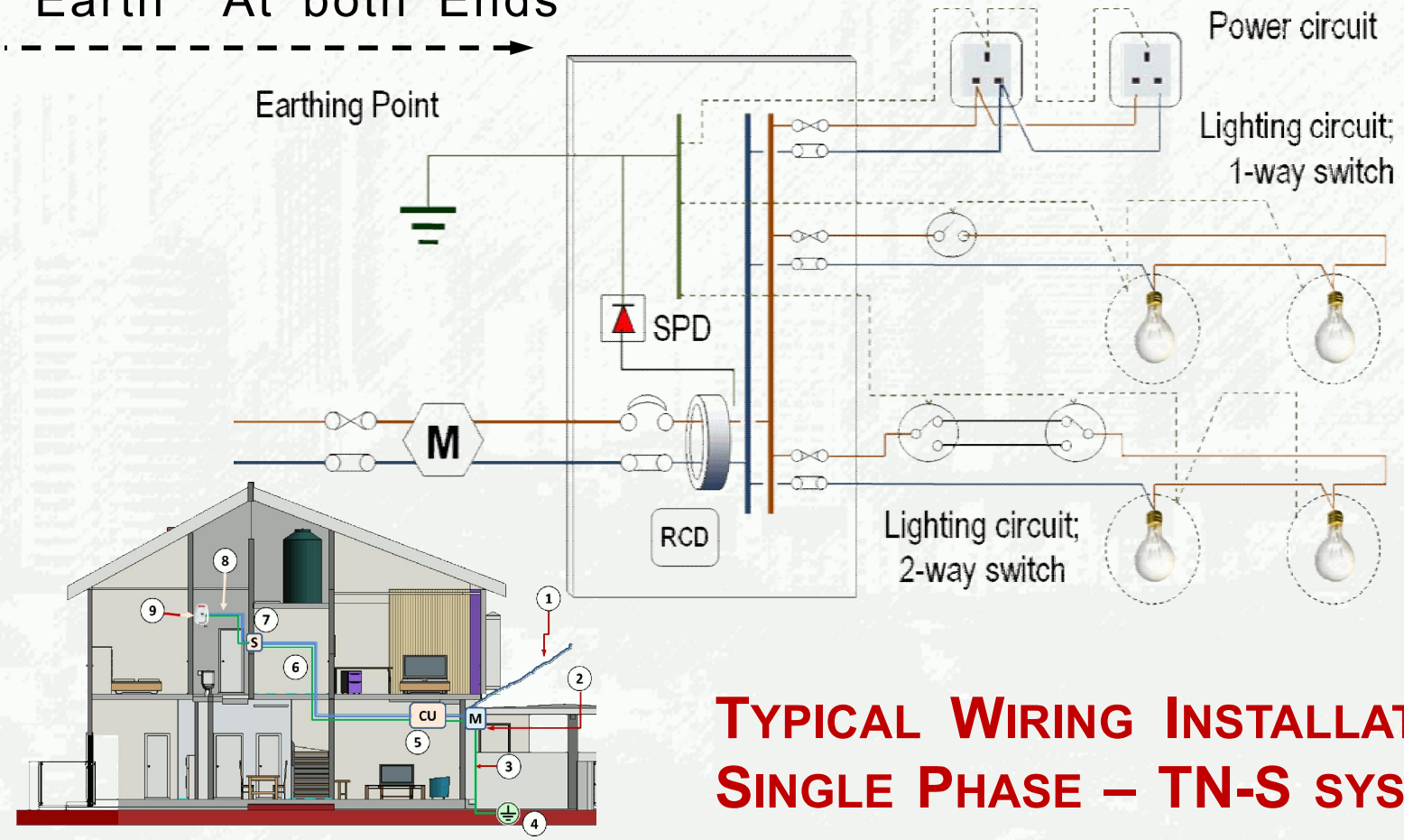
Wiring Installation
Bath & Shower



43 TYPICAL LANDED PROPERTY

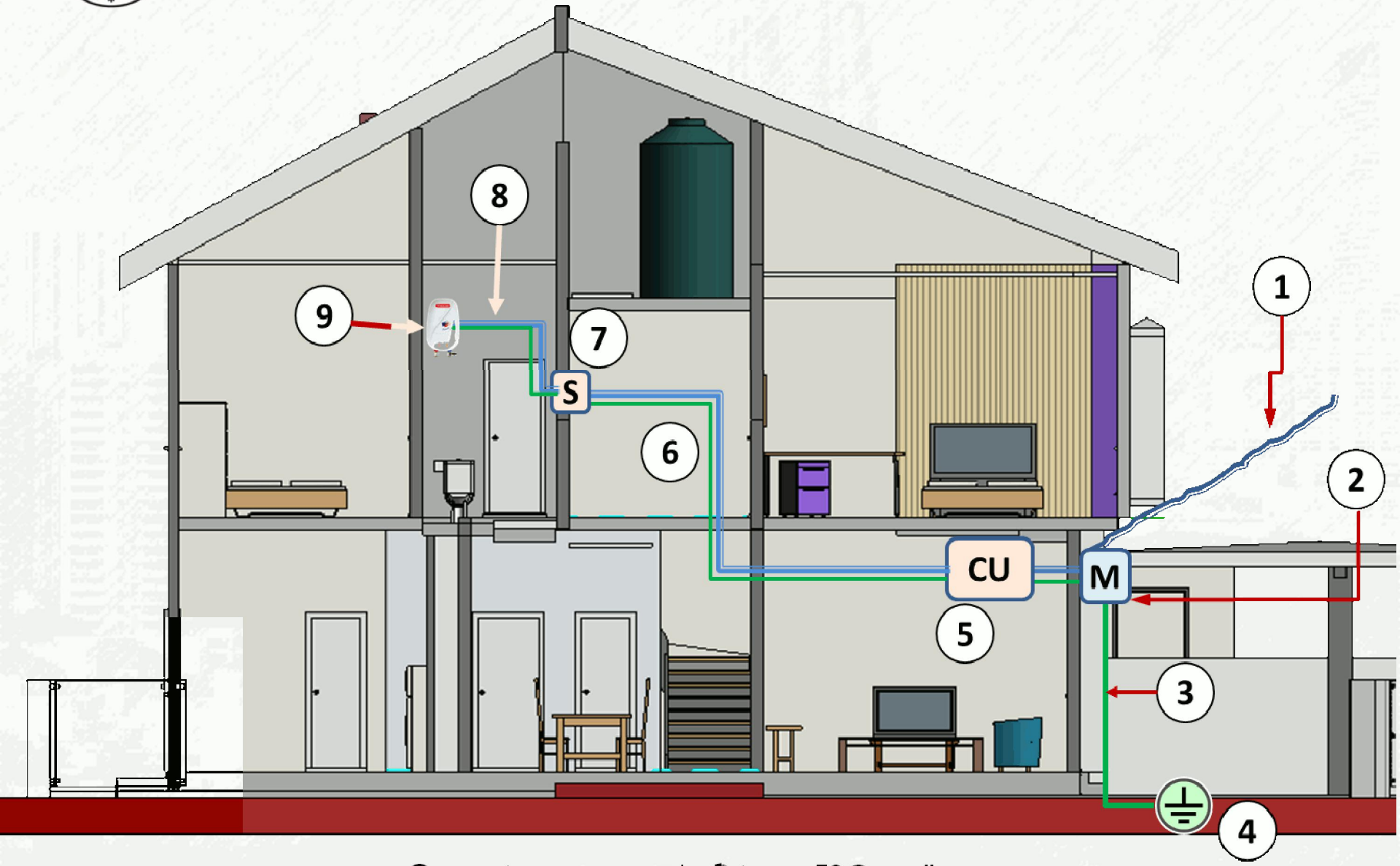
TT System (TNB Incoming, L+N)
Earth At both Ends

TN-S System (Final sub circuit, L+N+PE)
Earth at source only



TYPICAL WIRING INSTALLATION
SINGLE PHASE – TN-S SYSTEM

44 LANDED PROPERTY – WIRING CIRCUIT TO WH



45 LANDED PROPERTY – WIRING CIRCUIT TO WH

(1) TNB incoming cables (TT – Phase + Neutral)

(2) TNB meter and cut out fuse

(3) Earth cable from consumer unit to earth pit

(4) Earth pit with earth electrode

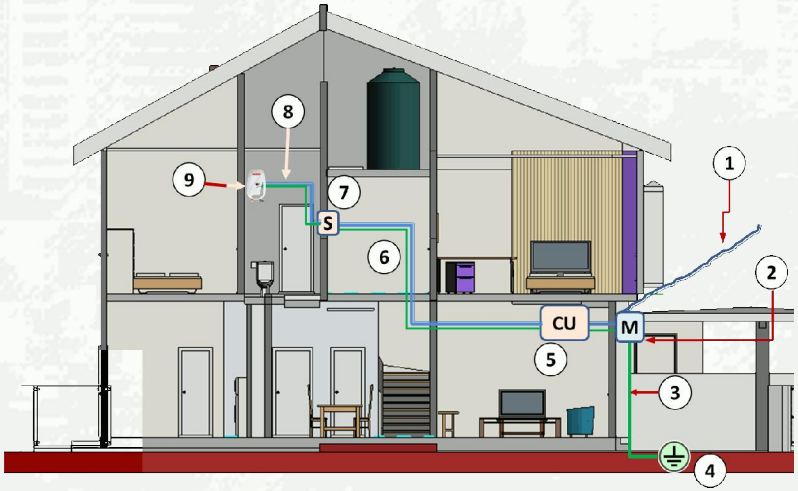
(5) Consumer unit (main switch board)

(6) Circuit to water heater (TNS P + N + PE)

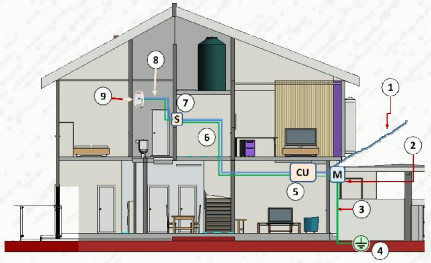
(7) Switch (2 pole) located at “arm’s level”

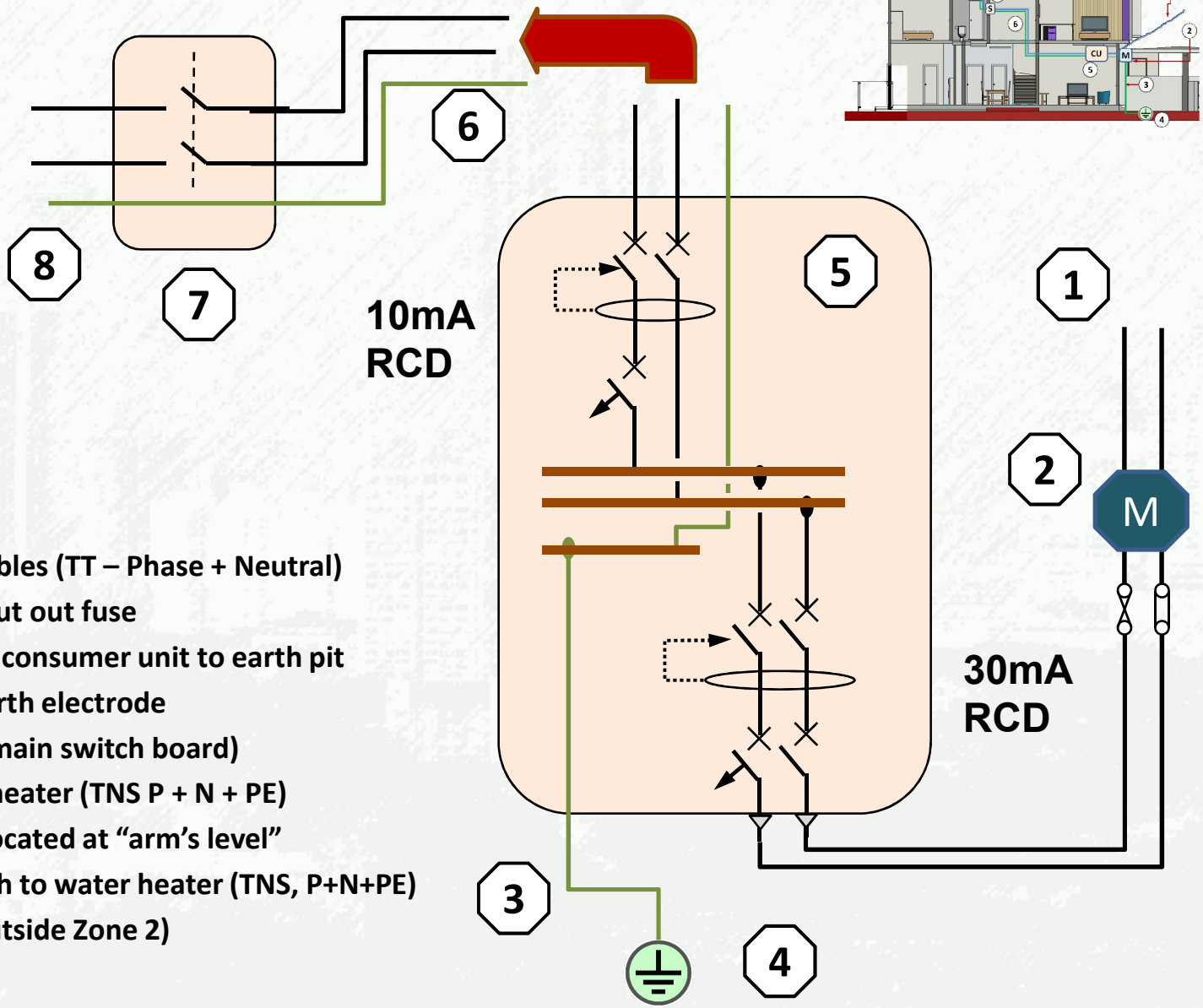
(8) Cable from switch to water heater (TNS, P+N+PE)

(9) Water heater (outside Zone 2)



46 TYPICAL LANDED PROPERTY

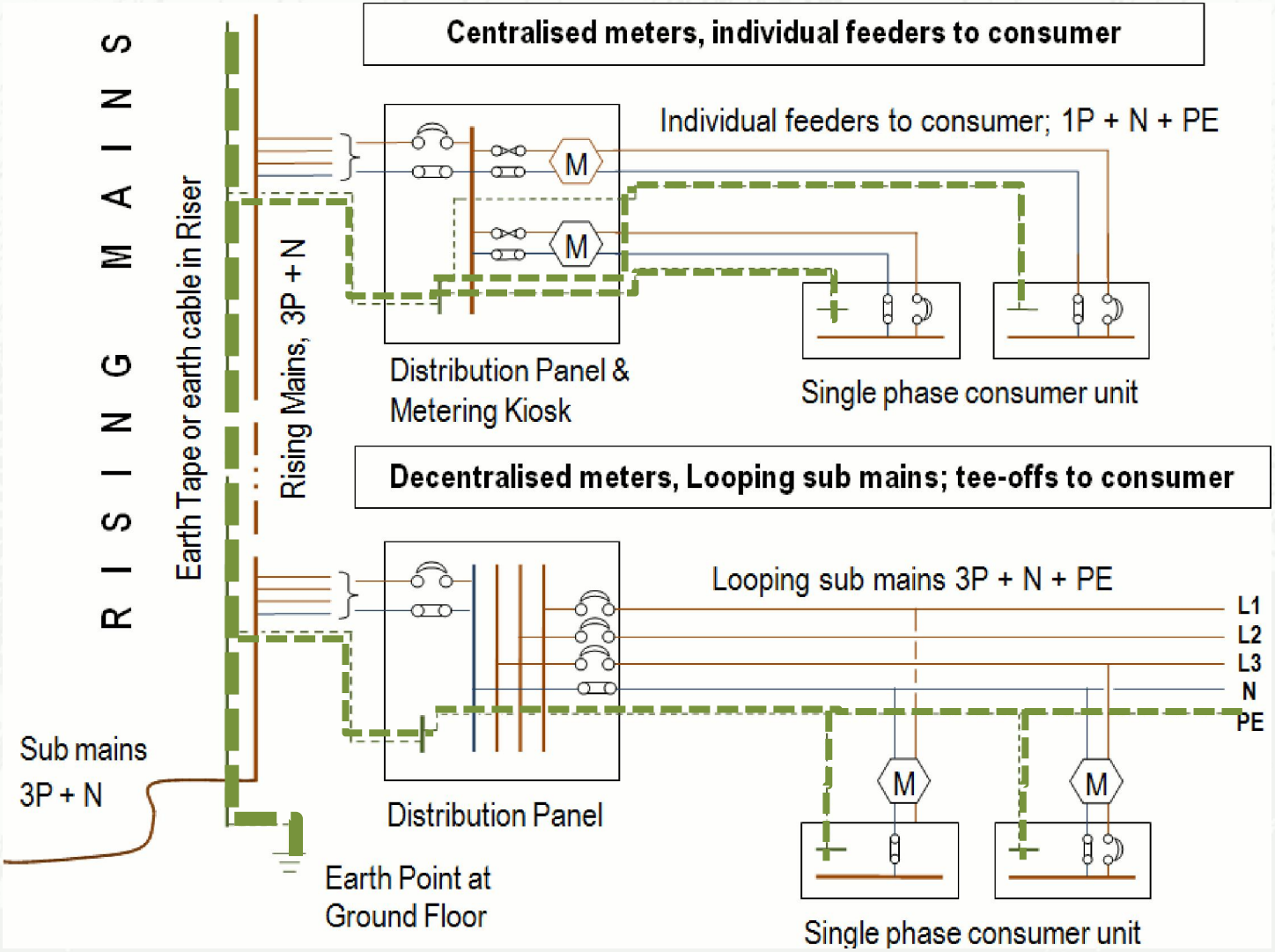




(1) TNB incoming cables (TT – Phase + Neutral)
(2) TNB meter and cut out fuse
(3) Earth cable from consumer unit to earth pit
(4) Earth pit with earth electrode
(5) Consumer unit (main switch board)
(6) Circuit to water heater (TNS P + N + PE)
(7) Switch (2 pole) located at "arm's level"
(8) Cable from switch to water heater (TNS, P+N+PE)
(9) Water heater (outside Zone 2)

47 TYPICAL INSTALLATION – HIGH RISE APARTMENT

NOTE EARTH LOOP FOR MULTI STOREY



48 WIRING COLOUR CODE

Table 2. Single phase supply: Wire or cable colour code	
Conductor	Colour Code
Live	Red
Neutral	Black
Protective Earthing	Green
Equipotential bonding	Green

Table 3. Three phase supply single phase circuit: Wire or cable colour code	
Conductor	Colour Code
Live – Red phase	Red
Live – Yellow phase	Yellow
Live – Blue phase	Blue
Neutral	Black
Protective Earthing	Green
Equipotential bonding	Green

49 WATER HEATER WIRING SCHEME

Table 5. Disconnection scheme of MCB, RCD, disconnector, PE and SEB				
Type of Circuit	MCB	RCD	Disconnector	Neutral / Protective Earth / SEB
Single phase	1 pole	2 pole	2 pole	No Break Permitted
Three phase	3 pole	4 pole	4 pole	No Break Permitted

Table 6. Minimum conductor sizes				
Rating (kW)	MCB/RCD (Minimum)	Live	Neutral	PE
≤ 3 kW	16 A	4 mm^2	4 mm^2	4 mm^2
> 3 kW to ≤ 5 kW	30 A	6 mm^2	6 mm^2	6 mm^2
> 5 kW to ≤ 8 kW	40 A	10 mm^2	10 mm^2	10 mm^2
> 8 kW to ≤ 10 kW	50 A	16 mm^2	16 mm^2	16 mm^2
For rating more than 10 kW, size the cable per MS IEC (IEC) 60364				

50 MINIMUM SIZE OF P.E. (ENERGY LET THROUGH)

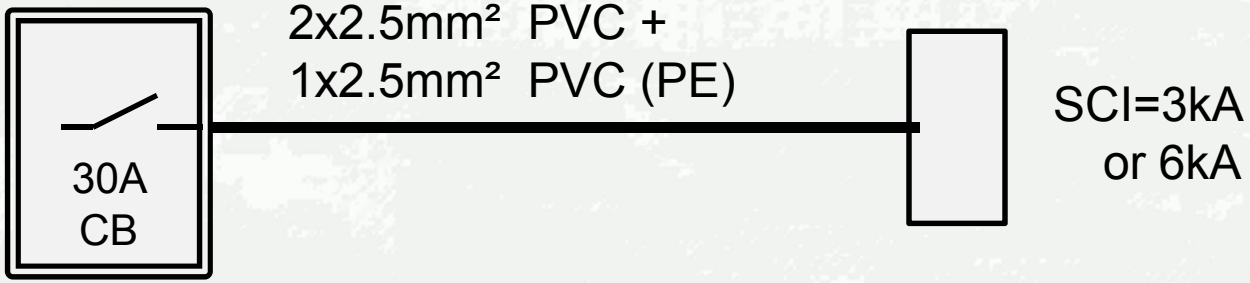
70°C PVC cables	k= 115	SCct I=	3 kA	5 kA	6 kA	10 kA	15 kA	25 kA
Using 20A MCB class C		t=	0.01 sec	0.01 sec	0.01 sec	0.01 sec	0.01 sec	0.01 sec
S min size of PE cable			2.61 m²	4.3 m²	5.2 m²	8.7 m²	13.0 m²	21.7 m²
Using 20A gG Fuse		t=	0.01 sec	0.01 sec	0.01 sec	0.01 sec	0.01 sec	0.01 sec
S min size of PE cable			2.61 m²	4.35 m²	5.22 m²	8.70 m²	13.04 m²	21.74 m²

The theoretical minimum Size of P.E. based on energy let through is shown above.

$$S = \frac{\sqrt{I^2 x\, t}}{k}$$

Case :

Calculating $I^2 t$ for PE:



IEC 60364–5–54
COORDINATING TRIP TIME & BREAKER RATING

(1) $I_B \leq In \leq Iz$

(2) $I_2 \leq 1.45 \times Iz$

I_B –decide current rating of circuit
I_B > load current

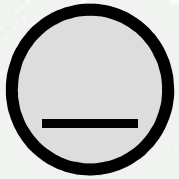
Select protective devices,
$In \geq I_B$

Check $I_2 < 1.45\ Iz$

Calculate cable size based on:
$Iz \geq In$

Calculate current from load

In = nominal current rating of protective devices



I_2 = current ensuring effective operation within time prescribed for protective device

Iz = current capacity of cable.

Protection devices

Cables

Electrical load

52 COORDINATING CABLE SIZE WITH PROTECTION

EXAMPLE: Water Heater Single Phase 3kW

1 **3kW** Estimate load current ≈ 3kW/(0.9x230V)
≈ 14A.

2 **16A** Choose rating of circuit I_B= 16A.

(1) $I_B \leq In \leq Iz$
(2) $I_2 \leq 1.45 \times Iz$

3 **20A** Choose protection device I_n= 20A or 30A ($I_n \geq I_B$)

4 **25mm²** Size cable $I_Z \geq I_n$; choose (Table B52-5)
2x6mm² PVC; I_Z ≈ 45A OR 2x4mm² PVC; I_Z ≈ 35A

5 **200s** Check $I_2 \leq 1.45 I_z$ ≈ 43.5A or 29A

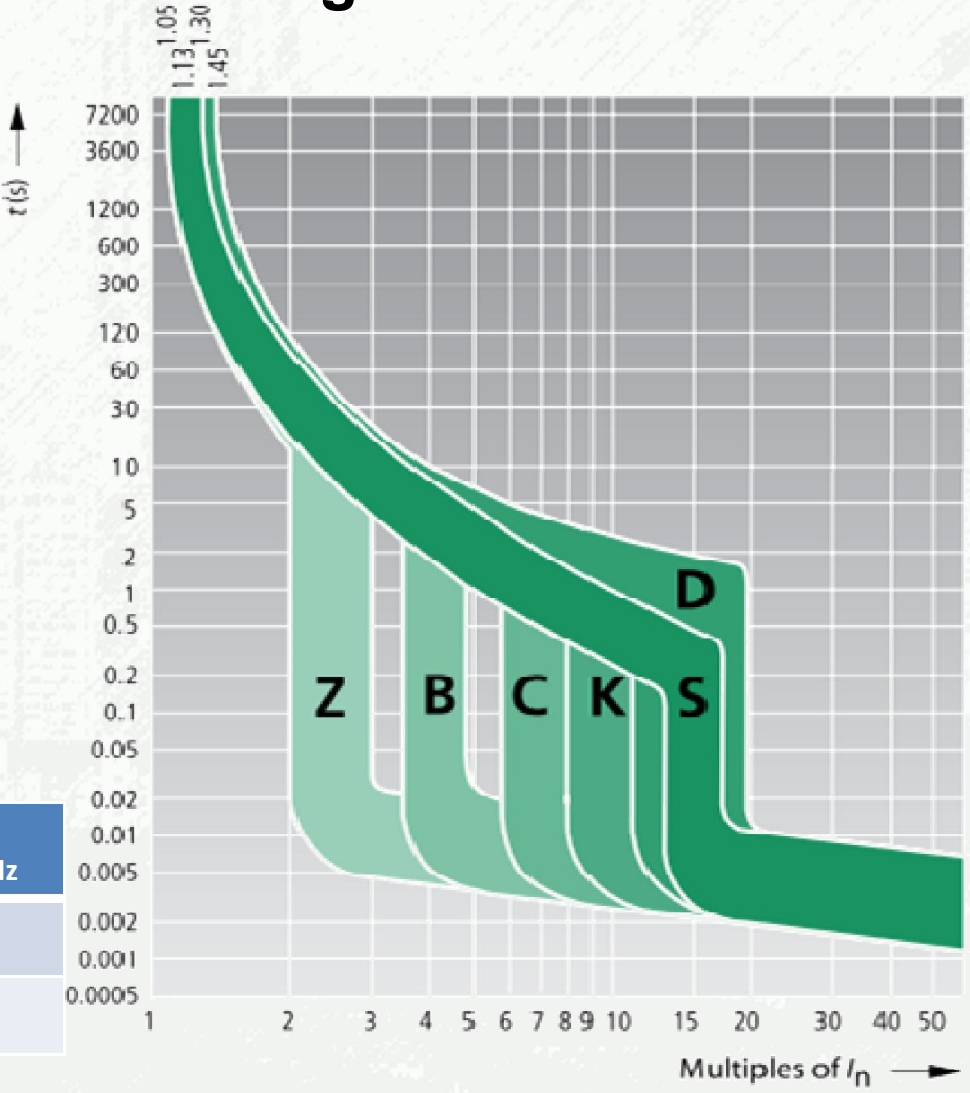
	$1.45I_Z$	I_Z (cable rating)	Effective trip I_2	Pass/Fail $I_2 \leq 1.45 \times Iz$
30A; 6mm²	65A	45A	44A	✓
20A; 4mm²	50A	35A	30A	✓

(1) $I_B \leq In \leq Iz$
(2) $I_2 \leq 1.45 \times Iz$

EXAMPLE: Water Heater Single Phase 3kW

Spaecified non-tripping current
$I_{nt} = 1.13 \times I_n$ *for* $t > 1\ h$
Specified tripping current
$I_t = 1.45 \times I_n$ *for* $t > 1\ h$

❶ $2.55 \times I_n$: $t = 1\text{-}60\ s\ (I_n < 32A)$
$t = 1\text{-}120\ s\ (I_n < 32A)$
❷ *Type B*: $3 \times I_n$: $t > 0.1s$
❸ *Type B*: $5 \times I_n$: $t > 0.1s$
❹ *Type C*: $5 \times I_n$: $t > 0.1s$
❺ *Type C*: $10 \times I_n$: $t > 0.1s$
❻ *Type D*: $10 \times I_n$: $t > 0.1s$
❼ *Type D*: $20 \times I_n$: $t > 0.1s$

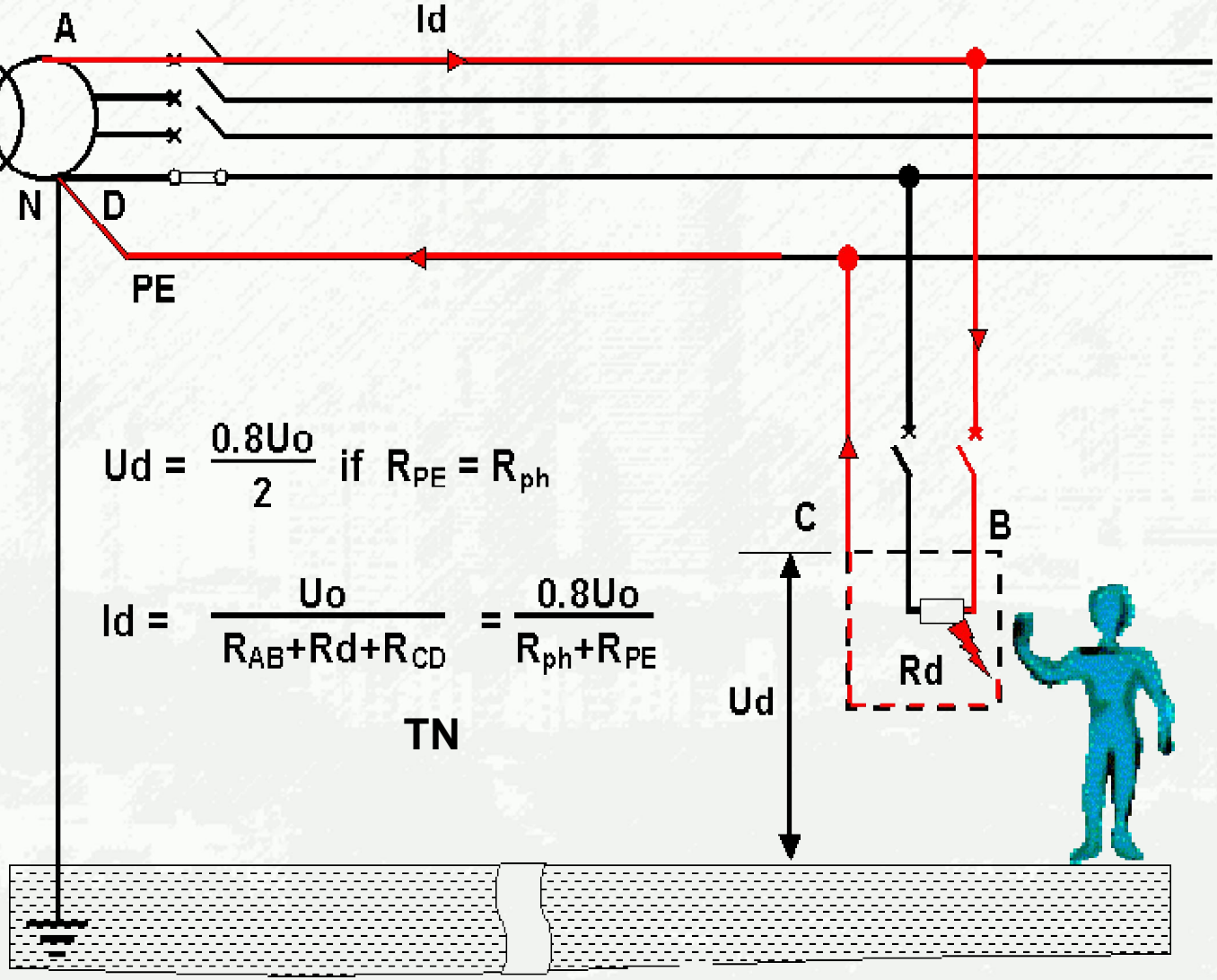


	$1.45I_Z$	I_Z (cable rating)	Effective trip I_2	Pass/Fail $I_2 \leq 1.45 \times Iz$
30A; 6mm²	65A	45A	44A	✓
20A; 4mm²	50A	35A	30A	✓

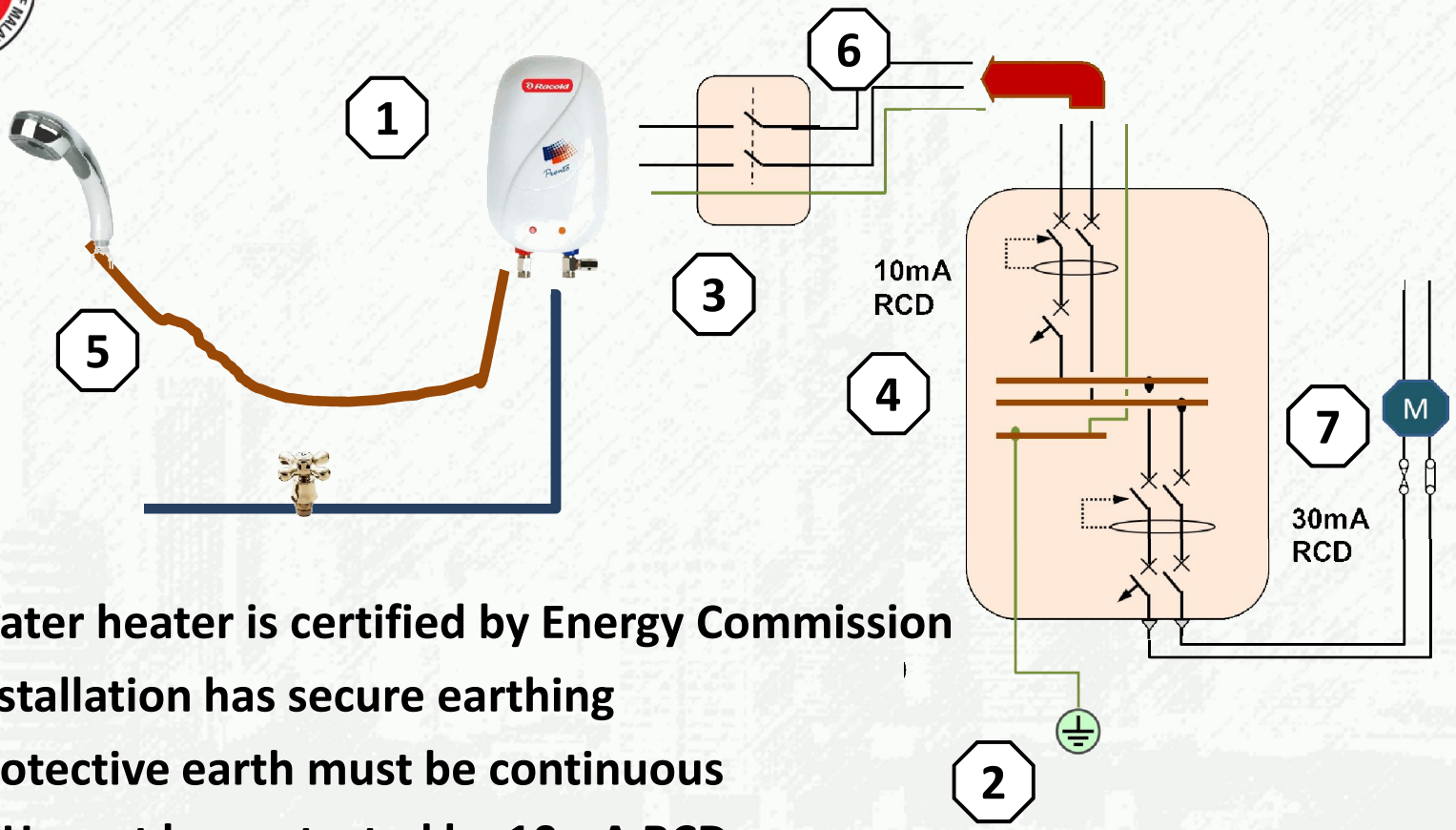
54 FAULT CURRENT IN TN-S SYSTEM

For 230/400V networks, Ud at around (0.8Uo/2) would exceed the limit of safe voltage even in dry conditions (UL=50V). Short circuit protection device (SCPD) required.

TN-C fault will be similar



55 SUMMARY OF SAFETY MEASURES



(1) Water heater is certified by Energy Commission

(2) Installation has secure earthing

(3) Protective earth must be continuous

(4) WH must be protected by 10mA RCD

(5) Flexible hose to be non-metallic

(6) Correct sizing of cables

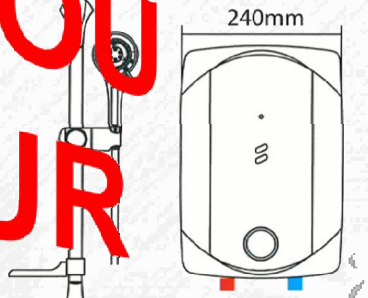
(7) Protective device at Main Switch Board

(8) Others: pressure relief valve

Suruhanjaya Tenaga
Energy Commission

NATIONAL CONFERENCE ON ELECTRICAL SAFETY 2015

THANK YOU FOR YOUR ATTENTION



Water Heater Safety

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9th November 2015