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7.2/12kV MINI T-CLAD

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I. INTRODUCTION

Recently, there have been many references from overseas, especially from the Middle East, concerning metal-cald units used for minimum oil volume circuit breakers as plant parts or one way of expanding the power reception and distribution networks. Coping with such export markets requires the following:

(1) The units must fulfill the specified ratings and specifications and have high reliability.
(2) They must be competitive with respect to price.
(3) They must have strong panel construction.
(4) They must be compact.
(5) They must be easy for the customers to install.

On the basis of new concepts, 7.2/12kV metal-clad units with high reliability have been developed to conform to a wide range of standards including IEC, BS, ANSI and JEM. An outline of these units is given here. The mini T-clad is a special name for a compact metal-clad unit accomodating a minimum oil volume circuit breaker (T-type circuit breaker).

II. FEATURES

The mini T-clad is a 7.2/12kV metal-clad unit designed to exhibit all of the features of the T-type circuit breakers including high performance, compactness and lightweight and easy maintenance. The rated breaking currents are less than 25A. They have four points and features as shown in *Fig. 1*.

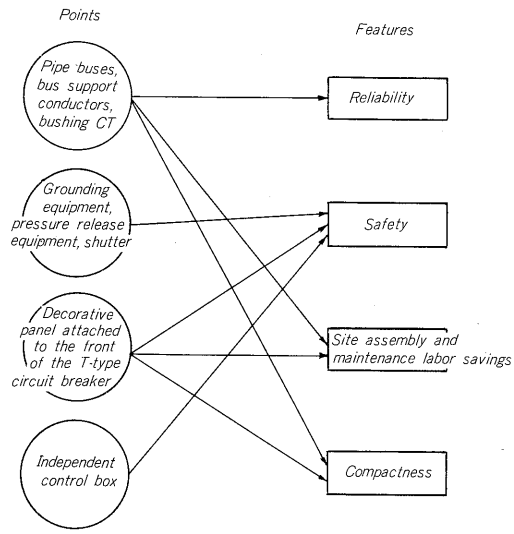


Fig. 1 Design points and features

1. Improved Safety and Reliability

A decorative panel is attached to the front surface of the T-type circuit breaker. Operations and inspections are performed from the outer surface of the panel and the control box containing the control and monitoring parts is independent a separate from the high pressure parts, which is very safe. The dangers involve in touching live parts and arc accidents inside the panel are avoided by means of grounding devices, shutters, pressure release equipment, etc. Because of the use of bus support conductors and bushing CT, there are no support insulators and few connection points and the reliability related to the main circuit conductors is greatly improved.

2. Labor Savings for Site Installation and Maintenance and Inspection

Simple series operations can be performed by combining pipe buses and bus support conductors. The insulation of the bus support is provided by attaching an insulation cover and sealing with tape. Since there are no bus support insulators, maintenance and inspections connected with the main circuit conductors such a cleaning and tightening of buses are easy.

3. Compactness

To minimize export packing, the height is suppressed to assure dimensions which permit container transport. By the use of the pipe bus and the bushing CT, the installation area is only one half and the volume one-third of that of the conventional types.

III CONSTRUCTION

Fig. 2 shows a outer view of the mini T-clad and *Fig. 3*

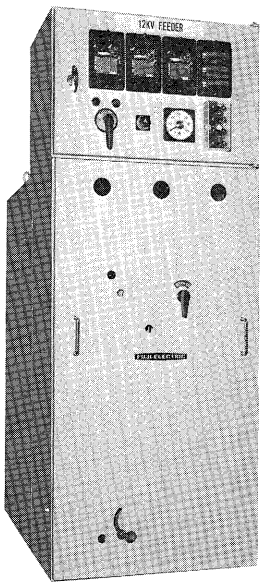
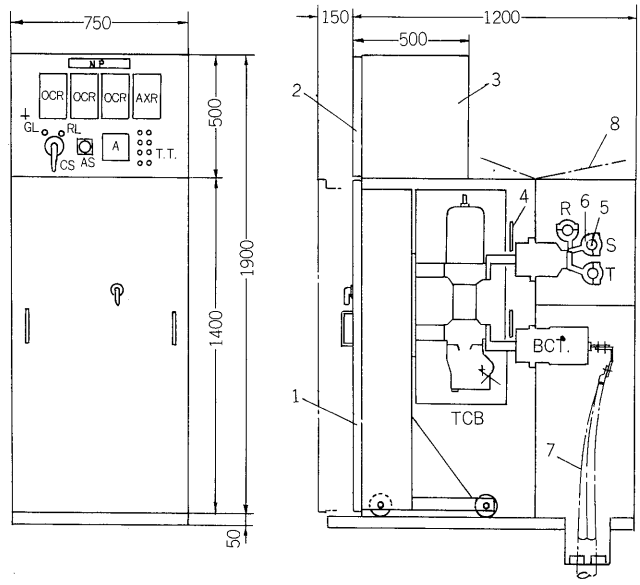


Fig. 2 Exterior view of mini T-clad



1. Front decorative panel
2. Door
3. Control box
4. Shutter
5. Pipe bus
6. Bus support conductor
7. Cable
8. Pressure release port

Fig. 3 Outline of mini T-clad

an outline of a typical mini T-clad. It consists basically of a breaker compartment, bus compartment and cable compartment. In the case of control and monitoring with the metal-clad unit, a control box is added to the top of the breaker compartment. Each compartment is independent and they are separated from each other by grounded metal.

1. Breaking Compartment

The T-type circuit breaker has a decorative panel attached to the front surface and there is no door attached to the front surface of the metal-clad unit. Therefore, switching of the T-type circuit breakers (including manual closing) and pulling out and inserting of the breaker can be performed from the metal-clad unit. Safe operations and inspections are possible since the T-type circuit breaker oil level meter, mechanical closing indicator, service meter and position indicator can be seen clearly from the metal-clad unit. A shutter is provided to prevent any careless touching of main circuit live parts after the T-type circuit breaker has been pulled out. The shutter is automatically opened and closed on both the power supply and load sides when the breaker is pulled out or inserted. The construction is such that the shutter can be operated manually separately on the power supply and load sides after the breaker is pulled out of the metal-clad unit for periodic insulation resistance and voltage withstand tests of the main circuit.

2. Bus Compartment

A pipe type bus with high mechanical strength is used and there is no bus support insulator. As can be seen in *Fig. 4,* the bus support conductors combine three functions: support of the buses, bus connection and branching.

The pipe bus is attached to the bus support conductor simply by insertion and tightening with bolts. The standard bus has insulation sheathing.

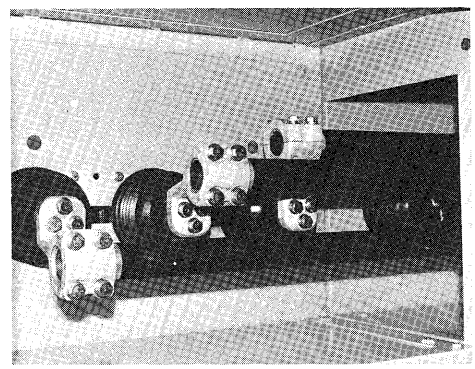


Fig. 4 Bus compartment

3. Cable Compartment

There is a bushing CT which forms a single unit with the contact of the disconnecting part of the T-type circuit breaker. The cable is connected to the CT terminals. The cable is fixed at the bottom part of the panel and led upward. Cable terminal treatment is performed. As an option, it is also possible to attach a grounding switch for grounding on the load side.

4. Control Box

When control and monitoring is performed, a control box is attached to the top of breaker compartment. The front surface is of the door type with indicators, meters and protective relays attached. There is a terminal board for control cables inside the box. The cables are brought up through the metal ducts on the breaker compartment side and attached to the terminal board.

5. Miscellaneous

1) Grounding switch (Optional)

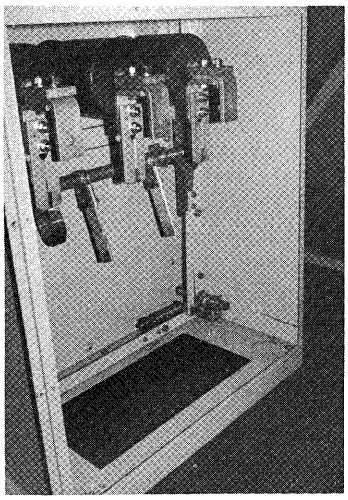


Fig. 5 Grounding switch

This switch is intended to assure the safety of the operators by grounding the power supply and load side cables during maintenance and inspection operations.

There are various types of such switches. *Fig. 5* shows an example: the disconnecting switch type grounding switch. This grounding switch is operated by a handle on the front of the panel when the T-type circuit breaker is in the disconnected position. There is a mechanical interlock which prevents closing when the T-type circuit breaker is in the connected position and also prevents the T-type circuit breaker from going into the connected position when the grounding switch is closed.

2) Pressure release device (Optional)

If an arcing accidents should occur inside the metal-clad unit, the pressure would rise inside the panel because of the arc energy and this would present a danger. To prevent this, pressure release ports are provided in the ceilings of the breaker and bus compartments and the pressure of the high temperature gas arising at the time of arcing accidents is released upwards.

IV. SATNDARD RATINGS AND SPECIFICATIONS

The standard ratings and specifications for the mini T-clads are shown in *Table 1* and the main structural specifications in *Table 2*.

V. STANDARD COMPONENTS

The types of T-type circuit breakers which can be accomodated in the standard dimensions of the mini T-clads are shown in *Table 3*. The other components are shown in *Table 4*.

VI. STANDARD CIRCUITRY AND PANEL CONSTRUCTION

In the planning of mini T-clads, the equipment is divided into units such as power reception, bus connections, power generation and auxiliaries (GPT, LA, etc.) from the single wire connection diagram, a block skeleton

Table 1 Standard ratings of mini T-clad

Rated voltage		7.2/12kV
Rated current		600A, 1,200A
Rated busline		600A, 1,200A, 2,000A
Rated frequency		50Hz, 60Hz
Rated short-time current		25kA, 3s
Rated breaking current		According to circuit breaker
Insulation class	Lightning impulses	75kV (1 x 40μs)
	Commercial frequency	28kV 1min
Control circuit withstand voltage		2kV 1min

Table 2 Standard construction of mini T-clad

Construction	Protection calss	1PH3 (IEC, and BS Standards)
	Front surface	Decorative panel (fixed)
	Rear surface	Fixed (with screws)
	Plate thickness	Outer covering 2.3mm
		Partition between high voltage chambers 3.2mm
Main circuits	Bus	Pipe buses
	Power supply side intake	Cable from bottom part of rear surface
	Load side intake	Cable from bottom part of rear surface
	Color separation	Red-yellow-blue (JEM: red-white-blue)
Control circuit	Control circuit	Right end at bottom of front surface
	Wire specifications	600V PVC 2mm²
	Wire color separation	Yellow (grounding wire: green)
	Terminal specifications	Fuji standard

Table 3 Type and ratings of circuit breaker

Name	Type	Ratings
	HF515-10M/600-150/6	7.2kV 1,600A 12.5kA
	HF515-10M/600-250/6	7.2kV 600A 20kA
	HF515-10M/1,200-250/6	7.2kV 1,200A 20kA
	HF515-10M/600-350/10	12kV 600A 18.4kA
	HF515-10M/1,200-350/10	12kV 1,200A 18.4kA
	HF515-10M/600-500/10	12kV 600A 25kA
	HF515-10M/1,200-500/10	12kV 1,200A 25kA

Table 4 Standard apparatus

Name	Type	Rating
CT	CBE1, 2-6 CBE5, 6-6, 10 CBE7-6, 10	For 6.9kV, 11.5kV □/5A 15~40VA
OCR	AI3PF-05	
AXR	K9821F	
A	SWR-3	
AS	NS387/3M	
CS	NS387/2EB	
RL, GL	SL102R/G	
TT	TT-2	

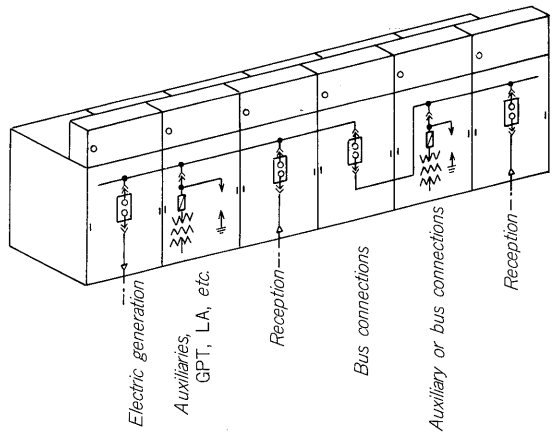


Fig. 6 Example of primary circuit pattern and arrangement

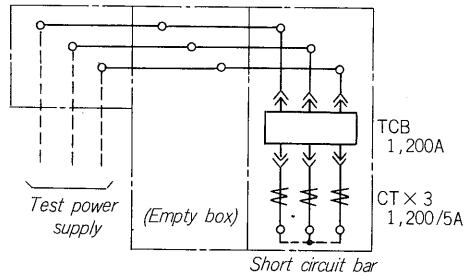


Fig. 7 Test connection diagram

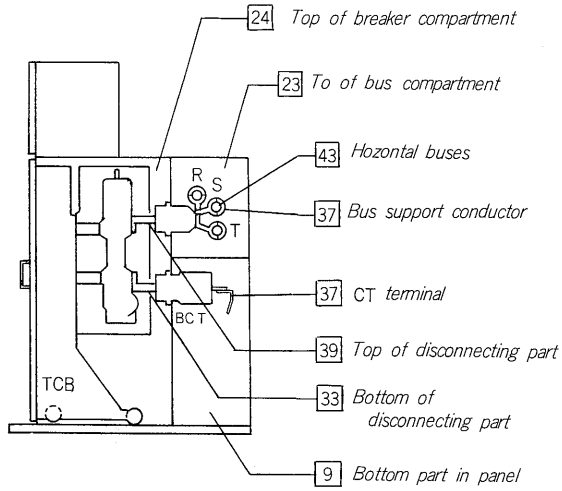


Fig. 8 Results of temperature-rise test

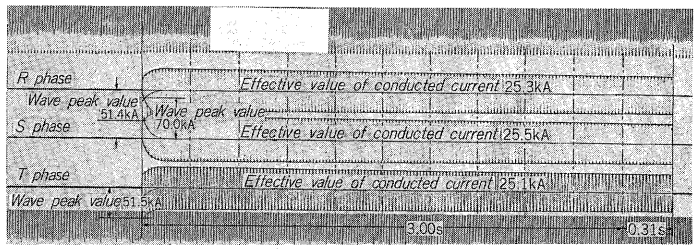


Fig. 9 Oscillogram of short-time current test

is prepared and the panel construction is decided. *Fig. 6* is an example of the main circuit pattern and panel composition. When buslines are connected, an auxiliary panel is necessary for turning of the buses.

VII. TESTS

Tests were performed with a mini T-clad with a rated voltage of 12kV, a rated current of 1,200A, a rated bus current of 1,200A and a rated short-time current of 25kA. *Fig. 7* shows the test circuit.

1. Temperature Test

The exterior cable terminals were short circuited with a shorting bar and 1,200A (3-phase) was applied. The temperature rise values are shown in *Fig. 8*. The temperature rise values in the conducting parts were within 43°C, which means that there is sufficient tolerance with respect to the standard value of 65°C (silver plating).

2. Voltage Withstand Test

For the commercial frequency voltage withstand test to ground and between phases, 28kV was applied for one minute and for the impulse voltage withstand test, lightning impulses of 75kV were applied five times each to the positive and negative poles for 4μs each time.

In the control circuit, 2kV was applied for one minute and the tests were passed in each case. There was also sufficient withstand to lightning impulses of 95kV when insulation barriers, etc. were provided.

3. Short-time Current Test

The exterior cable terminals were short circuited with a shorting bar and the rated short-time current of 25kA was applied for 3 sec. (peak value: 62.5kA). There were no mechanical damages or variations in the main circuit resistance. There was sufficient strength against thermal and mechanical stress. *Fig. 9* shows an oscillogram from this test

4. Mechanical Strength Test

These tests were performed to see if the mini T-clads can withstand the long distance transport and severe site entry and erection conditions which are expected in case of exports. There were no problems with respect to frame bending or damage to connections from loads applied during transport, bending and deformations due to rollers and bars and measurements of stress applied to the disconnecting part of the breaker.

1) Hoisting test

On the assumption of transport of the beaker equipped, the mini T-clad with the circuit breaker equipped (660 kg) was hoisted and subjected to impacts by inching of the crane. Measurements were made for deformations but no abnormalities were found. A strain gage was attached to the disconnecting part of the braker and the strain was measur-

ed with a resistance line deviation measuring device and a sufficient margin with respect to strengths of the materials.

2) Rolling test

Moving was repeated over a minimum of two rolls and the amounts of bending of the bottom plate before and after rolling were compared but the difference was in the 1mm range which can be disregarded.

VIII. CONCLUSION

The 7.2/12kV mini T-clad for export has been planned to meet the severe safety requirements in international standards, has been reduced in size for container transport and has a lower price.

The simple construction for easy site assembly is ideal for future metal-clad units for export which require mass production for rapid delivery.

Fuji Electric intends to complete this series with different ratings including those of recent international users who require safety and low prices.