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**Development of the Plastic Panel Radiator, "Clear Warm"**

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## **1. Abstract**

In the Kanto Region of Japan, gas-hot water floor heating systems are known to be the major heating method. Gas-hot water floor heating system is recognized as an extremely comfortable heating system which creates uniform temperature distribution and no feeling of air draft by heat of radiation for residents.

On the other hand a growing number of the latest Japanese house performance improved air-tightness and insulation under the impact of the consumers' growing concern about energy conservation and the enactment of Law Concerning the Rational Use of Energy. Therefore, it is important to develop not only gas-hot water floor heating systems, but other heating system which can be adapted to the situation of housing and consumers' needs.

Against this background, Tokyo Gas has developed new products focused on hot water radiators which warm by radiation and natural convection. Generally, many radiators are made of copper, iron, or other metals, but Tokyo Gas has succeeded in developing the "Clear Warm" as a completely new product by the improvement of total design in addition to the revision of constituent materials. Since the "Clear Warm" on sale in July 2010, its good features have been widely recognized and it has been given awards by outside organizations. The "Clear Warm" can be expected to expand in the future.

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## 2. Preamble

Gas-hot water floor heating system is recognized as an extremely comfortable heating system which creates uniform temperature distribution and no feeling of air draft by heat of radiation. On the other hand, in an effort to adapt to the recent housing situation, the growing concern for energy conservation, and the diversification of consumer, Tokyo Gas has developed new products focused on hot water radiators which can be more easily installed while achieving comfort equal to that of gas-hot water floor heating systems, Tokyo Gas has succeeded in developing the "Clear Warm" as a completely new type of hot water radiator with Mitsubishi Plastics Inc.

The "Clear Warm" is composed mainly of a semi-transparent polycarbonate panel, which is a so-called strengthened plastic, instead of metal materials used for ordinary radiators. The "Clear Warm" can provide users with many values, thanks to its use of translucent polycarbonate panels.

## 3. Outline of the "Clear Warm"

### 3.1 System configuration of the "Clear Warm"

The "Clear Warm" system is composed of the main unit for radiation, a hot water heater, hot water heating pipes, and a remote control device for a hot water heater. Using the heating and hot water system of Tokyo Gas, the "Clear Warm" can be installed up to three units of single-panel types or one of three-panel type to each hot water circulating system. To connect a number of single panel types, each adjoining the "Clear Warm" units is connected with under-floor pipe, so it is necessary to studied the pressure loss of pipes on the distances between the "Clear Warm" units and decide the installation location.

Figure 1 shows an outline of the configuration. Since the hot water heater with a hot water heating circuit is installed outdoors, the combustion gas does not flow into rooms and so the air inside the rooms is extremely clean.

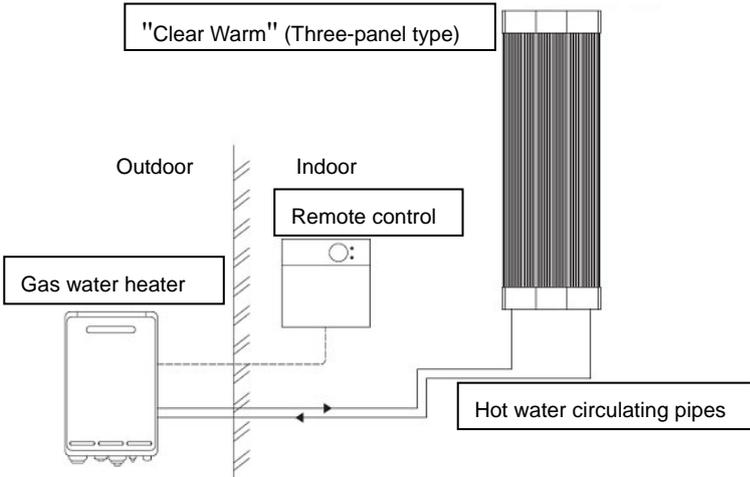


Figure 1. Radiator system configuration

And neither the combustion noise nor fan noise of the hot water heater unit was heard indoors, and so the rooms are extremely quiet during the operation of the "Clear Warm". Therefore, the "Clear Warm" is suitable for installation in a quiet bedroom or den. And the "Clear Warm" need not be connected to the household electric power supply, so that it can be used without worrying about a short circuit, electric shock and fire even when it is in a room with a sink, a bath undressing room, or other room where it might become wet.

There are 9 temperature settings in the specialized controller which change the temperature of the flowing heating water from about 60°C to about 75 °C and adjust the flow volume of the heating water by on-off control. With this controller, every user can control the radiation amount of the "Clear Warm". It operates at full power for 60 minutes after it is started up in order to promote the rise of the original room temperature.

### **3.2 Outline of the specifications of the "Clear Warm"**

The "Clear Warm" consists of three major components. These are: (1) Radiator panel unit: white cross-linked polyethylene pipes and polycarbonate panel, (2) Structural frame: aluminum frames, each with four slits, and top and bottom stays with fixed headers for hot water, and (3) white decorative cover. (1) The polycarbonate panel which is conformed to weather resistant specifications and outdoor specification is utilized as indoor use. So it can prevent discoloring caused by ultraviolet radiation deterioration and temperature, of concern to ordinary plastic, and also protect the interior cross-linked polyethylene pipes from ultraviolet radiation. (2) The aluminum frame is attached at its top and bottom by adjustable bolts, whose length can be adjusted by 50mm. Installation of the "Clear Warm" is completed by fixing these adjustable bolts between the floor and ceiling of the house. As a result of the effects of the adjustable bolts, the units can be continually adjusted from 2,400mm to 2,500mm to adapt to these differences, and "Clear Warm" is easily installed, even though ceiling heights vary in some houses. And the slits on the aluminum frame including a slit with width of about 10mm is provided so that the polycarbonate panel, which is the radiant heat medium, can be inserted and anchored in place. At the same time, 6mm wide slits are used to attach optional towel hangers as shown in Figure 2.



Figure 2. Towel hanger

Because there are the vertical slits throughout the aluminum frame, you can attach as many towel hangers as you wish at the heights you desire. Therefore, on the "Clear Warm", a towel hanger for adults and another for children can be installed at different heights, or towels of different kinds, hand towels and bath towels for example, can also be hung separately. The slits are the factor contributing to many variations of in the use of the "Clear Warm".

Other special features are the general purpose structures of (2) the aluminum frame and (3) the decorative cover. These are shaped that can be connected, assembling their structural parts permits the "Clear Warm" to be widened and the quantity of heat can be increased. And this use of common components also lowers its cost.

Figure 3 shows an outline of the "Clear Warm" and its dimensions. The circulating hot water is connected from under the floor to the inlet of the bottom header, which divides it into parallel flows which flow upward through the cross-linked polyethylene pipes. The hot water is turned back at the top header to flow downward through the cross-linked polyethylene pipes, and it returns to the circulating pipes from the bottom header outlet.

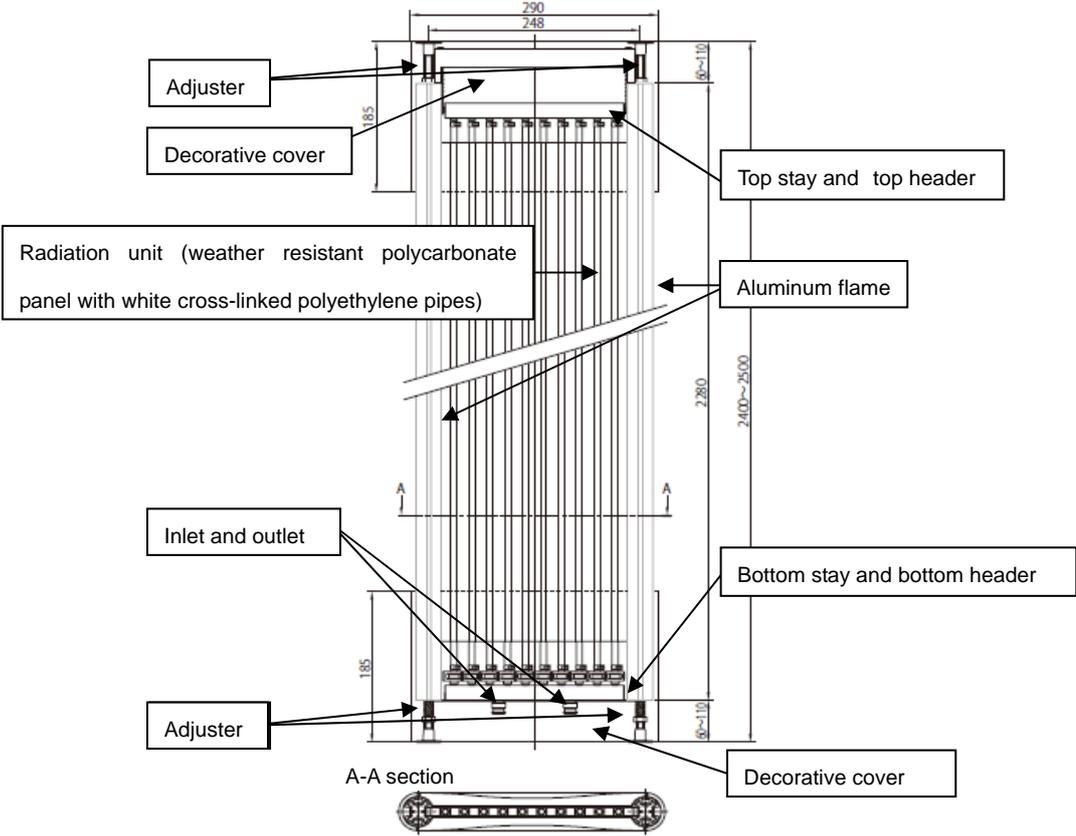
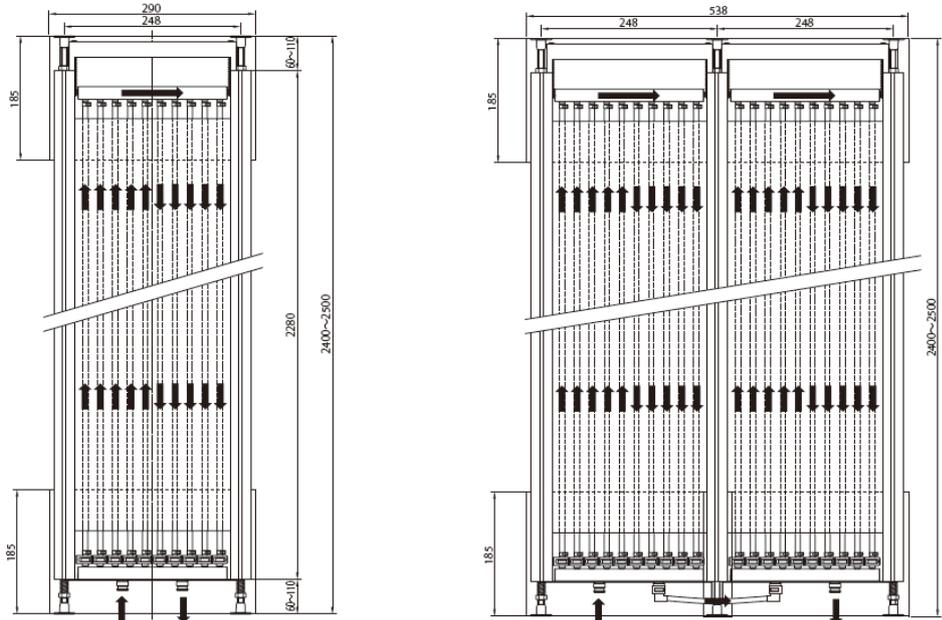


Figure 3. Outline and dimensions of the radiator

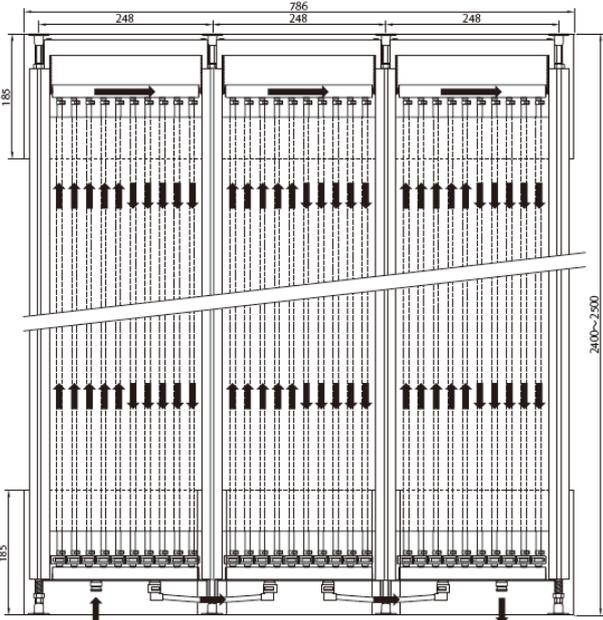
Figures 4(1) to (3) show the hot water route of circulating. About the "Clear Warm" with multiple polycarbonate panels shown by Figure 4(2) and (3), adjacent inlet and outlet of the bottom header are connected inside the decorative cover at the bottom. In this way, because the inlet and outlet of the headers are connected one to one, it is possible to maintain the flow velocity of the hot water flowing

through the cross-linked polyethylene pipes at a constant level. This easily pushes out air trapped inside the radiator, so that it is not necessary to do the air vent work essential to operate most hot water radiators, and users can use the "Clear Warm" at any time, without worrying about temperature irregularities.



(1) Single panel type

(2) Two-panel type



(3) Three-panel type

Figure 4. The hot water route of circulating

**3.3 Product line-up and specifications**

Figure 5(1) to (4) show the product lineup and sample installations, and Table 1 shows the product specifications. The lineup includes models called single panel type, two-panel type, and three-panel type. The appearance of radiator realizes a bright transparent design which users can easily harmonize with their housing space, by the result of a combination of semi-translucent polycarbonate panels, white cross-linked polyethylene pipes, and white decorative cover, creating a bright transparent design which users can easily harmonize with their housing space.



(1) Single panel type  
Sink and changing room



(2) Two-panel type  
Living room



(3) Three-panel type  
Bedroom



(4) Single panel type  
Layer installation in living room



(5) Single panel type  
with optional towel hanger

Figure 5. The "Clear Warm" lineup and sample installations

As for the basic installation methods, these models can be installed in narrow spaces as shown in Figure 5(1) or installed adjacent to the wall as shown in Figure 5(2) or (3) by taking advantage of the thin size of the "Clear Warm". In addition to using them installed separately in this way, a variety of other installations are possible as shown in Figure 5(4), using several of one model for example. The installation method shown in Figure 5(4) in particular, adds new value by taking advantage of their permeability to create a translucent partition dividing a living room and dining room.

Except a gas-hot water floor heating system installed under the flooring to completely, normal heating radiators exposed to living space. Some types of heater, their external appearance are difficult to harmonize with a housing or they obstructs daily life space, forcing users to go to the trouble of putting them away during the seasons they are not used. But a major good point of the "Clear Warm" is that thanks to its design features or added value, it can be installed as part of the body of housing without appearing Incongruity.

Figure 5(5) shows the appearance of a single panel type of the "Clear Warm" with optional towel hanger. Towel hangers are available for single panel type, two-panel type, and three-panel type, it is possible to freely hang the hand towels and bath towels on the bar.

Table 1. Product specifications

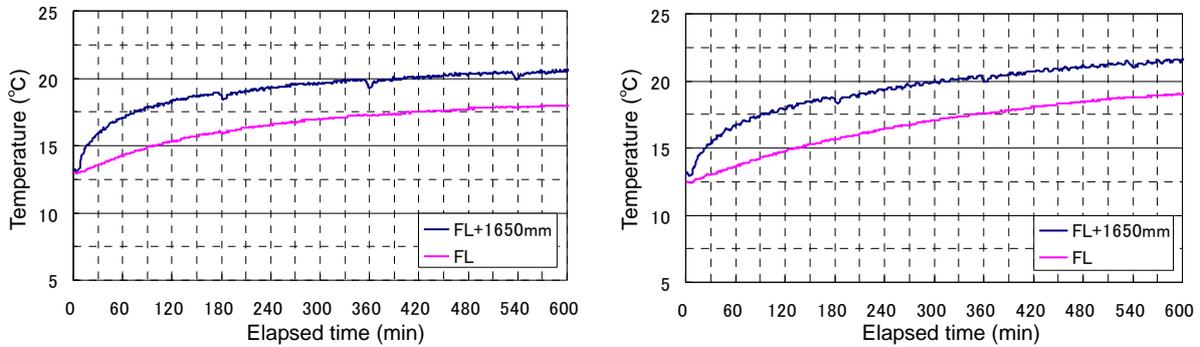
| Type                | Single panel type        | Two-panel type | Three-panel type |
|---------------------|--------------------------|----------------|------------------|
| Performance         | 370W                     | 640W           | 820W             |
| Dimensions (mm)     | H2400xW290xD42           | H2400xW538xD42 | H2400xW786xD42   |
| Installation height | 2400~2500mm ( variable ) |                |                  |

## 4. Performance

### 4.1. Increasing the room temperature

The increase of room temperature when a "Clear Warm" system is actually used was confirmed. The test site was a wooden test home inside an environmental testing laboratory of Tokyo Gas in Arakawa Ward in Tokyo. The external air temperature was 5°C, which was the estimated winter temperature in Japan, and the initial room temperature was set at 13°C. In the test home, a two-panel type was installed in a room A (approx. 9.7m<sup>2</sup>), while a three-panel type was installed in a room B (approx. 12.9m<sup>2</sup>), and it was operated at remote control setting 9 (highest setting). Both room A and room B face the external air on two walls, and the walls facing the external air are equipped with a standard window and a relatively large window from the floor to ceiling. There were curtains hanging in front of each window, it prevented the intrusion of cold air from the window surfaces to a certain degree. Figure 6(1) and (2) show the results of room temperature measurements made under these conditions. FL in the figure represents floor surface temperature, and FL+1,650mm represents the air temperature 1,650 mm above the floor. According to the results for the room A in Figure 6(1), the room temperature rose as time passed, from 13°C to approximately 17°C by 60 minutes, and to 18.5°C by 120 minutes after the start of system operation. And the results for the room B in Figure 6(2) also show an increase from

13°C to approximately 17°C by 60 minutes, and to 18°C by 120 minutes after the start of system operation, an increase of air temperature almost identical to that in the room A. Although there is a time lag compared with the air temperature, the floor surface temperature also increased in both rooms. Though the results show an example of the "Clear Warm" operated independently, it is presumed that actual usefulness would be better if it was used along with other heating systems from the start up.



(1) Two-panel type in room A (approx. 9.7m<sup>2</sup>)      (2) Three-panel type in room B (approx. 12.9m<sup>2</sup>)

Figure 6. Increase of room temperature

In addition, although numerical data is absent, monitor tests such as asking people to evaluate their sensations, have obtained high evaluations of the characteristics of the system. “Near the front of the panel, I could actually felt warm radiation.”, “It was pleasant because I did not feel any air draft.” and “I liked its quiet operation.”

#### 4.2 Surface temperature

Table 2 shows the maximum temperature of the "Clear Warm" surface, and as a reference value, the maximum surface temperature of electric oil heaters which widely sold in Japan. From the results of measurement, the surface temperature of the "Clear Warm" does not rise to cause burning even when users touched the surface momentarily.. The surface temperature of an electric oil heater reaches about 75°C at the time of maximum output, but the surface temperature of the "Clear Warm" is 42.7°C with its remote control setting at 4 (middle), and it is 54.8°C with its setting at 9 (highest) . The polycarbonate panels which are the radiating parts of the "Clear Warm" has a low thermal conductivity, so it would prevent these parts from becoming hot. As a consequence, they can be used relatively safely in the undress rooms as a toilet and undressing rooms of bath.

Table 2. Surface temperature in steady state

| Remote control conditions       | Maximum surface temperature |
|---------------------------------|-----------------------------|
| Setting 4 (middle)              | 42.7°C                      |
| Setting 9 (highest)             | 54.8°C                      |
| Reference : electric oil heater | Approx. 75°C                |

## **5. Topic**

According to the characteristics of the "Clear Warm" explained above, it was highly evaluated by the Kids Design Association, an NPO authorized by the Cabinet in 2010. The Kids Design Association awarded the "Clear Warm" the Kids Award/Special Award of jury president, which is the higher award offered under its approval system. The Kids Design Award is an award system established to achieve and promote the ideas: design contributing the safety and security of children, design leading to creativity and the future, and design to easily giving birth to and nurturing children. The Kids Design Association honored the "Clear Warm" in particular, for realizing both safety and good design and for being suitable for children and elderly people who must finely adjust their body temperature, thanks to its gentle radiation.

## **6. Conclusions**

Tokyo Gas has developed the hot water radiator, the "Clear Warm", made of the polycarbonate panels in cooperation with Mitsubishi Plastics Inc. The results of the verification of its performance as a radiator have shown that this new product provides the basic performance of a radiator, and that it is safer than a general purpose electric oil heater, because its surface temperature does not rise too high. Its design offers external appearance which, while novelty, harmonizes easily with housing space, and it offers the added value of usability as a partition. The above facts show that the "Clear Warm" has the potential for good sales and is sure to be widely used in the future.

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