Safety Design in Buildings

Kuwait Conference

Wednesday, December 06, 2017, Crowne Plaza Kuwait

Do your fire performance cables really give you the performance you are expecting?

Evolution of protocols for testing electrical cables for fire safety has led to an important divergence between the fire performances provided by the cables and the fire performances expected by customers.

The understanding amongst most users of fire safety cables is that the products they buy and use and specify will provide a level of fire performance in real emergency conditions commensurate with the performance implied by the testing procedure.
Unfortunately this is most often not the case.

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Jamie Groves

Sales Director

Mineral Insulated Cable Company Ltd

Jamie Groves is Sales Director MICC Group, the World's largest manufacturer of mineral insulated cables. Mr Groves has worked in sales and marketing for over 20 years and has a BSc Hons degree in media and marketing.

For the last 7 years he has travelled the globe promoting and selling MICC's World's leading fire survival cable, including over £2m of cable sales installed at the Kuwait University campus in their shelters.

His role is first and foremost to educate all levels of the supply chain, from end users to contractors, on the facts behind the standards, materials and manufacturer claims, helping customers make more informed choices the correct selection of the right fire proof cable for the application.

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Learning Objectives

- Distinguish between the real performances of essential wiring systems.
- Understand Global best practice for electric cables which enable life safety and firefighting interventions
- Dispel the media and advertising hype behind manufacturer's claims on cable fire safety based on material facts.

The purpose of this presentation is to convey technical knowledge to the conference participants.

The presentation also contains slides with text that summarises the content of the presentation and the main learning objectives.

These may be used to update CPD records for relevant organisations including the Chartered Institute of Building (CIOB).

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Cable Facts; What you need to know

Fire Proof Wiring Seminar

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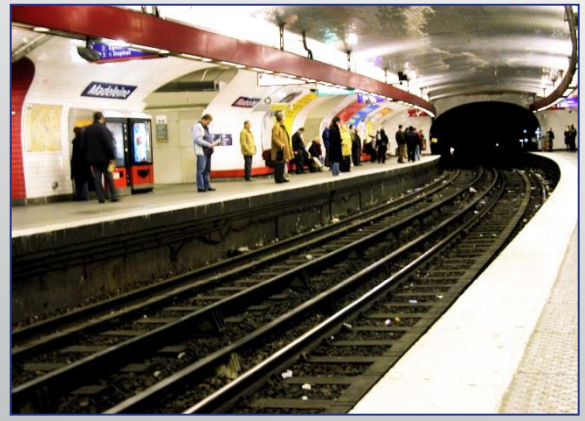
Fire Safe Wiring Systems

This presentation provides a clear, unbiased technical comparison of the fire performances for essential wiring systems designed to comply with current regulation based on materials and technology.



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The facts…….

Life safety and firefighting equipment often relies on the integrity of the essential wiring system to enable evacuation & firefighting operations.

British and IEC cable standards for fire resistance are common, but there are significant shortcomings to these standards which leads to products entering the market which may pass the tests but are unlikely to provide the intended performance in service.

In addition, the BS and IEC standards used for flame retardance, smoke and toxic combustion by-products testing of cables also have limitations resulting in the misleading assumption that cables so tested will be flame retardant, low smoke or limit toxic by-products under emergency conditions.

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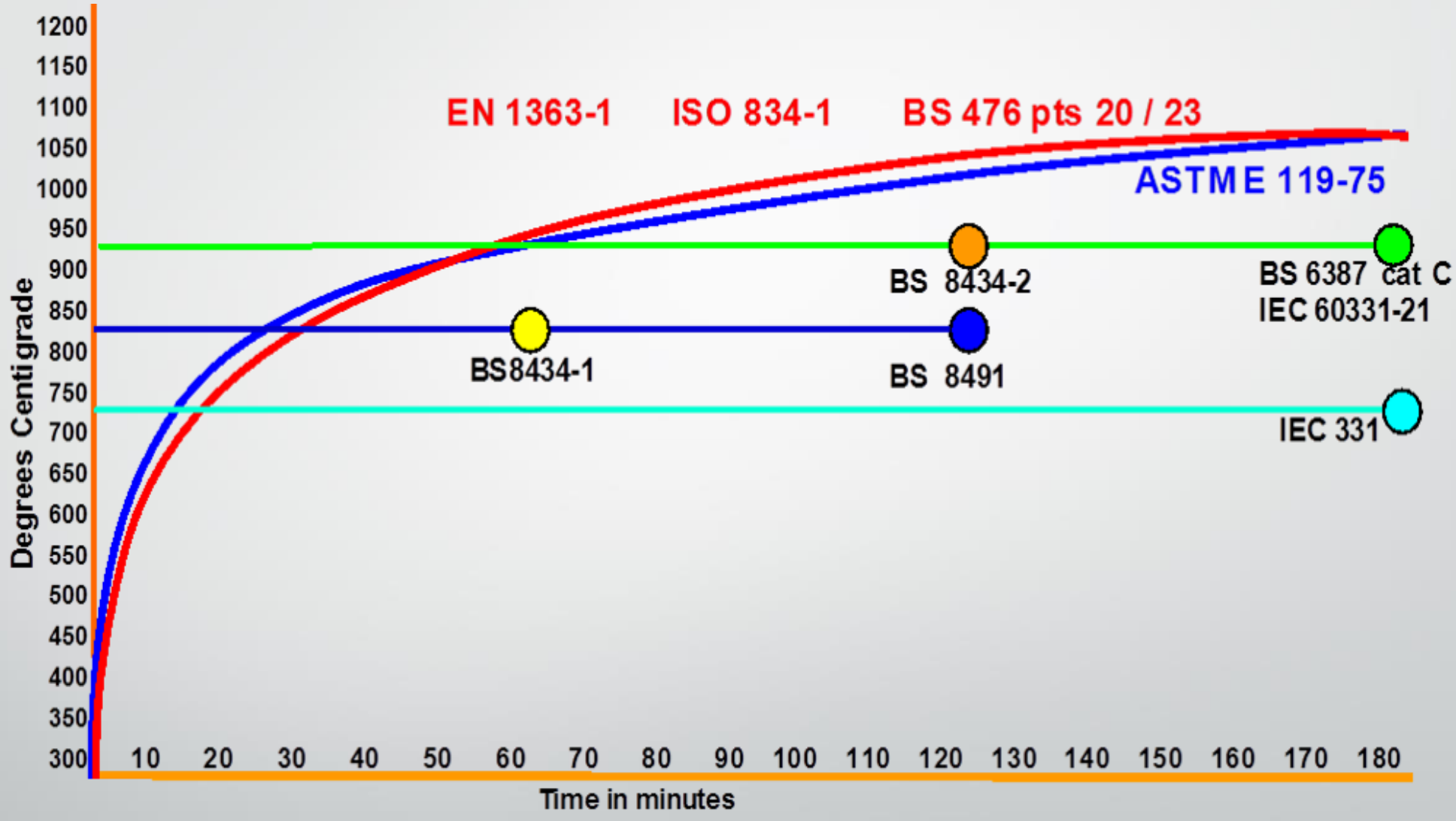

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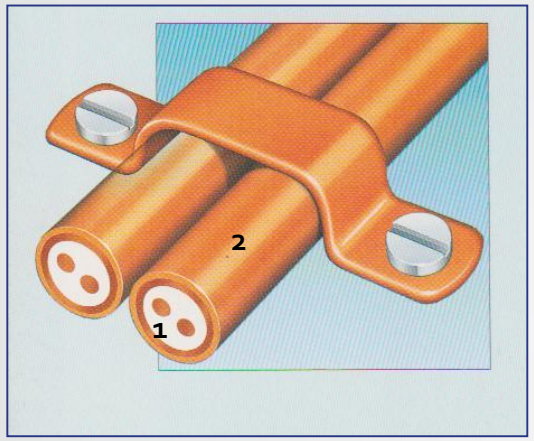
Three technologies for fire resistant wiring systems:

MICC - surface



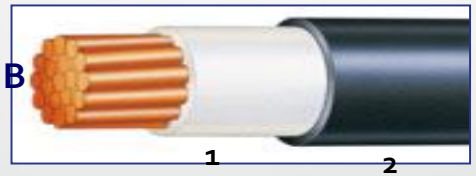
1) Magnesium Oxide insulation
2) Copper jacket

Polymerics - surface

A

1) Glass Mica Tape
2) XLPE or EPR or Polyolefin insulation
3) HFFR or LSOH jacket

B



High Ash Residue (HAR)

1) Ceramifiable or Silicone based
2) HFFR jacket

Thermal protection - buried

2" of concrete

Boxing or Trenching

Wrapping

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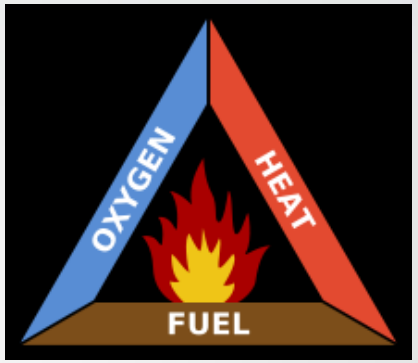
What is a fire ?



We know a fire requires three fundamental elements:

- **A fuel source**
- **Air (Oxygen)**
- **An ignition source**

It should be remembered that anything will burn if you get it hot enough so Initial / ambient temperature is critical

In a building or installation we generally consider two types of fuel/fire loads:

- **The fixed fire load** **(immobile)**
- **The temporary fire load** **(mobile)**

The **fixed fire load** is the building itself and all component parts and systems needed to make it work: This includes installed cables, conduits ceilings, walls, floors, fittings. (Often polymeric cables can represent the biggest fixed fire load in many installations)

The **temporary fire load** is what people bring into the building: This includes furniture, computers, curtains etc. and for shops the merchandise, decorations

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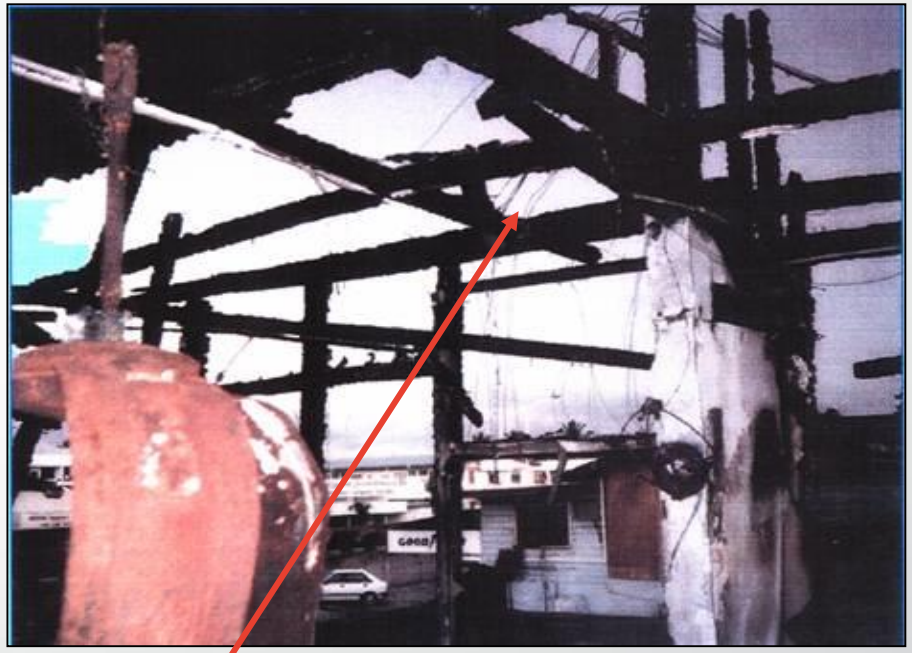
Fire effects in above ground building environments



Notice copper conductors have not melted.
Fire Temp < 1,083 Deg C

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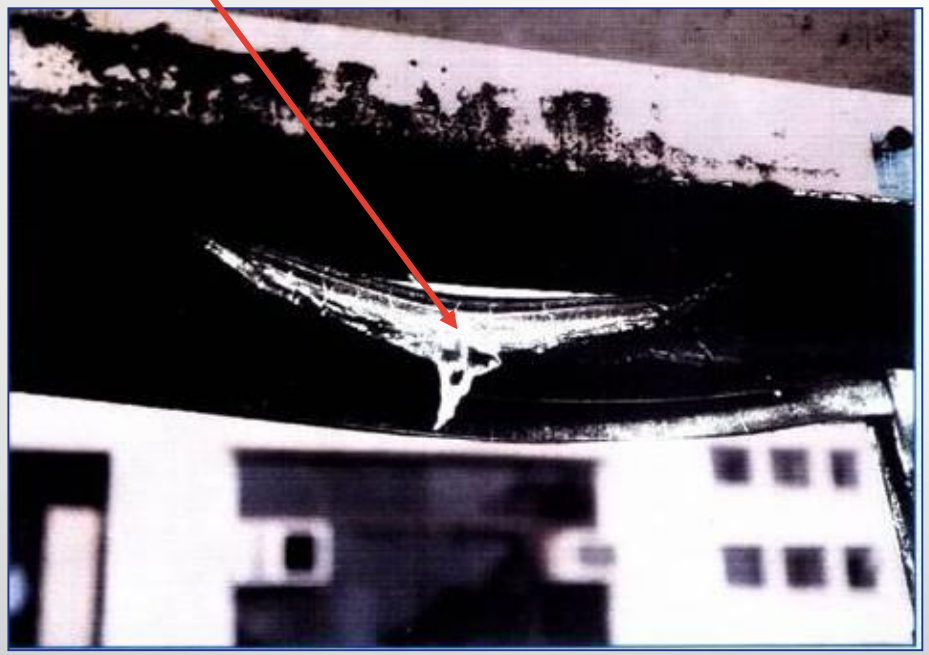
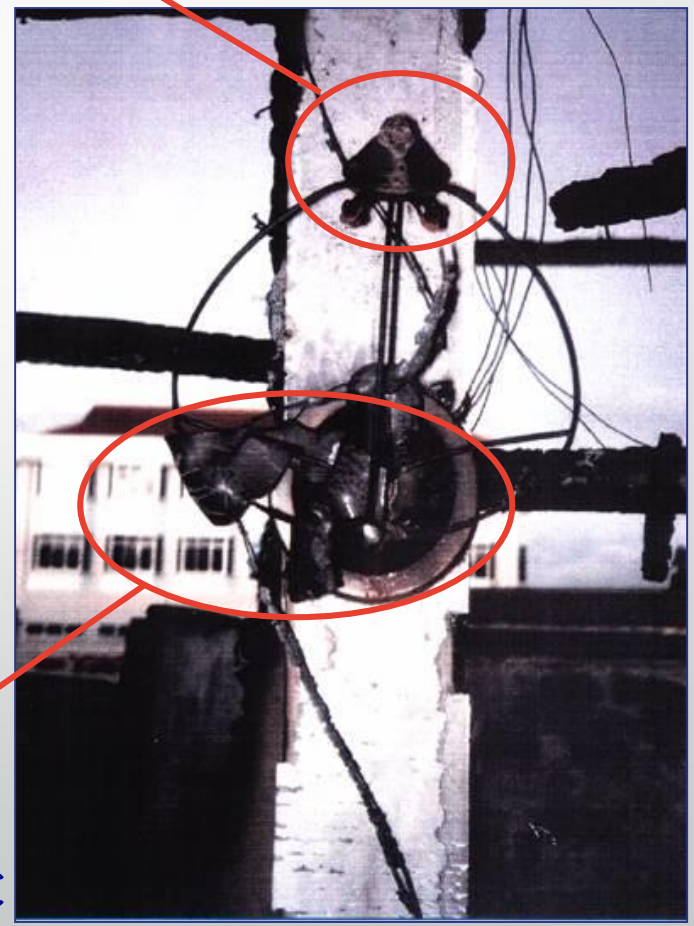
Fire effects in above ground building environments

Notice aluminum window frame started to melt.
Fire Temp > 660 Deg C



Brass decoration melted
Fire Temp >950 Deg C



Glass deformed
Fire Temp > 750 Deg C

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Common international flame tests for cables

IEC 60331, 750ºC 90 min
BS 6387 C, 950ºC 3 hrs
SS 299 pt 1 950 ºC 3 hrs
Circuit integrity

-1,

B/C/D

0-5.1

ropagation of cables

Smoke Obscurat
IEC 61034,
BSEN 610
AS/NZ
(3

logen & Corrosive Acid
emission tests
IEC 60754-1 & 2
BSEN 50267-2-1 / 2
AS/NZS 1660-5.3
AS/NZS 1660-5.4

EN 50200
Shock during

42ºC with mechanical

BS 8434-1 850ºC wi
then shock & water for

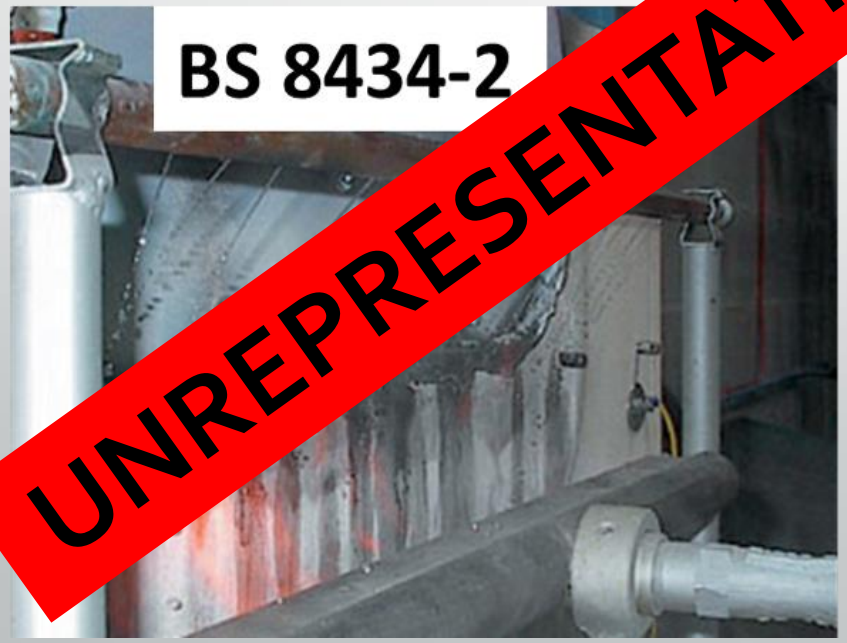
ck for 15 min

BS 8434-2 920ºC with mecha
90 minutes

ter

ALL THESE UNREPRESENTATIVE OF ANY REAL FIRE TESTS ARE

British Standards: Fire Resistant cable flame te



ALL THESE UNREPRESENTATIVE OF ANY REAL FIRE TESTS ARE

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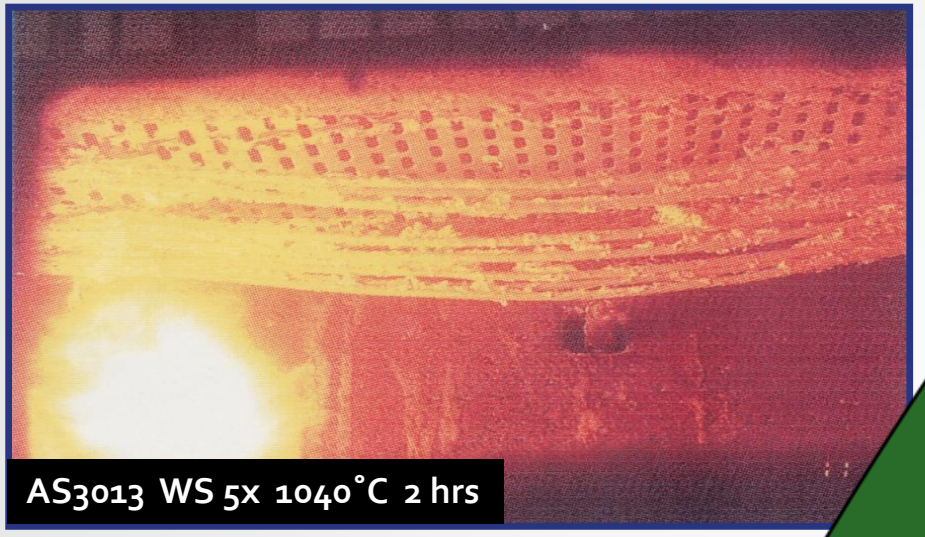
Modern ‘furnace’ tests for cables

Australia & NZ Furnace test AS 1530pt 4



Germany Furnace test ISO 834-1

USA & Canada F st ASTM E119-75

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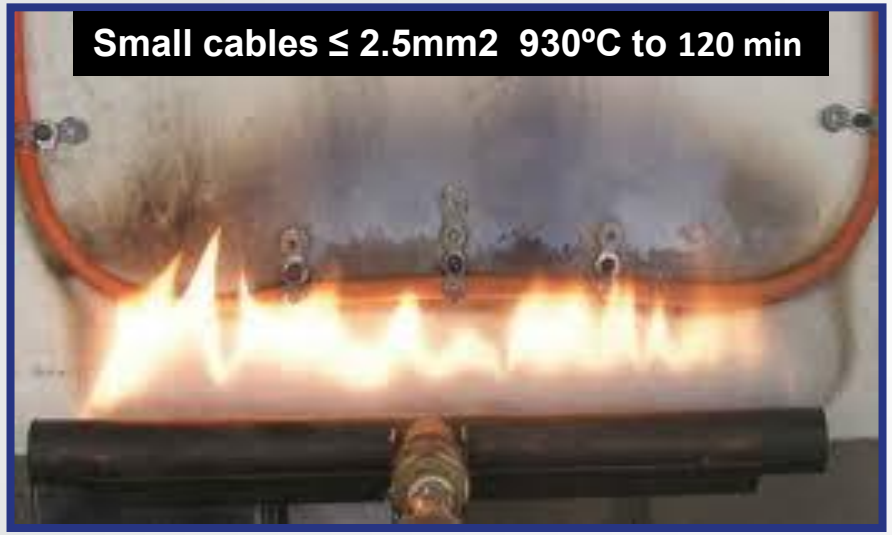
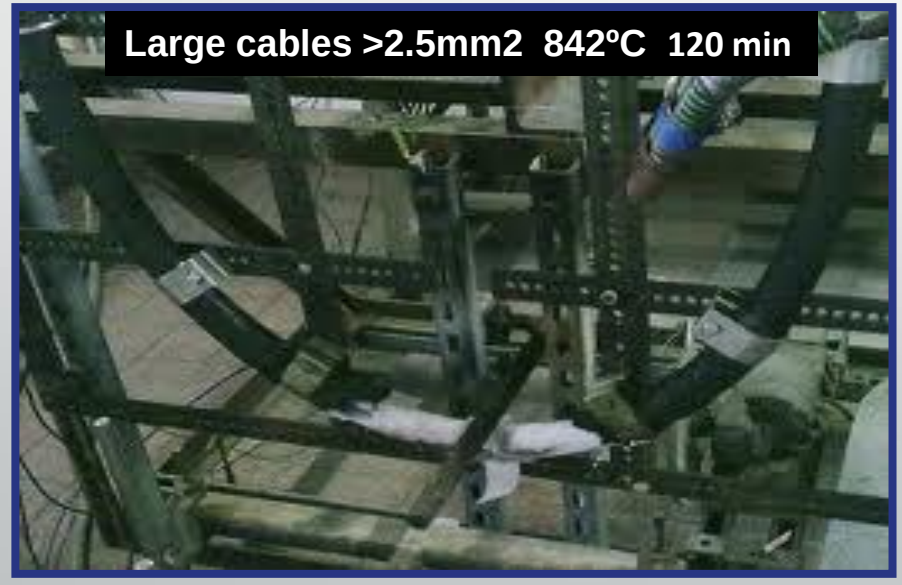
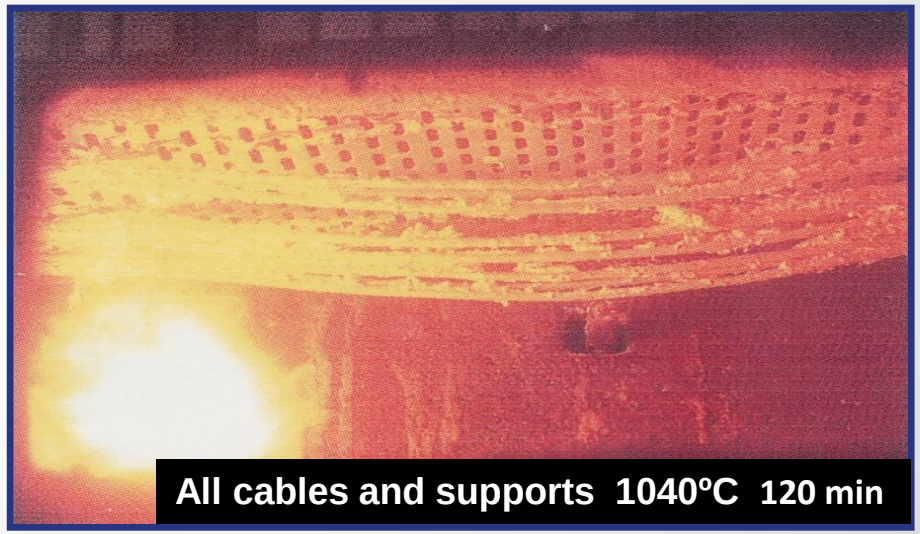
Flame test or Furnace test ?

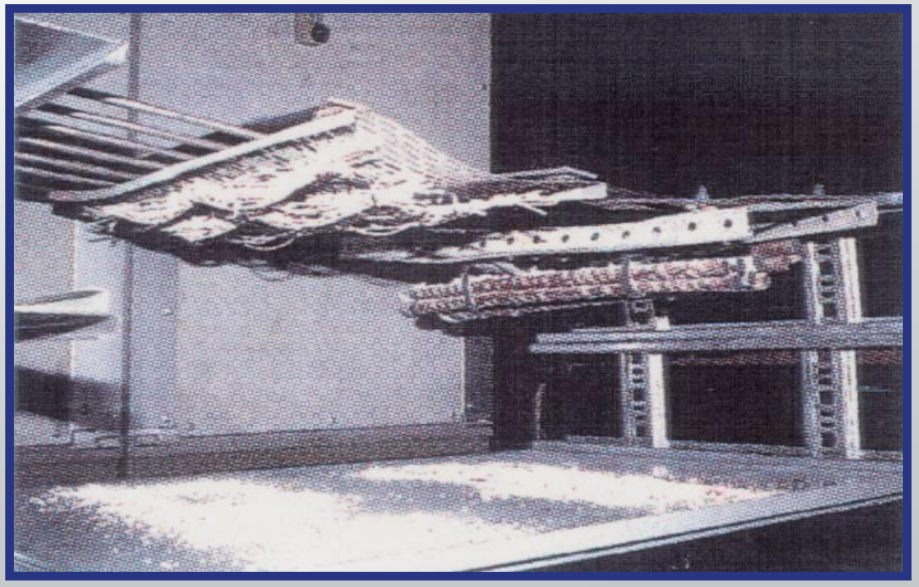
Flame tests BS 8434 & BS 8491





Furnace tests ISO 843-1 & EN 1363-1





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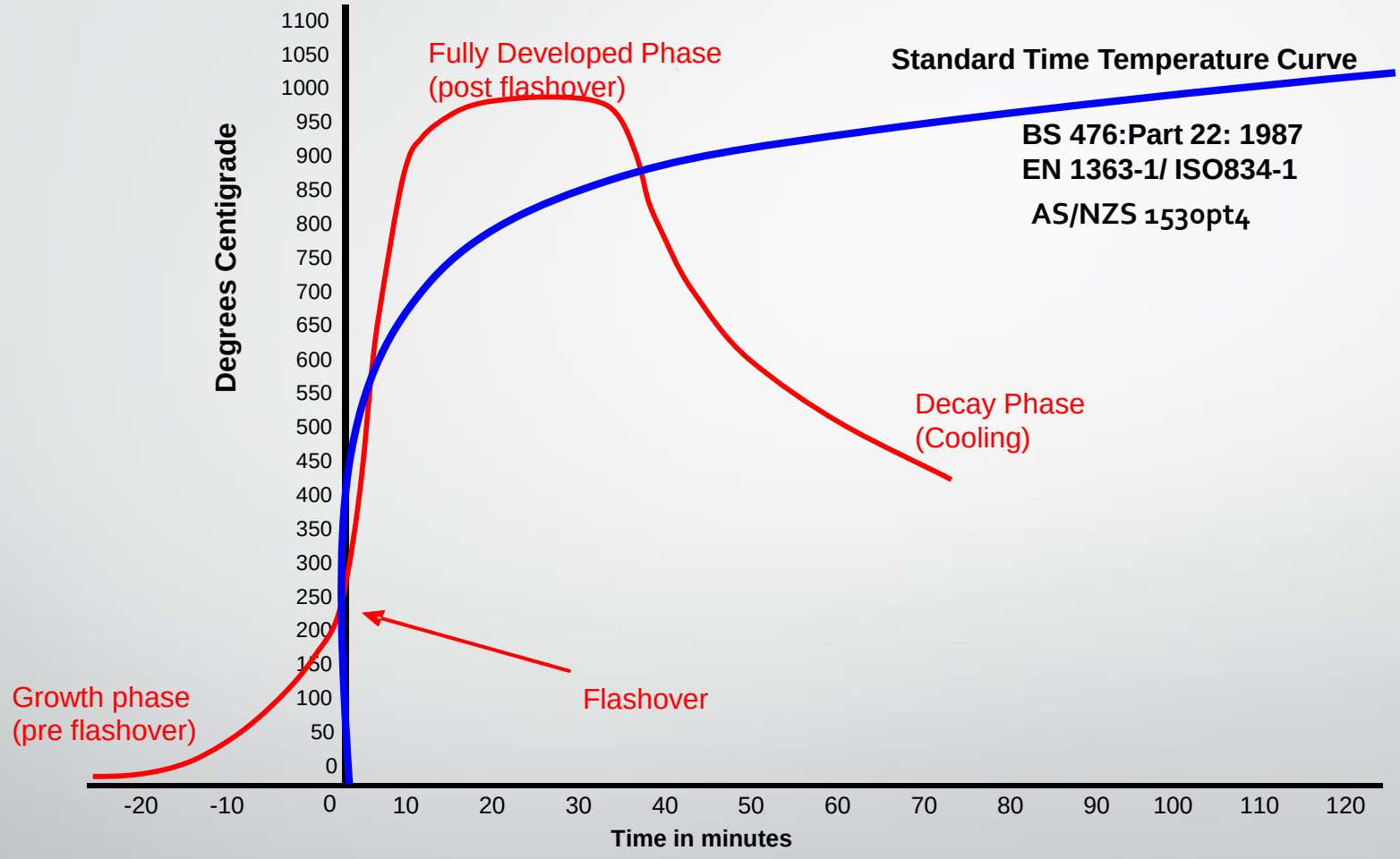
The ISO 834-1 time temperature curve plotted against a real fire curve showing point of flashover.



Typical fire development profile for above ground cellulosic buildings

REF: Chiltern International Fire Research
Fire Testing Assessment and certification

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Are all Fires the same ?

Euro Tunnel Fire 1996

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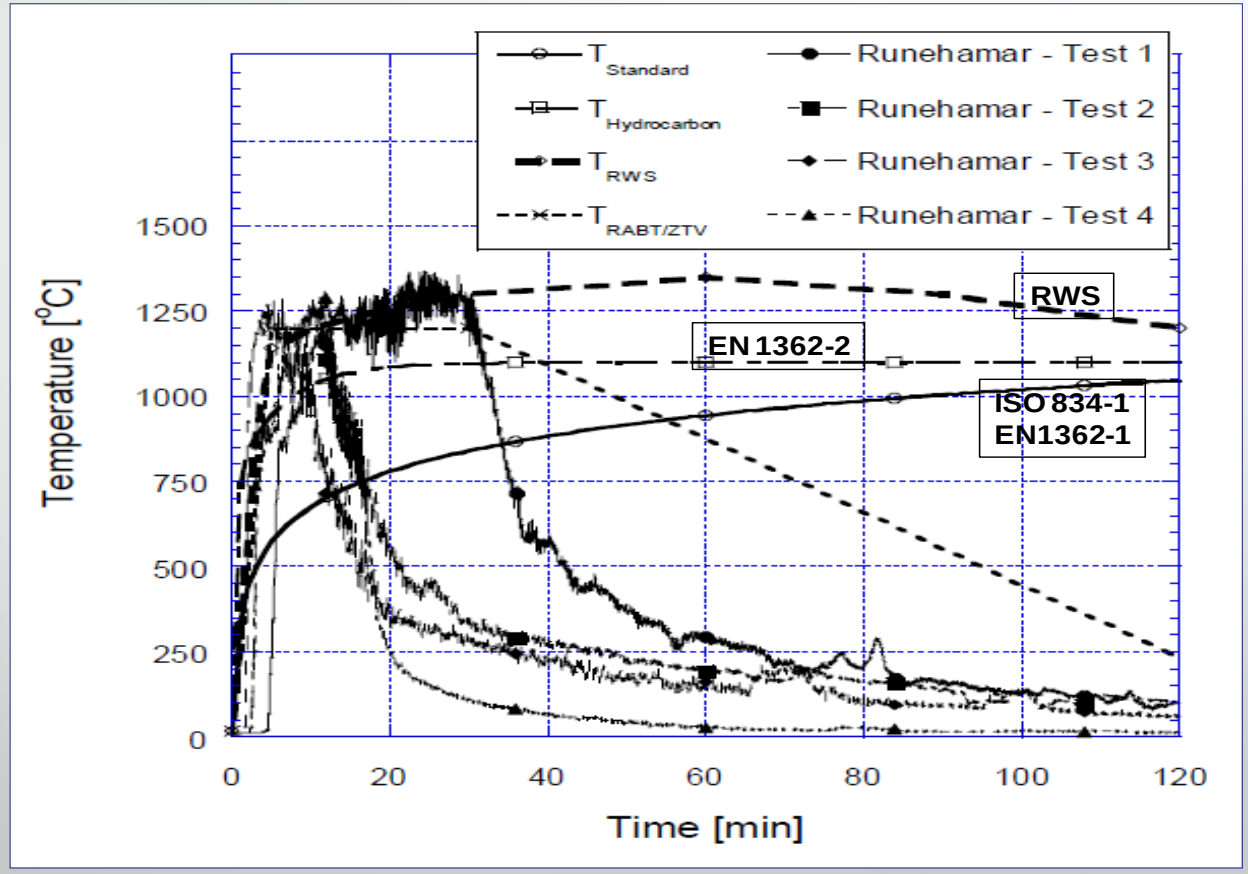
Are all Fires the same ?

It has been well established that in enclosed tunnel environments fire temperatures can exhibit a very fast rise time and reach temperatures well above the parameters of the standard fire time temperature curve of: ISO 834-1 (BS 476 pts 20 -23)



Based on full scale fire tests carried out in Tunnels utilizing road vehicles including passenger cars, busses, trucks with different loads and rail vehicles including Intercity and Metro/Underground carriages

Haukur Ingason and Anders Lonnermark of the Swedish National Testing and Research Institute presented a paper at the First International Symposium in Prague 2004: Safe & Reliable Tunnels

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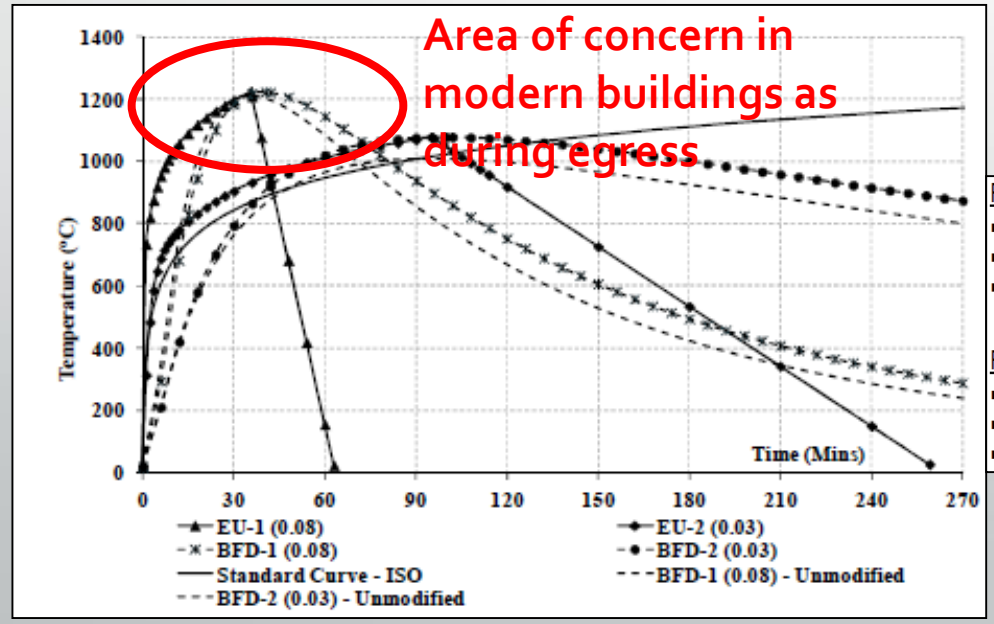
Are our existing Fire Resistant tests relative in todays' modern buildings ?

Recent research in has shown that actual fire resistance of building elements exposed to building fires can be less than their specified fire resistance (FRL) rating.

The fire rating of building elements all over the world is mostly determined by fire tests to the standard fire time-temperature curve given in BS476 pts20 to 24 (ISO 834-1). This curve was developed 100 years ago when buildings were made from wood, masonry and fabric and plastic did not exist.

Todays' modern buildings make use of thermoplastic materials, synthetic foams and fabrics. These materials are high in calorific value and increase both the speed of fire growth and heat release rate thus increasing the fire severity beyond that of the standard fire curve.

REF: Ariyanayagam, Anthony Deloge & Mahendran, Mahen (2013) QUT .
Fire safety of buildings based on realistic fire time-temperature curves.



Fire Curves EU-1 and BFD-1
- Fuel load – 1268 MJ/m^2
- Opening Factor – 0.08 $m^{1/2}$
- Thermal Inertia – 715 $J/m^2S^{1/2}K$

Fire Curves EU-2 and BFD-2
- Fuel load – 1268 MJ/m^2
- Opening Factor – 0.03 $m^{1/2}$
- Thermal Inertia – 702 $J/m^2S^{1/2}K$

Bwalya et al. (2008) conducted a fire load survey for family dwellings . Cellulosic material takes up the highest contribution, plastics occupy nearly 13 to 39% by weight (kg) and contribute 20 to 48% to the fire load (MJ).

Plastics and synthetic building materials did not exist when the standard time temperature curve we use today was established.

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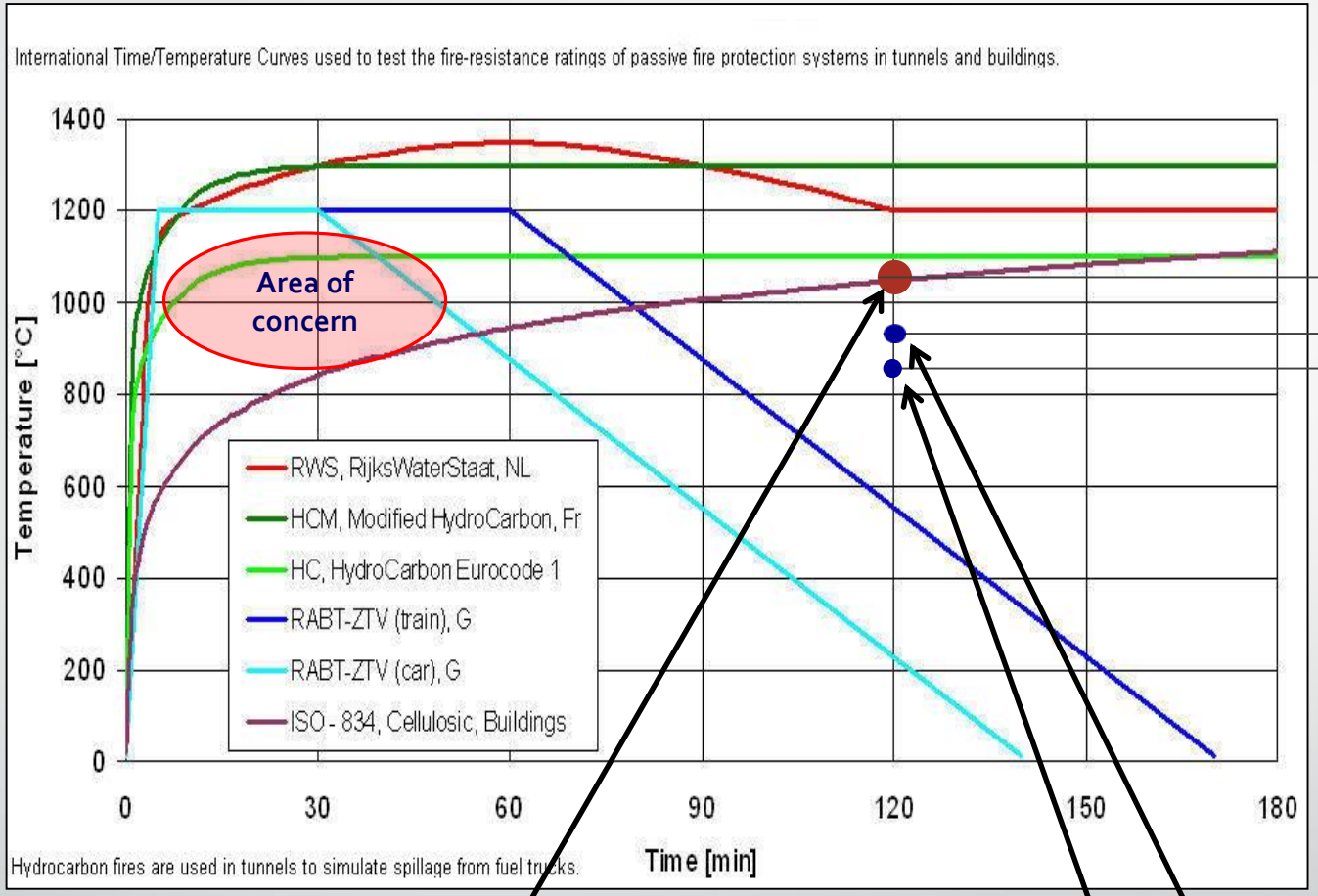
International cable Fire Resistance Tests



1040°C

930°C

842°C

Curve duration is adopted by:

ASNZS 3013 Australia/NZ

DIN 4102 Germany (90 min)

UL 2196 in USA & Canada

BS 8434-2 UK

BS8491:2008 UK

BSEN 50200 UK

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But today the risk is not only about single source fires

The potential for emergencies including terrorist attacks could include the smuggling of liquid fuels in soft drink containers. This spread across several carriages, trains, busses, cars or trucks - especially simultaneously at each end of a tunnel or at each exit of a large public underground shopping center could have far more extreme consequences.

Apart from fire the mechanical integrity of essential wiring systems needs to be robust.

Terrorist attacks have also included explosions. These events create extreme pressure waves which can turn objects, glass etc. into high velocity projectiles. Sometimes cables runs may also be exposed to explosive concrete spalling.

Extracts: The Metro Project – Final Report 2012

> Attacks underground potentially imply more damage and death simply because of the higher pressure and blast injuries, with the contained nature of the location also making it more difficult to escape the scene of attack and to receive help.

> Although hardened glass was used the tests show that not all the glass breaks up into small pieces. Some bigger pieces with a weight of up to 65 g were found stuck in the styrodur wall opposite the window.

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Should essential circuit cables be installed in conduit?

In USA September 2012 UL® announced it would no longer classify Fire Resistant Cables to UL2196 because a number of (polymeric) cables showed persistent inconsistency in testing and re-testing:

http://www.ul.com/global/eng/pages/offerings/perspectives/regulator/fire/cables/
http://ecmweb.com/safety/safety-and-compliance-fire-resistive-cable-products

Quote:

"A concern was brought to our attention related to the performance of these products in the presence of zinc. We validated this finding. As a result of this, we changed our Guide Information to indicate that all conduit and conduit fittings that come in contact with fire resistive cables should have an interior coating free of zinc"

The only cable technologies approved and listed by UL 2196 today for 'Unrestricted Installation' are: MICC and Metal Clad cables

I remind that Galvanised steel cable tray, cable ladder and conduit is a process involving the hot dipping of steel in a molten Zinc bath.

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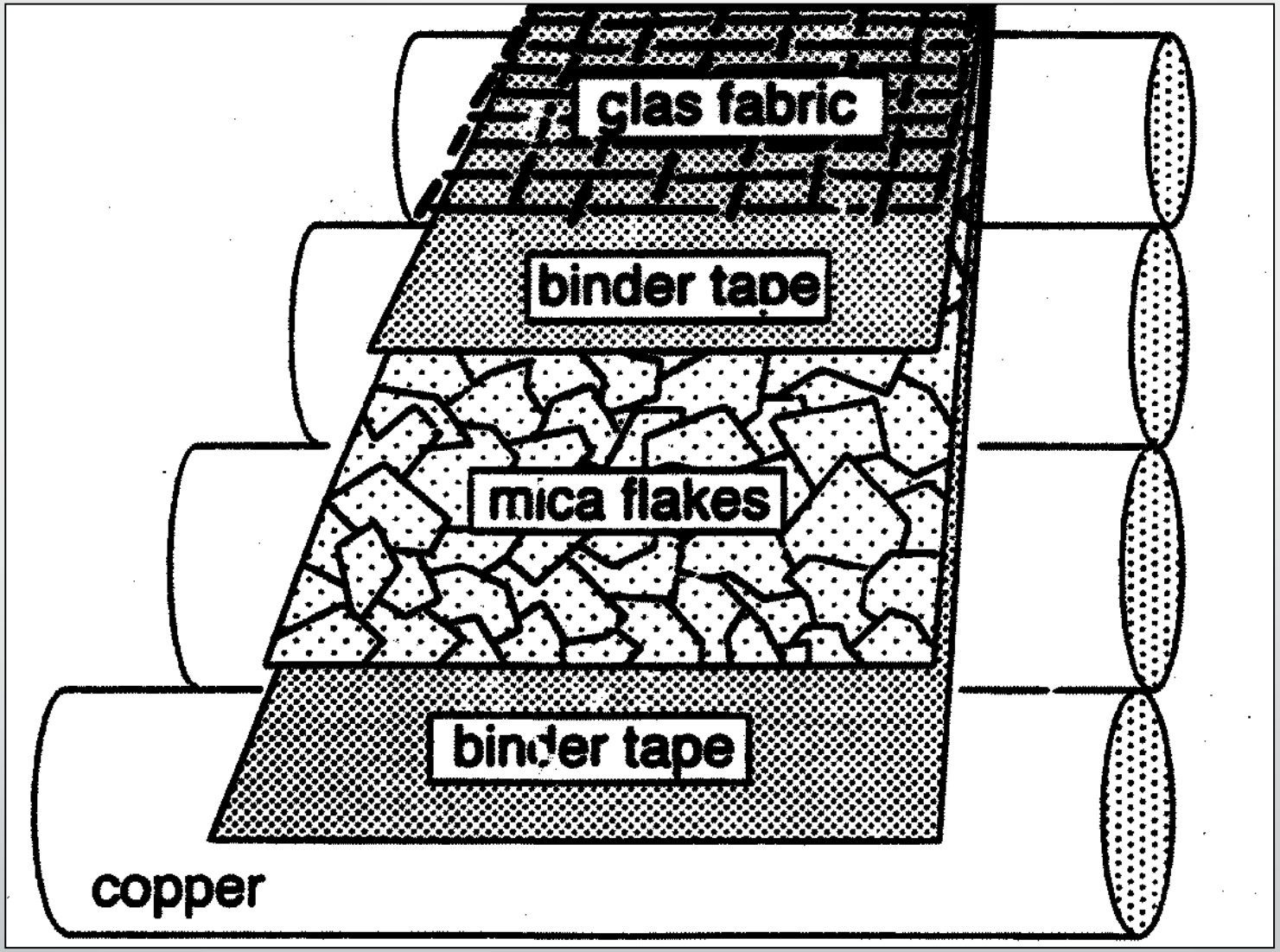
Fire reaction of Polymeric fire Resistant cables with Glass Mica Tapes



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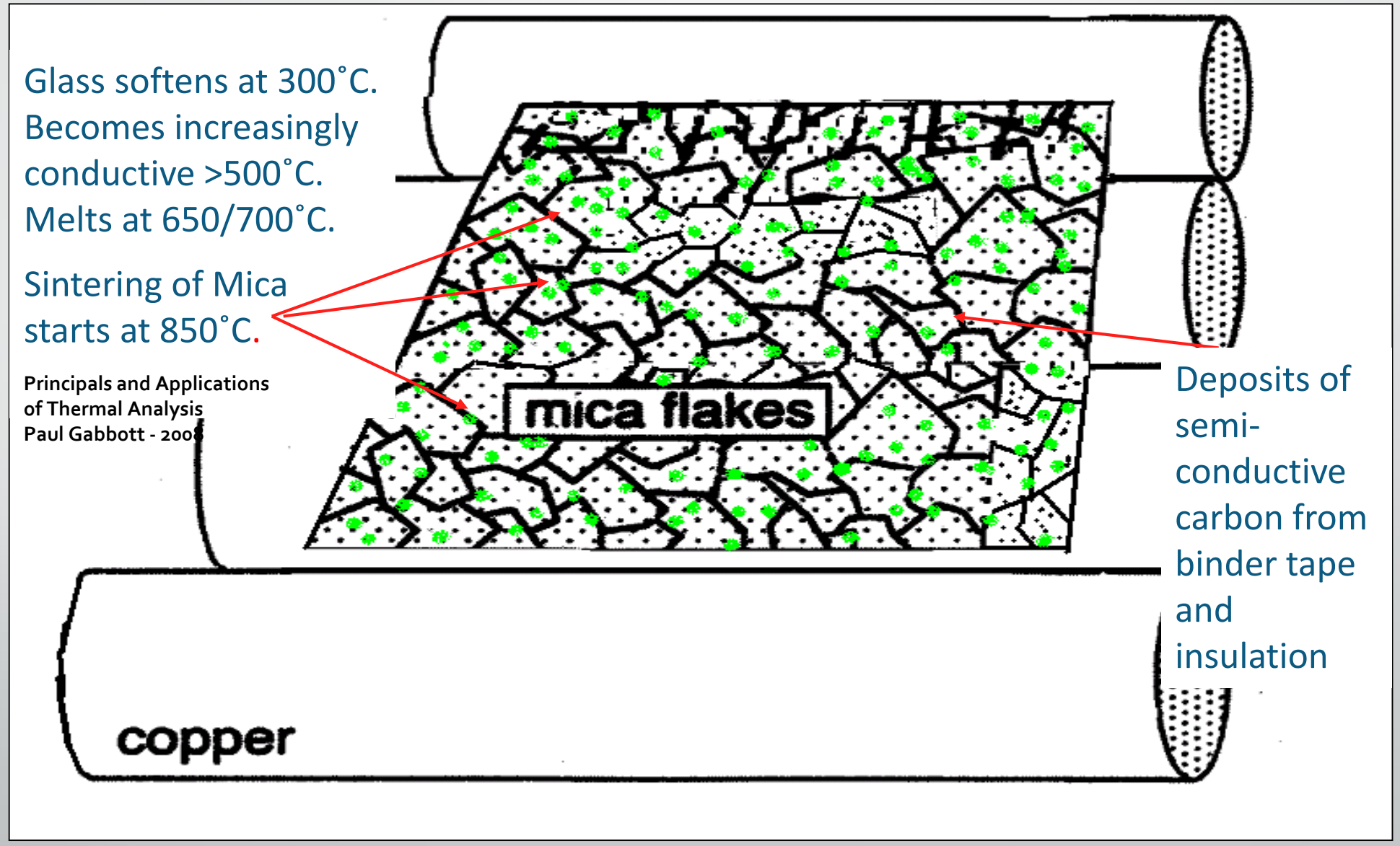
Fire reaction of Polymeric fire Resistant cables with Glass Mica Tapes

Glass softens at 300˚C.
Becomes increasingly conductive >500˚C.
Melts at 650/700˚C.

Sintering of Mica starts at 850˚C.

Principals and Applications of Thermal Analysis
Paul Gabbott - 2008



Deposits of semi-conductive carbon from binder tape and insulation

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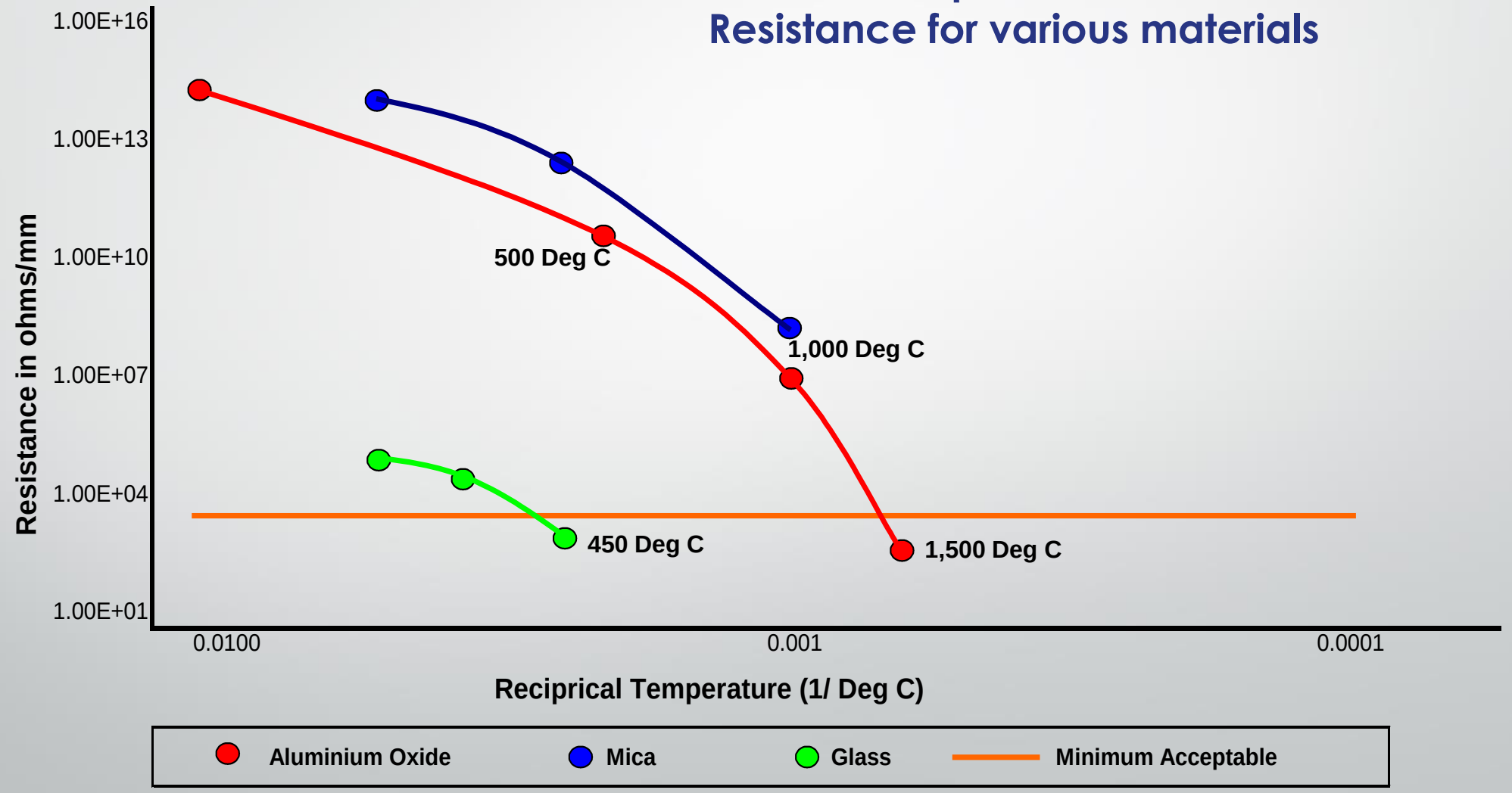
Fire reaction of Polymeric fire Resistant cables with Glass Mica Tapes

Effect of temperature on insulation Resistance for various materials



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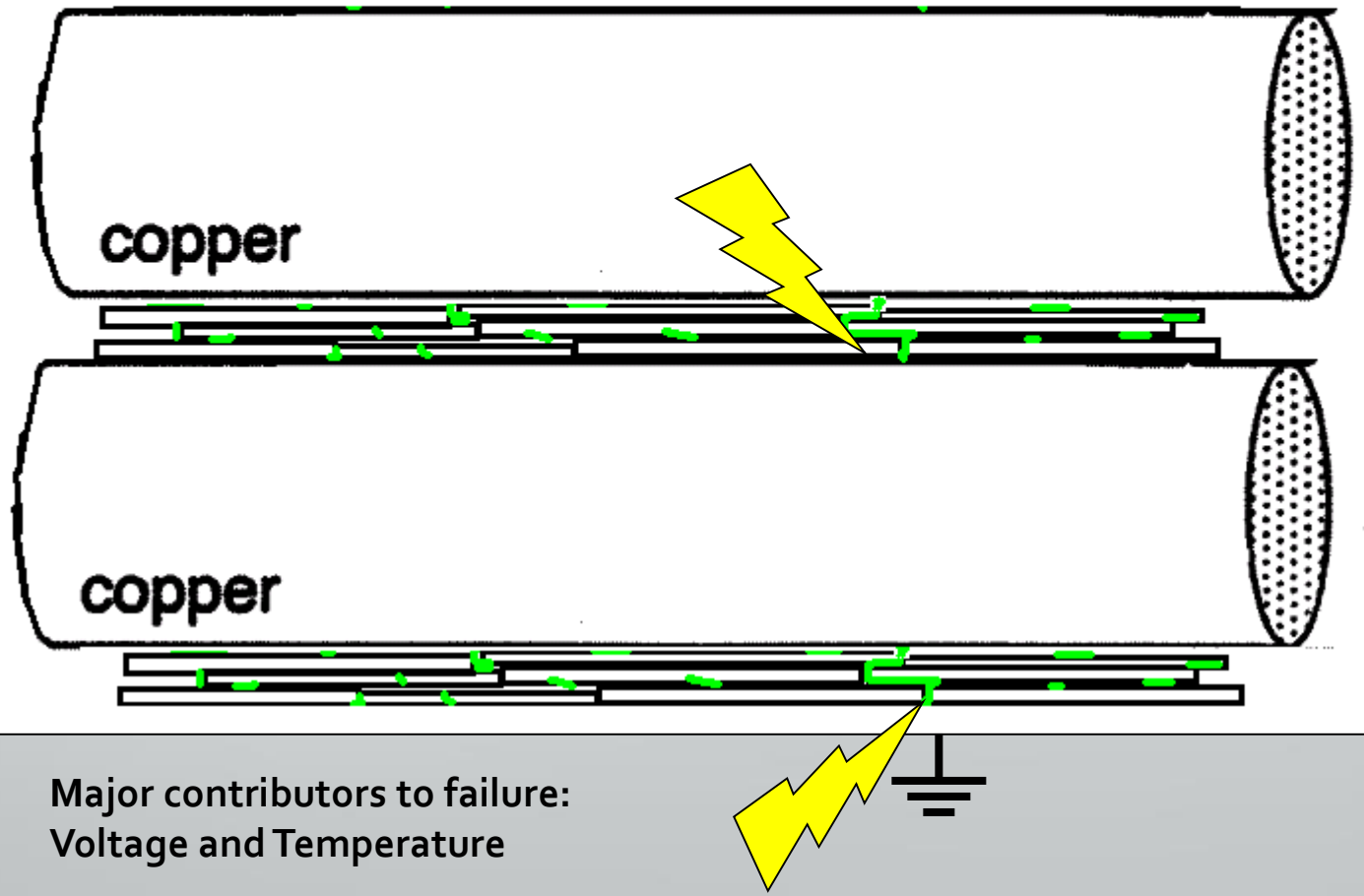
Common Failure Mode:
Polymeric Fire Resistant cables made with Glass Mica tapes:

If glass and/or carbon penetrates between mica flakes in proximity to earth or another conductor = failure

This can occur randomly anywhere along the length of the cable



Major contributors to failure:
Voltage and Temperature

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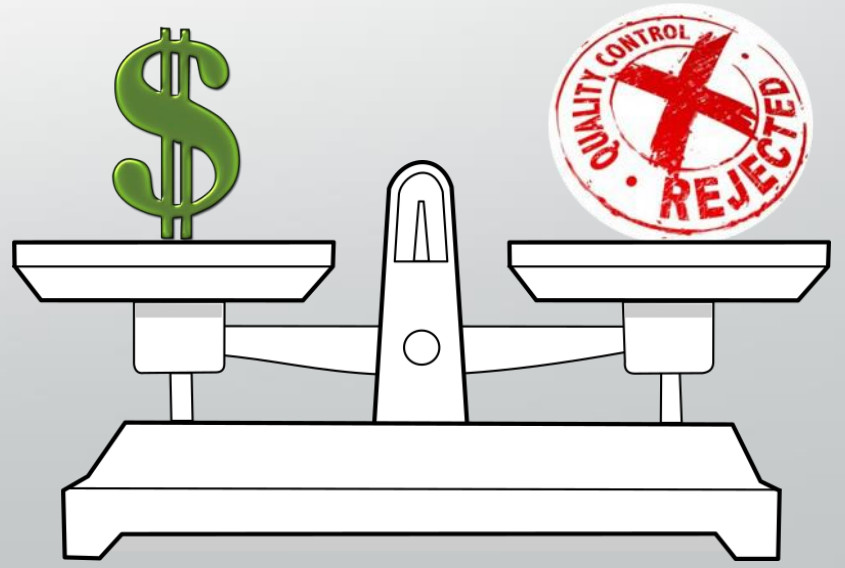
The commercial reality:

Mica Tapes come in different mica yields and qualities. The more (thicker) the mica and better the quality, the less likely a given cable sample will fail.

Mica is expensive, so manufactures who have the cheapest cables often have the least (thinnest) Mica.

Our standard commercial practice of competitive bidding ensures the cheapest cable wins the project.



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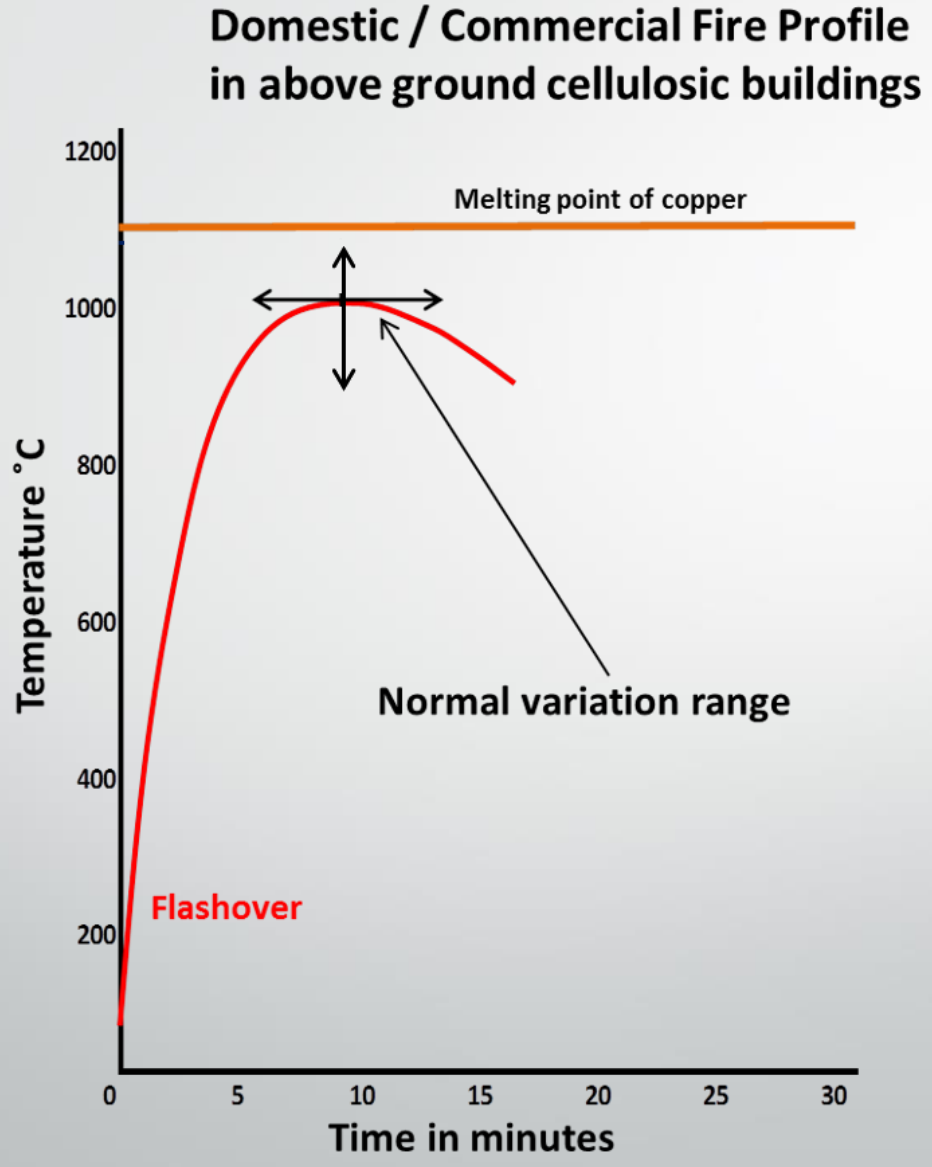
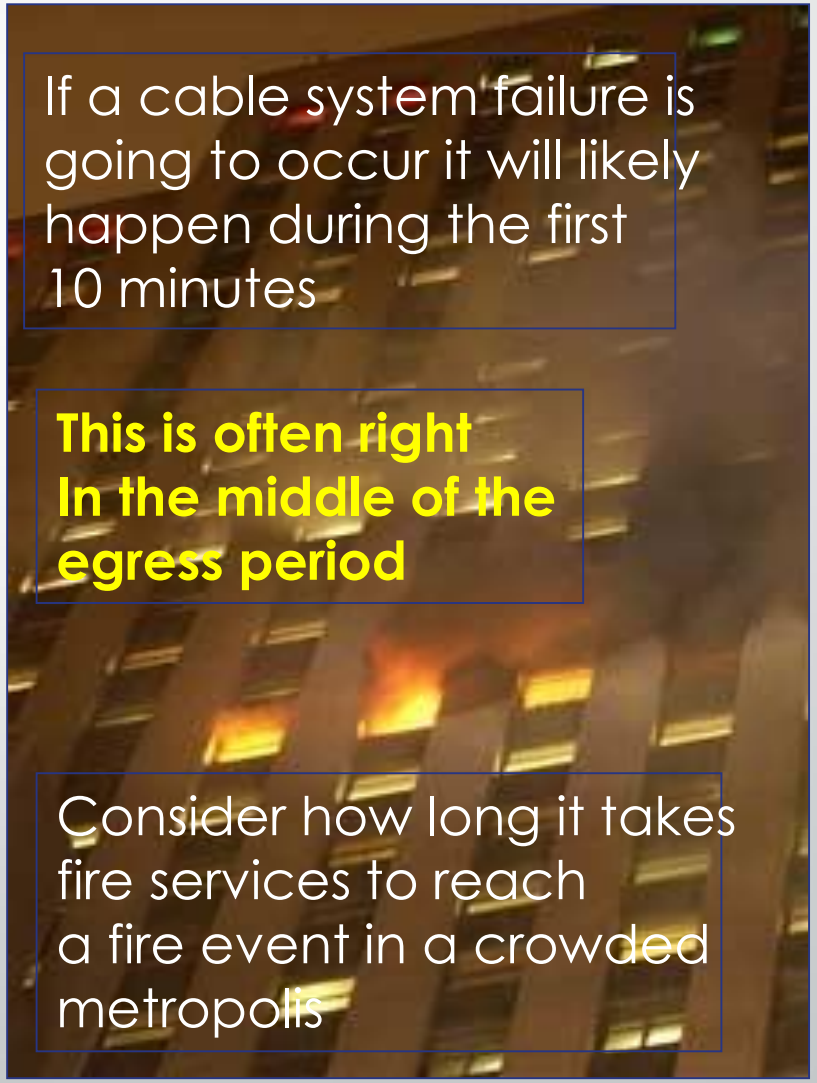
Fire safe wiring systems





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The Low Smoke myth

Many polymeric cable manufacturers claim the polymers they use for insulation and jackets are low smoke. They often justify this by claiming compliance to tests like BS EN 61034 .

These smoke obscuration tests are dependent on a specific sample weight of cable burned in a specific room / air volume.

These results are not predictive end use simulations.
(Smoke generation can be greater on high heating before flame and smoke volume is directly related to amount of material burnt)

Singapore MRT 2013 - Newton Underground Station. Cable overloaded and caught fire

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The Low Smoke myth

So how can a **BSEN 61034-2** compliant low smoke cable give off so much smoke ?

Smoke emissions in US-NBS Smoke Chamber (BS6401 conditions)

Material	Thickness (mm)	Maximum Specific Optical Density (DM) Non Flaming	Flaming
Plastics;			
UPVC	3	400	580
Polyethylene (PE) & XLPE	3	590	83
Polypropylene	3	550	162
Polystyrene	3	476	960
Plasticised PVC	0.75	430	650

Edgerley P G and Pettet K "The Effect of Pyrolysis and Combustion Temperatures on Smoke Density Fire and Materials" Vol 2 No 1 pp 11-17 1978.

PVC gives more smoke in flame but PE / XLPE gives more smoke on heating without flame

NFPA 130 calls for cables to be tested in flaming and non-flaming mode.

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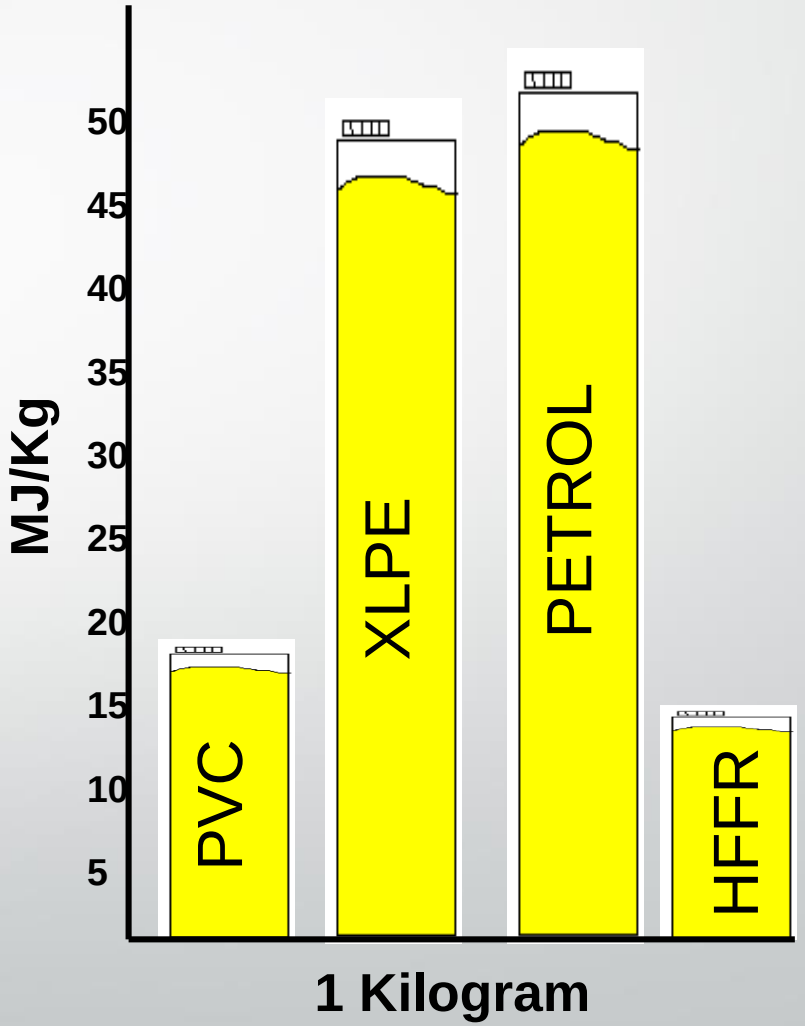
Ratio of heat release to oxygen consumption is proportional

Heat release values burning

Cable Material	Halogen	Flame Retardant	MJ/kg
MIMS / MICC		Y	0
TEFLON PTFE	H	Y	5
HFFR cable materials		Y	13
TEFZEL ETFE	H	Y	13.8
SILICONE RUBBER SI			15.5
Polyvinyl chloride PVC	H	Y	18
Wood			18.5
NEOPRENE RUBBER PCP	H	Y	24
Coal			25
EPR			28.5
CSP	H	Y	28
NYLON 66			33
POLYPROPYLENE PP			46
PE and XLPE			46
Petrol			48



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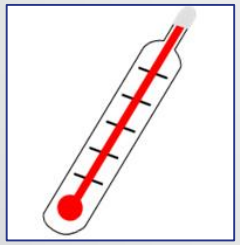
Holistic Fire Safety is NOT just about circuit integrity fire tests

Eliminating the risk

Smoke

Cables which emit NO smoke will provide significantly improved evacuation speed and save lives



Temperature rise and Oxygen depletion

Cables with NO calorific value which have a ZERO heat of combustion per Kg will eat NO oxygen and generate NO heat

Toxic and irritant gasses

Cables with NO organic content, NO calorific values and are Halogen free will generate NO toxic or irritant gasses at all including Carbon Monoxide and Hydrogen Cyanide

(*CO is often claimed to be responsible for most toxicity deaths in fires although HCN from burring man made fibers, plastics and materials is today becoming more predominant*)

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What does all this mean ?

Most cables made in UK and imported from reputable manufacturers comply with all cable construction standards and current test standards. Their performance to these tests is not disputed. What we must understand is fire performance is largely dictated by the materials used, not how well they are made.

Our built environments are getting bigger & more complex, we move to more underground, high rise and more complex environments, often evacuation times are longer and fire scenarios or the consequences of fire in these environments can be far more severe.

Fire scenarios in these buildings can often be more severe than the test methods for materials and especially cables that we currently employ.

We need to consider if simply adopting minimum and knowingly unrepresentative test standards is appropriate

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Areas of Special Risk

In the UK today British Standard BS8519:2010 and BS EN12485 define areas with ventilation limitations and areas such as underground car parks, loading bays and storage areas as "areas of special risk" These areas can experience fire temperatures up to 1,200°C requiring higher levels of fire protection than the minimum British Standards specify.

Note: storage areas can include retail environments in large underground or basement locations.

This is particularly important for electrical circuits enabling life safety and fire fighting equipment which are installed in or routed through these areas.

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What can we do ?

It is easy to justify decisions to specify or purchase cables based only on a ‘minimum standard’ and ‘cheapest price’.

“Especially when we have customers & stakeholders asking us to build to price or competition where wining on price is paramount”

When the limitations of current standards are known, it is critical to ensure that with “reasonable expertise” all precautions & factors are properly assessed.

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What can we do ?

There is one cable design which addresses all the issues raised in this presentation:

MICC Mineral Insulated cables

MICC cables have been used for many years, some still in use since the 1930's! However the influence of plastic cable manufacturers on standards committees and the commercial drive for ever cheaper solutions has reduced the fire safety of almost every life safety and firefighting system, except in America where MICC cables are still mandated.

825 Alloy MI cable >1,100˚C
Underground public areas (with high fire load), Road Tunnels, Petro/Chem & Hazardous areas

All Life Safety & Fire fighting equipment

Copper MICC cable < 1,083˚C
Above and below ground public areas & buildings with **long egress > 10 min**

Fireman's lift submains
Mechanical Switchboard sub main
Fire hydrant & sprinkler pumps
Smoke extraction & pressurization

Flexible FRC
Private, commercial and public Above ground areas & buildings with **short egress <10 min**

Life Safety & Firefighting equip.
Fire alarms, EWIS, EM Lighting

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MICC cable vs Polymeric FR cable

Mechanical integrity across normal and abnormal operating temperature range (Cable does not soften at operating or overload temperatures)

Non aging (no reduction in elongation at break to 50% absolute in 2.3 years at rated temp.)

Small Size (diameter) (less installation space needed)

Less fixings required (longer fixing distances due to less sag)

Water proof (LOSH materials are hydroscopic due to flame retardant fillers)

Radiation proof (use permitted in reactor chamber of Nuclear Power Station)

Bio/Chemical Hazard safe (fully sealed cable at each end and through full length)

Sharps &Crush resistant (not just unidirectional cut resistant)

No OHS issues (Occupational Health & Safety for installation and handling)

Proven fire protection performance (in service over 80 years)

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MICC cable vs Polymeric FR cable

Real fire circuit integrity performance by furnace testing
(Furnace testing 2 hours to 1,040°C + water spray)

Zero toxic emissions (not: just low halogen & high CO)

Zero flame propagation (not: limited flame propagation for external fire only)

Zero smoke (not: just 'claimed' low smoke)

Zero heat of combustion (not: high fuel element & high heat of combustion, & high oxygen consumption & high CO emissions)

Zero environmental impact in installation, service life & disposal (100% recyclable)

Zero impact from rodents, termites and insects
(not just no damage under the outer steel armour)

High Short Circuit Ratings (high safety - no self ignition)

High Overload resistance (high safety - no self ignition)

Characteristic Impedance (no significant change during fire or water-spray)

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Thank you, Any questions?

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