

Open Refrigerated Display Cases for Convenience Stores

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1. Introduction

In recent years in the convenience store (CVS) marketplace, competition between different store chains has intensified due to market saturation by the growing number of stores. The percentage of stores that are newly opened has been decreasing, and daily sales have not showed much growth. Accordingly, in order to differentiate itself from the competition, each chain develops new articles for sale and at the same time makes efforts to pursue better freshness control, improved product presentation and higher sales efficiency of existing articles such as prepackaged lunches, prepared foods, beverages, deserts and ice creams.

Moreover, due to the growing awareness of environmental conservation, CVS companies are promoting environmental measures such as the acquisition of ISO 14000 certification, reduction of power consumption in stores, recycling of article containers, and the utilization of new types of refrigerant in air-conditioners and refrigerators.

Under such circumstances, Fuji Electric has developed a new series of remote condensing-type ultra-slim, open refrigerated display cases for CVSs, the “EFT 40” series. This series is environment-friendly and provides excellent presentation and handling performance.

2. Special Features of the New EFT 40 Series

In response to requests and suggestions from CVSs, the EFT 40 series was developed with the goals of providing “excellent presentation of the articles being sold,” “ease of use” and a machine that is “environment-friendly.” Special features of this series are as follows.

2.1 Excellent product presentation

- (1) Product presentation is improved by adoption of a structure having terraced shelves and slanted back face with a shallow canopy.
- (2) Display area is increased by adoption of a low and thin shelf front to increase the effective display height within the display case and to enlarge the

effective display height between shelves.

2.2 Ease of use

- (1) Shelves and deck pans are equipped with a sliding mechanism to improve the ease of the replenishing articles and of cleaning.
- (2) In order to be compatible with various kinds of articles, a sliding steel shelf version and a thin glass shelf version are available as an option for each model.

2.3 Concern for the environment

- (1) High freshness control and energy savings are realized by a microcontroller installed as standard equipment.
- (2) Plans to use the new refrigerant HFC are established by utilizing highly clean tubes and ensuring the required cooling performance.
- (3) Power saving is realized by utilizing a slit air curtain, inverter ballast and DC fan motors.

3. Specifications

Specifications of the EFT 40 series and features of each model are given in Table 1.

4. Structure

The external appearance of the EFT40 series is shown in Fig. 1.

4.1 Enhanced product presentation

4.1.1 Terraced shelves

In order to enhance product presentation, this series is equipped with terraced shelves having a slanted back face and a shallow canopy that is 50 mm smaller than the former types, resulting in better fenestration and improved product presentation and visibility. If cool air blows down from the ceiling of the canopy as in the former machines, formation of an air curtain becomes impossible in the new machines because the position of the cool air outlet is shifted back due to adoption of the shallow canopy. Moreover, adoption of slanted back face makes it impossible to

secure the required quantity of air flow and degrades the cooling performance due to increased draft resistance of the circulating cool air flowing in the duct. Accordingly, the EFT40 series adopts both a wide backflow system that blows cool air out from the slanted back face and a slit air curtain to achieve uniform cooling performance and enhance product presentation.

4.1.2 Low rail height

In a CVS having limited floor area, increasing the number of stages of the display shelves is one way to enlarge the area of product display. Accordingly, the effective inside height of the newly developed display case was extended through lowering the front rail

height by 100 mm below that of the former machine. In addition to lowering the rail height, by reducing the shelf thickness, an additional shelf stage could be realized, thereby increasing the display area by about 15 % compared to the former machine. A cross section of the display case structure is shown in Fig. 2.

4.2 Ease of use

4.2.1 Sliding steel shelf

Unlike supermarkets and department stores, the selling point of CVSs is that they supply convenience all day long, 365 days a year. For this reason, it is important that CVSs replenish and restock articles for first-in first-out turnover effectively during business

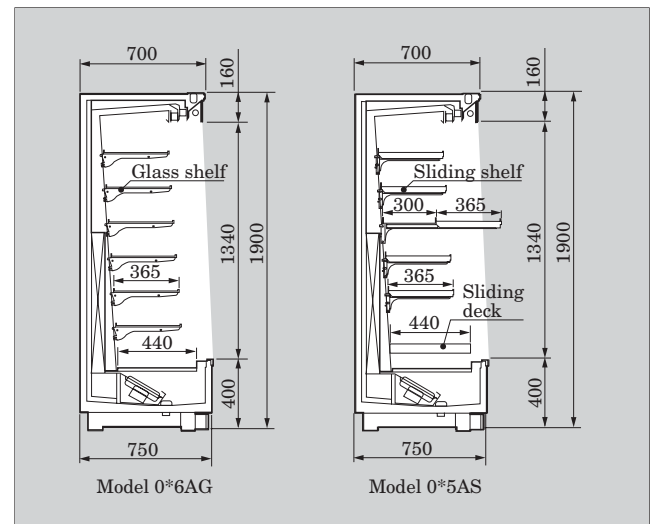
Table 1 Constitution of models of EFT40 series

| Machine model number Item | | EFT40D2 (HFC) | | | | | | EFT40D2 (HCFC) | | | | | |
|----------------------------------|---------------------|---------------------------------------------------------------|---------------|---------|---------|---------------|-------------------------|-------------------------------|---------------|--------|--------|---------------|-------------------------|
| | | 036 AG4 | 035 AS4 | 046 AG4 | 066 AG4 | 065 AS4 | 065 AC4 | 036 AG | 035 AS | 046 AG | 066 AG | 065 AS | 065 AC |
| Application | | Beverages, prepared foods, deserts, prepackaged lunches, etc. | | | | | | | | | | | |
| Working temperature (°C) | | 3 to 20 | | | | | | | | | | | |
| Effective internal volume (L) | | 531 | | 707 | 1,061 | | | 531 | | 707 | 1,061 | | |
| Display area (m ²) | | 2.38 | 2.07 | 3.17 | 4.76 | 4.14 | 4.45 | 2.38 | 2.07 | 3.17 | 4.76 | 4.14 | 4.45 |
| External dimensions | Overall height (mm) | 1,900 | | | | | | | | | | | |
| | Overall length (mm) | 915 | | 1,220 | 1,830 | | | 915 | | 1,220 | 1,830 | | |
| | Canopy depth (mm) | 700 | | | | | | | | | | | |
| | Front depth (mm) | 750 | | | | | | | | | | | |
| | Rail height (mm) | 400 | | | | | | | | | | | |
| Refrigerant | | R404A | | | | | | R22 | | | | | |
| Type of ballast | | Inverter ballast | | | | | | Magnetic circuit type ballast | | | | | |
| Type of internal fan | | DC fan motor | | | | | | AC fan motor | | | | | |
| Method of defrosting | | Off-cycle defrosting | | | | | | | | | | | |
| Shelf structure | Number of rows | 1 | 1 | 1 | 2 | 2 | 2 | 1 | 1 | 1 | 2 | 2 | 2 |
| | Number of stages | 6 | 5 | 6 | 6 | 6 | 5 | 6 | 5 | 6 | 6 | 6 | 5 |
| | Type of shelf | Glass | Sliding-steel | Glass | Glass | Sliding-steel | Glass and sliding-steel | Glass | Sliding-steel | Glass | Glass | Sliding-steel | Glass and sliding-steel |

Fig.1 Appearance of EFT40 series



Fig.2 Cross-sectional structure of EFT40 series display case



hours in order to avoid losing sales opportunity. Accordingly, a sliding steel shelf was developed to facilitate the repositioning of articles and the replenishment of articles at the rear of the shelf. For the slide rail, stainless steel having excellent durability and strength was used to realize smooth handling performance and high reliability. The structure of this sliding shelf is shown in Fig. 3.

4.2.2 Flexible construction of shelves

The sliding shelf is effective for articles that are relatively tall and are easy to group together such as beverages, spirits and health drinks. However, for low-profile articles such as prepackaged lunches, prepared foods and deserts, the product presentation must include a sense of cleanliness and drama. Accordingly, a low-profile glass shelf with good fenestration and sense of cleanliness was developed, adopting a full-face glass and transparent front tag rail.

Either a sliding shelf or glass shelf can be chosen freely as an option by each store chain according to the kinds of articles they will vend; the structural body of the display case will remain the same.

4.3 Concern for the environment

4.3.1 Control using a microcontroller

Fig.3 Structure of sliding shelf

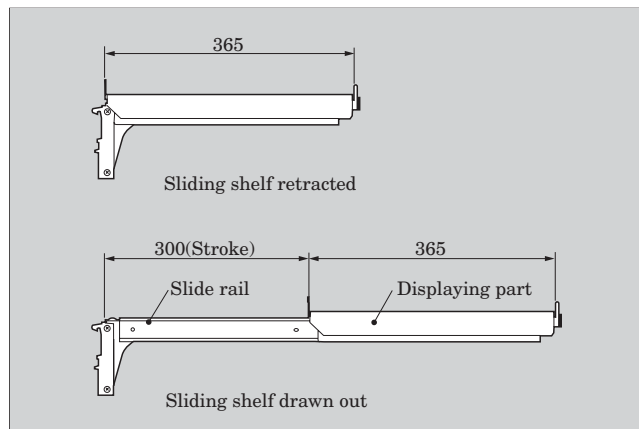
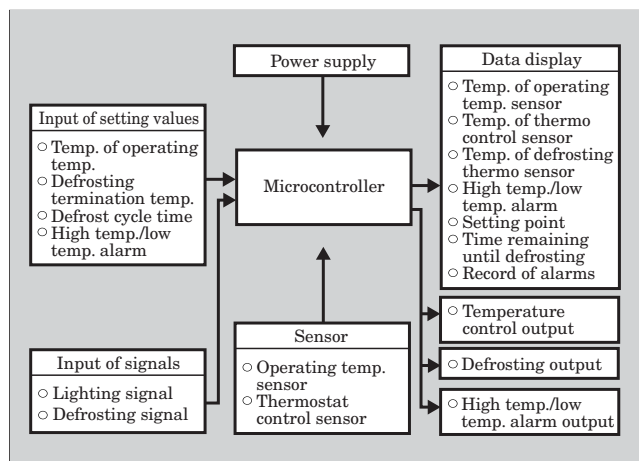


Fig.4 Input and output configuration of microcontroller



All models in the EFT40 series are equipped with a microcontroller to perform centralized control of temperatures in the display case and of alarm functions. Temperature fluctuation within the display case can be controlled more precisely than when using a mechanical thermostat. Moreover, it is also possible to externally output temperature data indicated by sensors at various positions as well as to confirm operating conditions and change settings from an external location through a phone line. This enables operation and acquisition of operating conditions from a backyard location. Temperature settings for prepackaged lunches, beverages, deserts, etc., can be changed over a wide temperature range in intervals of 1°C by changing settings on the microcontroller without having to implement changes on the display case. Figure 4 shows the input and output configuration of the microcontroller.

In the case of a failure or during a regular inspection, the time required to diagnose the operating conditions and estimate the cause of failure can be reduced because a record of the past three alarms is recorded by an alarm log function. The reduction in work time required for inspection and repair thus realized is significant for CVSs that operate 24 hours per day.

4.3.2 Adoption of HFC

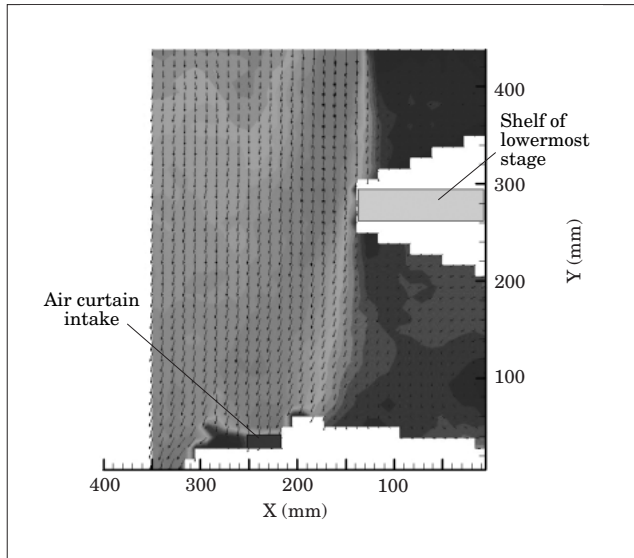
An HCFC reduction plan was enacted according to the Montreal Protocol, and Fuji Electric is working to accelerate the conversion from HCFC to HFC. In recent years, Fuji Electric has promoted the adoption of HFC for self-contained type open refrigerating display cases, and 80 % of those types of cases have already converted. Separate type ultra-slim multi-deck open display cases for CVSs also have adopted HFC for the first time in Fuji's open display case after two-years of field experiments.

In the EFT40 series, use of easy-to-handle azeotropic refrigerant is effective because charging of the refrigerant is sometimes carried out when replacing parts in the refrigeration system and adjusting the cooling performance. Accordingly, R404A refrigerant was adopted. This refrigerant is easy to maintain and has a relatively low value of high pressure. Regarding the tubing materials, clean tubes that have high inside cleanliness were used because oil used for the conventional tubes during manufacturing and assembling processes might cause sludge in the R404A system and water might cause an insulation fault with the compressor.

4.3.3 Reduction of power consumption

Power consumption of the display cases accounts for 60 % of the total power consumption of a CVS and is the most important factor for reducing the power consumption of a CVS. In the EFT40 series, consideration was given to the three major factors influencing power consumption of the display case, that is, refrigeration capacity, power for illumination and power for

Fig.5 Distribution of air curtain velocity vectors



internal fans, and measures were taken to reduce the power consumption of each of these factors.

- (1) Use of a new slit air curtain to reduce the required refrigeration capacity

Fuji Electric's usual types of open display cases utilize Fuji's own proprietary slit air curtains. However, in the EFT40 series, if the usual type slit air curtain is applied, a larger refrigeration capacity would be required due to the low rail height structure with terraced shelves. Accordingly, behavior of the air curtain was visualized to determine a suitable airflow balance between the innermost slit jet, inner jet and outer jet and an appropriate refrigeration capacity, and as a result, a new innermost jet was developed. This realized a low rail height construction without increasing the required refrigeration capacity and reduced the required capacity by 25 % when converted to a rail height identical to that of the former machine. Figure 5 shows the distribution of air curtain velocity vectors flowing near the shelf of the lowermost stage.

- (2) Application of inverter ballast

Due to the adoption of a terraced shelf construction, fenestration of in-store illumination and canopy illumination was improved and the ceiling illumination of the former machine was eliminated. Moreover, inverter ballast was adopted for the canopy illumination to achieve brightness with power savings. Due to the elimination of ceiling illumination and use of an inverter, power consumption was reduced by 63 %.

- (3) Use of DC fan motors

The cooling temperature of the remote condensing type multi-deck open display case is relatively high

Table 2 Power savings of EFT40 series (as compared to former type)

| Machine model number | | | Former type MFT50D2 -065AG | EFT series EFT40D2 -066AG | Ratio of saved energy/(%) |
|-----------------------------------------|------------------------------|-------|----------------------------------|---------------------------------|---------------------------------|
| Item | | | | | |
| External dimen- sions | Overall height (mm) | | 1,900 | | — |
| | Overall length (mm) | | 1,830 | | — |
| | Canopy depth (mm) | | 750 | 700 | — |
| | Front depth (mm) | | 750 | | — |
| | Rail height (mm) | | 500 | 400 | — |
| Area of front opening (m ²) | | | 2.3 | 2.5 | — |
| Refrige- ration capacity | Required capacity (kW) | | 1.63 | 1.54 | 6 |
| | Evaporating temperature (°C) | | -10 | | — |
| | Refrigerant | | R22 | | — |
| Illumi- nation | Number of lamps | | 4 | 2 | 50 |
| | Power consumption (W) | 50 Hz | 152 | 56 | 63 |
| | | 60 Hz | 152 | 56 | 63 |
| Internal fan | Number of fans | | 3 | | 0 |
| | Power consumption (W) | 50 Hz | 87 | 48 | 45 |
| | | 60 Hz | 99 | 51 | 48 |

and ranges from 3 to 20°C. Therefore, Fuji Electric adopted an off-cycle defrosting system utilizing heat from the ambient air, and this system had a lower running cost than the electric heater based defrosting system used for low temperature display cases. With the off-cycle defrosting system, fans in the display case are operated all day long and the power consumption by the fans accounts for a large fraction of the total power consumption. Accordingly, DC fans were adopted and power savings of 45 % was achieved.

The power savings achieved by the newly developed type 066 machine is shown in Table 2.

5. Conclusion

In the above, the EFT40 series of remote condensing-type ultra-slim multi-deck open refrigerated display cases for CVSs was introduced. Performance of this newly developed series is highly appreciated by customers. However, CVS market demands are ever-changing and the speed of change will increase more and more. Fuji Electric intends to continue to supply products that can keep pace with market demands and to promote environmental issues such as reuse and renewal.

Lastly, we would like to thank our customers and persons concerned for their continuing guidance and help in this development.



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