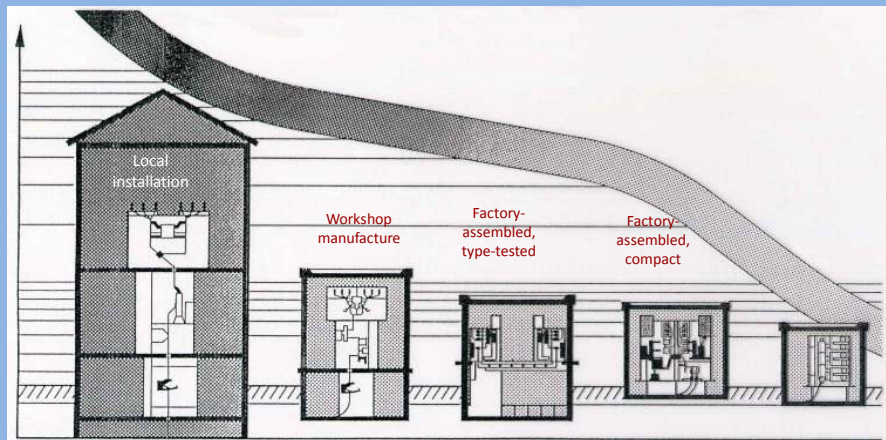


GIS

Gas Insulated Switchgear

MV Switchgear since 1950's



Air-insulated

Air/solid-insulated

Cast-resin insulated

January 20, 2014 Sharif Ahmed
Senior Member IEEE

Page 1

What is SF6

Its Sulphur Hexafluoride

SF6 Gas

***Sulphur Hexafluoride
is a colourless, odourless,
chemically neutral, and inert
gas, non-inflammable and 5
times heavier than air, not
toxic and not ozone
depleting.***

Is SF₆ a Health Hazard

Pure SF₆ is physiologically completely harmless for humans and animals; it's even used in medical diagnostic. Due to its weight it might displace the oxygen in the air, if large quantities are concentrating in deeper and non ventilated places.

Legislation for chemicals does not categorise SF₆ as a hazardous material.

Is SF₆ harmful for the environment?

It has no ecotoxic potential, it does not deplete ozone. Due to its high global warming potential it may contribute to the man made greenhouse-effect, if it is released into the atmosphere. However in electrical switchgear the SF₆ gas is always used in gas-tight compartments, greatly minimising leakage. This make the real impact on greenhouse effect negligible

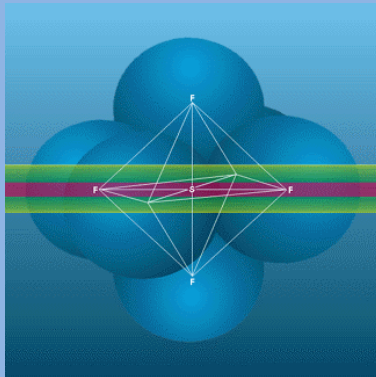
SF6 Gas Insulated Switchgear

- ***What is Gas Insulated Switchgear***
- ***The Switchgear where SF6 Gas is the insulating medium.***
- ***Why this Gas is chosen for insulation medium?***
- ***Lets see the characteristics of SF6 gas***

January 20, 2014 Sharif Ahmed
Senior Member IEEE

Page 1

Characteristics of SF6 Gas



- ***Non-poisonous, non-flammable, inert, self-restoring insulation***
- ***Dielectric strength 6x better than air***
- ***Low current arcs are self-extinguishing***
- ***SF₆ only insulates – not used for interrupting, therefore, no arcing by-products.***
- ***No oxidation inside of enclosure***
- ***Gas leakage rate < 0.1% annually***

January 20, 2014 Sharif Ahmed
Senior Member IEEE

Page 1

What is Medium Voltage Vacuum GIS?

- **Gas Insulated Switchgear where the insulation Medium is SF₆**
- **Low pressure SF₆ used as an insulating medium for all primary components**
- **Because of the SF₆ under pressure Dielectric strength is 6x better than air**
- **With a higher Insulation the distances between the live parts and earth are reduced.**
- **Because of the reduced clearances between the life parts the size of the Switchgear is reduced and you get a much smaller foot print of the Gear.**
- **Vacuum interrupter technology is used in GIS Gears**
- **Circuit Breakers are fixed mounted in GIS Gears**

January 20, 2014 Sharif Ahmed
Senior Member IEEE

Page 1

What is Medium Voltage Vacuum GIS?

- **Primary components are virtually maintenance-free due to controlled gas environment**

SF₆ for lightning withstand level is up to 200 kV BIL at 38 kV

- **Integral disconnecting is by the use of a three position selector switch: - - **Connected, Disconnected & Ground Positions****

The Vacuum interrupters used are good for up to 30,000 normal operations and 50 fault operations.

Make-proof earthing by means of the vacuum circuit-breaker

Hermetically bolted / Sealed switchgear housings

Cable connections are with inside-cone plug-in system, or for connection of gas-insulated and solid-insulated bars

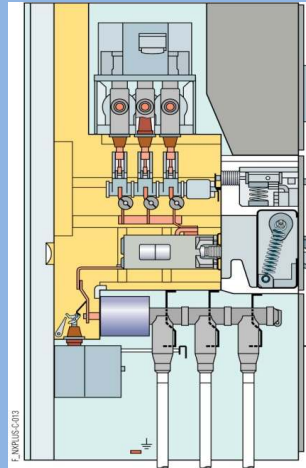
Very small foot prints

January 20, 2014 Sharif Ahmed
Senior Member IEEE

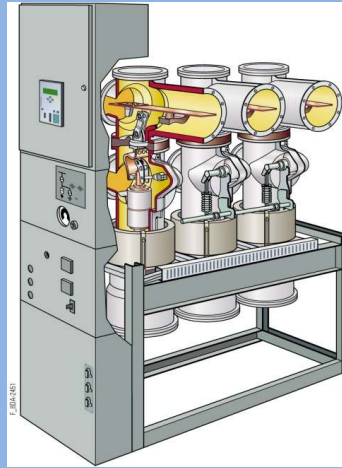
Page 1

Gas Insulated Switchgear

Three phase encapsulation



*Single Phase encapsulation
(W600mmxD1625mmxH2350mm)*



January 20, 2014 Sharif Ahmed
Senior Member IEEE

Page 1

Key Features – MV Vacuum GIS

Offers high reliability

*Offers high flexibility through modular design
Offers high safety by Inherently Arc Resistance
iso phase design*

Features small foot print design for total cost savings

Increased immunity to the surrounding environments

Maximizes revenue and profit by low maintenance

*Delivers low a total cost/risk of ownership over product
life cycle*



January 20, 2014 Sharif Ahmed
Senior Member IEEE

Page 1

Arc Resistant

Arc Resistant AS PER ANSI

- ANSI 37.20.7-2007



January 20, 2014 Sharif Ahmed
Senior Member IEEE

Page 1

For Major Operational Activities, Reduced Level Of PPE Can Be Used For MV GIS

- Comparison of PPE³ level required for operations

Activity	MV Air-Insulated Switchgear (AIS) ¹	MV GIS
Open/close circuit breaker	HRC 2 (door closed) ² HRC 4 (door open)	HRC 0
Isolate circuit	HRC 4 (racking, door open or closed) (Note: isolation in metal-clad requires racking to test or disconnect position)	HRC 0 (operation of three-position switch to open position)
Application of safety grounds	HRC 4	HRC 0

January 20, 2014 Sharif Ahmed
Senior Member IEEE

Page 1

Technical Data

* Maximum	IEC	IEC	ANSI	IEC	IEC	ANSI
Rated Voltage (kV)	7.2	12	15	17.5	24	38
Rated Power Frequency Withstand Voltage (kV)	20	28	36	38	50	80
Rated Lightning Impulse Withstand Voltage (kV)	60	75	95	95	125	200
Rated Short Circuit Breaker Current* (kA)	40	40	40	40	40	40
Rated Short Time Current 3 Sec* (kA)	40	40	40	40	40	40
Rated Short Circuit Making Current* (kA)	104	104	104	104	104	104
Rated Busbar Current* (A)	5000	5000	5000	5000	5000	5000
Maximum Circuit Breaker Rating* (A)	4000	4000	4000	4000	4000	4000

January 20, 2014 Sharif Ahmed
Senior Member IEEE

Page 1

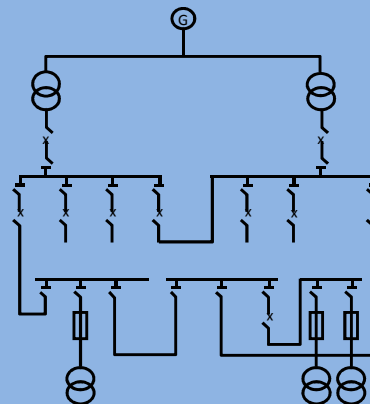
Main Applications for Medium-Voltage Switchgear

Generation level
and high-voltage
system

Primary distribution
level

Secondary distribution
level

Low
voltage



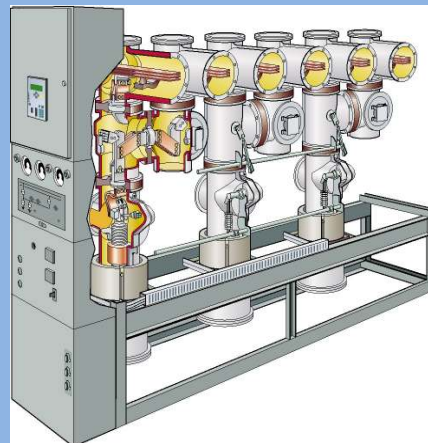
January 20, 2014 Sharif Ahmed
Senior Member IEEE

Page 1

Single Bus bar & Double bus bar single phase encapsulated Gear



Single Bus bar



Double Bus bar

January 20, 2014 Sharif Ahmed
Senior Member IEEE

Page 1

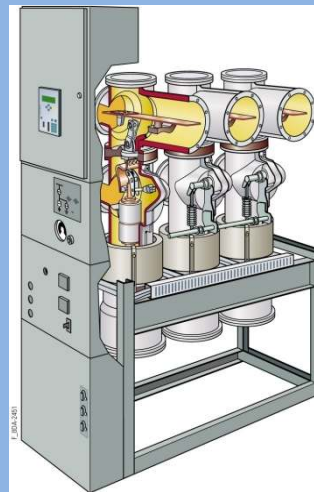
Situation with Gas-Insulated Switchgear

Today's state of the art is gas-insulated switchgear with the following main benefits:

- Small, compact dimensions
- Independent of environmental effects and climate
- Widely maintenance-free
- Maximum safety for staff
- Low fire risk
- Arc-fault tested

Advantages:

- Low invest for buildings due to compact dimensions and climate-independent design
- Maximized power supply reliability
- Maximum personal safety
- Lowest life cycle costs
- Reduced operational costs



January 20, 2014 Sharif Ahmed
Senior Member IEEE

Page 1

Maximum Security of Operation

Separate compartments for busbar and circuit-breaker offer a maximum degree of availability

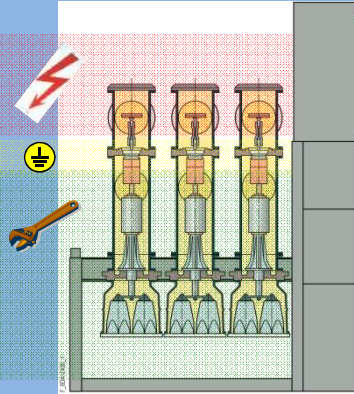
Busbar (in operation)

Attention: High voltage

Feeder earthed (earthing)

Circuit-breaker

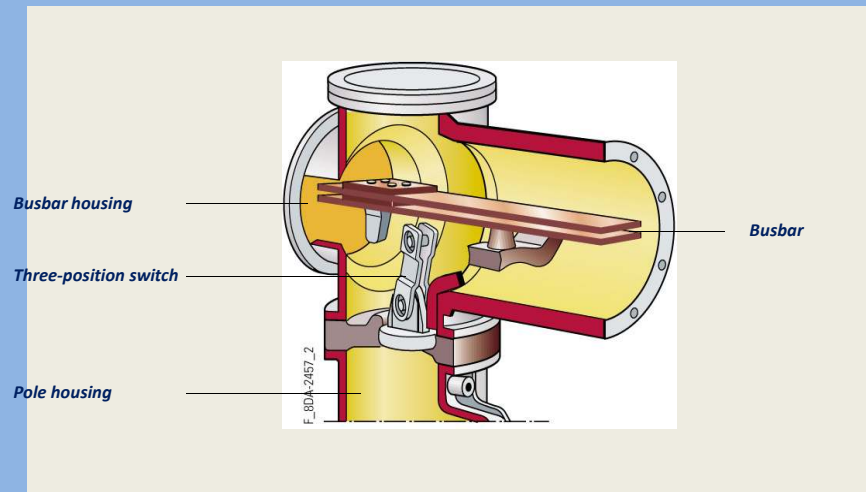
Access without danger to current transformer, feeder voltage transformer, cable plugs, operating mechanisms



January 20, 2014 Sharif Ahmed
Senior Member IEEE

Page 1

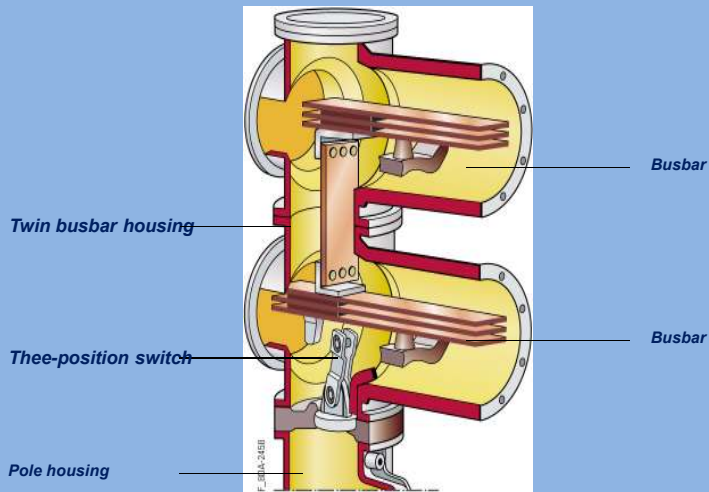
Bus bar Design



January 20, 2014 Sharif Ahmed
Senior Member IEEE

Page 1

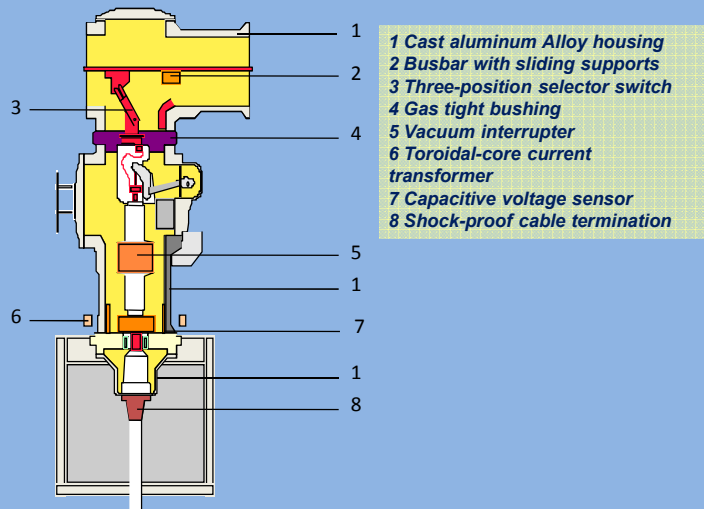
Busbars of higher ratings upto 5000A



January 20, 2014 Sharif Ahmed
Senior Member IEEE

Page 1

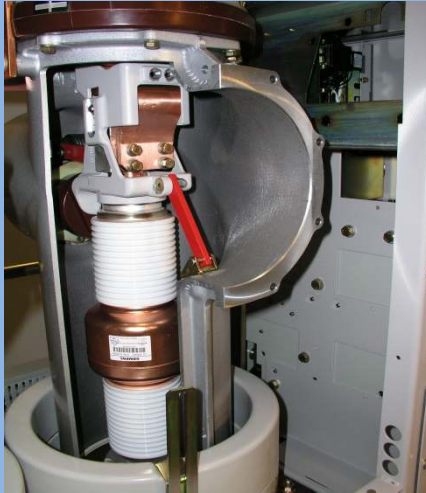
Single Busbar Switchgear: Cross Section of Single Pole



January 20, 2014 Sharif Ahmed
Senior Member IEEE

Page 1

Vacuum interrupter mounted in Circuit Breaker pole housing

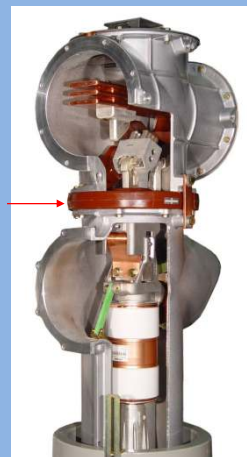


January 20, 2014 Sharif Ahmed
Senior Member IEEE

Page 1

Cast Resin Bushing separating Gas Chambers

- ***Routine tests including:***
- ***X-ray test***
- ***High voltage test (HV)***
- ***Partial discharge test (PD)***
- ***Helium leak test***



January 20, 2014 Sharif Ahmed
Senior Member IEEE

Page 1

Vacuum Interrupters

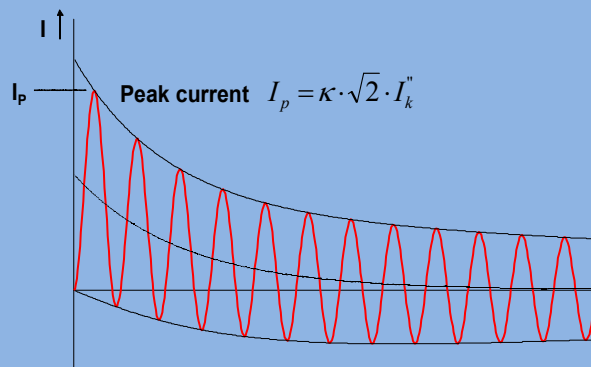
✓ Proven Vacuum Interrupters



January 20, 2014 Sharif Ahmed
Senior Member IEEE

Page 1

Rated peak and/or making current



IEEE: I_{ma} or $I_p = 2,6 \cdot I_k$ at 60 Hz

IEC: I_{ma} or $I_p = 2,5 \cdot I_k$ at 50 Hz

$2,6 \cdot I_k$ at 60 Hz

$2,7 \cdot I_k$ at 50 Hz if ratio X/R > 14 (i.e. $\tau > 45$ ms)

January 20, 2014 Sharif Ahmed
Senior Member IEEE

Page 1

Interrupters used in GIS

- The interrupters used are designed for 30,000 normal operations.
- 50 Fault operations
- The Breakers are normally operated at 5 cycle
- The Breakers can also be operated at 3 cycles if requested by the client.
- The symmetric value of short circuit current is 40kA.
- Max making current 104kA which is asymmetric value of current.
- The short circuit ratings offered by different manufactures are 25kA, 31.5kA and 40kA.

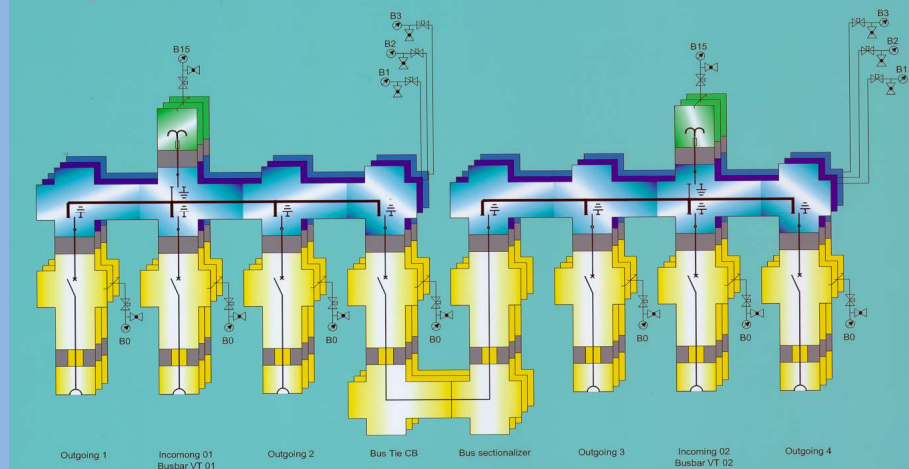
January 20, 2014 Sharif Ahmed
Senior Member IEEE

Page 1

Compartmentalization

Single Busbar Switchgear

Arr. of gasfilled compartments



January 20, 2014 Sharif Ahmed
Senior Member IEEE

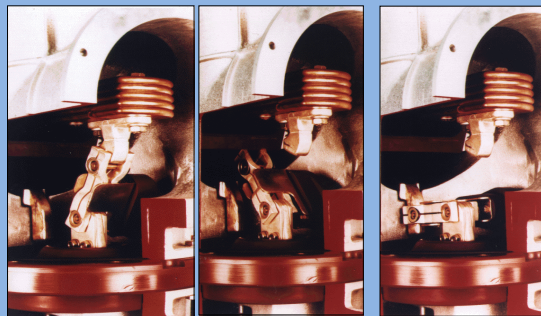
Page 1

Manometer for checking Gas pressure



January 20, 2014 Sharif Ahmed
Senior Member IEEE

Three Position Selector Switch



ON

OFF

GROUNDED

January 20, 2014 Sharif Ahmed
Senior Member IEEE

Viewport for Three Position Switch



January 20, 2014 Sharif Ahmed
Senior Member IEEE

Page 1

Three Position Selector Switch View by Camera



Web cam designed Cameras outside of the gas chambers with plug and play Fire wire /USB2.0 Connections to any laptop

Design via Video Cameras

January 20, 2014 Sharif Ahmed
Senior Member IEEE

Page 1

View Port via Video Camera For Disconnecter and Grounding Switches

January 20, 2014 Sharif Ahmed
Senior Member IEEE

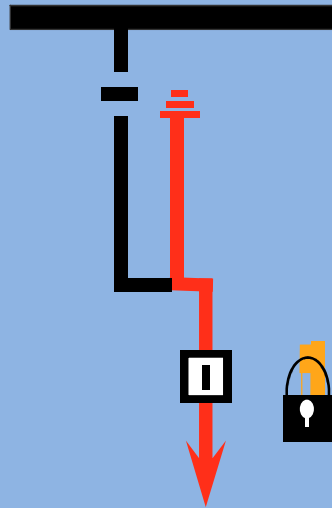
Page 1

Three Position Selector Switch

January 20, 2014 Sharif Ahmed
Senior Member IEEE

Page 1

Feeder Earthing with the Circuit-Breaker



1) Close the “earthing switch” of the three-position switch

- Ready to earth
- Electrical OFF-signals are suppressed

2) Close the circuit-breaker

- Feeder earthed

3) Padlock the “feeder earthed” interlock

- The circuit-breaker is blocked mechanically
- Signalling contact: Feeder earthed (option)

January 20, 2014 Sharif Ahmed
Senior Member IEEE

Page 1

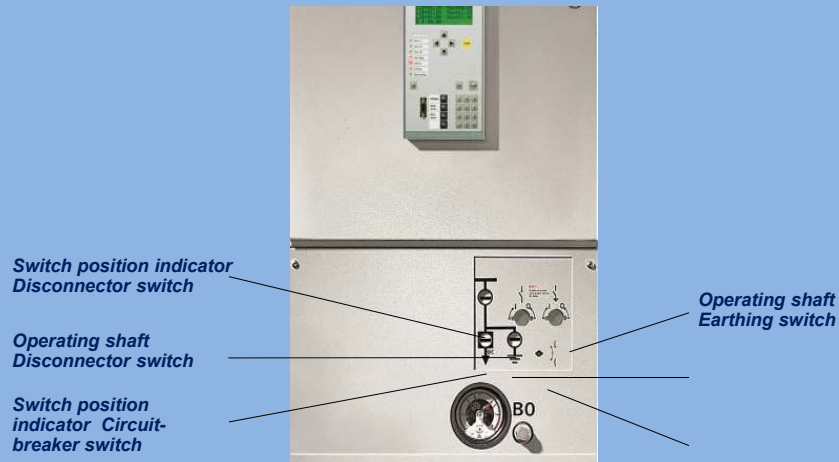
Lock out Tag out



January 20, 2014 Sharif Ahmed
Senior Member IEEE

Page 1

Operation of Three Position Switch



January 20, 2014 Sharif Ahmed
Senior Member IEEE

Page 1

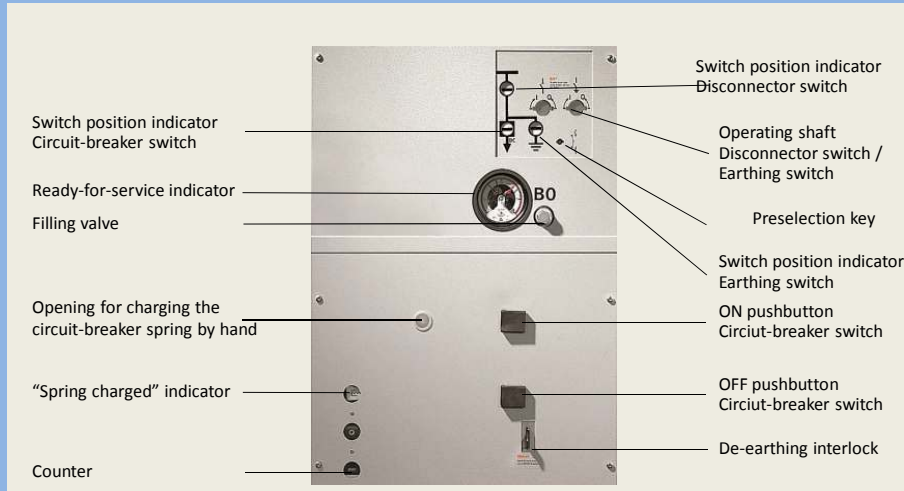
Operation of a Single Phase Encapsulated GIS



January 20, 2014 Sharif Ahmed
Senior Member IEEE

Page 1

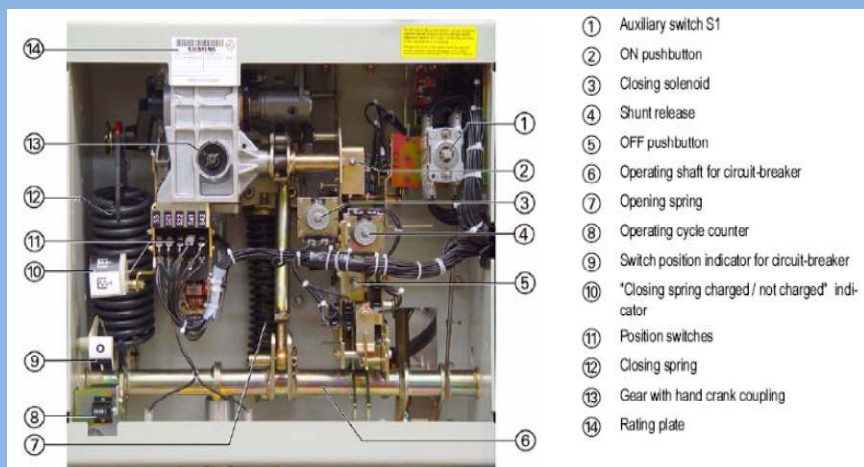
Operation of a Single Phase Encapsulated GIS



January 20, 2014 Sharif Ahmed
Senior Member IEEE

Page 1

Circuit Breaker operating mechanism



January 20, 2014 Sharif Ahmed
Senior Member IEEE

Page 1

Operating Tools



Fig. 19: Operating lever for DISCONNECTING function



Fig. 20: Operating lever for READY-TO-EARTH function (cross bar marked red)



Fig. 21: Emergency operating lever



Fig. 22: Hand crank to charge the closing spring



Fig. 23: Double-bit key 5 mm

January 20, 2014 Sharif Ahmed
Senior Member IEEE

Page 1

Interlocks (Selection)

Interlocks are designed according to IEC 62 271-200

Standard interlocks

- *Three-position disconnecter against circuit-breaker – mechanical*
- *Disconnecter against earthing switch (within three-position disconnecter) – mechanical*
- *Locking device at the circuit-breaker switch*
- *Locking device at the three-position disconnecter switch*

Additional interlocks

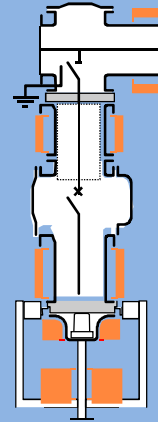
- *Electromagnetic interlock at the three-position switch / disconnecter switch*
- *Electromagnetic interlock at the three-position switch / earthing switch*

January 20, 2014 Sharif Ahmed
Senior Member IEEE

Page 1

Current Measurement Toroidal (Window) Type Current Transformer

- **Conducting paths form the primary winding, free from dielectric and thermal stress**
- **Secondary components outside enclosure and easily accessible**
- **No dielectric stress on cast resin components**



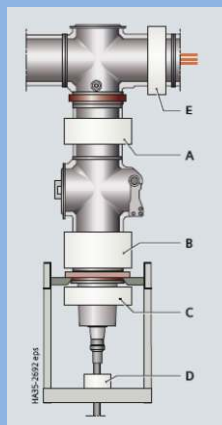
January 20, 2014 Sharif Ahmed
Senior Member IEEE

Page 1

Current Measurement

Ring-core current transformers:

- **Main circuit as primary part without dielectric and thermal problems**
- **Secondary part accessible outside the enclosure without hazard**
- **Free of dielectrically stressed cast-resin parts.**



Current transformer installation (basic scheme)

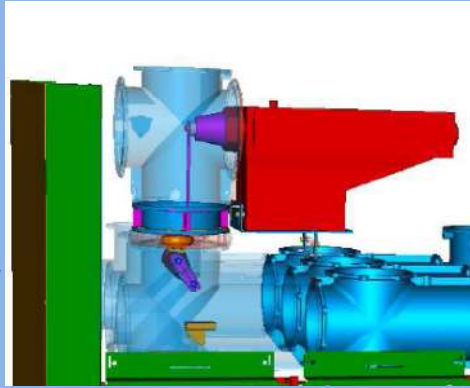
- B Feeder current transformer on the circuit-breaker housing
 - C Feeder current transformer on the panel connection housing
 - D Feeder current transformer on the cable
 - E Busbar current transformer
- Option:
A Feeder current transformer between circuit-breaker and three-position disconnector on the busbar

January 20, 2014 Sharif Ahmed
Senior Member IEEE

Page 1

Fused Busbar Voltage Transformer

- *Single-pole insulated*
- *SF₆ filled gas switch compartment*
- *Protection of busbar by gas-tight barriers*
- *Safely removal using ground switch*
- *Fused and disconnectable*

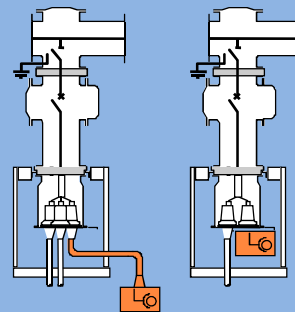


January 20, 2014 Sharif Ahmed
Senior Member IEEE

Page 1

Line Side (Cable Side) Voltage Transformer

- *Plugged-in panel connection*
- *Metal-enclosed*
- *Either plugged-in directly or mounted separately and connected via a plug-in cable*
- *Completely shockproof*
- *Outside main circuit*



Mounted Separately

Plugged-in Directly

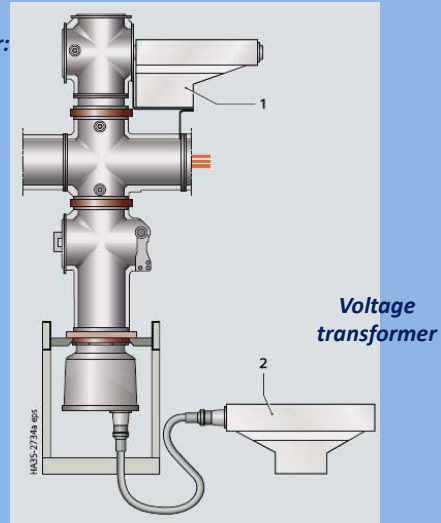
January 20, 2014 Sharif Ahmed
Senior Member IEEE

Page 1

Line-Side (Cable-Side) Voltage Transformer

Line-side (cable-side) voltage transformer:

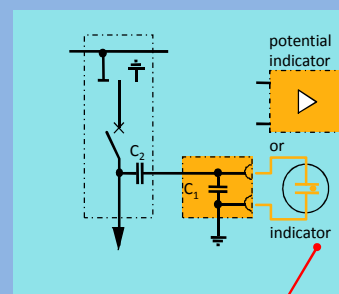
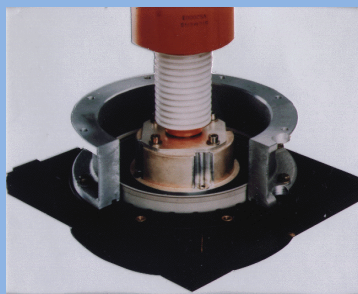
- Plugged-in panel connection
- Mounted separately and connected via a plug-in cable
- Grounded Metal-enclosed
- Wye / Wye connected
- 100% shock proof
- Outside main circuit.



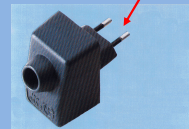
January 20, 2014 Sharif Ahmed
Senior Member IEEE

Page 1

Capacitive voltage indication



- coupling electrode built into the pole-support plate of the circuit breaker
- for checking for dead state of each pole



January 20, 2014 Sharif Ahmed
Senior Member IEEE

Page 1

Low-Voltage Compartment

- **Height:** 850 mm
1200 mm (option)
- **Removable, bus wires and control cables plugged in (via 6 or 10-pole coded module plug connectors)**
- **Panel control via conventional control devices or digital bay controller**
- **Customer-specific equipment (protection, control, metering, annunciation)**
- **Wiring in H07VK, optionally also heat-resistant and halogen-free**



January 20, 2014 Sharif Ahmed
Senior Member IEEE

Page 1

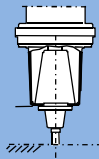
Plug-in Cable termination system



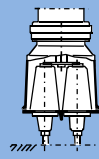
January 20, 2014 Sharif Ahmed
Senior Member IEEE

Page 1


Various multiple cable terminations



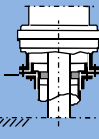
Single Cable Plug-in



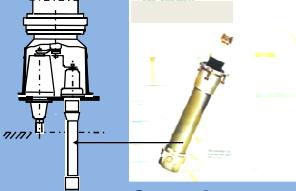
**2 or 3 Cables per Phase
with Plug Size 3**




**6 Cables per Phase
With Plug Size 1 to 3**



**Termination for
Tubular Gas Bar**



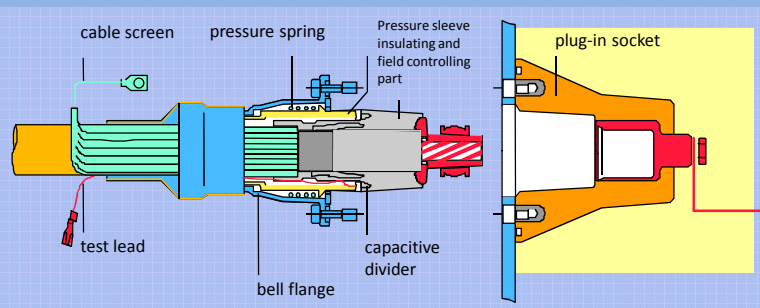
Surge Arresters



**Termination for
Solid-Insulated Bar**

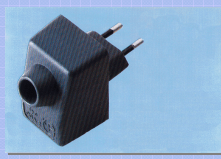
January 20, 2014 Sharif Ahmed
Senior Member IEEE Page 1

Plug-in cable termination system



plug-in socket

- inner-cone system acc. DIN 47637
- metal-enclosed, all-insulated
- dead front
- integrated capacitive voltage tap for checking for dead state



January 20, 2014 Sharif Ahmed
Senior Member IEEE Page 1

Cable connector



January 20, 2014 Sharif Ahmed
Senior Member IEEE

Page 1

Dummy connector



Dummy Cable Connector

- for sealing and voltage-proof closing of CONNEX bushings.
- suitable for outdoor use or offshore-/soil-proof

No.	Size	Max. operating voltage U_m (kV)	Use 1 aboveground	Packing unit	Weight (kg)
827 150 003	2	42	aboveground	1	0.6

January 20, 2014 Sharif Ahmed
Senior Member IEEE

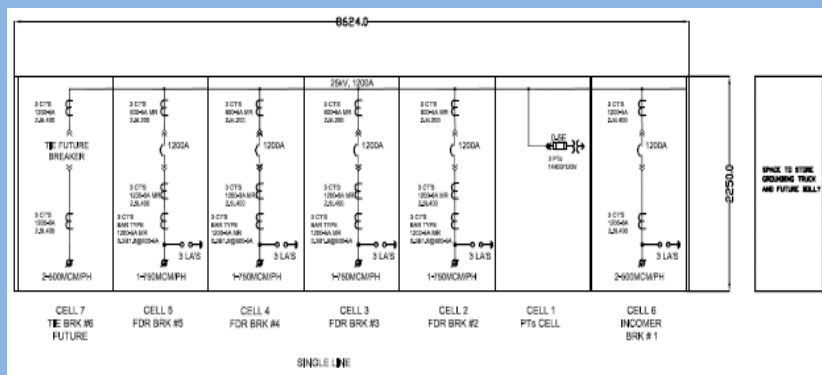
Page 1

Cable connections in GIS



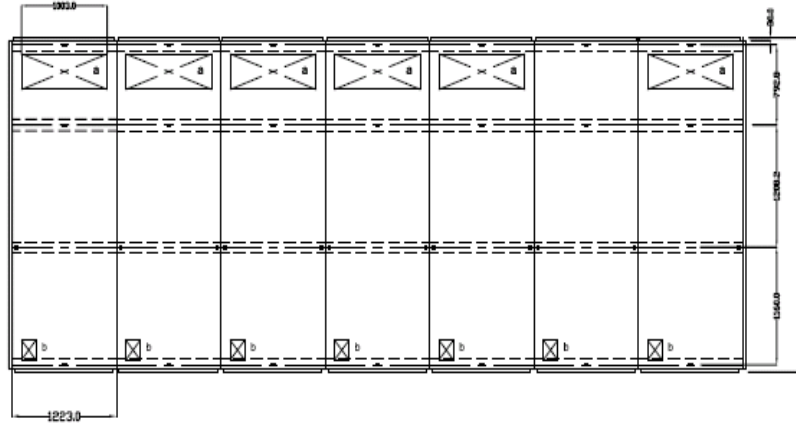
January 20, 2014 Sharif Ahmed
Senior Member IEEE

25kV AIS Line-up



January 20, 2014 Sharif Ahmed
Senior Member IEEE

Physical Dimensions & Number of Cells of AIS

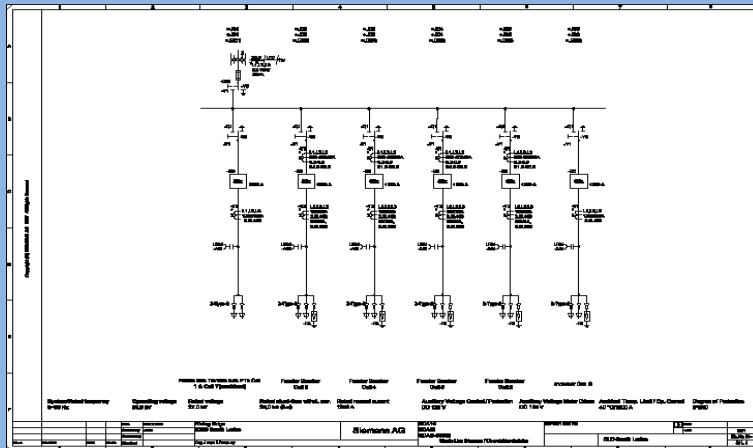


TYPICAL FLOOR PLAN

January 20, 2014 Sharif Ahmed
Senior Member IEEE

Page 1

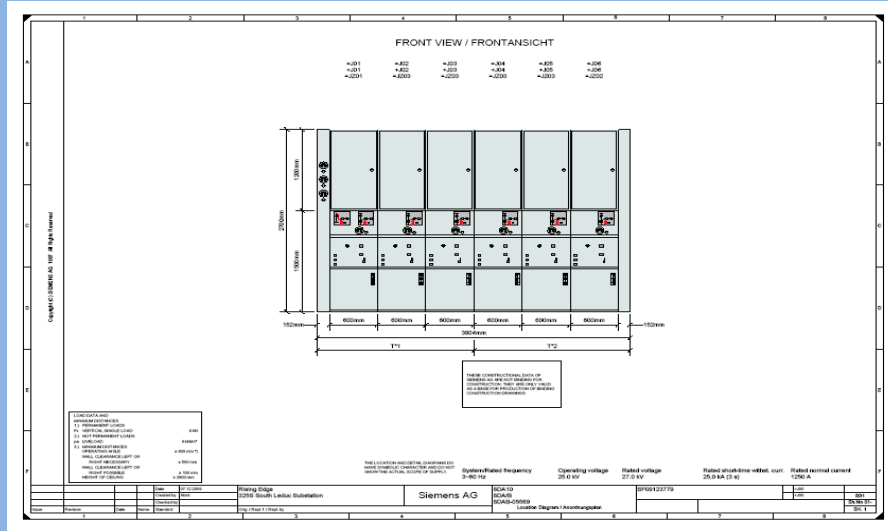
25kV GIS for same Switchgear



January 20, 2014 Sharif Ahmed
Senior Member IEEE

Page 1

Number of Cells and dimensions for GIS



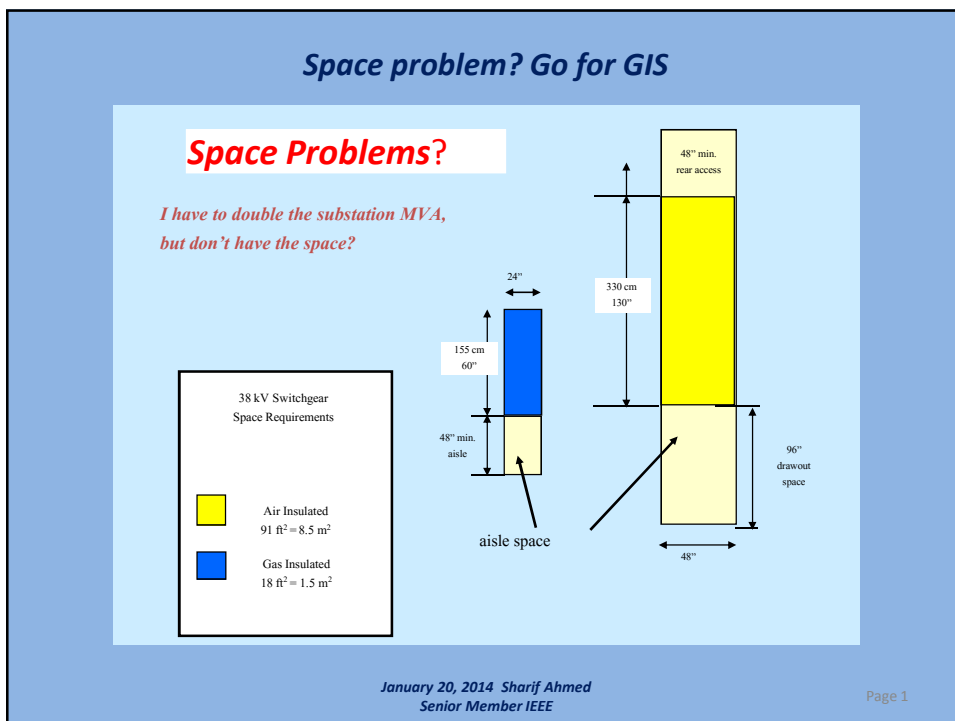
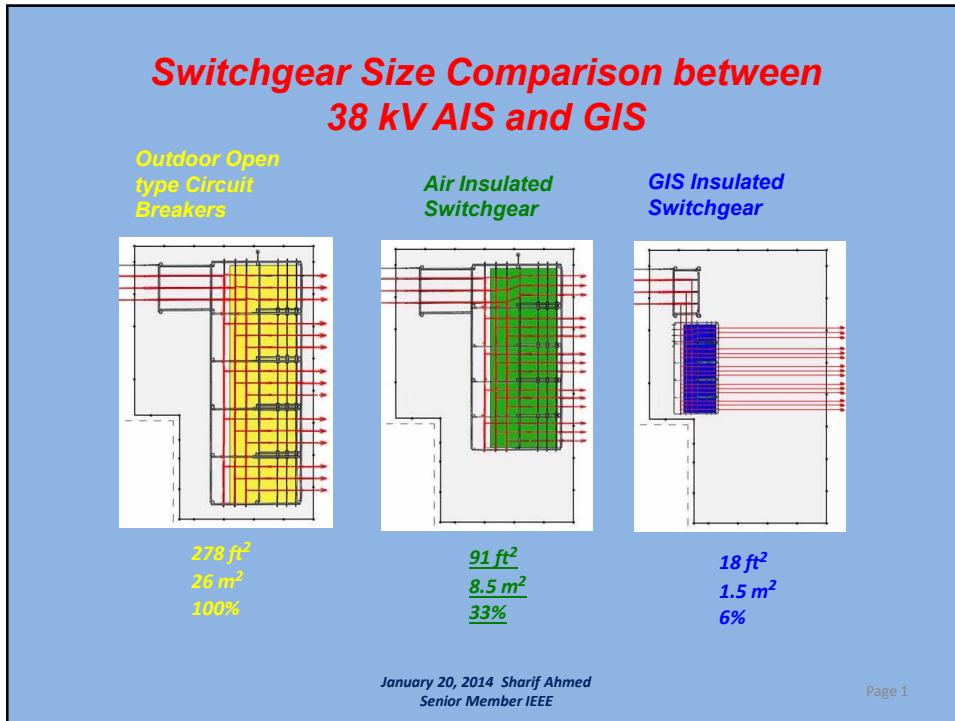
January 20, 2014 Sharif Ahmed Senior Member IEEE

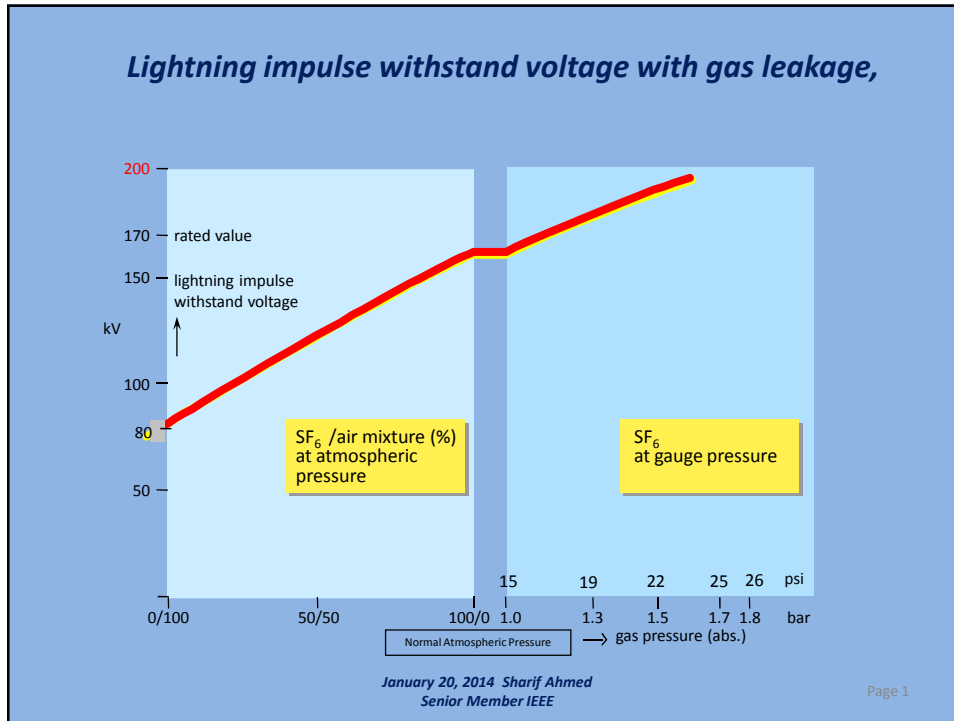
A Closer Look at GIS vs AIS



GIS Requires 20% of space needed for air-insulated designs

January 20, 2014 Sharif Ahmed Senior Member IEEE





AIS VS GIS

Advantages of using 35kV GIS in comparison to 35kV AIS Switchgear Dimensions

AIS	GIS
<ul style="list-style-type: none"> • Width: 1500mm • Depth: 2400mm • Area per Section ≈ 3,6m² • Operating Aisle ≈ 1.5m 	<ul style="list-style-type: none"> • Width: 600mm • Depth: 1625mm • Area per Section ≈ 1m² • Operating Aisle ≈ 0.8m
<ul style="list-style-type: none"> • Example with 10 sections: • Area required AIS ≈ 36 m² • Operating Aisle ≈ 23m² 	<ul style="list-style-type: none"> • Example with 10 sections: • Area required AIS ≈ 10m² • Operating Aisle ≈ 5m²

January 20, 2014 Sharif Ahmed
Senior Member IEEE

Page 1

ADVANTAGES OF GIS

AIS

AIS maintenance will be required after 5 years of service.

Maintenance means:

- *Switch off of lines, feeder and busbars*
- *Grounding*
- *All CB's in test position*
- *Test function of CB's and all other switching devices*
- *Remove the draw out section and dismantle panels partly in order to get access to busbars and cable sections*

GIS

GIS maintenance will required after 5 years

Maintenance means:

Visual Inspection

AIS MAINTENANCE

- *Clean the panels from dust*
- *Lubricate all bearings and surfaces*
- *Check panel function and put board back into service*
- *Estimated time per panel: 4 hours*
- *Estimated cost per hour: US\$ 100*
- *For 10 panels:*
- *Estimated time : 1 week*
- *Estimated cost : US\$ 4000*
- *Shutdown time for customer process machines is not considered*

AIS VS GIS

Advantages using MV GIS in comparison to MV AIS Availability

AIS

- During maintenance period, the switchgear is out of service.*
- *Provisions for alternative supply routes must exist.*
 - *Switching over procedures need to be followed*
 - *After maintenance original conditions need to be established*

GIS

- GIS S/G is maintenance free*
- *No human errors can occur due to hermatically sealed isolation. Therefore peace of mind for customer will be ensured.*

ADVANTAGES OF GIS IN COMPARISON TO AIS

Following risks have to be taken into account by using AIS switchgear:

- *Switching failures*
- *Disturbances in the network may appear*
- *Human errors may occur due to left tools, loose connections, unscrewed bolts, unfixed covers etc. Therefore the risk of failures inside the switchgear (arc fault) is very high.*

ADVANTAGES OF GIS IN COMPARISON TO AIS

Environmental Aspects

AIS

- Influence of dust, humidity and vermin
- to all active parts as busbars, breakers,
- cable connections:
- Need of maintenance, sequence
- depending from environmental
- Influence
- • By high humidity hygrometer and
- or heaters in cable compartment is
- necessary. Therefore additional
- costs and control is necessary
- By vermin's, special measurements
- in building, cable compartments,
- switchgears, such as alarming,
- shielding etc. are necessary.

GIS

- No enviromental influence
- to maintenance free,
- Hermatically sealed S/G.
- Busbars are single pole
- gas insulated and
- probability of internal
- faults are substantially
- reduced and flash over
- between phases is not
- possible

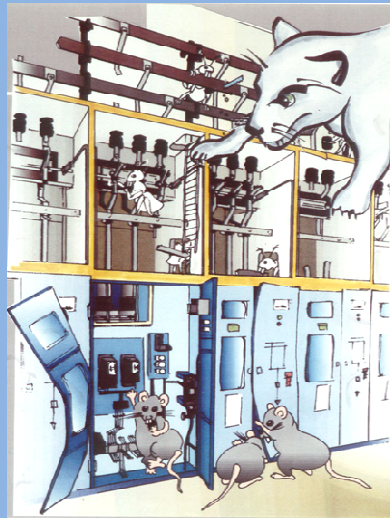
- No influence of insulation
- level. Peace of mind.

January 20, 2014 Sharif Ahmed
Senior Member IEEE

Page 1

Environmental Problems

- Dust?**
- Salt?**
- Moisture?**
- Corrosive gases?**
- Mice?**
- Rats?**
- Cats?**
- Squirrels?**
- Snakes?**
- Altitude?**



January 20, 2014 Sharif Ahmed
Senior Member IEEE

Page 1

ADVANTAGES OF GIS IN COMPARISON TO AIS

AIS

*Therefore additional costs and control is necessary.
Flash over between phases are possible and busbar differential protection may be required.
Influence of altitude:
With increase of the altitude, the insulating capacity of insulation in air decreases due to the decreasing air density. Depending on the altitude a correction factor has to be taken into account.*

GIS

No influence of altitude on insulation level.

ADVANTAGES OF GIS IN COMPARISON TO AIS

Spare Parts

AIS

*For an estimated live time of 30 years the following spares have to be taken therefore
Into account by using AIS technology:
Lubricants, screws, bolts, nuts, contact fingers for draw out unit
Isolators, bushings
Therefore additional cost for spares and storage room will arise for the customer.
Further more staff for exchange the parts have to be provided.*

GIS

*No spares for high voltage portion are required
no additional cost for spares & storage.*

Reliability

AIS

By using AIS switchgear, risks of failures due to human error, maintenance, environmental aspects and switching in network will appear.

GIS

None of the AIS mentioned risk factors will appear by using GIS equipment. Therefore GIS switchgear has a much more higher contrast to AIS Switchgear.

10 year life cycle cost for AIS versus GIS switchgear

Description	Frequency in 10 years (AIS)	Duration (days)/Qty	Cost	AIS	GIS
<i>*Indoor substation</i>				A	A+
<i>Arc Resistance</i>				B	0
<i>Real Estate</i>		40' X 18' vs. 21' X 10'	\$/sqf	C	C -
<i>Installation at site</i>		crane vs. forklift / manhours		D	D -
<i>Spare breaker</i>		1	\$	E	0
<i>Grounding Device</i>		1	\$	F	0
<i>Routine Maintenance Interval</i>	3	5	\$/hour	E	E -
<i>**Suits according to NFPA 70E</i>		5	\$	F	0
<i>Outage maintenance</i>	1	5	\$/hour	G	0
<i>Lost of production</i>			priceless	-	-
<i>No phase to phase fault</i>			priceless		
			Total:	H	H -25% cheaper

* Indoor Substation 27kV, 31.5kA, 1200A - Typical 10 section lineup with 2 mains, 1 tie, and 7 feeder breakers

** Arc flash suits required when racking non-arc resistance equipment above 1000 volts

Customer Benefits

- **Environmental Independence**
- **Compactness**
- **Maintenance-free Design**
- **Personal Safety**
- **Security of Operation, Reliability**
- **Economy, Ecology**

January 20, 2014 Sharif Ahmed
Senior Member IEEE

Page 1

General Information

The gas-insulated switchgear is for application in nearly all branches like:-

Airports & Ports	Automotive	
Buildings		
Cement Industries	Chemicals & Pharma	Contractors
Food & Beverage	General Industries	Mining
Offshore Industries	Oil & Gas	Paper Industries
Semicondor	Steel & Aluminium Industries	Utilities
Transportation & Railway	Water	Windfarms

January 20, 2014 Sharif Ahmed
Senior Member IEEE

Page 1

GIS is used in the following Industry



Steel and Aluminium Industry



Utilities



Oil - Offshore



Transportation Systems



Wind Farms Offshore



Mining



Transportation Systems

January 20, 2014 Sharif Ahmed
Senior Member IEEE

Page 1

GIS is used in the following Industry



Tourism & Hotels



Paper



Oil & Gas



Chemical



Food & Beverage



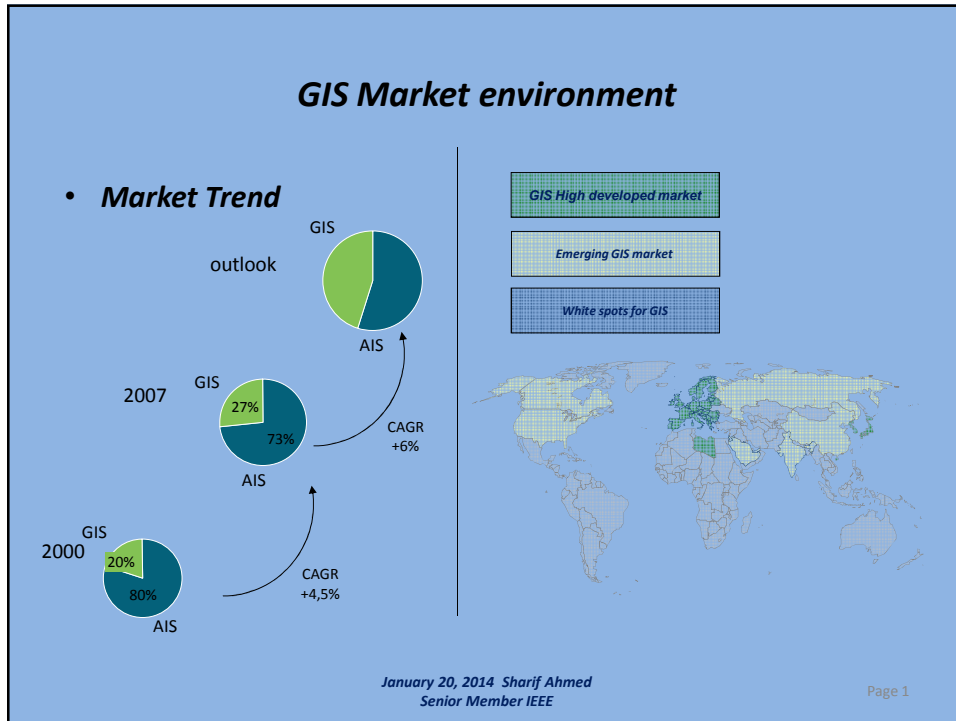
Airports & Airlines



Automotive

January 20, 2014 Sharif Ahmed
Senior Member IEEE

Page 1



Thanks

Thank you for your attention

Questions?

January 20, 2014 Sharif Ahmed
Senior Member IEEE

Page 1