Fire retardant coatings for electric cables

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Abstract

Fire Retardant Intumescent Coatings have been studied for fire protection of PVC Insulated Power Cables. The fire performance of coated cables has been assessed by employing standard methods. The coatings were found quite effective in reducing the burning behaviour of power cables. Significant improvement in circuit failure time is noted in coated cable specimens.

Introduction

ELECTRICAL cables are extensively used in all the major industries. These are mostly run through underground cable tunnels, trenches, overhead cable trays and ducts. Any fire incidence in the vicinity of these may result in the spread of fire along the cable trays as modern production facilities demand long run of power and control cables all over the plant area. It is well known that most fires are caused by a short circuit. Any fire incidence causes extensive damage when it spreads along the electrical cables and through these cables to other combustible materials. In order to prevent vertical or lateral spread of fire through cables all apertures or openings which are part of vertical or horizontal segregating element, through which cable or cable trays pass should therefore be segregated. It is essential that these are sub-divided into smaller zones. This may be done by providing fire barriers at different intervals by sealing all the openings with the use of fire retardant/ resistant materials. Such barriers are not applicable for existing electric cables systems. Rapid and unrestrained propagation of fire can also be checked by applying an effective fire retardant coating on electric cable. Application of coating is also possible in existing cable systems. Various fire retardant coatings are studied by various workers to retard the burning characteristics of cellulosic materials such as wood and wood based products [1-10]. However, no attention has been paid towards fire protection of electric cables using suitable coatings. Therefore, there is ample scope to develop fire retardant coating for electric cables.

There are two types of coatings that retard the spread of fire. One type of coatings, called fire retardant non-intumescent coatings, uses additives such as borax, boric acid, antimony trioxide, zinc oxide and chlorinated compounds which do not support combustion [1-5]. The other type is called fire retardant intumescent coating, which, when heated produces residues which are puffed up or are swelled by escaping gases. A combustion residue can be efficiently puffed up in order to produce a tough insulating foam over the surfaces to protect the materials [1,7-12]. These coatings perform better than simple fire retardant coatings. This paper is concerned with the development and evaluation of fire retardant intumescent coatings for electric cables.

Experiments

Preparation and application of coating

Fire retardant intumescent coatings were prepared by mixing the following main ingredients:

- Dehydrating agent such as organophosphorous compounds, ammonium phosphates.
- Spumific or blowing agent such as cyanoguanidine
- Carbonific agent such as 2-2 bishydroxymethyl 1-3 propanediol; starches.
- Plasticizer
- Thickening agent such as sodium salt of D-mannuronic acid
- Pigments

Binders such as acrylic emulsion and amino resin.

The coatings were prepared by mixing ingredients of 325-400 mesh size with appropriate quantity of thickening agent, antisettling agent, emulsifying agent, antifoaming agent, binder and plasticizer. Requisite amount of water

was added in order to obtain brush consistency. It was stirred vigorously with heavy duty stirrer. The fire retardant intumescent coating thus prepared is applied with brush on PVC insulated electric cables of different diameter. In order to obtain an effective fire retardancy the cables were coated with different amounts of coating to achieve various coating thicknesses. The effect of coating thickness on fire performance is determined.

Evaluation of cable coating

Physical properties such as colour, odour, specific gravity, flexibility etc. were evaluated adopting standard procedure and are recorded in Table-1.

TABLE - 1: PHYSICAL PROPERTIES OF COATING

Colour	:	Off white
Odour	:	Faint odour
Consistency	:	Brushable
Surface finish	:	Matt finish
Specific gravity (As per IS-101)	:	1.2 - 1.3
pH value	:	6 to 8
Flexibility (As per IS-10810)	:	No cracking or disbonding observed

Fire performance of coating

Fire performance of coating is evaluated by following standard procedure:

Preparation of specimen

PVC insulated three and a half core aluminium conductor armoured cable specimens of length 1200 mm and of outer diameter 31 mm were taken. The cables were coated with different amount of coating to achieve 1.0 mm to 3.0 mm dry coating thickness. 100mm sheath of outer covering of the cable was removed from each end of the specimens. At one end of the cable, the conductor wires were suitably connected for electrical connections and at the other end the exposed cores were spread apart to avoid contact with each other. The specimen was held horizontally by means of suitable clamps at each end of the sheathed portion. The middle portion of cable was supported by two metal rings, placed approximately 300 mm apart and all the metal part of the supporting apparatus were properly earthed. The cores of the cable under test were connected to separate phases for obtaining three sets of connections to the three phases. Adjacent conductors were connected to different phases. The test was carried out in a chamber provided with means of disposing of gases resulting from the burning cable.

Heat source

A tubol type gas burner of 610 mm long is used to ignite the samples. A thermocouple was fixed parallel to the burner and 75mm above it to measure the temperature of the flame. The LPG is used as a fuel. The air supply and flame height were so adjusted that 750°C temperature obtained throughout the test.

Evaluation procedure as per IEC-331

After fixing up the cable specimens in the test apparatus, 440V, 3 Phase, 4 wire electric supply was connected to the cable and the cable remained energised with rated supply throughout the test. The cable was then lowered into position so that it remained parallel to the burner and its lower surface was 75 mm above the burner. The evaluation was started with the initial measurement and final adjustment of the flame temperature of the heat source to 750°C at the height of 75mm.

The flame and rated voltage were applied continuously till circuit breaks. Few samples were exposed at 750°C for 20 minutes and then energised test was carried out after 12 hours when flame has been extinguished, using rated voltage (as above) to check the continuity of the electric cable. Observations made during the evaluation are recorded in Tables - 2 & 3.

Results and discussion

It is evident from table 2 & 3 that fire retardant coating is very effective in reducing the burning characteristics of electric cables. No flame spread or flaming was observed during exposure in coated specimens. Circuit failure time was also increased significantly in coated specimens. It is noted that fire performance is also dependent upon cable dia and thickness of the coating. It is observed that for 31 mm cable dia about 2.8 mm coating thickness is required to pass re-energise test after 20 minutes exposure while in case of 20 mm cable dia thickness of cable coating is required about 3.2 mm.

The main constituents of fire retardant intumescent coating under study are spumific, carbonific and dehydrating agents. When this combination is exposed to fire,

TABLE - 2: RESULTS AS PER IEC - 331

Cable dia (mm.)	Coating thickness (mm.)	Failure of circuit Time Min.	Sec.
20	Uncoated	3	17
20	1.5 - 1.7	9	45
20	2.0 - 2.2	17	40
20	2.5 - 2.7	20	24
20	3.0 - 3.2	21	38
31	Uncoated	4	29
31	1.5 - 1.8	13	38
31	2.0 - 2.2	20	42
31	2.5 - 2.6	22	54
31	3.0 - 3.2	26	49

TABLE - 3: FIRE PERFORMANCE AS PER IEC-331
(Re-energise test)

Cable dia (mm.)	Coating thickness (mm.)	Time of exposure (min.)	Re-energise test result
20	2.8 - 3.0	20	Fail
20	3.2 - 3.5	20	Pass
31	2.0 - 2.5	20	Fail
31	2.8 - 3.0	20	Pass
31	3.0 - 3.2	20	Pass

carbonific agent react with an acid evolved by dehydrating agent and produces a large amount of carbonaceous char which produces a non-combustible barrier to protect the substrate. Spumific agent gives off non-combustible gases causing the foamable carbon to produce a honeycomb blanket resulting highly effective insulation [7-9]. The binder on softening forms an expandable skin over the carbonaceous char to resist the escape of gases produced by spumific agent. All these reactions take place within the coating, thereby the material is well protected from heat.

Conclusion

The fire retardant coating employed is found quite effective in reducing the flammability of electric cables. Circuit failure time is also increased significantly in the coated cables. When rated voltage was given to cables after exposing for 20 minutes in fire coated cables they were found in workable condition.

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