Low Voltage Air Circuit Breaker
Type AE-SW Series

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1. Product Overview and Features

The product line-up of the newly introduced AE-SW series air circuit breakers is shown in Table 1. The series comprises a total of nine models, from 630A to 4000A frames. Each model is available in the following four different kinds of outline modules: fixed type, drawout type, 3-pole type, and 4-pole type.

Major features include:

1. The compact-sized AE2000-SWA model has been added.
2. Thanks to extended operating durability, high reliability is achieved (mechanical durability has been increased from 10,000 to 25,000 cycles for 630 through 1600 AF).
3. By virtue of increased high-voltage breaking capacity, superior short-circuit protection performance has been achieved (from 50 kA to 65 kA at AC 690 V for 630 through 2000 AF, and from 50 kA to 75 kA at AC 690 V for 2000 through 4000 AF).
4. On the strength of enhanced short-time withstand performance, the coordination range has been expanded (from 65 kA to 75 kA in terms of 1-second duration values for 2000 through 3200 AF).
5. The enhancement of insulation resistance has resulted in a higher safety. (The rated impulse withstand voltage of the main circuit has been increased from 8 kV to 12 kV.)
6. Retrofitting to existing previous models is possible.
7. Electronic trip relays that are capable of flexibly meeting wide-ranging customer needs.

2. Compact-sized AE2000-SWA

The newly introduced AE-SW-series 2000A frame products are available in two models: (1) AE2000-SWA (compact-sized type) and (2) AE2000-SW.

The compact-sized AE2000-SWA has been downsized to the 1600A-frame outline dimensions, along with a reduction in weight, in order to reduce the panel size.

As for rated breaking capacity and rated short-time withstand current specifications, we decided to adopt a performance rating of 65 kA, which is on a par with comparable specifications for 1600A-frame products.

Figure 1 shows the conductor structure of the ACB.

![Conductor structure of air circuit breaker](image)

From the line-side terminal, current passes through the line-side junction, line-side conductor, main contact, movable conductor, flexible conductor (thin copper plate), load-side conductor, load-side junction and load-side terminal, in that order.

Temperature rise in various portions of the ACB are ascribable to Joule heat generated by the specific resistance of each individual part and the contact resistance at the junctions, connections and contacts. Finding ways to reduce these resistances present an important challenge to us.

The major measures we have taken to suppress temperature rise are enumerated below:

1. An increase in the conductor cross-sectional area of the flexible conductor (thin copper plate)
2. Reduction in contact resistance by virtue of increased contact surfaces of the junction connections
3. Securing of shear planes in the connector junctions by means of high-precision fine blanking of the contact surfaces of the connections
4. Vertical embedding of the conductors on the cradle

![Table 1 AE-SW-series product line-up](image)

<table>
<thead>
<tr>
<th>A</th>
<th>630</th>
<th>1000</th>
<th>1250</th>
<th>1600</th>
<th>2000</th>
<th>2500</th>
<th>3200</th>
<th>4000</th>
</tr>
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*Fukuyama Works*
(5) An increase in the conductor cross-sectional area (plate thickness) of the central pole conductor on the cradle
In order to grasp the efficacy of the measures taken, we performed thermal analysis by means of a thermal circuit network. (See Figs. 2 and 3.)
As a result, we could quantitatively estimate the temperature rise that would be achieved with improved contact resistance, specific resistance and thermal dissipation in individual places without the need to perform temperature-rise testing on actual air circuit breakers on a measure-by-measure basis. This approach proved useful in narrowing down effective measures. On the aforementioned specifications concerned with the measures implemented, we verified that they were within spec by checking efficacies represented by the thermal circuit network and also by performing temperature-rise testing on actual air circuit breakers.

3. Enhancement of Operating Durability
The number of operating cycles for the newly introduced AE-SW-series air circuit breakers has been increased from 10,000 to 25,000 cycles for 630 to 1600A frames and from 10,000 to 20,000 cycles for 2,000 to 4,000A frame, thereby attaining the world’s highest operating durability performance.

Figure 4 shows a cross-sectional view of the ACB, and Figs. 5 through 7 show operating stages of the mechanical section and the conductor section. Since impulsive load acts on each individual part with energy stored in the closing spring at the time of closing operation, the securing of rigidity and reliability of each individual part poses an important challenge to us for an improved number of operating cycles.
Below, we describe technical issues and their solutions:
(1) Quantification of impulsive load acting on each part
(2) Establishment of a margin of safety for each target operating cycle count
(3) Collection and organization of S-N curve data on candidate materials
(4) Establishment of a design technique that takes the notch factor of shaft parts into consideration
As for the measurement of impulsive loads, we employed distortion gauges for quantification. Taking into consideration variation in materials, we set an allowable repetition cycle count in relation to the target cycle count and established a margin of safety in relation to the fatigue limit of materials.
As to candidate materials for adoption into mechanism sections, we performed repetitive fatigue testing of test pieces and built a reference databank of S-N...
4. Electronic Trip Relay

As to electronic trip relays for the newly introduced AE-SW-series units, we achieved the development of electronic trip relays capable of meeting diverse requirements by selectively combining various kinds of modules with one common ETR base equipped with basic tripping functionality.

The lineup of these various modules is as follows:

(1) Main setting modules, each of which incorporates an overcurrent-protection characteristic tailored to a specific application (WS: General use, WM: Generator protection use, WB: Special use)

(2) Optional setting modules, each of which incorporates optional functionality such as ground-fault protection or a 2nd additional pre-alarm (G1: Ground-fault protection, N5: Neutral pole 50% protection, E1: Earth leakage protection; AP: 2nd pre-alarm)

(3) Power supply units (available in 5 kinds) designed to supply power to trip indicator LEDs, extension modules etc.

(4) Extension modules for measuring current, voltage, power etc.

(5) Displays for indicating measured values, alarm information, etc.

(6) Interface units for making connections to various field networks

(7) I/O units for remotely controlling circuit breakers

We have thus far discussed the major features of the newly introduced AE-SW-series air circuit breakers. In the future, we are determined to continue offering air circuit breakers oriented toward customer satisfaction.