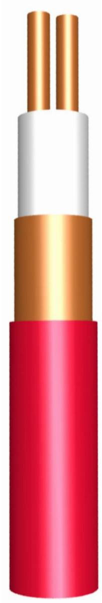


Mineral Insulated Cable…… A cable for today and tomorrow!

Bill Davis
Technical and Business Development Director

'If MIC had never been introduced, the industry would be actively pursuing the development of a similar product today.'

Introduction

Mineral insulated cable dates back to the 19th century when in 1896 a Swiss patent was issued for a cable using powdered inert material for insulation. The design gradually gained acceptance and by the 1930's manufacturing systems for large scale commercial production were fully developed and in place. From the very beginning, MI cable was recognized for its robust fire proof construction and as such it was used in shipbuilding and for other applications where circuit integrity for critical systems was essential

The MI cable available today is nearly identical to the cable constructions commercially produced almost a century ago. Whilst MIC has not changed as an inter-connection cable on systems where circuit integrity is critically important, modern alarm and control systems are far different from the rudimentary systems used in the past century.

Since the introduction of MIC, the world has witnessed a dramatic transformation in electronics, communications, telephony, power generation, and information technology. Today's world seems many light years ahead of the world of the 1930's. So is MI cable obsolete? Is it outdated technology? This paper explores the relevance of mineral cable in the new digital age.

Fire Performance Cable Constructions

Whilst there are a number of fire performance cable designs in the market place, most fall into one of three categories: Mineral insulated, Mica-taped insulated, and polymer insulated (silicone or similar). Each insulating system provides some degree of fire survivability and will comply with applicable test requirements. The selection of cable is dependent on the application, risk assessments and codes of practice such as BS5839

It is well established that for ultimate fire survivability there is no better cable then mineral insulated cable. Mineral insulated cable will not burn, will continue to operate in temperatures exceeding 1000°C, is waterproof, radiation resistant, corrosion resistant, rodent proof, and will withstand direct impact from falling debris.

It is the dielectric material, magnesium oxide that gives this cable its superior fire survival characteristics. Compacted magnesium oxide will not burn, does not emit fumes and remains stable up to 2800°C. Since it is largely inert and mechanically stable, there is almost no change in either its dielectric or mechanical properties making MIC unaffected by fire and other severely adverse conditions.

It's clear that MI cable provides outstanding mechanical protection in a fire but are there other issues that should be considered? Does mechanical protection alone determine reliability? Will MIC cope with the demands of today's fire alarm systems and what about future fire alarm system requirements?

A Case for Data Integrity

As fire performance standards continue to become more stringent and as fire safety systems become more intelligent and integrated the need for data integrity under extreme conditions must be considered.

It's universally understood that the digital age has transformed all aspects of our lives. On a regular basis we are directly or indirectly influenced by digital technology in the form of the internet, telecommunications, automotive controls, heating controls, lighting controls, building security systems, traffic management systems, fire detection and alarm systems........the list is endless.

It is generally accepted that the digital age began in the 1990's with the development of digital communications over the internet and with advances in microelectronics. Digital communication is a new age technology but already we hear phrases such as "latest generation" technology as if the digital age has been around for many decades. The fact is, digital communications is evolving more rapidly than any technology ever introduced and generational life spans are brief.

Ten years ago most digital "systems" could be categorised as islands of automation. Systems were developed in isolation to provide a specific function or service. In the building industry this could be in the form of a digitally controlled heating or air conditioning unit. Independent of this, one might find a digitally based power management system and likewise a digitally based fire detection and alarm system, each system independent from the other.

As digital technology evolved there was a natural progression towards integrated systems built around linked networks. These systems could share information and provide coordinated control actions. Many of today's modern building management systems operate on this principle. Additionally, modern detection devices used in building management systems often have on-board intelligence. These units pass critical information to the host system. For example, some building control sensors can communicate location, temperature, operational status, and more to the host. In the event of a fire, intelligent detection devices can provide valuable data that can be acted on quickly (and automatically) to isolate the affected location, control ventilation to minimise flame spread, alert and direct emergency services, and so on.

The Connection

To simplify the installation of these intelligent systems, automatic sensors, manual call points and sounders are connected by either a single daisy chain or bus connection. In such configurations, each peripheral (sounder, manual call point, automatic detector) receives its power and participates in bi-directional communication along one pair of conductors.

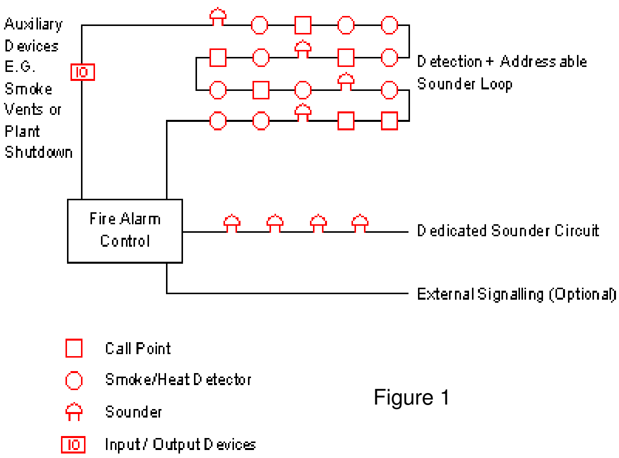


Figure 1

The performance requirements of the interconnection cable must now include both a capability to pass low frequency current to power the devices together with an ability to pass, without degradation or attenuation, the higher frequency digital component that constitutes the signalling of information. This system is often referred to as an addressable system as each of the peripherals on the loop must have a unique address to identify it to the panel and each peripheral digitally returns the requested

analogue measured value and other information. The systems integrity is dependent on all components functioning as designed and significantly dependent on the data transmission characteristics of the interconnecting cable.

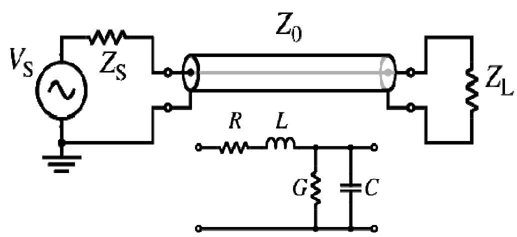
For a cable to be suitable for data transmission, its ability to pass high frequency data is critical to maintain a low system error rate. For fire survival cables intended to carry data, this ability must be maintained during the fire situation because this is the precise situation where reliable communication is a prerequisite.

Return to Sender – Address Unknown!

Cable transmission terms such as attenuation, near end crosstalk (NEXT), far end crosstalk (FEXT) have fairly obvious meanings. These terms relate to signal loss and power transfer along and between transmission lines hence reduced signal reception and definition.

Impedance and return loss are amongst the more abstract terms that need to be better understood so that specifiers and system manufacturers can judge the integrity of the overall system.

Figure 2



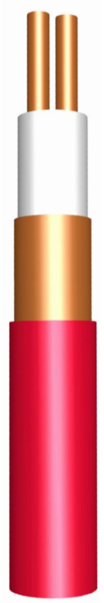
Impedance variations within a cable degrade signal quality and prevent the complete transmission from reaching its intended destination. Some is reflected and returned to the sending device or it bounces between features in a cabling system. These reflections are referred to as return losses. Return losses are a complex contribution of step changes in characteristic impedance and cumulative effects of structural variations in cabling otherwise known as Structural Return Loss (SRL).

Characteristic impedance of cable is determined by the dielectric constant of the insulating material and the geometry of the cable design. If there is any physical alteration to cable geometry and/or change to the insulation's dielectric constant there will be a change in characteristic impedance creating a high incidence of SRL. To prevent data corruption an interconnecting cable must maintain constant characteristic impedance.

This requirement is particularly challenging in cable systems where the insulation is polymer based as these react to and are changed by high temperatures. Most soft skinned fire performance polymers have a relative dielectric constant between 2 and 3 but when exposed to fire the resultant char has a much lower value, significantly changing the cables' characteristic impedance. Under these circumstances data integrity is compromised and reliability questionable. However, under the same conditions the dielectric constant of mineral cable remains constant when exposed to fire. Characteristic impedance is unaltered and therefore data integrity remains intact.

Test Data

To determine changes to characteristic impedance in a fire situation controlled laboratory tests were conducted on soft skinned and MI cable. Cables were subjected to an open flame followed by a water spray to simulate conditions during fire fighting operations. Impedance trace data was recorded and compared throughout the tests with the results following:



Silicone Insulated Fire Performance Cable

Graph 1 shows the cable characteristic impedance of a silicone insulated fire performance cable before exposure to fire or water (Green Trace), after exposure to fire at 830℃ (Red Trace), followed by exposure to water (Blue Trace). Variations in characteristic impedance are clearly evident. These variations are the result of a change in the dielectric constant from solid silicone to silicone oxide char when exposed to fire and due to the ingress of water in the micro-pores of the charred dielectric. Exposure to water creates two effects: a change in the shape of the trace and also an alteration to values.

When exposed to fire the characteristic impedance varies from the standard cable by more than 10% at 90 kHz and above 600 kHz. These variations will cause signal attenuation and therefore data communication may be unreliable at specific baud rates. After exposure to water the impedance differs by more than 10% at almost all frequencies. The differences in impedance between the unaffected cable and this portion of it are sufficiently large to suggest that data communication at any useful rate may be unreliable, rendering an addressable alarm system unable to function in a dependable fashion.

Mica-Taped Fire Performance Cable

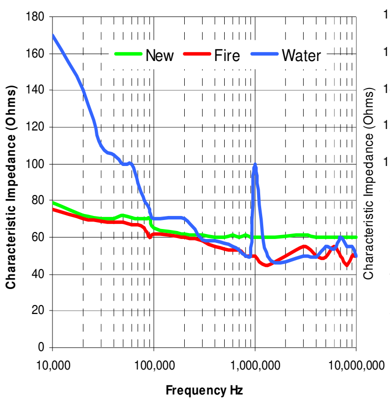
Graph 2 shows similar results on a cable with a mica taped construction.

Again, it can be seen that variations in characteristic impedance occurred when exposed to fire with unacceptable variations at numerous points along the trace. As with the silicone insulated cable water significantly affected the characteristic impedance at nearly all frequencies. The result clearly suggests that data integrity can be severely compromised with a mica-taped fire performance cable under these conditions.

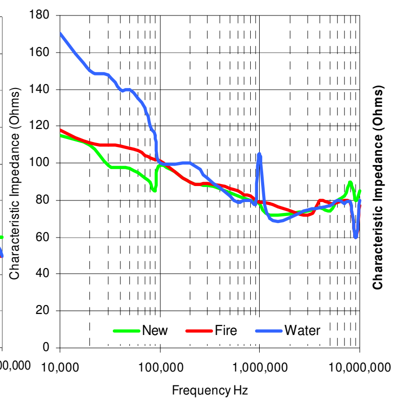
Mineral Insulated Fire Performance Cable

As anticipated, there is no significant change in the characteristic impedance from any of the test protocols as can be seen in graph 3. The insulation, magnesium oxide, is inert and its electrical properties are unchanged at temperatures less than its melting point of 2800℃. The waterproofing member is a thick copper outer tube which again remains unchanged up to its melting point of 1083℃. This cable is therefore capable of transmitting data under fire situations at rates beyond 100 kbaud making it the cable of choice for addressable alarm systems in use today.

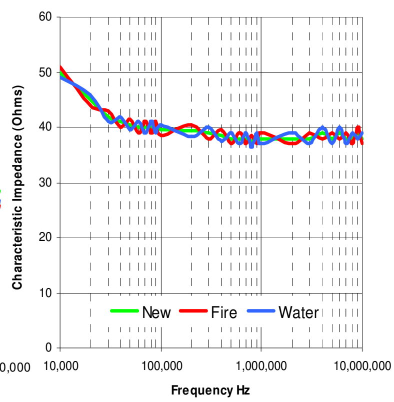
Graph 1
Silicone Cable

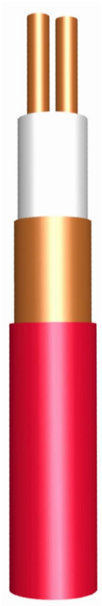


Graph 2
Mica Taped Cable



Graph 3
Mineral Insulated Cable





Conclusion

As fire alarm and building management systems become more advanced there will be increasing requirements for reliable data communications between devices and networks. Future systems will provide more than just fire detection capabilities. These systems will likely provide fire fighters detailed intelligence about source location, flame spread, temperature, atmosphere, and other significant pieces of information that will help make appropriate evacuation and fire fighting decisions possible.

Given the role of cable in providing the primary communications link between devices, panels, and peripheral networks, it's imperative that it provide the level of service necessary when subjected to severe conditions. Where data integrity is an issue there is only one type of cable that can offer the level of performance required and that is Mineral Insulated Cable.