The Ultimate Fire
Survival Cable System

nVent

PYROTENAX

PYRO MI Fire Survival Cable

Information Sheet for Electromagnetic Pulses (EMP) and nVent PYROTENAX Pyro MI Wiring Cables

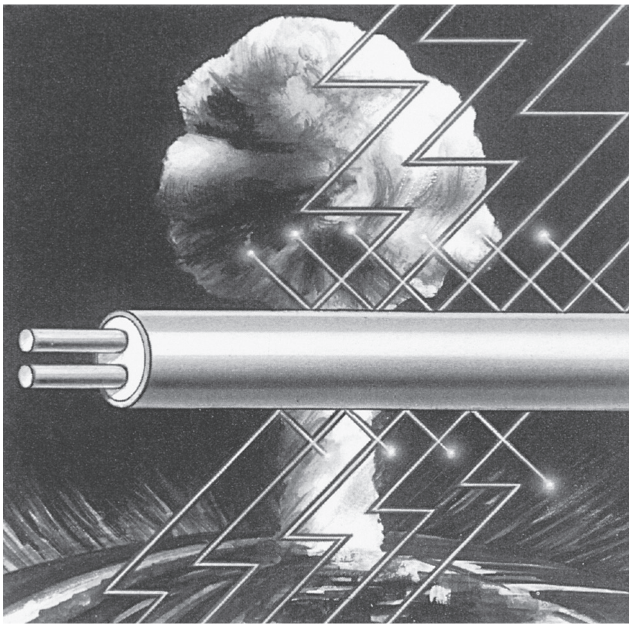
When a nuclear explosion occurs an electrical disturbance is produced in addition to blast, heat and radiation. This disturbance is in the form of an electro-magnetic pulse (EMP), which occurs at almost the same time as the detonation, giving rise to very strong electro-magnetic and electric fields. The peak field strength can reach tens of kilovolts per metre within nanoseconds of the detonation.

If electric cables are exposed to electro-magnetic pulses, heavy currents may be set up in the metal sheath or armour, generating transient voltages between the outer screen and the cable conductors. The threat of EMP to communications has been known for some years with prime concern being related to telephone networks, computer systems and military signalling, but EMP can also be a threat to the operation of power systems and cables, unless sufficient protection can be incorporated in the installation. Protection of wiring cables and the reduction of pulse intensity to connected equipment may be achieved as follows:

1. Voltage surges between the sheath and cable conductor can be limited by using a sheath with a good screening factor.
2. Sheath currents can be reduced by means of efficient earthing.
3. Surge diversions and/or filters can be connected to equipment and cable terminations. The types available are
   similar to those currently used for protection against lightning strikes although they must be designed for the much faster EMP induced current rise times.

For effective protection against EMP it is, therefore, essential to use cables which combine good screening of the conductors and good earthing.

It is also important to ensure that all terminal boxes and enclosures are designed to provide a screening performance at least as good as that of the cable sheath. In the absence of satisfactory screening very high voltages of some tens of kV can occur across the cable insulation. These voltages may result in cable breakdown or, alternatively, cause the damage or failure of expensive associated equipment with the loss of a vital service.



Examples of standard wiring systems which include a metallic screen are:

- **Copper sheathed nVent PYROTENAX Pyro E MI Wiring Cable**
- **Cables with steel wire or braiding**
- **Cables inside a steel conduit**

The effectiveness of braided wire shields is dependent upon the detailed construction including the wrap angle of the shield wires, the wire material and the number of layers. The best protection against the effects of EMP is obtained by the use of a continuous homogeneous screen such as that provided by the sheath of an MI cable or steel conduit.

The more important requirements for a good screen are listed in the table overleaf, which compares the effectiveness of nVent PYROTENAX Pyro MI Cable with that of a number of alternative cabling systems.

It is generally accepted that the most useful measure of cable shielding performance is given by the Surface Transfer Impedance, low values of transfer impedance being necessary in order to keep EMP interference to a minimum.

COMPARISON OF SHIELDING EFFECTIVENESS OF VARIOUS CABLE CONSTRUCTIONS

Shield Requirement	Cable System			
	Pyro MI Insulated Cable	Steel Wire Armoured (SWA)	Silicone Rubber Insulated Cores Al Foil/PVC Outer	Steel Conduit
Low Resistance	Excellent	Fair	Good	Fair
Complete Coverage	Excellent	Poor	Fair	Excellent
Light Weight	Excellent	Fair	Good	Poor
Strength	Good	Good	Fair	Excellent
Ease of Electrical Connection	Excellent	Fair	Good	Fair
Flexibility	Good	Good	Good	Poor

Work has been carried out in conjunction with the Atomic Energy Establishment at Winfrith to measure the transfer impedance of a representative range of Pyro MI Cables and a typical twin core 2.5 mm2 steel wire armoured cable. Values of surface transfer impedance are plotted against frequency in Fig. 1 and these values are in close agreement with those calculated from a theoretical cable shield equation derived by S. A. Schelkunoff ("The electromagnetic theory of coaxial transmission lines and cylindrical shields"
- Bell System Technical Journal 13,532-579, 1934).

Fig. 1 includes theoretical values for both MI cables and a twin core 1.5 mm^{2} silicone rubber insulated cable with an aluminium screen for further comparison.

It will be seen that for Pyro MI Cables the surface transfer impedance is equivalent to the d.c. resistance of the sheath up to approximately 1kHz, reducing significantly at higher frequencies. The transient voltage induced at frequencies above 1MHz are of no practical significance, the values being extremely small compared to the system operating voltages. As would be expected the heavy duty 4-core, 25 mm^{2} Pyro MI Cable (CC4H25) exhibits better transfer impedance characteristics than the heavy duty twin-core 2.5 mm^{2} cable (CC2L1.5), due to the increased overall diameter and sheath thickness.

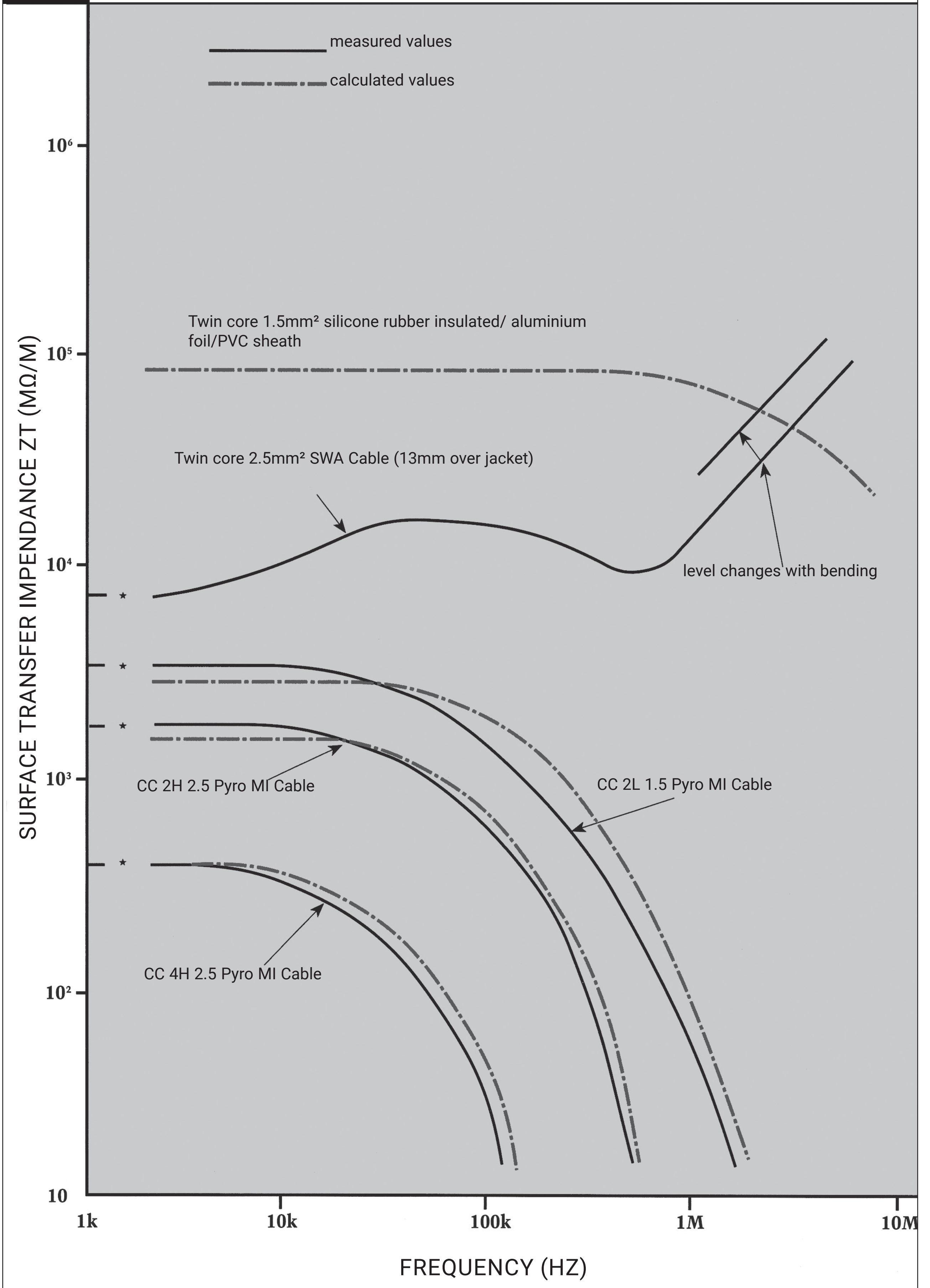
As shown in Fig. 1 the d.c. resistance of the screen in the SWA cable is higher than for the equivalent size of MI cable. The performance at very low frequencies would therefore be inferior to that of Pyro MI Cables. Owing to the stranded construction of the screen in SWA cables, oscillations can occur at high frequencies due to the reactive coupling of the strands. The practical tests also showed that the transfer impedance of SWA cable can be adversely affected by bending as indicated in Fig. 1. Furthermore, at frequencies above 1MHz the surface transfer impedance actually increases in value.

The relatively poor EMP performance of the silicone rubber insulated cable, as indicated by the calculated figures in Fig. 1, is attributable to the thinness of the aluminium foil screen and the lower conductivity of aluminium compared to copper. A further disadvantage from the point of view of resistance to EMP is that the foil screen is only wrapped around the cores and the seam is not welded. Seam quality is one of the most important factors in determining shielding performance, since seam resistance can cause currents to flow in a non- manner, whilst gaps in the seam can allow the passage of EMP interference through the shields.

Pyro MI Cables provide a unique solution to the problem of electromagnetic pulse interference as the solid drawn copper sheath provides the required screening and earth, with low electrical resistance and the other intrinsic advantages associated with Pyro MI Cable, such as durability, non-ageing properties, radiation resistance, fire survival characteristics, small overall diameter and high corrosion resistance. In particular there is no need for installation in conduits or for the provision of braiding or steel wire armouring, all of which carry penalties in terms of weight and flexibility.

Pyro MI Cables supplied by nVent UK Limited are, therefore, considered to be ideally suited for the wiring of military establishments, communication centres, large shelters, hospitals, public buildings and other important installations where protection against the effects of EMP is required.

Fig 5 **Variation in surface transfer independance with frequency showing excellent screening performance of Pyro MI Wiring Cables compared with alternative cable types.**



* Ro values (dc resistance of screen)

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