
Safe and secure power distribution

Arc fault protection solutions



The Noble Art of Switchgear

Arc Fault Protection

Power system operation fault statistics reveal that a vast majority of the switchgear arc faults are caused by incorrect human actions or by aging network equipment. One way of reducing human-related or equipment-associated fault risks is to focus investments on technological solutions that enhance the operating environment.

The basic necessity of a switchgear arc fault protection system can be investigated from the probability aspect of arcing faults or from the aspect of their adverse effects. The perspective of investigation usually focuses on staff safety and security and on asset management. Both sectors are of essential business importance for network companies as well as industrial enterprises.





**Impacts of power system arc faults**

Electric arcs may cause instant and severe burns to persons happening to stay close to the fault, when it arises. Typically, this is the case if the arc incident is caused by an incorrect switchgear operation. The arc flash easily causes a fire, which, in addition to the immediate damage, also creates fire gases and consequential damage due to smoke and stain. The fire gases of burning electrical devices are particularly dangerous for people residing in the same area.

The effective life-time of distribution network equipment is typically in the range of decades. Network companies and industrial enterprises aim at maximizing the operational life-time of their equipment and to reach the financial goals.

Equipment fault proneness a function of time

As the life-time of electrical devices extends over decades, changes constantly occur in their operational proximity and the customer base they serve. The legislation and regulations may also change over the operational life-time of the equipment. For instance, a switchgear system, which originally was intended for limited supply of power to a small population centre, may later have to supply power to a shopping mall serving thousands of customers seven days a week. The role of the switchgear system may also have become more critical. Possible power outages may cause considerable economic losses to the customers.

Furthermore, the loading of the switchgear has grown and for this reason a second power transformer has been installed in parallel with the first one. In peak load situations the transformers can be run in parallel, which also causes the short circuit power to increase. At the same time the arc fault energy and the resulting damage in case of an arc fault increase.



Changing working manners pose risks

In power systems the maintenance need of the primary system equipment is generally small. Therefore the equipment maintenance intervals tend to be fairly long. There is also just a limited need to perform local control of such components as breakers and switches. Under these circumstances the personnel will not obtain the necessary experience to work with power system components. The personnel's lack of experience will pose an increased risk of making mistakes during maintenance work and fault clearance activities. The probability of accidental arc faults is also increased by changes in the utility's

work staff. The fact that when the current maintenance people of the network companies reach the age of retirement, the familiarity of the new staff with the network systems decreases on a local level. In addition, the need of the network companies to outsource maintenance functions further add to the risks of human errors.

Over the years the working conditions of the devices degrade. The aging and degeneration of protective structures and auxiliary furnishing expose the equipment to dust, moisture, temperature variations and rodents. The condition of the switchgear system is also affected by stress factors and excessive loading, which may cause untightening of joints and degeneration of bushings.



By investing in protective equipment such as arc fault protection, the safety and security of the switchgear system can be enhanced. The investment done in protection equipment will also extend the life-time of the switchgear installation, postponing possible investments in new switchgear or even substations to a later date.

Milliseconds that count

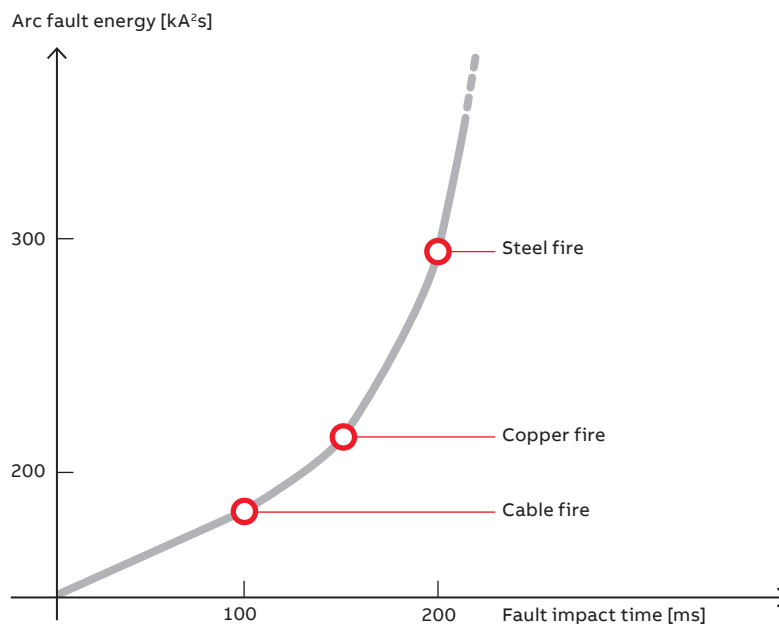
Time is a critical parameter in reducing the effects of arc faults, as the arc incident energy rapidly increases by time. An arc fault lasting for 500 ms may cause severe damage to the installation. If the arc flashes for less than 100 ms the damage is often limited, and if the arc is extinguished in less than, say 4 ms the damage will be insignificant.

Operating time

The operating time of the protection is the prime factor with regard to the elimination of the adverse effects of arc faults, seen not only from the point of view of staff safety and security, but also from the switchgear and environmental point of view. When the selectivity of the protection system is based on time grading, the protection operating time at switchgear faults is typically hundreds of milliseconds. With a separate busbar protection system a total operating time of about 100 milliseconds can be achieved, much depending on the speed of the circuit breaker.

By installing an arc fault protection system the operating time can be halved. This means that the switchgear damage is reduced to a tolerable level, typically limited to a single switchgear cubicle. A total operating time of a couple of milliseconds can be reached by using a separate arc flash eliminator for earthing the busbar. This procedure causes the electric arc to die out immediately at the moment of earthing. Due to the ultra-fast earthing function no significant pressure increase will develop in the switchgear system and no significant damage will arise.

— Arc fault damage as a function of the arc fault energy and the arc fault impact time.





Selectivity

In conventional arc fault protection solutions electrical faults in the cable terminations of outgoing feeders are typically handled by the busbar protection system, although these faults could be eliminated using the circuit breaker of the faulted outgoing feeder. Modern arc fault protection systems are not restricted by lack of selectivity. When an arc fault protection system is used the interruption caused by a cable termination fault affects only the consumer loads supplied by the faulted cable feeder. In cable termination faults the whole substation will normally be blacked out resulting in a much more widespread interruption of the power supply.

An earth-fault rapidly tends to develop into an arcing fault, because the operating time of the basic earth-fault protection system is usually relatively long. Arc fault protection systems are

also capable of detecting arcing faults between the phase conductors and the switchgear frame. Even in phase-to-frame faults the operating time of the arc fault protection system is as short as for inter-phase arc faults.

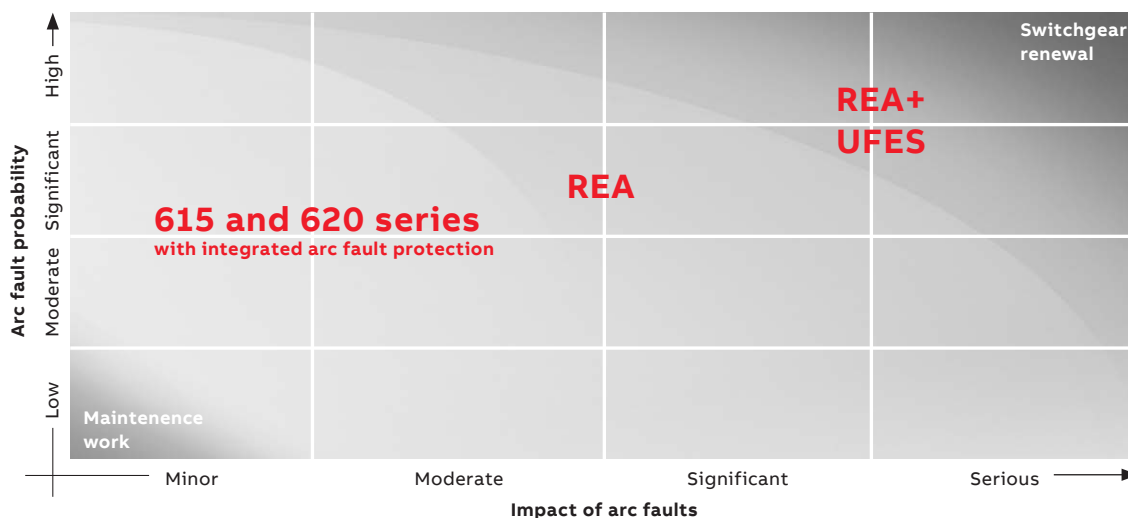
Redundancy

A reliable function of the protection system is of crucial importance for critical network nodes. These cases justify the implementation of a redundant protection system, fully independent of the basic protection system. An autonomous arc fault protection system perfectly fulfils this requirement, as its function is based on a different physical phenomenon than conventional protection solutions and on a dedicated technology.

An ABB solution for any application

ABB's arc fault protection systems provide appropriate solutions for both green field projects and retrofit installations.

The arc fault protection introduction tool presents a product portfolio diagram mapping alternative strategies and solutions.



From the comprehensive and compatible arc fault protection system assortment the customers can choose their solutions according to their own preferences. An already existing main protection scheme can be completed with an independent arc fault protection system or it can be upgraded by using protection relays with integrated arc fault protection in the basic functionality set-up. The ABB arc fault protection systems provide detection and isolation of arcing faults starting from either earth faults or from short circuits.

The selection of the appropriate arc fault protection system preferably starts with a risk mapping, which, on one hand, focuses on the probability of the development of an arc fault, and on the other hand, on the effects of a possible arc fault.

The probability of the development of arc faults is especially related to human factors but also to the structure and the state of the switchgear system, the physical stress imposed on the system and the environmental stress on the system.

In the evaluation of the consequences of arc faults the implications on the staff safety and security must be studied, as also the impacts on the power distribution, the buildings and

the rest of the proximity. Furthermore, industrial customers may suffer great losses of production due to arc faults.

The volume and type of investments needed to enhance the safety and security of the power system, and the reliability of the power distribution can be studied by performing risk analyses.

In the process of choosing an arc fault protection solution for an existing switchgear system, its expected remaining life-time is of significant importance. There are two alternative strategies to choose from. Either the operational life-time of the switchgear system can be prolonged by additional investments, or the whole switchgear system can be renewed.

In modern switchgear systems the probability of damage due to arc faults is comparatively low. Despite of that, it can, of technical and assembly reasons, be recommendable to provide the switchgear panel with a system-wide supervision solution serving for the whole operational life-cycle of the switchgear system.

Please contact your local ABB product or service sales in order to perform a risk mapping for an arc incidence in your power system installation.



The 615 and 620 series protection relays

with integrated arc fault protection are adapted to switchgear systems, which are important for the distribution network and its customers. In these systems the consequences of arc faults can be considerable to the personnel and the surrounding, although the probability of an arc fault is low. Due to the integration of arc fault protection into the basic protection set-up the 615 series relays present a universal solution. The operating time including detection and submission of a trip signal from the 615 series protection relays is typically 7–10 ms. The operating time of the circuit breaker (30–60 ms) will additionally delay the arc fault extinguishing.



The REA arc fault protection system

suits switchgear systems, where the damage to the proximity has been limited by means of constructional measures, but which are highly critical from the point of view of the distribution network and the customers. Switchgear systems having already served their time are examples of installations, in which REA arc fault protection easily can be installed afterwards. The REA arc fault protection system is also a perfect match for replenishing the protection system of double busbar switchgear systems. The operating time including fault detection and submission of a trip signal from the REA arc fault protection system is <2.5 ms. The operating time of the circuit breaker (30–60 ms) will additionally delay the arc fault extinguishing.



UFES (Ultra-Fast Earthing Switch)

is suited for switchgear systems, where staff safety and security, and switchgear arc fault and fire damage are crucial. Switchgear systems of shopping malls, buildings, mining industry, off-shore applications and other limited-size switchgear systems are typical examples of this category. The fault detection and elimination time of an UFES arc fault elimination solution is typically <4 ms.

REA and UFES as an integrated solution

meets switchgear systems, where staff safety and security is of great significance and the switchgear system is of utmost importance for the distribution network and its customers. Switchgear systems of this type are usually feeding hospitals, traffic nodes and process industry facilities. The typical operating time of the REA and UFES solution for detecting and eliminating an arc fault is <4 ms.



Our references speak for themselves

Over the past decade thousands of ABB arc fault protection systems have been delivered to over 40 countries worldwide. Systems have been installed in distribution systems of power utilities and heavy industry production facilities, such as paper, steel, petrochemical and chemical industry plants.

Arc fault protection systems have also been integrated in the power distribution systems of airports and harbours and in power distribution systems of commercial and society service facilities like shopping centres, water works and sewage treatment plants, also including marine and off-shore installations.



Helsinki International Airport, Finland

Aviaenergia Oy supplies secured power to the critical functions of the Helsinki Airport, including air traffic control and surveillance functions. In line with the company's strategic decision also the recently erected new 20 kV substation supplying power to the top ranking Helsinki

airport was equipped with ABB arc fault protection of the REA product line. Due to the location of the substation at the Helsinki airport, safety and security measures and possible outages caused by faults must be seen as part of the stringent airport safety program.



Detmarovice Power Plant, Czech Republic

The Detmarovice Power Plant was built 1972 through 1976, and with its capacity of 800 MW it is the largest coal-fired power plant in Moravia. In a modernization project the power plant had been equipped with ABB's modern REA arc fault protection. At an accident in 2002 the

REA system obviously saved the lives of two workers and minimized damage to mere smoke and dust detriment. The estimated repair costs would have mounted to approx. \$1.6 million USD, had the plant not been provided with arc fault protection.

Hanover Waterworks, Stadtwerke Hannover AG, Germany

Hanover's municipal utility supplies energy, water and other services to the citizens. The utility operates three waterworks providing drinking water to a total of 650,000 inhabitants in the metropolitan area of Hanover. The 50 years old switchgear system of the second largest Fuhrberg waterworks has recently been replaced by a

modern switchgear system including IEC 61850 compliant REF615 feeder protection and control devices with integrated arc fault protection. Arc fault protection was a necessity, because, according to the requirement, the switchgear system had to be re-energized within half an hour after a fault-related power outage.

Wacker Chemie AG, Germany

Staff safety and security is of number one priority to Wacker Chemie AG and its chemical plants. In this context Wacker Chemie also needs to minimize the arc fault hazards in connection with medium voltage switchgear systems. Wacker Chemie therefore needed a solution for minimizing the effects of such hazards.

ABB provided an innovative retrofit solution based on a new technology for arc elimination, the Ultra Fast Earthing Switch (UFES). The UFES system provides greatly enhanced staff safety and security during arc faults and radically minimizes arc-fault related damage.



Pellessmäki substation, Savon Voima Verkko Oy, Finland

Staff safety and security have always been put in focus at Savon Voima Verkko. Already in the 1990's the power utility took a decision that all new substations would be equipped with arc fault protection. The utility has also carried out upgrading projects concerning existing substations, in which ABB's REA arc fault protection systems were installed. As a network operator Savon Voima Verkko sees as its

duty to assure staff safety and security, and to maintain power supply even in fault situations. Besides improving constructions, instructions and guidance it is important that risks caused by human error also are considered in the protection system of substations. As outsourcing is used to an increasing extent in substation work today, the risks related to human errors are accentuated.

Yale University Medical Campus, USA

The most important aspect of any electrical system is to have the best protection available to the personnel working with and on these systems. A recent installation that utilizes ABB's REA Arc Flash Protection System at the Yale University Medical Campus for both bus protection and arc flash hazard reduction

experienced a bus fault resulting in an arc flash event. REA successfully detected the fault and cleared it before the traditional bus differential protection (87 function) could detect the fault and pickup. The quick response time of REA resulted in no injuries to nearby personnel and minimal damage to the switchgear.

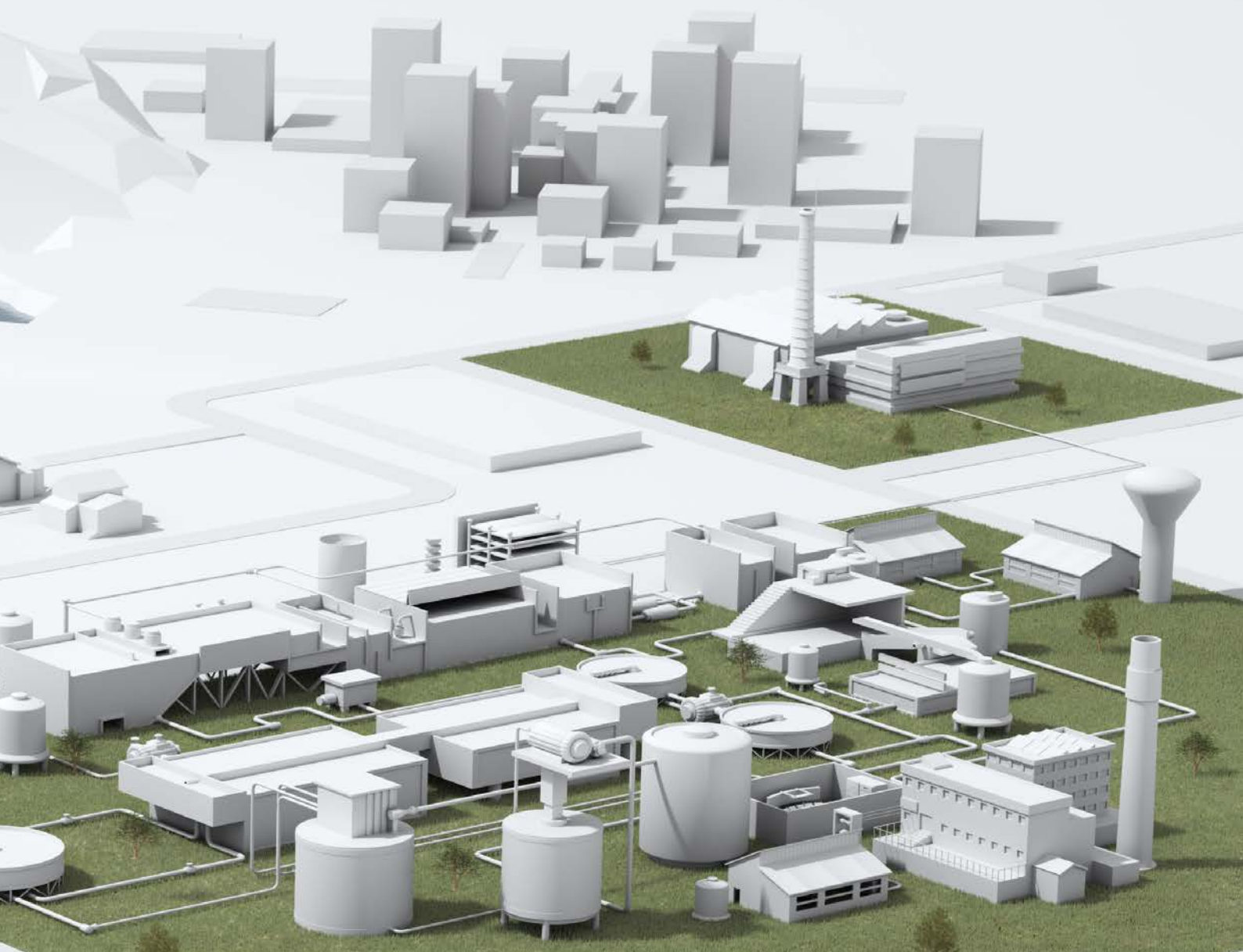




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