Guideline for the Design, Installation, Inspection, Testing, Operation and Maintenance of Water Heater Systems

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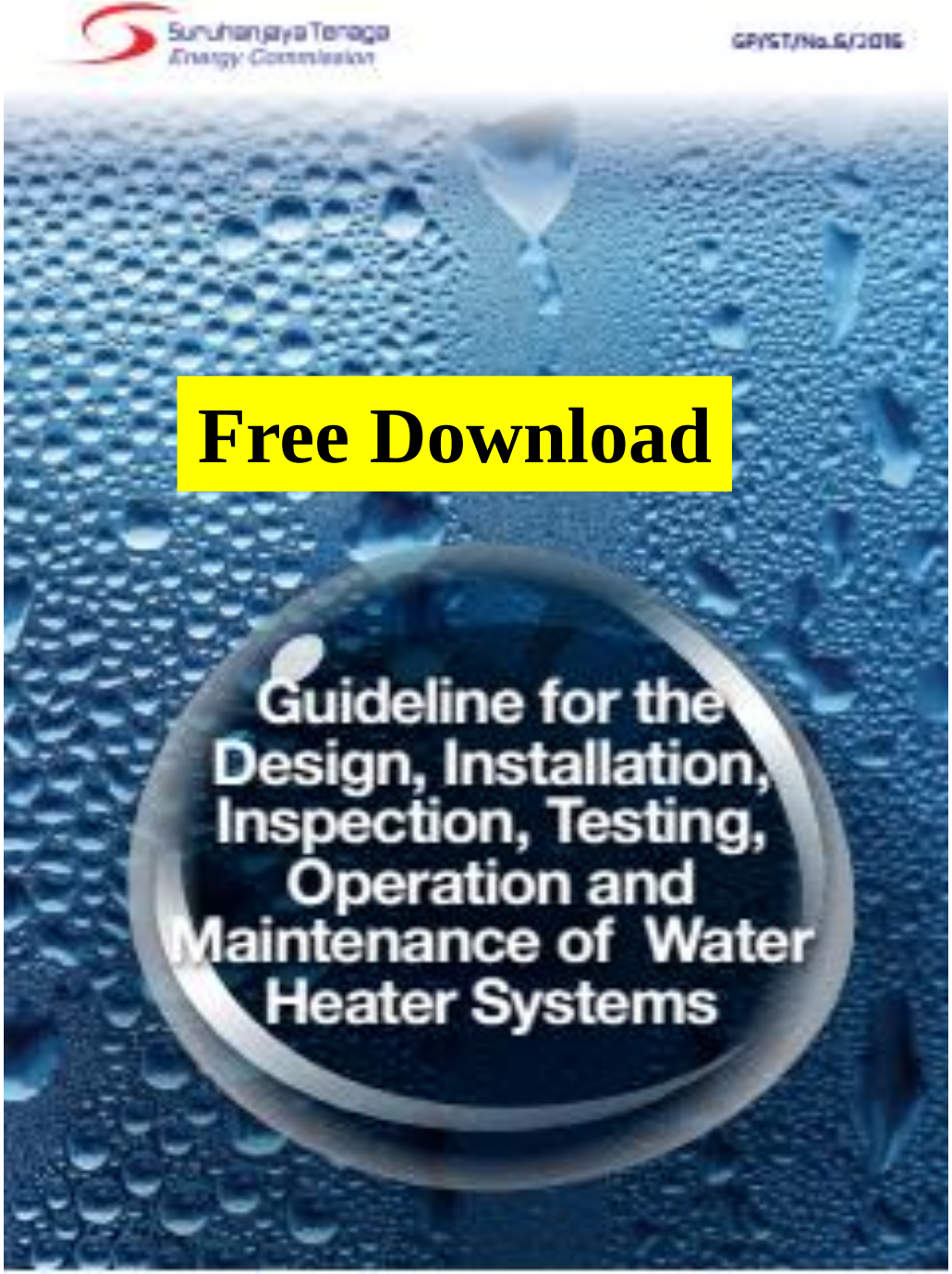
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Energy Commission
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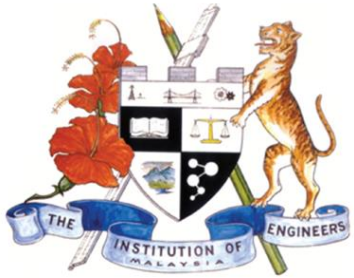
Guideline for the Design, Installation, Inspection, Testing, Operation and Maintenance of Water Heater Systems



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Citation and Commencement

1. *This guideline is issued in exercise of power conferred by Section 50c of Electricity Supply Act 1990 [Act 447];*
2. *Shall come into operation on the date of registration: 7th April 2017;*
3. *Energy commission may at anytime amend, modify, vary or revoke this guideline or may issue written notices from time – to time in relation to this guideline*

Scope

1. ***Design, installation, inspection, testing, operation and maintenance of water heater systems used in:***

   a. ***Residential buildings;***

   b. ***Commercial buildings;***

   c. ***Hotels;***

   d. ***Resort; etc.,***

Scope

2. Shall apply to:

a. Instantaneous water heaters;

b. Storage water heaters (Up to 300 litres); and

c. Solar water heaters (Up to 300 litres) which may include an auxiliary heat source to ISO 9459 – 2: 1995 (Solar Heating – Domestic Water Heating Systems)

3. Address:

a. Safety aspects of electrical wiring and accessories; and

b. The safety and efficiency aspects in the operation and use of water heater systems

Not Within Scope

1. ***Safety requirements of the water heater itself (Products) covered by other Malaysia Standards, including:***

   a. ***MS IEC 60335 – 1:2013: Household and Similar Electrical Appliances – Part 1: General Requirement;***

   b. ***MS 1597 – 2 – 35:2010 (IEC 60335 – 2 – 35:2006, MOD): Household and Similar Electrical Appliance – Safety – Part 2 – 35: Particular Requirements for Instantaneous Water Heater (2nd Edition); and***

Not Within Scope

1. ***Safety requirements of the water heater itself covered by other Malaysia Standards, including (Continue):***

   c. MS 1597 – 2 – 21:2010 (IEC 60335 – 2 – 21:2012, MOD): Household ad Similar Electrical Appliance – Safety – Part 2 – 21: Particular Requirements for Storage Water Heater (2nd Edition); and

Standards

1. ***Products:***

   a. ***MS IEC 60335–1:2015: Household and similar electrical appliances–Safety–Part 1: General requirements;***

   b. ***MS 1597–2–35: 2010: Household and similar electrical appliance–Safety–Part 2–35: Particular requirements for instantaneous water heaters;***

   c. ***MS 1597 – 2 – 21: 2015: Household and similar electrical appliance–Safety–Part 2–21: Particular requirements for storage water heaters***

Standards

2. ***Electrical installations:***

   a. ***MS IEC 60364: Electrical installations of buildings;***

   b. ***(Residential) MS 1979:2015: Electrical installations of buildings – Code of practice;***

   c. ***(Non–residential or non–domestic) MS 1936:2016: Electrical installations of buildings – Guide to MS IEC 60364***

3. ***Mechanical installations:***

   a. ***Guideline for the design, installation, inspection, testing, operation and maintenance of water heater systems***

Requirements of Water Heaters (Product) and Mechanical Installations:

Mr. Tee Tone Vei

Safety

1. *Product Safety: Sub – standard water heaters and materials;*
2. *Electrical isolation safety: Isolation barriers;*
3. *Bio safety: Legionnaire diseases risk;*
4. *Thermal safety: scalding or burns risk;*
5. *Pressure safety: Explosion risk;*
6. *Electrical shock safety: Electric shock ad electrocution risk;*
7. *Poor access for installations;*
8. *Sub – standard workmanship;*
9. *No maintenance*

Similar Risks

ST: Approval of Electrical Equipment

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APPROVAL OF
ELECTRICAL EQUIPMENT
(ELECTRICITY REGULATIONS 1994)
INFORMATION BOOKLET
2016 EDITION

18	WATER HEATER including HEATING ELEMENTS IF SUPPLIED SEPARATELY	(a) Storage • is for heating and storage of water for bathing, washing or similar purposes; • incorporates a heating element; and • has a storage capacity not less than 4.5 L or not more than 680 L.	Storage Water Heater	MS IEC 60335-1:2013 MS 1597-2-21:2011	IEC 60335-1:2006 IEC 60335-2-21:2004 with modification
		(b) Instantaneous • is for heating water; • is of the instantaneous type; and • incorporates live parts in contact with water.	Instantaneous Water Heater	MS IEC 60335-1: 2013 MS 1597-2-35:2010	IEC 60335-1:2006 IEC 60335-2-35:2006 with modification

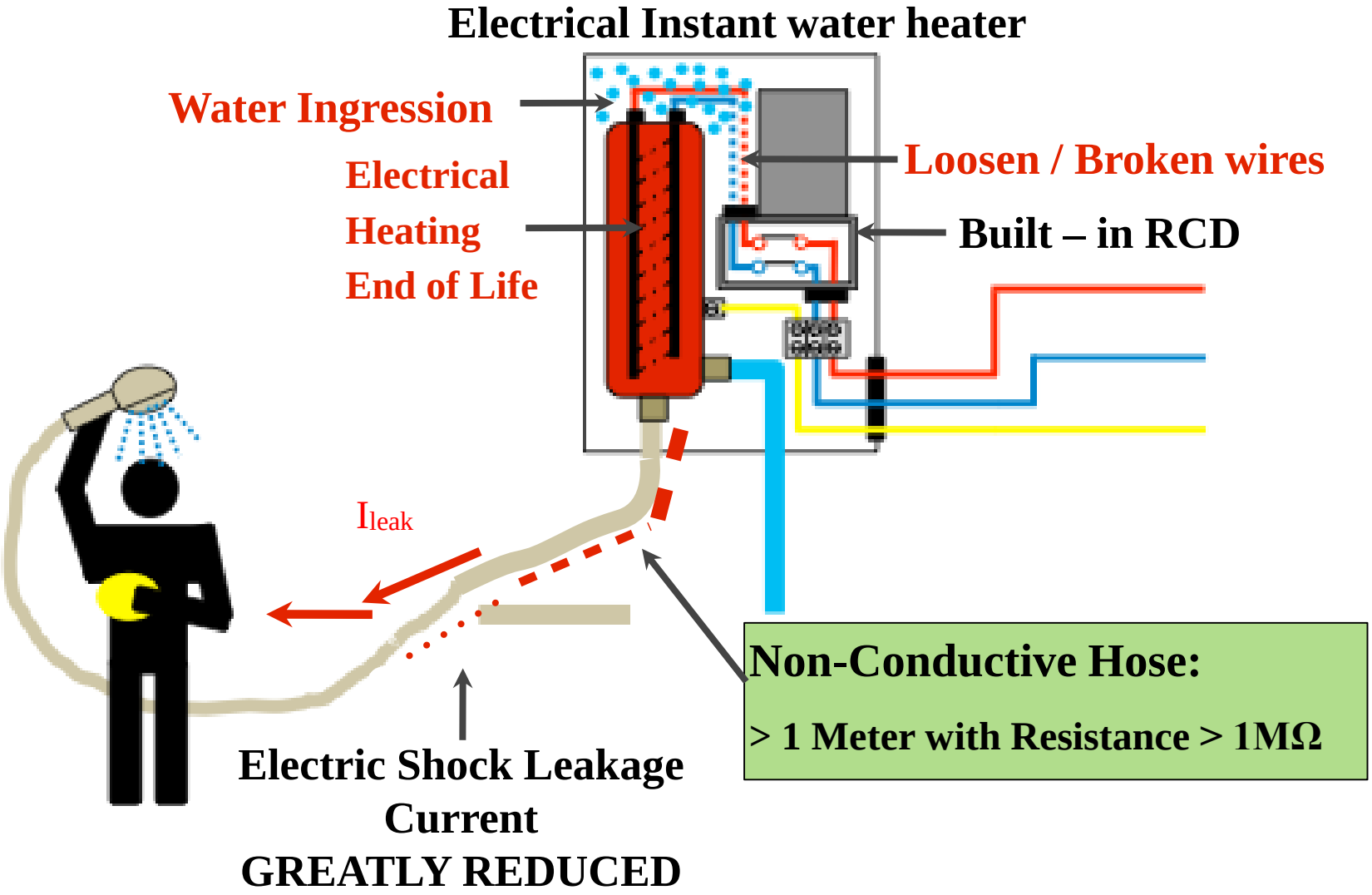
Approved Water Heaters, Malaysia

Electrical Isolation: Conductivity of Bathing Water

1. ***Pure water is a good insulator or non – conductive electrically;***
2. ***Dissolved salts increase water conductivity;***
3. ***Conductivity reduces with smaller cross – sectional area and longer length of paths of water***

	Electrical Conductivity (S·m-)
Copper	59.6 x 10^{6}
Aluminium	37.8 x 10^{6}
Sea water * An average salinity of 35 g/kg	5
Drinking water	0.0005 to 0.05
Deionized water	5.5 x 10^{-6}

Electrical Isolation: Non – Conductive Hose and Isolation Barrier



Electrical Isolation: Non – Conductive Hose and Isolation Barrier

1. *1 meter non-conductive bathing water pathway reduces electric shock leakage current to < 0.005A @ 1,250 ohm.cm or 125 kOhm.m*

   a. *MS IEC 60364: Safe $I_{leak} \leq 0.00025A$;*

   b. *IEC 60479: Safe $I_{leak} < 0.005A$*

Non Conductive Hose
MS1597–2-35:2010

Isolation Barrier
Latest MS 1597-2-21:2015

Electrical Isolation: Isolation Barriers

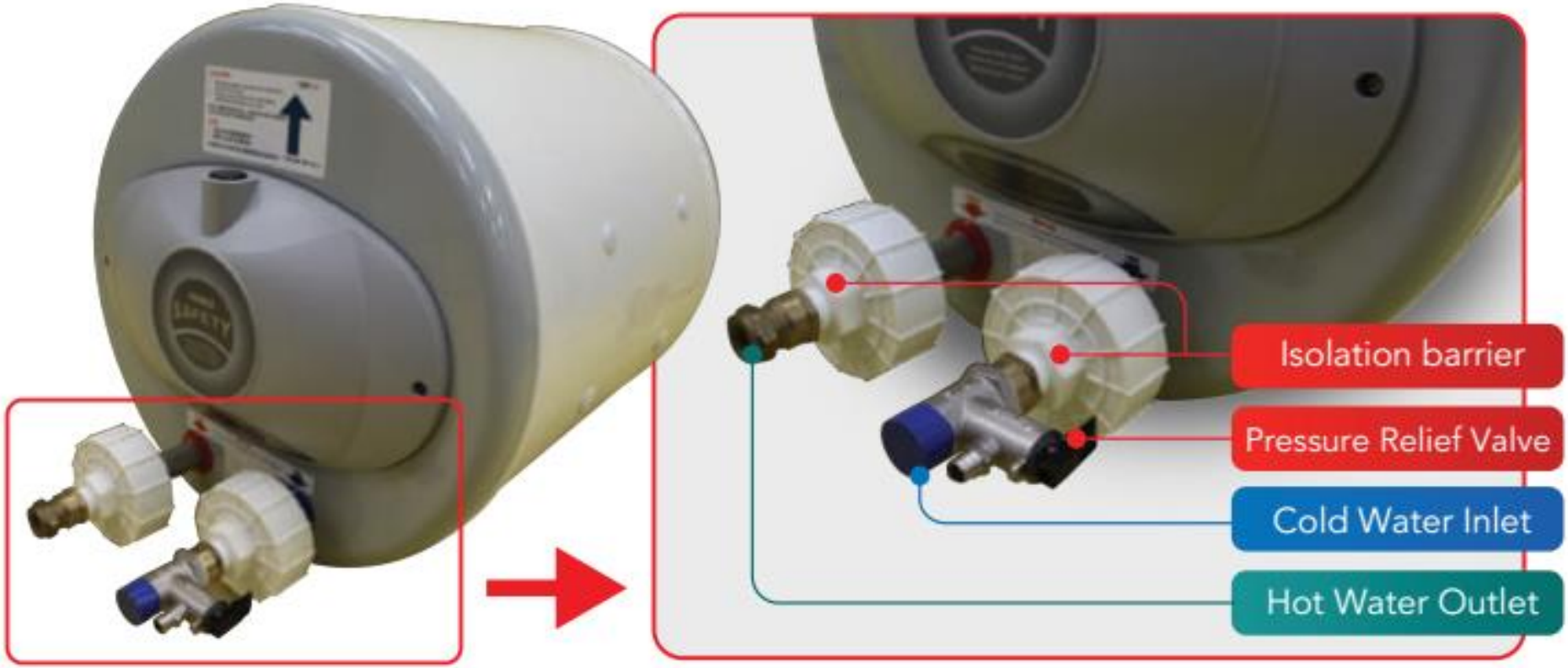
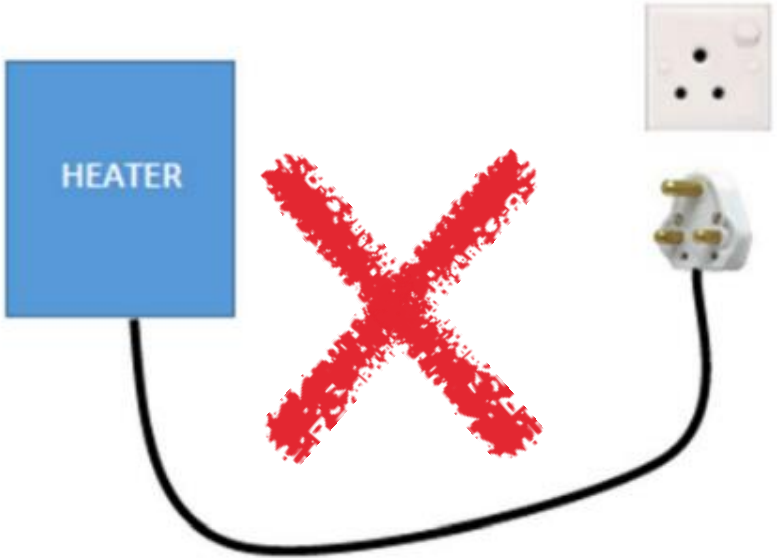
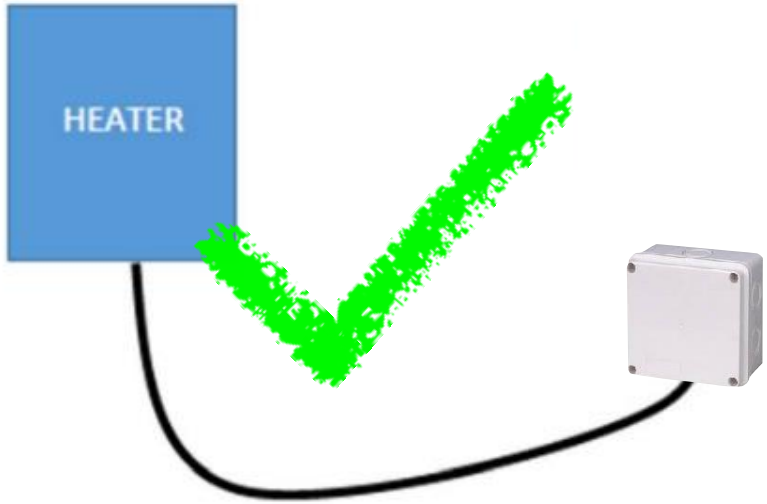


Figure 10: Installation of Isolation Barriers.

Cable Connection

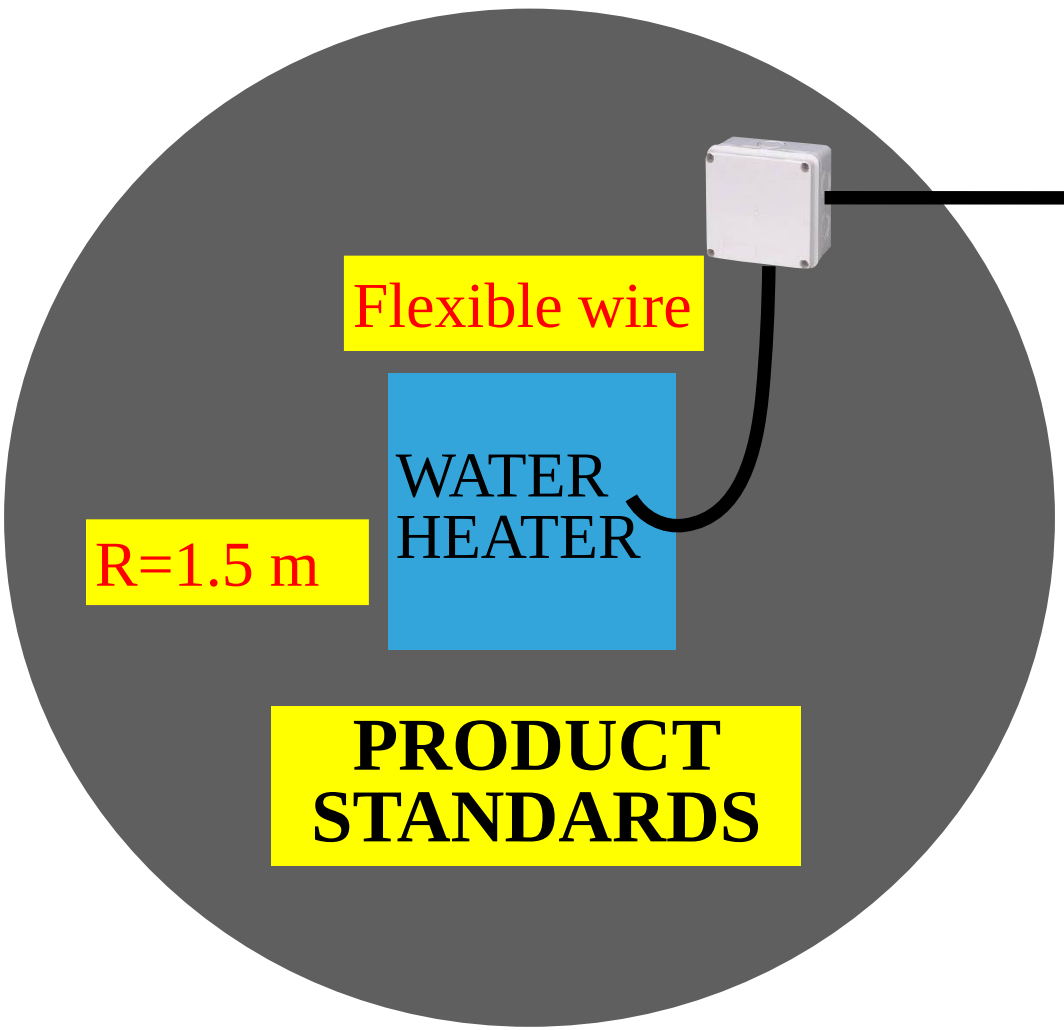


WRONG



CORRECT

Cable Connection and Enhanced Protection by RCD



ELECTRICAL INSTALLATIONS STANDARDS

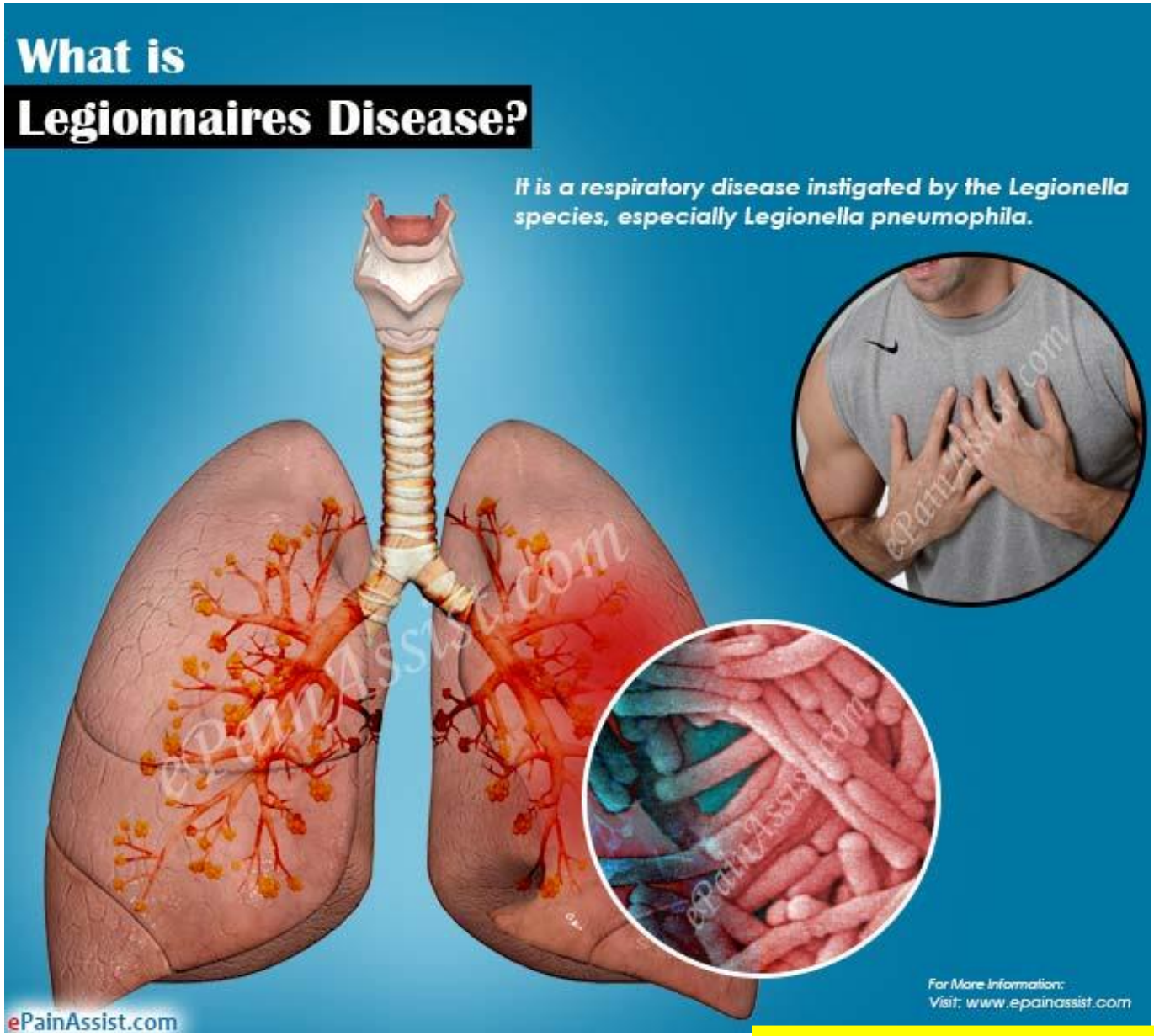
Approved IP 65 Junction Boxes

Approved Terminal Blocks or Connectors

850^{O}C Flame Retardant

Flammable !

Bio Safety: Legionnaires Disease

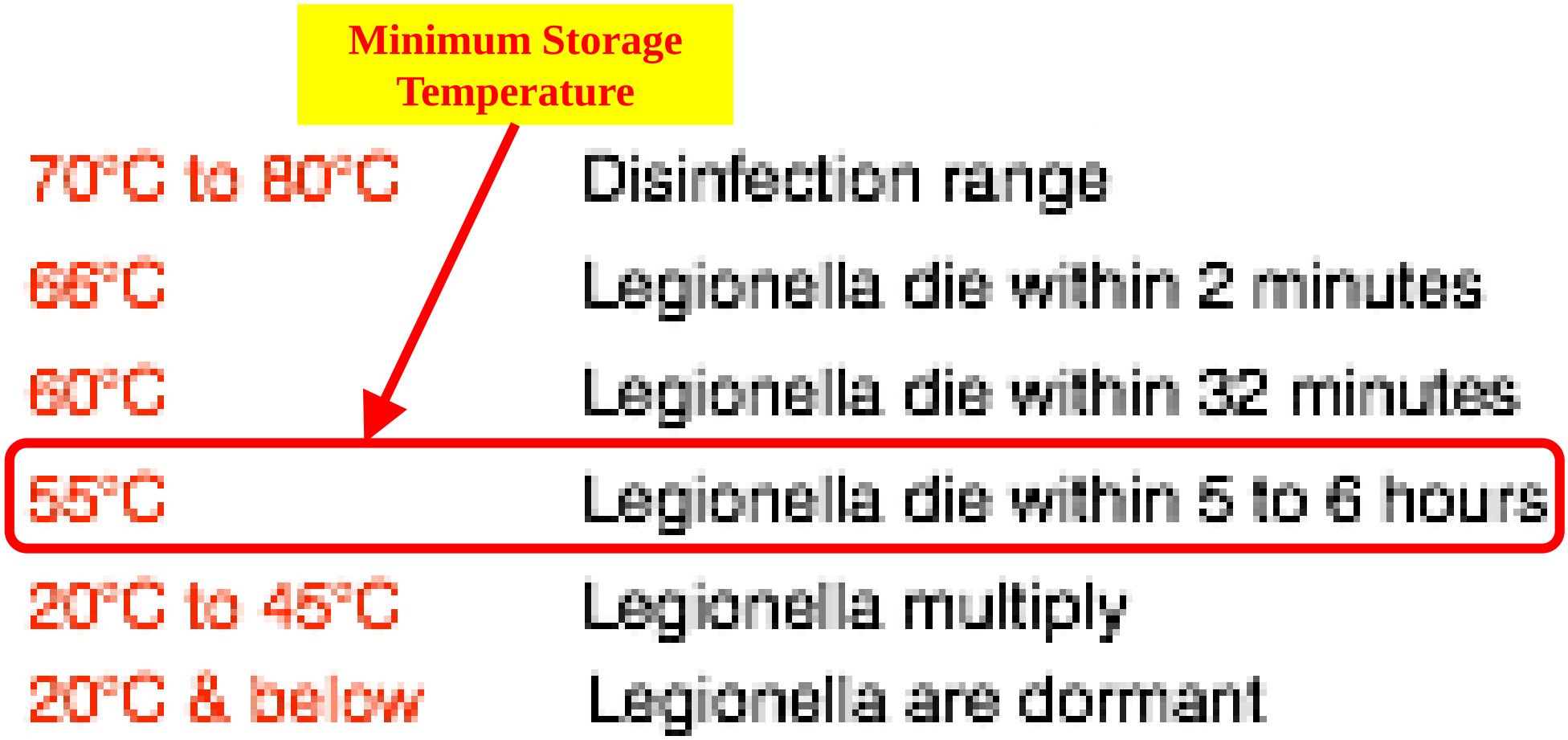


Source: ePainAssist

Bio Safety: Legionnaires Disease

1. *Cause lung infection (Pneumonia);*
   a. *Antibiotics are an effective medical treatment;*
   b. *The most useful approach is prevention with the proper water system such as water heater systems*
2. *Fatality rate:*
   a. *10% – 15%;*
   b. *Hospital patients: Can reach 80%;*
3. *Grows in warm water*
4. *Transmits by inhalation of contaminated aerosol – Example: Cooling tower cold & hot water system*

Legionnaires Disease and Water Temperature



Source: Chartered Institute of Plumbing & Heating Engineering, UK

Thermal Safety – Scalding or Burns Risks:

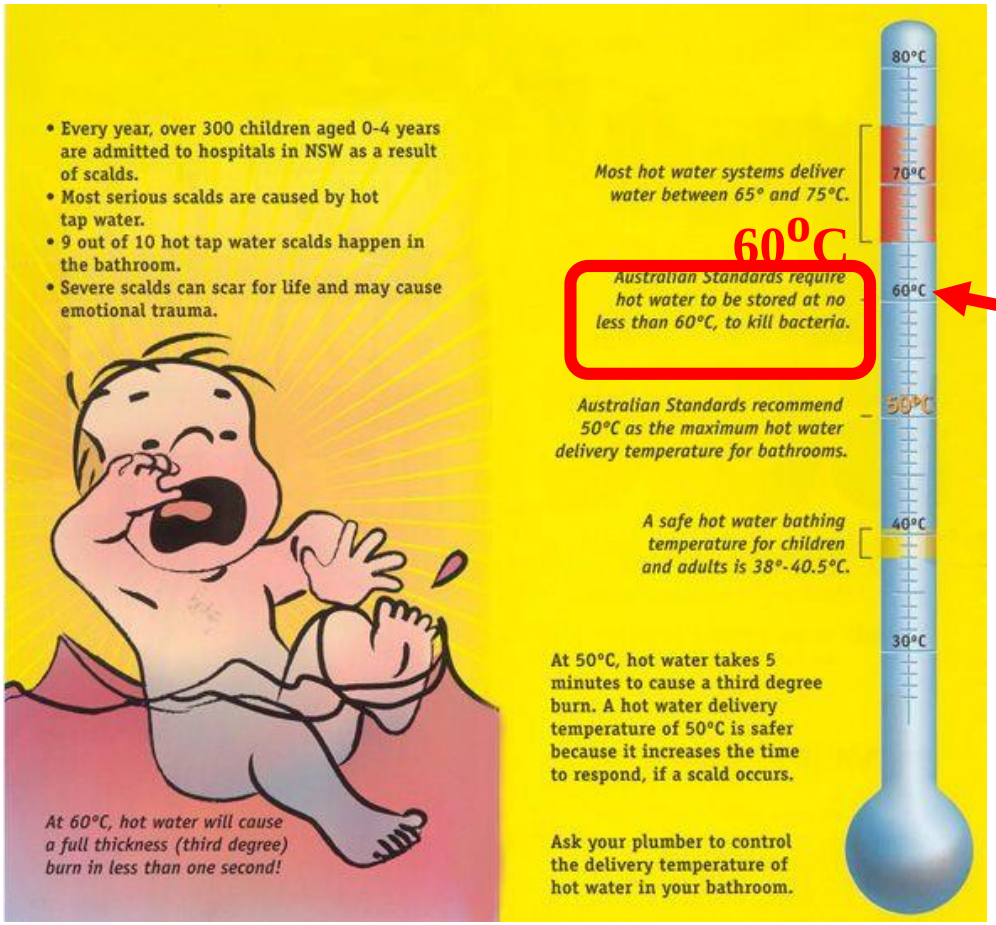
Skin Scalding Temperature

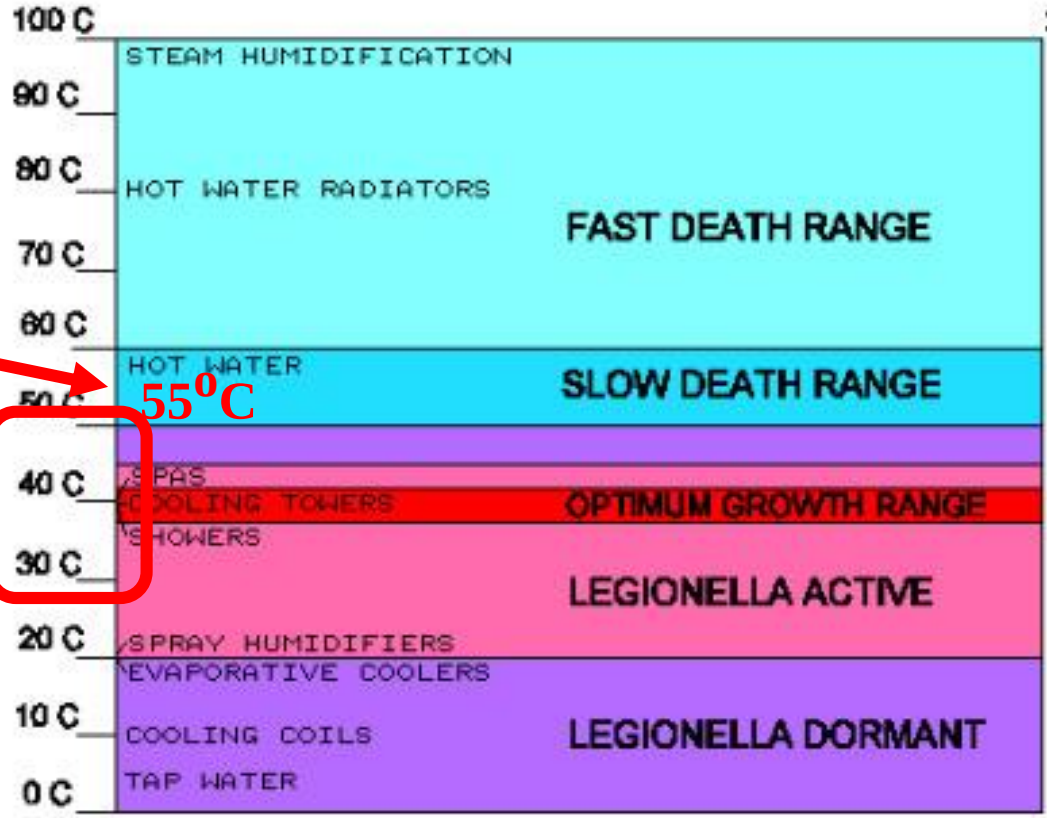
Maximum Storage Temperature

65°C	a partial thickness burn in about 2 seconds
60°C	a partial thickness burn in about 5 seconds
55°C	a partial thickness burn in about 15 seconds
50°C	a partial thickness burn in about 90 seconds

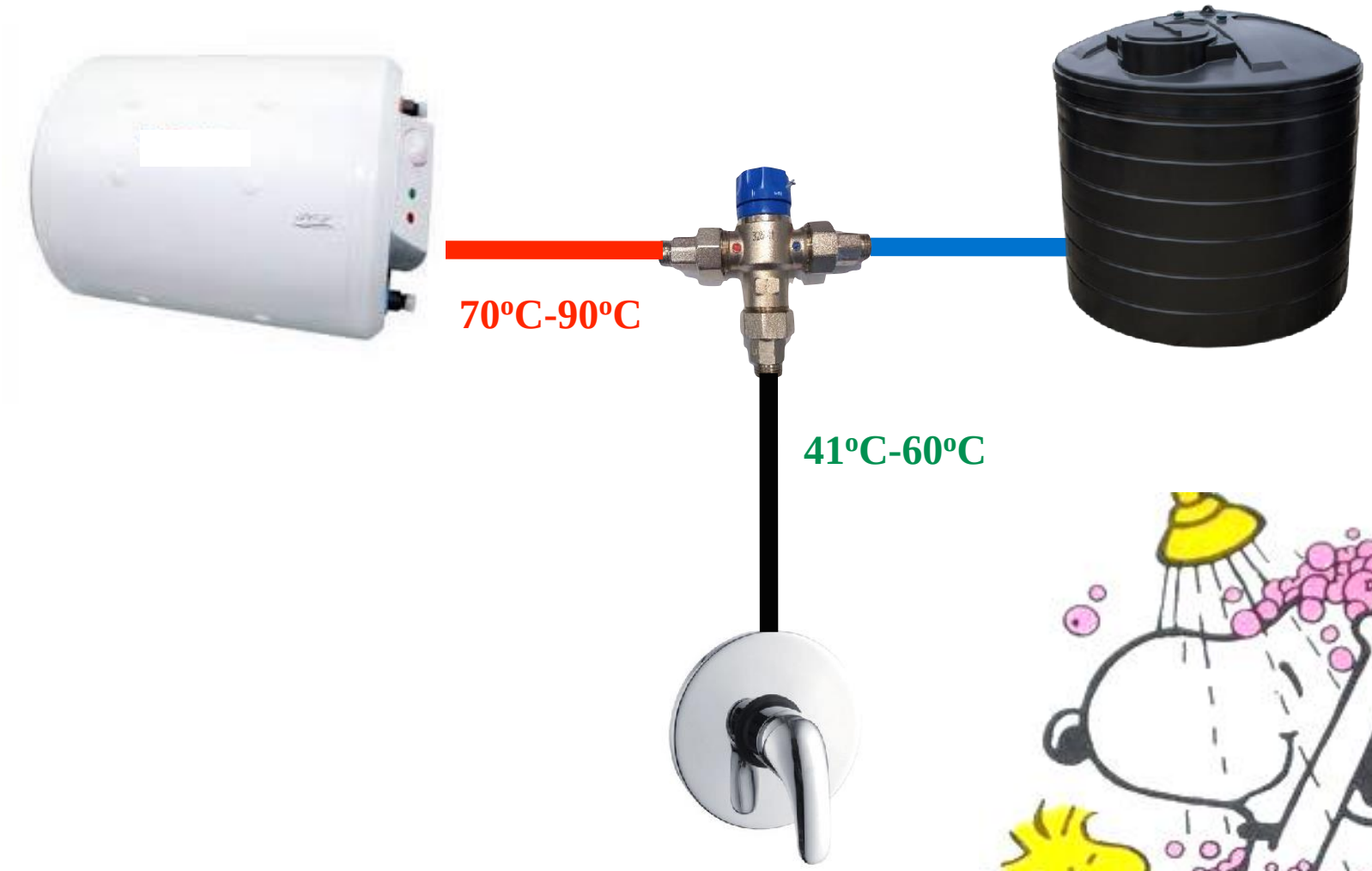
Source: Chartered Institute of Plumbing & Heating Engineering, UK

Safe Bathing Temperature Range





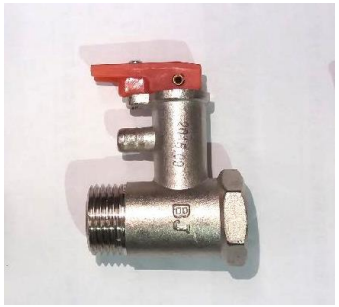
Thermostatic Mixing Valve



Pressure Safety: Explosion Risk

1. ***MS IEC 60364 and MS 1597 – 2 – 21: Three (3) level of pressure safety protection***

THERMO CUT-OUT ~92 ^{O}C → **Manual Reset** → Safety Protection MS IEC 60364 / MS 1597 – 2 – 21



PRV / TPV +1 Bar / 92 ^{O}C → Auto Reset → Functional / Safety Protection MS 1597 – 2 - 21

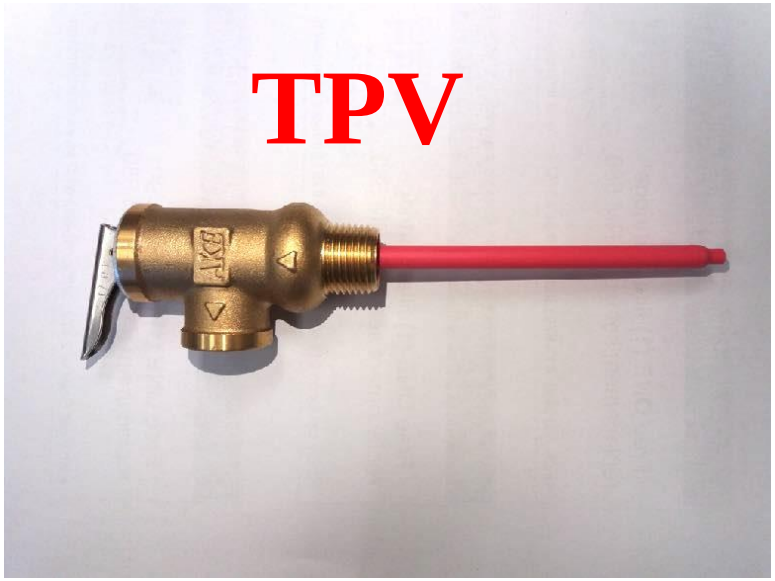
THERMOSTAT 45 ~75 ^{O}C → Auto Reset → Functional Protection MS IEC 60364 / MS 1597 – 2 - 21

Temperature / Pressure Relief Valves

1. *Two types:*

   a. *TPV (Better protection compared with PRV): Temperature and pressure relief valve – Typically designed to relieve pressure at 150 psig and on temperature at 90^{o}C*

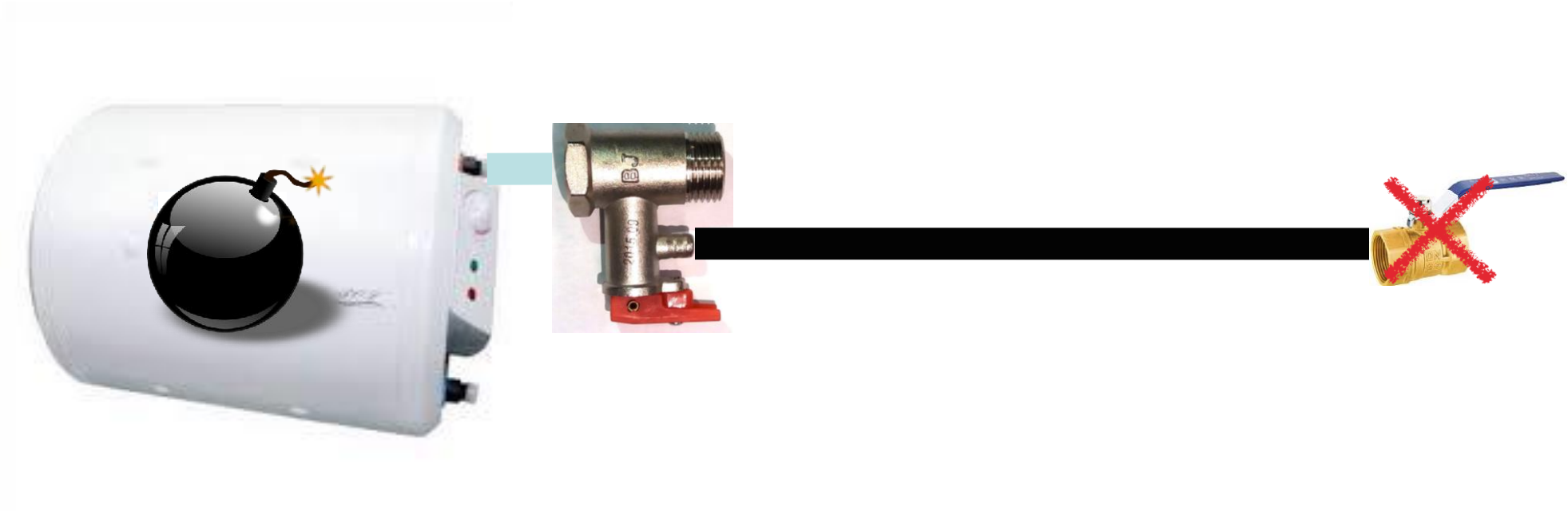
   b. *PRV: Pressure relief valve*



Relief Valves: Proper Discharge

Do Not Install Shut Down Valve

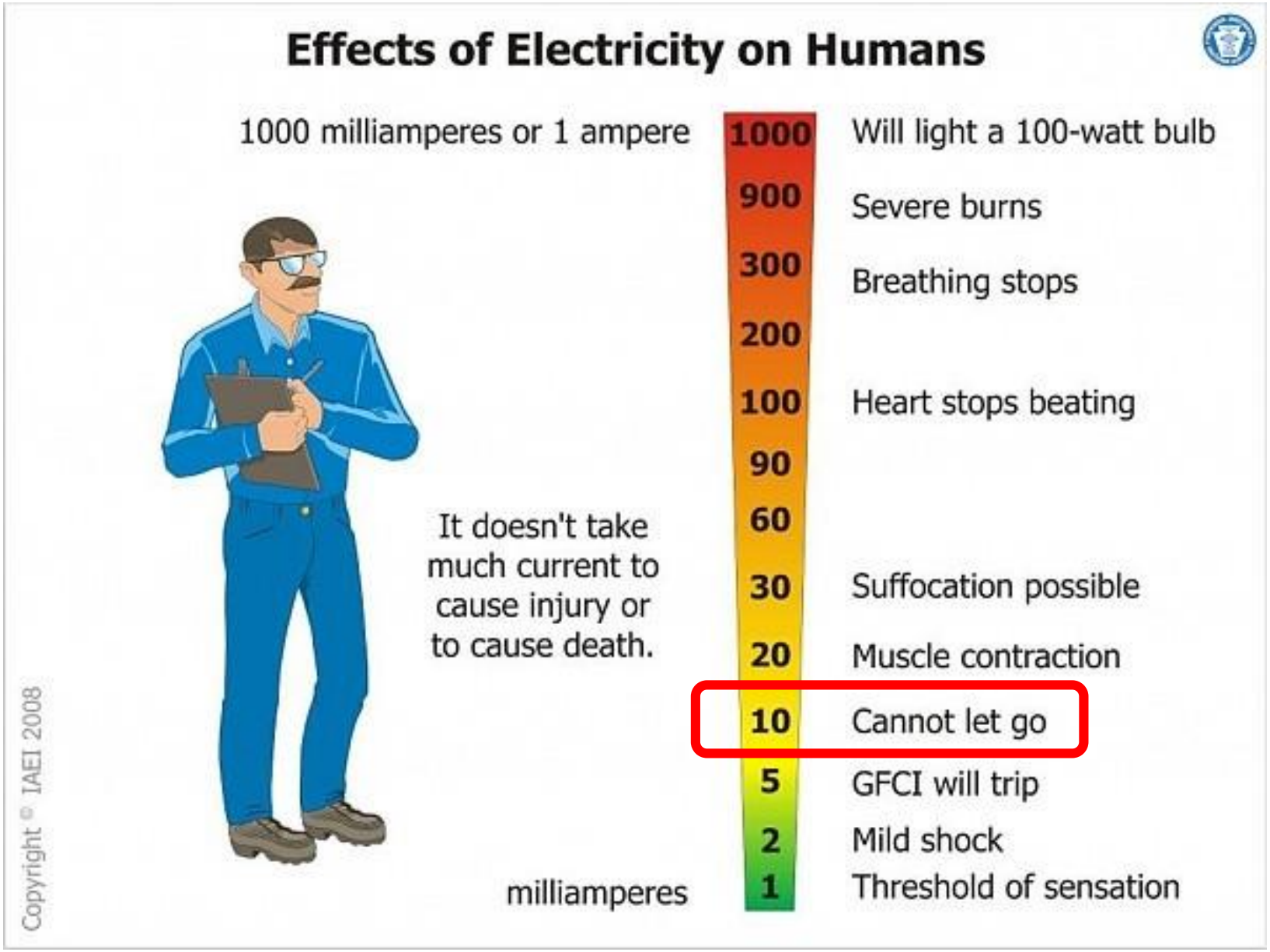
Pressure Safety: A Premium Resort



Electrical Safety: Statistics

1. *Water heater system installations per year:*
    a. *Instant water heater: ≈ 400k – 500k;*
    b. *Storage water heater: ≈ 80k to 100k;*
    c. *Solar water heater: ≈ 20k*
2. *Electrocution: Reported since year 2009*
    a. *Instant water heater: 5 cases;*
    b. *Storage water heater: 4 cases;*
    c. *Solar water heater: 1 case*

10 mA Electric Shock Current May be Fatal



Sub – Standard Wiring Works: Statistics

1. ***9 reported electrocution cases within past 7 years:***

   a. ***Residual current devices (RCD): All main RCD not functioning;***

   b. ***Water heater in normal working conditions including built – in RCD;***

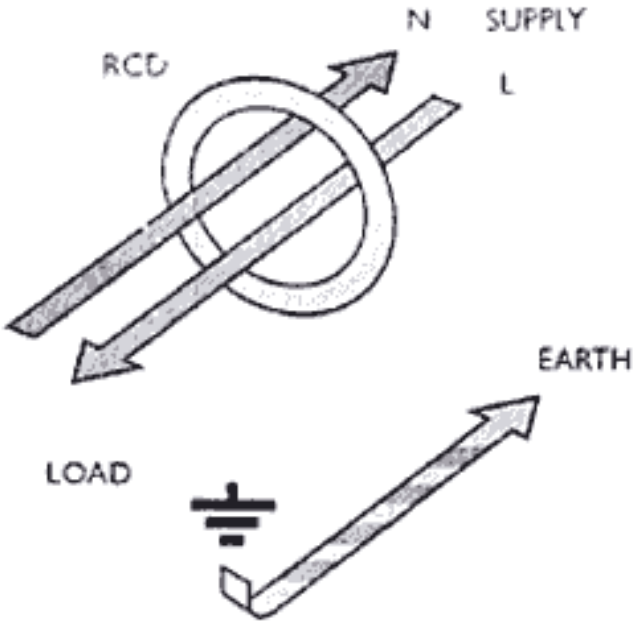
   c. ***1 case: Undersized incoming cable;***

   d. ***6 cases: Electrified earth cable, leakage from other circuit to water heater systems and electrocution through water heater;***

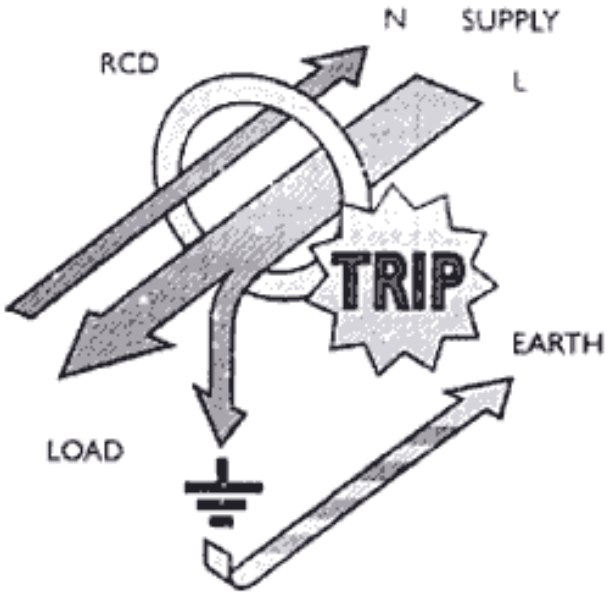
   e. ***2 cases – Causes not positively identified***

Leakage Current From Other Circuit

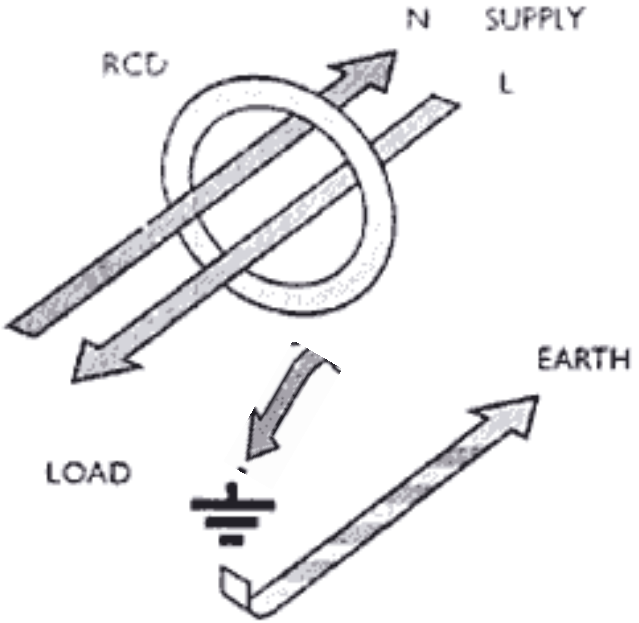
No Leakage Current: No Trip



Leakage Current by Same Circuit: Trip

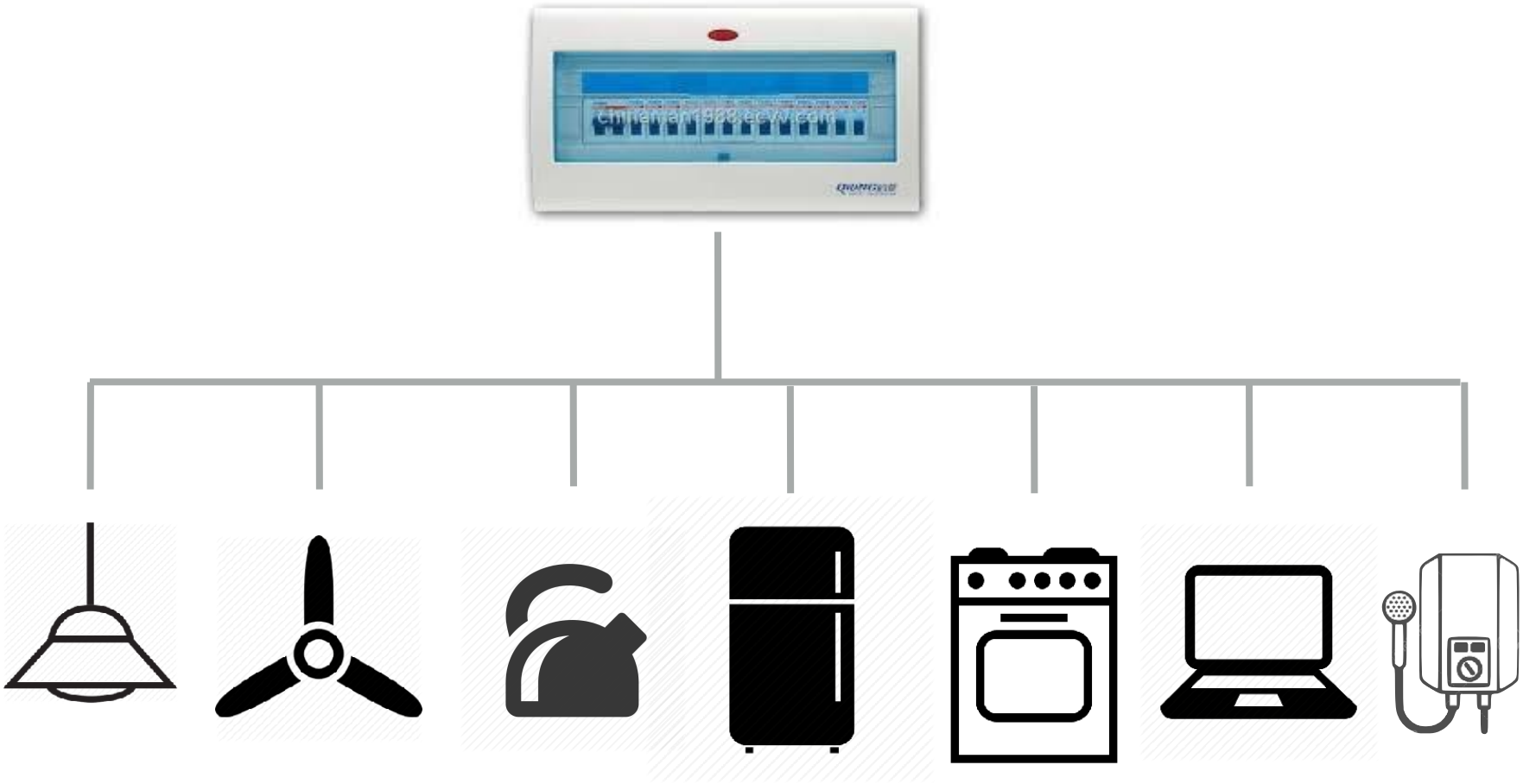


Leakage Current from Other Circuit: No Trip

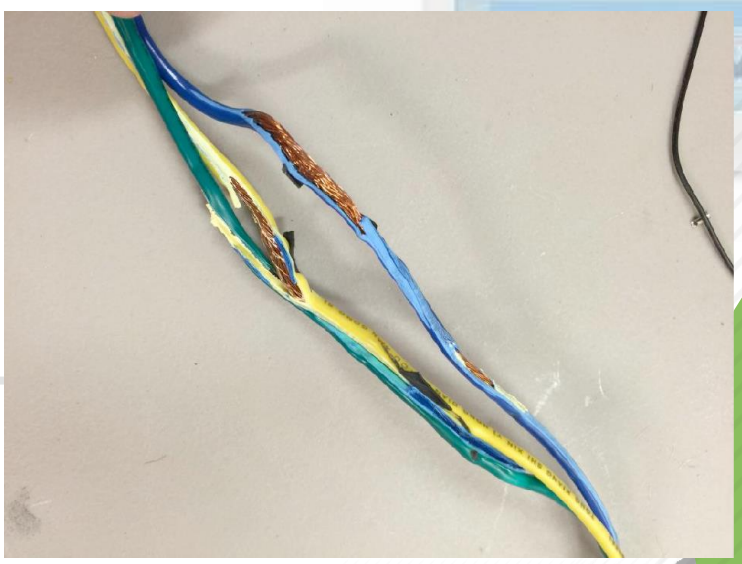


Source: Study Electrial.com

Typical Domestic Electrical Installations

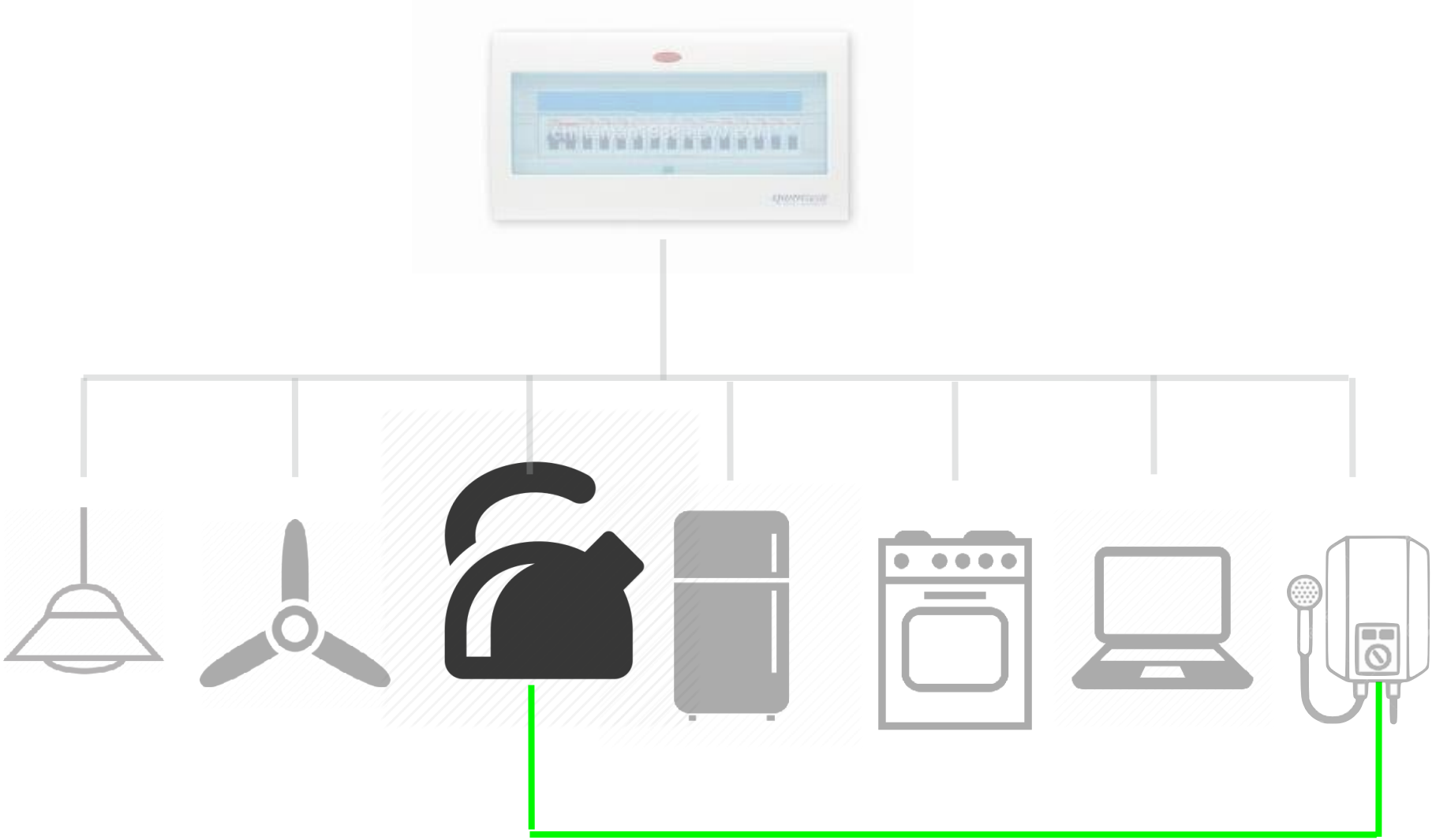


Electric Shock Fault and RCD Malfunction

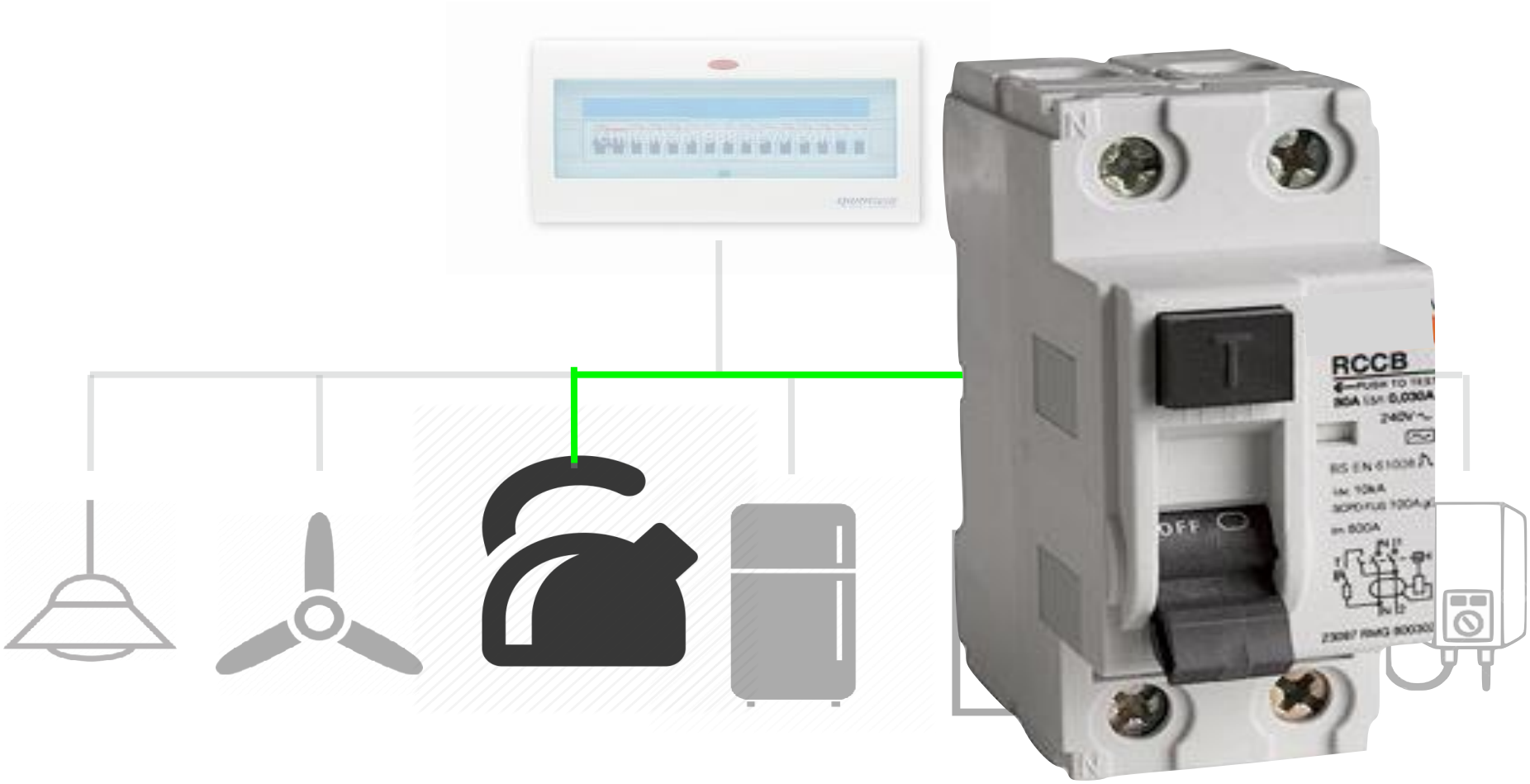


Cable LIVE & EARTH Short Circuit!

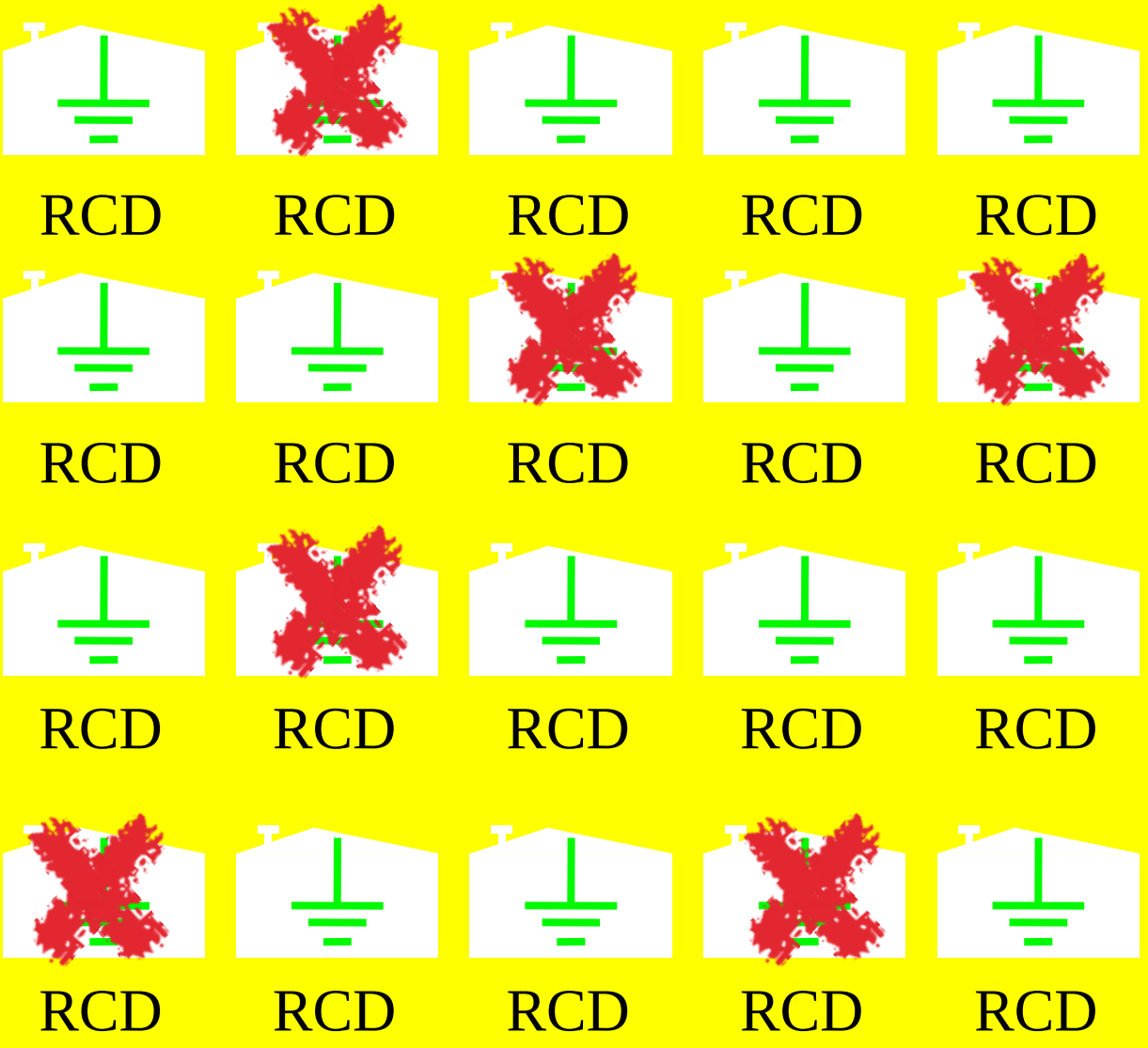
Electric Shock Fault and RCD Malfunctions / Defective Earthing



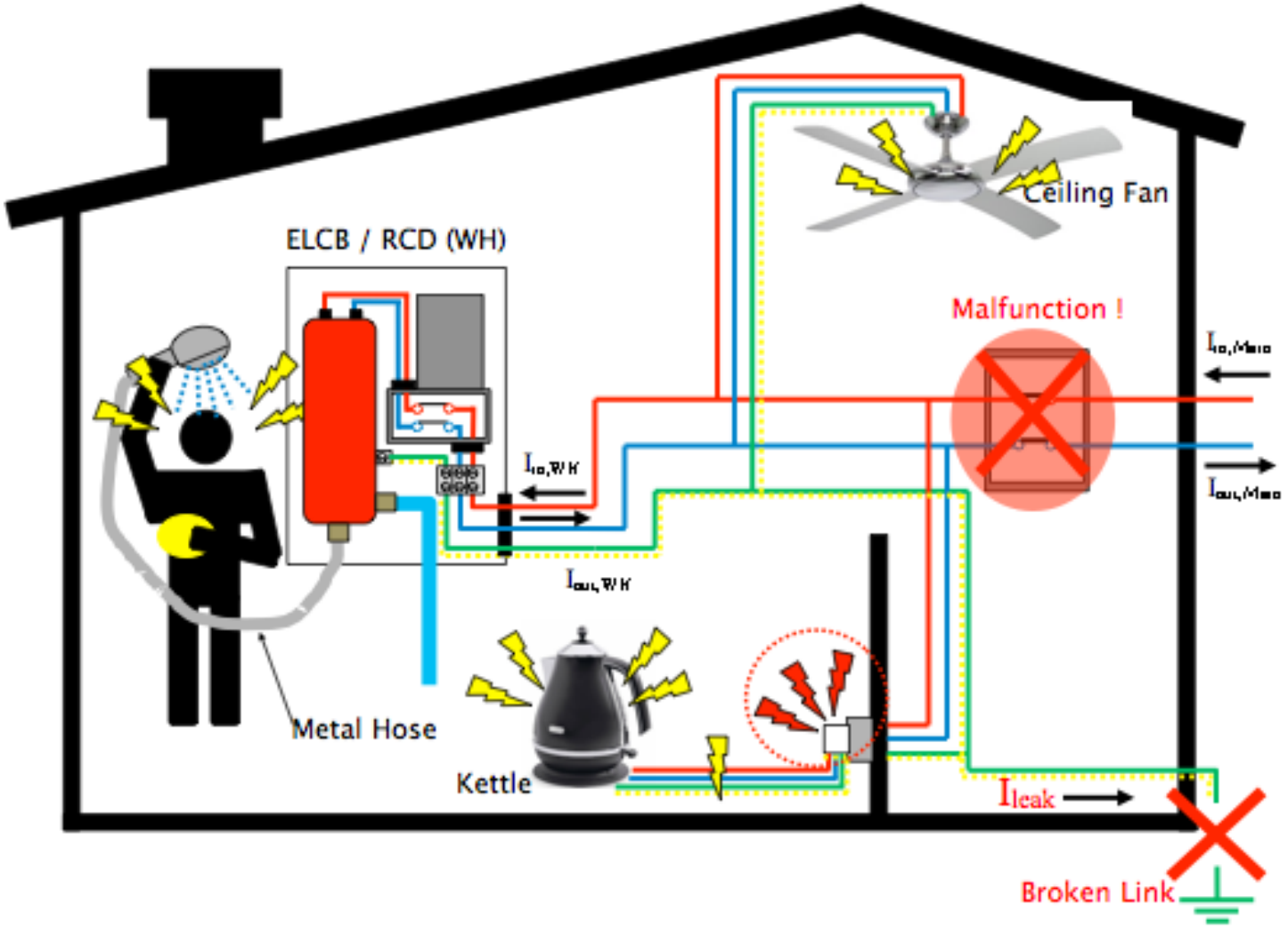
RCD Malfunctions



Defective Earthing



A Case for News Reporting



Broken Earth +
RCD
malfunction +
Metallic hose

= SURE DIE!

Reasonable Access: At Least 60 cm x 60 cm in the Vicinity of Water Heater System

Working Spaces:

Standards: IEC 60364 / BS 7671:2008

132.12 Accessibility of electrical equipment

Electrical equipment shall be arranged so as to afford as may be necessary:

(i) sufficient space for the initial installation and later replacement of individual items of electrical equipment

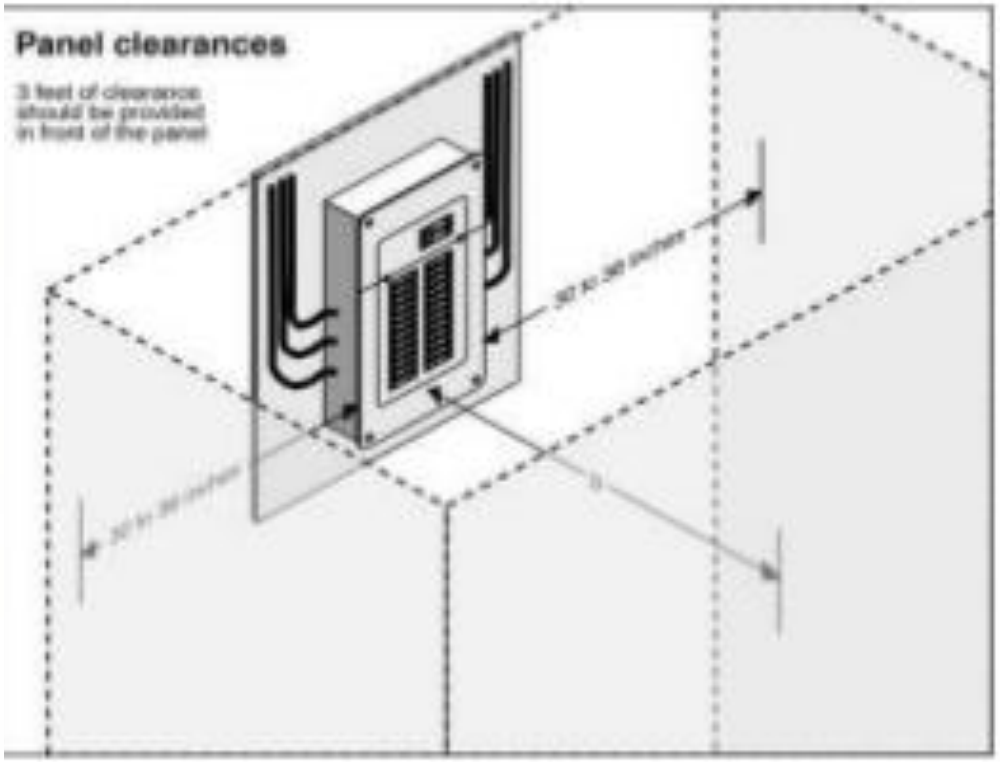
(ii) accessibility for operation, inspection, testing, fault detection, maintenance and repair.

Suruhanjaya Tenaga – Non – Domestic Electrical Installations Safety Code: Working Space

Table 9: Minimum safety and working clearance

Nominal Voltage U_n (kV)	Maximum Voltage U_m (kV)	Minimum safety phase to earth air clearance (mm)	Minimum work safety clearance (mm)
0.151-1	-	-	1,250
6	7.2	500	3,000
11	12	500	3,000
33	36	500	3,000
66	72.5	700	3,100
132	145	1,100	3,600
275	300	1,600	4,100
500	525	3,600	6,400

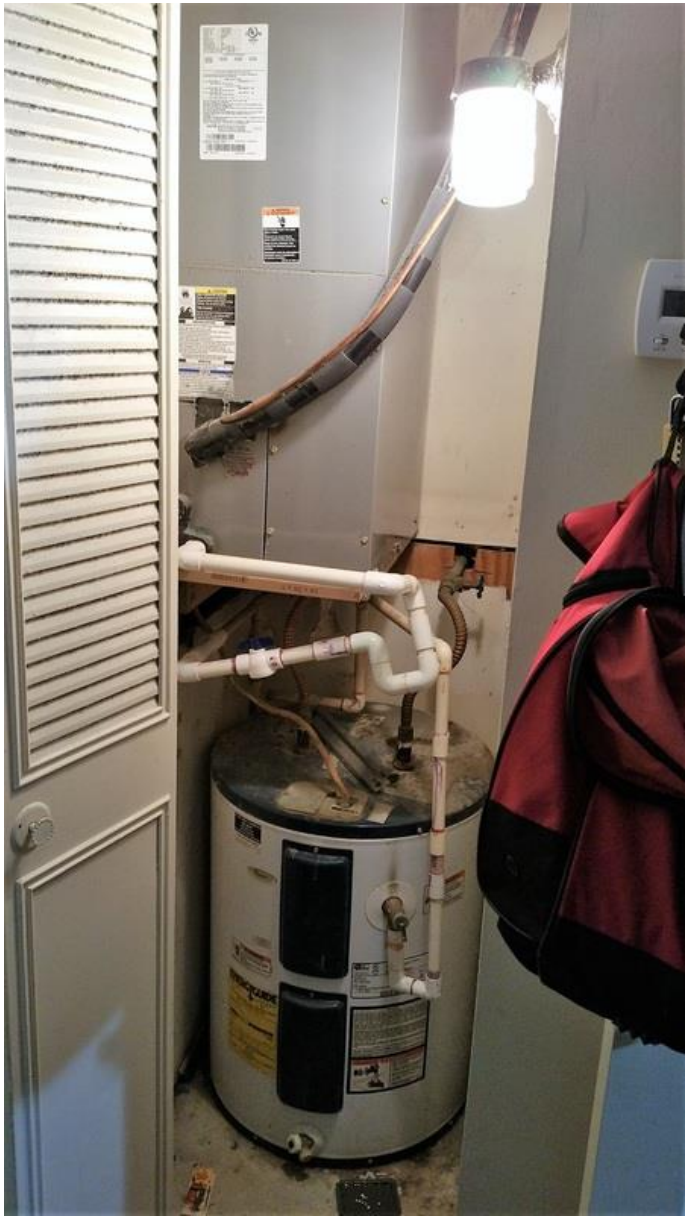
NEC: Working Spaces



Source: John Newquist

Sub – Standard Workmanship

Source: House Maintenance



Source: HomePro

Sub – Standard Workmanship

Source: House Maintenance

No Maintenance

Source: TEEAM

Consequences of Water Heater Accidents

Seremban:

Malaysian Study in Korean University Electrocuted While Taking Bath

Source: Free Malaysia Today

Consequences of Water Heating Accidents

Source: Shout, UK

Amputated Hand

Source: Library Med. Utah.Edu, USA

Consequences of Water Heater Accidents

Mont Kiara Condominium:

Exploding Boiler: Expat Escapes Unscathed

Source: NST

Requirements of Electrical Installations

Regulatory Requirements and Standards Compliance

1. *Electricity Supply Act 1990 [Act 447} and Electricity Regulations 1994;*
2. *Residential or similar installations: MS 1979: 2015: Electrical Installations of Buildings – Code of Practice;*
3. *Non – Residential or similar installations: MS 1936: 2016: Electrical Installation of Buildings – Guide to MS IEC 60364;*
4. *Non – Domestic Electrical Installation Safety Code*

Regulatory Requirements and Standards Compliance

5. *IEC 60364 – 7 – 701: 2006: Low Voltage Electrical Installations – Part 7 – 701: Requirements for Special Installations or Locations – Locations containing a bath or shower*
6. *MS IEC (IEC) 60364: Electrical Installations of Buildings; and*
7. *MS IEC (IEC) 60038:2008: IEC Standard Voltages*
   a. *Malaysia complies with European Agreement – RD 472 D2*

Earthing System and Nominal Voltages

1. ***MS IEC (IEC) 60364:***

   a. ***Earthing system: TT earthing system;***

2. ***MS IEC (IEC) 60038 (Malaysia complies with European Agreement RD 472 S2):***

   a. ***Single/Three Phase: 230/400Vrms –6 % +10%***

   b. ***Frequency: 50 Hz + 1 Hz, –6% +10%;***

Registered Contractor and Competent Person

1. ***All electrical installation work on water heater system shall be carried out by:***

   a. Competent person such as wireman registered with Suruhanjaya Tenaga;

   b. Electrical contractor registered with Suruhanjaya Tenaga

Equipment Product Standards: Table 1

1. *All electrical installation equipment shall comply with Table 1*

   a. *If no MS or IEC standard exists, the relevant IEC standard shall apply;*

   b. *The competent person shall carry out a risk management to ensure the risk of use is within the acceptable level; and*

   c. *All equipment shall be approved by Suruhanjaya Tenaga if required*

Equipment Product Standards: Table 1

Table 1: Electrical Standard for Installation Equipment

EQUIPMENT	STANDARD
Consumer Unit	IEC 61439–3:2012
Final distribution board	IEC 61439–3:2012
*Miniature Circuit Breaker (MCB)	MS IEC 60898–1:2007 (confirmed 2011) MS IEC 60898–2:2007 (confirmed 2011)
Circuit breaker	MS IEC 60947–2:2010
*Residual current device (RCD)	MS IEC 61008–1:2012 MS IEC 61008–2:2003 (confirmed 2011) MS IEC 61009–1:2012 MS IEC 61009–2:2003 (confirmed 2011)
Wire and cable for fixed wiring 450/750V PVC insulated cable (non-sheathed) 600/1000V PVC insulated cable (non-armoured)	MS 2112–3:2009/ MS 2112–4:2009 MS 2100:2007/ MS 2101:2007/ MS 2102:2007/ MS 2103:2007

Equipment Product Standards: Table 1

Table 1: Electrical Standard for Installation Equipment

EQUIPMENT	STANDARD
Cable trunking and ducting conduit	MS 1777:2006 MS IEC 61386:2010
Double pole switch (Up to 63A)	**MS IEC 60669:2012 (Non – Electronic)
Flexible wire and cable	MS 2112–5:2009
Connector	MS IEC 60998-1:2005 (confirmed 2015) MS IEC 60998-2-2:2005 (confirmed 2015) MS IEC 60998-2-3:2005 (confirmed 2015) MS IEC 60998-2-4:2005 (confirmed 2015) MS1873:2005 MS1873-22:2006 IEC 60670-22:2003+AMD1:2015

Equipment Product Standards: Table 1

Table 1: Electrical Standard for Installation Equipment

EQUIPMENT	STANDARD
Connection unit (joint box), junction box, terminal blocks, cable lug	MS 1540:2015 MS1838:2015 MS1873:2005 BS 1363-4:1995+A4:2012
*MCB – RCD combinations such as RCBO are acceptable as replacement ** Electronic switches are not permitted by MS IEC 60364	

Wire or Cable 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

Wire or Cable Colour Code

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

Wire or Cable Colour Code

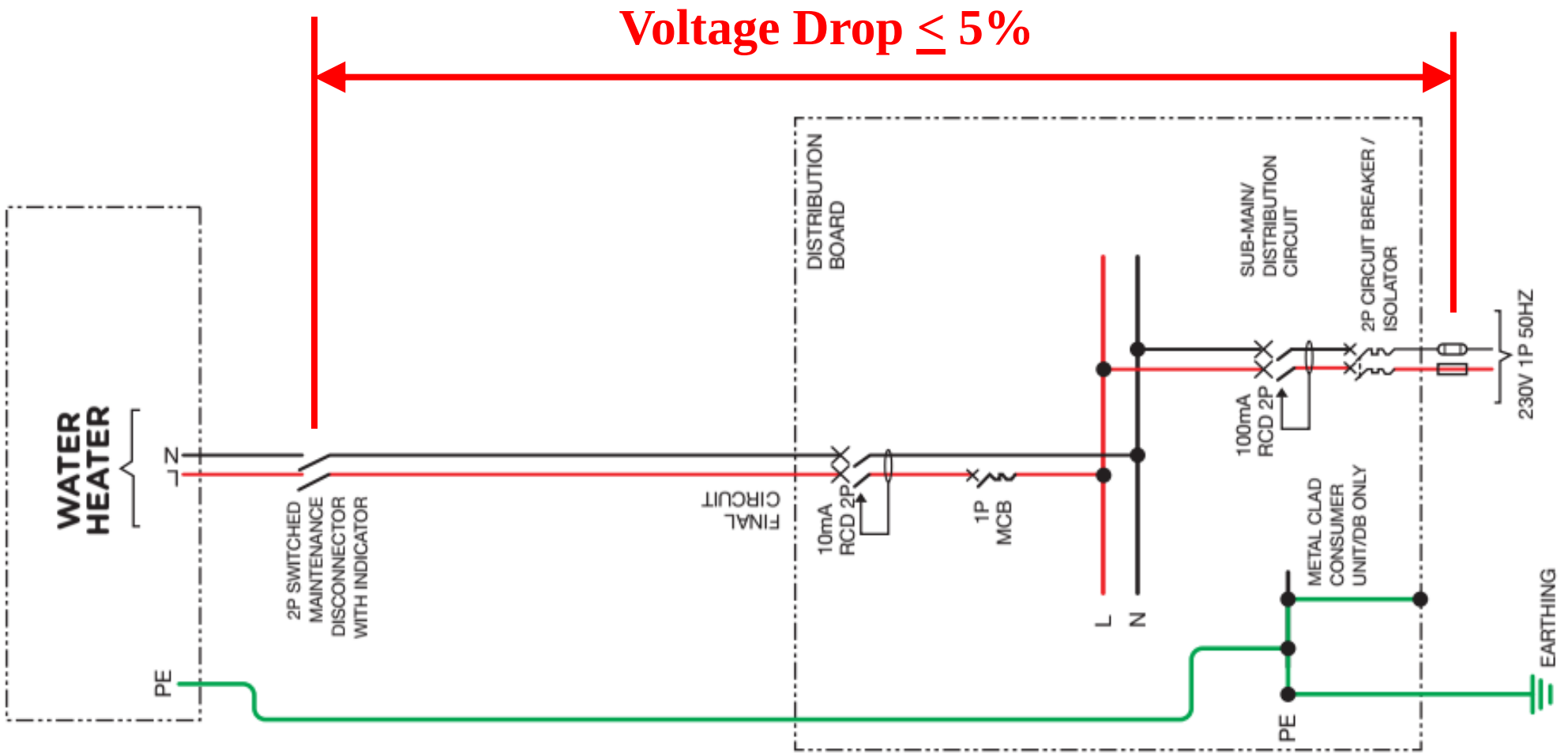
Table 4: Three phase supply three phase circuit: Wire or cable colour code.

Conductor	Colour Code
Live – Red / Yellow / Blue	Red / Yellow / Blue
Neutral	Black
Protective Earthing	Green
Equipotential bonding	Green

Voltage Drop

1. *The maximum voltage drop shall be ≤ 5% of nominal voltage (230/400) from point of coupling with the electricity provider (From final distribution board or consumer unit to the disconnector of water heater system);*
2. *If the final circuit is less than or equal to 50 meters: Checking voltage drop is not required*
3. *If the final circuit is more than 50 meters: Checking voltage drop is required*

Voltage Drop

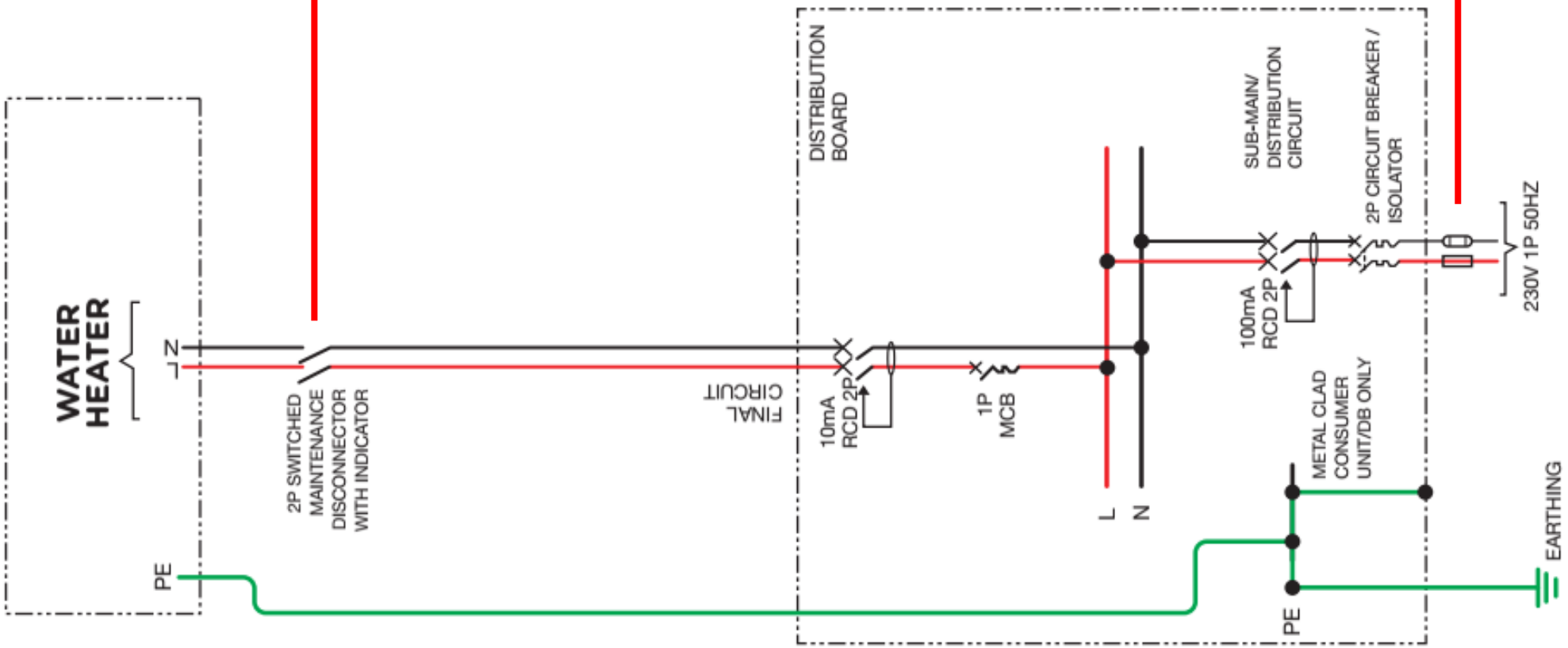


Utilization Voltage

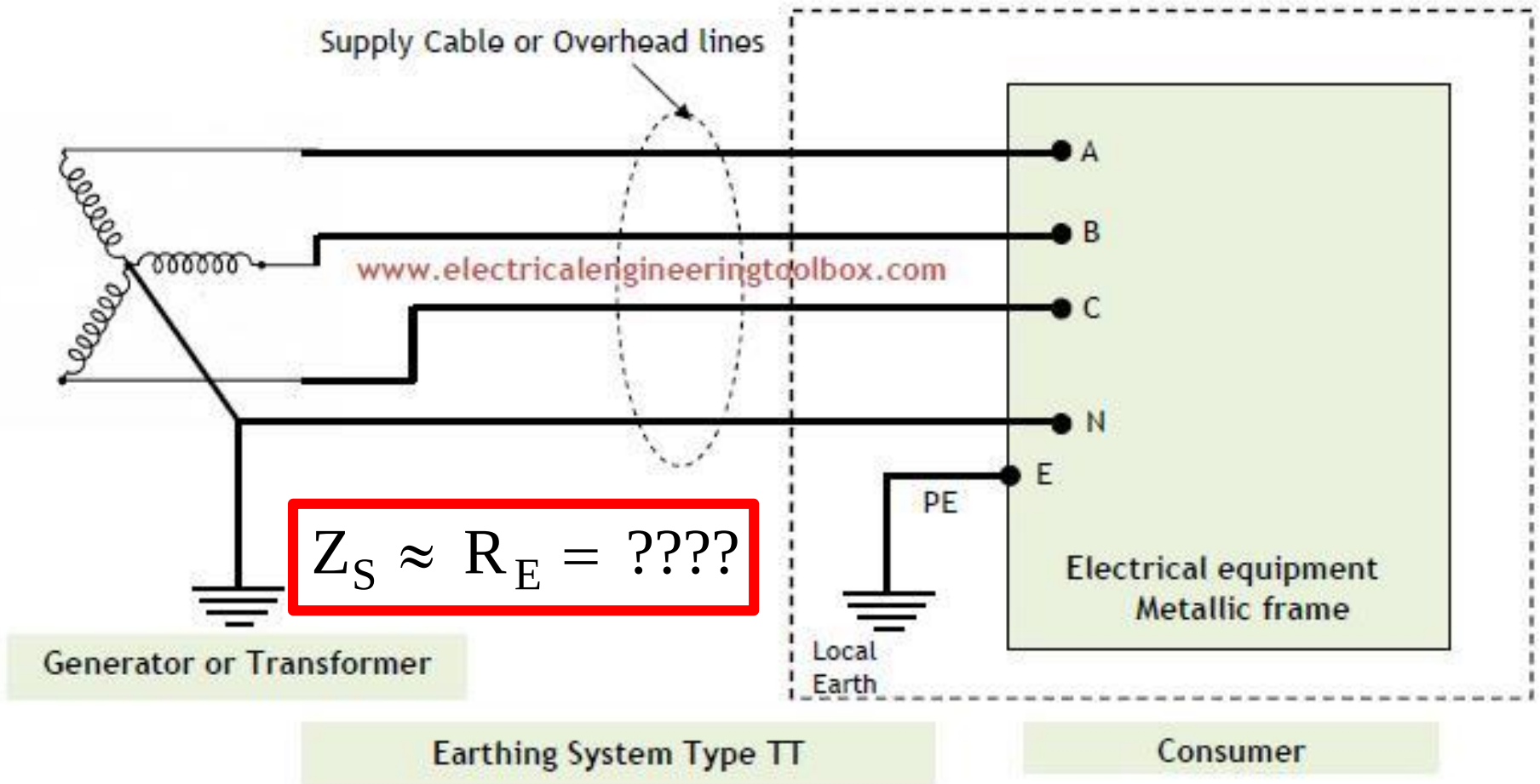
Min. Nominal Voltage = 216.2 V

Min. Utilization Voltage = 204.7 V

Max/ Voltage Drop = 5% = 11.5V



Earthing Impedance, Zs (≈ RE, Resistance for TT Earthing System



Non – Domestic Electrical Installations Safety Code

Table 3: Maximum earth fault impedance (z_s) for RCDs

RCDs rated leaking current / residual current (mA)	Maximum earthing impedance (ohms)
	120 Volts < Supply Phase Voltage, Vp < 230 Volts
30	1667
100	500

$$Z_S = \frac{50}{I_n}$$

For RCB with 30 mA Sensitivity $\Longrightarrow I_n = 0.03\ \text{A};$

$$Z_S = \frac{50}{I_n} = \frac{50}{0.03} = 1{,}667\ \Omega$$

The Story of Zs

1. ***Non – Domestic Electrical Safety Code – 100 mA RCD: ≤ 500 Ω***
   a. ***Electric shock protection by RCD***
   b. ***Must include safety factor 0.5 – 0.8 for soil resistivity variation***

$$Z_S = \frac{50}{I_n}$$

2. ***MS 1979 and MS 1936: ≤ 10 Ω <<< 500Ω;***
   a. ***Electric shock protection by RCD;***
   b. ***"Overkill ??"***

$$Z_S = \frac{50}{I_n}$$

3. ***MS IEC 62305 / BS 7671: ≤ 200 Ω***
   a. ***Electric shock protection by RCD;***
   b. ***Can cause electrical installation instability***

$$Z_S = \frac{50}{I_n}$$

The Story of Zs

4. TNB: ≤ 1 Ω;

a. Earth fault protection

b. Example: 10% of 2,000A ACB setting = 200A with safety factor = 0.8

$$Z_S = \text{safety factor} \times \frac{230}{I_n} = 0.8 \times \frac{230}{200} = 0.92\,\Omega$$

5. American:

a. National Electrical Code (NEC) – NEC 250.56: ≤ 25 Ω;

b. NFPA and IEEE: ≤ 5 Ω

6. Telecommunication: ≤ 1 Ω

The Story of Zs: Equipotentialization

????

Water Heater Final Circuit

1. ***Shall be dedicated outgoing final circuit originating from final distribution board or consumer unit:***

   a. ***Shall not be used and/or shared for any other purpose;***

   b. ***Shall not be shared conduit / trunking with any lighting circuit or non – final power circuit***

   c. ***Shall be installed in rigid conduit/trunking with space factors: Conduit ≤ 40% or trunking ≤ 45%;***

   d. ***Preferably fixed wiring***

Water Heater Final Circuit

2. *No cable jointing except terminations into electrical accessories such as double pole water heater switch;*

3. *Incoming of final distribution board or consumer shall have a series MCB – RCD (≤100 mA sensitivity) protection scheme;*

4. *Outgoing dedicated final circuit shall have a series MCB – RCD (≤ 10 mA sensitivity) protection scheme;*

Example of Water Heater Final Circuit

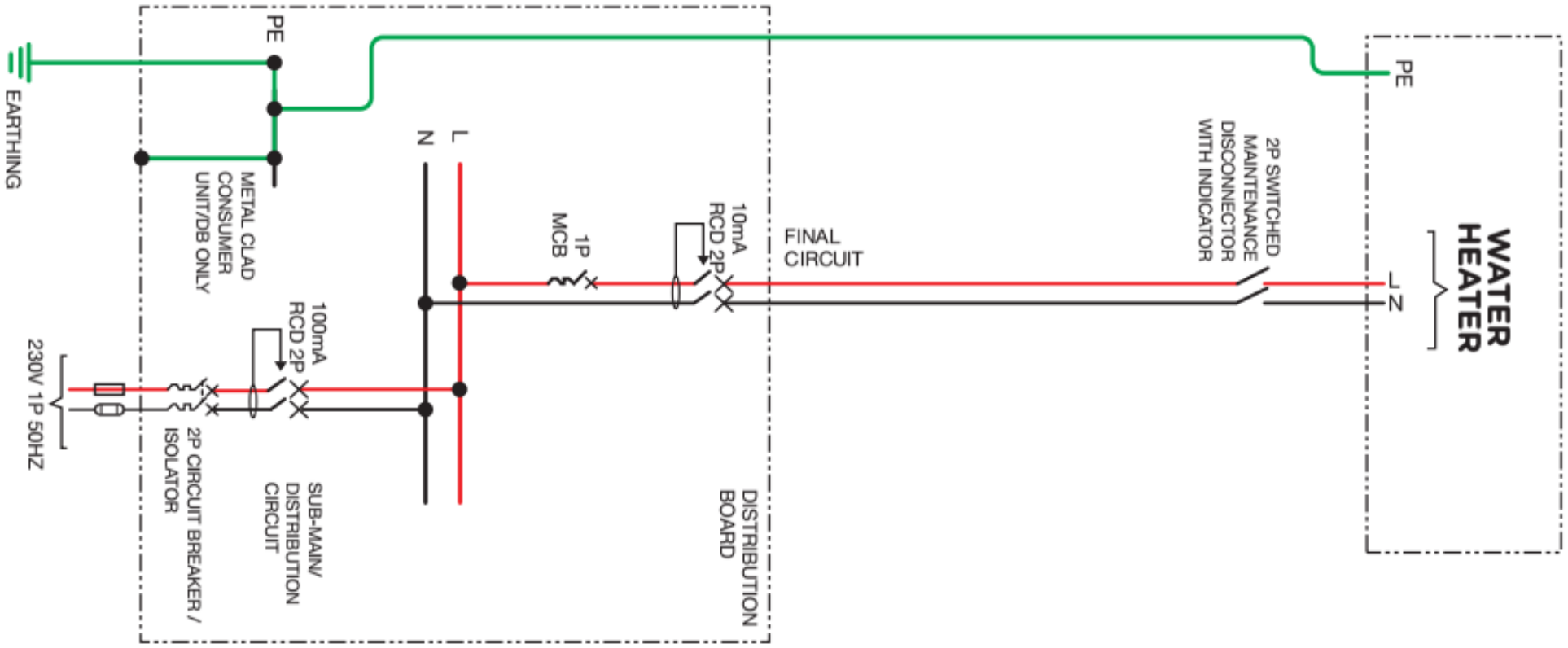


Figure 1: Example of schematic diagram for single-phase water heater.

Example of Water Heater Final Circuit

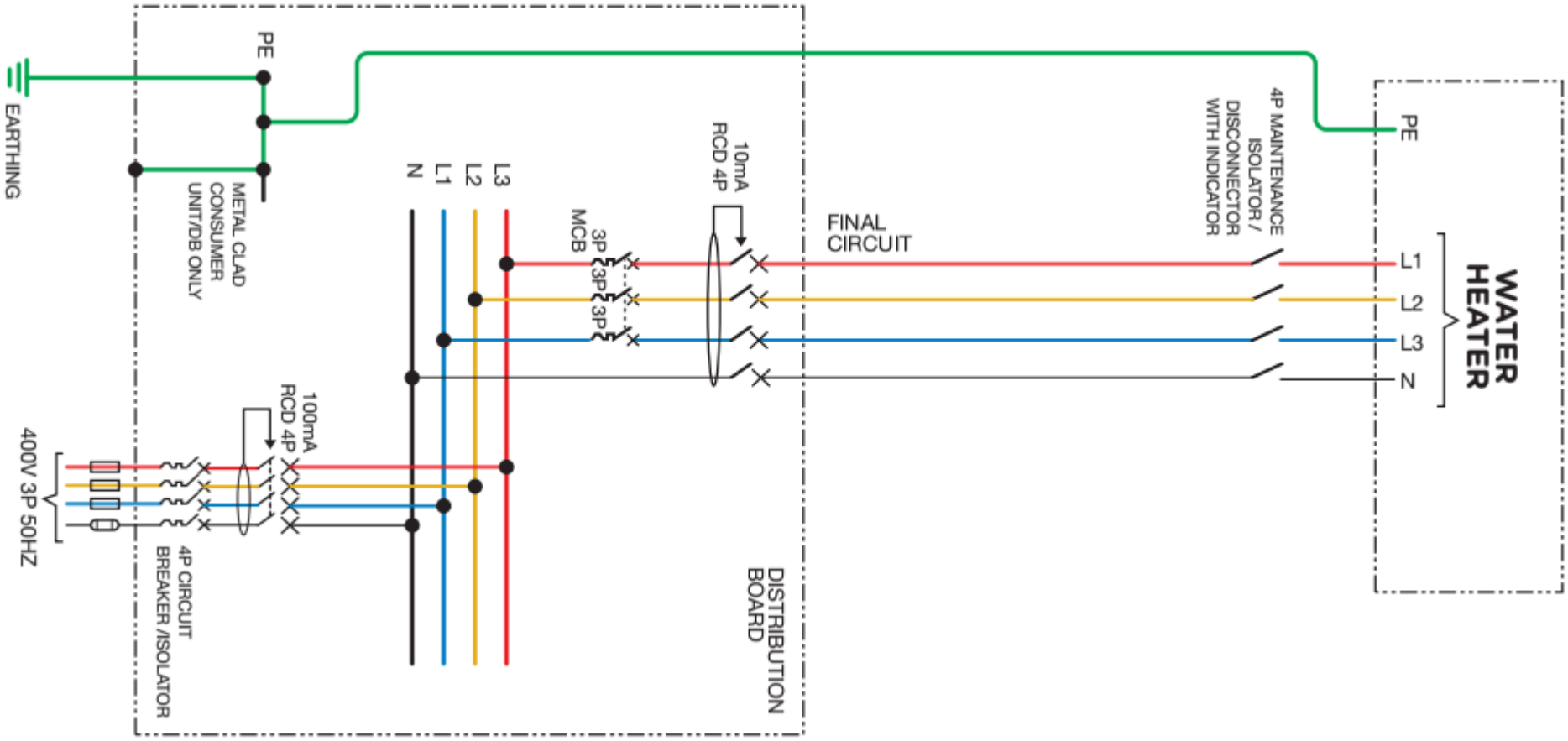


Figure 2: Example of schematic diagram for three-phase water heater.

Note: Supplementary Equipotential Bonding (SEB) shall be installed for additional protection as per Clause 701.415.2 of IEC 60364-7-701:2006, Clause 544.2 of MS IEC 60364-5-54:2004 and Annex B of MS IEC 60364-5-54:2004.

Example of Water Heater Final Circuit

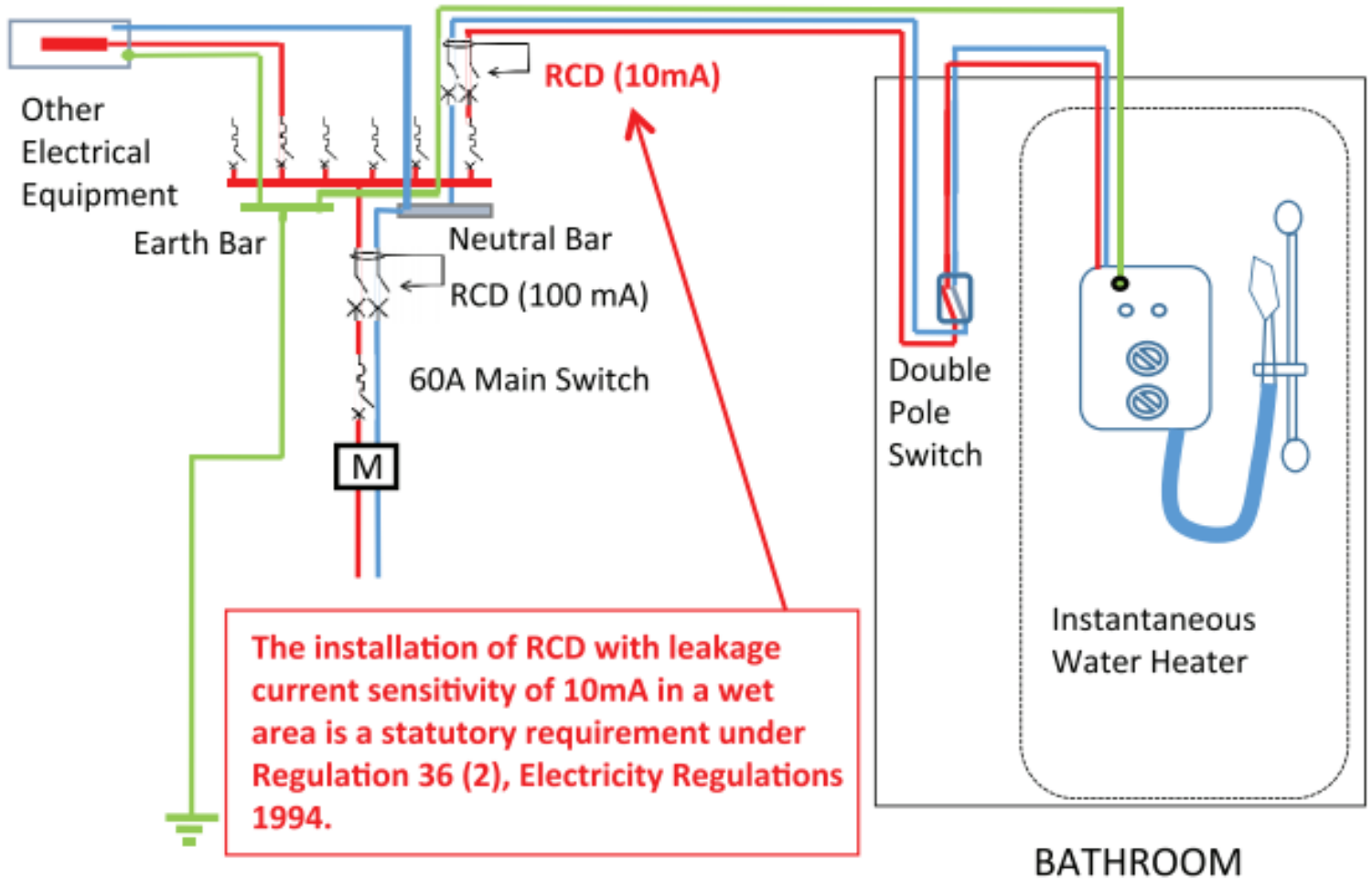


Figure 3: The installation of RCD for instantaneous water heater with leakage current sensitivity of 10mA in a wet area.

Example of Water Heater Final Circuit

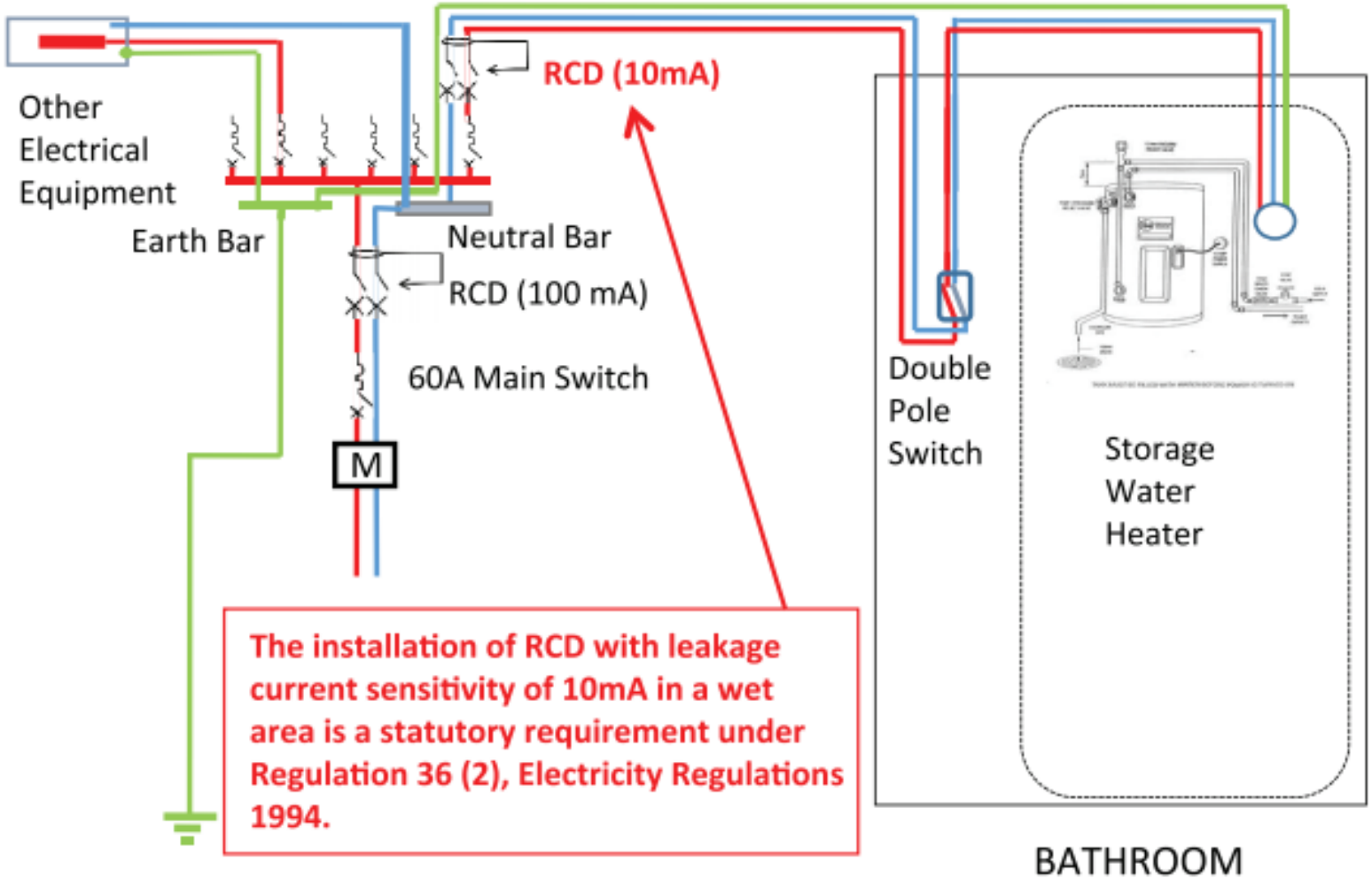


Figure 4: The installation of RCD for storage water heater with leakage current sensitivity of 10mA in a wet area.

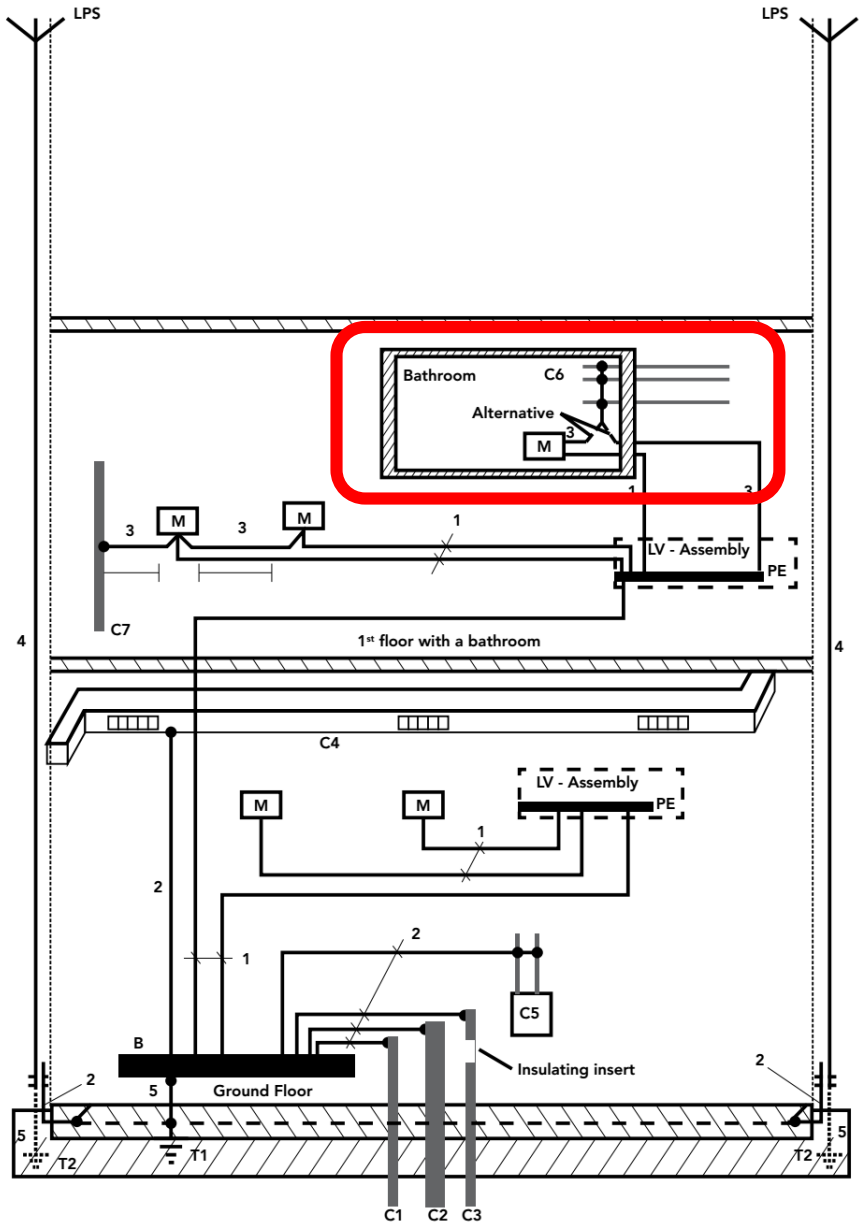
Suruhanjaya Tenaga
Energy Commission

KOD/ST/No.4/2016

NON-DOMESTIC ELECTRICAL INSTALLATION SAFETY CODE

Earthing and Protective Conductor Terms

Bath Room



Water Heater Final Circuit

4. The disconnection scheme of the MCB, RCD, isolator / disconnector, switches and protective earthing (PE) shall be per Table 5

Table 5: Disconnection scheme of MCB, RCD, Isolator / Disconnector, Switches and PE.

Type of Circuit	MCB	RCD	Isolator / Disconnector	Switches	PE
Single phase	1 pole	2 pole	2 pole	1 pole	No Break Permitted
Three phase	3 pole	4 pole	4 pole	3 pole	No Break Permitted

Water Heater Final Circuit

5. The MCB, RCD and cross sectional area of conductor shall be per Table 6 for single phase water heater final circuits

a. Only electrical grade copper conductor is permitted

Table 6: Minimum conductor sizes.

Water Heater Rating @ 230V	Load	MCB/ RCD (Minimum)	Live	Neutral	PE
≤2,856W	12.4A	16A	4 mm^2	4 mm^2	4 mm^2
>2,856W to < 3,570W	15.5A	20A	4 mm^2	4 mm^2	4 mm^2
>3,570W to < 4,462W	19.4A	25A	4 mm^2	4 mm^2	4 mm^2
>4,462W to < 5,711W	24.8A	32A	4 mm^2	4 mm^2	4 mm^2
>5,711W to < 7,139W	31A	40A	6 mm^2	6 mm^2	6 mm^2
>7,139W to < 8,924W	38.8A	50A	10 mm^2	10 mm^2	10 mm^2
For ratings of more than the above table, the cable shall be sized as per MS IEC 60364					

IEC 60364–7–701:2006: Zoning of Bath Room

1. *IEC 60364 – 7 – 701: Electrical installations of Buildings – Part 7 – 701: Requirements for Special Installations or Locations – Locations Containing a Bath or Shower;*
2. *Zone 0: Not permitted to install water heater;*
3. *Zone 1 (Spray hazard area): Any equipment installed in zone 1 shall have IP rating ≥ IPX5*

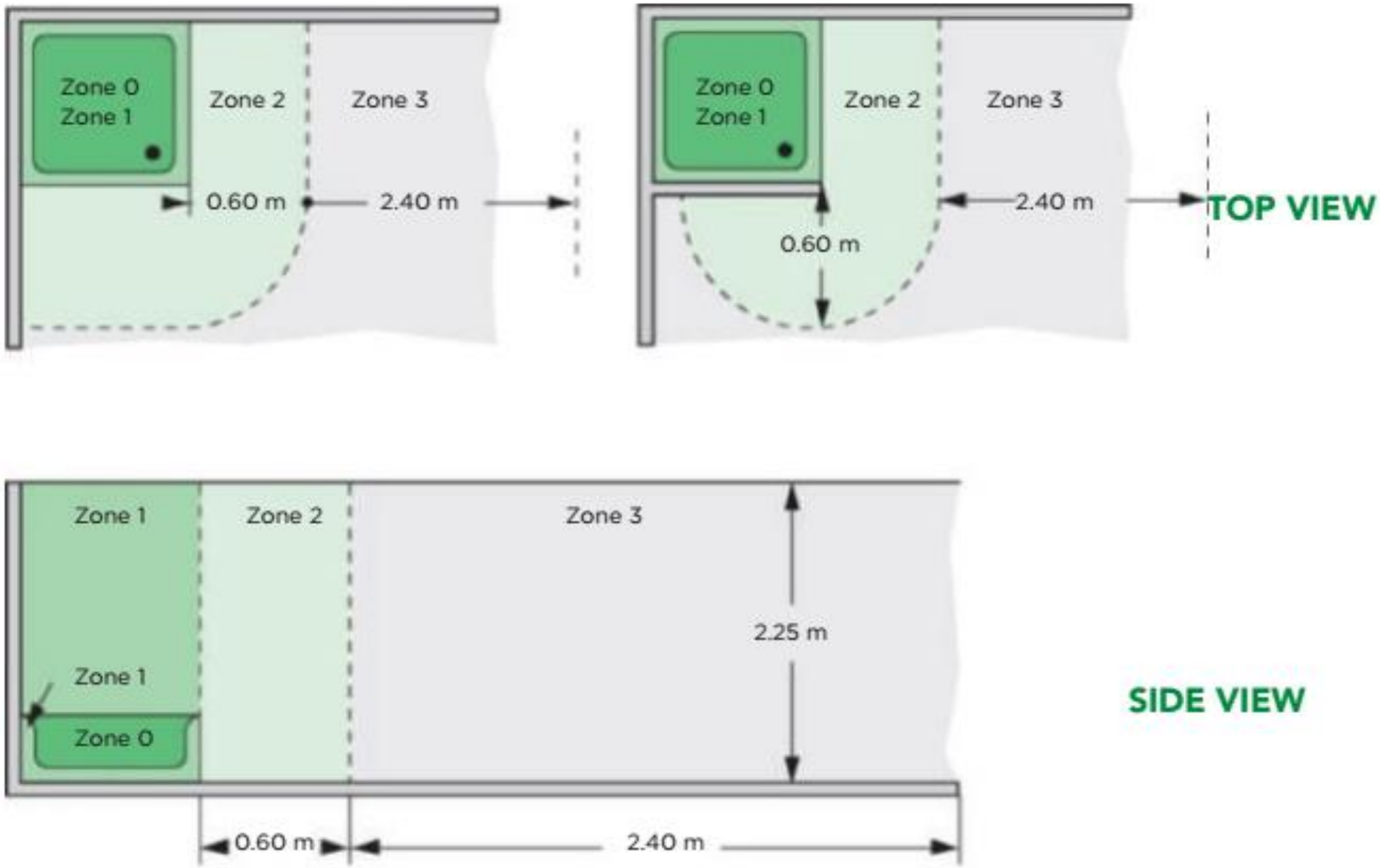
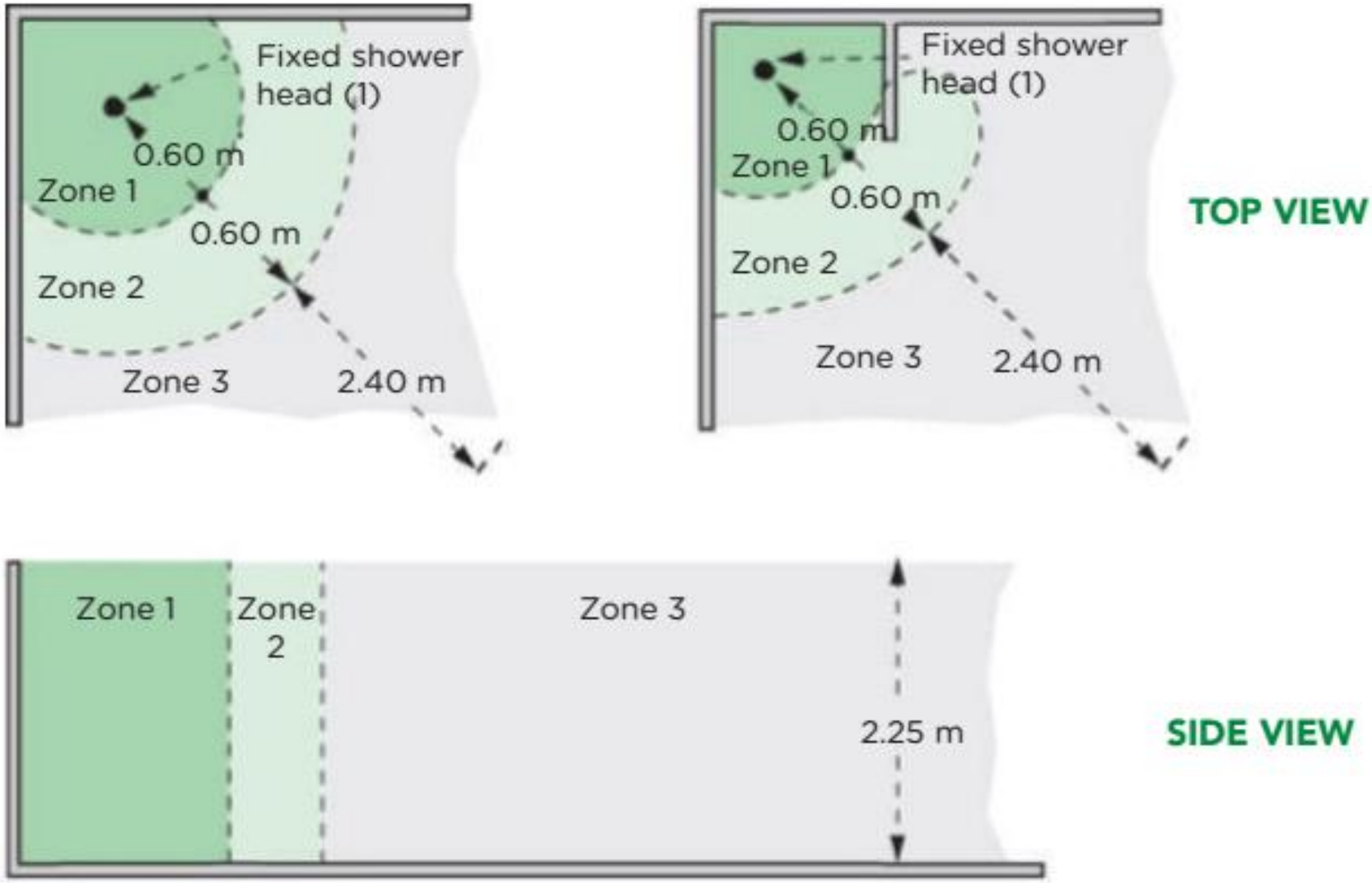


Figure 7: Zones 0, 1, 2 and 3 in proximity of a shower with basin.



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

Figure 8: Zones 0, 1, 2 and 3 in proximity of a shower without basin.

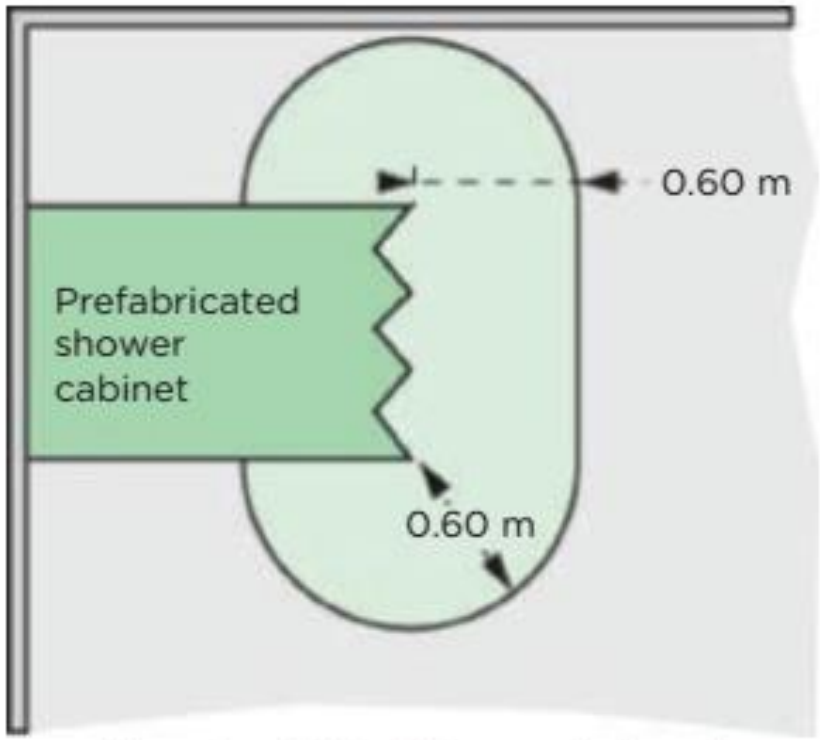
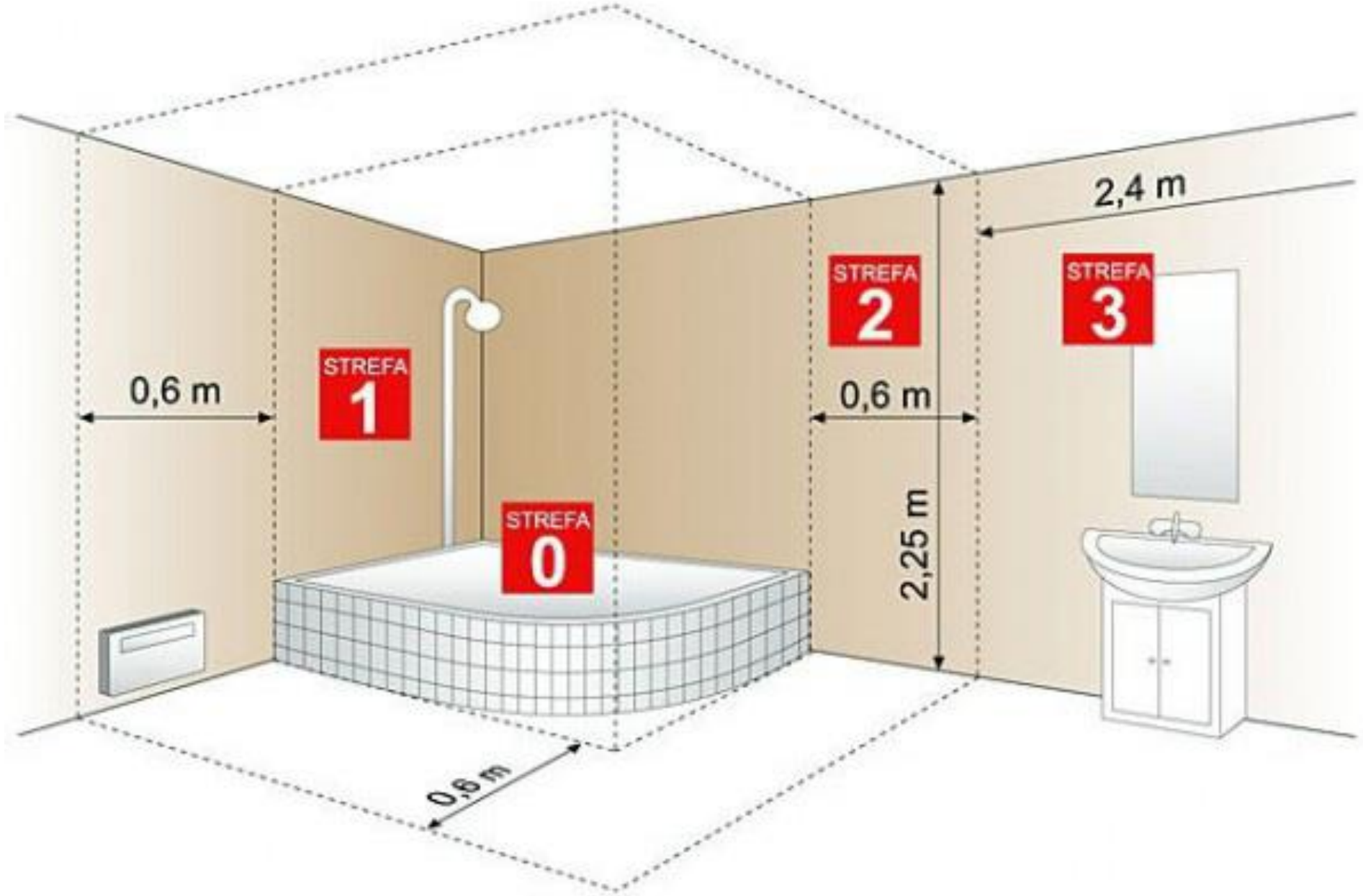
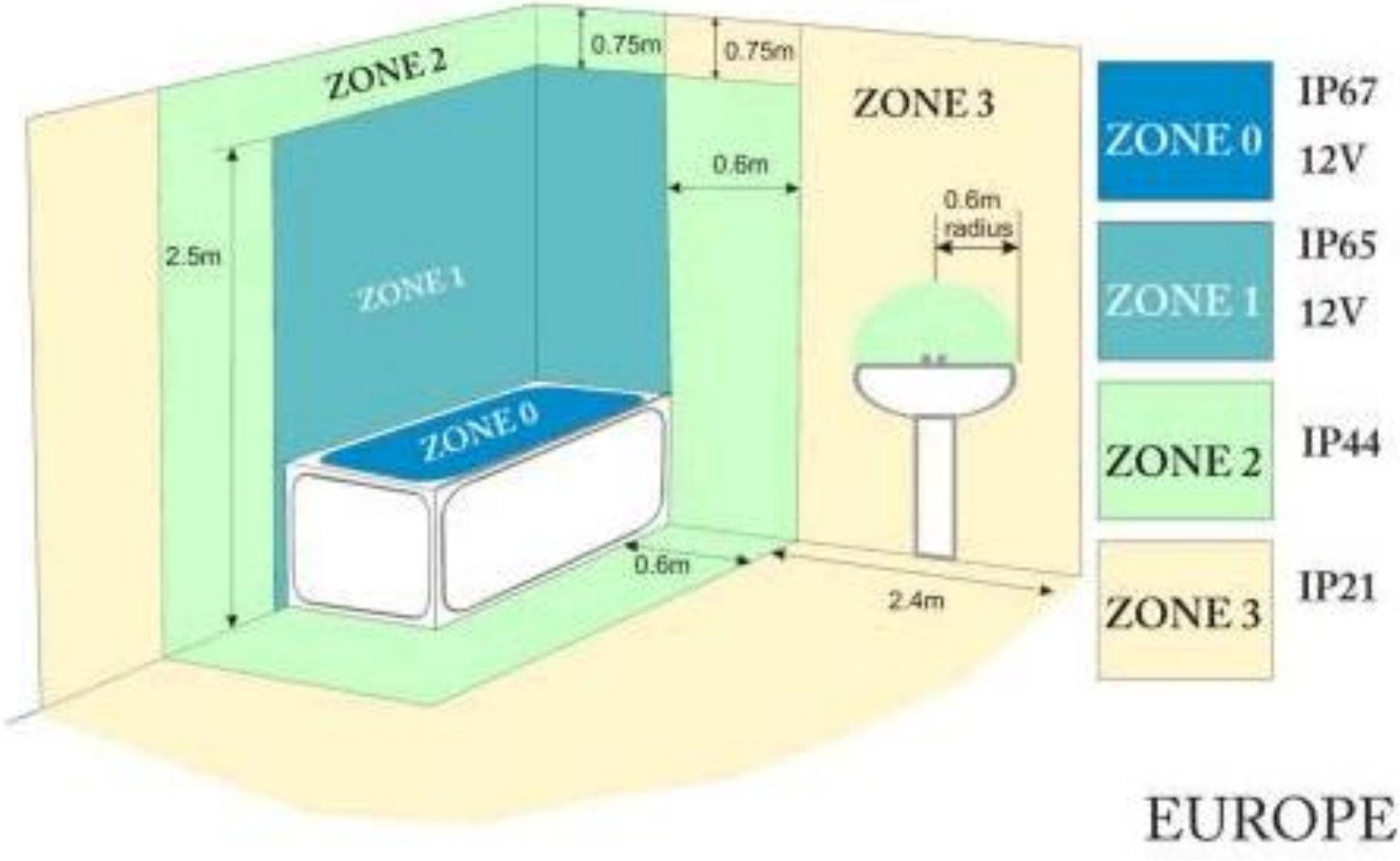
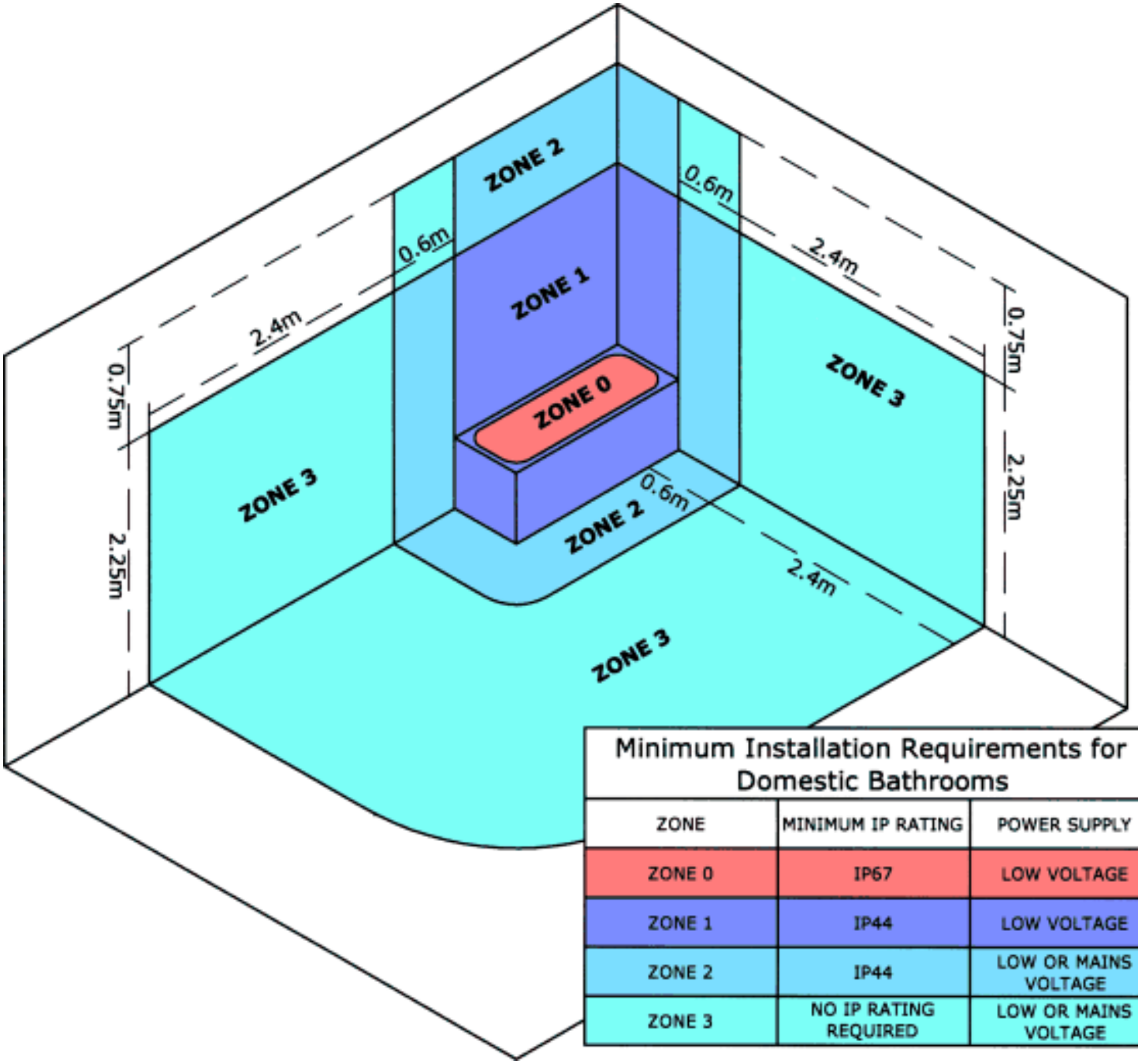


Figure 9: No switch is permitted within 60 cm of the door opening of a shower cabinet.


2,4 m
STREFA
2
STREFA
3
STREFA
1
0,6 m
0,6 m
STREFA
0
2,25 m
0,6 m


ZONE 2
0.75m
0.75m
ZONE 3
0.6m
0.6m
radius
2.5m
ZONE 1
ZONE 0
0.6m
2.4m
ZONE 0
IP67
12V
ZONE 1
IP65
12V
ZONE 2
IP44
ZONE 3
IP21
EUROPE



Minimum Installation Requirements for Domestic Bathrooms		
ZONE	MINIMUM IP RATING	POWER SUPPLY
ZONE 0	IP67	LOW VOLTAGE
ZONE 1	IP44	LOW VOLTAGE
ZONE 2	IP44	LOW OR MAINS VOLTAGE
ZONE 3	NO IP RATING REQUIRED	LOW OR MAINS VOLTAGE

End of Module

Any Questions