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도장 오염이 Electric Cable 의 성능에 미치는 영향 연구

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A Study on Effect of Coating Stain on the Performance of Electric Cable

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Abstract

After the installation of electric cables at block, PE(pre-erection) and hull stages, the coating stains on the electric cable sheath were unavoidably occurred by additional painting process. According to class rules, paint or coating applied on the electric cables shall not adversely affect the mechanical, chemical or fire resistant characteristics of the electric cable sheath. However, there has not been quantitatively studied about the effect of coating stains on properties of sheath materials. In this study, we tried to investigate the effect of coating stains on the performance and deterioration of sheath materials by using FTIR, SEM analysis, flame retardant, high potential voltage and tensile test. The results showed that coating stains, which were occurred during painting work on site could not adversely affect on the performance and deterioration of sheath materials.

※Keywords: Coating stain(도장오염), Electric cable sheath(전선 피복제), FTIR(적외선분광분석), Flame retardant test(난연성 시험), High potential voltage test(내전압 시험)

1. 서론

The electric cable for vessel is used for various purposes such as the power, control system and communication.

In the shipbuilding industry, the installation of electric cables in the engine room block frequently was performed before the final painting work. Despite of many protection efforts to prevent coating stains on electric cable sheaths these were unavoidably occurred by the

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additional painting work, as shown in Fig. 1.

According to class rules, a paint or coating applied on the electric cables shall not adversely affect the mechanical, chemical or fire resistant characteristics of the electric cable sheath.

However, there has not been quantitatively studied about the effect of coating stains on properties of sheath materials.

In this study, we tried to investigate the effect of coating stains on the performance and deterioration of sheath materials by using the infrared, SEM analysis, flame retardant, high potential voltage and tensile test.

Fig. 1 Coating stains on electric cable sheath(above) and protection by vinyl material(below)

2. Experimental

For this study, it was used that three types of sheath materials.

Table 1 shows the characteristics of these sheath materials. The base monomer of the ST2 sheath is polyvinyl chloride and the SHF1, SHF2 sheath is polyethylene and ethylene vinyl acetate.

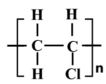
Generally, the ST2 sheath applied on a general purpose, the SHF2 sheath applied on a specific purpose.

Table 1 The characteristics of sheath materials

Sheath name [1]	Base monomer	Forming system
ST2	Polyvinyl chloride [2] (PVC)	thermoplastic
SHF1	LDPE, EVA [3] copolymer	thermoplastic
SHF2	LDPE, EVA copolymer	thermosetting

1) designated by international electrotechnical commission (IEC)

2)



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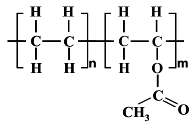


2.1 Preparation of coated sheath specimens

For preparation of coated sheath specimens, commercial epoxy and alkyd paints were applied on each sheath material and dried for 15days. Dry film thickness was 80±15 ㎛.

These paints mainly applied in the engine room block. Considering the condition of painting work , the thinner was mixed 5% by volume.

2.2 Infrared, SEM analysis, flame retardant test, high potential voltage and tensile test

Infrared analysis was carried out by using FTIR-ATR spectrometer (Perkin Elmer Spectrum GX) in the wave region between 4000 and 500cm^{-1}, resolution 4 cm^{-1} and 32 number of scan. Tensile test was performed by using the sheaths of dumbbell type(ASTM D 638) at the cross head speed of 250 mm/min. Flame retardant test was performed according to IEC 60332-1. High potential voltage test was performed to monitor leakage current and the voltage was supplied 0, 10, 20, 30, 40, 50 KV, respectively.

3. Results

3.1 Flame retardant test

This test was performed according to IEC(international electrotechnical commission) 60332-1 standard. Fig. 2 shows the requirement of this standard on a flame retardant property of a sheath material. The requirement is the limit of charring within 50mm at the top of a cable from flame starting point.

Fig. 3 shows flame retardant test results of sheath materials.

There was not charring within 50mm of the top of alkyd and epoxy coated cables from flame starting point and the charred area of coated cables was almost equal to that of uncoated cables.

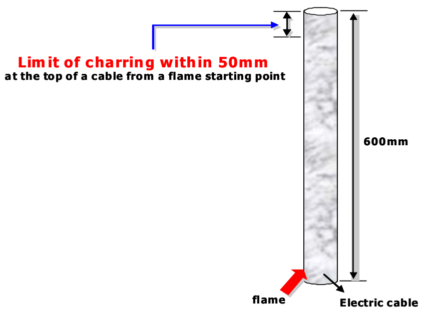


Fig. 2 The requirement of IEC 60332-1 standard on the flame retardant property of a sheath material.

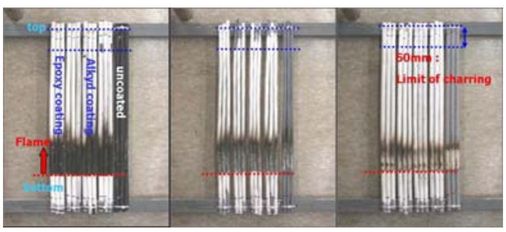


Fig. 3 Flame retardant test results of left)ST2 middle)SHF1 right)SHF2 sheath

These results show that the requirement of IEC 60332-1 standard is adequately met and there is little difference on the flame retardant property between the uncoated and coated condition.

3.2 Tensile test

This test was performed according to IEC 60811-1 standard. For the requirement of this standard on the tensile property of a sheath material, ST2 sheath shall have the tensile strength above 1.276kgf/mm^2, elongation above 150%. SHF1 and SHF2 sheath shall have the tensile strength above 0.918kgf/mm^2, elongation above 120%.

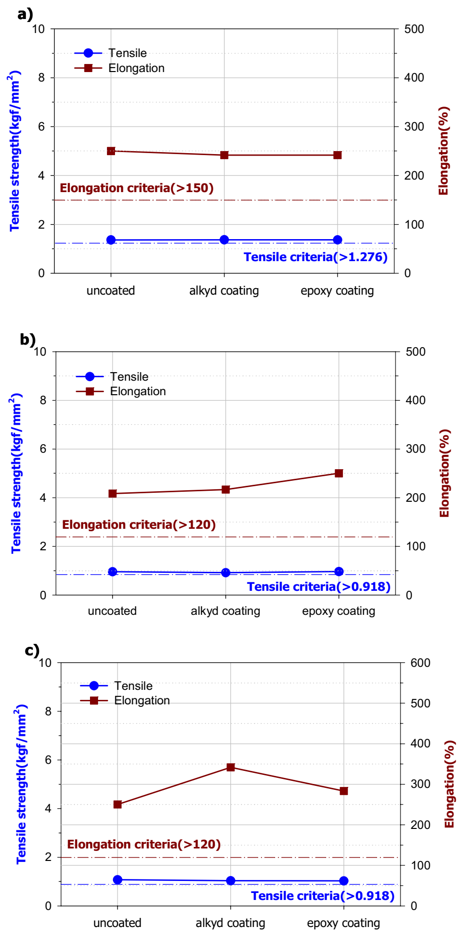


Fig. 4 Tensile test result of a)ST2 b)SHF1 c)SHF2 sheath

Fig. 4 shows tensile test results of a)ST2 b)SHF1 c)SHF2 sheath. Blue line indicates the tensile strength, red line indicates elongation and dash-dot line indicates the requirement of this standard.

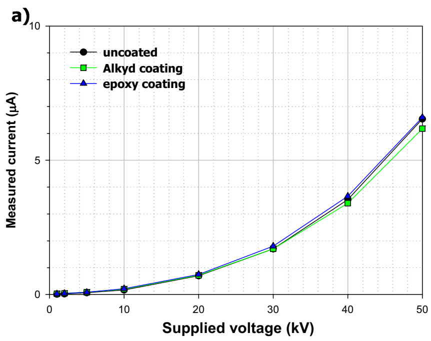
There was not the decrease of the tensile property of coated sheaths, in comparison with that of uncoated sheaths and the requirement of IEC 60811-1 standard was met.

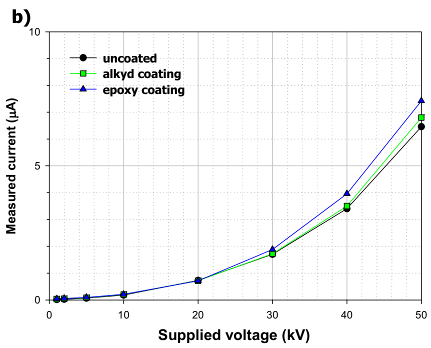
These results show that coatings does not adversely affect on the mechanical property of sheath materials.

3.3 High potential voltage test

This test is helpful in finding nicked or crushed insulation. So we applied this test to checking the isolation property of coated sheaths.

Fig. 5 shows high potential voltage test results of a)ST2 b)SHF1c)SHF2 sheath.





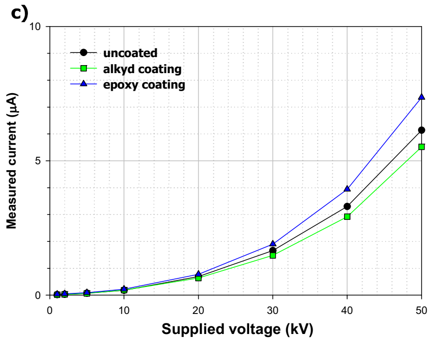


Fig. 5 High potential voltage test result of a)ST2 b)SHF1 c)SHF2 sheath

The measured current gradually increased as increase of the supplied voltage both of uncoated and coated sheaths.

However, although the supplied voltage was very high, the measured current was very low as the current unit of ㎂.

In addition, there was little difference on the measured current between uncoated and coated condition.

These results show that coated sheath materials have good isolation and coatings does not adversely affect on the isolation property of sheath materials.

3.4 Infrared analysis

This analysis was performed to investigate the deterioration of sheath materials by coatings.

We could expect that if sheath materials are deteriorated by coating materials, there are any changes of the IR spectrum such as the intensity of transmittance bands and the position of peaks, in comparison with that of intact condition.

For example, Fig. 6 shows IR spectra of deteriorated ST2 sheath after immersion in the commercial epoxy thinner for 24 hours.

The intensity of transmittance bands broadly decreased all over wave number range and the peaks at 2957~2857 cm^{-1}, 1724 cm^{-1}, 1122 cm^{-}

[1] and 1072 cm^{-1} disappeared.

These results show molecules or molecule groups forming a ST2 sheath material was deteriorated by the chemical reaction with the commercial epoxy thinner.

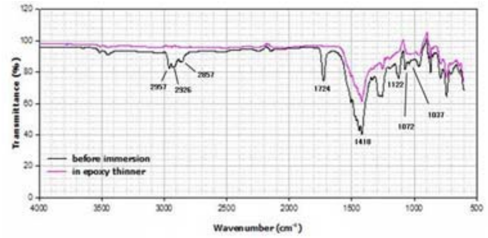


Fig. 6 IR spectra of deteriorated ST2 sheath after immersion in commercial epoxy thinner for 24 hours

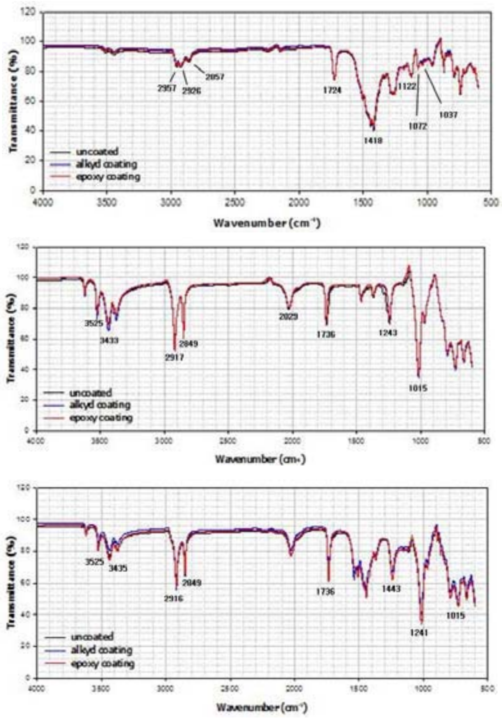


Fig. 7 IR spectra of coated above)ST2 middle)SHF1 below)SHF2 sheath.

Fig. 7 shows IR spectra of coated sheath materials.

There were hardly changes of IR spectra of alkyd and epoxy coated sheath materials, in comparison with that of intact sheath materials.

As mentioned before, these results show alkyd and epoxy coating included thinner 5% by volume can not cause the deterioration of sheath materials.

3.5 SEM analysis

SEM analysis was performed for the observation of micro defects, especially cracks by coating materials.

Fig. 8~10 shows SEM images of the surface of coated sheath materials, in comparison with the uncoated condition.

Winkles and holes originally existed on the surface of intact sheath materials. Except for those, cracks were not observed on the surface of coated sheath materials.

These results show that the internal stress caused during film formation can not be occur any cracks on the surface of sheath materials.

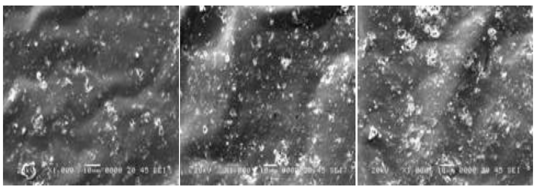


Fig. 8 SEM images of ST2 sheath left)uncoated middle)alkyd coating right)epoxy coating

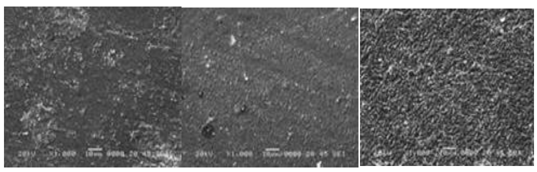


Fig. 9 SEM images of SHF1 sheath left)uncoated middle)alkyd coating right)epoxy coating

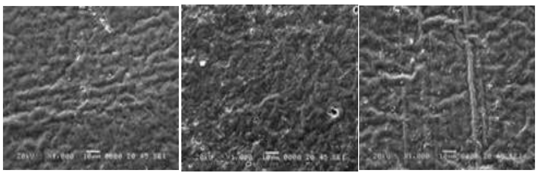


Fig. 10 SEM images of SHF2 sheath left)uncoated middle)alkyd coating right)epoxy coating

4. Conclusion

We investigated the effect of coating stain on the performance and deterioration of sheath materials, It was confirmed the follow results

1. The flame retardant, tensile and isolation property of coated sheath materials were adequately met the requirement of each standard and there was little difference on these properties between uncoated and coated condition
2. Each coating material did not cause the deterioration, micro defects of sheath materials

From these results, it seems reasonable to conclude that coating stains, which are occurred during painting work on site can not adversely affect on the performance and deterioration of sheath materials.

Reference

● IEC 60331, test on electric and optical fibre cables under fire condition.

● IEC 60811, Common test methods for insulating and sheathing materials of electric cable.

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