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APPLICATION NOTE
FIRE SAFETY CABLES

Selection and sizing of conductors supplying electrical equipment that must remain functional during a fire

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June 2014

Document Issue Control Sheet

Document Title:	Application Note – Fire Safety Cables
Publication No:	Cu0109
Issue:	03
Release:	June 2014
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Reviewer(s):	Roman Targosz

Document History

Issue	Date	Purpose
1	December 2010	Initial publication
2	September 2011	Improved and summary added, to publish it in the framework of the LE Good Practice Guide
3	June 2014	Reviewed

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SUMMARY

Cables that are exposed to fire while being expected to retain their functionality and provide power to essential equipment at another location must be appropriately selected and sized. This is not only a question of an appropriate insulation. Designers must take account of the increased electrical resistance at elevated temperature.

Manufacturers offer cables and accessories that will survive a standard cellulose fire for 30, 60 or 90 minutes when correctly specified and installed.

A first step to specifying a suitable fire safety cable is a good knowledge of the temperature rise characteristic in areas affected by the fire.

A second step is the correct selection and erection of the cable. This includes the correct sizing of the conductor. Cables, including fire safety cables, are specified in terms that reflect their normal duty conditions; design parameters under fire conditions are rarely, if ever, specified. The designer must take into account the consequent effects of the increased electrical resistance on current carrying capacity, voltage drop, short circuit capacity and mechanical strength of the conductors. Special care should go to the current carrying capacity of the conductor if it is to supply electrically driven fire pumps or elevators required for firefighting, since their motors could draw high starting currents. The circuit protection and related values (e.g. the touch voltage level) should also be adapted to fire conditions, as it must be designed to function with significant higher loop impedance than normal.

This paper provides a clear methodology for designing fire safety circuits based on the derivation and application of correction factors and standard cable parameters.

Having selected the appropriate cable, it must be installed properly, using suitable accessories and following the manufacturer's restrictions.

INTRODUCTION

The maintenance of safety services in a building during an emergency is vital if the situation is to be contained and the lives of occupants and emergency workers preserved. The first objective is to provide, as far as possible, safe evacuation routes from the affected areas and to ensure that all services required for fighting the fire are maintained for the required time. Another objective may be to ensure the preservation of services in areas of the building not directly affected by fire to provide a safe environment for evacuees from affected areas, pending complete evacuation, or the end of the incident. Finally, the preservation of property is important.

The time for which safety services are required to operate depends on the use of the building and the number and type of occupants involved. While it may be feasible to evacuate a dwelling or a small office building in a short time, larger or higher buildings, or those used by the public will take much longer[1]. The longer that safety services remain operational, the better the chance of bringing a fire under control and reducing property damage.

THE DEVELOPMENT OF A FIRE

The key to specifying a suitable fire safety cable is a good knowledge of the temperature rise characteristic in areas affected by the fire. Although the exact process depends on the location and materials involved, temperature-time curves have been developed to model some typical fires and are defined in standard EN 1363-2:1999:

- Standard temperature-time curve
- Hydrocarbon curve
- External fire exposure curve
- Parametric temperature-time curves
- Tunnel curves

The best known of these is the standard temperature-time curve illustrating cellulose fires, which is commonly used in the fire-testing of buildings. The standard temperature-time curve is expressed by the formula:

$$T = 345 \log(8t + 1) + 20$$

where:

T – temperature, in °C

t – time, in minutes

Figure 1 shows the temperature rise against time curve of the development of a cellulose-fuelled fire i.e. a fire fuelled mainly by wood and wood-based materials such as paper.

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[1] Following an explosion in World Trade Center 1 in 1993, the evacuation took more than 4 hours during which over 1000 people were injured, many due to smoke inhalation. Fortunately, the fire had been extinguished.
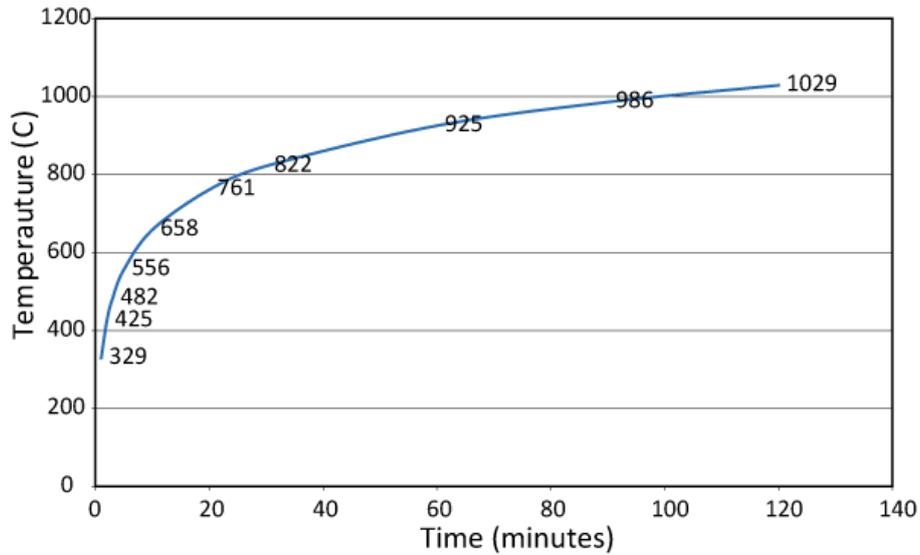
Figure 1 – Time – temperature for standard cellulose fires [1].

About 30 minutes after the initiation of a building fire the temperature reaches about 850°C and continues to grow after that.

The rate of a building fire development depends on many factors, but most importantly on the fire load density. The fire load, expressed in mega-joules per square metre (MJ/m^2), is the average calorific value of combustible materials per square metre of the building floor area or of a fire zone area within the building. The building structure, type and function, as well as external factors, also have an effect.

Where other materials are involved, such as hydrocarbon fuels, the growth of the fire may be faster and reach a higher temperature, as illustrated in Figure 2. In this case additional protection must be provided for the cable, for example, by using fire resistant ducts as well as fire safety cables.
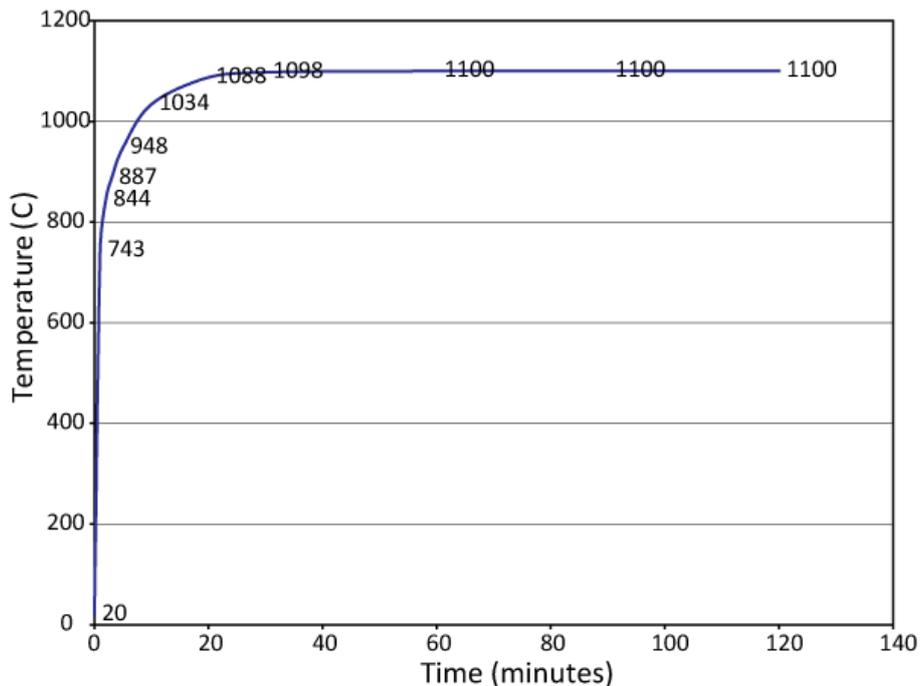

Figure 2 – Time - temperature characteristic for hydrocarbon fires.

The characteristic of a tunnel fire is shown in Figure 3. This curve was developed by the Rijkswaterstaat (ministry of transport) in the Netherlands. It is based on the assumption that, in a worst case scenario, a 50 m³ fuel, oil or petrol tanker fire with a fire intensity of 300 MW could occur, lasting up to 120 minutes. The curve was based on the results of testing carried out in the Netherlands in 1979 and recently confirmed in full-scale tests in the Runehamar tunnel in Norway.
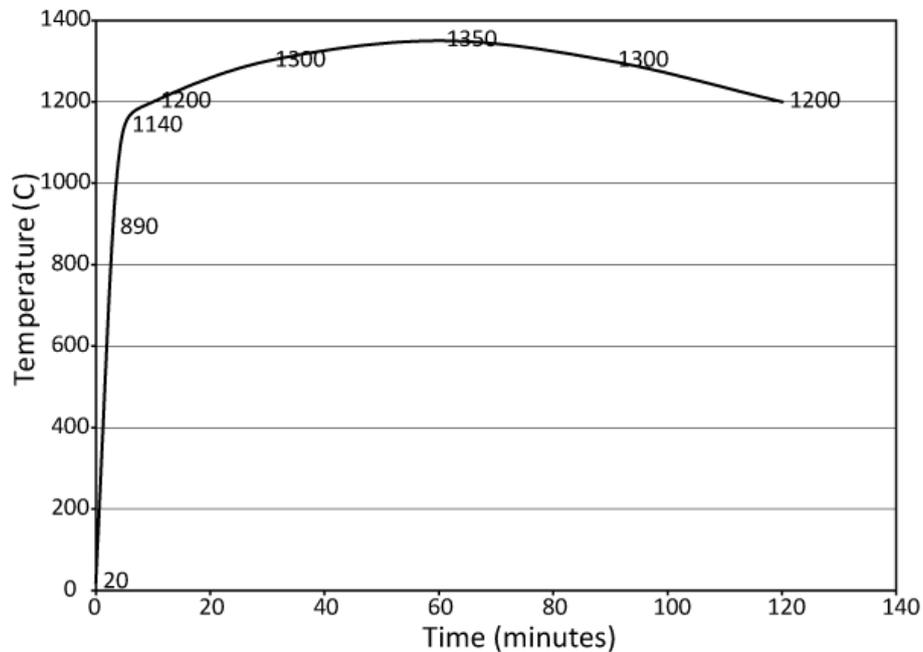

Figure 3 – Time - temperature for tunnel fires.

These graphs illustrate the models used for testing and assessment of fire protection materials. Real fires are different in that the temperature profile is far from constant. For example, in the Channel Tunnel fire in 1996, which burned for seven hours, the general temperature is thought to have reached around 800 °C with hot spots of up to 1300 °C where hydrocarbons were locally involved.

FIRE SAFETY CABLES

Enhanced fire protection is required wherever there is increased risk due to high levels of occupancy (especially by people unfamiliar with the environment), by the nature of the activities normally carried out, or because the potential consequences may be unacceptable in terms of loss of life, loss of historical artefacts, economic losses, etc. Typical locations include:

- Public buildings and spaces – cinemas, theatres, hotels, museums, transport hubs and shopping centres
- Buildings with vulnerable occupants – schools, hospitals and day-care centres
- Where evacuation and rescue access may be difficult – mines, tunnels
- Hazardous locations – chemical manufacture and storage, bulk powder storage
- Sensitive infrastructure – data centres, communications facilities, banks
- High-rise buildings, in which fire could spread extremely fast, which could hamper firefighting and human evacuation

The type of equipment that needs to be available during a fire includes:

- Smoke venting systems, including pressurisation and depressurisation fans
- Electrically operated fire shutters and smoke curtains
- Firefighting elevators
- Sprinkler and wet-riser pumps
- Equipment for explosion prevention and suppression
- Command and communications systems, including audible warning devices and public address systems
- Lighting

Since the normal cables commonly used for electrical installations would be damaged at temperatures much lower than those experienced in a fire, only cables and wires specifically designed for the purpose should be used for fire safety duty.

SELECTION AND ERECTION

The important considerations when installing fire safety services are:

1. Fire safety cables are characterised in terms of the minimum time for which they are required to remain functional in a fire as circuit integrity classes E30, E60 and E90 (DIN VDE 4102 part 12) or fire resistance classes PH15, PH30, PH60 and PH90 (EN-50200). Remaining 'functional' means that the cable retains sufficient mechanical strength, insulation resistance and current carrying capacity to maintain circuit integrity and operation of the load. Because of the high conductor temperatures experienced during a fire, the resistance is much higher than during normal service and this must be taken into account in the design stage.
2. Fire safety cables should be installed in continuous lengths without joints – it is normally available in lengths up to 500 m. If joints are essential, they should be carefully located in areas of lower risk and given adequate additional fire protection.
3. The route should be carefully planned to avoid areas of particularly high fire risk, such as areas used for fuel or chemical storage and handling, powder handling and paper file storage. Fire safety services should be kept separate from other cabling. Where cables are installed in vertical ducts or risers, fire

stops must be provided[2] (as is required for all cables) to prevent fire spread in the event that the enclosure is breached. All cable accessories (mounting clips, etc.) should have a fire rating similar to that of the cable to avoid the extra mechanical stress that could occur in the event of failure of restraining clips. Installation restrictions, such as minimum bend radius, should be strictly observed. Fire safety services must be installed above a sprinkler system to avoid contact with water, which would rapidly reduce their insulating properties.

4. Where the expected fire temperature (or the required exposure time) is greater than that provided by fire safely cables, the installation route must be provided with additional fire protection. This may apply, for example, to hydrocarbon fires or tunnel fires.

5. Power supply circuits of equipment which operation is vital during a fire must consist of copper conductors or copper core cables. They must have a TN earthing connection and a short-circuit protection, but do without residual current breakers and overcurrent protection.

Cable construction

Three classes of safety cables are available for application under fire conditions, i.e. those with ceramizing silicone-rubber insulation, those with mica tape wound under a polymer insulation and copper-clad mineral insulated cables. Generally, safety cables satisfy the following requirements:

- Halogen free
- Fire retardant according to IEC 60332-3
- Low smoke generation according to IEC 61034-1 and -2
- No emission of corrosive gases according to IEC 60754-2
- Insulation integrity according to IEC60331
- Circuit integrity according to DIN 4102 part 12, or other national standards

Fire safety cables are tested by heating them in a furnace with a temperature with a temperature profile according to, e.g., DIN 4102-Part 12 which follows the standard cellulose fire model. Because of the large amounts of energy taken up by chemical reactions in the cable insulation and sheathing materials during heating, the conductor temperature lags considerably behind for the first thirty minutes but then closely follows the furnace temperature.

Circuit integrity classes are listed in Table 1. The standard defines requirements and test method for fixings, cable ducts, sheaths, protective conduits and connectors. The test determines the time for which the system remains functional during a test fire where neither short circuit nor a current interruption occurs in the test installation.

No.	Circuit integrity class	Minimum maintenance of functionality time
1	**E 30**	$\geq$ 30 minutes
2	**E 60**	$\geq$ 60 minutes
3	**E 90**	$\geq$ 90 minutes

Table 1 – Circuit integrity class E – according to DIN 4102-12 [3].

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[2] In 1975, a fire in an office suite on the 11th floor of World Trade Centre 1 spread over 6 floors in the risers housing power and communications cables because they had large floor openings and no fire stops. Fortunately, the fire did not break out of the riser. The fire burned for three hours, badly damaging part of one floor by fire (900 m^2) and six floors by smoke and water. Cost: $2 million.

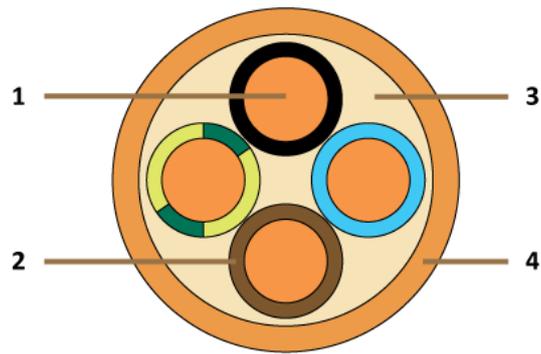Typical cable constructions are illustrated in Figure 4, 5 and 6.

Figure 4 – Fire Safety Cable with ceramizing insulation (1: bare copper; 2: ceramizing halogen-free insulation; 3: inner covering; 4: halogen-free outer sheath).
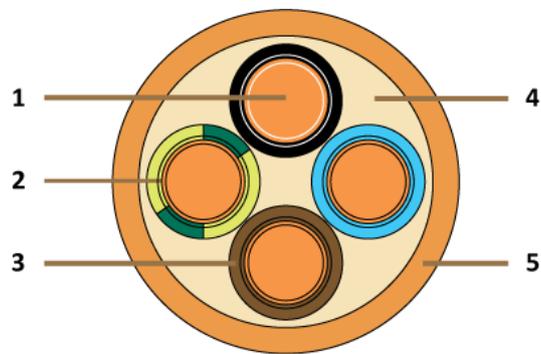

Figure 5 – Fire Safety Cable with mica insulation (1: bare copper; 2: mica tapes; 3: halogen-free insulation; 4: inner covering; 5: halogen-free outer sheath).

Figure 6 – Mineral insulated cable.

CONDUCTOR SIZING

The resistance of the conductors in a cable subject to fire will increase by a factor of about 4.5 compared with that at normal temperature. This must be taken into account when choosing the cable conductor cross section. More specifically, it must be considered that:

1) The voltage drop at high temperature must be sufficiently low to allow equipment to start and run effectively
2) The circuit protection scheme must be designed to function with significantly higher loop impedance than normal

In normal electrical applications, the resistance of a copper conductor can be calculated by the following formula, which is valid up to about 200 °C:

$$R = R_{20}(1 + \alpha_{20}\Delta T)$$

where:

R_{20} is the conductor resistance at 20 °C, in Ω

α is the temperature coefficient of resistance at 20 °C, per K, namely α = 0.0039 for copper

$\Delta T = T_k - 20$ is the temperature difference, in K

T_k is the final temperature, in K.

At temperatures higher than 200°C, the relation describing the conductor's resistance becomes non-linear and is given by the formula:

$$R = R_{20}(1 + \alpha_{20}\Delta T + \beta_{20}\Delta T^2)$$

where:

$\beta_{20} = 6.0 \times 10^{-7} \ K^{-2}$

Alternatively, application of the Wiedemann-Franz law yields:

$$R = R_{20}\left(\frac{T}{T_{20}}\right)^{1.16} = R_{20}\left(\frac{T}{293}\right)^{1.16}$$

where:

R is the resistance at temperature T

R_{20} is the resistance at 20 °C (293 K)

T is the temperature in K. i.e., temperature in °C + 273.

Neither approach is particularly accurate, resulting in an increase of the resistance values by a few percent. However, given the many uncertainties in a real fire situation, this small uncertainty is of little practical consequence. The important result is that the resistance of a conductor specified at 70 °C is increased by a factor of about 4.5 under PH90 conditions. Equation 4 is used for all calculations in this paper.

Because buildings are often compartmentalised into fire zones to reduce fire spread, cables feeding fire protection equipment are rarely exposed to fire temperatures over their entire length. The part of the cable not affected by the fire will operate at the normal temperature appropriate to the loading, while that exposed to fire has increased resistance. The task of the designer is to assess which areas may be simultaneously affected by fire in the worst case and assess the proportion of cable length that may be affected. The total conductor resistance is then calculated by assuming normal resistance for the length unaffected by fire and applying a multiplication factor to the length that is affected.

$$R_T = \frac{\big((100 - y) + (xm)\big)R_N}{100}$$

Where

R_T is the resistance of the conductors, in Ω

R_N is the resistance of the conductor under normal conditions, in Ω

y is the percentage of the cable length estimated to be affected by fire

m is the resistance factor appropriate to the fire conditions as Table 2

Correction factors for parameters specified at 70 °C	Required survival conditions		
	PH30	PH60	PH90
m	3.84	4.27	4.52
$\sqrt{m}$	1.96	2.07	2.13

Table 2 – Correction factors for cables at required survival conditions

Alternatively,

$$R_T = qR_N$$

Where:

R_T is the resistance of the conductors, in Ω

R_N is the resistance of the conductor under normal conditions, in Ω

q is the resistance factor appropriate to the fire conditions and the proportion of conductor affected as given in Table 3.

Proportion of cable length in hot zone [%]	Coefficient of resistance increase of cable conductors (q)		
	Class E30 conditions	Class E60 conditions	Class E90 conditions
0	1.00	1.00	1.00
10	1.28	1.33	1.35
20	1.57	1.65	1.70
30	1.85	1.98	2.06
40	2.14	2.31	2.41
50	2.42	2.64	2.76
60	2.70	2.96	3.11
70	2.99	3.29	3.46
80	3.27	3.62	3.82
90	3.56	3.94	4.17
100	3.84	4.27	4.52

Table 3 – Coefficients of resistance increase for cable conductors under fire conditions.

The increased resistance must be taken into account in calculating the appropriate size of a conductor to maintain the voltage drop within required limits and to ensure that the protective circuits can operate effectively.

Sizing the cable requires a progressive assessment of current-carrying capacity, voltage drop, and short circuit performance, with the selected size being the largest size that results from these requirements. The next sections provide a process for selection using commonly quoted 70 °C parameters.

CURRENT-CARRYING CAPACITY

Normally, the current-carrying capacity of a cable is specified as that which will result in a particular conductor temperature rise under nominal installation conditions. Typically, cable tables give data for a 70 °C conductor temperature, which corresponds to a 40 K rise. Under PH90 conditions the surrounding temperature is 986 °C, which is only about 100 K below the melting point of copper. In order to ensure that the conductor does not melt – which would be accompanied by a large increase in resistance that would destroy integrity – it is necessary to limit the power dissipated in the cable. A simple approach is to limit the power dissipated in the conductor under fire conditions to a value similar to that in normal operation. However, as usual, the current value to be used is the rating of the protective device, rather than the actual load current.

$$P_H = I_H^2 R_H \leq P_N = I_N^2 R_N$$

where:

P_H is the power dissipated in a unit length of conductor at the load current under fire conditions, in Watts

I_H is the nominal rating of the protective device, in Amps

R_H is the resistance of a unit length of conductor under fire conditions, in Ω

P_N is the power dissipated in a unit length of conductor for a conductor temperature of 70 °C

I_N is the normal rated current of the conductor at 70 °C

R_N is the resistance of a unit length of conductor at 70 °C.

Hence,

$$I_H^2 \leq \frac{I_N^2}{R_H} = \frac{I_N^2}{m}$$

$$I_H \leq \frac{I_N}{\sqrt{m}}$$

The current carrying capacity, quoted for the cable for normal duty in embedded conduit, must therefore be $\sqrt{m}$ times the current carrying capacity required under fire conditions.

As an example, a cable is required to carry 10 A under PH90 conditions. The protective device is rated at 16 A, so the cable must have a current carrying capacity, at 70 °C conductor temperature, of $\sqrt{m}$ times 16 A, this is 16 * 2.12 = 34 A. As a result, a 10 mm^2 conductor might be chosen.

CIRCUIT PROTECTION

The protection of fire safety circuits is similar to that for other circuits – automatic disconnection of supply within the required maximum time as specified in standard IEC 60364, Part 41 or in local derivatives.

Residual Current Circuit Breakers (RCCB) should not be used for protection of fire safety circuits because of the high reliability requirements of the functions served. At the high temperatures involved, leakage currents between live conductors and from live conductors to earth increase due to ionisation of the insulation leading to uncontrolled tripping of RCCBs and loss of safety.

Because it is recommended that fire safety cables are installed in single un-jointed lengths, it follows that each circuit will be separate with a dedicated protective device at the origin. Obviously, it is essential that this distribution panel is in a secure location where the risk of being affected by fire is minimised as far as possible.
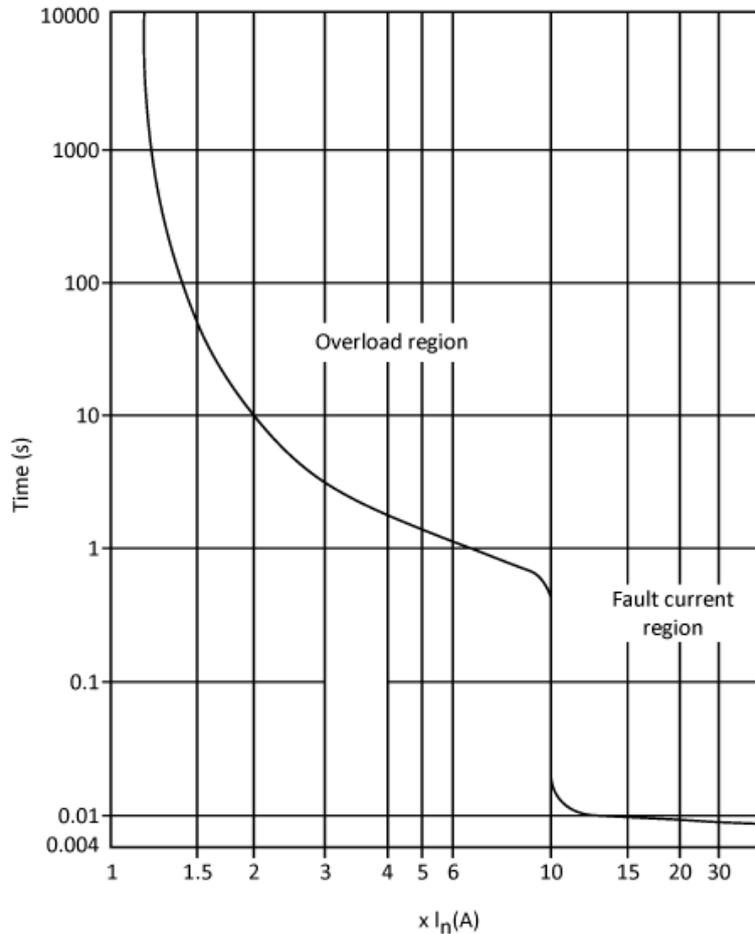
Figure 7 – Characteristic of a typical miniature circuit breaker.

The characteristic curve of a typical circuit breaker is shown in Figure 7. The so-called 'inverse time' part of the characteristic is designed to protect against over-current. It allows for substantial short overloads without tripping, because the rate at which the cable conductor temperature rises due to the extra heat generated is relatively slow due to the high specific heat of the copper conductors. As the over-current level increases, the time to respond reduces rapidly to restrict the rise in temperature and reduce the risk of damage. The characteristic takes advantage of the inherent short time over-current tolerance of the cable and allows short duration inrush currents to flow without tripping the breaker.

The instantaneous characteristic is intended to respond very rapidly to fault current. Fast action is needed because fault currents are high enough to pose a high risk of damage to load circuits.

It must be remembered that the objective of protecting a fire safety cable under fire conditions is very different from normal circumstances. In normal circumstances, the cable itself must be protected from damage to preserve its future service life, while under fire conditions, the functionality of the service provided must be preserved while the cable has no remaining useful life. In any event, the existence of a significant overload condition under fire conditions will inevitably lead to loss of the circuit and the functionality of the load due to either cable damage or operation of the breaker. There are some mitigating factors. Firstly, the circuit is likely to supply fixed equipment, so it is not subject to random changes in the same way as other final circuits, and it is not likely to be overloaded as long as the circuit and its load equipment remain undamaged. Secondly, the conductor is already oversized, so it has a considerably higher thermal capacity than normal, giving some protection against short overloads.

Protection against fault current is very important because a fault may pose a danger to rescue services and may be the cause of fire spread. Meeting the fault current criterion requires that the loop impedances – both the line-neutral and line-protective conductor loops – are sufficiently low for the protective device to operate if a fault should occur at the remote end of the circuit. It must be remembered that the tolerance on the instantaneous trip current of circuit breakers is rather wide – the actual trip current may be up to twice the nominal current.

Care should be taken to ensure that the protective device is capable of breaking the prospective short circuit current at the source. This level is likely to be higher than normally encountered in a final circuit because the circuit origin is likely to be electrically closer to the point of common coupling to improve resilience.

The unit conductor resistance under fire conditions is:

$$R_h = rm$$

where

R_h is the resistance of one metre of conductor under fire conditions, mΩ

r is the resistance of one metre of conductor at 70 °C (from cable tables), mΩ

m is found from Table 2.

The circuit loop resistance is[3]:

$$R_H = rqL \; m\Omega$$

where R_H is the loop resistance under fire conditions, in mΩ

r is the resistance of one metre of conductor at 70 °C (from cable tables), in mΩ

q is found from Table 3

L is the length of conductor in the loop, in metres.

Continuing the earlier example, the circuit breaker has a nominal current rating of 16 A and, for a class D device, a maximum instantaneous breaking current of 640 A. The maximum permissible loop impedance is therefore 0.36 Ω.

A 10 mm^2 conductor has a resistance of 2.8 mΩ per metre at a conductor temperature of 70 °C and 12.66 mΩ under fire conditions. Given the maximum permissible loop resistance of 360 mΩ, the maximum length of 10 mm^2 conductor subject to fire would be around 28 metres – or a circuit length of just 14 metres. The conductor size must be increased until a suitable size is found.

If automatic disconnection cannot be guaranteed in a reliable way, a reduction of the maximum touch voltage U_T to the conventional level $U_L \leq 25$ V is allowed. In order to guarantee an effective protection against electric shock in such a case, all accessible conductive parts of the protected equipment must be bonded to the main earthing bar of the building.

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[3] We simplified the calculations by taking only the resistive part of the impedance into account; the reactance is of minor importance here.

The required cross-section S_{PE} of the protective conductor is:

$$S_{PE} \geq \frac{I_a \cdot l \cdot k_p}{\gamma \cdot U_L}$$

where:

l is the length of the protective conductor that connects the equipment to the main earthing bar [m]

I_a is the current that trips the protection of the feeder circuit of the equipment [A]

γ is the conductivity of the protective conductor [1/Ω.m]

k_p is the ratio of the protective conductor resistance to R_{20}

U_L *is* the conventional touch voltage limit, i.e. 25 V.

VOLTAGE DROP

Because of the importance of voltage stability to the proper working of any electrical or electronic device, the voltage drop between the incoming supply at the point of common coupling and the terminals of the end-use equipment should be limited to 5% under normal conditions and 10% under emergency conditions.

If the protection conditions mentioned above have been met, it is almost certain that the voltage drop requirement has also been met. If the short circuit current under fire and fault conditions would be > 20 times the load current, then the voltage drop under fire conditions would be less than 5%. In case of doubt, the voltage drop can be calculated from the circuit loop impedance (see page 12).

However, there are two very important and related considerations:

- Some equipment, such as fire pumps, may be brought into use some time after the fire has developed. Equipment of this type often requires very large starting currents and these must be taken into account if the equipment is to be available for use when required.
- A fire safety circuit may supply a number of co-located items of equipment. In that case it is necessary to examine the effects of starting a heavy load on the performance of items already running. Some quite simple devices, such as electromagnetic contactors, are very sensitive to reduced voltage operation. If the voltage drop is too high, contactors may release and shut off other vital equipment, adversely affecting the ability to fight the fire, survive in the immediate environment, or make a safe escape.

MOTOR STARTING CURRENTS

Electrically driven fire pumps present a particular problem because they draw starting currents many times higher than the running current. The fire safety circuits supplying them must be designed to supply this starting current under fire conditions.

Squirrel-cage induction motors are normally used in fire pumps drives because of their simple construction and high reliability. However, their starting currents are normally five to eight times their nominal running current and the power factor varies with load. Deep-bar or double-cage induction motors have much smaller starting currents and higher starting torque than normal design squirrel-cage induction motors. In addition, the power factor of an induction motor is low during low-load starting. Larger motors – above 5.5 kW – are normally provided with starter systems to reduce the starting current.

The motor torque is proportional to the square of the line voltage so a decrease in the supply voltage of only 10% results in a torque decrease by 19%. An excessive voltage drop at the motor terminals may cause the motor to stall.

The speed-torque characteristics of a squirrel-cage induction motor, at different supply voltage values are shown in Figure 8.
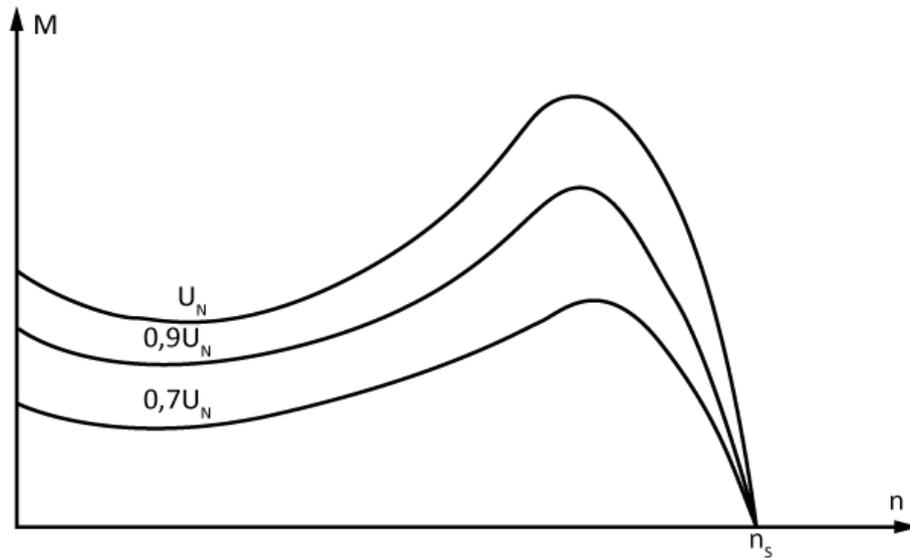

Figure 8 – Speed-torque characteristic of a squirrel cage motor against supply voltage.

The voltage drop in a squirrel-cage induction motor feeder circuit during motor start should not exceed the values given in Table 4.

Motor start type	Permissible voltage drop ΔU [%]
Low-load starting	35
Heavy duty starting, frequent	15
Heavy duty starting, occasional	10

Table 4 – Permissible voltage dropduring motor starting.

The voltage drop in a squirrel-cage induction motor feeder circuit during motor start can be calculated from the formula:

$$\Delta U_\% = \frac{100 \times \sqrt{3}}{U_n} \times (R_T \times \cos \varphi_r + X \times \sin \varphi_r) \times I_r$$

Where:

R_T is the motor feeder circuit resistance under fire conditions, calculated using equation 6 or 7, in Ω

X is the motor feeder circuit reactance, in Ω

U_n is nominal voltage, in Volts

I_R is the motor starting current, according to manufacturer's data, in Amps

$\varDelta U\%$ is the permissible percentage voltage drop at which starting can be guaranteed, according to manufacturer's data

$cos\varphi_r$ is the power factor of the motor at start-up, according to manufacturer's data.

Since the power factor of an induction motor is low during start-up, the reactance of the circuit should be taken into account when calculating voltage drop.

Because of the high starting current and high circuit resistance, it will be necessary to oversize the circuit conductors appreciably. Methods of reducing the starting current by wye-delta switching or soft starting [4] should be considered, although oversizing will still be necessary.

PHYSICAL INSTALLATION

Having selected the appropriate cable, it must be installed using suitable accessories with a similar level of fire resistance. The manufacturer's restrictions on bending radius must be strictly observed and the mounting arrangements should be such that the cable will not sag under fire conditions.

The feeder of the safety services' switchboard must have a 90 minutes fire resistance, it must be water-resistant or protected against water, and it must be connected upstream from the fire switch to avoid that it gets disconnected in case the fire switch is opened.

Note: The increase of the conductors' electrical resistance in case of a fire can be neglected if the cables are laid inside an approved fire resistant cable duct of which the manufacturer can guarantee that the temperature inside the duct will not surpass 100°C.

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[4] *'Basics for practical operation Motor starting', Rockwell Automation,*

http://literature.rockwellautomation.com/idc/groups/literature/documents/wp/mot-wp003_-en-p.pdf

CONCLUSION

Fire safety circuits require a careful design if they are to perform well. The designer must take into account the increased electrical resistance of the conductors under fire conditions and the consequent effects on current carrying capacity, voltage drop and short circuit capacity. This paper has discussed how simple multiplication factors can adapt the standard 70 °C parameters for cable sizing and predict performance under fire conditions.