

KC TUBE



**Heat Exchanger Tube
with Internal Protective Resin Film**



SHINKO METAL PRODUCTS CO.,LTD.



The corrosion resistance of the copper alloy tubes used in heat exchangers is heavily dependent on the state of the protective film on the inside walls of the tubes. If the cooling water is clean, aluminum-brass tubes will develop a natural protective film with excellent corrosion preventive performance, but low-quality cooling water can cause accelerated corrosion, and industry has demanded a solution. If the cooling water contains excessive amounts of material deposited on tube walls, it is also essential that cooling tubes be cleaned to remove any deposits.

To address these requirements, we developed these copper alloy tubes with resin protective films on internal surfaces, and under the name “KC Tubes” they have earned high praise from industry.

This pamphlet describes some of the key characteristics of KC Tubes for technical reference by users.

1 Features

Corrosion resistance

The inner surface of the tube is protected against corrosion, providing excellent resistance to corrosion caused by short-term pollution of cooling water.

Foreign matter cleansing effect

The tubes offer excellent durability to cleaning by sponge balls or other methods, making them a good choice for cooling water which requires frequent cleaning to remove deposited matter.

Thermal conductivity

The reduction in the heat transfer coefficient due to the resin film is only 5% compared with aluminum brass bare tube under the test condition same as power plant condenser, demonstrating excellent performance even with the protective coating. And because pollution by corrosion byproducts during operation is minimal, possible reduction in the coefficient during operation is also suppressed.

2 Corrosion resistance

Table 1 indicates the water flow test results in a one pass model condenser. To better observe the corrosion dynamics where localized peeling of the resin film has occurred for some reason, the film was scratched prior to testing.

Table 1 Water Flow Test Results

Seawater	Corrosion depth (in mm) Values in parentheses are for scratched	
	KC Tube	Uncoated aluminum-brass tube
Clean seawater (sponge ball cleaning: 3 balls/time/week)	None (0.02 to 0.04)	0.03 to 0.05
Seawater with mild pollution (sponge ball cleaning: 3 balls/time/week)	None (0.03 to 0.07)	0.09 to 0.21

Note: Mild pollution: Clean seawater artificially polluted with 0.2 ppm S2- x 1H/day.
Flow rate: 2.5 m/s
Test duration: 6 months

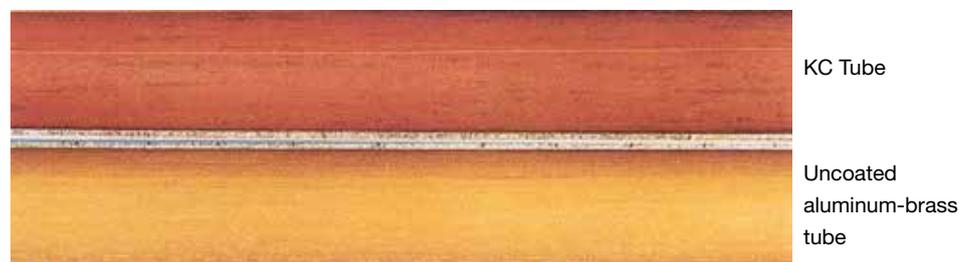
The resin coating showed no swelling or peeling under any test conditions, and no corrosion was detected in regions protected by the film. Corrosion in the pre-scratched regions was less than that observed in unprotected aluminum-brass tubing. This fact is due to the low potential difference between the covered portions and the tube surface, and the formation of a film with high polarization resistance around the scratched region, thereby suppressing corrosion even if localized peeling is present.

Table 2 Examples of Natural Potentials

KC Tube	-210mV SCE
Uncoated aluminum-brass tube	-220mV SCE

Photograph 1 After Model Condenser Testing

Clean seawater



Seawater with mild pollution

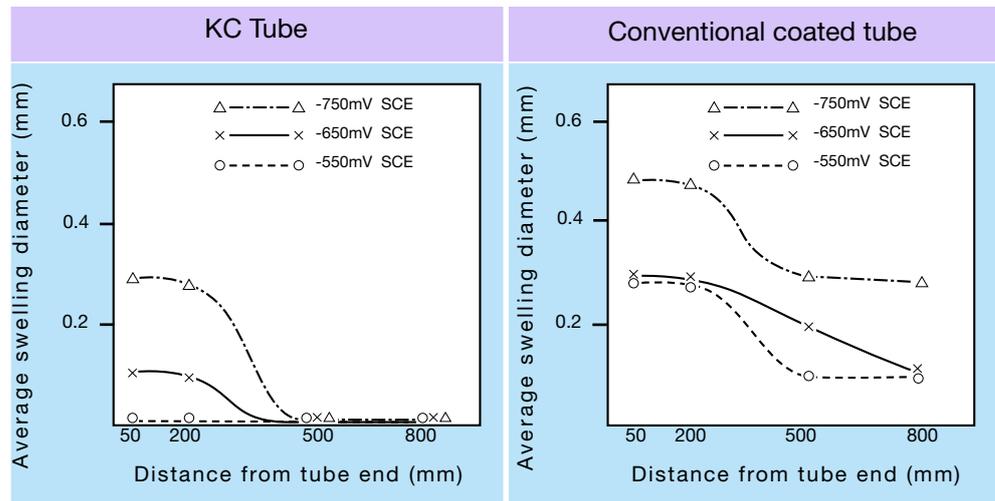


3 Film Durability

(1) Film swelling due to cathodic protection

Resin films have a tendency to swell under the effects of cathodic protection, but the high sealing performance of the film used in KC Tubes significantly reduces the swelling that occurs inside tubes. Swelling can be minimized to the point where it presents no problems in practical application by maintaining the potential of the tube plate surface at about -550 mV SCE.

Fig. 1 Film Swelling Due to Cathodic Protection



Model condenser test
Potential control: Constant-potential electrolysis
Flow rate: 2 m/s
Test duration: 25 days

(2) Durability to sponge ball cleaning

The protective film exhibited absolutely no damage after passing 300,000 medium-hard sponge balls through the tubing, demonstrating that for all practical purposes coating wear from sponge balls can be safely ignored.

KC Tube delivers superior durability even in situations where frequent sponge ball cleaning is used to remove deposited material.

4 Heat Transfer Performance

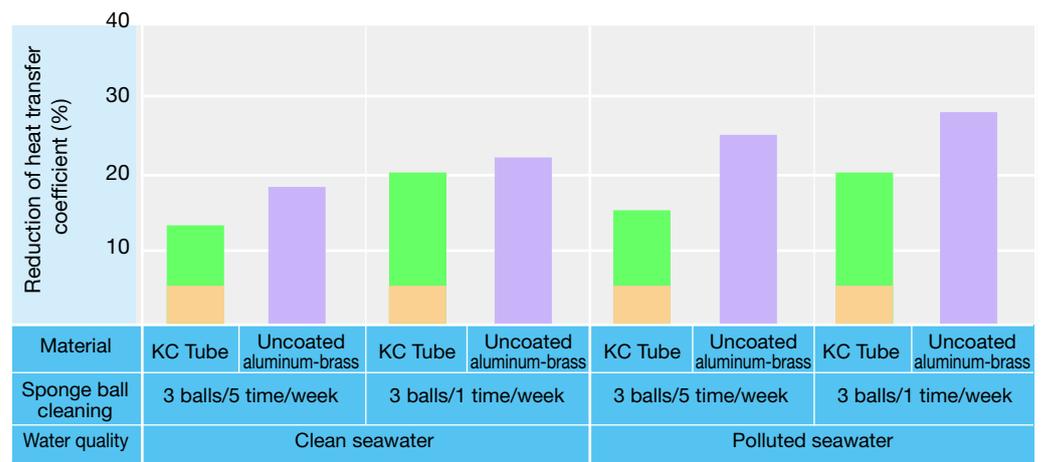
(1) Thermal resistance of film

The thermal resistance of the resin coating in the inner surface is about $1.5 \times 10^{-5} \text{m}^2 \text{K/W}$, which is equivalent to a 5% reduction in the coefficient of heat transfer for a condenser using aluminum-brass tubing with 1.24 mm wall thickness. Heat transfer performance is extremely high for tubing with protective film.

(2) Coefficient of heat transfer in use

KC Tube is largely free of corrosion products, and easy to clean in the event that deposits are generated by the cooling water, so that the coefficient of heat transfer in actual use is significantly superior to that of uncoated tubes.

Fig. 2 Coefficient of Heat Transfer After Live Testing in Model Condenser



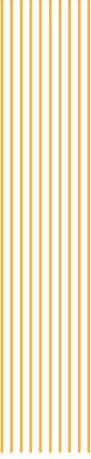
Test duration: 15 months
Flow rate in tubes: 2 m/s

■ Reduction due to film
■ Reduction due to deposits
■ Corrosion products + depos-

(3) Conclusion

The thermal resistance of the tube film has been minimized, and as build-ups occurring during operation can be removed easily, heat transfer performance is significantly higher than that of uncoated aluminum-brass tubes.

KC Tubes have been used as replacements in plants where ferrous ions are implanted to form a protective film, eliminating the need for ion implantation to form the initial protective film, and helping avoid overall system performance degradation.



5 Usage of KC Tubes

(1) Handling

Transport, storage and installation of the KC Tubes is handled in the same way as standard uncoated tubes. The protective film will not peel even under normal flexing during installation.

(2) Tube expanding

From the viewpoint of expanding workability, in principle, both ends of tubes are delivered without protective film on the expanding regions. The end regions are amply protected by cathodic protection, and there should be no worries of corrosion even when used without protective film. Please use them as expanded (without coating the expanded regions).

(3) Cathodic protection

Use of cathodic protection on resin-coated tubes may cause swelling in protective film near the tube ends. The tight sealing performance of the film used in KC Tubes, however, offers swelling significantly lower than that encountered in conventional film-coated tubes. If the potential of the tube surface is maintained at about -550 mV SCE, swelling can be suppressed to the point where it can be safely ignored in practical use.

In cases where potential distribution may be non-uniform due to partial replacement or other reasons, please set the polarization resistance for the most noble region to -500 mV SCE.

(4) Tube internal cleaning

Sponge balls are appropriate for cleaning foreign deposits from the interior of the tubes during operation. Carborundum balls will damage the resin protective film, however, so normal balls are recommended.

Cleaning with brushes or jets, when water flow stopped, can also be used to easily remove deposits.

(5) Eddy current flaw inspection

When eddy current flaw inspection is used to detect tube wall thinning, it should be implemented using normal parameters. The film has no effect on the inspection process, and the parameters are therefore the same as for tubes with no coating.

(6) Prevention of foreign matter influx

Sharp foreign objects inside the tube may damage the protective film, and so standard measures should be taken to prevent influx.

(7) Ferrous ion injection

When all tubes in the system are KC Tubes, corrosion prevention effectiveness will be excellent even without ferrous ion injection. If only some tubes are replaced and ferrous ion injection is being used to minimize corrosion on other tubes, continue that injection normally. The entire system will achieve improved heat transfer performance because, compared to uncoated tubes, it will not require as high an injection concentration to create the initial film.



6 Supported specifications

Type of film:	Epoxy resin
Film thickness:	5 to 15 μ m avg.
Tube flaring:	No coating on flared ends (about 50 mm; length adjustable to customer request)
Material:	Copper alloy (JIS H3300-C4430, C6872, C7060, C7150, etc.)
Dimensions:	Straight tubes OD : 16 to 38 mm (ID 13 mm min.) Length : 25,000 mm max. U-shaped tubes Bend radius : 1.5 D min. 800 mm max. Leg length : 10,000 mm max.



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