

# IEC 62477

## SAFETY REQUIREMENTS FOR POWER ELECTRONIC CONVERTER SYSTEMS and EQUIPMENT

Dash 1: Power electronic converters up to 1000  
V AC or 1500 V DC

Part 2: Power electronic converters from 1000  
V AC or 1500 V DC up to 36 kV AC or 54 kV DC

Presented by:  
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TC22 MT9

Event: General meeting 2019  
Date: 2019-10-20  
Location: Shanghai, China



International  
Electrotechnical  
Commission

# Personal presentation

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# Standardization activities

**2004 – 2007:** Expert of the IEC SC22G MT11 (IEC 61800-5-1)  
**Since 2012:** Convenor of IEC SC22G MT11 (IEC 61800-5-1)

**2011 – 2014:** Convenor of IEC SC22G MT9 (IEC 61800-2)

**2005 - 2011:** Expert of the IEC TC82 WG6 (IEC 62109-1 / -2)

**2006 - 2012 :** Convenor of IEC TC22 PT5 (IEC 62477-1)  
**Since 2013:** Convenor of IEC TC22 MT9 (IEC 62477-1)

**Since 2016** Chairman of SC22G

**Since 2007:** Expert of IEC TC109 MT1 and 2 (IEC 60664 series)  
**Since 2011:** Member of ACOS as TC109 representative  
**Since 2013:** Chairman of TC109

# Agenda

1. Walk through of IEC 62477-1/2 and their use for risk mitigation according to the principles of IEC guide 116.
2. The potential use of IEC 62477-1/2 in miscellaneous (future) power conversion applications.
3. The potential future AC/DC power infrastructure and benefit of IEC 62477-1/2.
4. Responsibilities according to IEC guide 104
5. Global harmonization
6. Open discussion / Questions

# IEC 62477 family

Following documents are considered in this presentation:

[IEC 62477-1:2012/AMD1:2016](#) Edition 1.1 (2016-07-28)  
[CD/IEC 62477-1 \(2019\) \(22/309/CD\)](#) (*Under maintenance by TC22MT9*)

**Safety requirements for power electronic converter systems and equipment - Part 1: General**

[IEC 62477-2:2018](#) Edition 1.0 (2018-06-21)

**Safety requirements for power electronic converter systems and equipment - Part 2: Power electronic converters from 1 000 V AC or 1 500 V DC up to 36 kV AC or 54 kV DC**

# Walk through of IEC 62477-1/2 and it's use for risk assessment according to IEC guide 116.



IEC 62477-1

Edition 1.1 2016-07

**CONSOLIDATED  
VERSION**

**VERSION  
CONSOLIDÉE**



GROUP SAFETY PUBLICATION  
PUBLICATION GROUPEE DE SÉCURITÉ

Safety requirements for power electronic converter systems and equipment –  
Part 1: General

Exigences de sécurité applicables aux systèmes et matériels électroniques de  
conversion de puissance –  
Partie 1: Généralités



IEC 62477-2

Edition 1.0 2018-06

**INTERNATIONAL  
STANDARD**

**NORME  
INTERNATIONALE**

GROUP SAFETY PUBLICATION  
PUBLICATION GROUPEE DE SÉCURITÉ

Safety requirements for power electronic converter systems and equipment –  
Part 2: Power electronic converters from 1 000 V AC or 1 500 V DC up to 36 kV  
AC or 54 kV DC



IEC GUIDE 116

Edition 2.0 2018-11

**GUIDE**

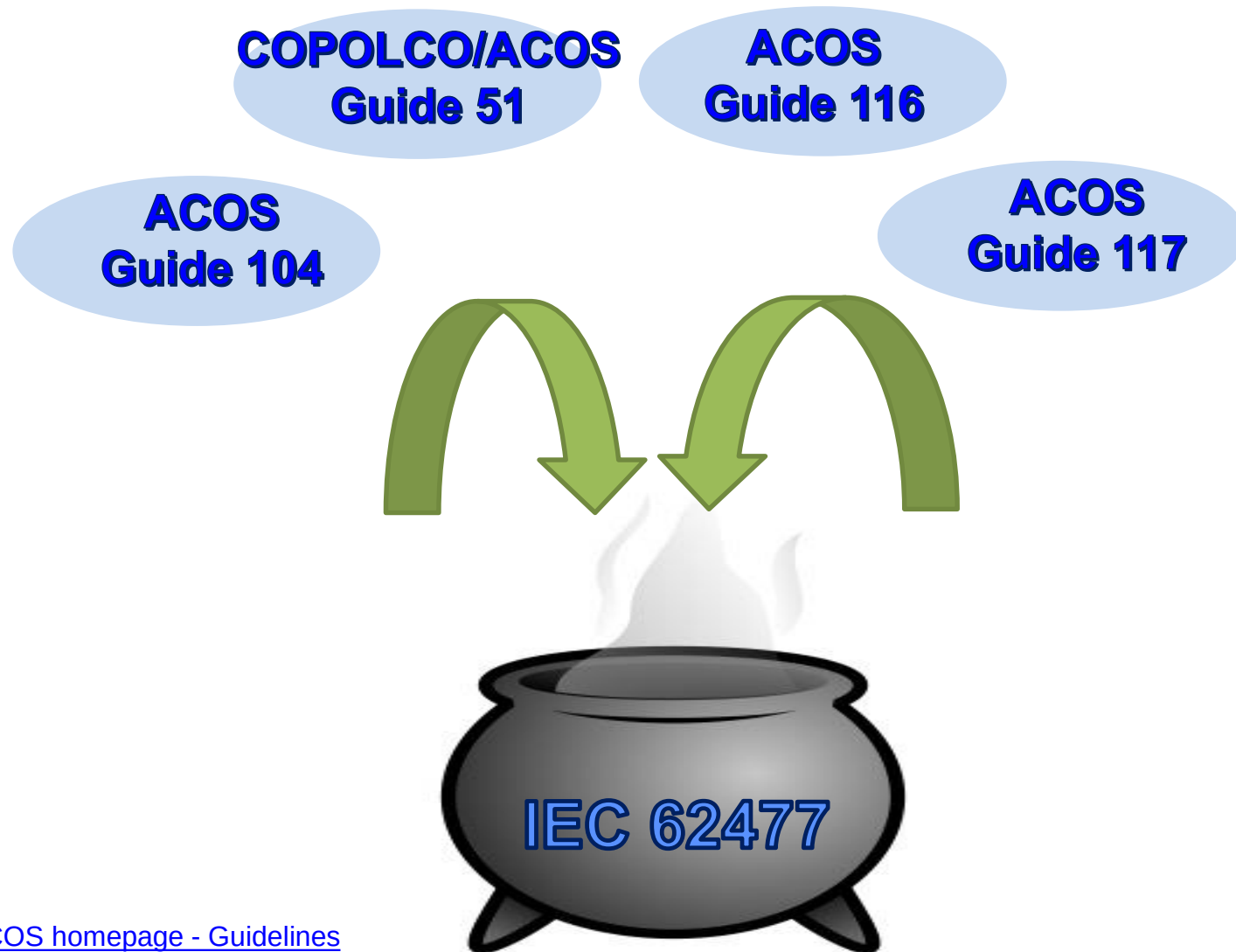


Guidelines for safety related risk assessment and risk reduction for low voltage  
equipment



# Origin of IEC 62477-1

Horizontal IEC/ISO guides considered



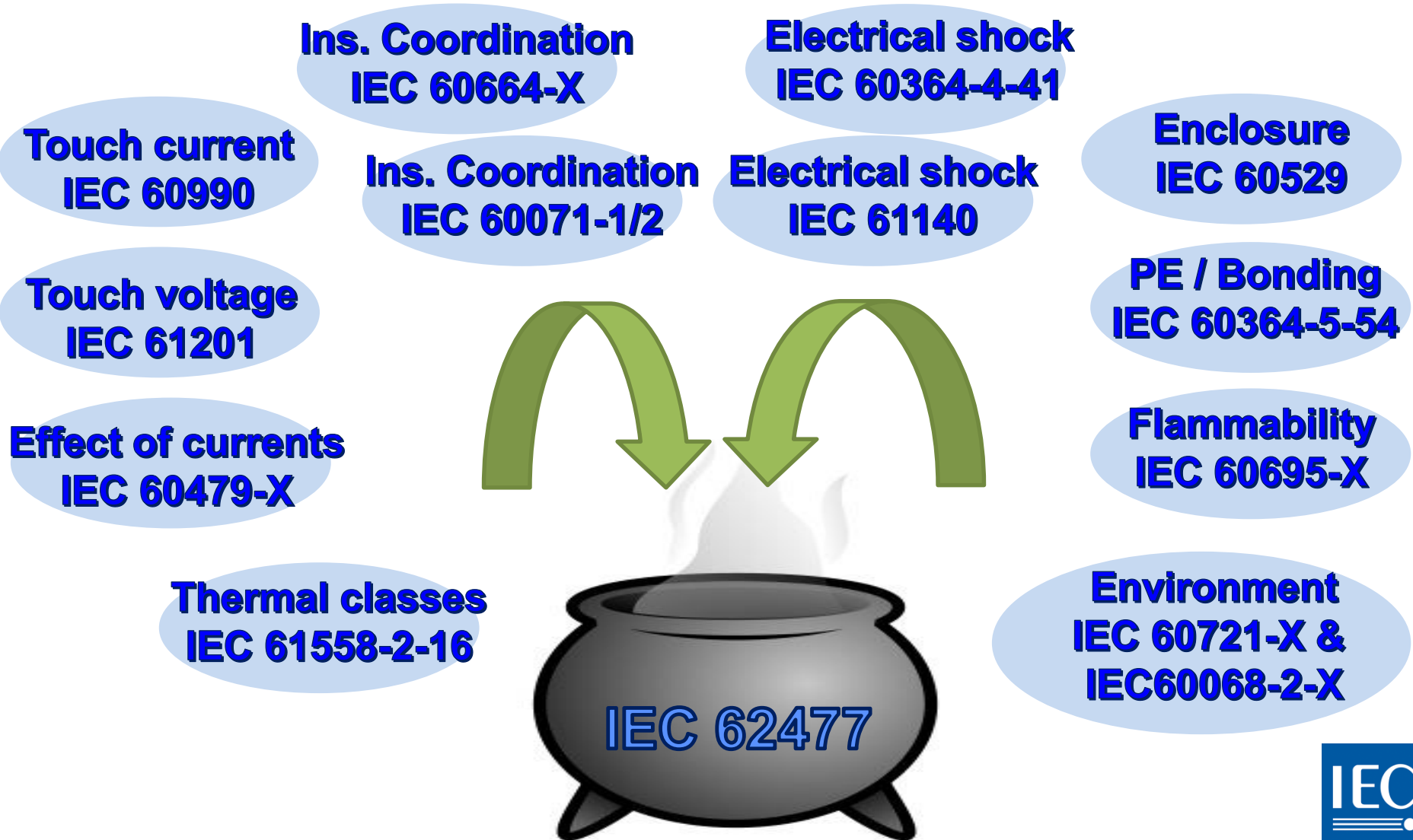
# Origin of IEC 62477-1

Horizontal standards considered



IEC 62477

Seminar October 2019



# Origin of IEC 62477-1

Power applications considered



IEC 62477

Seminar October 2019

**Fuel Cell**  
**IEC 62282-X**

**Machine**  
**IEC 60204-1**

**Switch-gear**  
**IEC 61439-1**

**Installation**  
**IEC 60364-X**

**BDM/CDM**  
**IEC 61800-5-1**

**Wind**  
**IEC 61400-X**

**IT**  
**IEC 60950-1**

**Solar**  
**IEC 62109-1**

**UPS**  
**IEC 62040-1**

**Other**  
**Renewable energy**  
**Source/storage**

**SMPS**  
**IEC 61204-7**



**IEC 62477**



# IEC guide 116

## IEC Guide 116: clause 4 - Basic principles (Abstract)

The minimum **necessary RISK reduction** is the reduction in RISK that has to be achieved to meet the **TOLERABLE RISK** for a specific situation.

The concept of necessary RISK reduction is of fundamental importance in the development of the SAFETY requirements for electrical equipment.

The purpose of determining the **TOLERABLE RISK** for a specific **HAZARDOUS EVENT** is to state what is **deemed reasonable** with respect to both components of RISK.

# IEC guide 116

## IEC guide 116 cl. 5 - Determination of the limits (abstract)

- **RISK ASSESSMENT** begins with the determination of the **limits of the LV equipment**. The limits of the LV EQUIPMENT are listed herein by grouping them in four categories.
- They serve the purpose to define the **INTENDED USE** and to consider **REASONABLY FORESEEABLE MISUSE**.

# IEC guide 116

## IEC guide 116 cl. 5 - Determination of the limits (abstract)

- a) Use limits,<sup>#</sup> (e.g. operating modes, interventions by operator, service, maintenance etc.)
- b) Space limits. (e.g. movement, space, human interaction, machine-power interface)
- c) Time limits,<sup>#</sup> (i.e. "useful lifetime")
- d) Other limits. (E.g. Environmental, housekeeping)

<sup>#</sup> including the INTENDED USE and the REASONABLY FORESEEABLE MISUSE.

# IEC guide 116

## IEC Guide 116: Clause 6 Hazard identification (Abstract)

RISK ASSESSMENT is the systematic identification of possible hazards:

- HAZARDOUS SITUATIONS and
- HAZARDOUS EVENTS

during all phases of the LV equipment life cycle.

Damage to persons and/or domestic animals or property.

Phases of the life of the electrical equipment to consider:

- a) transport;
- b) assembly and installation;
- c) commissioning;
- d) use, maintenance by the user and servicing by service personnel;
- e) de-commissioning, dismantling and disposal as far as SAFETY is concerned.

# IEC guide 116

## Essential requirement for protection against hazards

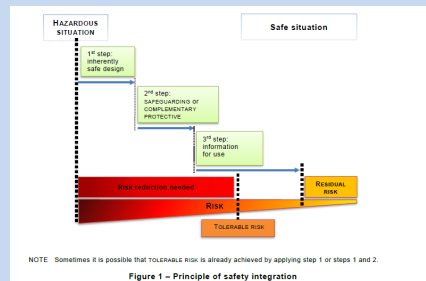
E.g.  
European  
LVD 2014/35/EU  
Annex I

AS/NZS3820  
(Essential safety  
requirements)



## Risk mitigation (IEC Guide 116)

4. Basic principles
5. Limits
  - Intended use
  - Reasonable foreseeable misuse.
  - Environment.
6. Hazard id.
7. Risk identification
8. Risk evaluation
9. Risk reduction

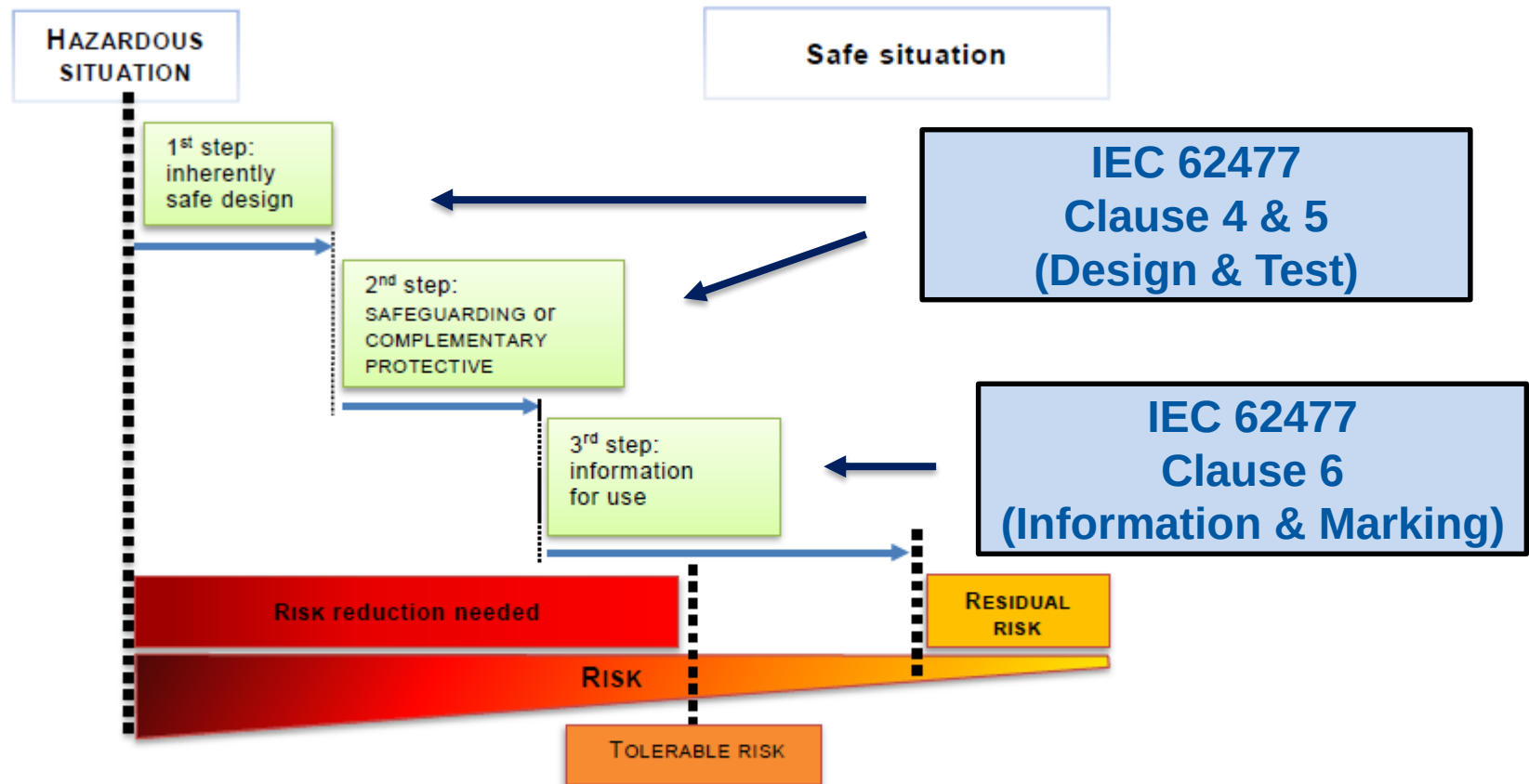


## Relevant hazards (Guide 116 - Annex D)

### Relevant hazards e.g:

- A.4 Electrical
- A.5 Mechanical
- A.6.3 EMF
- A.6.6 Fire
- A.6.7 Temperature
- A.6.8 Acoustic Noise
- A.6.11 Unattended operation
- A.6.12 Connection to and interruption from power supply
- A.9 Information

# IEC guide 116 vs. IEC 62477



NOTE Sometimes it is possible that TOLERABLE RISK is already achieved by applying step 1 or steps 1 and 2.

Figure 1 – Principle of safety integration

# Guide 116

(Safety related risk assessment and risk reduction)

- Intended use
- Reasonable foreseeable misuse
- Limits

## Annex D

### Relevant hazards E.g:

- A.4 Electrical
- A.5 Mechanical
- A.6.3 EMF
- A.6.6 Fire
- A.6.7 Temperature
- A.6.8 Acoustic Noise
- A.6.11 Unattended operation
- A.6.12 Connection to and interruption from power supply
- A.9 Information



# IEC 62477-1

## 4. Protection against hazards

- 4.1 General
- 4.2 **Fault and abnormal** operating conditions
- 4.3 **Short circuit and overload** protection
- 4.4 Protection against **electric shock**
- 4.5 Protection against **electrical energy** hazards
- 4.6 Protection against **fire and thermal** hazards
- 4.7 Protection against **mechanical** hazards
- 4.8 Equipment with **multiple sources** of supply
- 4.9 Protection against **environmental stresses**
- 4.10 Protection against **sonic pressure** hazards
- 4.11 Wiring and connections
- 4.12 Enclosures
- 4.13 Components
- 4.14 Protection against elec

## 5. Test

## 6. Information and marking

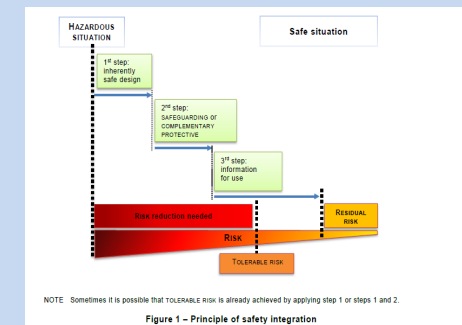
- 6.2 Information for **selection**
- 6.3 Information for **installation** and **commissioning**
- 6.4 Information for **use**
- 6.5 Information for **maintenance**

**Awareness  
of type of  
hazard and  
risk**

# IEC guide 116 vs. IEC 62477

## Benefit of the IEC 62477 series:

- Developed in order to **support the concept of IEC guide 116** and Cenelec guide 32 for CE marking.
- Well-balanced between **risk evaluation and deterministic measure** using concepts from basic and group safety publications.
- Risk mitigation of relevant hazards by the **3 step process** from IEC guide 116.
- **TC22 collaborative** approach to adopt new measures for risk mitigation for specific power electronic applications.  
(According to Guide 104)



# LVD/35/EU, IEC guide 116 vs. IEC 62477

29.3.2014

EN

Official Journal of the European Union

L 96/357

## DIRECTIVE 2014/35/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

of 26 February 2014

on the harmonisation of the laws of the Member States relating to the making available on the market of electrical equipment designed for use within certain voltage limits

### Article 3

#### Making available on the market and safety objectives

Electrical equipment may be made available on the Union market only if, having been constructed in accordance with good engineering practice in safety matters in force in the Union, it does not endanger the health and safety of persons and domestic animals, or property, when properly installed and maintained and used in applications for which it was made.

The principal elements of the safety objectives are listed in Annex I.

#### **Short form:**

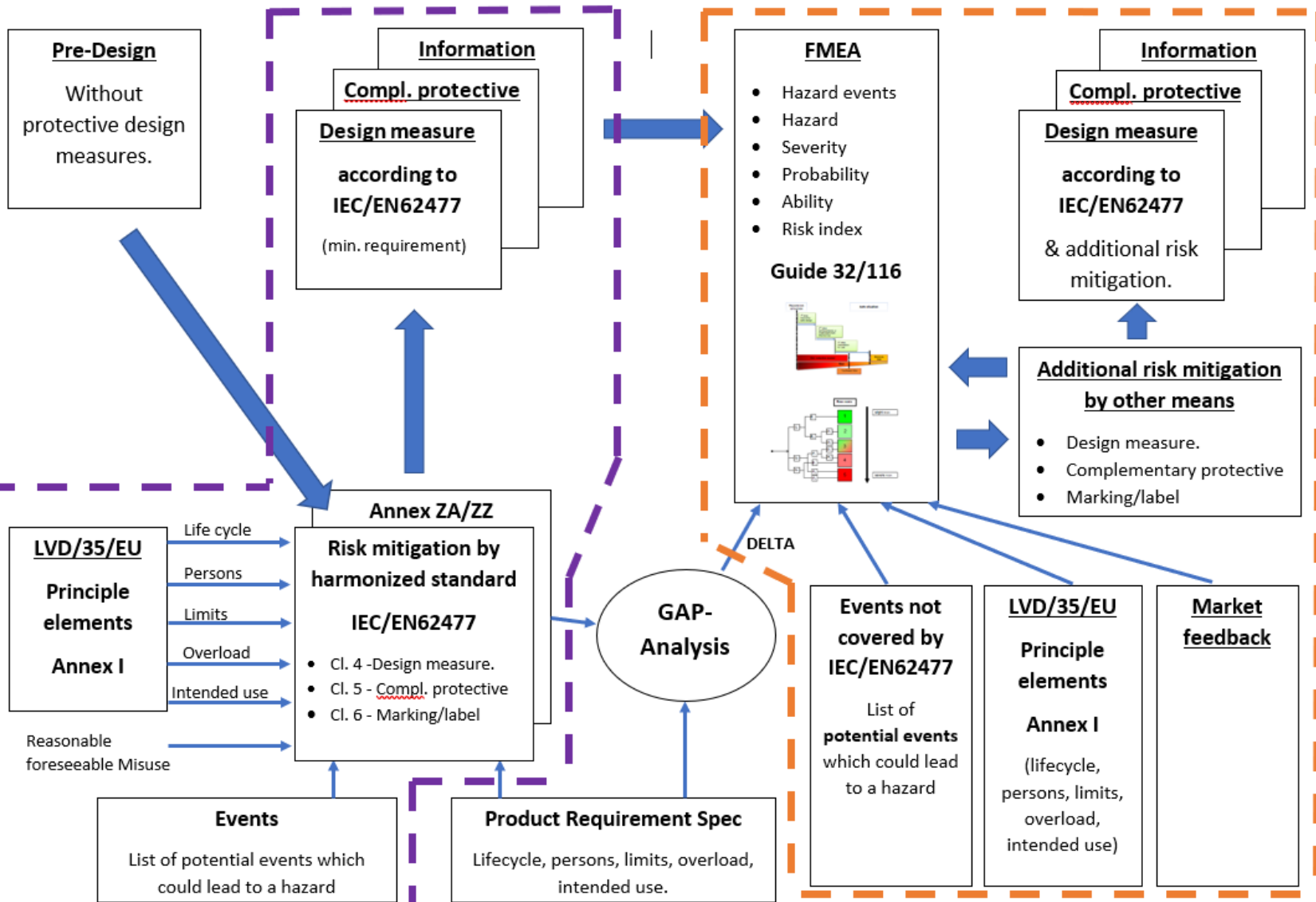
LVD/35/EU require full coverage considering all relevant risks and hazards.

Compliance with harmonized std. might not be sufficient if the standard does not cover all relevant hazards.

# LVD/35/EU, IEC guide 116 vs. IEC 62477

## Risk and hazard assessment step 1

## Risk and hazard assessment step 2



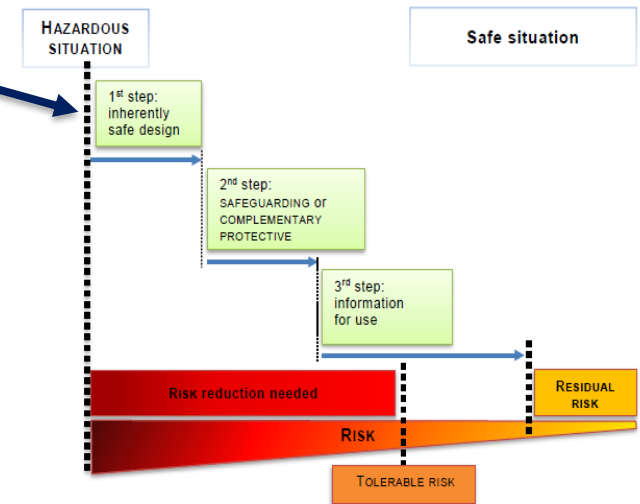
# Clause 4 - Protection against hazards

## Overall purpose of clause 4:

Cl. 4.1: Definition of the **fundamental frame** of the hazard evaluation.

Cl. 4.2: **Risk evaluation** considering single fault / abnormal conditions.

Cl. 4.3-4.14: **Design requirement**, mainly deterministic considering horizontal and group safety publication for risk mitigation.



NOTE Sometimes it is possible that TOLERABLE RISK is already achieved by applying step 1 or steps 1 and 2.

Figure 1 – Principle of safety integration

# Clause 4.1 - General

## Frame of the fundamental concept of hazard evaluation

### Lifetime, intended use & foreseeable misuse (4.1)

- Intended use
- Reasonably foreseeable misuse
- Normal, abnormal and single fault conditions
- Hazardous events
- Expected lifetime
- Life cycle (Installation, normal operating conditions, commissioning and maintenance)
- Competence (ordinary <> skilled persons)

### Limits (4.9 & 4.4.7):

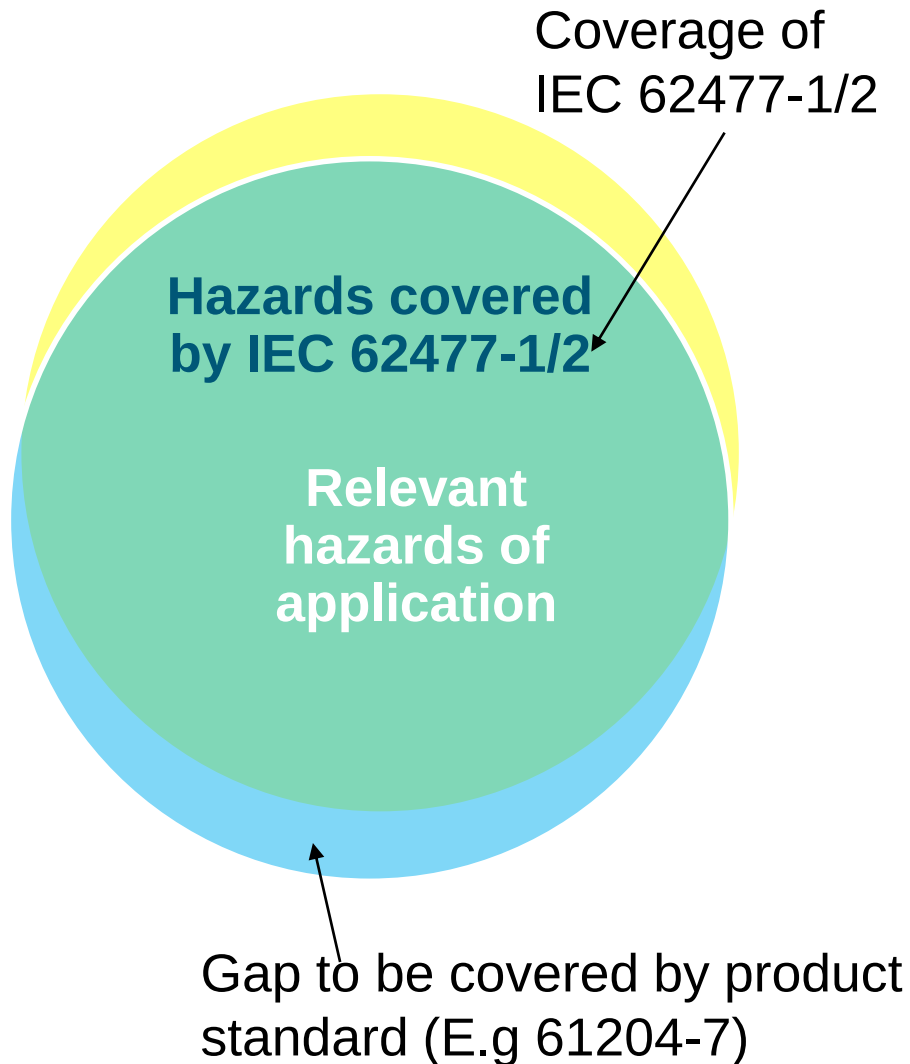
- Climatic and mechanical conditions (4.9)
- Electrical characteristics and micro environment (4.4.7)

## Clause 4.1 - General

Manufacturers and product committees using this standard as a reference document shall clearly specify what is contained in the *PECS*, covered by and evaluated according to this standard.

This shall as a minimum cover the *PEC* including the load interface and supply interface.

# Clause 4.1 - General



Further considerations to be made by TC's using the IEC 62477-1 in their application to cover gaps considering relevant hazards.



# Clause 4.2 – Fault and abnormal conditions

## Evaluate single fault / abnormal conditions (4.2):

- Circuits
- Component
- Insulation systems
- Ports



## Define:

- Lifetime, intended use and foreseeable misuse (4.1)
- Limits (4.9, 4.4.7)



## Evaluate potential impact on:

- EM-force & thermal hazards  
Decisive voltages
- Electric shock hazard
- Energy hazard
- Fire and thermal hazard
- Mechanical hazard
- EMF hazards
- Arc fault hazard (4.100) (part 2)
- Other hazards



## Consider:

**Inherent design and compl. safety measure**  
according to cl. 4.3 – 4.14

**Compliance test**  
according to cl. 5.2.1 – 5.2.9

**Information and marking**  
according to cl. 6.2. – 6.5

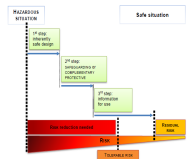


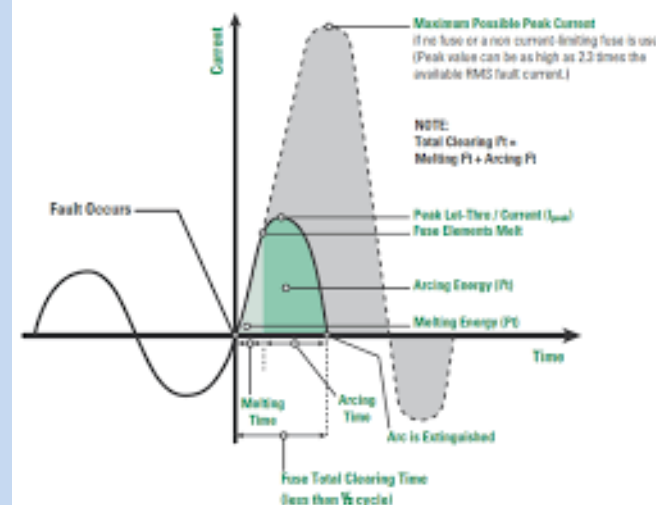
Figure 1 – Principle of safety integration

# Clause 4.3 – Short circuit and overload

## Two options:

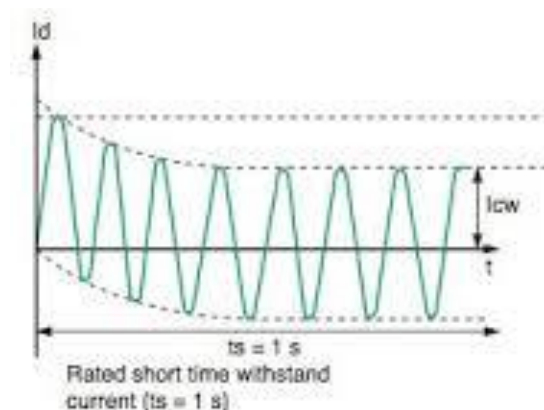
### Conditional short circuit rating: ( $I_{CC}$ ) (Opt. 1)

- conditional short-circuit current ( $I_{CC}$ ),
- characteristics of the short-circuit protective device, and
- maximum permitted prospective short-circuit current.
- minimum required prospective short-circuit current ( $I_{CP,MR}$ ).



### Short time withstand current ( $I_{CW}$ ) (Opt. 2)

- rated short time withstand current ( $I_{CW}$ ),
- associated (permitted) duration and
- rated (permitted) peak withstand current ( $I_{PK}$ ).



# Clause 4.3 – Short circuit and overload

## Output short circuit ability

Considering short circuit and over current contribution to open down stream protective devices.

Output side of PECS

Amperes and time.

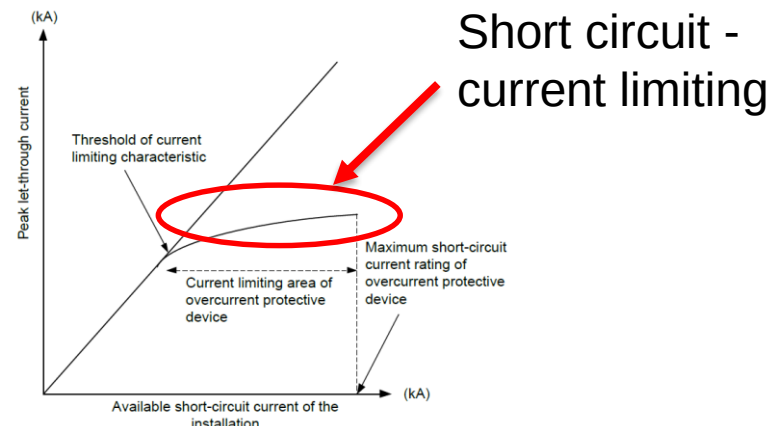


Figure N.3 – Example of tripping characteristic of a current-limiting fuse

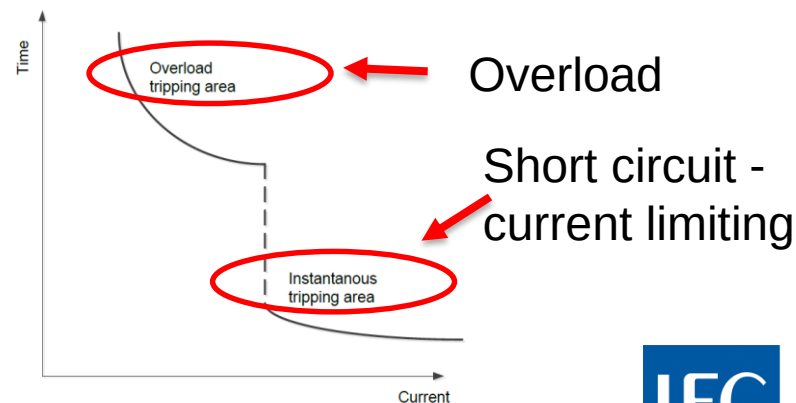


Figure N.2 – Example of tripping characteristic of a circuit breaker

# Clause 4.4 – Protection against electrical shock

## Fundamental concept of IEC 61140 (2016) (4.4.1 – 4.4.6)

### Safe to touch voltage - DVC As (4.4.2):

- Env. Condition (Dry / Wet)
- Body contact (finger, hand, body)
- Max. Voltage (RMS/Peak/DC)
- Impulse withstand voltage
- Normal / single fault condition.
- Protection requirement

### Desisive voltage classification DVC B and C (4.4.2):

- Max. voltage (RMS/Peak/DC)
- Impulse withstand voltage
- Temporary Over Voltage
- Protection requirement

### Protection measures:

- Basic protection 4.4.3
- Fault protection 4.4.4
- Enhanced protection 4.4.5



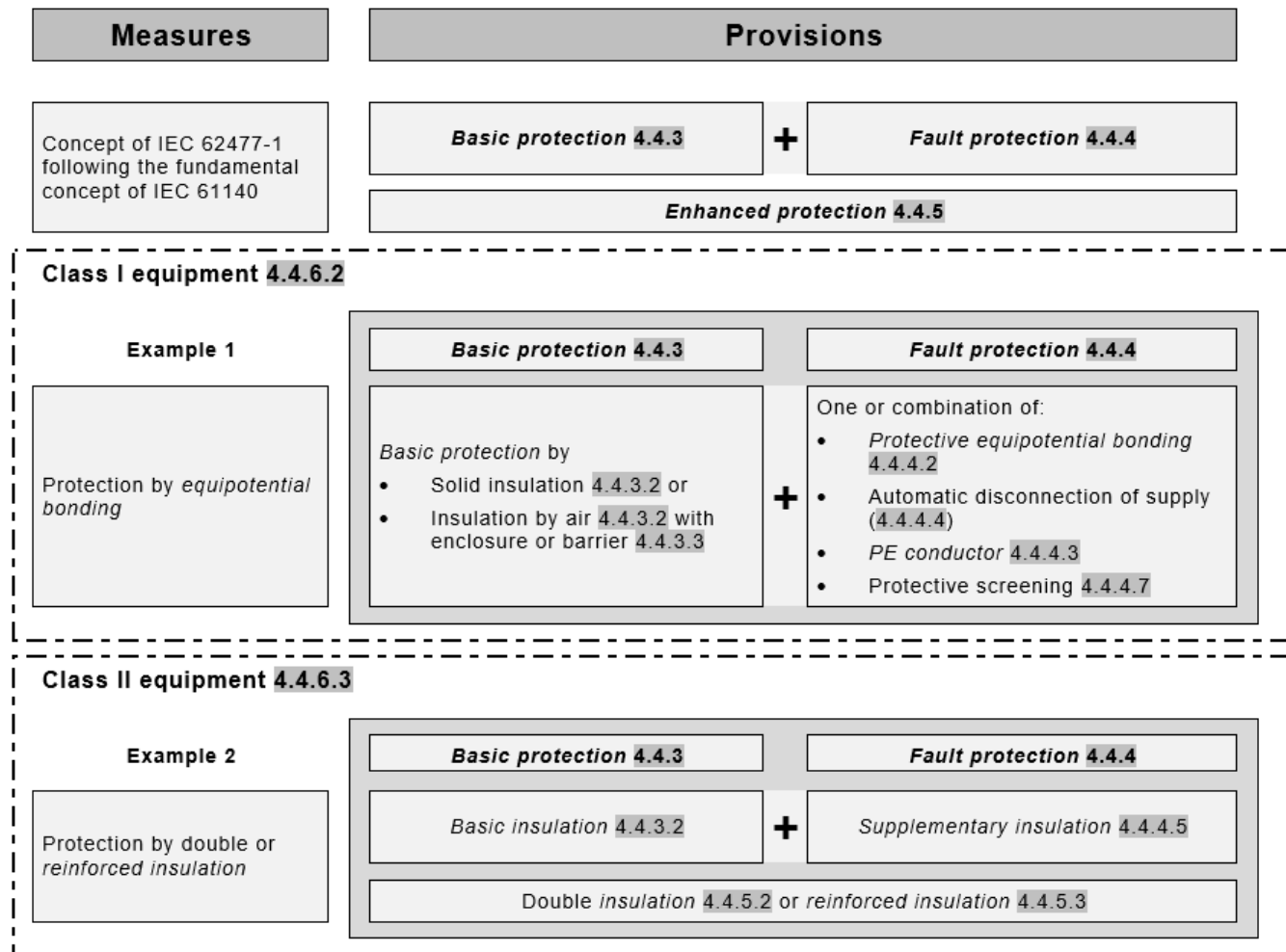
### Equipment types 4.4.6:

- Class I
- Class II
- Class III



# Clause 4.4 – Protection against electrical shock

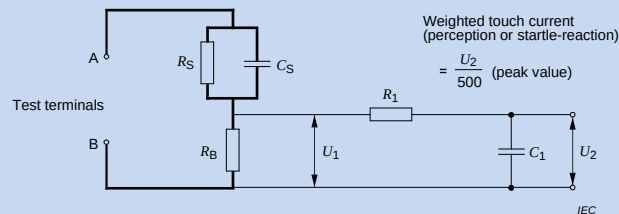
## Fundamental concept of IEC 62477 (Based on IEC 61140) (4.4.1 – 4.4.6)



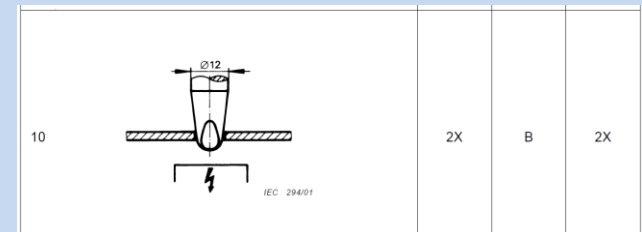
# Clause 4.4 – Protection against electrical shock

## Other horizontal concepts considered (4.4.1 – 4.4.6)

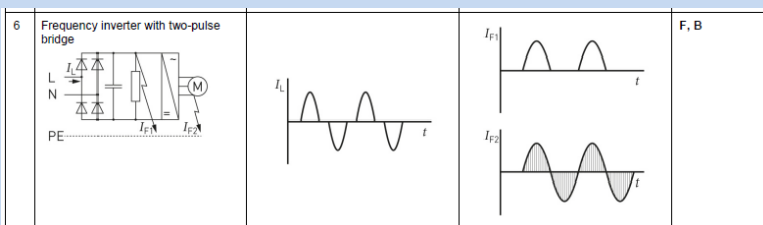
### IEC 60990 / IEC 61140: Touch / leakage current:



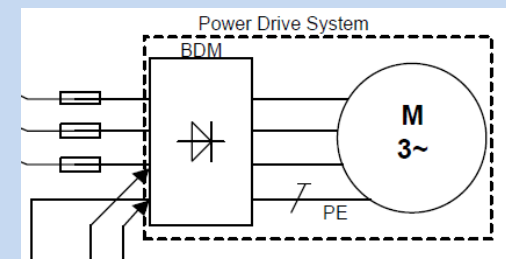
### IEC 60529 (1989) + A1 + A2 Protection against access (IP)



### IEC 60755 (2017): RCD vs. PECS compatibility



### IEC 60364-4-41(2005), A1 (2017) Automatic disconnect



# Clause 4.4 – Protection against electrical shock

## Fundamental concept of IEC 60664-1 (2007) & 60071-1 (2011) (cl. 4.4.7.1 – Insulation - General)

### Environmental conditions:

- pollution degree (1, 2, 3)
- over voltage category (I to IV)
- altitude (> 2000 m sea level)

### Voltage considerations:

- system voltage
- impulse withstand voltage
- temporary overvoltage
- working voltage (RMS / DC)
- recurring peak voltage
- frequency until 30kHz

### Grid configuration:

- supply system earthing (TN, TT, IT, Delta)
- mains / non-mains supply (e.g DC-supplies)

### Mechanical / physical aspects:

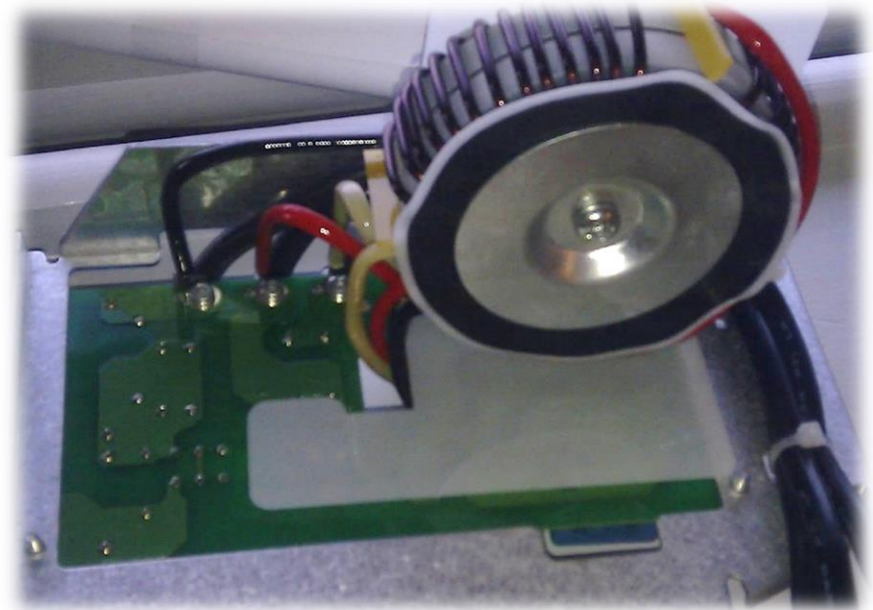
- location and type of insulation
- material characteristics (CTI, PWB)
- field homogeneity

# Clause 4.4 – Protection against electrical shock

**Fundamental concept of IEC 60664-series  
(cl. 4.4.7 – Insulation – clearance, creepage and solid insulation )**

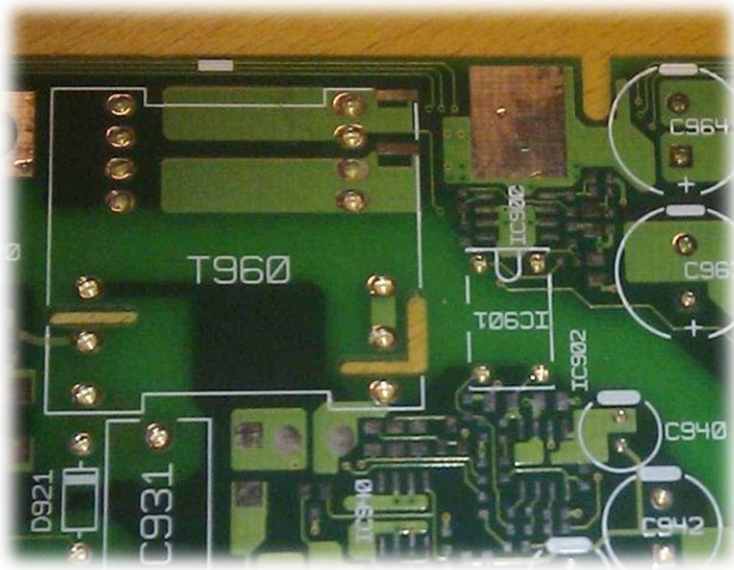
## IEC 60664-1 (2007)

- **Clearance (4.4.7.4)**
  - Homogeneity
  - altitude
- **Creepage distances (4.4.7.5)**
  - PWB
  - Other materials
- **Solid insulation (4.4.7.8)**
  - sheet materials
  - Thin sheet materials
  - PWB



# Clause 4.4 – Protection against electrical shock

**Fundamental concept of IEC 60664-series  
(cl. 4.4.7 – Insulation – clearance, creepage and solid insulation )**



## **IEC 60664-4 (2005)**

- Frequency > 30kHz (4.4.7.4.3)

## **IEC 60664-3 (2016)**

- Coating and potting (4.4.7.6)

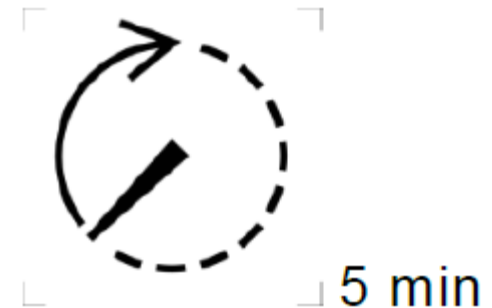
# Cl. 4.5 – Protection against elec. energy hazards

## Operator access areas:

- 2V
- and
- 20J or
  - Limited power source

## Service access areas:

- Stored capacitors 20J
- 5s
- Warning (discharge time)



# Cl. 4.6 – Protection against fire and thermal hazards

## Fundamental concept of fire mitigation

### Fire mitigation measures:

#### Components:

- Maximum temperature (Normal/single fault)
- Flammability (Class VX)

#### Circuits:

- Limited energy level

#### Enclosure:

- Flamability (5VA)
- Openings (top/bottom/side)
- Doors and covers construction

#### Final application for risk mitigation:

- Non-combustable materials
- Final application enclosure



# Cl. 4.6 – Protection against fire and thermal hazards

## Fundamental concept of thermal consideration

### Temperature limits:

Components e.g.:

- Inductive parts - Insulation systems (IEC 61558-2-16)
- Wires, busbars and terminals
- Power modules
- Capacitors
- Printed wiring board

### Hot surface:

Accessible parts temperature IEC guide 117:

- Temperature limits
- Materials (Thermal conductivity)
- Time of accessibility

Mounting surfaces temperature



# Cl. 4.7 – Protection against mechanical hazard

## Fundamental concept of mechanical protection

### General:

- shall not release sufficient energy to lead to a hazard,
- E.g expulsion of material into an area occupied by personnel.

### Design requirement:

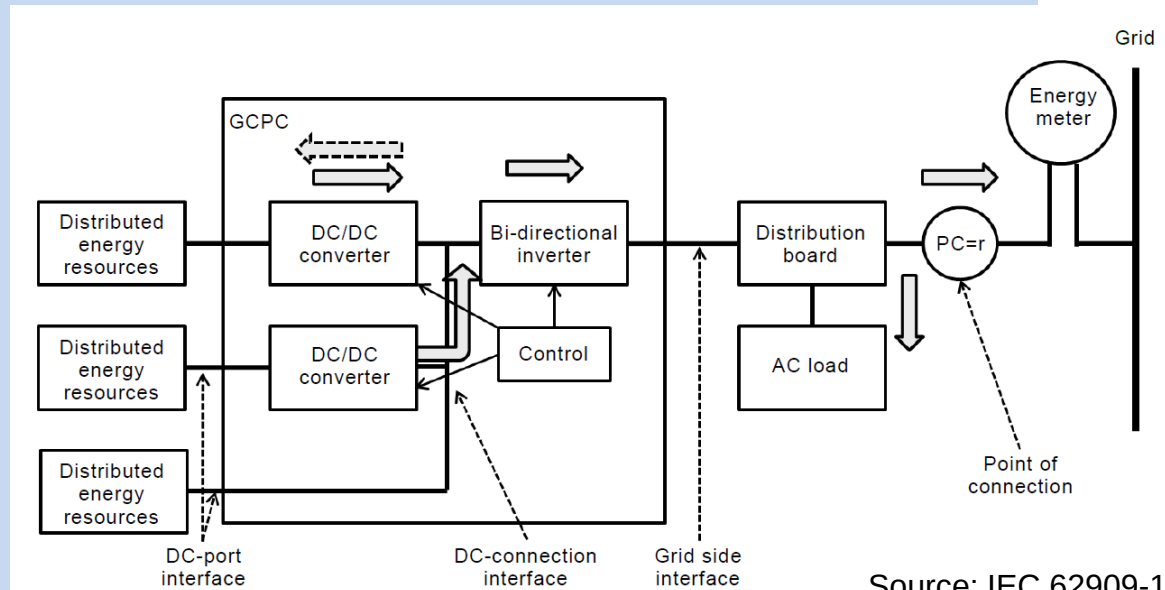
- Liquid cooling:
  - Risk evaluation according to 4.2
- **News in CD2 62477-1**
  - Rotating parts – IP2X protection
  - Expelled parts
  - Sharp edges

# Cl. 4.8 – Multiple source of supply

## Multiple supply consideration

### Risk evaluation according to 4.2 considering:

- Connections for different circuits
- Supply plugs – interchangeable
- Any other hazards
- Back feed
- Islanding
- Touch current
- Wire damage due to high over current



Source: IEC 62909-1

## Cl. 4.9 – Protection against environmental stresses

### Environmental stress consideration (Environmental limits of the PECS)

#### General:

Suitable environmental conditions for service, operation, storage and transportation.

#### Environmental service conditions:

- Indoor conditioned
- Indoor unconditioned
- Outdoor unconditioned



## Cl. 4.9 – Protection against environmental stresses

### Environmental stress consideration (Environmental limits of the PECS)

#### Design requirement:

- Coolant temperature (min/max)
- Ambient temperature (min/max)
- Humidity (Steady state / condensing)
- Pollution degree
- Mechanical (Vibration)
- Chemical active substances (salt)
- Mechanically active substances (dust & sand)
- Biological (Mould/fungus/rodents/termites)
- UV resistance
- Over Voltage Category
- Altitude (Thermal)
- Altitude (insulation coordination)

Environmental  
limits to be defined  
by manufacturer.

## Cl. 4.10 – Protection against sonic pressure hazards

**Does sound pressure  
exceeds 70 dBA (hazardous  
level)**



**Documentation shall  
provide information**



## Cl. 4.11 – Wiring and connection

### Wiring and connection consideration

#### General (cl. 4.11.1):

- Protection from mechanical damage during *installation* and use.
- suitable for the electrical, mechanical, thermal and environmental conditions of use.

#### Design requirement:

- Insulation of conductor
- Stranded wire
- Routing and clamping
- Identification of conductors and terminals
- Splices and connections
- Accessible connections
- Interconnections
- Supply connections
- Terminals
- Provisions for shield connection

## Cl. 4.12 – Enclosure

### Enclosure consideration

#### General (cl. 4.12.1):

- suitable for use in their intended environments.
- adequate mechanical strength
- no hazard occurs when subjected to such handling as may be expected.
- deflect parts which might become loose, separated or thrown from a moving part (single fault)

#### Design requirement:

- Handles and manual controls
- Cast metal
- Sheet metal
- Stability requirement for enclosure
- Strain relief
- Polymeric enclosure stress relief
- Internal condensation or accumulation of water
- Polymeric enclosure UV resistance

# Cl. 4.13 – Components

## Component consideration

### General (cl. 4.13.1):

- used within their specified ratings during normal operating conditions
- suitable for the environmental and electrical conditions

### Two options:

- a) comply with it's relevant ***component* safety standard**, or
- b) when no relevant *component* safety standard exists, the component shall be subjected to all the **applicable design requirement of this standard**.

### Specific design requirement:

- PTC thermistors
- Mains supply cords
- Components bridging insulation (basic, supplementary or enhanced) e.g. Capacitors, RC units and EMC filter
- Wound components
- Plug and socket-outlets

# Cl. 4.14 – Protection against EM-fields

## EMF consideration (new in 2nd edition)

### General:

- protect persons against electromagnetic fields.
- exposure of EMF has to be limited by
  - the *PECS* itself or
  - with external measure

### Annex Q (informative):

#### Q.1 General

(source: World Health Organisation)

#### Q.2 Requirements against exposure of EMF from ICNIRP:2010.

- general public exposure
- occupational exposure
- transportation and storage

#### Q.3 Protection of persons against exposure of EMF

- general public access areas
- general, service and restricted access areas
- distance/ time limitation



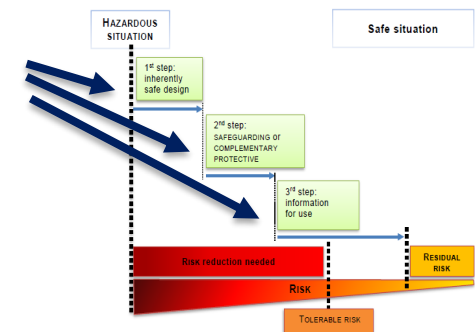
# Cl. 4.100 – Arc flash (IEC 62477-2 Annex AA)

## Arc flash consideration

### General consideration with impact on solution:

- Accessibility types (10 types)
- Competence of persons in proximity of PECS
- Product property
- Design measure for arc mitigation.
- External protective measures.
- Information and marking

Balance between "Design", "Protective measure" and "Information and marking" depends on the competence of the persons in proximity of the product. (General public, instructed persons or competent person)

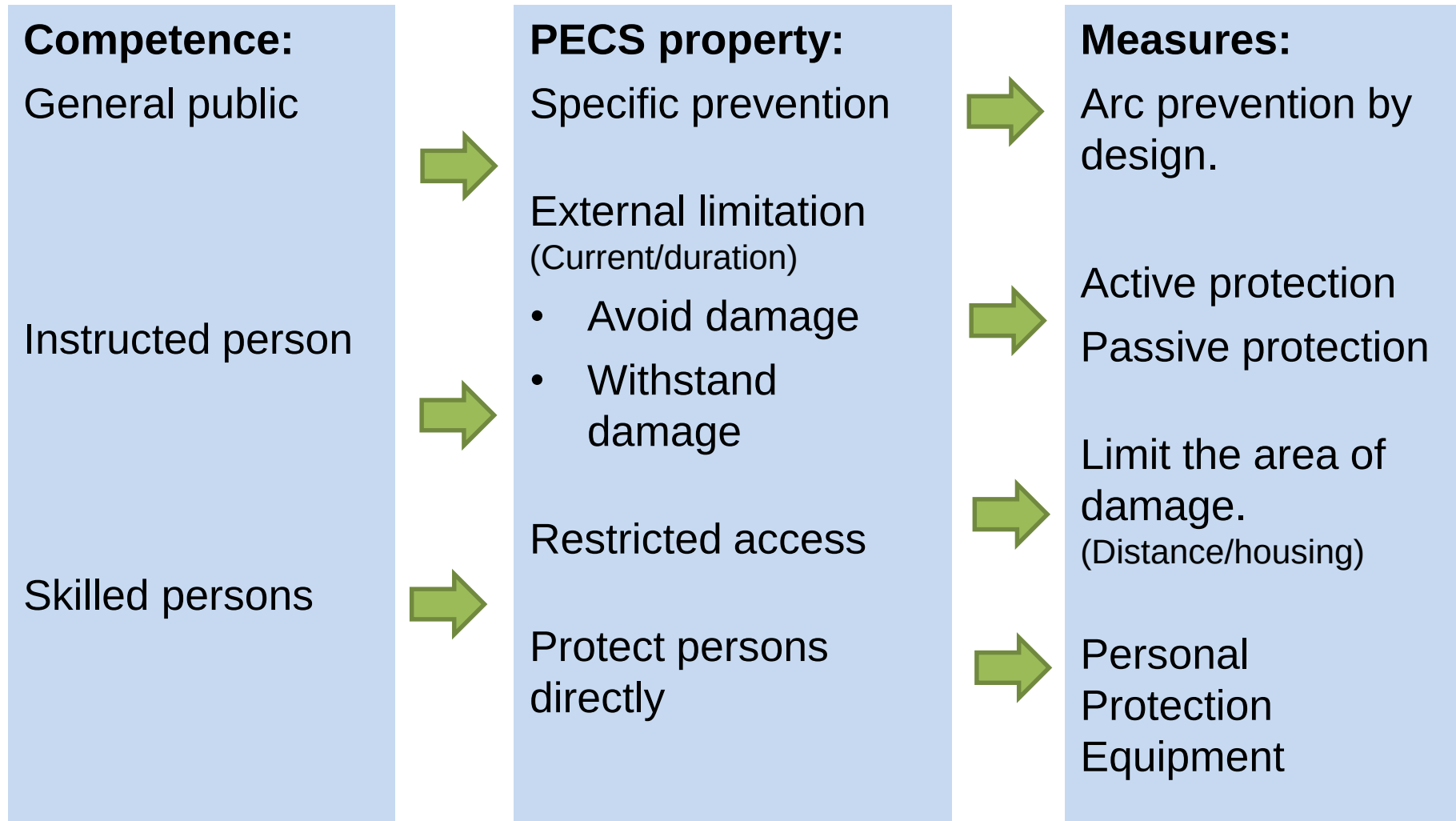


NOTE Sometimes it is possible that TOLERABLE risk is already achieved by applying step 1 or steps 1 and 2.

Figure 1 – Principle of safety integration

## Cl. 4.100 – Arc flash (IEC 62477-2)

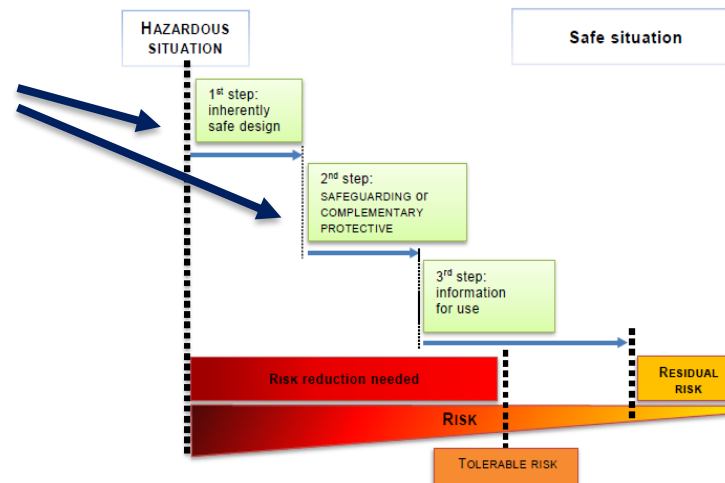
### Fundamental arc flash consideration



# Clause 5 - Test

## Overall purpose of clause 5:

Cl. 5.1: Definition of the fundamental conditions for testing.



NOTE Sometimes it is possible that TOLERABLE RISK is already achieved by applying step 1 or steps 1 and 2.

Figure 1 – Principle of safety integration

- Cl. 5.2: Compliance test to **verify** whether
- the **risk mitigation** by clause 4 is sufficient.
  - **additional design measures** or **supplementary protective measures** are required for sufficient risk mitigation.
  - **additional information** or marking shall be specified.
  - Strong link between clause 4 design requirement and clause 5 test requirement.

# Clause 5.2 – Test

## Cl. 5.2.1 – Visual inspection

Evaluation of design measure for:

- All aspects in clause 4 where visual inspection is required.
- Evaluation of design
- Datasheet
- Warning label
- Test sample



**Applicable test:**

- Visual inspection

# Clause 5.2 – Test

## Cl. 5.2.2 – Mechanical test

Evaluation of mechanical related design measure for:

- Insulation coordination (4.4.7)
- Basic protection by enclosure (4.4.3)
- Environmental conditions (4.9)
- Wiring and connection (4.11)
- Enclosure design (4.12)



### Applicable test:

- Clearance & creepage distances test.
- Non-accessibility test
- Ingress protection test (IP rating)
- *Enclosure* integrity test
- Deflection test / Impact test
- Steady force test, 30N /250N
- Drop test / Stability test
- Stress relief test
- Wall or ceiling mounted equip. test.
- Handles and manual control
- Securement test
- Strain relief test

# Clause 5.2 – Test

## Cl. 5.2.3 – Electrical test

### Evaluation of electrical related design measure for:

- Electrical shock hazards
  - Basic protection (4.4.3)
  - Fault protection (4.4.4)
  - Enhanced protection (4.4.5)
  - Insulation (4.4.7)
  - Capacitor discharge (4.4.9)
- Energy hazard (4.5)
- Fire and temp. hazard (4.6)
- Enclosure (4.12)
- EMF (4.14 / Annex Q)



### Applicable test:

- Impulse withstand voltage test.
- AC or DC voltage test
- Partial discharge test
- Protective impedance test
- Touch current measurement test
- Capacitor discharge test
- Limited power source test
- Temperature rise test
- Protective equipotential bonding test
- Input test
- Separable thin sheet material test
- Mandrel test
- Determination of working voltage
- Electromagnetic field (EMF)

# Clause 5.2 – Test

## Cl. 5.2.4 – Abnormal operation test

### Evaluation of design measure for:

- Fault and abnormal operating conditions (4.2)
- Short circuit and overload protection (4.3)
- Insulation (4.4.7)
- Mechanical hazard (4.7)



### Applicable test:

- *Protective equipotential bonding s/c withstand*
- Output short circuit
- *Short time withstand current (I<sub>cw</sub>)*
- Output overload
- Breakdown of *components*
- PWB short circuit
- Loss of phase
- Cooling failure
- Inoperative blower
- Clogged filter
- Loss of coolant
- Covering of openings for cooling air



### Potential additional protective measures:

- S/C protective device

# Clause 5.2 – Test

## Cl. 5.2.5 – Material test

### Evaluation of design measure for:

- Fault and abnormal operating conditions (4.2)
- Short circuit and overload protection (4.3)
- Insulation (4.4.7)
- Mechanical hazard (4.7)



### Applicable test:

- High current arcing ignition
- Glow-wire
- Hot wire ignition
- Flammability
- Flaming oil
- Cemented joints
- Durability of marking
- Thin sheet material

# Clause 5.2 – Test

## Cl. 5.2.6 – Environmental test

**Evaluation of complete design considering the environmental conditions:**

- Environmental stresses (4.9)



**Applicable test:**

- Dry heat
- Damp heat
- Vibration
- Salt mist
- Dust and sand

**Applicable marking:**

- Environmental conditions



# Clause 5.2 – Test

## Cl. 5.2.7 – Hydrostatic pressure test

### Evaluation of liquid cooling design measures:

- Liquid cooling (4.7.2)



### Applicable test:

- Hydrostatic pressure

## Clause 5.2 – Test

### Cl. 5.2.8 – Electromagnetic fields test

#### Evaluation of EMF design measures:

- Electro Magnetic Force (4.14 / Annex Q)



#### Applicable test:

- Annex Q

### Cl. 5.2.9 – Internal SPD monitoring test

#### Evaluation of design measures for monitoring of devices for limitation of impulses:

- Insulation (4.4.7)



#### Applicable test:

- Internal SPD monitoring

# Clause 6 – Information and marking

MAKING MODERN LIVING POSSIBLE



## Design Guide

### VLT® AutomationDrive FC 301/302

0.25-75 kW



Type: FLX 17

PV input: 1000 VDC, max. 3 x 13.5 A  
250 - 800 VDC MPP

Output: 3P + N + PE - 230/400V, 50 Hz, Class I  
S nom = 17 kVA, 3 x 25.6 A max  
P nom @ cos(Ph)1 = 17.0 kW  
P nom @ cos(Ph)0.95 = 16.2 kW  
P nom @ cos(Ph)0.90 = 15.3 kW

Chassis: IP65, Temp -25°C to 60°C



Functional Safety: VDE 0126-1-1 / A1, VDE AR-N 4105

Made in Denmark

Danfoss Solar Inverters A/S



# Clause 6 – Information and marking

## Overall purpose of clause 6:

Cl. 6.1: General

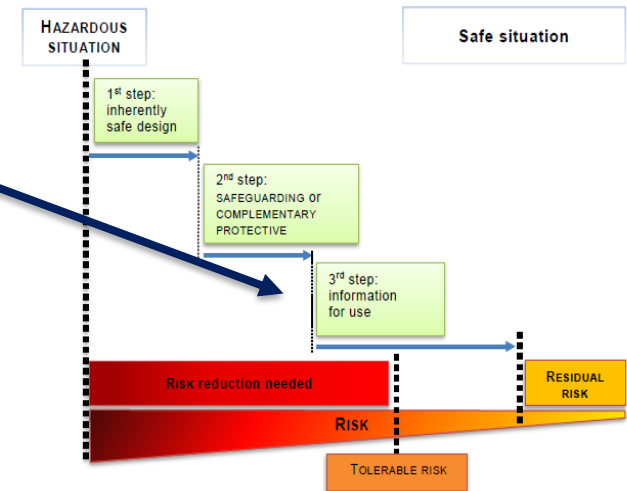
Cl. 6.2–6.5: Information required for safety

- selection (6.2)
- installation (6.3)
- commissioning (6.3)
- operation / use (6.4)
- maintenance (6.5).

of the PECS.

This includes information about:

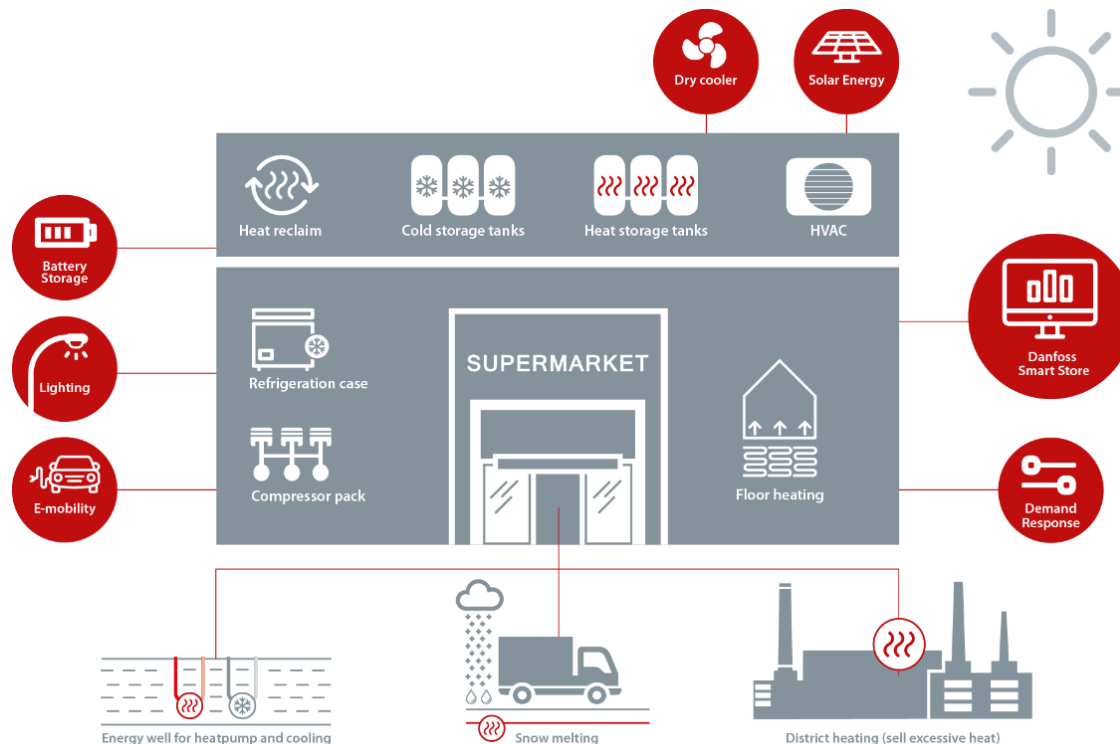
- Intended use and limits (e.g. environmental conditions)
- specified additional protective measures.
- needed information and marking for additional risk mitigation.
- Strong link between clause 4 design requirement and clause 6 “information and marking” requirement.



NOTE Sometimes it is possible that TOLERABLE RISK is already achieved by applying step 1 or steps 1 and 2.

Figure 1 – Principle of safety integration

# The potential use of IEC 62477-1/2 in miscellaneous (future) power conversion applications.

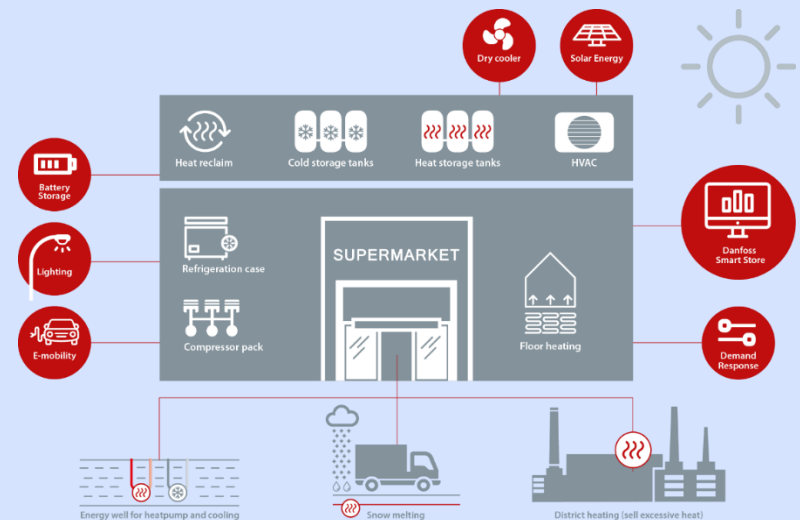


# The potential use of IEC 62477-1/2 in miscellaneous (future) power conversion applications.

## Driving factors for power electronic:

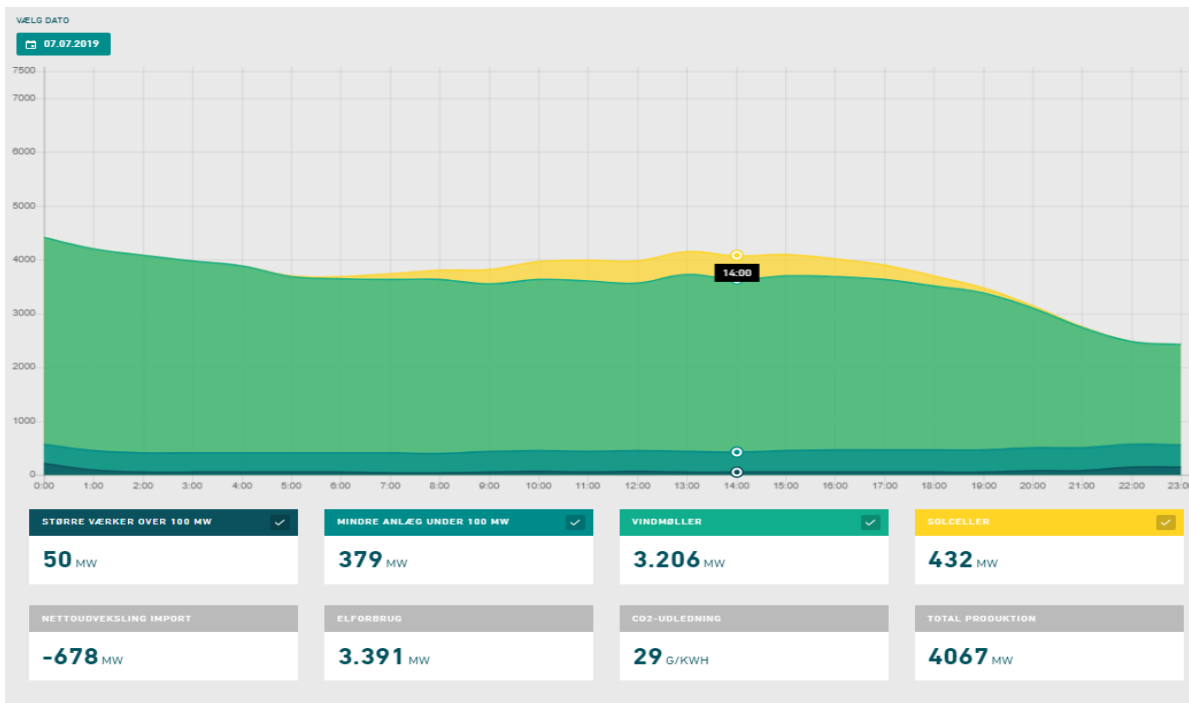
Global CO<sub>2</sub> reduction resulting in many new DC-applications:

- Local DC-grid distribution system
- Consumer => Prosumer
- Public and private transportation
- Marine propulsion
- Renewable energy generation
- Energy storage
- Food cooling for waste reduction



# The potential use of IEC 62477-1/2 in miscellaneous (future) power conversion applications.

Energy generation of renewable energy sources:



Source: Energinet.dk ([Link](#))

Wind



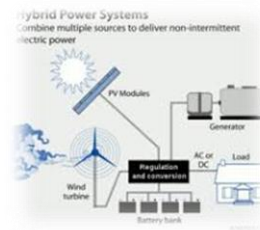
Solar



Hydro



Hybrid power



Wave energy



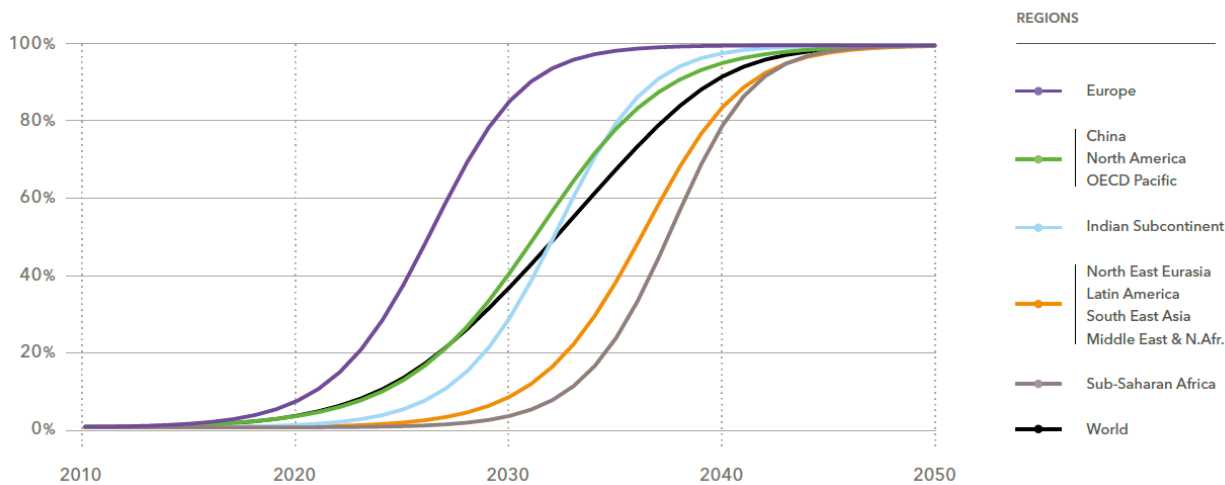
Tidal



# The potential use of IEC 62477-1/2 in miscellaneous (future) power conversion applications.

## Transportation and energy storage:

MARKET SHARE OF ELECTRIC VEHICLES IN NEW LIGHT VEHICLE SALES



Source: 2017 DNV GL energy transition outlook – renewables, power, and energy use

## Car charging



## Public transportation



## Marine



## Energy storage



# The potential use of IEC 62477-1/2 in miscellaneous (future) power conversion applications.

Traditional power electronic applications:

Motion/process control by Drives:



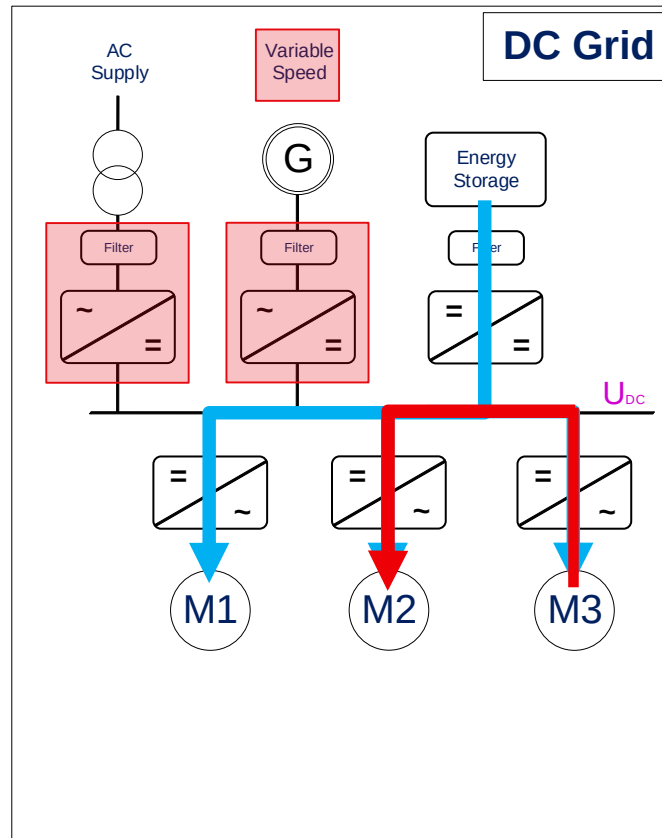
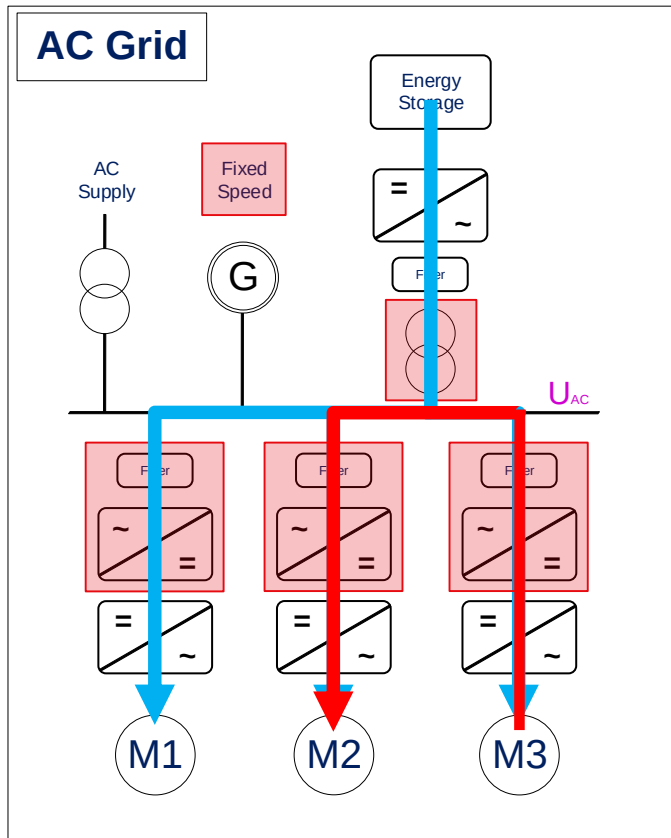
UPS / Datacentre:



SMPS



# AC Grid vs DC Grid



## DC Grid benefits

**Variable speed generators**

**Less filters and transformers**

**Improved system efficiency**

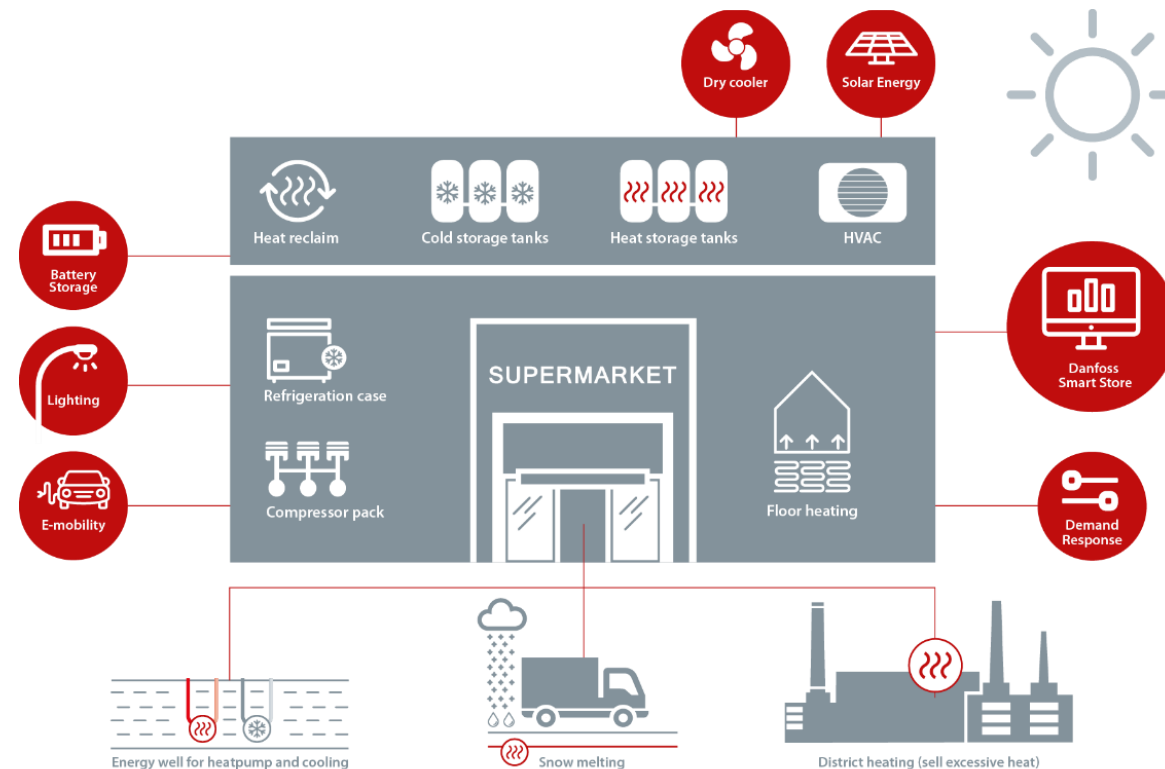
**10-20% reduced system foot print**

**Efficient reuse of regenerative energy**

No reactive power  
No synchronization needed  
Easier service access

# Supermarket of the future

From Energy **Consumer** to Energy **Prosumer**



## Total energy store:

- Heat recovery with CO<sub>2</sub> as refrigerant
- Use refrigeration compressors for heat pump purposes where cooling load is low and heating load is high (winter).
- Install heat/cooling storage units (to store energy where electricity price is low and/or COP is high).
- Sell excessive heat from refrigeration system into the district heating system.
- **Combine Photovoltaic (PV) and refrigeration/ heating into a local “micro-grid power system”**

# High voltage applications considered for IEC 62477-2

Minerals - Mining



Minerals - Cement



Hydro Power



Marine & Shipbuilding



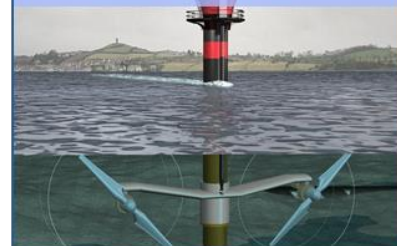
Oil & Gas



Wind Energy



Tidal Energy



Machine Builders



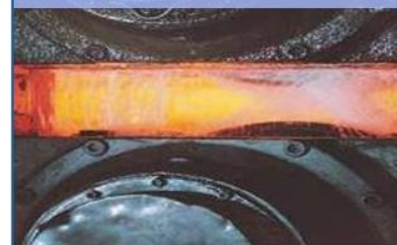
Chemical



Water & Wastewater



Metals



Energy



# Responsibilities according to IEC guide 104



## IEC GUIDE 104

Edition 5.0 2019-07

## GUIDE



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The preparation of safety publications and the use of basic safety publications  
and group safety publications



# Responsibilities according to IEC guide 104

## Abstract from IEC Guide 104:

### Liaison:

A TC with a horizontal safety function or a group safety function shall **respond to requests for liaison from product TCs (see 7.1), and keep them informed** about the progress of relevant work.

### Requests from product TCs for new work:

A TC with a horizontal safety function or a group safety function **shall consider any request from a product TC (see 7.4.1) within three months**, or longer if acceptable to the product TC.

It may be necessary to handle such requests by correspondence, if a plenary meeting of the TC with the safety function is not scheduled for some time.

# Responsibilities according to IEC guide 104

## Abstract from IEC Guide 104:

### Requests from product TCs for new work:

- The TC with the SAFETY function shall inform the PRODUCT TC whether or not it considers that the **proposals are appropriate and sufficiently general to be included in a BSP or a GSP.**
- If the proposals are **not considered appropriate by the TC with the safety function**, it shall, in close liaison with the relevant product TC, make an **alternative proposal to cover the needs of product TCs.**
- Such proposals shall **not conflict** with the basic principles explained in the basic safety publication or group safety publication.

# Responsibility according to IEC guide 104

Application 1  
specific  
requirement

Application 2  
specific  
requirement

Application 3  
specific  
requirement

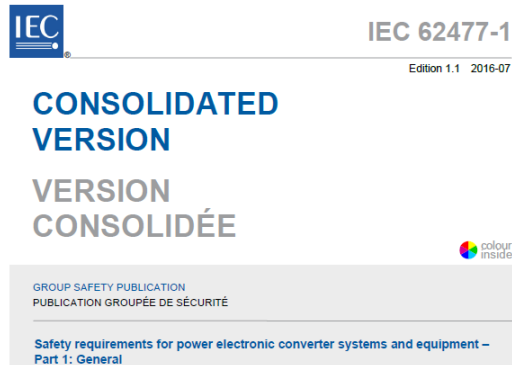
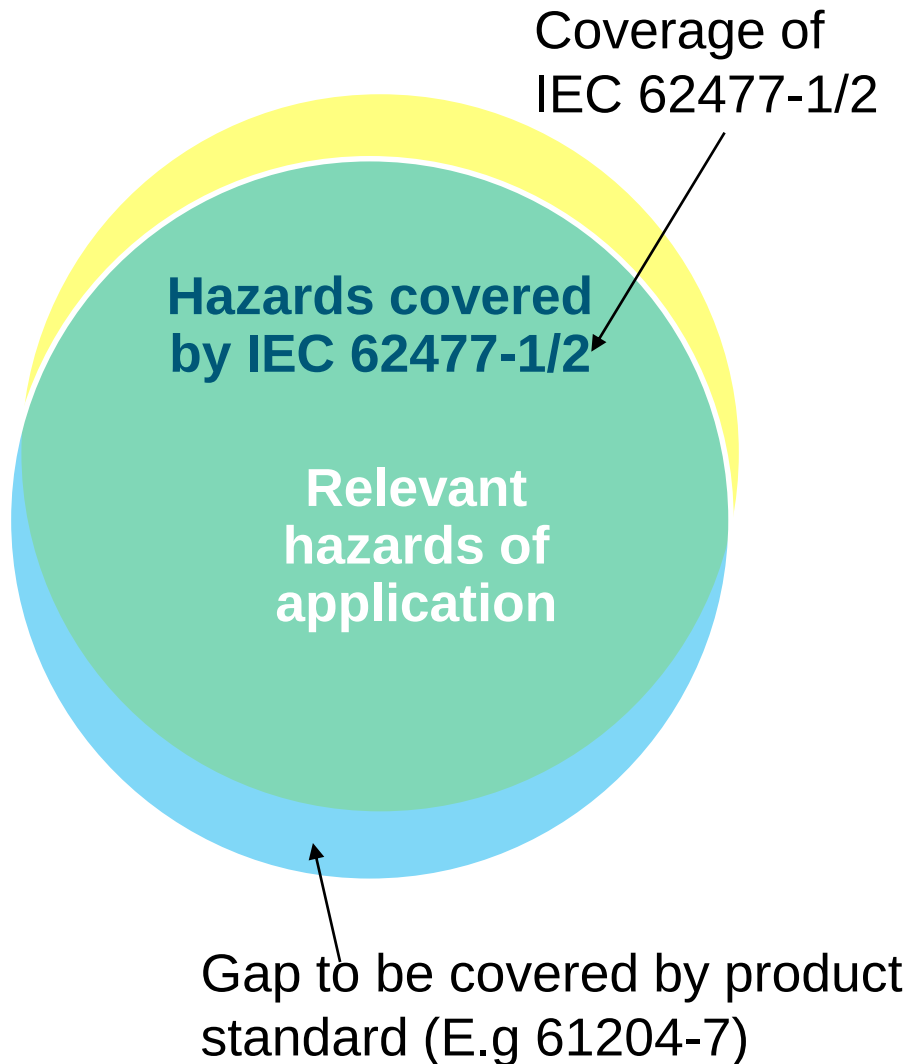


Application n  
specific  
requirement

**Common requirement relevant for  
2 or more applications / products.  
(sufficiently general)**



# Responsibility according to IEC guide 104



Further considerations to be made by TC's using the IEC 62477-1 in their application to cover gaps considering relevant hazards.



# Group safety function of IEC 62477-1

The following projects are using the IEC 62477-1:

- IEC 62477-2 (TC22) Safety requirements for power semiconductor converter systems - Part 2: Power Electronic Converters from 1000 V a.c. or 1500 V d.c. up to 35 kV a.c.  
**Status: IS Published 2018-06-21**
- IEC 62040-1 (SC22H) Uninterruptible power systems (UPS) - Part 1: Safety requirements  
**Status: IS Published September 2017**
- IEC 61800-5-1 (SC22G) Adjustable speed electrical power drive systems - Part 5-1: Safety requirements - Electrical, thermal and energy  
**Status: On-going, CD2 published June 2019**
- IEC 61204-7 (SC22E) Low-voltage switch mode power supplies - Part 7: Safety requirements  
**Status: IS Published November 2016**
- IEC 62909-1 (SC22E) Bi-directional grid connected power converters - Part 1: General requirements  
**Status: IS Published May 2017**
- IEC 62909-2 (SC22E) Bi-directional grid connected power converters - Part 1: General requirements. Part 2: Interface of GCPC and distributed energy resources and additional requirements to Part 1  
**Status: IS Published March 2019**

## Group safety function of IEC 62477-1

### Further TC's considering IEC 62477-1:

- IEC 62109-1 (TC82) Safety of power converters for use in photovoltaic power systems - Part 1: General requirements.  
**Status: No information about start of maintenance**  
(Tim Zgonena – Projectleader IEC 62109-1)
- IEC 61400-7 (TC88) Wind turbines -  
Part 7: Safety of wind turbines power converters  
**Project on stand-by waiting for the CDV 62477-1**
- IEC 62282-3-400 (TC105) Fuel cell technologies - Part 3-400: Stationary fuel cell power systems - Small stationary fuel cell power system with combined heat and power output.
- IEC 61851-23 (TC69) Electric vehicle conductive charging system - Part 23: DC electric vehicle supply equipment

# Global harmonization

## Europe:

EN 62477-1+A1 (2016)

In the process of being listed under  
the LVD directive (LVD/35/EU).

## Japan:

JIS C 62477-1

## China:

In process of  
development as  
CN national std.

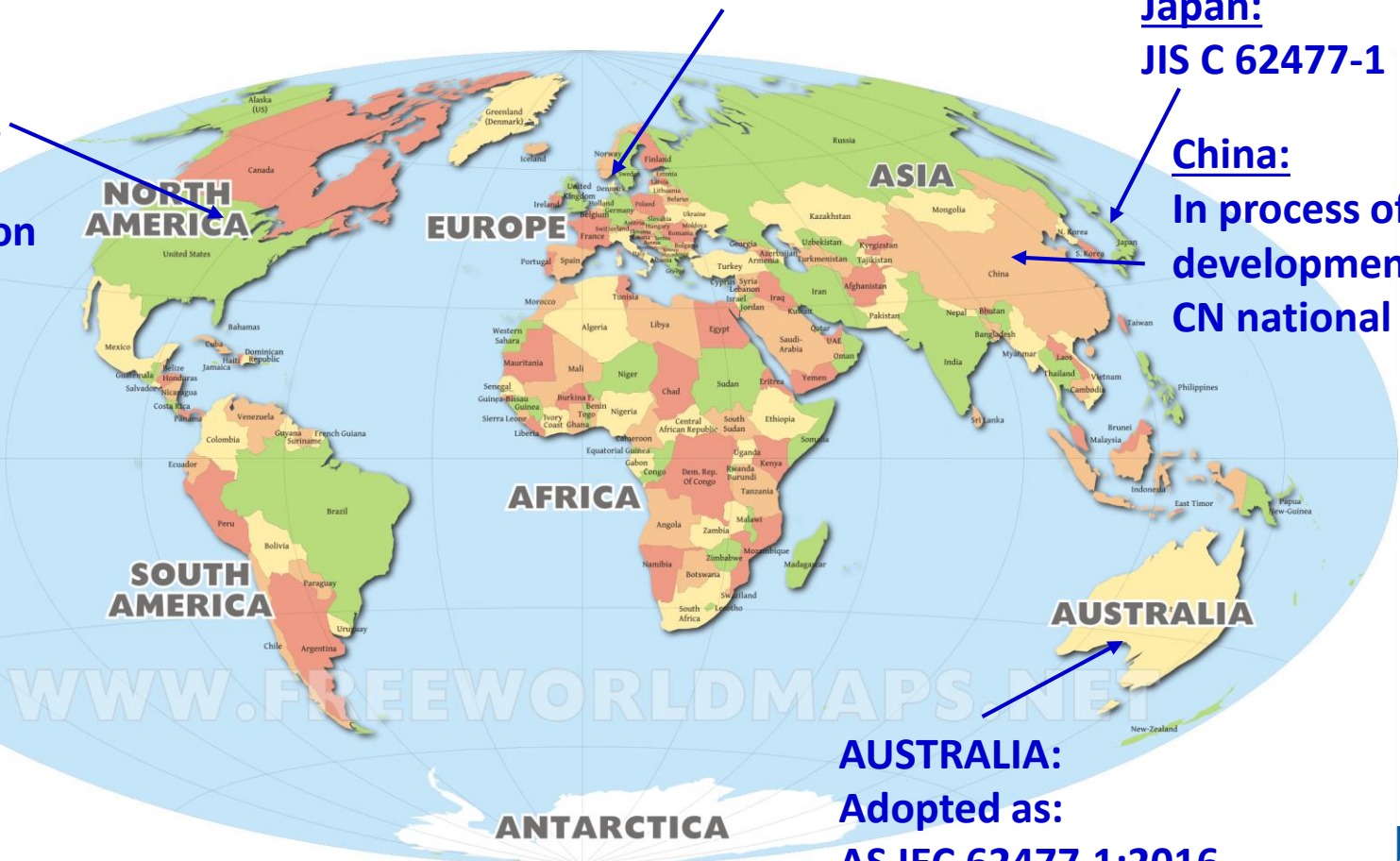
## US/Canada:

UL/CSA 62477-1

Close cooperation  
with CANENA

## Expected:

CSA and UL for  
STP voting by  
mid-year 2020.



**AUSTRALIA:**  
Adopted as:  
AS IEC 62477.1:2016

# Thank you for your attention

## Questions ?

**Presented by:**  
**Preben Holm, Convenor**  
**TC22 MT9**

**Event: General meeting 2019**  
**Date: 2019-10-20**  
**Location: Shanghai, China**



International  
Electrotechnical  
Commission