# Commercialization of Mobile Gas Insulated Switchgear (GIS)

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**Abstract**

**The mobile gas insulated switchgear is a Gas Insulated Switchgear (GIS) loaded on a trailer section of a truck. The mobile GIS is utilized to take emergency measures. In the event of a switching facility accident, the mobile GIS can promptly arrive on site and can be operated temporarily and take remedial measures. The demand for this equipment has recently increased its use during facility renovation work or large-scale disaster response.**

**We commercialized the mobile GIS based on the expertise of the Cubicle-type GIS (C-GIS). We adopted composite bushings at the points of power lead-in and lead-out. Compared with performance characteristics of conventional equipment, this type of GIS is superior in all respects such as maneuverability, reliability, safety, maintenance, inspection, installation space, and is economical.**

## 1 Preface

The mobile gas insulated switchgear is a Gas Insulated Switchgear (GIS) loaded on a trailer section of a truck. The GIS is a set of various substation equipment packed in a single sealed tank. It is used to take emergency measures in the event of a switchgear facility accident or at the time of switchgear facility renewal work.

Based on many lessons learned from recent large-scale disasters, the prompt disaster response measures have been studied and the significance of mobile GIS has been highlighted. Against such background and based on our expertise of the Cubicle type GIS (C-GIS), we have commercialized a mobile GIS. We adopted composite bushings at the power lead-in and lead-out points. Compared with performance characteristics of conventional equipment, this type of GIS is superior in all respects such as maneuverability, reliability, safety, maintenance, inspection, installation space, and is economical. This paper introduces the features and specifications of the mobile GIS.

## 2 Specifications and Features

Table 1 shows the ratings of the mobile GIS. Fig. 1 shows the mobile GIS construction and Fig. 2 shows the internal construction and major accommodated equipment. This mobile GIS is designed based on the latest design of the C-GIS. A Vacuum Circuit-Breaker (VCB), Disconnector with an Earthing Switch (EDS), Earthing Switch (ES), Surge Arresters (SAR), and Current Transformers (CT) are accommodated in the package. The accommodated equipment has the common design of C-GIS equipment so that the delivery period is shortened and maintainability is improved.

### 2.1 VCB Unit

For the VCB, its pole unit employs a Vacuum Interrupter (VI). Since arcs generated during current interruption are processed under vacuum inside the VI, it is unnecessary to use the $SF_6$ gas as a current interruption medium, so no decomposed gases are generated. For this reason, the $SF_6$ gas can be used as an insulation medium. Consequently, a low gas-pressure design is possible and it is unnecessary to dispose of decomposed gases. The VCB is the most acceptable circuit breaker for any mobile GIS.

### 2.2 EDS Unit

The EDS unit is used to assure stability for insulation performance and security for current carrying performance. The EDS unit is designed based on the linear OFF system for which actuators for ON, OFF, and EARTH are allocated in a straight

**Table 1 Ratings**

Ratings of the GIS and its accommodated devices are shown.

| Device name | Items | | Ratings |
|---|---|---|---|
| GIS | Rated voltage | | 72/84 kV |
| | Rated withstand voltage | Short-duration power-frequency | 140/160 kV |
| | | Lightning impulse | 350/400 kV |
| | Rated continuous current | | 800/1200 A |
| | Rated short-time withstand current | | 25/31.5 kA-2.0 s |
| | Insulation medium | | $SF_6$ |
| | Rated gas pressure | | 0.07 MPa·G |
| | Applicable standard | | JEM-1499・JEC-2350 |
| VCB | Rated voltage | | 72/84 kV |
| | Rated continuous current | | 800/1200 A |
| | Rated breaking current | | 25/31.5 kA |
| | Rated break-time | | 3 cycles |
| | Operating system | | Motor-charged spring closure and tripping |
| | Applicable standard | | JEC-2300 |
| EDS | Rated voltage | | 72/84 kV |
| | Rated continuous current | | 800/1200 A |
| | Operating system | Disconnector | Motor-powered/manual |
| | | Earthing switch | Manual |
| | Applicable standard | | JEC-2310 |
| ES | Rated voltage | | 72/84 kV |
| | Operating system | | Motor-charged spring |
| | Applicable standard | | JEC-2310 |
| SAR | Rated voltage | | 84/98 kV |
| | Nominal discharge current | | 10 kA |
| | Switching charge current withstand capability class | | C |
| | Applicable standard | | JEC-2374 |

line. The EDS unit can operate a Disconnector (DS) and ES for maintenance use with a single operator unit. As a result, this unit realized a light-weight and compact design, and secured operational safety.

## 2.3 Operation and Maintenance

As an insulation medium, a low-pressure $SF_6$ gas is sealed in the tank. The reason equipment using a low gas pressure is adopted, is because it is unnecessary to lower gas pressure on-the-go or raise gas pressure to start operation. Such a feature greatly contributes to high mobility.

Composite bushings are used at the lead-in and lead-out points. Compared with porcelain bushings, they are lighter and have outstanding vibration resistance. We realized the reduction of total mass of equipment as a whole and the center of gravity was lowered.

Since equipment accommodated in the package adopts the modular design, any faulty unit can be promptly replaced with a sound one recovering the entire system quickly.

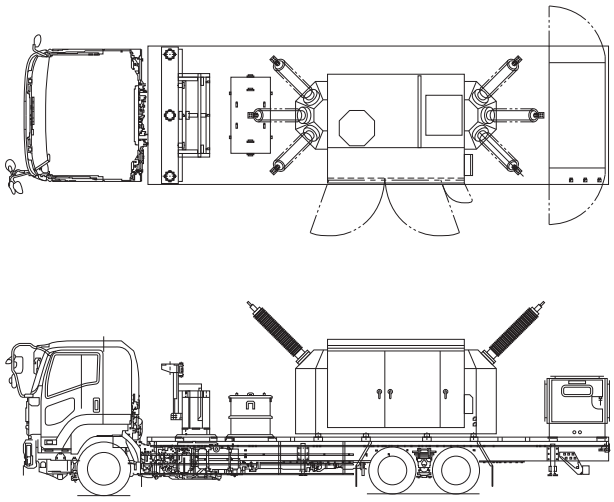


**Fig. 1 Construction**

The GIS, operation panel, and protective control panel are mounted on a trailer section of a truck.

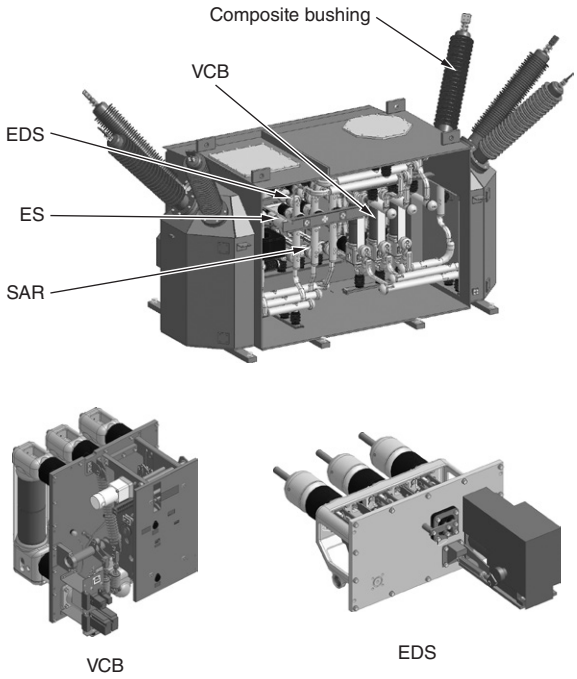



**Fig. 2 Internal Construction and Major Accommodated Equipment**

The internal construction of the GIS is shown. Each accommodated equipment has the modular design and can be easily replaced in the event of a failure.

## 3 Designing Expertise

The switchgear designed for the mounting on trailer section of a vehicle faces total mass and overall size restrictions. It is important to consider the optimal allocation of these devices and reduction of package tank weight, since equipment to be accommodated are already determined.

### 3.1 Insulation Design Technology

We used to make structural design based on the 3D-CAD. In this connection, a three-dimensional electric field analysis was carried out by actively using 3D-CAD data. Fig. 3 shows an example of electric field analysis for the main circuit conductors. Through close coordination between structural design and electric field design, we realized the optimum shape of the main circuit and the optimization of the equipment layout. The withstand voltage test was carried out on an actual mobile GIS and its adequacy was confirmed.

### 3.2 Structural Design Technology

For the reduction of tank mass, it is essential to grasp the displacement and stresses of the tank at the time of the structural design. Fig. 4 shows the result of the tank stress analysis at the time of gas filling. We confirmed that the displacement and stress generated in each part of the tank were within the design standards.

### 3.3 Running Test

Fig. 5 shows a view of running test. The running test was carried out under the condition that the GIS was loaded on the trailer section of the truck. We conducted various test items such as

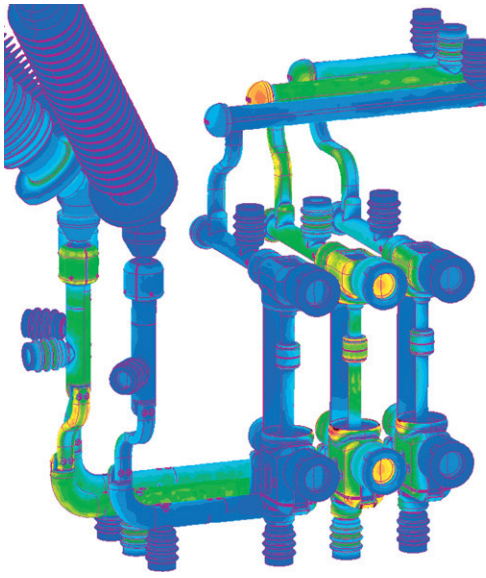
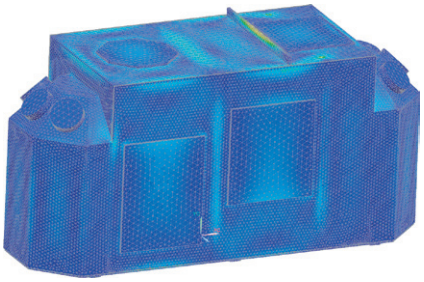
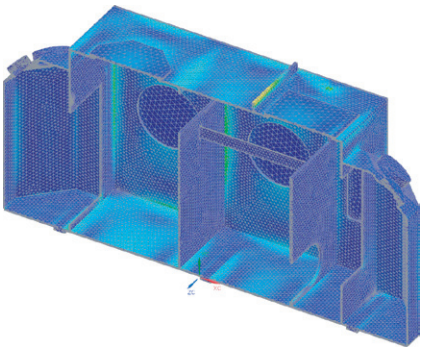


**Fig. 3** Example of Electric Field Analysis for Main Circuit Conductors

An example of the insulation design is shown. This design is based on a three-dimensional electric field analysis by using the use of the Finite Element Method (FEM). By using the 3D-CAD data, insulation design can be carried out with high accuracy.



(a) Exterior



(b) Interior

**Fig. 4** Result of Tank Stress Analysis

An example of structural design is shown. This design is based on a three-dimensional stress analysis by using the FEM. The tank mass is reduced by grasping the stresses and displacement to be generated.

**Fig. 5** A view of Running Test

A view of running test of the mobile GIS is shown. The soundness of equipment was confirmed under the various conditions such as, a sudden start, sudden braking, and running on a bumpy road.

tests under sudden start, sudden braking, and running on a bumpy road. Through testing, we confirmed that there was no adverse reaction in the external structures, main-circuit current conductors, nor the operation of each equipment. In addition, we measured acceleration values at each part and concluded that there was no problem in mechanical strength.

## 4 Postscript

We commercialized the mobile GIS for applications such as facility renewal work and measures for emergency response. This significant product is indispensable to support infrastructures in the event of large-scale natural disasters. We continue to promote the mobile GIS as a product that delivers high reliability and positive product experiences to the end-users.