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FIRE-RESISTANT CABLES FOR SAFETY SYSTEMS OF FACILITIES WITH INCREASED RISKS IN FIRE CONDITIONS

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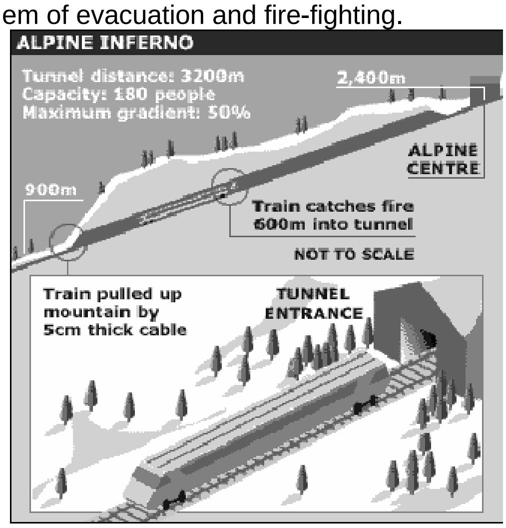
INTRODUCTION

Electric cables are sometimes used in the environment with increased risks if the fire has already developed. In such fire conditions it is necessary to secure the functioning of the feeding electric systems such as firefighting cranes, systems for increase of the extinguishing water pressure, automatic extinguishing systems, emergency lighting of evacuation roads, fire-alarm systems etc. Such a way will facilitate the evacuation of the persons there, the access of the rescue teams and the firemen, same as the fire-fighting itself.
On the functioning of these systems depend the lives of the persons caught at the place of fire, of the firemen participating in the fire-fighting, and the volume of the material damage caused by the fire.
Picture 1 is taken from BBC News (1), shows a sketch of the mountain railway tunnel in Kaprun, Austria, with clearly presented specific features of the tunnel: the danger of the fire breaking out isn't increased by itself, but the consequences of the occurred fire are much heavier – the 155 death-casualties in the year 2000. were in fact caused by a difficult access to the place of occurrence and the therewith connected problem of evacuation and fire-fighting.



Picture 1. *Sketch of the mountain railway tunnel in Kaprun, Austria (1).*

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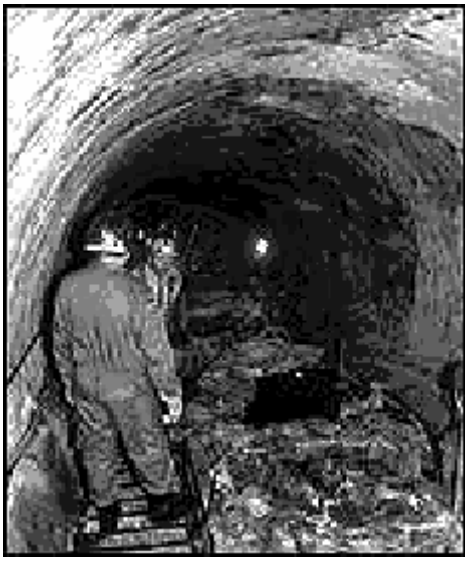
The rescue teams could not approach the place of accident until the fire was extinguished by itself, and because of that the number of casualties was so large. Pictures 2 and 3 show the interior of the tunnel after the fire.

Picture 2. *Interior of the tunnel after fire (1)*



Picture 3. *Interior of the tunnel after fire (1)*

To prevent the interruption of the safety systems operation in situations when they are mostly needed, special, so called “fire-resistant” cables have been developed, which secure the functioning of the safety systems even in the fire conditions.

During installation and application such cable acts as a common cable. But, the special quality of this cable is manifested in the fact that unlike the common cable which lose their insulation very quickly when they start to burn, causing thus a short circuit between individual cores, the “fire-resistant” cables do not lose their insulation properties even at the temperatures over 1000°C, when exposed to an open fire.

The fire-resistant cables have been developed as a response to the fire out-break situations with a large number of human casualties and material damages, and with time their application has been prescribed in the safety standards for the production of transport means, roads, tunnels etc., ensuring thus that the newly constructed facilities (tunnels, buildings, sport halls and other places anticipated for mass gatherings), i.e. the transport means (ships, railway trains...) would be safe for usage in normal conditions and that they would reduce the danger to people and property in the conditions of fire.

However, the facilities whose construction has started before the application of these regulations, as a rule do not contain such safety systems, i.e. their fitting has depended on the availability of such solutions at the time of the project preparation, as well as on the “good will” of the investor to pay for such solutions. As even today there are many of such facilities in operation, the modernisation of

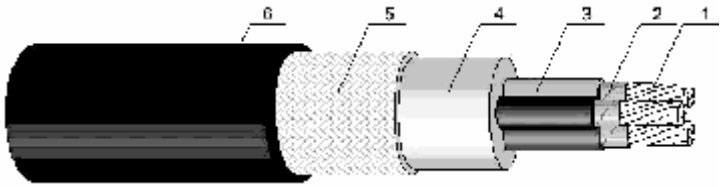
facilities by fitting of the prescribed safety systems is in the interest of safety of the people and of their property. A good opportunity for such measures is provided during periodical maintenance, reconstruction and renewal of destroyed buildings.

METHODS OF FIRE-RESISTANCE CHECKING

The actual fire-resistance of cables is confirmed in tests, as prescribed in the method IEC 60331-11 (2). However, it still does not mean that the cable installed within a cable route will preserve its fire-resistance. The fire conditions at the place of application will cause a deformation of the cable route, what may lead to mechanical strains and the subsequent breaking of the insulation material and the electric short circuit occurrence.
Because of that, methods have been developed to simulate the place of the fire outbreak – the cable route itself. During these tests the cable is installed in grooves and channels similar to those at the place of application and the fire outbreak is simulated by a gradual warming of the route. Such test is prescribed in a standard DIN 4102 (3).
DIN 4102 (3) is a German standard defining the behaviour of the construction materials and elements in the fire conditions, which has been adopted in German original as a Croatian standard under the name HRN DIN 4102 (4) by the State institute for standardization and measurement. The scope of the standard is to prescribe the repeated tests with simulated conditions of the fire outbreak and development, and the method proving that the condition of the cable system function has been preserved.

CABLE CERTIFICATION ACCORDING TO HRN DIN 4102 STANDARD

The certification of the cables BX0-HFVO 3G2.5 mm^2, BX0-HFVO 4x50mm^2 and TBX(Z1)OZO-HFVO 4x2x0.75mm^2 has been performed at the “Laboratory for Thermal Measurement”, which has been authorized by the State institute for standardization and certificate issuing of the Republic of Croatia to perform the tests and issue the certificates.
Picture 4 shows basic construction elements of fire-resistant cables.

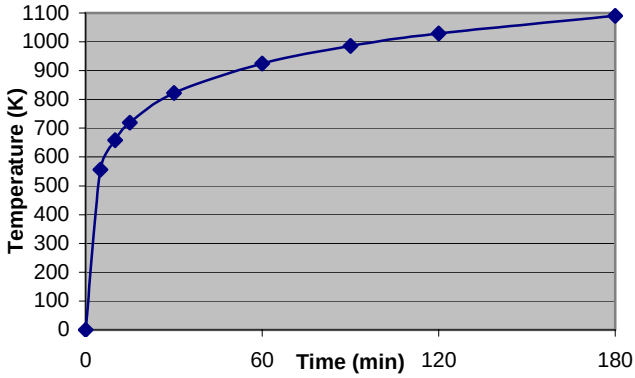


Picture 4. *Construction elements of fire-resistant cables 1. conductor; 2. mineral insulation; 3. polymer insulation; 4. inner sheath; 5. screen; 6. sheath*

HRN DIN 4102-2 (5) defines the construction elements and generally the test method, while HRN DIN 4102-12 defines actual requirements concerning the cable function preservation.
The cable sample is tested in a chamber of minimal dimensions l·h·w=2000mm·3000mm·2500mm. The test conditions are given by a fire curve, stating the time-dependant temperature, where υ represents the momentary measured temperature in the chamber, υ_0 the starting temperature in the chamber, t the time in minutes (DIN 4102 Teil 2 (6)):

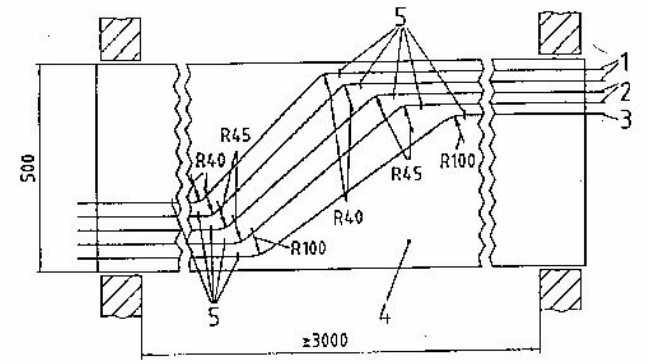
Table 1. *Time dependence of temperature. υ - momentary measured temperature; υ_0 – starting temperature; t – time*

t/min	υ-υ_0 K
0	0
5	556
10	658
15	719
30	822
60	925
90	986
120	1029
180	1090



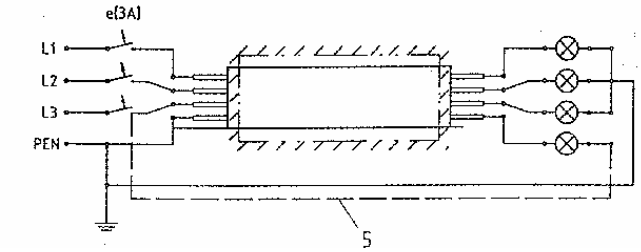
Picture 5. *Fire curve given in form of table and diagram*

The actual temperature in a chamber may deviate from the set one for ±100 K within the first 5 minutes, ±10% within the first 30 minutes, and ±5% after 30 minutes. The heating oil EL according to DIN 51 603 t1 (7) or diesel oil according to DIN 51 601 (8) could be used as a fuel for warming up of the chamber. The heating oil has been used in this specific case.
The test was performed on cables which, laid in the fire-resistant cable grooves, simulate the cable route. The cables change their direction within the route, stating thus the place of the most probable breakdown (picture 6).

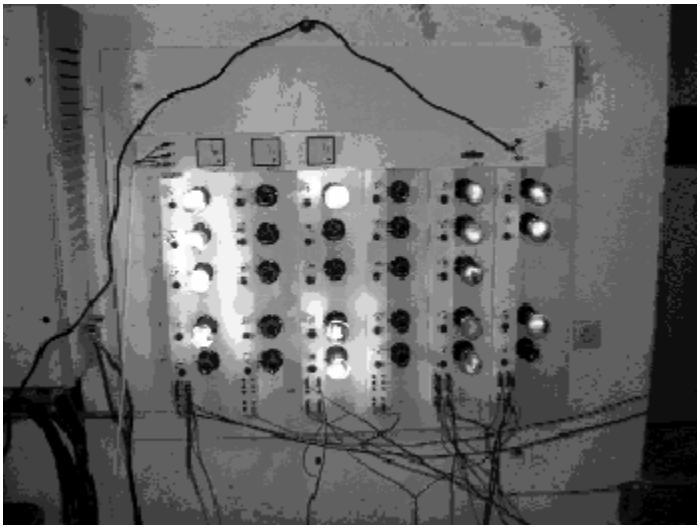


Picture 6. *Diagram presentation of tested cable route with cable bending radiuses and route dimensions in millimetre DIN 4102 Teil 12 (9)*

Pursuant to the requirements of the standard HRN DIN 4102-12, the class of function preservation E 90, it is considered that the cable has met the request of function preservation if during 90 minutes there would be no short circuit or interruption of the electric current flow in the tested cables. In this connection, the temperature within the chamber changes according to the fire curve from the ambient temperature (~23°C) to (986±49.3)°C. The short circuit occurrence is detected as a fuse ejection resulting in extinguishing of the control bulb (pictures 7 i 8).



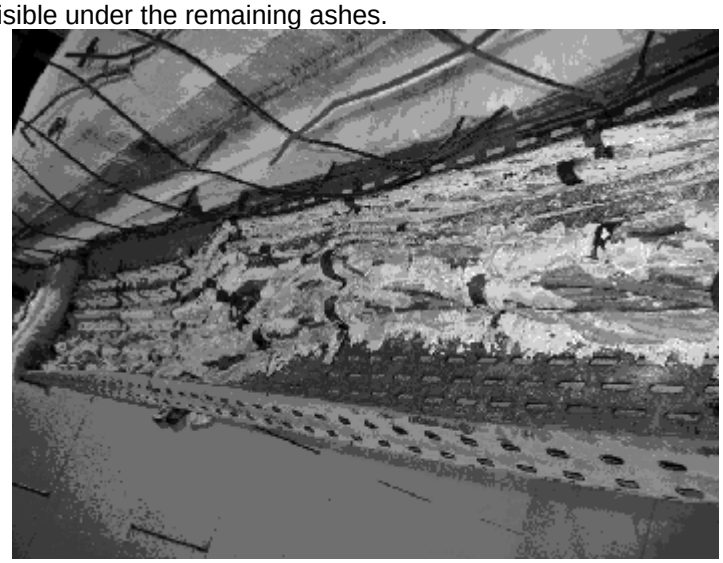
Picture 7. *Electric diagram of cable connection DIN 4102 Teil 12 (10)*



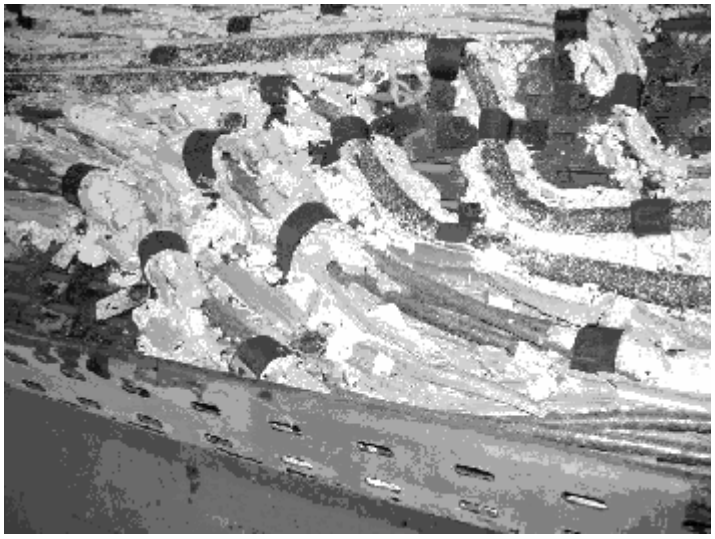
Picture 8. *Control bulbs*

Picture 9. *The window-view of the chamber. Metal groove with laid cable is visible*

Picture 9 shows the interior of the chamber during the test. Pictures 10 and 11 clearly show that the polymer insulation has completely burned leaving white ashes. The cable function was retained by the mineral insulation, visible under the remaining ashes.



Picture 10. *Picture of cable route after termination of tests.*



Picture 11. *Detail of cable route after termination of tests.*

CONCLUSION

The test has proved that the tested cables BX0-HFVO 3G2.5 mm^2, BX0-HFVO 4x50mm^2 and TBX(Z1)OZO-HFVO 4x2x0.75mm^2 meet the strict safety requirements stated in the standard HRN DIN 4102 (4) for cables installed within a cable route.
The certificate on conformity which has been issued on the basis of this test, confirms that the stated cables meet the requirements of the standard HRN DIN 4102-12 (11). The certificate is being issued for a specific type of cables of a specific producer, at which basis is being approved their fitting into the safety systems such as the tunnel Sv. Rok at the motorway Zagreb-Split, for which purpose the certification has been also carried out.

LITERATURE

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2. IEC 60331-11
3. DIN 4102
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5. HRN DIN 4102-2 – Behaviour of construction materials and elements in fire conditions – 2. part: Construction elements – Terms, requirements and tests (DIN 4102-2: 1977), 1996, State institute for standardization and measurement.
6. DIN 4102 Teil 2, Deutches Institut Für Normung e. V., page 5
7. DIN 51 603 Teil 1, Deutches Institut Für Normung e. V.
8. DIN 51 601, Deutches Institut Für Normung e. V.
9. DIN 4102 Teil 12, Deutches Institut Für Normung e. V., page 6
10. DIN 4102 Teil 12, Deutches Institut Für Normung e. V., page 8
11. HRN DIN 4102-12 – Behaviour of construction materials and elements in fire conditions – 12. part: Preservation of electric cables system function – Requirements and tests (DIN 4102-12: 1998), 2000, State institute for standardization and measurement.