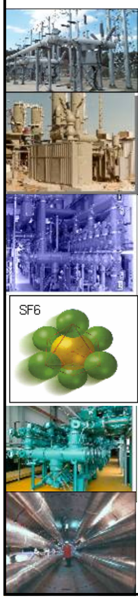

IEEE

Substations Committee
Subcommittee K0
Working Group K2
Module
Gas Insulated Transmission Line (GIL)
Basics

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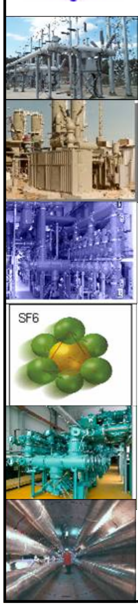

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GIL Basics

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GIL Basics

A Introduction to GIL

Introduction to GIL
420 kV Above Ground Installation

Cumulated Length 17 km - PP9 Saudi Arabia
Longest 420 kV GIL Installed in the World

Introduction to GIL
300 kV Tunnel Installation

System Length 1 km - Palexpo, Switzerland
Underground Part of a GIL/Overhead Line

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Introduction to GIL
GIL Units

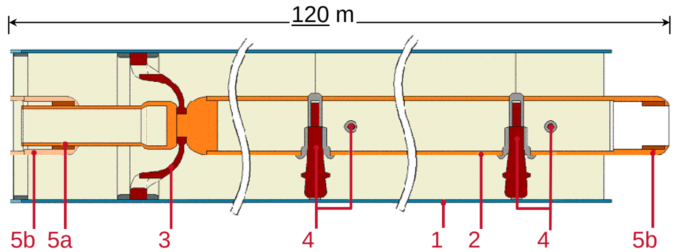
Only 4 GIL units are needed to build a transmission line:

- Straight unit
- Angle unit
- Disconnector unit
- Compensator unit

Introduction to GIL
Straight Unit

- Typical length of 120 m
- Bending radius down to 400 m

1 enclosure
2 inner conductor
3 conical insulator
4 support insulator
5a male sliding contact
5b female sliding contact



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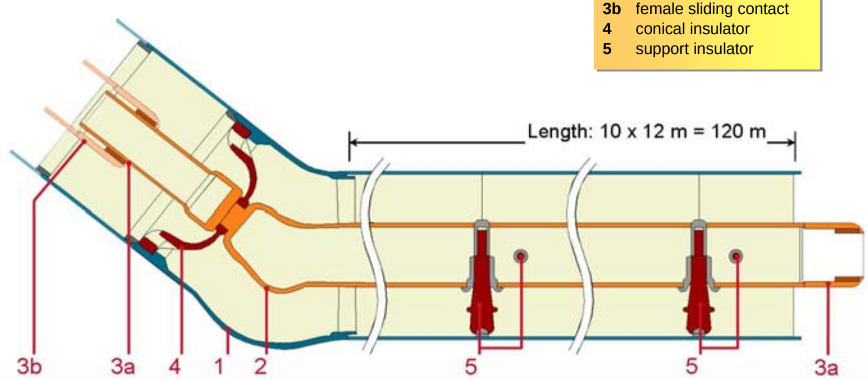
Introduction to GIL
Angle Unit

- For directional changes
- Flexible angle from 4° to 90°

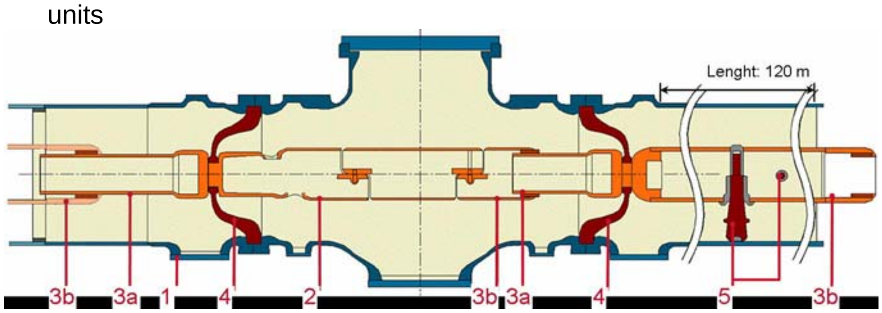
1 enclosure
2 inner conductor
3a male sliding contact
3b female sliding contact
4 conical insulator
5 support insulator



Introduction to GIL
Disconnector Unit

- Separation of gas compartments
- Connection point for sectional commissioning of the GIL
- Location of the decentralized monitoring units

1	enclosure
2	inner conductor
3a	male sliding contact
3b	female sliding contact
4	conical insulator
5	support insulator



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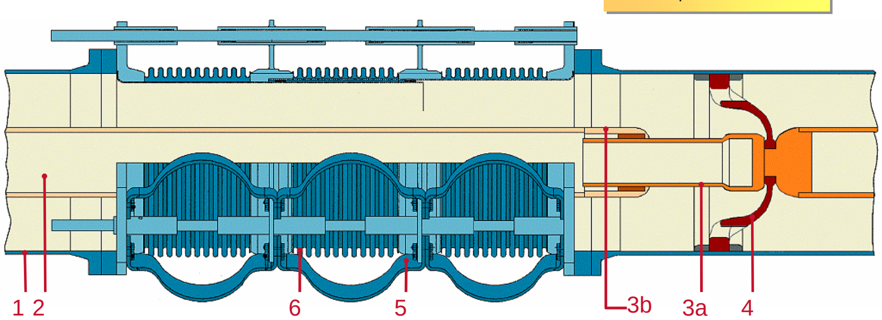
Introduction to GIL
Compensation Unit

- Compensation for the thermal expansion of the enclosure
- Flexible connectors are leading the current

1	enclosure
2	inner conductor
3a	male sliding contact
3b	female sliding contact
4	conical insulator
5	flexible connector
6	compensator bellow



Introduction to GIL
Advantages

- 30 years of experience with gas-insulated systems
- High reliability and high safety because of the metallic enclosure
- Low operating costs: resistive and capacitive
- Practically no ageing because of insulating gas
- Very low electromagnetic fields
- No external influence in the case of an internal failure (low fire risk)
- Operates like an overhead line, with autoreclosure

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Introduction to GIL
Cumulated Length of GIL World-wide

Ur kV	Cumulated length m
1200	420
800	1200
550	52.650
420	63.600
362	10.107
242/300	32.900
72/145/172	37.100
73 to 1200	198.000

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GIL Basics

B Design Features of GIL

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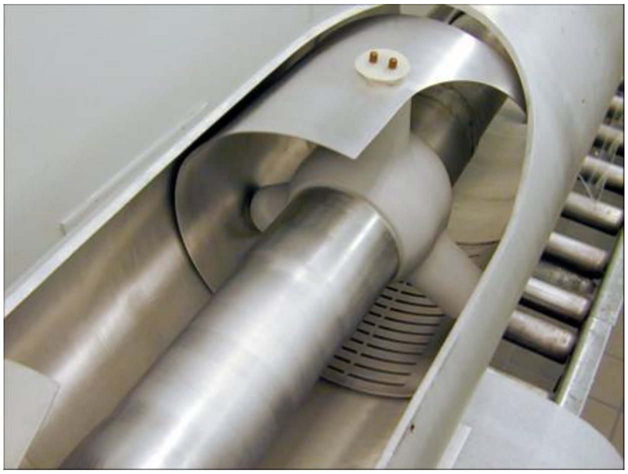
Design Features of GIL
GIS Tri-Post Support Insulator (Particle Trap)



Design Features of GIL
Four Examples

- **Low transmission losses and investment costs**
- Low electromagnetic fields
- High quality automated welding
- No external impact due to internal failure.

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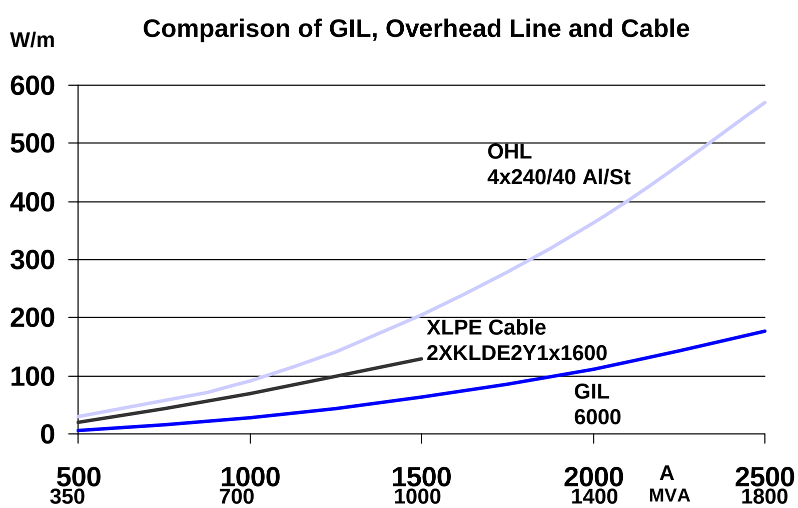
Design Features of GIL
Transmission Losses

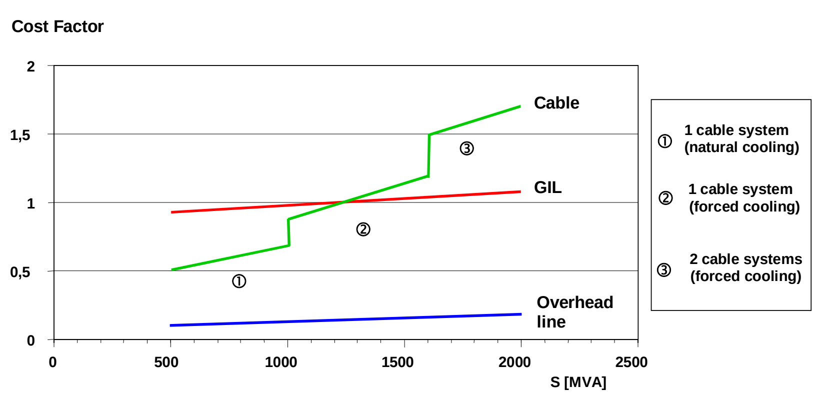


Design Features of GIL
Transmission Losses

Comparison of Overhead Line (OHL) with GIL
Cost of Losses

		OHL	GIL
Transmission power	**MW**	**1400**	**1400**
Losses per system meter	**W/m**	**580**	**180**
Losses per 32 system kilometer (20 miles)	**MW**	**18.56**	**5.76**
Difference between GIL and OHL	**MW**	**Δ 12.80**	
Additional Losses of the OHL per year	**USD**	**10,908,000.-**	
(Energy cost: $0.10/kWh x 8,600 h x 12,800 kW)			

Design Features of GIL
Cost Comparison of 420 kV Cable, OHL and GIL



Design Features of GIL
Example Two

- Low transmission losses
- **Low electromagnetic fields**
- High quality automated welding
- No external impact due to internal failure

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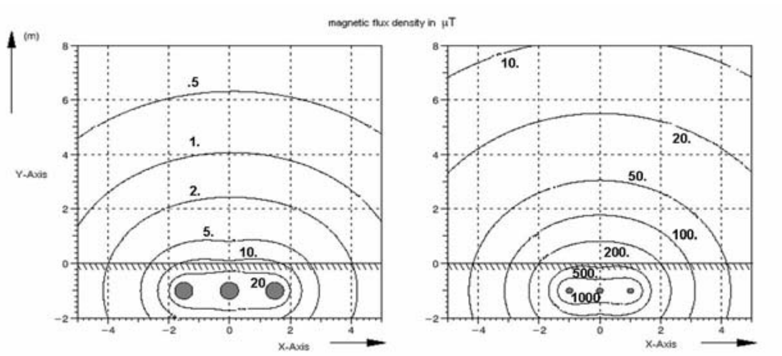
Design Features of GIL
Low Electromagnetic Fields

- Rated Current: 2500 A
  Magnetic Flux Density Calculated GIL and Cable



400 - kV - GIL compared to 400 kV - cable (cross-bonding)
magnetic flux density at a rated current of 2500 A

Design Features of GIL
Example Three

- Low transmission losses combined with low electro-magnetic fields
- Low electromagnetic fields
- **High quality automated welding**
- No external impact due to internal failure

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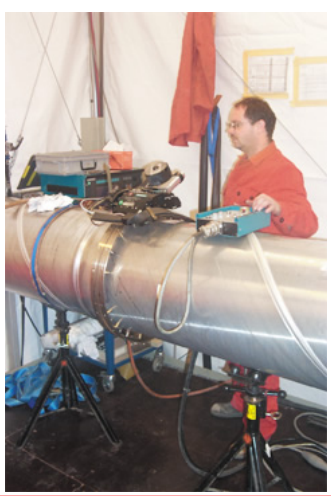
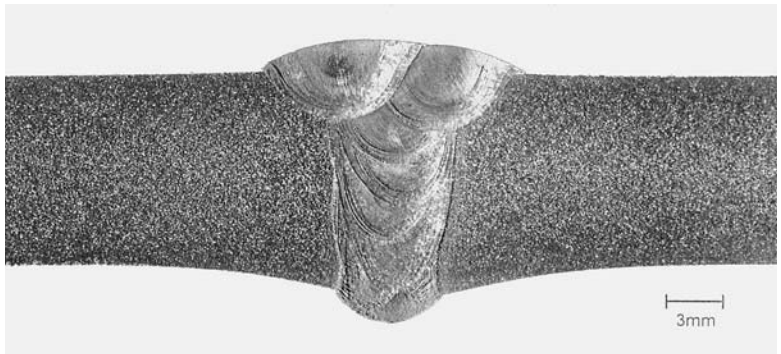
Design Features of GIL
High Quality Automated Welding



Design Features of GIL
High Quality Automated Welding

Microscopic View of the Weld



Design Features of GIL
Example Four

- Low transmission losses combined with low electro-magnetic fields
- Low electromagnetic fields
- High quality automated welding
- **No external impact due to internal failure**

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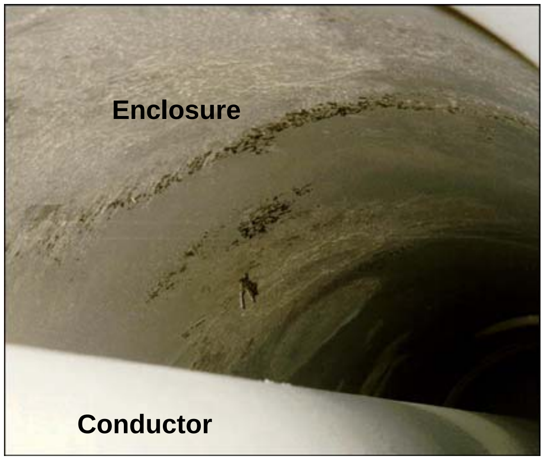
Design Features of GIL
No External Impact Due to Internal Failure

View inside the GIL. Test Conditions: 63 kA, 500 ms



- No external impact
- Low pressure increase
- Operation similar to over head lines

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Contents
GIL Basics

C Development and Manufacturing

Development and Manufacturing
Steps of Development

More than 40 years of experience in gas insulated technology

- 1960 : Start of fundamental studies in research and development of SF_6-technology
- 1968 : Delivery of first GIS
- 1974 : Delivery of first 420 kV GIL
- 1976 : Delivery of first Directly Buried GIL
- 1985 : Delivery of 550 KV and 8000 A High Power GIL
- 2001 : First Gasmixture GIL of 300 kV installed in Geneva, Switzerland
- 2007 : Delivery of first 800 kV, 4000 A GIL

more than 190 km in more than 100 projects installed world-wide

more than 5700 km-years of operation

Development and Manufacturing
High Voltage Test – 420 kV/3150 A GIL

Development and Manufacturing
Short Circuit Current Test – 63 kA

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GIL Basics

D Typical GIL Layout

Typical GIL Layout
Arrangement in a Tunnel

Two Three Phase Systems
U_N = 420/550 kV
I_N = 3150 A
Tunnel Diameter 3 m

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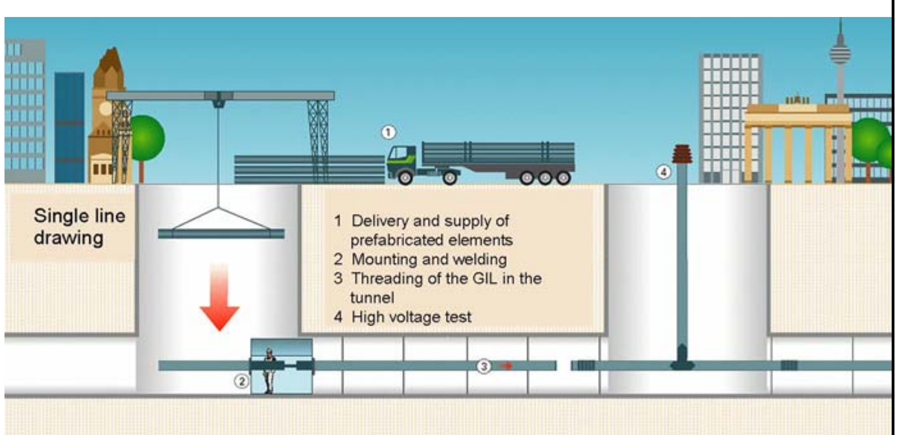
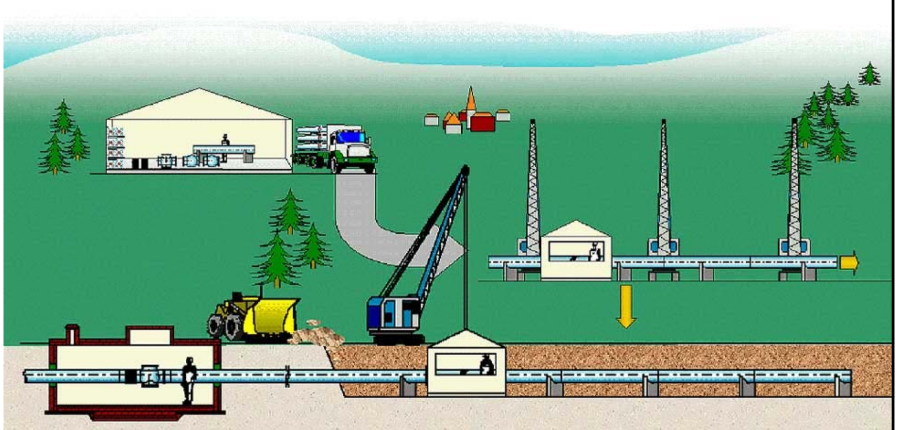
Typical GIL Layout
Principle Tunnel Laying Process



Typical LayoutDirectly Buried (3)

Orbital Welding and Backfill in the Trench

Typical GIL Layout
Principle Tunnel Laying Process



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E Testing

Testing
High Voltage Testing

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GIL Basics

F Installation

Installation and Commissioning
Shipping and Transportation

Delivery Transport Units

Installation and Commissioning
Sequences of Erection

Contact System Connection

Corrosion protection on enclosure. Note no special protection from dirt trench or weather conditions during assembly.

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Installation and Commissioning
Sequences of Erection

Shaft Welding Tent in the Tunnel

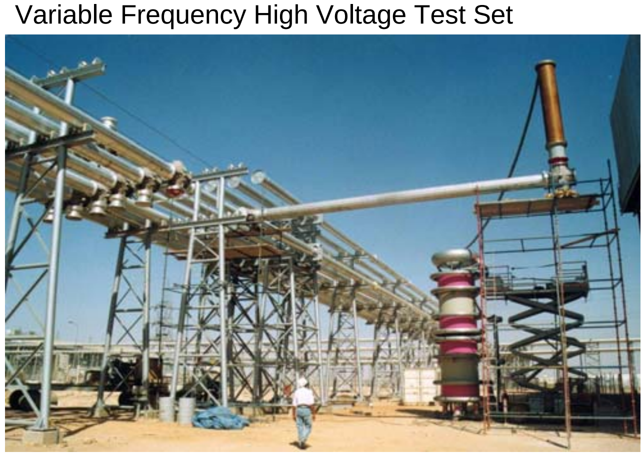
Installation and Commissioning
Sequences of Erection

Flange Connection

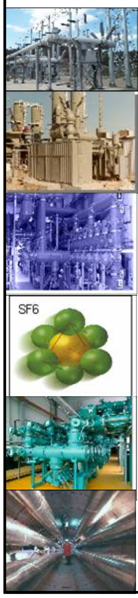
- No special tools required
- No extensive protection from weather or dirt required
- Assembly is complete in about 15 minutes

Installation and Commissioning
On-Site Testing

Variable Frequency High Voltage Test Set



Designed to test long lengths of GIL and short lengths of conventional cable.



Thank you for your attention

for

the GIL Basics Module.