ABB AG – CALOR EMAG MEDIUM VOLTAGE PRODUCTS

UFES - Ultra-Fast Earthing Switch

Active internal arc protection

V2017-0612-WH

UFES - Ultra-Fast Earthing Switch

Active internal arc protection

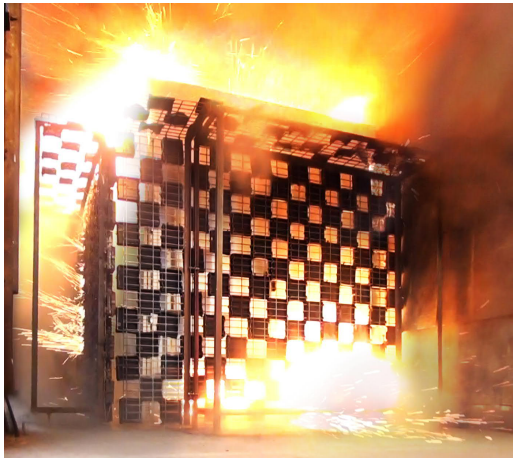
Agenda

- Internal arc faults
- Protection concepts
- Ultra-Fast Earthing Switch type UFES
  - Principle
  - Components
- Differentiation of protection concepts
- Product portfolio
- Benefits

Internal arc faults

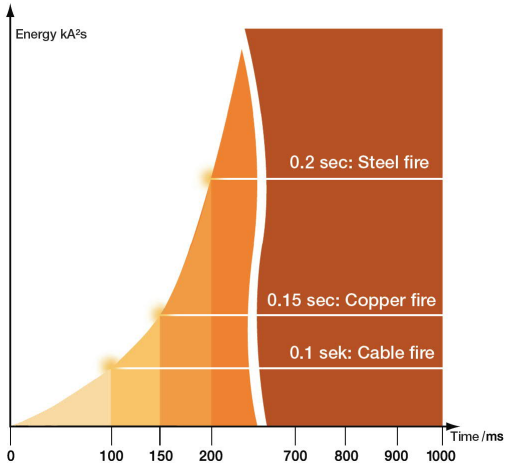
Fault characteristics

- An internal arc arises when at least part of the current passes through a dielectric (usually air)
- Consequences:
  - Uncontrolled release of energy with arc power up to 40 MW
  - Arc plasma with temperatures up to 20.000 °C (five times of the sun surface temperature)
  - Rapid pressure rise inside of the switchgear (depending on design also in the environment)
  - Light with illuminance more than 2000 times higher than a typical office light
  - High acoustic stress level
  - Explosive release of plasma, fragments and toxic gases



Internal arc test

Standard: Under normal operating conditions



Energy release

Thermal impact on equipment

Internal arc faults

Reasons of formation

Human-related causes:

- Working on energized equipment (Intended or unintended)
- Disregard of the 5 safety rules
- Left tools after working on equipment
- Installation faults (cable connections, busbar joints)

Technically related causes:

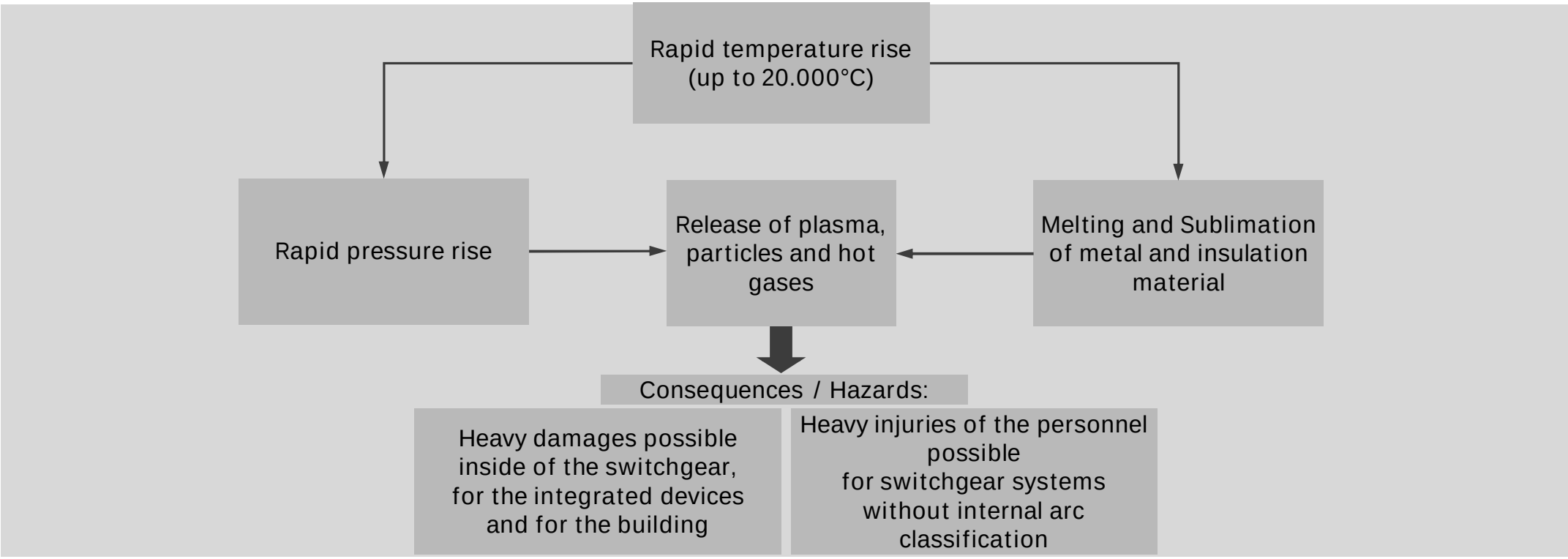
- Ageing and wear
- Defect devices
- Overvoltage
- Overtemperature

Environmental causes:

- Moisture and dirt
- Corrosion
- Small animals inside of the switchgear

Internal arc faults

Impacts



Internal arc faults

Impact on switchgear and devices

Circuit-breaker

... after internal arc impact

Switchgear

... after internal arc impact

Internal arc faults

Impact on the environment

Substation

... after internal arc impact

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Protection concepts

Switchgear with passive protection

Passive internal arc protection

– Arc faults covered by overcurrent protection of conventional protective relay only

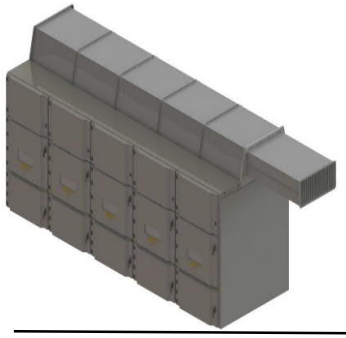
→No differentiation between internal and external faults!

→Consideration of selectivity requirements!

– Min. time for arc breaking:

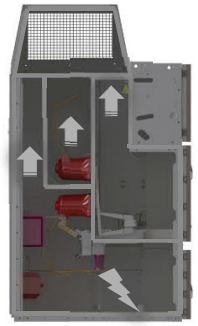
Setting of protective relay
+ Switching time CB
+ Arcing CB

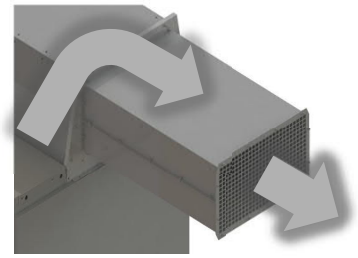
– Arc breaking time: ~ 100 - 1000 ms

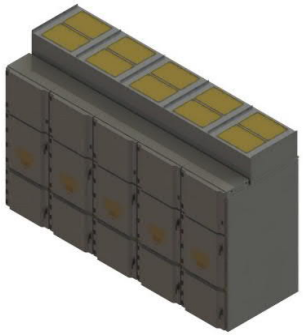


Pressure relief duct

→ Pressure relief to outside areas

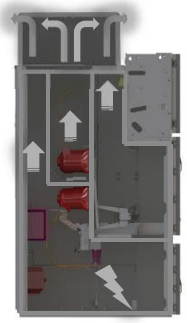


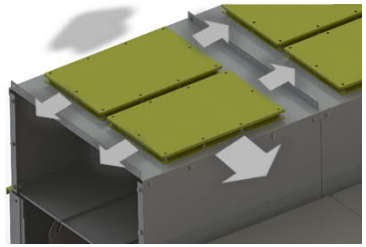




Top chimney

→ Pressure relief into the switchgear installation room



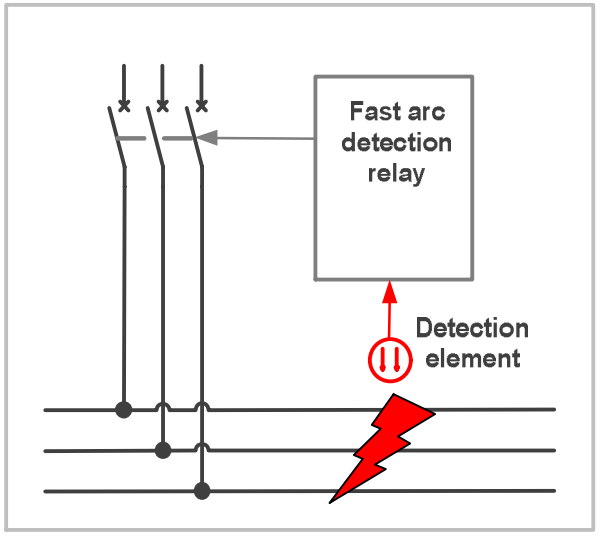


Protection concepts

Active internal arc breaking

Application of fast arc protection relay

- Operation independently of protective relay(s)
- Fast detection of an internal arc fault typically by means of:
  - Light sensing
  - Current sensing (Instantaneous current)
- Adjustable threshold levels
- Arc breaking time ~ 60…80 ms
  (Detection time + CB switching operation + CB arcing time)



Principle

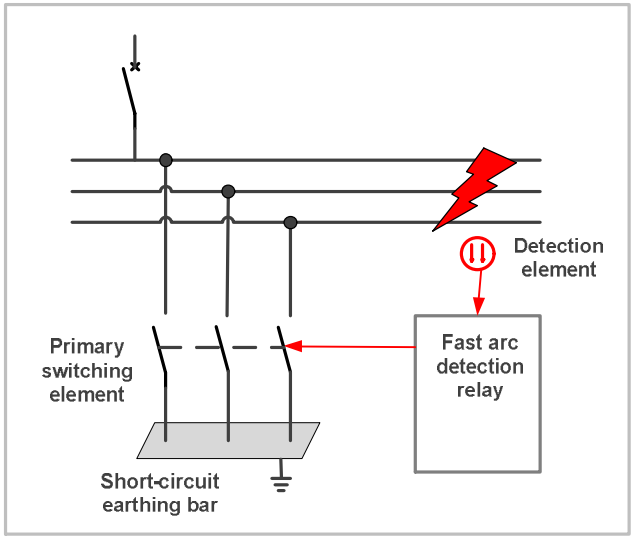
Fast relay with CB combination

Protection concepts

Active arc elimination

Application of an Ultra-Fast Earthing Switch

- Operation independently of protective relay(s)
- Fast detection of an internal arc fault typically by means of:
  - Light sensing
  - Instantaneous current sensing
- Adjustable threshold levels
- Arc elimination by means of ultra-fast short-circuit earthing with specific primary switching elements
- Max. time for arc elimination: ~ 4ms after detection!



Principle

Ultra-Fast Earthing Switch

UFES - Ultra-Fast Earthing Switch

Active internal arc protection

Agenda

- Internal arc faults
- Protection concepts
- Ultra-Fast Earthing Switch type UFES
  - Principle
  - Components
- Differentiation of protection concepts
- Product portfolio
- Benefits

Ultra-Fast Earthing Switch type UFES

The basis for effective protection

Components

3 UFES primary switching elements (PSE)

– Ultra-fast initiation of a 3-phase earthing immediately after detection of an internal arc fault

– Elimination of the arc in consequence of arc voltage collapse

UFES electronics

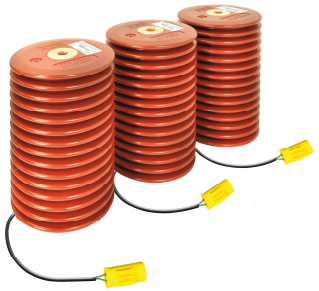
– 2 fast and reliable UFES electronic units:

  • Type QRU1: Equipped with own detection units (light and current) to identify an internal arc fault

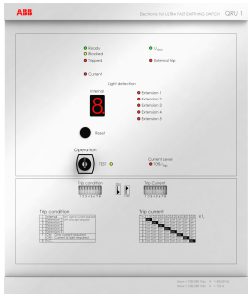
  • Type QRU100: Interface to external arc detection systems (e.g. ABB REA) w/o own detection units

– Energy storage for the tripping of the UFES PSE

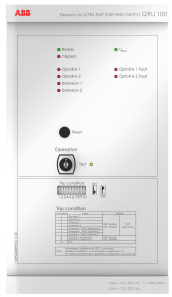
– Tripping of the UFES PSE



UFES primary switching elements



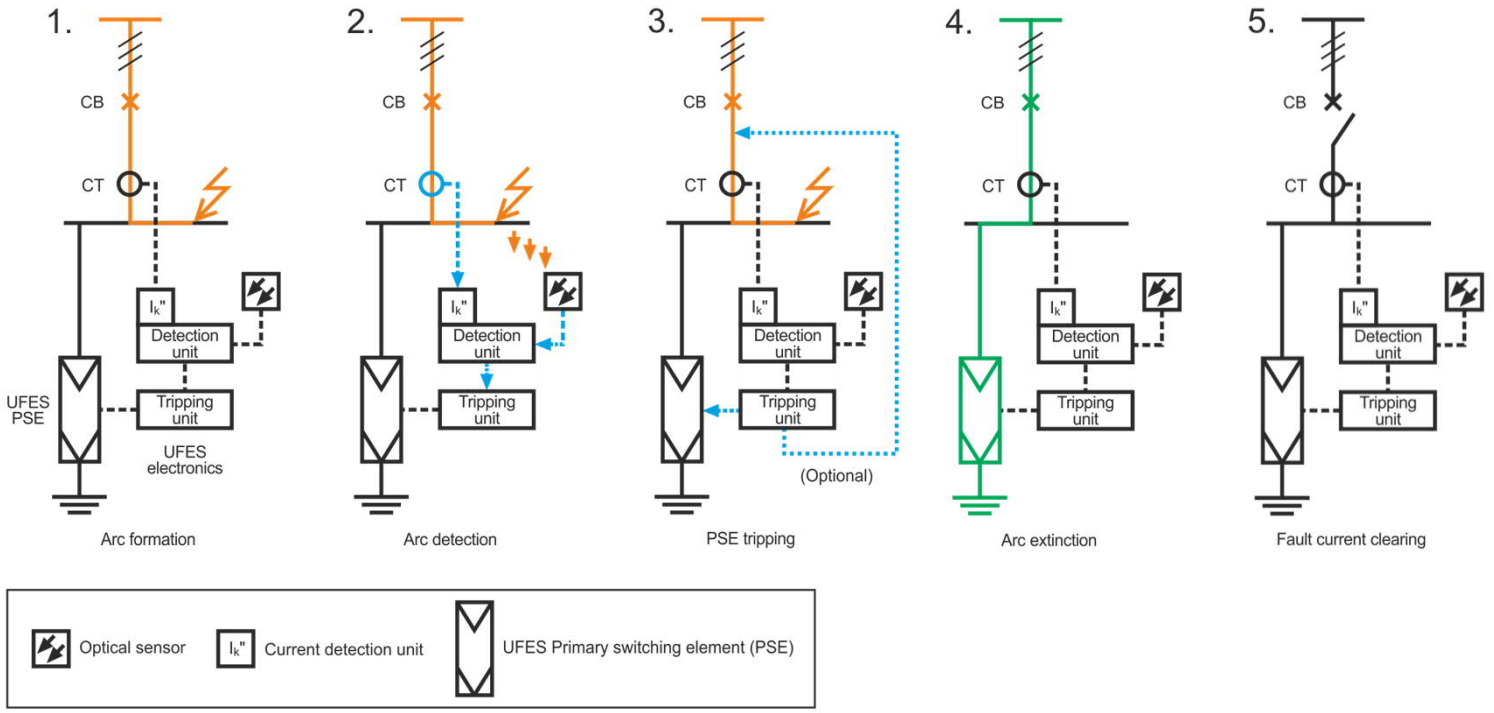
Electronic detection and tripping unit type QRU1



Electronic tripping unit type QRU100

Ultra-Fast Earthing Switch type UFES

Sequence of tripping operation



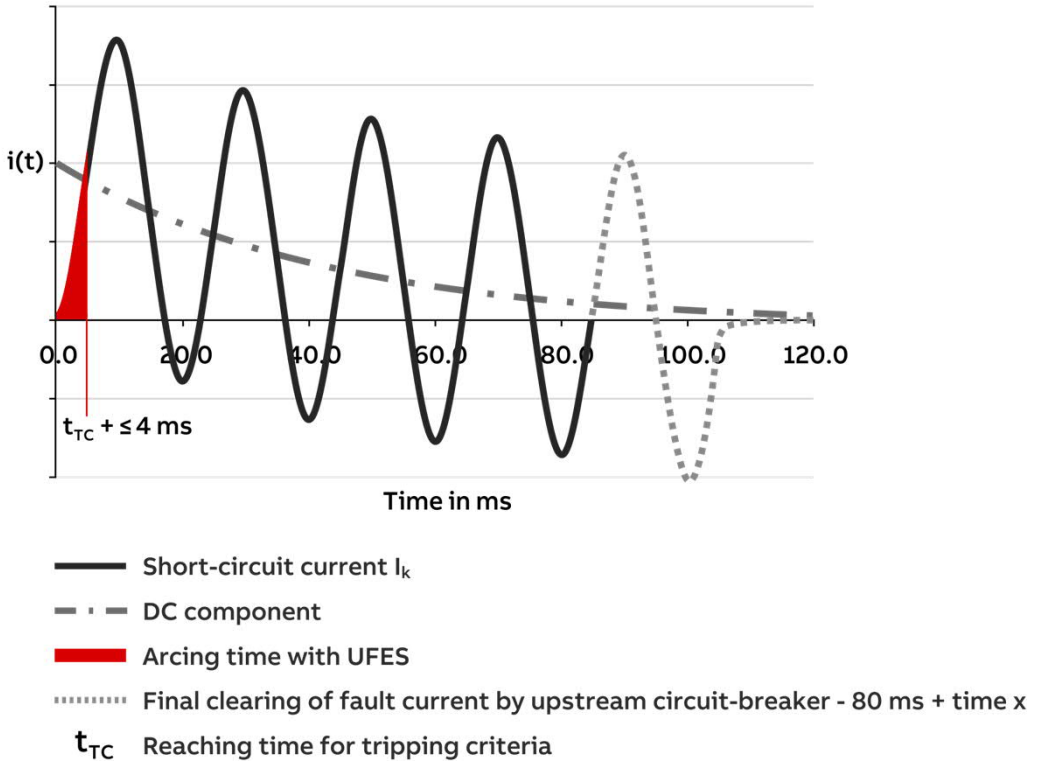
Ultra-Fast Earthing Switch type UFES

Ultra-fast reaction time

Minimizing arc duration

– Effective limitation of damage requires fastest intervention

– Extinction time of the Ultra-Fast Earthing Switch:
< 4 ms after fault detection

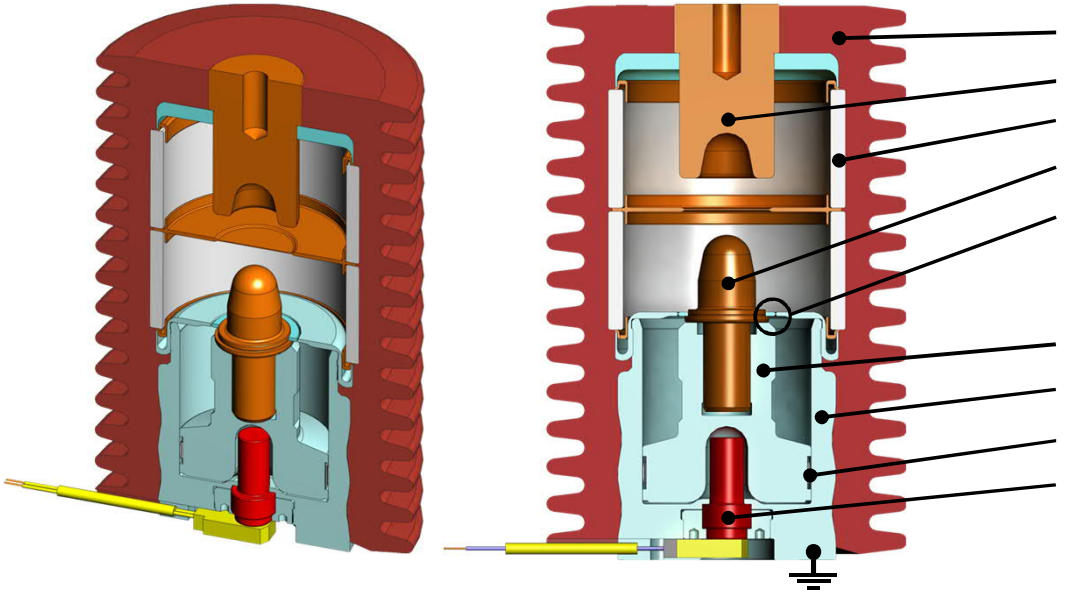


Ultra-Fast Earthing Switch type UFES

Primary switching element (PSE)

Characteristics

- Vacuum interrupter and operating system integrated in one compact unit
- Fast and reliable micro gas generator operating mechanism
- Fast switching time of ~ 1.5 ms
- Easy handling
- Low-maintenance
- Flexible installation



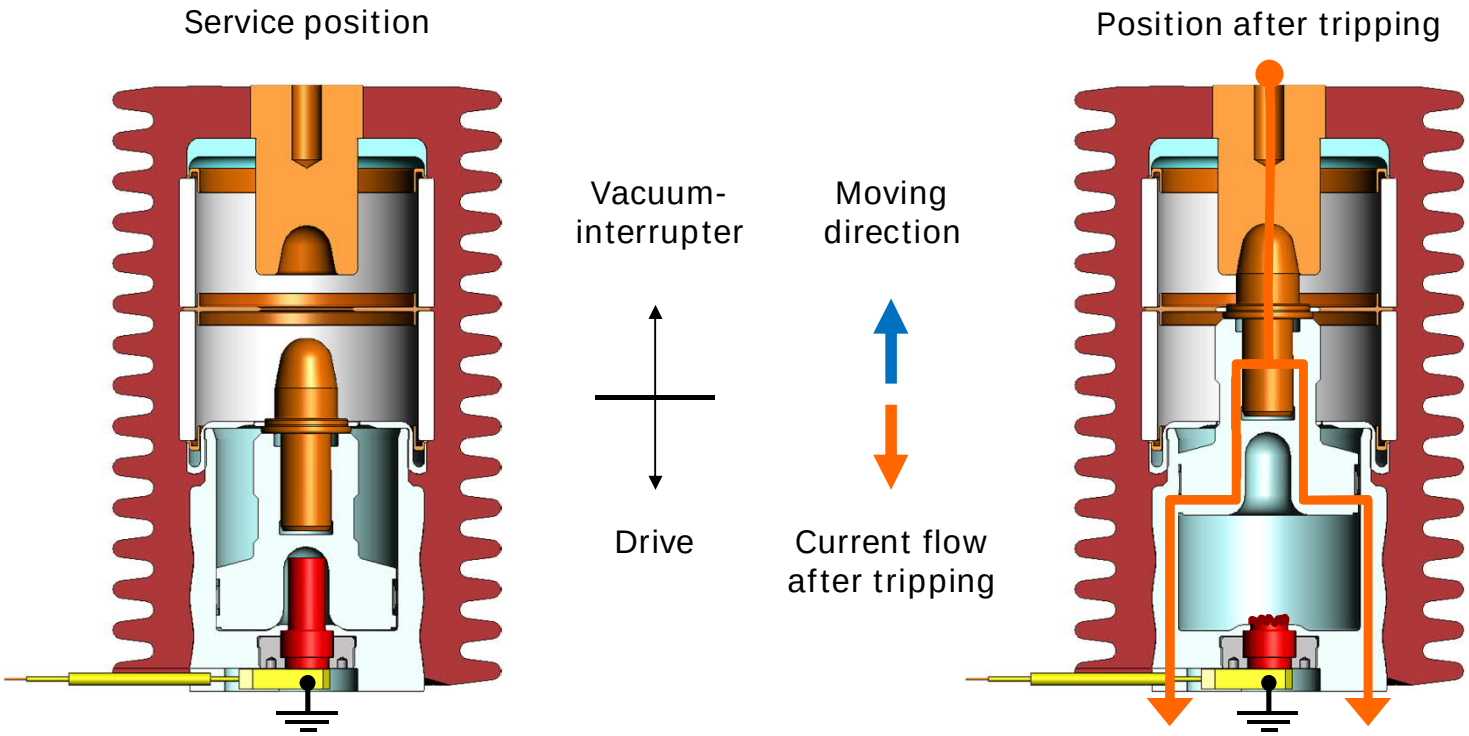
Primary switching element

Section view

Dimensions:	
Ø	137 mm
Height	210 mm
Max. weight	~ 5,5 kg

Ultra-Fast Earthing Switch type UFES

Primary switching element (PSE) - Switching operation

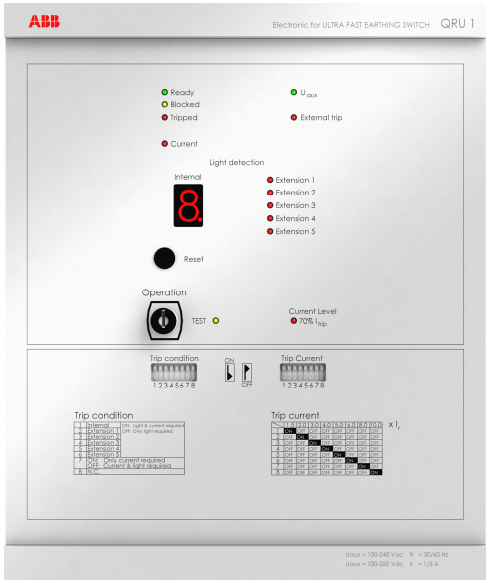


Ultra-Fast Earthing Switch type UFES

UFES electronics type QRU1

Features

- Electronic detection and tripping unit
- Completely in fast analogue technology (no micro processor)
- 9 optical inputs for light detection
- 3 current inputs for monitoring of the instantaneous current value
- Up to 5 x 30 additional optical inputs with ABB arc guard type TVOC-2
- Fast fault localization by use of single lens sensors
- Self monitoring
- Testing mode for functional check
- Simple DIP-switch configuration



Electronic detection and tripping unit type QRU1

ABB arc guard type TVOC-2

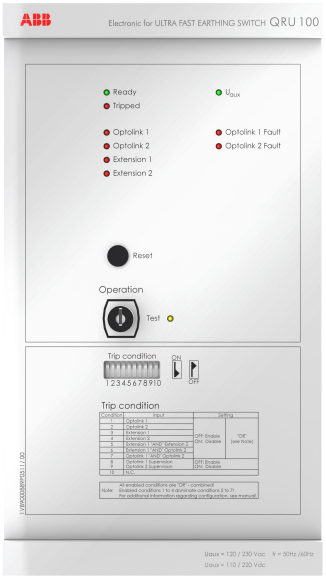
Lens sensor for optical detection

Ultra-Fast Earthing Switch type UFES

UFES electronics type QRU100

Features

- Electronic tripping unit
- Ideal for extension of ABB arc detection systems
- 2 Optolink inputs for connection of the ABB REA101 relay
- 2 high-speed inputs (HSI) for connection of external arc detection systems (after technical clarification)
- Self monitoring including the Optolink connection to the REA system
- Logical combination of the external detection units by use of DIP-switches
- Testing mode for functional check



Electronic tripping unit type QRU100

ABB arc detection system type REA

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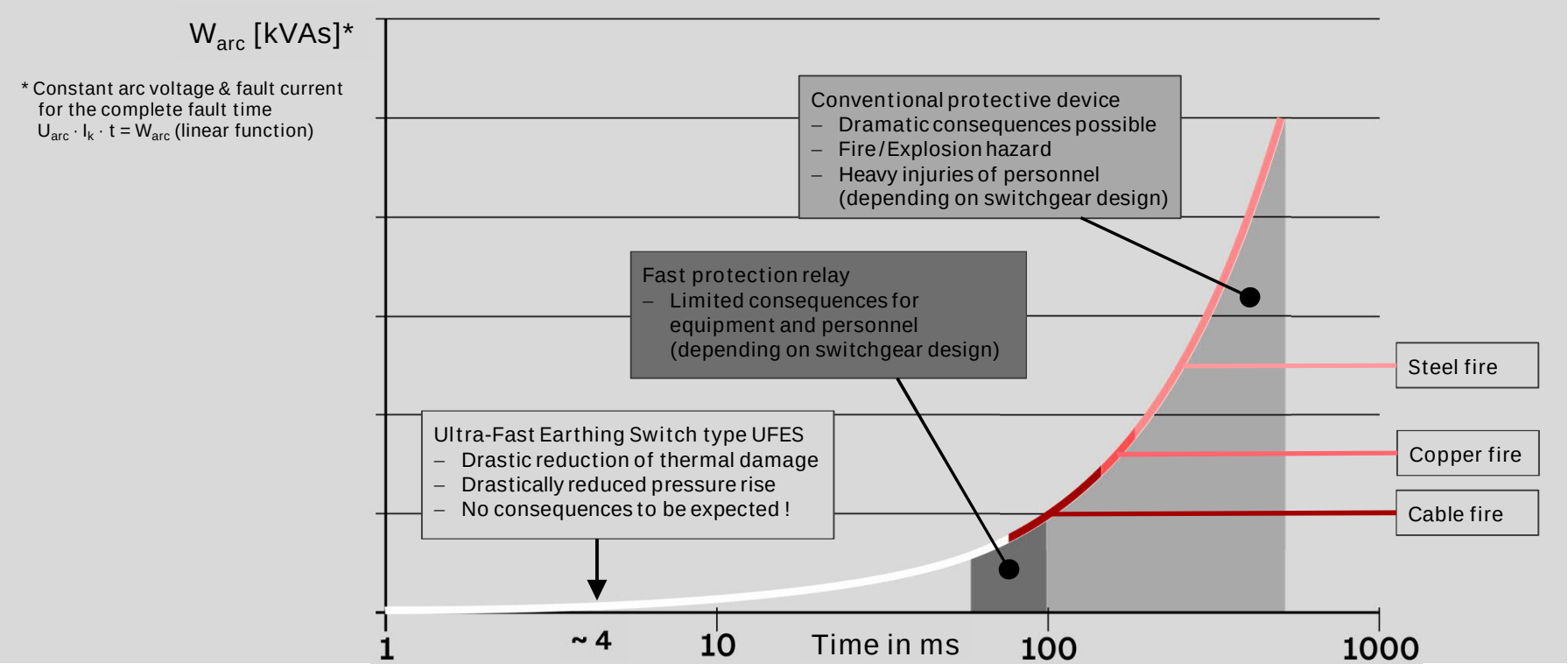
Differentiation of protection concepts

Reduced arc energy



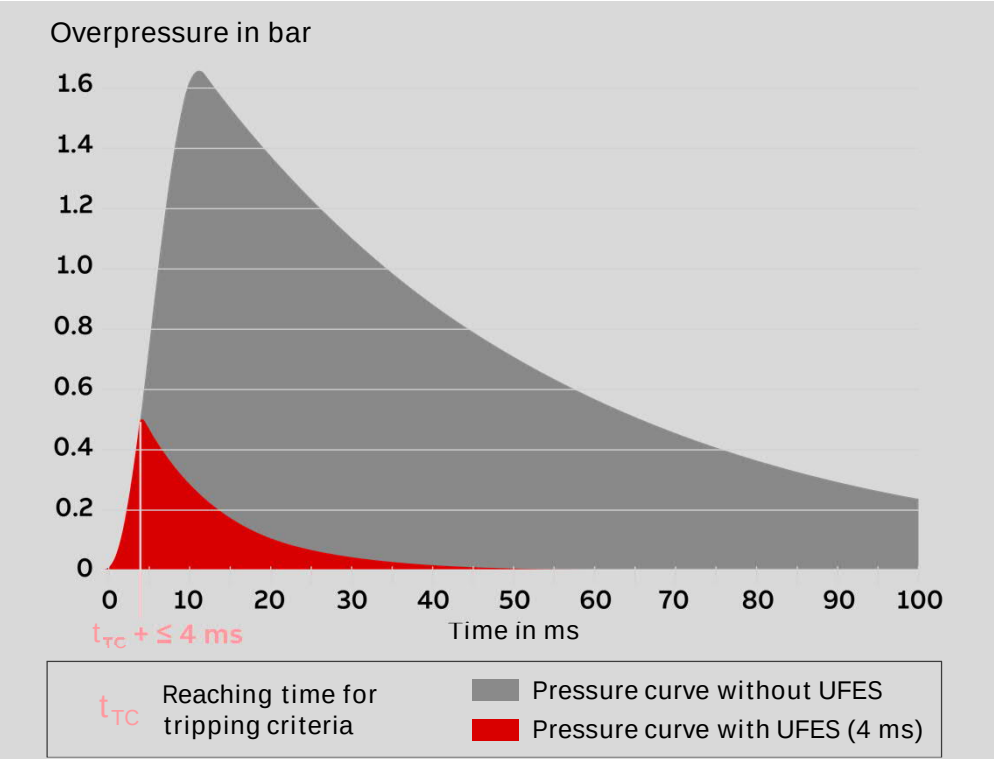
Differentiation of protection concepts

Reduced pressure rise inside of the switchgear

Exemplary pressure curve

Compartment of an air insulated medium voltage switchgear with and without UFES for an arc fault current of 50 kA (rms) and 130 kA (peak).

– Pressure peak inside of the compartment …
  - … without UFES: ~ 1.65 bar
  - … with UFES: ~ 0.45 bar



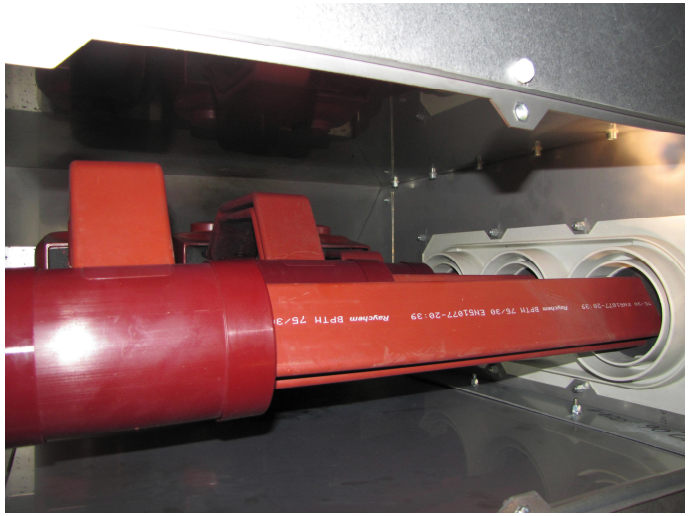
Differentiation of protection concepts

Internal arc test with and without UFES

Busbar compartment

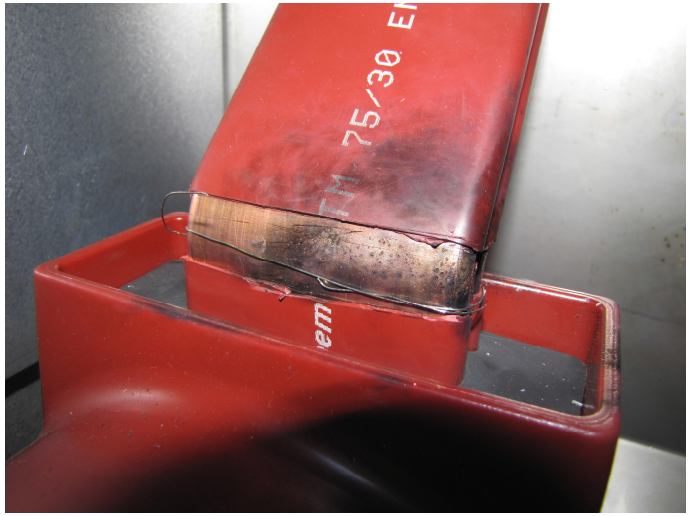
without UFES

Busbar compartment



with UFES

Point of fault initiation



with UFES

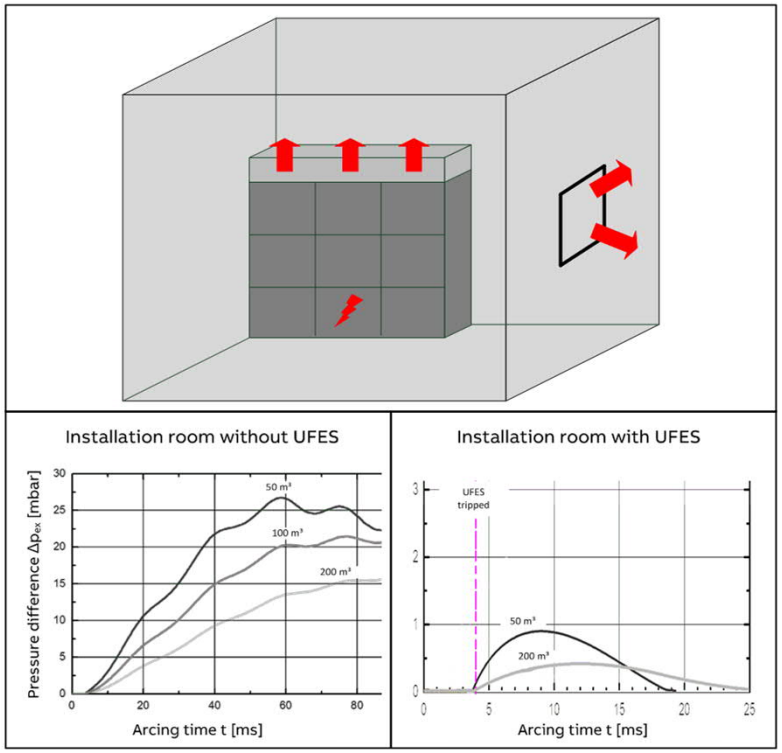
Differentiation of protection concepts

Reduced pressure rise in the installation room

Simulation*

- Object:
  Metal-clad switchgear, 800 mm panel width
- Fault:
  3-phase, 40 kA_{rms}
- Fault location:
  Cable connection compartment
- Free available room volume:
  50 m³, 100 m³, 200 m³
- Pressure relief opening (Room):
  1 m²

*This simulation is for illustrative purpose only and does not replace the pressure calculation based on the actual conditions!



Type of wall	Permissible room overpressure / m² [mbar]
Brick wall	3 - 10
Reinforced brick wall	30
Precast concrete	50
Cast-in-place concrete	>70
Concrete room cells	130

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Ultra-Fast Earthing Switch type UFES

Applicable for highest requirements

Available ratings

- Maximum rated voltage:
  - U_r = 40.5 kV
- Maximum rated short-time withstand current for medium voltage:
  - I_k = 50 kA (3s), 63 kA (1s) (for U_r = 17.5 kV)
- Maximum rated short-time withstand current for low voltage :
  - I_k = 100 kA (0.5s) (for U_r = 1.4 kV)

Primary switching element

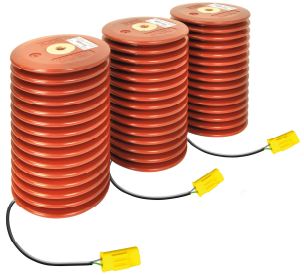
Ultra-Fast Earthing Switch type UFES

Available as … loose components

UFES-Kit-100 as OEM product, consisting of:

Electronic tripping unit type QRU100

1 set (3 off) Tripping cables (10 m) with special plug for PSE and electronic

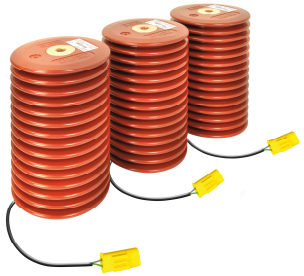


3 Primary switching elements (PSE)

UFES-Kit-1 as OEM product, consisting of:

Electronic detection and tripping unit type QRU1

1 set (3 off) Tripping cables (10 m) with special plug for PSE and electronic



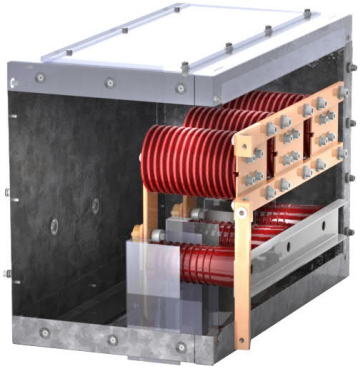
3 Primary switching elements (PSE)

Ultra-Fast Earthing Switch type UFES

Available as … ABB Service retrofit solution

UFES Service Box

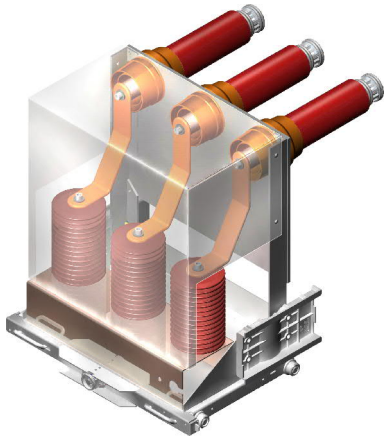
Service Box application
side mounted



Service-Box

UFES truck

UFES truck application
in UniGear ZS1

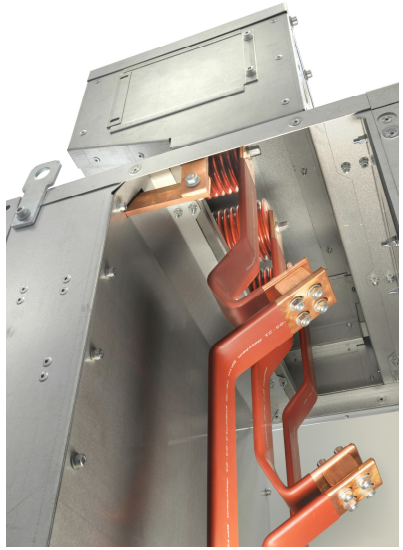


UFES truck

Ultra-Fast Earthing Switch type UFES

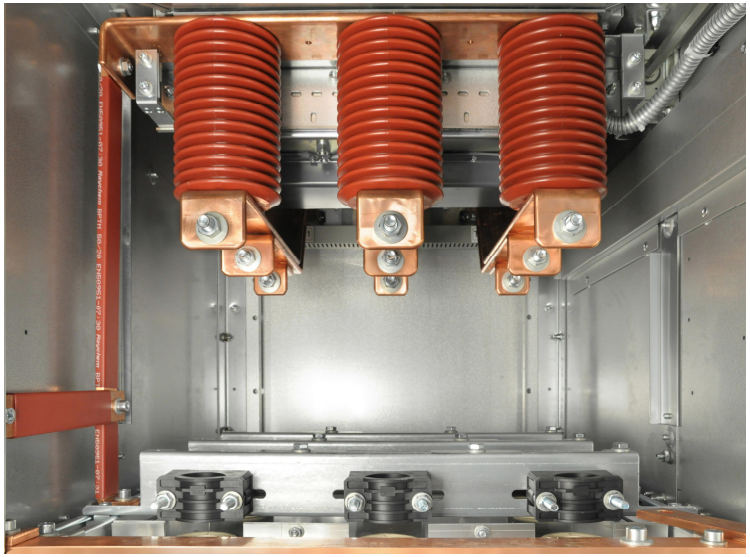
Available for … ABB switchgear (AIS)

UFES in UniGear ZS1



Installation in separate top box

UFES in UniGear ZS1

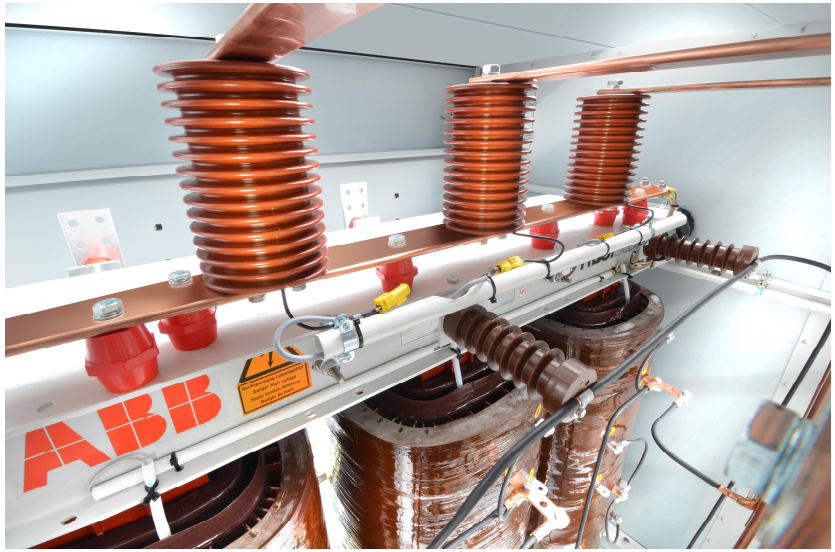


Installation in cable compartment

Ultra-Fast Earthing Switch type UFES

Available for … ABB dry type transformer

UFES for RESIBLOC



PSE installed on transformer primary side

Ultra-Fast Earthing Switch type UFES

Certified protection

VdS Schadenverhütung:

– The registered trademark “VdS” is a well known quality seal for products and services, which has its origin in the umbrella organization of the German insurance industry

DNV - GL:

– One of the worldwide leading companies, offering technical services for the testing and certifying of components for maritime application

UL – Underwriters Laboratories:

– The well known UL quality mark stands for proven compliance with technical standards and safety regulations in the USA and Canada

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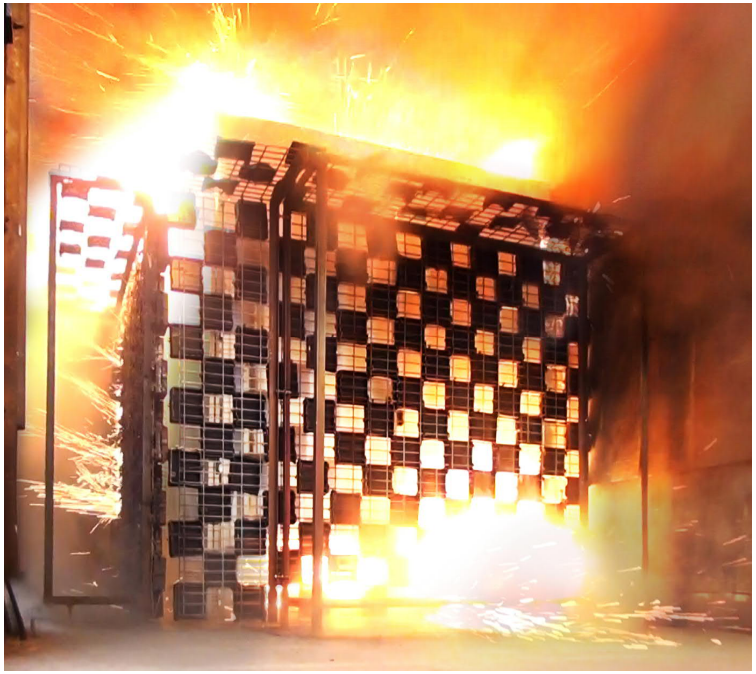
Ultra-Fast Earthing Switch type UFES

Unbeatable advantages

Minimizing the hazardous impacts of an internal arc fault

– Major effects:
  - Rapid temperature and pressure rise
  - Explosive release of hot plasma

– Secondary effects:
  - Strong visual and acoustic load for persons
    → Danger of visual impairment and hearing damage
  - Development and explosive release of hot toxic gases



Ultra-Fast Earthing Switch type UFES

Unbeatable advantages

– Greatly increased operator safety…
  • for personnel working on the switchgear or in the direct environment of the switchgear

– Drastic reduction of downtimes
  • by reduction of the arc impacts to an absolute minimum

→ Greatly increased system and process availability!

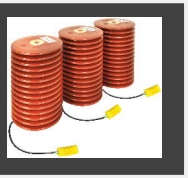
– Drastic reduction in repair costs and consequential costs
  • due to avoidance of heavy damages inside of the switchgear, of the equipment and of the direct environment

– Solution for locations with limited pressure relief opportunities
  • by application of active protection concepts

Unbeatable advantages by minimizing major and secondary effects of internal arc faults!

Proactive protection for electrical switchgear

Overview of concepts

Motivation	Switchgear with 100% passive protection concept 	Passive protection concept with fast arc detection relays 	Active protection concept with ultra-fast arc elimination devices 
Personnel safety under normal operating conditions	✓	✓	✓
Compliance to legal safety regulations & national standards	✓	✓	✓
Building protection	✓	✓	✓
Reducing switchgear damage to acceptable levels; Enabling money savings	×	✓	✓
Enhanced personnel safety with greatly attenuated arc fault „side effects“ also under maintenance conditions	×	×	✓
Minimizing mechanical and thermal impacts on equipment; Enabling money savings	×	×	✓
Building protection also for pressure sensitive environment	×	×	✓
Securing electrical power delivery; Increasing process / system availability	×	×	✓