1. Introduction

The "WS-V Series" new molded case circuit breaker (MCCB) and earth leakage circuit breaker (ELCB) lineup introduces the new F-Style small models for machinery, and offers interchangeable outer dimensions and improved interrupting performance while maintaining one rank higher ampacity for use in switchgears and switchboards (Table 1). This paper describes the features of the "WS-V Series" in terms of standardization and value analysis (VA).

2. Standardization of Outer Dimensions and Employed Technologies

The Expanded Impulsive Slot-Type Accelerator (ISTAC) technology is used in the ‘S’ and ‘H’ class models having a width ranging from 75 to 105 mm (Fig. 1). Compared with the structure of the conventional ISTAC, the new stationary contact holder has an extended lower conductor (the part shown in Fig. 1 through which current B flows) to greatly enhance the repulsive force exerted on the moving contact arm at the time of a short-circuit interruption. With this structure, the torque and acceleration speed for opening the contact are doubled from those of the previous design, and the maximum peak current during interruption is reduced by 10%. As a result, the following performances have been achieved:

1. New lineup of ‘S’ class, 75 mm width, 125A frame models. The breaking capacity of the 250A frame is greatly increased.
2. The characteristic of Icu = Ics is achieved for all ‘S’ class models (Icu and Ics: Performance guaranteed for two and three consecutive breaking operations, respectively).
3. One rank higher ampacity for ‘H’ class models (Previously unavailable rated current for 125 A with 90 mm width; 250 A with 105 mm width).

In addition, the new interruption technology, re-

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Table 1 WS-V Series specifications

<table>
<thead>
<tr>
<th>Frame A</th>
<th>32</th>
<th>63</th>
<th>125</th>
<th>250</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class</td>
<td>C</td>
<td>C</td>
<td>S</td>
<td>C</td>
</tr>
<tr>
<td>For machine (F Style)</td>
<td>7.5/7.5</td>
<td>7.5/7.5</td>
<td>15/15</td>
<td>30/15</td>
</tr>
<tr>
<td>For switchboard</td>
<td>7.5/7.5</td>
<td>7.5/7.5</td>
<td>15/15</td>
<td>30/15</td>
</tr>
<tr>
<td>WS series (Former type)</td>
<td>7.5/4</td>
<td>7.5/4</td>
<td>15/8</td>
<td>25/13</td>
</tr>
</tbody>
</table>

Upper column: Short-circuit breaking capacities Icu/Ics (kA) at 230VAC, Lower column: Overall dimensions width*length*height (mm) (3-pole models)
ferred to as the blowout type double-break mechanism, is employed in the ‘R’ class models to achieve a breaking capacity of AC 415 V / 150 kA with the same outer dimensions as those of class ‘C’ of the 250A frame.

Some of the main functions of the switching mechanism in the circuit breaker include: to interlock the handle and the moving contact arm, to open the moving contact arm at a high speed in response to the activation of a tripping device when an overcurrent occurs, and to push the contacts against each other with appropriate force to prevent abnormal heat generation or poor contact while a current passes through.

The requirements to satisfy these functions depend on the rated current, breaking capacity, etc., and hence the design of the conventional switching mechanism is totally different for each size group. In order for the WS-V Series to standardize the switching mechanism among three different size groups of 75 mm, 90 mm and 105 mm width models, the design was newly optimized to standardize the parts and side view layout (Fig. 2). As a result, the 75 mm and 90 mm width models are now completely compatible and 50% of the parts are the same as used for the 105 mm width model.

3. VA by Downsizing

The new F-Style lineup of products, which are smaller than conventional products, for machinery and industrial control panels has been added to the WS-V Series (32/63A frame and 125A frame). The width of the 32A and 63A frames is reduced to 54 mm (Fig. 3), resulting in a smaller product with less usage of plastics such as base and cover materials, as well as metal materials such as for current-path conductors and contacts.

The 54 mm width models use the arc-driven breaking technology, which has been used in miniature circuit breakers (MCBs) for reducing the width. In the arc-driven breaking mechanism, arc-extinguishing grids are placed away from the contacts and the arc is quickly separated from the contacts, resulting in less wear of the contacts. To apply this system to the MCCB and ELCB, the grid design and the shape of the commutation runner and exhaust port, all of which are important points when using the arc-driven breaking mechanism, have been optimized by detailed simulation using fluid analysis and electromagnetic analysis. Compared with the previous products, the arc-driven breaking technology has almost doubled the 3-time breaking capacity (Ics) while reducing the volume to 55%.

In the MCB that uses the arc-driven breaking system, each pole is equipped with a switching mechanism for opening/closing of contacts. Therefore, it is not feasible to install optional inner accessories, or standardize the outer dimensions between the MCCB and ELCB. To overcome this problem, while keeping the layout of the moving contact arm and stationary contact holder optimized for the arc-driven breaking system, multiple moving contact arms of all poles are interlocked to the single switch mechanism using a crossbar, in the same way as for the 75 mm width model (Fig. 4). In addition, the switching mechanism is configured as a two-stage tripping structure to satisfy the requirements of both instantaneous tripping activated by a plunger and long time-delay tripping via a bimetal element. This structure enables the adoption of the arc-driven break-
ing system as well as the use of built-in accessories and size compatibility, which are indispensable features for the MCCB and ELCB lineup. The ELCB has a built-in electronic circuit to detect a leakage current using the signal from the zero-phase current transformer (ZCT). To provide power to this leakage detection circuit, the conventional model uses a harness, which is connected to the main circuit terminal by using crimp-type terminals and screws. In contrast, the new 54 mm width model provides power by making contact between the main circuit terminal and the leakage detection board by using a push spring. This configuration not only reduces the wiring space and power load area, but enables one-touch assembling of the leakage detection unit, thus significantly improving productivity.

4. Standardization of Internal Accessories

Internal accessories for the MCCB and ELCB are designed as user installable cassettes, so specifications can be easily modified and order placement is simplified. For the WS-V Series, cassette-type accessories are interchangeable among the 75 to 105 mm width models. This is more convenient for users by reducing both the lead time for shipment and the number of stocked units. Figure 5 shows the interchangeable cassette-type accessories for the 32A to 250A frame models. Features of the internal accessories for the WS-V Series are as follows:

(1) New JIS, IEC and GB certifications have been obtained for the same unit.

(2) Undervoltage tripping (UVT) device for the 250A frame is now one of the cassette-type accessories.

(3) ELCB is equipped with an optional shunt (voltage) tripping (SHT) device.

To achieve common use of the internal accessories among various frames of the WS-V Series, one of the challenges was to develop a tripping device that fits the smallest size of 75 mm width model, and also to drive the tripping load of the main unit for the maximum size of 105 mm width model.

The dimensions of the internal accessory space in the 75 mm width model are 18 mm (W) × 43 mm (L) × 30 mm (D), while the tripping load required for the switching mechanism of the 105 mm width model is about three times greater than that of the 75 mm width model. To generate a high tripping force within a limited volume, the following measures were taken:

(1) Electromagnetic analysis to determine the method for improving magnetic characteristics.

(2) Optimum structural design to reduce the required load.

(3) Improved winding accuracy by using an NC winding machine.

In addition, cassette-type accessories have also been developed for the F-Style product lineup (54 mm width models), the industry’s smallest 32A/63A frame products to be stored within a limited space, by making the accessories 20% smaller than those of the 75 mm width or larger models.

This paper has described the features of the new WS-V Series and its technologies in terms of standardization and value analysis. We will continue to develop products that meet customers’ needs.