

# Gas-insulated switchgear (GIS)

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Asset Policy

# Gas-insulated switchgear

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- ◆ 'Metal-enclosed switchgear in which the insulation is obtained, at least partly, by an insulating gas other than air at atmospheric pressure' (IEC 60050 (441))

# Benefits of GIS

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- ◆ Compact size:
  - ◆ May be built closer to load centres
  - ◆ Replacement/extension within existing substation boundaries
  - ◆ Low visual impact – easily screened, may be housed within building of appropriate style
- ◆ Immunity to pollution:
  - ◆ Low number of exposed insulators
  - ◆ May be sited in exposed coastal areas or near sources of industrial pollution

# Substation Primary Insulation

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National Grid policy is:

- ◆ ‘Outdoor Air Insulated switchgear will be used at pollution severity Class III (or less) sites, except where other elements of this policy are overriding.’
- ◆ ‘Gas Insulated Switchgear (GIS) substations shall only be considered where lifetime related conditions (such as pollution, permanent space restriction or public visual amenity) preclude the use of open terminal equipment and the terms of this policy are met.’

# Why does National Grid install GIS substations?

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- ◆ Historically substations were AIS as this was the only available technology.
- ◆ However, this resulted in a number of difficulties
  - ◆ Pollution when in close proximity to industrial or coastal
  - ◆ Insufficient space for AIS when constructing new substations/extensions (e.g. inner cities)
  - ◆ Planning laws for National Parks, AONBs and Green Belts only permit AIS substations where there is 'no demonstrable alternative'.









# Considerations for GIS compared to AIS

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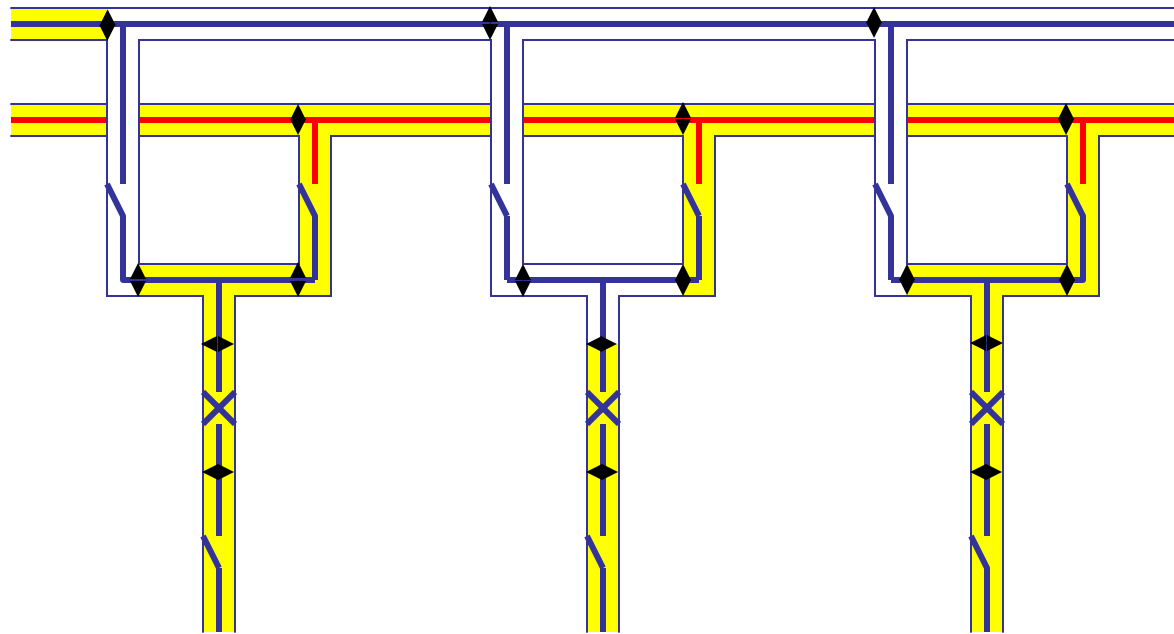
- ◆ GIS designers need to take into account the following:
  - ◆ Extension involves using equipment of the same type or special adapters
  - ◆ Possible requirement for future extension

# Considerations for GIS compared to AIS

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- ◆ Isolation gas density dependent
- ◆ Availability of adjacent circuits
- ◆ Safety issues limiting work adjacent to pressurised gas compartment partitions
- ◆ Leads to partitioning of GIS into gas compartments

# Impact of partitioning on availability



— circuit in service

— circuit out of service

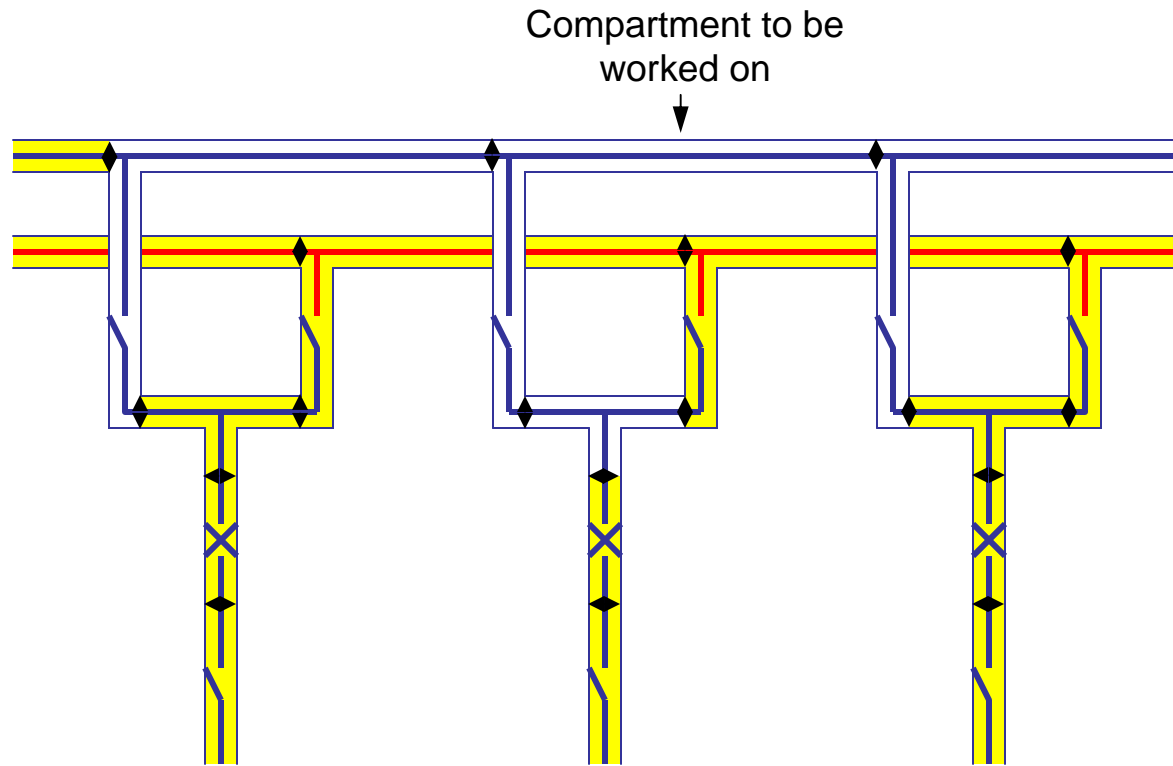
— Gas compartment at filling pressure

— Gas compartment at atmospheric pressure

Gas compartment at filling pressure

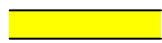
Gas compartment at atmospheric pressure

# Impact of partitioning on availability

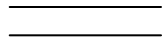


— circuit in service

— circuit out of service

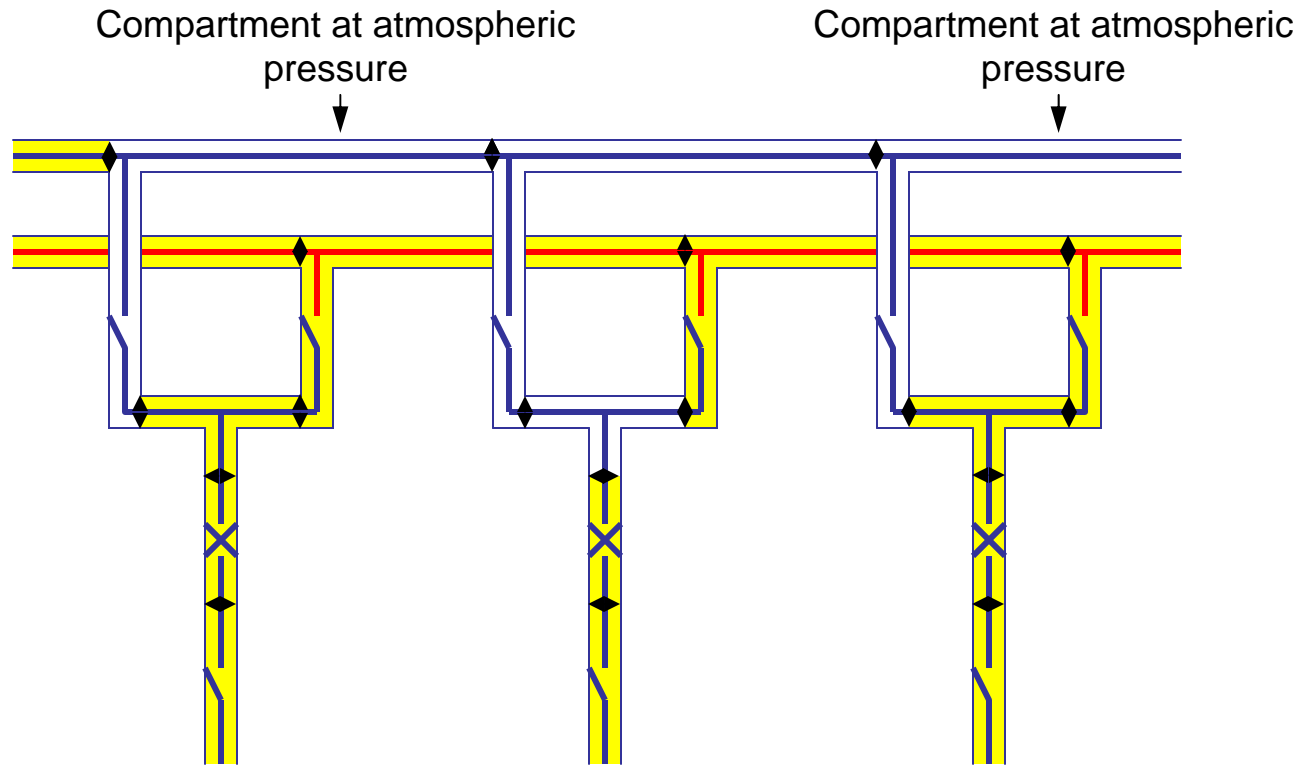


Gas compartment at filling pressure



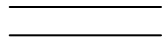
Gas compartment at atmospheric pressure

# Impact of partitioning on availability



— circuit in service

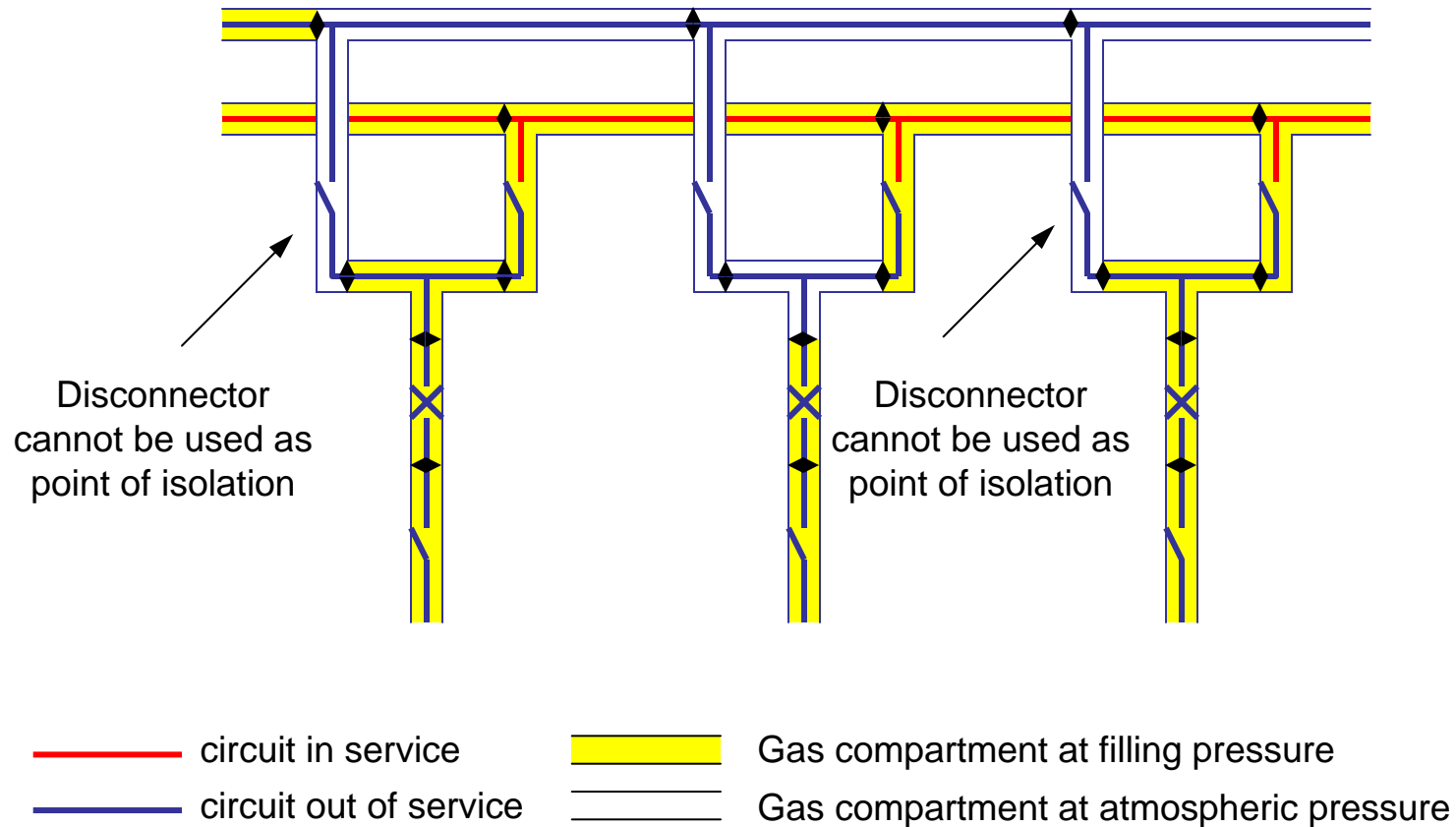
— circuit out of service



Gas compartment at filling pressure

Gas compartment at atmospheric pressure

# Impact of partitioning on availability



# Impact of partitioning on availability

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- ◆ This intervention would require 3 circuits to be out of service simultaneously
- ◆ Such a design would not be acceptable to National Grid

# Impact of partitioning on availability

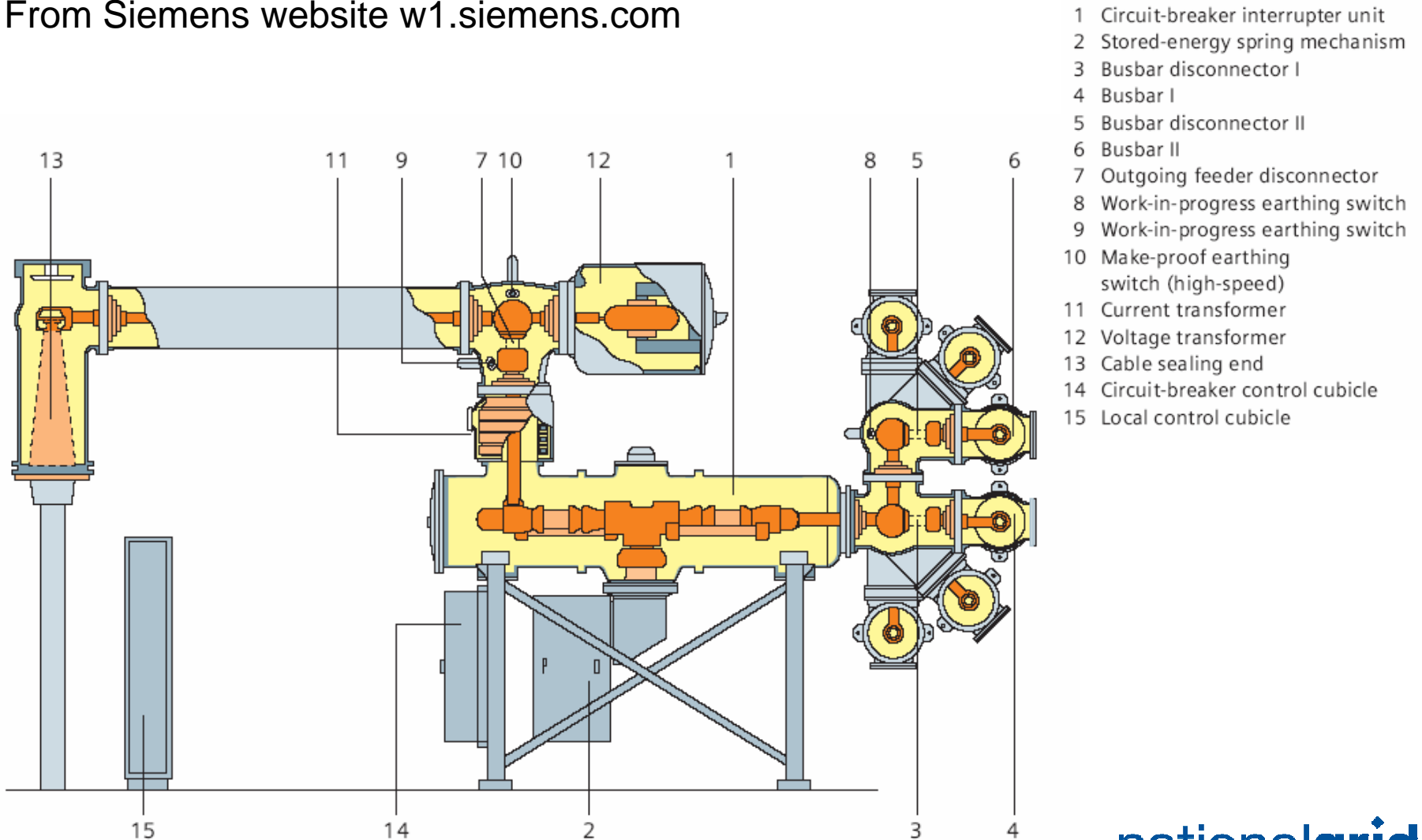
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Technical specification for Substations:

- ◆ 'The design of a substation shall permit installation, extension, operation and maintenance (preventive and corrective) with a maximum of one circuit (including any circuit requiring intervention) and one section of busbar out of service simultaneously.'

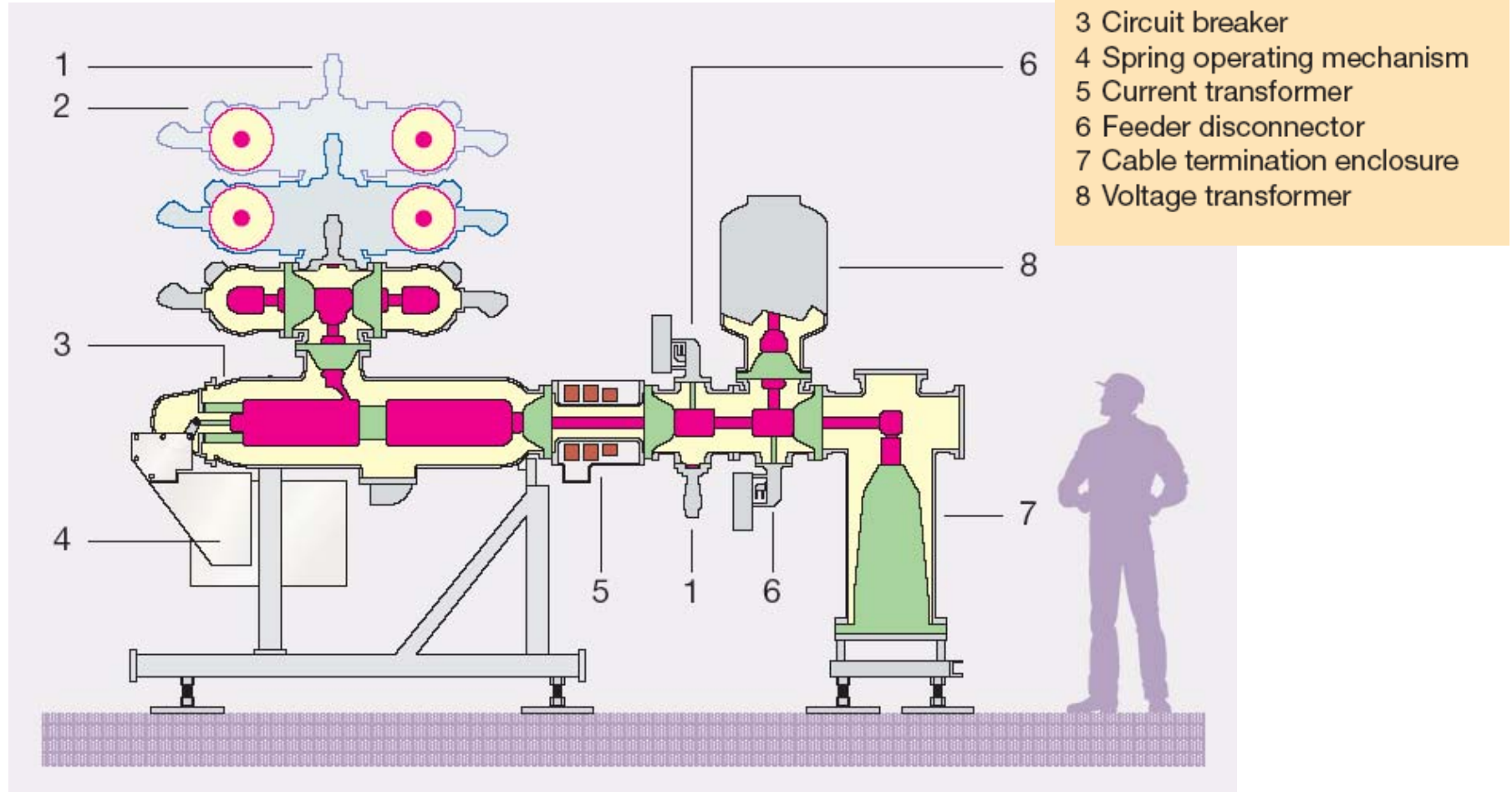
# Design and construction of GIS

From Siemens website w1.siemens.com



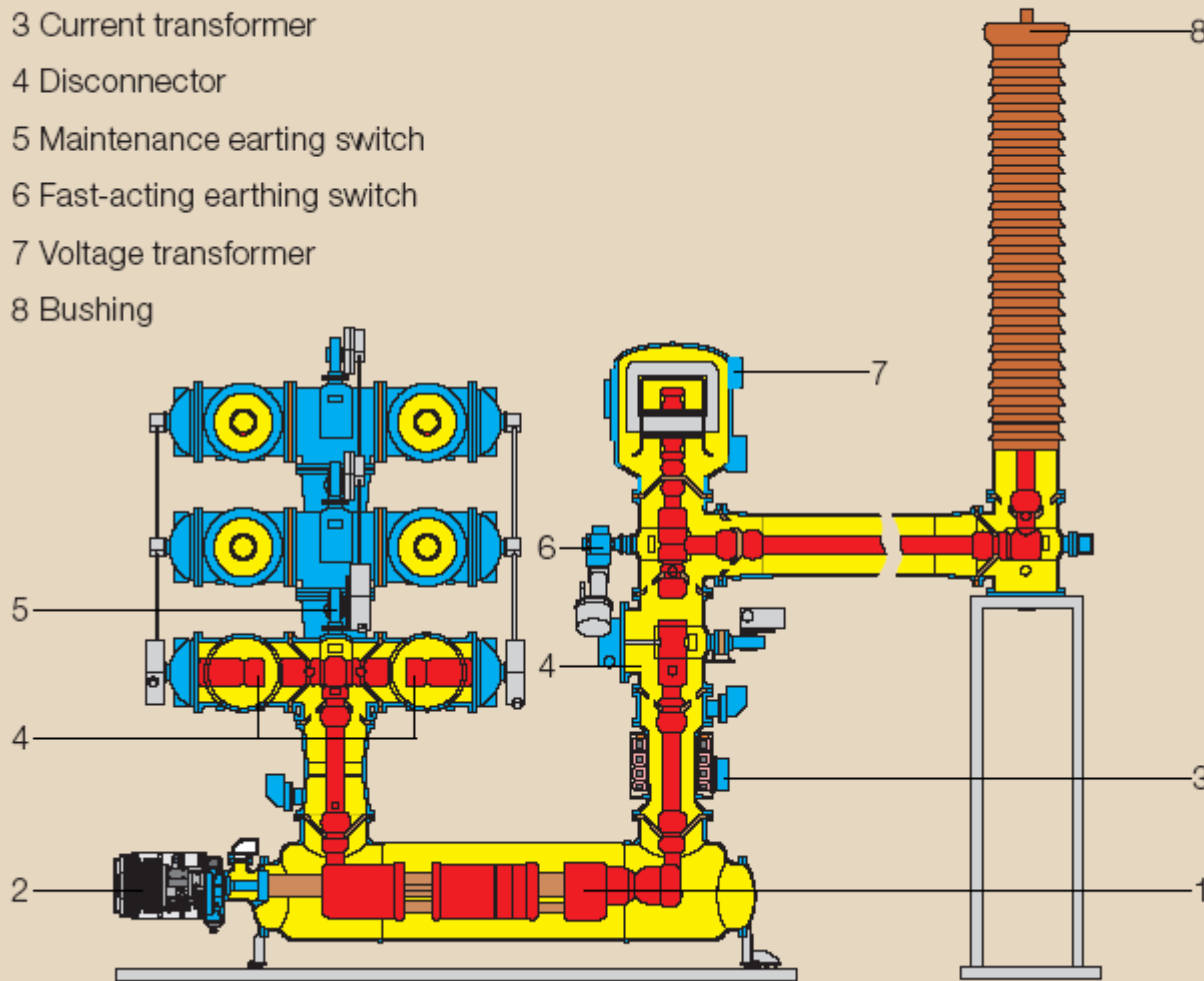
# Design and construction of GIS

From Areva website [www.areva-td.com](http://www.areva-td.com)



# Design and construction of GIS

- 1 Circuit-breaker
- 2 Operating mechanism (circuit-breaker)
- 3 Current transformer
- 4 Disconnecter
- 5 Maintenance earthing switch
- 6 Fast-acting earthing switch
- 7 Voltage transformer
- 8 Bushing



From ABB website  
[www.abb.com](http://www.abb.com)

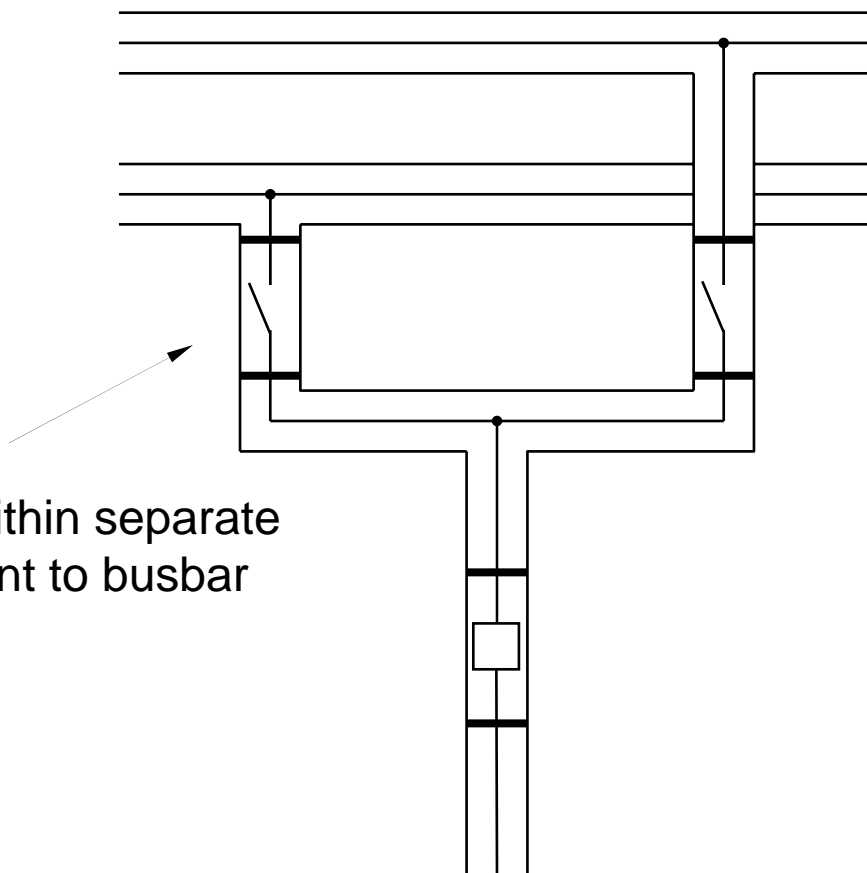
# Gas compartments and partitioning

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- ◆ Initially CEGB/National Grid procured equipment from British manufacturing base
- ◆ GIS designs incorporated bus selector disconnectors in separate gas compartments to the Main and Reserve Busbars
- ◆ Long busbar gas compartments

# Gas compartments and partitioning

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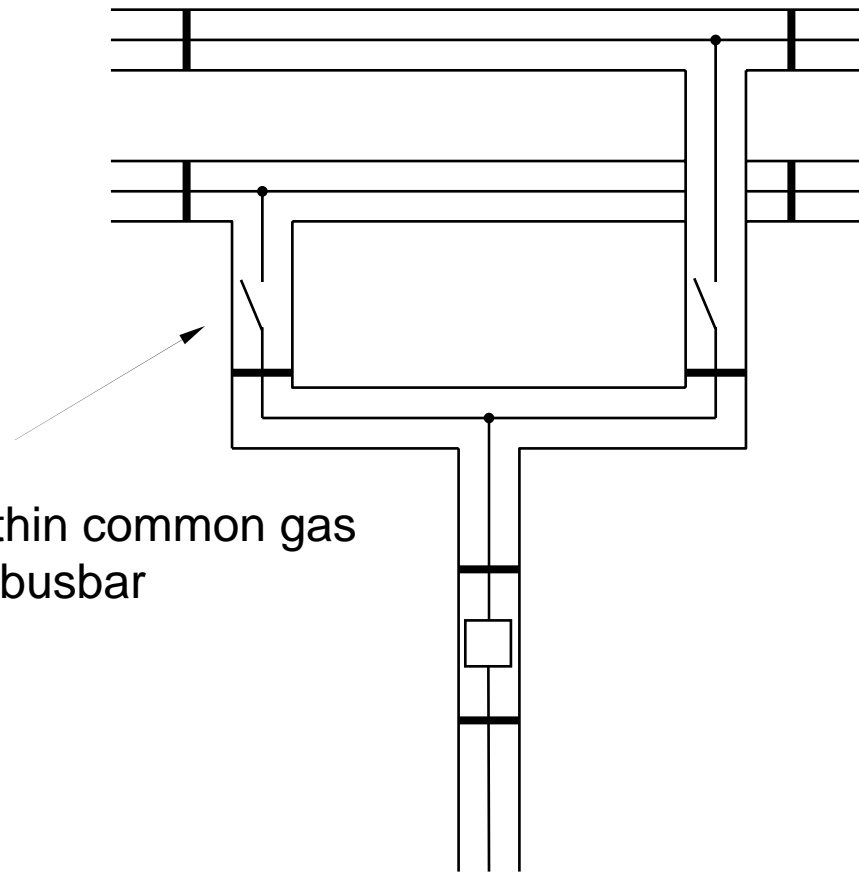
Disconnector within separate gas compartment to busbar

# Gas compartments and partitioning

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- ◆ Since the early 1990's National Grid has procured from a European wide manufacturing base
- ◆ Most European GIS designs incorporate bus selector disconnectors within Main and Reserve busbar gas compartments

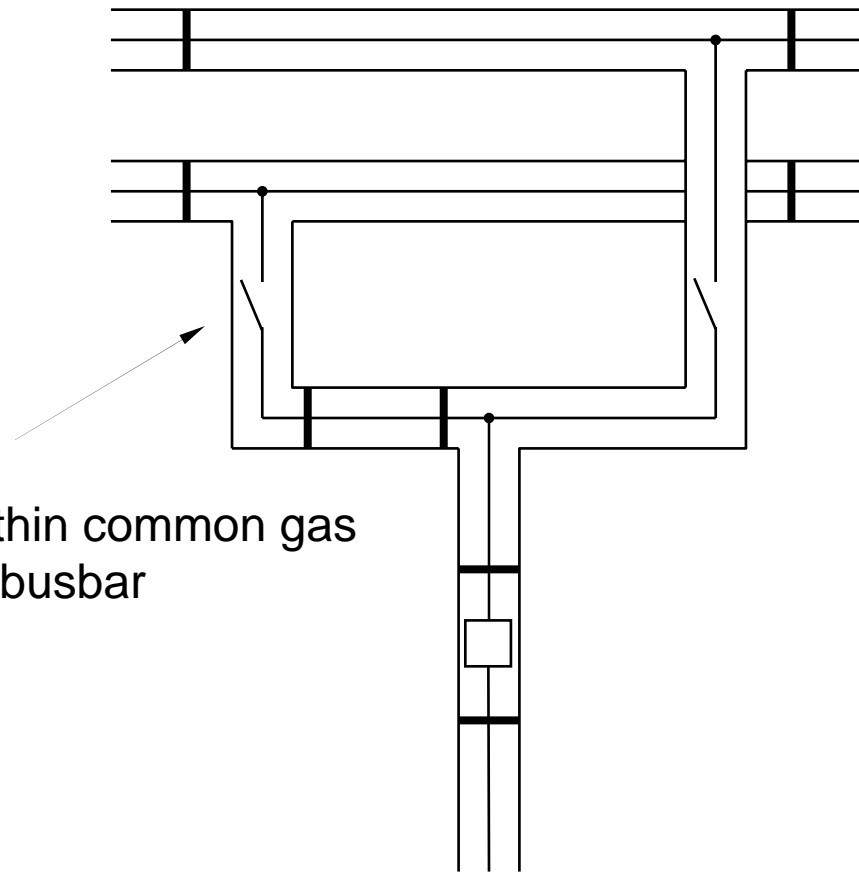
# Gas compartments and partitioning



Disconnecter within common gas compartment to busbar

ABB ELK-3

# Gas compartments and partitioning



Disconnecter within common gas compartment to busbar

Areva T155

# Maintenance (typical)

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## GIS general

- ◆ General condition of equipment, support structures, earthing connections
- ◆ Gas pressure/density level and trend
- ◆ Gas quality (HF/SO<sub>2</sub>, O<sub>2</sub>, H<sub>2</sub>O)
- ◆ Calibration of pressure/density gauge/transducer
- ◆ Alarm setting and operation

# Maintenance (typical)

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## Disconnectors and earthing switches

- ◆ Mechanism heater operation
- ◆ Number of operations
- ◆ Trial operations
- ◆ Motor operating time and current
- ◆ Operation of position indicating device
- ◆ Condition of auxiliary switches, wiring and connections
- ◆ Condition of linkages and gears, lubrication
- ◆ Operation of interlocks

# Maintenance (typical)

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## Circuit-breakers

- ◆ Number of operations
- ◆ Trial operations
- ◆ Contact timing/travel record
- ◆ Checks according to type of mechanism (spring/hydraulic/pneumatic)

# GIS service experience

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- ◆ CIGRE WG 23.02, 'Report on the Second International Survey on High Voltage Gas Insulated Substations (GIS) Service Experience', Ref. 150, February 2000
- ◆ Major failure rate for GIS 300-500 kV commissioned after 01/01/1985:
- ◆ 2.58 per 100 circuit-breaker bay years

# GIS service experience

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*'Major Failure – failure of a major component or element of the GIS which causes the lack of one or more of its fundamental functions. NOTE: A major failure will result in an immediate change in the system operating conditions, e.g. the protective equipment being required to remove the fault, or will result in the mandatory removal from service within 30 minutes for un-scheduled maintenance.'*

$$\text{Major failure rate} = \frac{\text{Number of major failures}}{\text{Sum of circuit-breaker bays x years in service}}$$

## Main component involved in failure, 300-500 kV

|                                    |       |
|------------------------------------|-------|
| Circuit-breaker or switch          | 27.3% |
| Disconnecter                       | 20.5% |
| Earthing switch                    | 0.6%  |
| CT                                 | 1.9%  |
| VT                                 | 4.3%  |
| Busbars                            | 6.2%  |
| Busducts and interconnecting parts | 24.2% |
| SF6/air bushing                    | 9.3%  |
| Cable box                          | 0.6%  |
| Transformer interface              | 2.5%  |
| Surge arrester                     | 1.9%  |
| Other                              | 0.6%  |

# Classification of symptoms, 300-500 kV

|                                      |       |
|--------------------------------------|-------|
| Breakdown between poles              | 1.9%  |
| Breakdown across open poles          | 1.9%  |
| Breakdown to earth, solid insulation | 25.8% |
| Breakdown to earth, gas insulation   | 36.5% |
| Failure to open on command           | 13.2% |
| Failure to carry current             | -     |
| Loss of mechanical function          | 0.6%  |
| Loss of SF6 gas                      | 4.4%  |
| Failure of pressure relief device    | -     |
| Enclosure burn through               | 1.3%  |
| Partial discharge                    | 1.9%  |
| Locking in open or closed position   | 2.5%  |
| Other                                | 10.0% |

# GIS service experience

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- ◆ CIGRE WG A3.06 is conducting a reliability survey of High Voltage equipment at present
- ◆ The survey covers circuit-breakers, disconnectors, earthing switches, instrument transformers and includes both AIS and GIS equipment
- ◆ The results are not yet published