SIMPLE NON-DESTRUCTIVE DIAGNOSTIC METHOD OF FACILITY PIPES WITH USE OF INFRARED CAMERA

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ABSTRACT

The service life of structures is over 60 years. But the service life of facilities pipes is 10-15 years because of influence of rust and other factors.
To rehabilitate deteriorated pipes is necessary for long-time use of structures, and it is important to periodically diagnose the rust conditions of pipes.
Therefore, a system for diagnosis of the situations of internal rusting of pipes was developed, with nondestructive and easy diagnosis of pipes in broad range as the objective.
This system temporarily heats the film for heat storage, which is adhered to the external surface of the pipe, and picks up changes in the temperature of the film with an infrared camera.
The picked up images are recorded with a video tape recorder, and rust conditions of the pipe interior are diagnosed from the played back images.
Dummy rusts of thickness 5mm, ϕ 20mm and up could be visualized in the experiments.
Furthermore, good matching was obtained between thermographs and situations of the pipe interior as a result of application of the system to actual rusted pipes, and thus the effect of this system was confirmed.

1. INTRODUCTION

In the pipes (Carbon steel pipes for ordinary piping) used for construction facilities, when used as they are over a decade, damage such as a leak or blockage is prone to come about due to corrosion on the internal surface of pipes. Therefore, diagnosis of the pipes is made by a destructive or non-destructive method and based on the result, a repair work is done.
In the non-destructive diagnosis, measurement of the pipe thickness is mainly made with the use of an ultrasonic thickness meter.
The ultrasonic thickness meter is used for a point measurement.
Therefore, for a pipe interior where corroded position is not clear, multi-point measurement is required and it takes much inspection time. Also, rust or scale cannot be detected.
Thus, as a simple method for detecting a corroded position inside the pipe at a presage of the diagnosis with the ultrasonic thickness meter, an infrared camera method (thermography method) was examined. However, the infrared camera method available conventionally was not a simple method because of a picture processing having been required since a temperature distribution on the outer surface of pipe where temperature changes quickly after heating of the outer pipe surface is photographed.
This report describes the result obtained by examining an easy-to-operate simple infrared camera method which has succeeded in delaying the change in temperature distribution by providing a thermal resistance layer on the outer pipe surface.

2. METHOD OF STUDY

2.l Principle of Infrared Camera Method and Problem Encountered

The infrared camera method discussed here is a method available for detecting the existence of corrosion by photographing a temperature distribution on the outer pipe surface coming according to difference in heat transfer characteristic as a heat image with an infrared camera.
This method can pick up corrosion by making use of such a

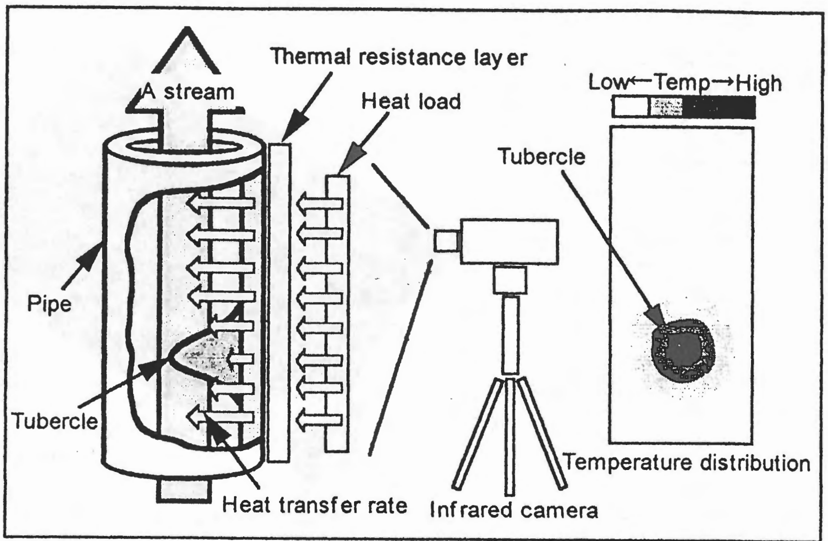

Fig.1 Diagnose the pipe with the use of infrared camera

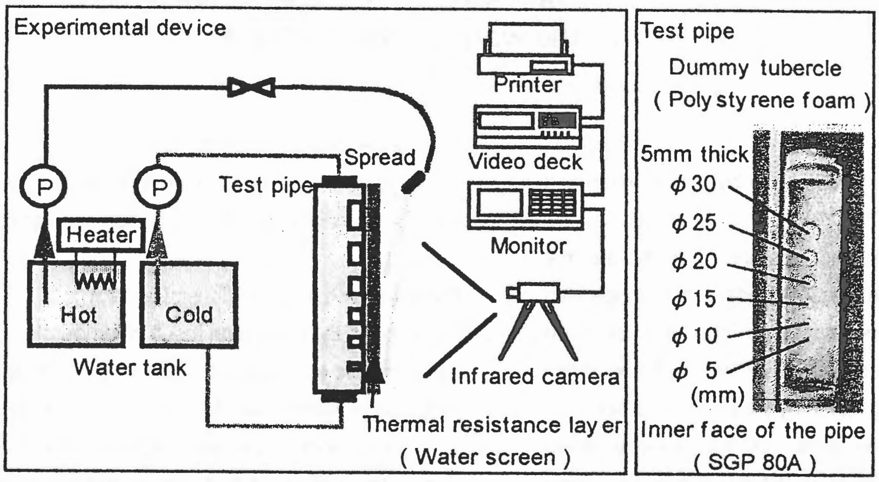

Fig.2 Experimental device and a test pipe

characteristic that a heat transfer rate in a pipe thickness direction lowers in case where a tubercle corrosion product (hereinafter called as a tubercle) has been produced in a pipe.

So far, a method has been employed which applies a heat load to the outer pope surface and photographs the temperature distribution by the infrared camera.

However, there has been such a problem that the heat transfer rate is high because of the heat conductivity of pipe being high and when a general-purpose infrared camera is used, it fails to follow a temperature distribution changing with lapse of time.

Fig.1 shows a method taken in this study to diagnose the pipe with the use of infrared camera.

Supposing that the temperature distribution can be retained for a long time by putting a substance having a low heat conductivity on the outer pipe surface and it is possible to monitor with the infrared camera, examination was made on the thermal resistance layer and heat load conditions.

2.2 Experimental Method

Fig.2 shows the experimental device and a test pipe.

The experimental device was made up of ; infrared camera (TVS-2100 made by Nihon Avionix Co.),video deck, test pipe, internal pipe liquid circulating pump and thermal resistance layer.

For the thermal resistance layer, a water screen and a sheet-like solid substance were employed and the water screen was formed by a method which winds a cloth having good water retentively on the outer surface of pipe. As the thermal resistance layer, for retaining the water screen, 2 kinds of fiber, natural fiber and synthetic fiber were examined and 3 kinds of sheet like solid substance, that is, vinylic, acrylic and rubbery ones were examined, respectively.

For applying a heat load to the thermal resistance layer, 2 type, that is, a warm water (wet type) and sheet heater (dry type) were employed.

This drawing shows a method which applies the load by using

Table.1 Conditions of simulation

Pipe	Internal surface	Heat transmission coefficient	5000W/m^2℃
	External surface	Heat transmission coefficient	8W/m^2℃
	Size	Type	SGP80A
		Outside diameter	89.1mm
		Inside diameter	80.7mm
		Thickness	4.2mm
	Dummy tubercle	Material	Poly styrene foam
		Diameter	ϕ 30mm
		Height	5mm
Simulation soft			COSMOS/M

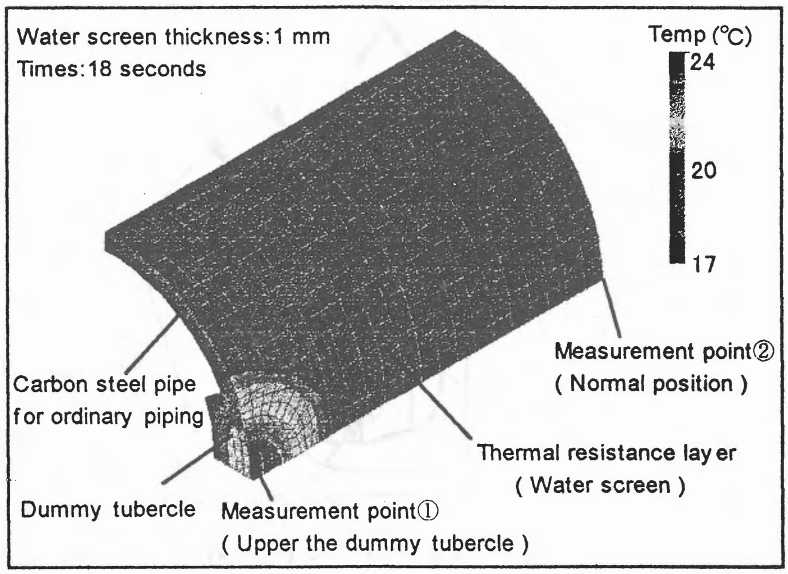

Fig.3 Simulation result of temperature distribution at the water screen surface

the warm water.

The thickness of the thermal resistance layer was examined by simulation.

In the experiment, the heat load was applied to the thermal resistance layer provided on the outer surface of test pipe with water kept flowed into the test pipe and a change in temperature distribution taking place with lapse of time at the thermal resistance layer was taken by the infrared camera.

As the test pipe, a carbon steel pipe for ordinary piping (hereinafter simply referred to as SGP) which has been galvanized and sized 80A (ϕ 89.1mm) and 400mm long was employed. And, as a dummy tubercle put on the inner face of the pipe, a Polystyrene foam (5mm thick) of ϕ 5mm to ϕ 30mm was used.

For selection of the material of thermal resistance layer and the criteria for head load conditions, such conditions that the dummy tubercle can be confirmed clearly were provided.

3. RESULTS AND EXAMINATIONS

3.1 Examination of Material of Thermal Resistance Layer

(1) Simulation of Temperature Distribution According to Thermal Resistance Layer

Simulation was made as to a temperature distribution at the outer surfer of pipe at a time when a water screen has been put on the outer surfer of pipe as a thermal resistance layer and the influence of the thermal resistance layer thickness.

Table.1 shows the conditions of simulation.

Fig.3 shows the simulation result of temperature distribution at the water screen surface. This is the simulation result of temperature distribution obtained in l8 seconds after applying a heat load once to the water screen at the outer surface of pipe. It has come out that a temperature distribution arising due to a tubercle at the inside of pipe can be retained for a long time by forming a water screen on the outer surface of pipe.

Fig.4 shows the influence of water screen thickness.

When the water screen thickness is 5mm, the changing rate of temperature distribution is slow; however, supposing that since a temperature change taking place according to the existence of dummy tubercle at a tame when the water screen thickness is 0.2mm is lesser than that when the thickness is 1mm, it is difficult to image, the water screen thickness has been set to 1mm maximum.

(2) Examination of Material of Thermal Resistance Layer

In a method (wet type) utilizing the water screen as the thermal resistance layer, a water screen holding cloth was used by winding for retaining an uniform water screen on the

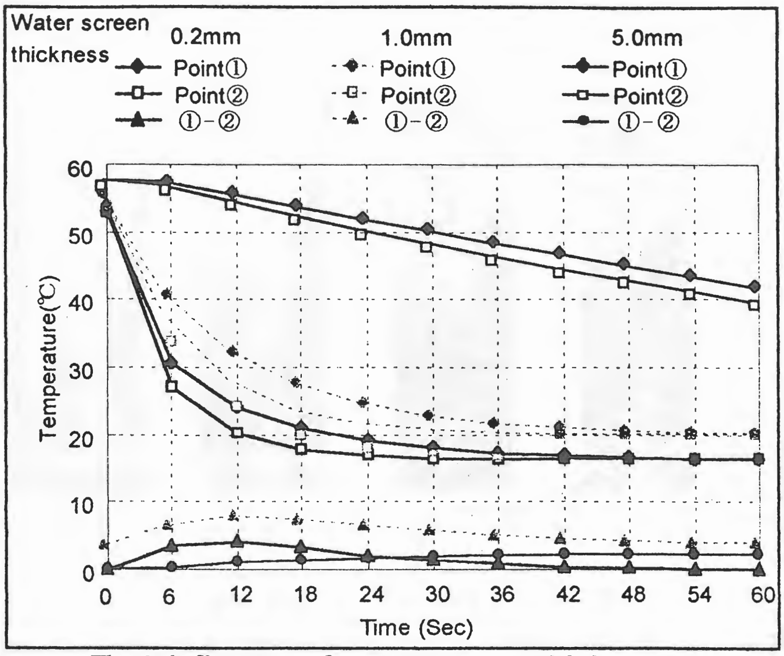

Fig.4 Influence of water screen thickness

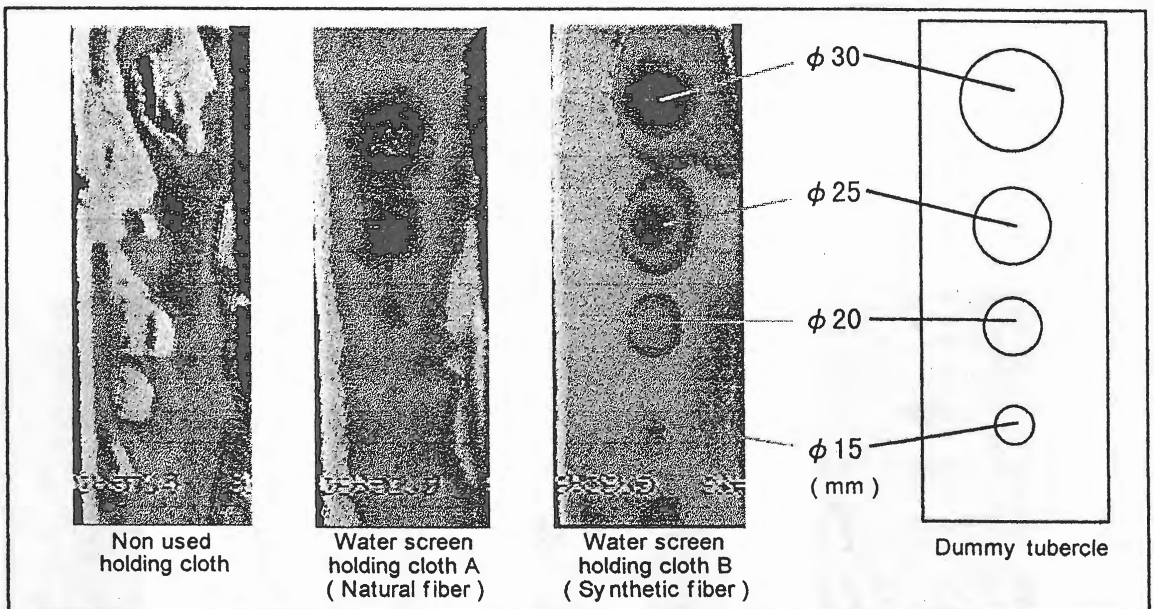

Fig.5 Examination results of the thermal resistance layer materials of wet type

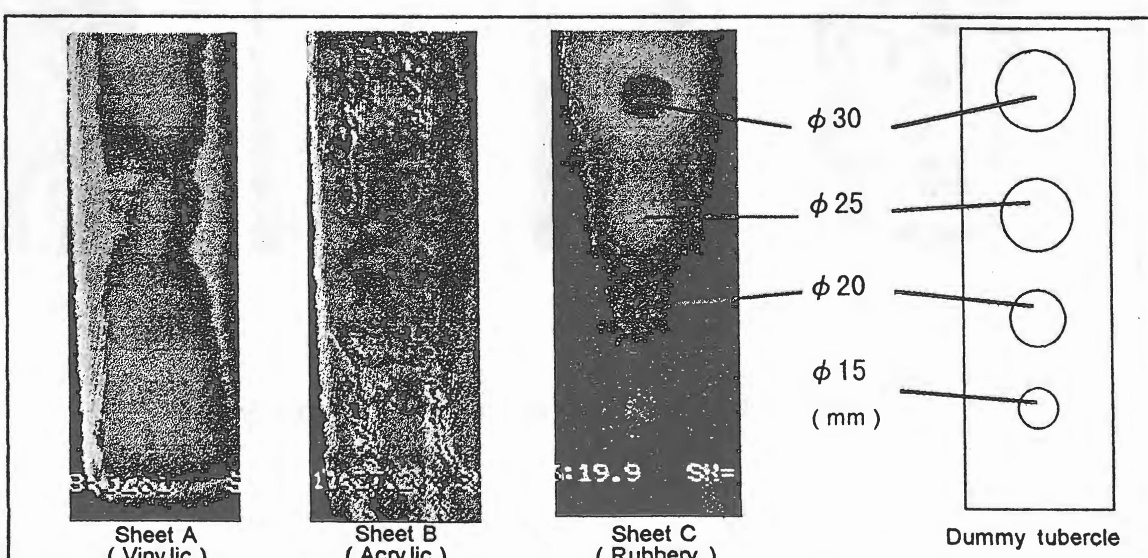

Fig.6 Examination results of the thermal resistance layer materials of dry type

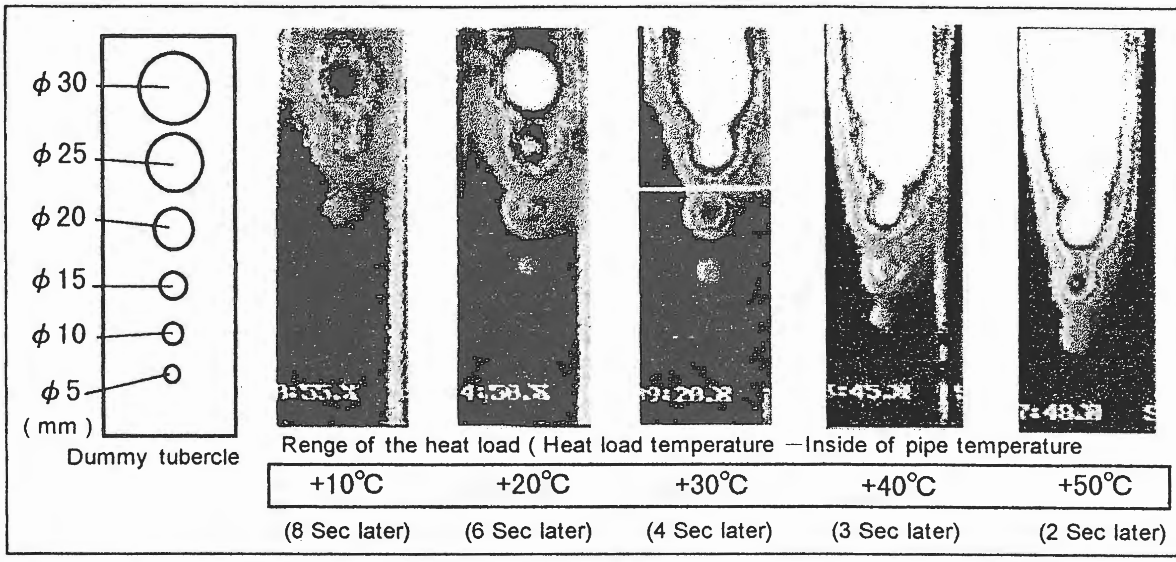

Fig.7 Example of the examination results of a renge of the heat load given to the thermal resistance layer

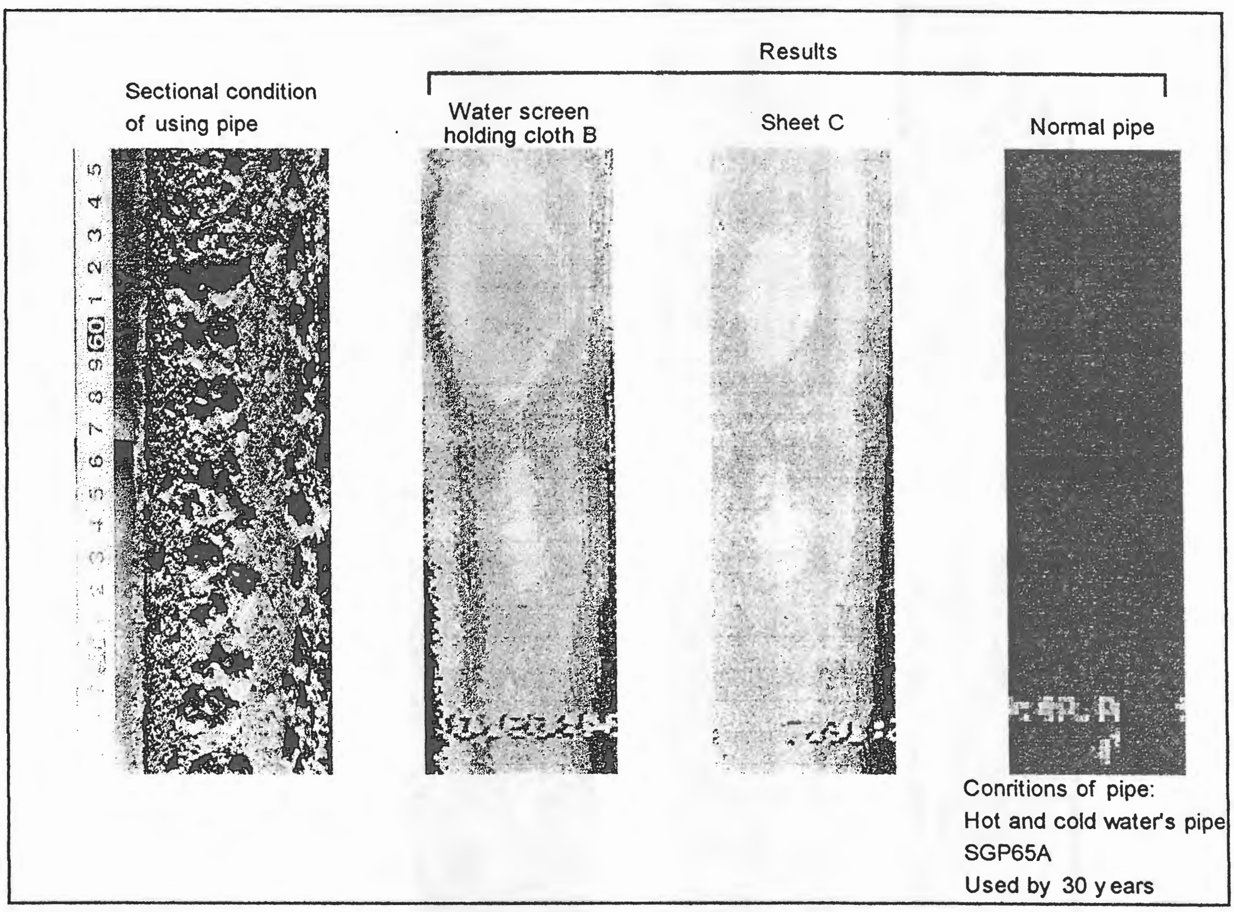

Fig.8 Application result at apipe used actually

outer surface of pipe. On the other hand, a sheet-like solid was used for a dry type.

Fig.5 and **6** show the examination results of the thermal resistance layer materials of wet type and dry type. It was a water screen holding cloth B made of synthetic fiber for the wet type and a sheet C made of rubber for the dry type that the dummy tubercle could be displayed as an image clearly. The detectable limit of dummy tubercle is ϕ15mm in the case of the wet type and ϕ20mm in the case of the dry type, and it has become clear that the wet type can provide better sensitivity than the dry type.

Whilst, the reason why a clear image was unable to be assured is that the thickness of thermal resistance layer becomes ununiform or an air pocket is produced inside the thermal resistance layer.

3.2 Examination of Heat Load

Fig.7 shows an example of the examination results of a range of the heat load given to the thermal resistance layer. This figure shows a case of the wet type.

It has been understood that for the range of heat load applied to the thermal resistance layer, a range of 20℃ or more where a dummy tubercle of ϕ15mm in diameter can be detected is necessary. Also, even when the heat load is at a side where the temperature is lower than that of fluid at the inside of pipe, the same result has been obtained.

3.3 Demonstration at Pipe Used Actually

Fig.8 shows the application result at a pipe used actually.

It has become clear that in both wet and dry types, a tubercle mark at the inside of pipe can be displayed as an image and in the image, a congested place of small tubercles is detected as a large tubercle.

4. CONCLUSION

As a method which diagnoses an internal corroded condition of the pipes used for construction facilities in a simple way, a non-destructive inspection method using a thermal resistance layer provided on the outer surface of pipe and an infrared camera was examined and the following conclusions have been obtained:

(1) It has come to light that by a method forming a thermal resistance layer on the outer surface of pipe, a produced temperature distribution can be retained for a long time and a tubercle at the inside of pipe can be detected by an infrared camera.

(2)A detecting accuracy of a dummy tubercle (Polystyrene foam) provided inside a pipe of SGP 80A is ϕ15mm in the case of a wet type and ϕ20mm in the case of a dry type, respectively.

(3) A material which is applicable to the thermal resistance layer has been selected.

(4)As a heat load applied to the thermal resistance layer, a load of at least 20℃ is necessary.

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