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Recent Corrosion Protective Steel Pipes†

1. Introduction

JFE Steel supplies a wide range of corrosion-protective steel pipes which are galvanized, painted, or plastic-coated, at inside and/or outside of the pipe, as optimum piping materials for individual applications and sites, such as water supply, electric power, telecommunications, and pipelines for crude oil and natural gas transportation.

JFE Steel has recently commercialized a polyethylene-coated steel pipe, PLS-F, applicable to underground, indoor, and outdoor use for the gas line, and a 3-layer polyethylene-coated steel pipe using fusion-bonded epoxy primer to meet the pipeline needs of the global market. This report introduces these two new products.

2. Polyethylene-Coated Steel Pipe for Gas Line, PLS-F

JFE Steel pipes for the domestic gas line are mainly galvanized steel pipes and steel pipes with an outside coating of polyethylene or polyviny lchloride (PVC). Conventionally, steel pipes with an outside coating of polyethylene have been used for underground, and pipes with an outside coating of PVC have been used for indoor and outdoor applications. Following the recent revision of the Building Standard Act of Japan, JFE Steel has commercialized a new polyethylene-coated steel pipe, PLS-F, as a steel pipe that can be used for underground, indoor, and outdoor services, based on the conventional polyethylene-coated steel pipe (PLS) for underground use.

2.1 Advantages of PLS-F

The advantages of PLS-F are as follows:

(1) Wide application range (underground, outdoor, indoor, and penetration through fire compartment).
(2) Screw joints and mechanical joints can be used.
(3) Excellent resistance to heat and chemicals and high low-temperature-impact strength.

The coating structure of PLS-F is shown in **Fig. 1**.

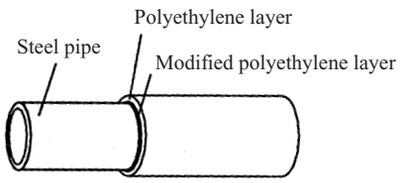

Fig. 1 Coating structure for PLS-F

2.2 Typical performance of PLS-F

2.2.1 Evaluation for penetration through fire compartment

A pipe that penetrates through a fire compartment installed in a building to prevent the spread of fire is required to undergo a fire-resistance performance test[1,2], as illustrated in **Fig. 2**, to evaluate the ability to resist the spread of fire at the penetration section of the pipe. The test requests that the pipe does not induce fire to spread to the non-heated side, does not generate cracks after the burning of coating through which flames could penetrate, and that the backside temperature does not exceed either 210°C, or +180°C of initial temperature. **Table 1** shows the results of the tests carried out under

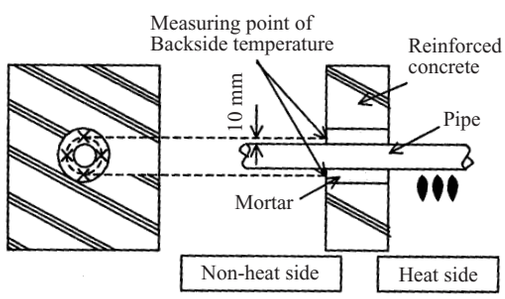

Fig. 2 Illustration of fire-resistance test

Table 1 Summary of fire-resistance tests for fire wall/floor with PLS-F

	Presence of crack through wall/floor	Backside temperature (°C)
Fire floor with PLS-F (n2)	No	146
	No	147
Fire wall with PLS-F (n2)	No	135
	No	131

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specified conditions[2] at a designated organization, Japan Testing Center for Construction Materials. The PLS-F provided with appropriate heat resistance showed good results, and was approved by the Minister of Land, Infrastructure and Transport, and also acquired Performance Appraisal by Fire Protection Equipment and Safety Center of Japan.

2.2.2 Heat resistance

As shown in **Photo 1**,the coating of PLS-F does not disbond from the pipe and suffers very little discoloration, compared with PVC-coated steel pipe, even after a thermal ageing test (200°C for 1 h) simulating usage at a kitchen. **Figure 3** shows the penetration depth into the plastic coating in indentation tests at specified temperature-levels with a 2.5 kg load applied for 24 h. The hardness of the PVC-coating significantly decreased in the temperature range from 60°C to 80°C, while the hardness of the coating of PLS-F decreased very little. This shows that PLS-F has equivalent or higher heat resistance than PVC-coated steel pipe.

2.2.3 Weather resistance

Weather resistance is essential for outdoor applications. The coating of PLS-F is weather-resistant, and showed excellent durability in an accelerated weathering test using a weatherometer, providing fully satisfactory performance.

3. 3-Layer Polyethylene-Coated Steel Pipe with Fusion-Bonded Epoxy Primer for Linepipe Applications

Most polyethylene coated steel pipes for pipeline have a thermosetting epoxy layer as the primer to improve the corrosion resistance. There are two groups of epoxy primer, powder type and liquid type. The liquid-type primer is applicable in a thin film, and the powder-type primer, fusion-bonded epoxy primer, readily forms a thick film, thereby forming a highly durable coating. The specification grade of overseas long-distance pipelines has been enhanced to meet rising demands for growing use in severe environments, and the system using fusion-bonded epoxy primer has become the standard. In response to the movement, JFE Steel has commercialized a 3-layer polyethylene-coated steel pipe with fusion-bonded epoxy. The coating structure is shown in **Fig. 4**.

3.1 Typical Performance of 3-Layer Polyethylene-Coated Steel Pipe with Fusion-Bonded Epoxy Primer

Since a linepipe is generally under cathodic protection, the phenomenon called “cathodic disbanding” occurs, in which the coating starts to peel from a damaged point of the coating. Accordingly, the resistance to cathodic disbanding is an important performance item for plastic-coated steel pipes. The heat cycle resistance at very low temperatures is also important for plastic-coated steel pipes used in cold areas such as Russia. The recently commercialized 3-layer polyethylene-coated steel pipe with fusion-bonded epoxy primer has excellent performances as given in **Table 2**, and fully satisfies the specifications of linepipes for transporting natural gas and other materials.

	Initial	Heat aging (after 200°C × 1 h)
PLS-F		
PVC coated steel pipe		

Photo 1 Change of appearance after heat ageing

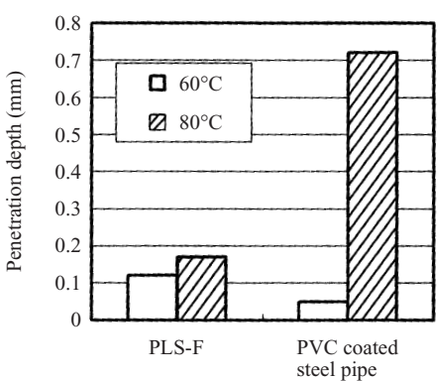

Fig. 3 Results of indentation test (DIN 30670)

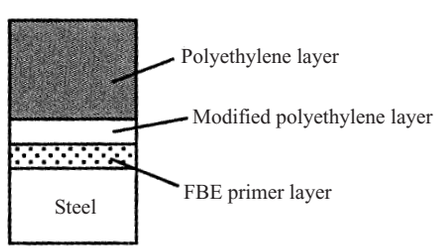

Fig. 4 Coating structure of 3-layer polyethylene with fusion bonded epoxy

Table 2 Performance of 3-layer polyethylene coated steel pipe with fusion bonded epoxy primer

	Representative specifications		Results
	Test conditions	Criteria	
Cathodic disbonding resistance	60°C, −1.5 V, 28 days	Disbonding radius ≦ 15 mm	< 5 mm
Heat cycle resistance	−60°C, 8 h ⇔ 23°C (water), 15 h	No delamination after 15 cycles	No delamination after 30 cycles

4. Conclusion

Two products recently commercialized for the domestic gas line and for the linepipe of natural gas were introduced. These products are widely applicable in various fields and offer excellent durability, and will be of benefit to customers in various applications.

References

1) The Building Center of Japan. The Building Standard Law Enforcement Order Article 129-2-5, Paragraph 1, Item (7-c). Flame Insulating Performance Test for Pipes that Penetrate Fire Compartments.
2) Fire Protection Equipment and Safety Center of Japan. Fire-Resistance Test for Piping that Penetrate Fire Compartments.