TOSHIBA

Leading Innovation

Gas Insulated Transformer

Toshiba Transformers History & Background

As power consumption in urban areas increases, a large number of substations have been constructed underground, beneath commercial buildings, parks and public spaces. Safety and the avoidance of fire incidents is the most important consideration for substations in urban areas. Compact and cost effective solutions are required for substations installed in areas where space is limited. Gas insulated transformers (GITs) instead of Oil immersed transformers (OITs) offer the best solution for overcoming the sharp increase in electric power demand in large cities.

History of Toshiba Power Transformers

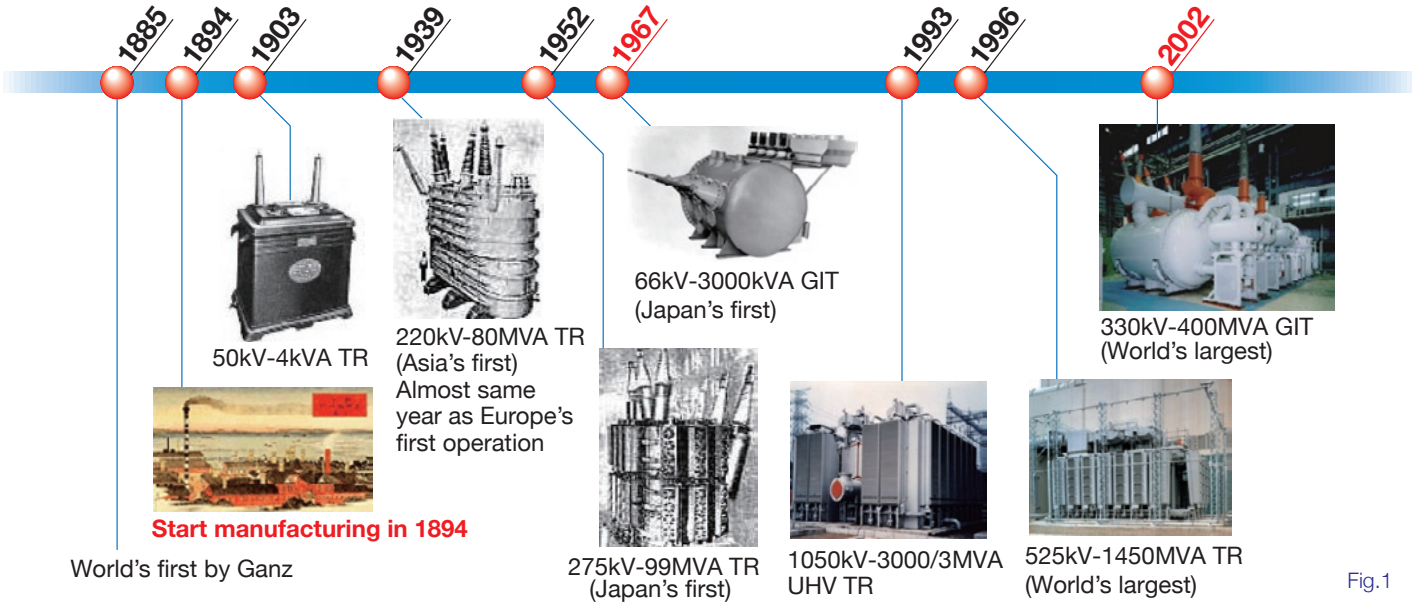


Fig.1

Only 9 years after the world's first transformer was manufactured, Toshiba started supplying transformers to the market in 1894. Since then, Toshiba has been one of the most innovative transformer manufacturers in the world. In 1967, Toshiba delivered the first GIT, 66kV, 3MVA transformer to the market, which features excellent characteristics for safety and environmental friendliness.

GIT World wide application

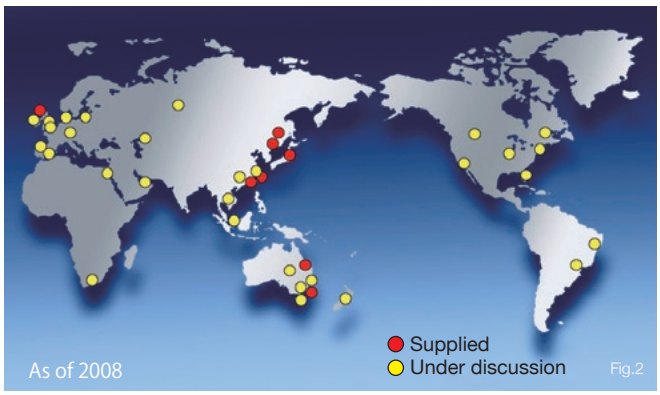


Fig.2

Toshiba has supplied a large number of GITs all over the world and there are many GIT projects planned for the future.

Underground Substation within a business complex

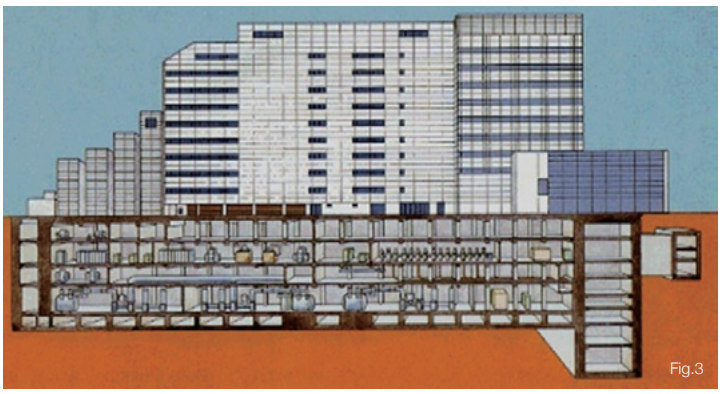


Fig.3

Application: GITs excel in explosion-proof safety and are widely used in underground and indoor substations in urban areas. GITs are also installed in environmentally critical areas where oil leakage is prohibited.

Advantages of GIT Technology

Excellent features of GIT

Features	Advantages with GIT
Non-flammability	GITs employ SF6 gas as the insulation & cooling medium, which avoids the need for fire fighting equipment, oil collection tanks and pits outside the transformer room.
Non-explosive feature	Since the rise in tank pressure for an internal fault is very small compared with the GIT tank withstand strength, the GIT tank will not explode on internal fault ensuring the safety of equipment within the substation.
Compactness	Since neither a conservator nor pressure relief arrangement is required, the height of the transformer room can be reduced. For the case of a 275kV 300MVA class application, approximately 2 to 2.5 meter reduction in height can be achieved.
Excellent interface with Gas Insulated Switchgear (GIS)	The application of GIT together with GIS offers a very compact substation design as the equipment is installed in the same room. A significant cost reduction for civil construction can thus be achieved.

Pressure rise on internal fault

Significant tank pressure increases do not occur during internal failures due to the Gas characteristics. The risk of a tank explosion or fire incident can be completely eliminated.

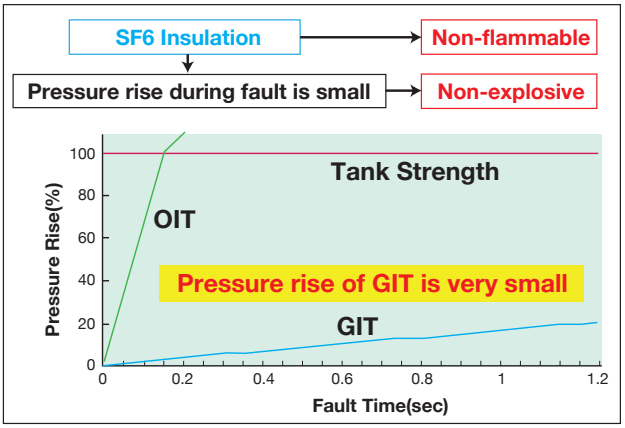


Fig.4

Compact substation design through application of GIT

As oil is not used in a GIT, a fire wall between the GIT and GIS or separate rooms are not required. Therefore GIT and GIS can be installed in the same room. This arrangement enables a compact substation to be achieved.

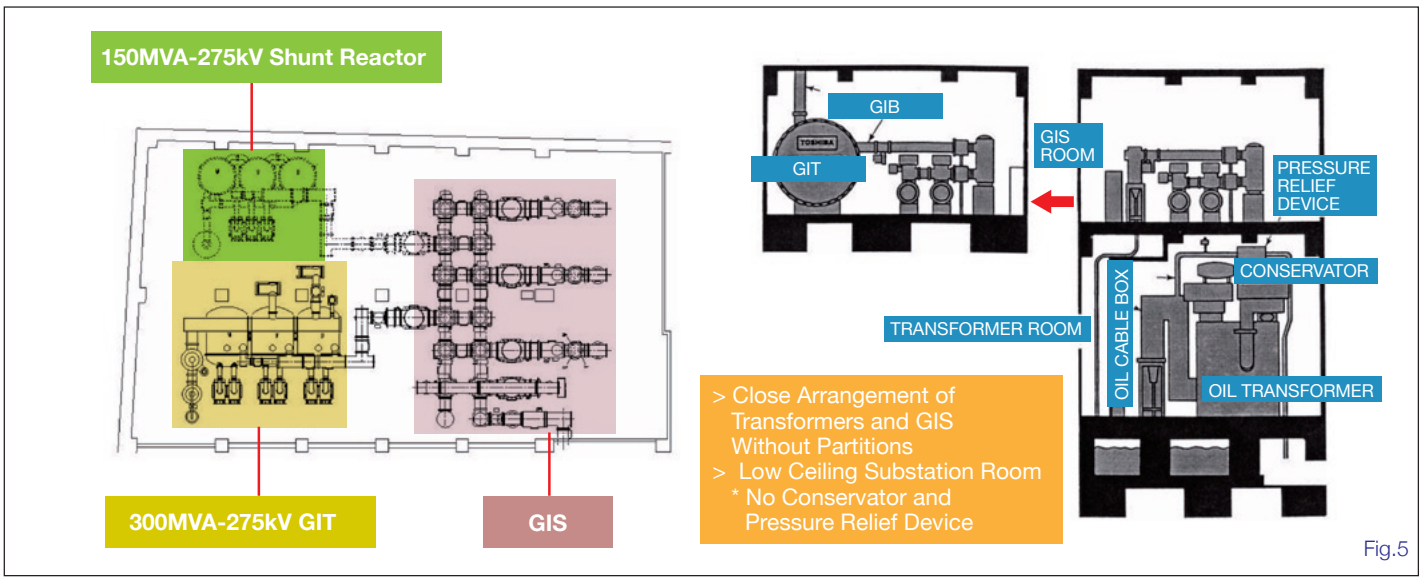


Fig.5

Construction

Features of GIT

Oil Immersed Transformer (OIT)	→	Gas Insulated Transformer (GIT)

① Insulation / Cooling

Insulating Oil	→	SF_6 Pressure 0.14 or 0.43MPa-g(20℃)

② Solid Insulation Material

Oil Impregnated Paper, Pressboard	→	PET Film,PPS Film, Aramide Paper, Pressboard

③ Conservator

Necessary	→	Unnecessary

④ On-Load Tap Changer

Diverter Switch

Arcing Switching in Oil	→	Vacuum Interrupter

Tap Selector

Slide Contact	→	Roller Contact

The construction of a GIT is basically the same as an OIT, with the exception of insulating material and cooling medium. Therefore, broad experience of OIT technology can be applied to GIT design, manufacturing and maintenance.

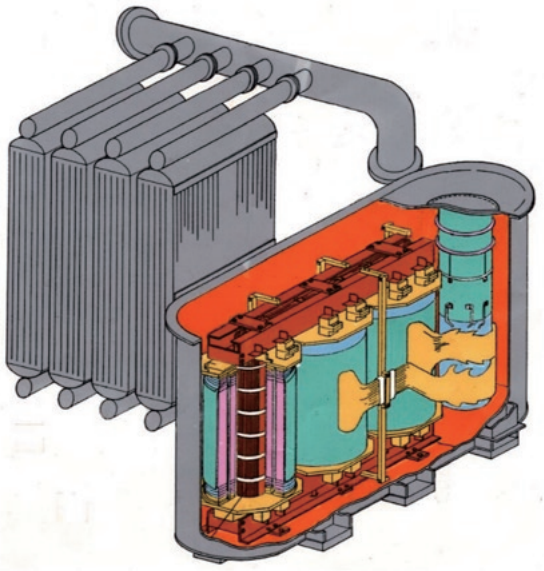


Fig.6

Cooling system

Cooling design for GIT

The concept of the external cooling design for a GIT is nearly the same as that for an OIT; for this reason various types of cooling method can be applied.

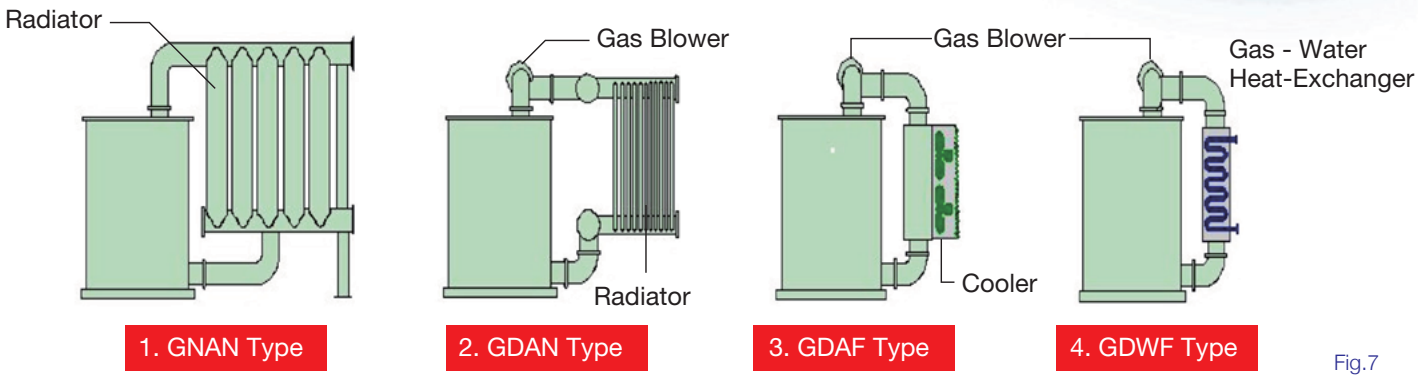


Fig.7

Flexibility in substation design

GDAN/GDAF-20/63MVA - 110kV GIT

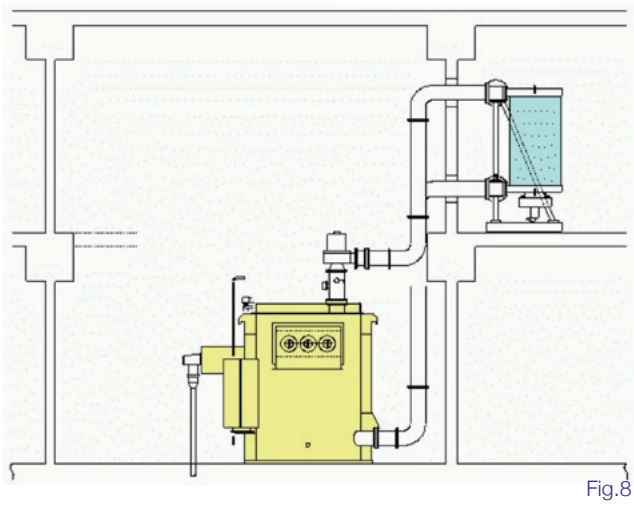


Fig.8

Since the head pressure of SF6 gas is negligibly low, cooling equipment can be located above the GIT level as indicated in the figure. The GIT offers excellent flexibility when locating components such as radiators or coolers.

Water cooling system for urban substations

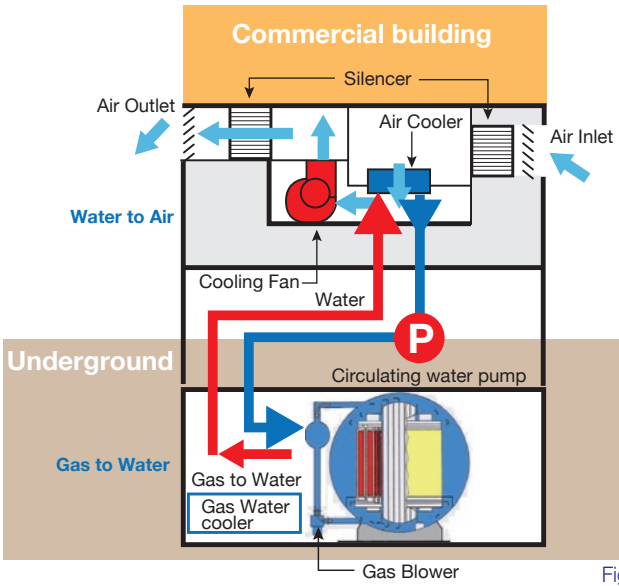


Fig.9

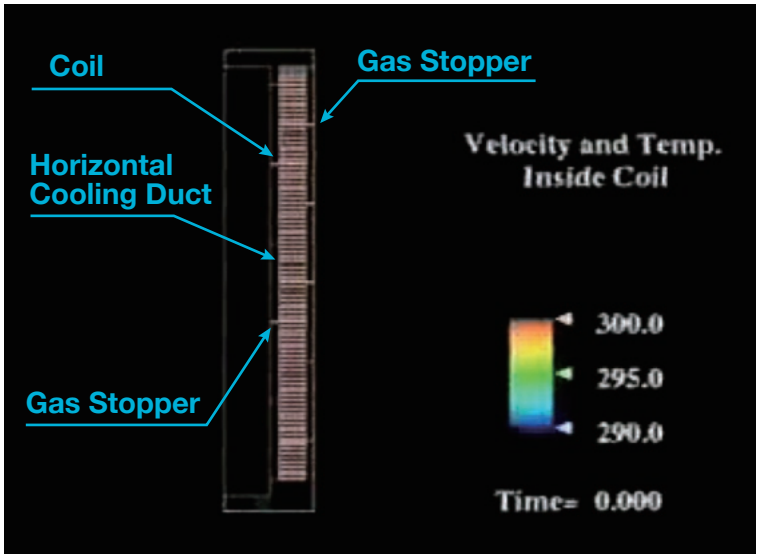
A water cooling system is widely used in large-capacity underground and/or indoor substations. The heat generated from a GIT is efficiently transferred to water-air heat exchangers by water flow. The cooling system is usually located on the top floor of the substation building.

Computer Aided Engineering (CAE)

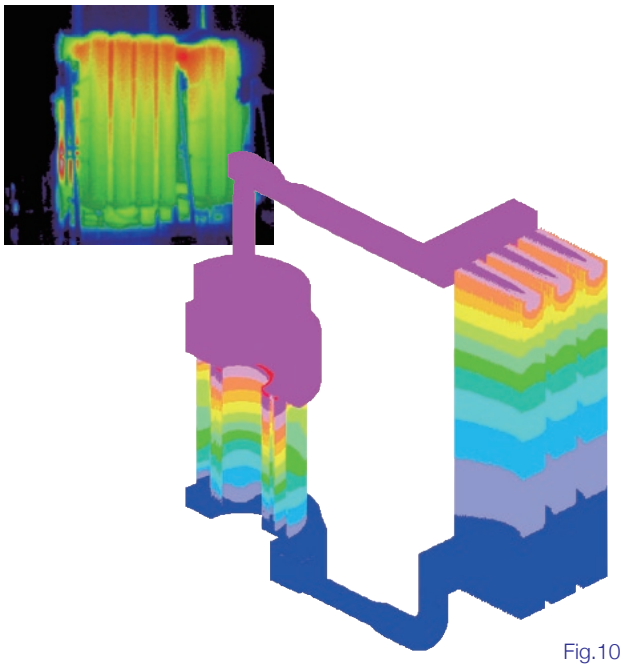
Temperature analysis for GIT design and GIT room considerations

In the cooling design for the GIT winding or substation buildings, Computer Aided Engineering (CAE) methods can be applied. The calculation using CAE for the airflow inside the building and/or outside is very useful during the planning stage of the substation building.

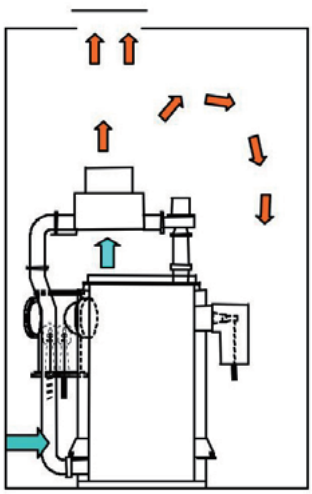
Winding cooling



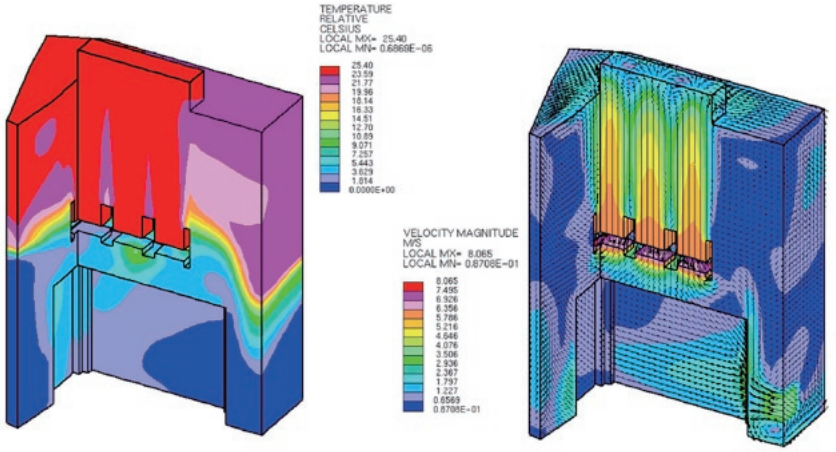
Radiator cooling



Transformer room cooling



Exhaust Flow Late = 760m3/min, No-Duct



Air Temperature distribution

Air velocity vector and distribution

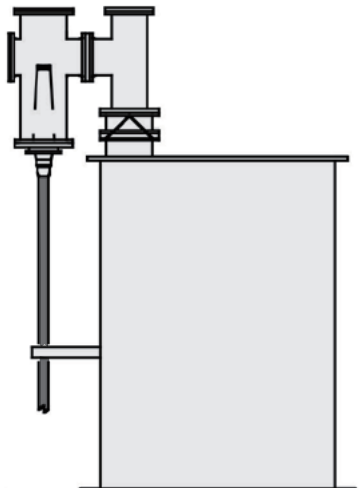
Fig.11

Fig.10

The calculation result used in the figure shows that the top cooler arrangement is suitable in terms of efficient substation cooling for this case. Positions of coolers can be decided by carrying out the CAE analysis taking into consideration the arrangement of the substation.

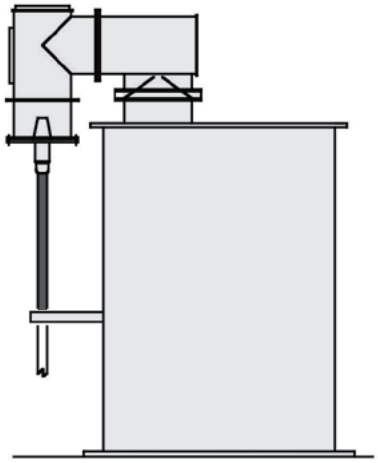
Interface with other substation equipment

There are various types of terminal construction for GIT applications. In order to reduce the space required for the terminal construction, cable connection or GIB direct connection is widely applied instead of air bushing connection especially for underground or indoor substations.



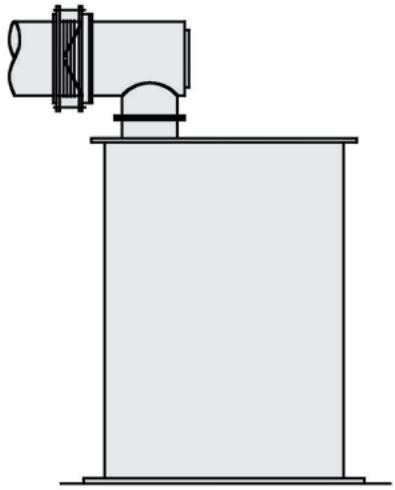
Cable connection

The cable interface construction is well defined and termination work can be done in a secure manner in accordance with the international standard (IEC or others).



Plug-in connector interface

Gas treatment work at the cable compartment is not required during installation work in the case of the plug-in connector. A plug-in connector is usually only applied for small capacity, low voltage GITs due to availability of the connector.



Gas Insulated Busbar (GIB) direct connection

GITs can be installed together with GIB or GIS in the same room by applying either GIB or GIS direct connection as shown in Fig. 5 on Page 2.

Fig.12

On-Load Tap Changers (OLTC) & Accessories

Line-up of OLTC for GIT

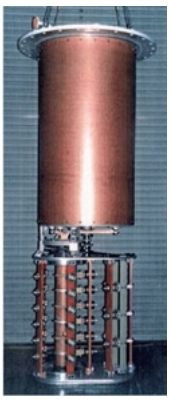
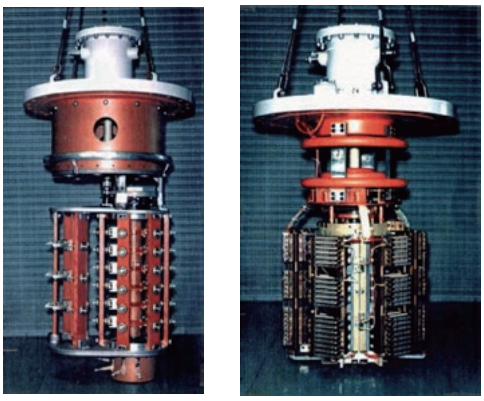
Type	GVT-D100AL	GVT-M100CL	GVT-100DH
Photo			
Step Voltage	1200V	1500V	2500V
Rated Current	380A	600A	870A

Fig.13

Sudden gas pressure relay

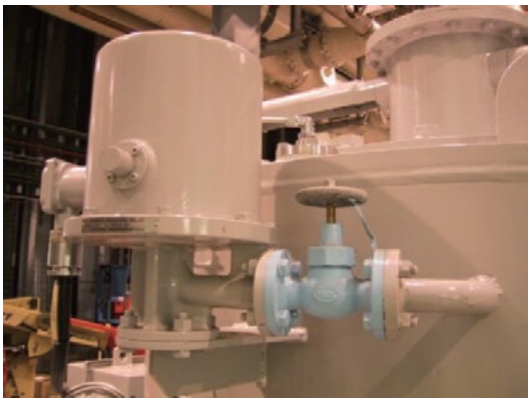
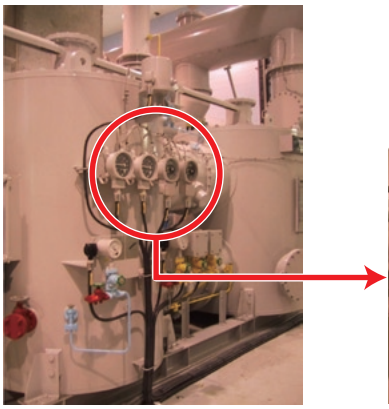
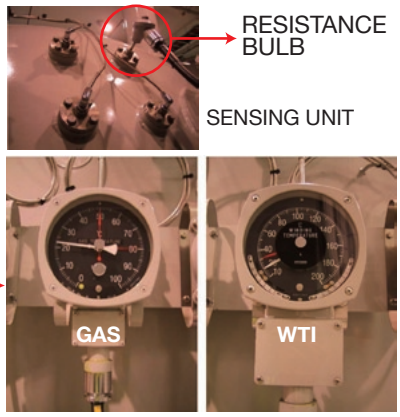


Fig.14

Temperature indication





DIAL TYPE THERMOMETER

Fig.15

Comparison between accessories for GIT and OIT

Item		GIT	OIT
Protective Device & Accessory	Temperature	Gas Temperature Indicator Winding Temperature Indicator	Oil Temperature Indicator Winding Temperature Indicator
	Leak	Gas density relay Compound gauge	Oil Level gauge
	Protection	Sudden gas pressure relay (OLTC)	Buchholtz relay, Gas detection relay, Pressure relief device,
	Others	———	Oil Preservation System Dehydrating Breather
Air ventilation		Ventilation to outdoors	Ventilation with fireproof dampers to outdoors

Table.1

Diagnostics & Maintenance

GIT Diagnostics

The integrity of GITs can be checked and a failure cause analysis can be made using gas chromatography. Using a simple gas detective tube device, GIT integrity can be confirmed at site.

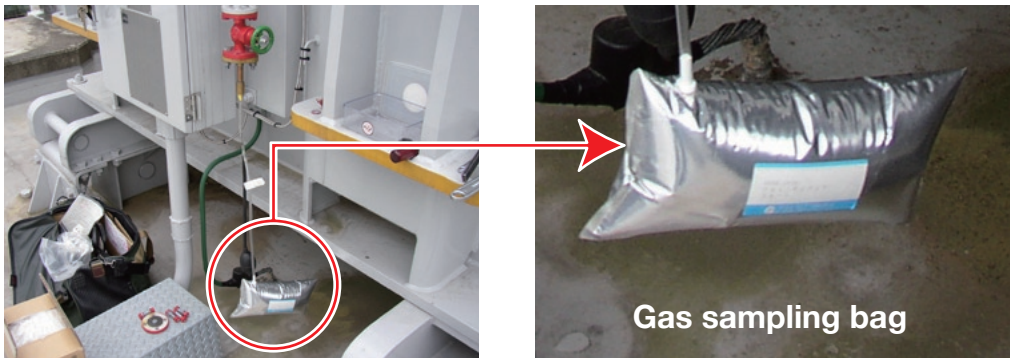


Fig.16

GIT Maintenance Program (Example)

NO.	Maintenance Item	Required maintenance period						
		Every 2 years	Every 3 years	Every 5 years	Every 10 years	Every 15 years	30 years	when failure occur
1	Gas analysis	✓						
2	Replenish the bearing grease of gas blower		✓					
3	Gas blower bearings				✓			
4	Exchange Gas blower					✓		
5	Indication and protection devices				✓			
6	Exchange Gas pressure sensor			✓				
7	Exchange Bushing						✓	
8	Exchange control cable Wiring						✓	
9	Inspection of OLTC			✓				
10	Exchange a Cooler							✓
11	Exchange O-ring, Gasket							✓
12	Running repairs of small gas leakage							✓

Maintenance cycle & items for GITs

Table.2

Typical application

OIT and GIS application

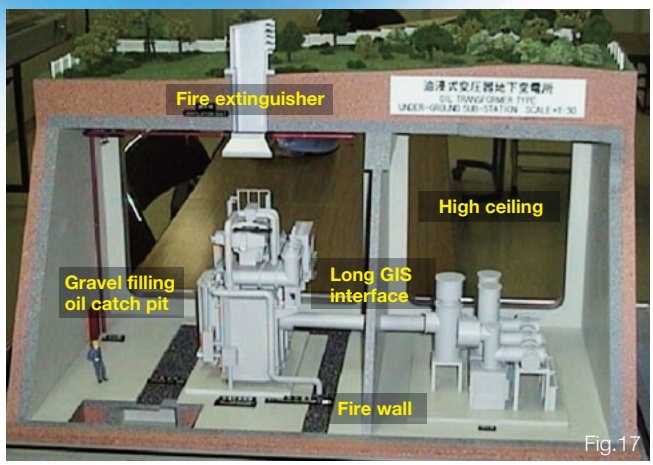


Fig.17

OIT and GIS must be separated by a fire wall or installed in separate rooms dependent upon the fire risk.

GIT and GIS application

Fig.18

As oil is not used in both GIT and GIS equipment, neither a fire wall nor separate rooms are required. By installing both GIT and GIS in the same room, a compact substation can be realized.

Applied Voltage, Capacity & Gas pressure

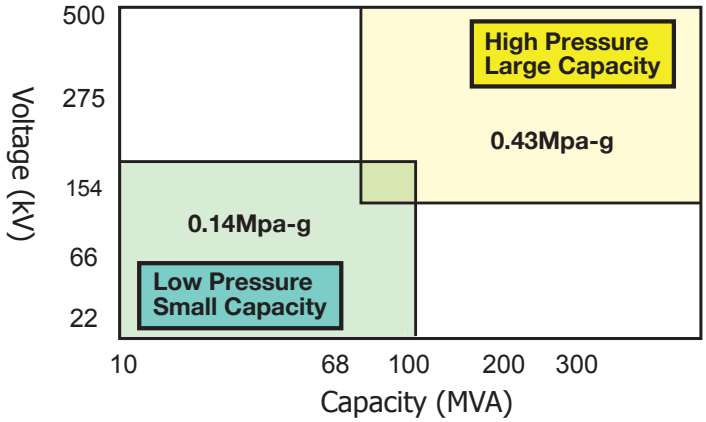


Fig.19

Toshiba supplies a wide range of GITs with low pressure gas and high pressure gas technology.

15/50MVA - 110kV GIT in underground substation

Low pressure design:
0.14MPa-g


Fig.20

400MVA GIT in underground substation

High pressure design:0.43MPa-g

Fig.21

Environmentally friendly feature

39MVA-132kV GIT near Australian national park

Fig.22

The Hydro Power station shown in this photograph is located in the wet tropical area within a world heritage site. A GIT was provided at the power station to remove the risk of oil leakage.

Control for SF_6 gas emission

SF_6 gas emission from gas-insulated equipment in Japan

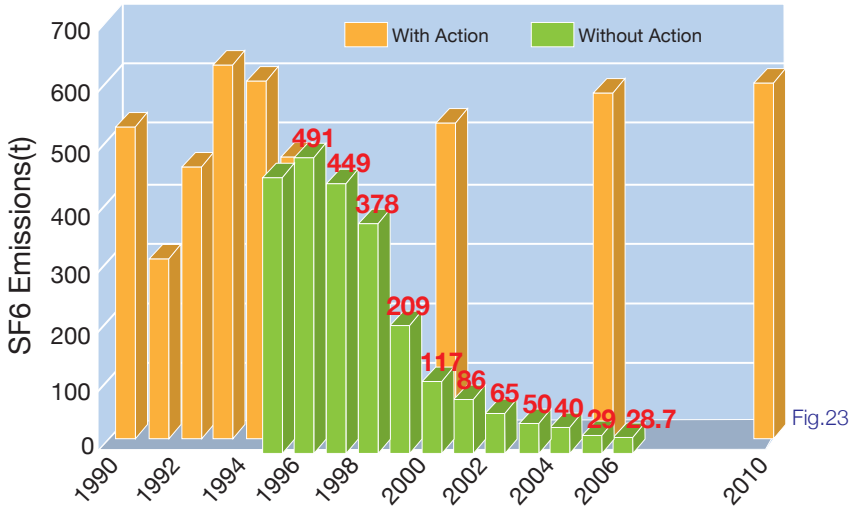


Fig.23

Gas leak test at the factory

Fig.24

In order to confirm no gas leakage from the GIT tank, gas leak tests are performed at the factory for all GIT tanks. At site the gas leak test is performed on re-assembled parts to ensure no leakage.

Electric power companies and Electric equipment manufacturers in Japan have made tremendous efforts to reduce SF6 gas emissions based on an agreed voluntary target. With careful gas treatment and complete SF6 gas recovery systems, the amount of SF6 gas emission from gas insulated equipment has been dramatically reduced as indicated by the green bars.
If no action had been taken, the amount of SF6 gas emissions would still be increasing as indicated by the orange bars.

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