II JORNADAS TÉCNICAS - ABB EN PERÚ | APRIL 6, 2017

Safety and availability in GIS

Service Continuity

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ABB

Agenda

ABB GIS

Safety and Availability in GIS

- GIS main differences with AIS. What is a gas compartment?
- Service Continuity
- International Standards

GIS designs for Service Continuity

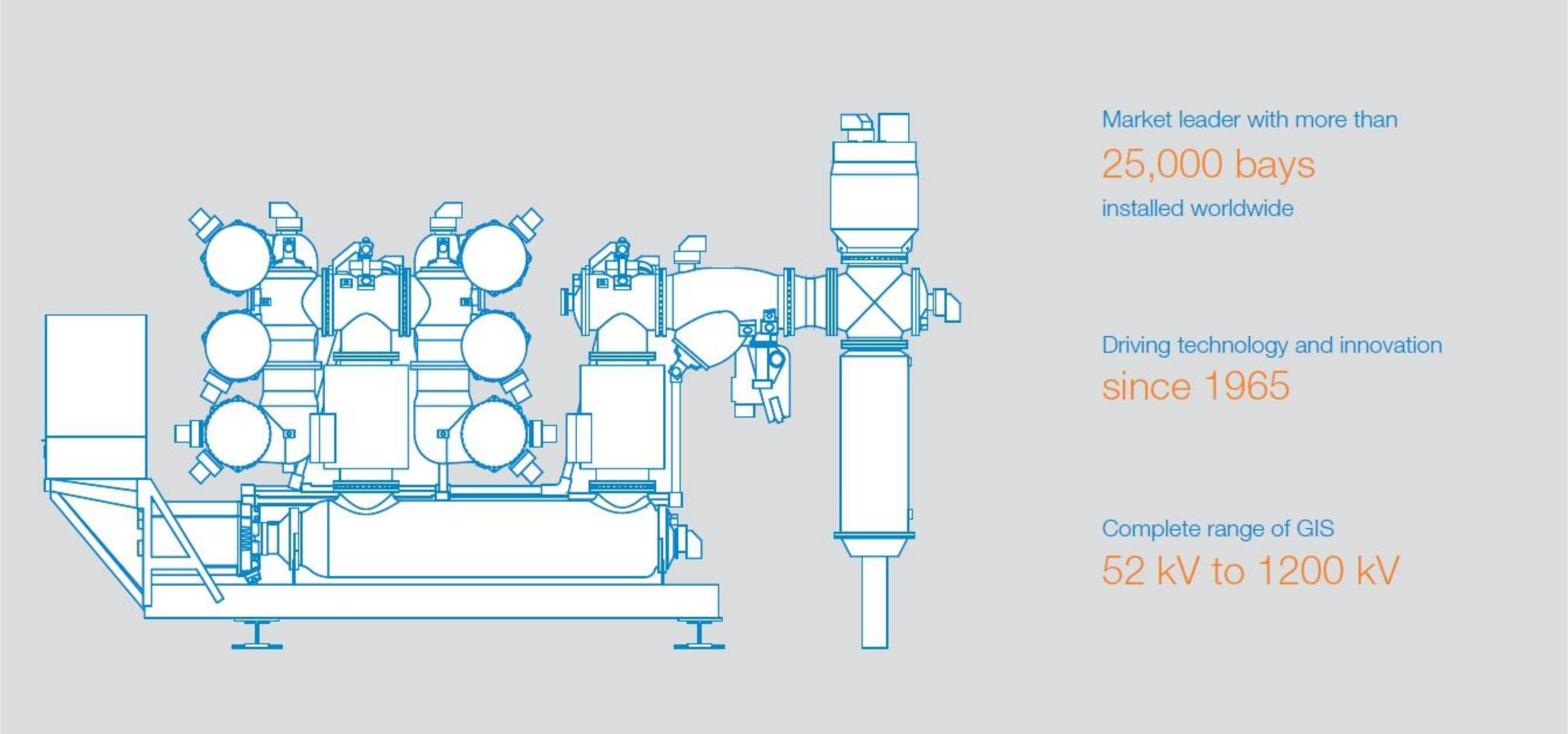
- ABB Solution: Service Continuity Concept
- ABB Solution: Repair cases
- Other solutions in the market

Conclusions

ABB GIS

ABB GIS

50 years of innovation



GIS ABB

Factory Network

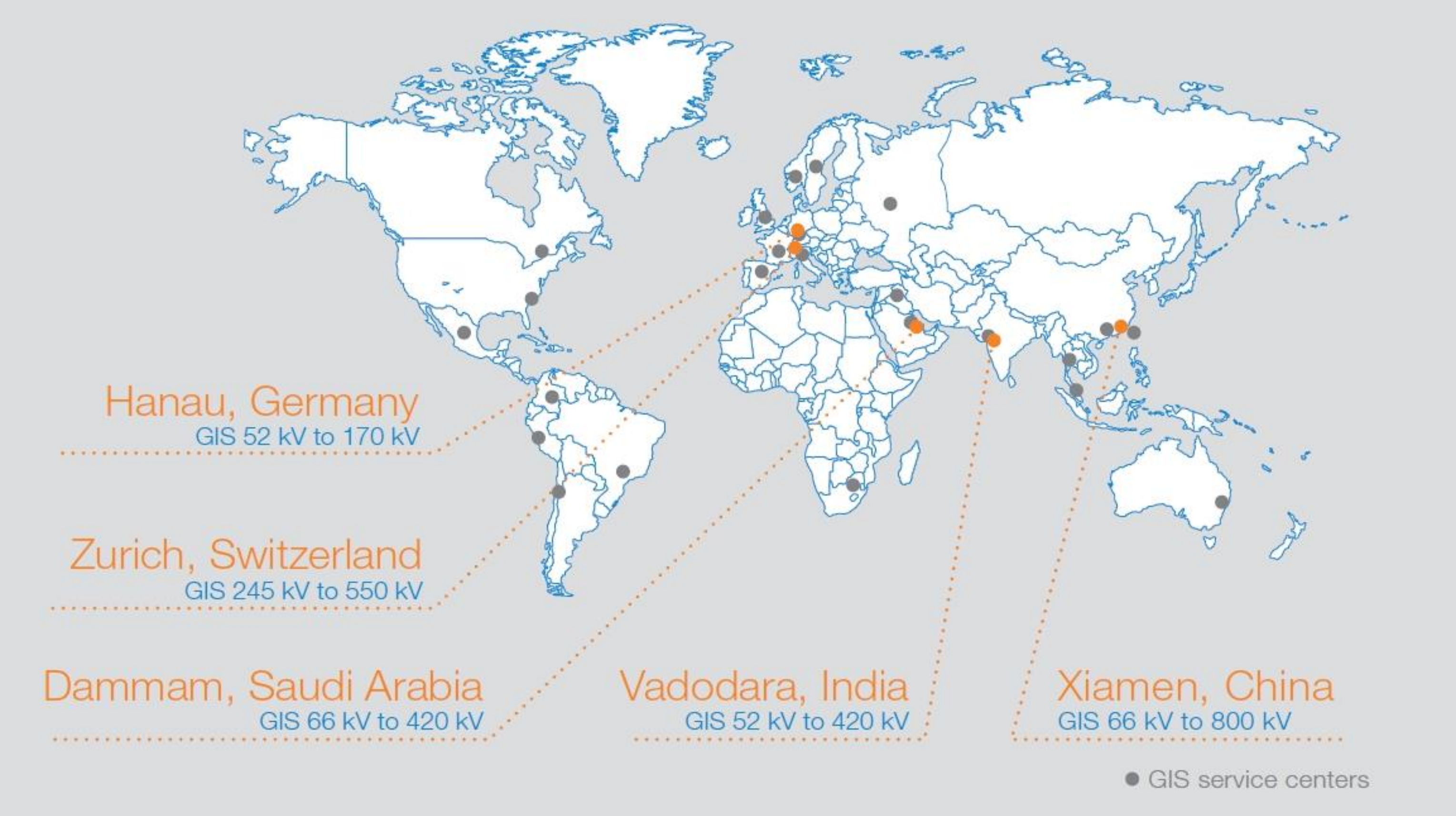


ABB GIS

A lot of «first time»

1967 – 170 kV GIS

1976 – 550 kV GIS

1987 – 800 kV GIS

1992 – 145 kV GIS in prefabricated housing

1997 – Most compact 123 kV GIS

2008 – Ultra high-voltage 1100 kV GIS substation

2009 – Largest urban substation

2012 – Ultra high-voltage 1200 kV GIS substation

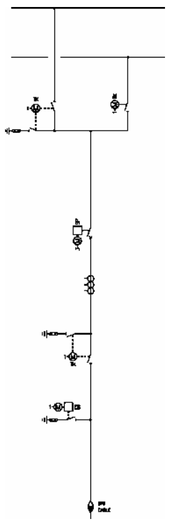
2013 – Compact 420 kV substation

2015 – Eco-GIS substation

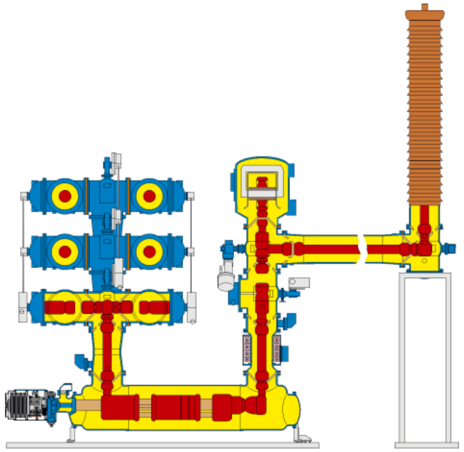
Safety and availability in GIS
GIS main differences with AIS
What is a gas compartment?

GIS main differences with AIS

What is a GIS?



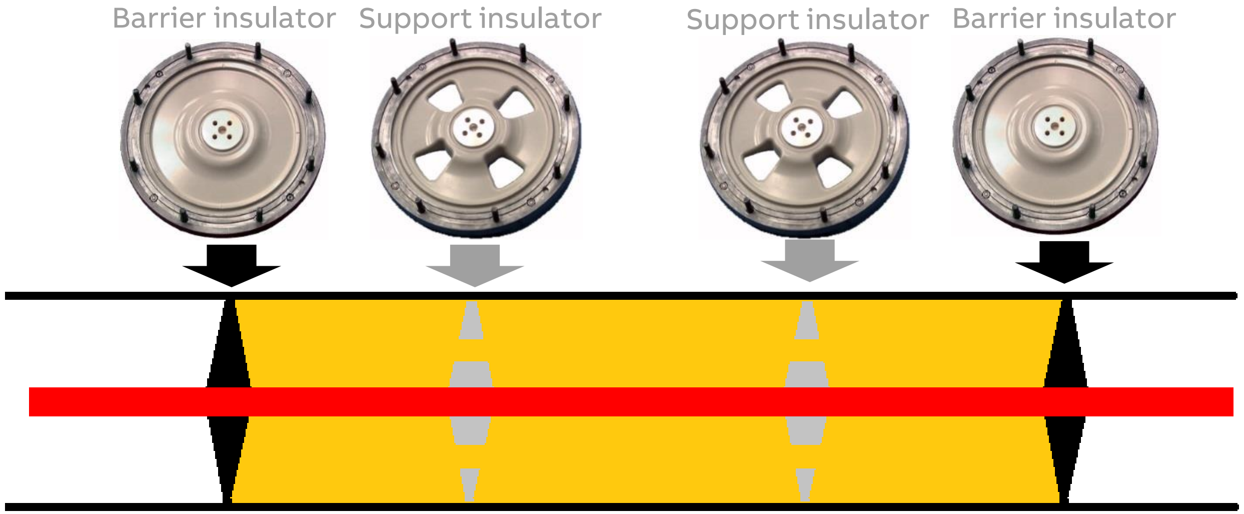
- Usual substation components arranged in
  - Metal enclosures (Aluminum or steel)
  - Insulated with gas (SF_6) at high pressure
  - Components which are segregated into independent gas zones for operational flexibility



- High reliable equipment and system
- **Assures availability during**
  - **Maintenance**
  - **Repair**

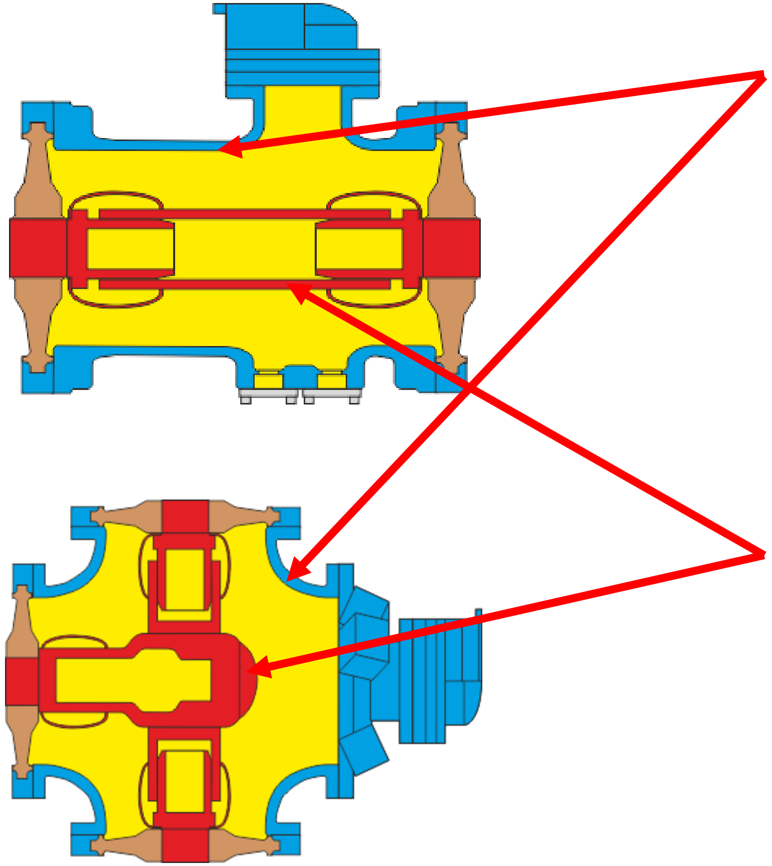
Gas compartment

Components



Gas compartment

Enclosure and conductor

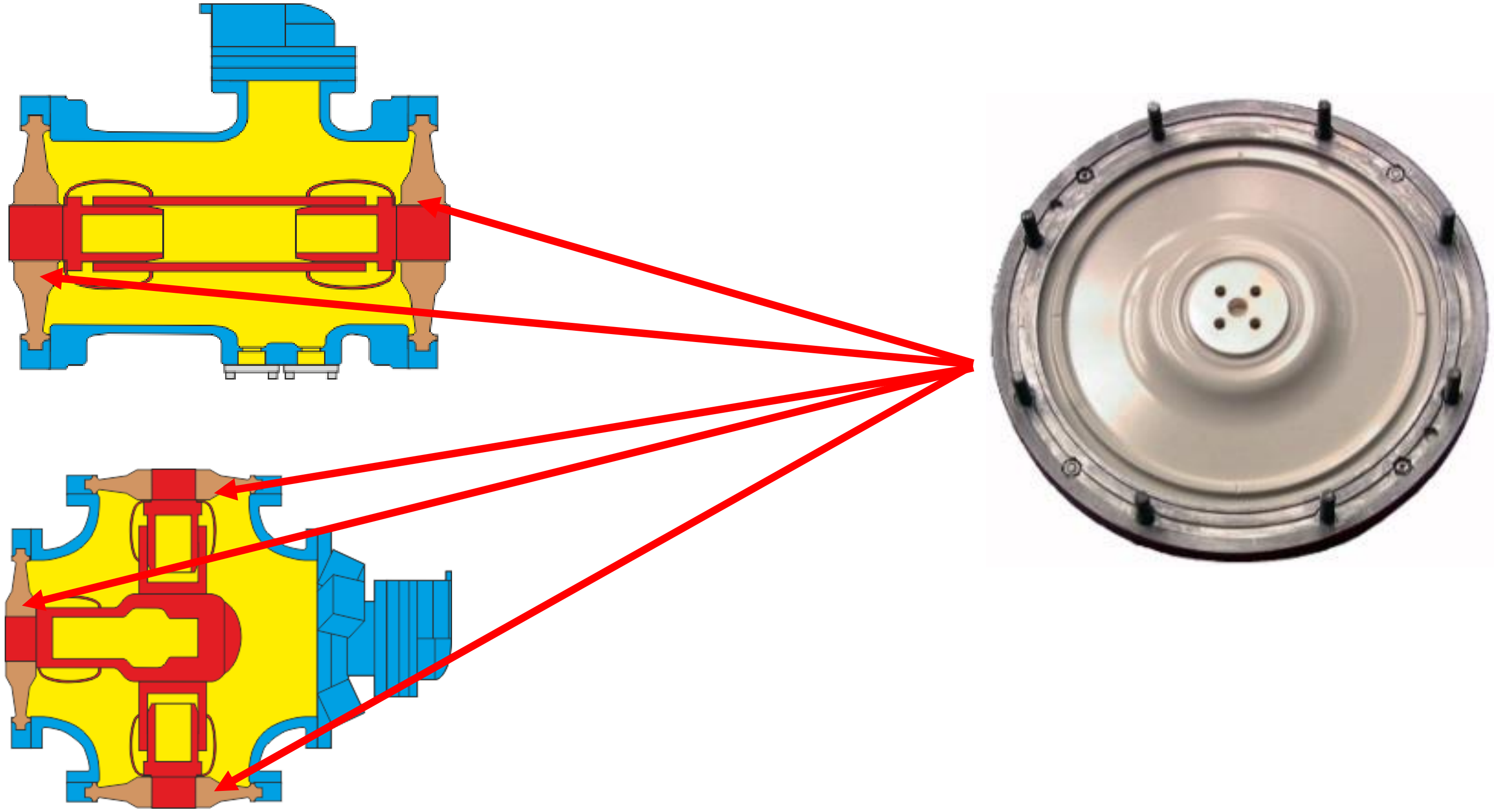


The enclosure can vary in length and shape, it’s form by an Aluminum casting

Aluminum (or copper) conductor

Gas compartment

Barrier Insulator



Gas compartment

Barrier Insulator

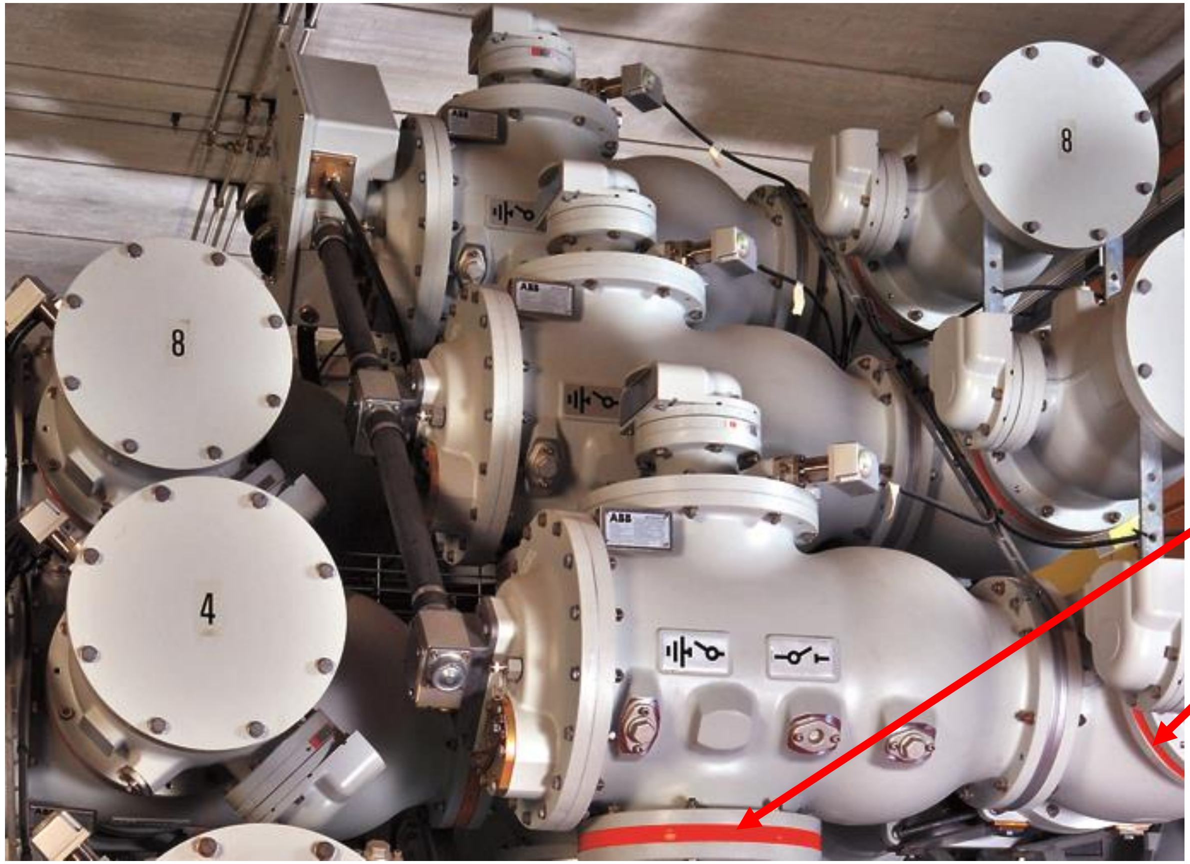
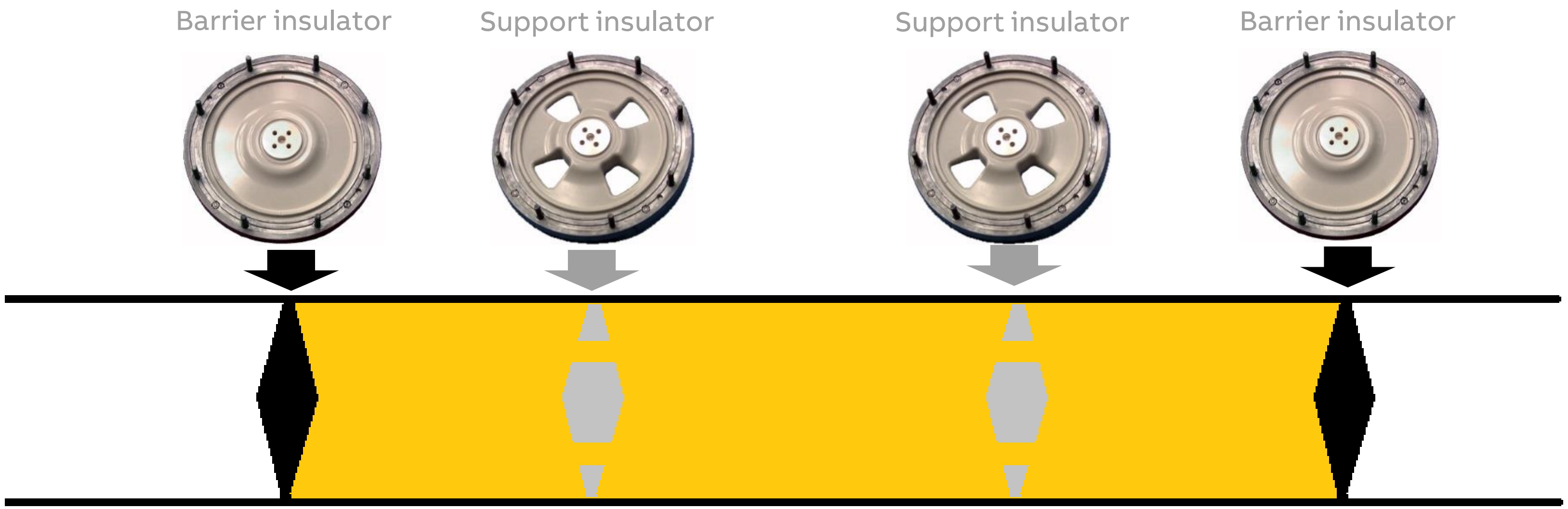


ABB clearly identify them with orange color

Gas compartment

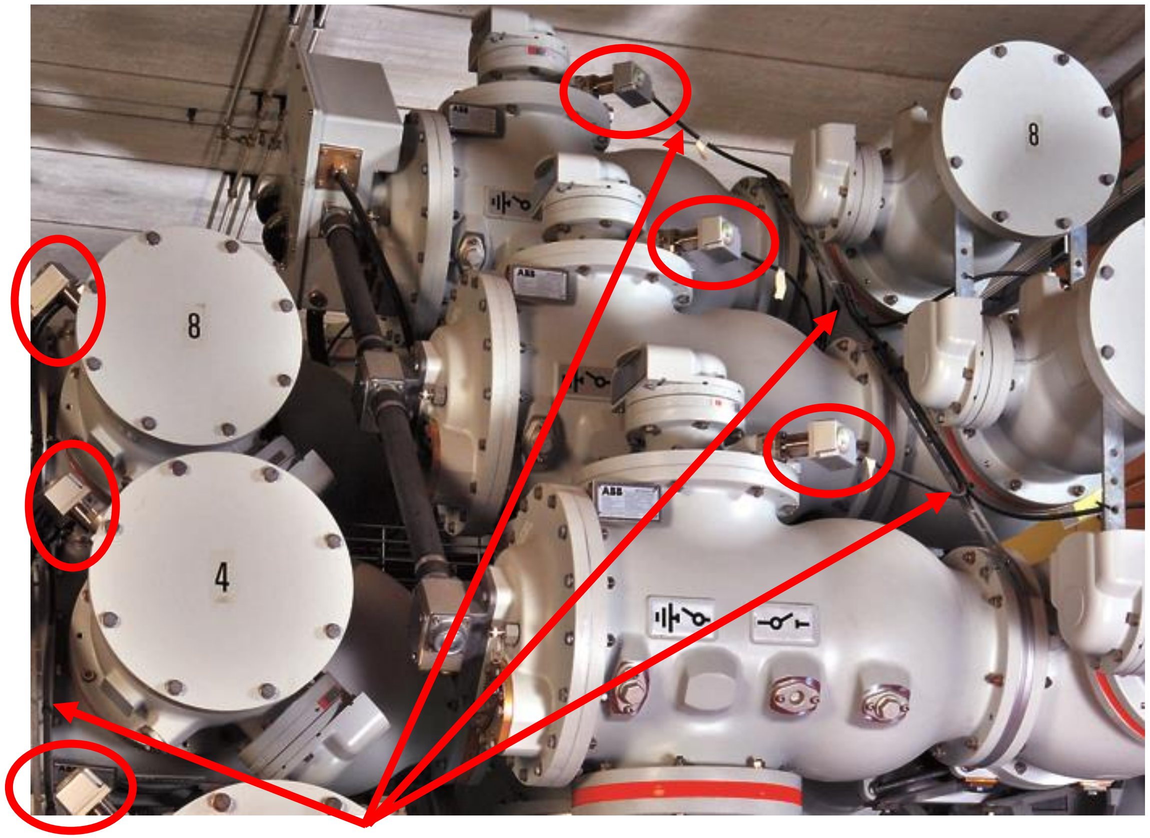
Support Insulator



- ABB's design of gas compartments at the busbar provides extra mechanical support by using support insulators in order to reduce mechanical stress and increase safety when maintenance or repair is performed

Gas compartment

Density Monitor

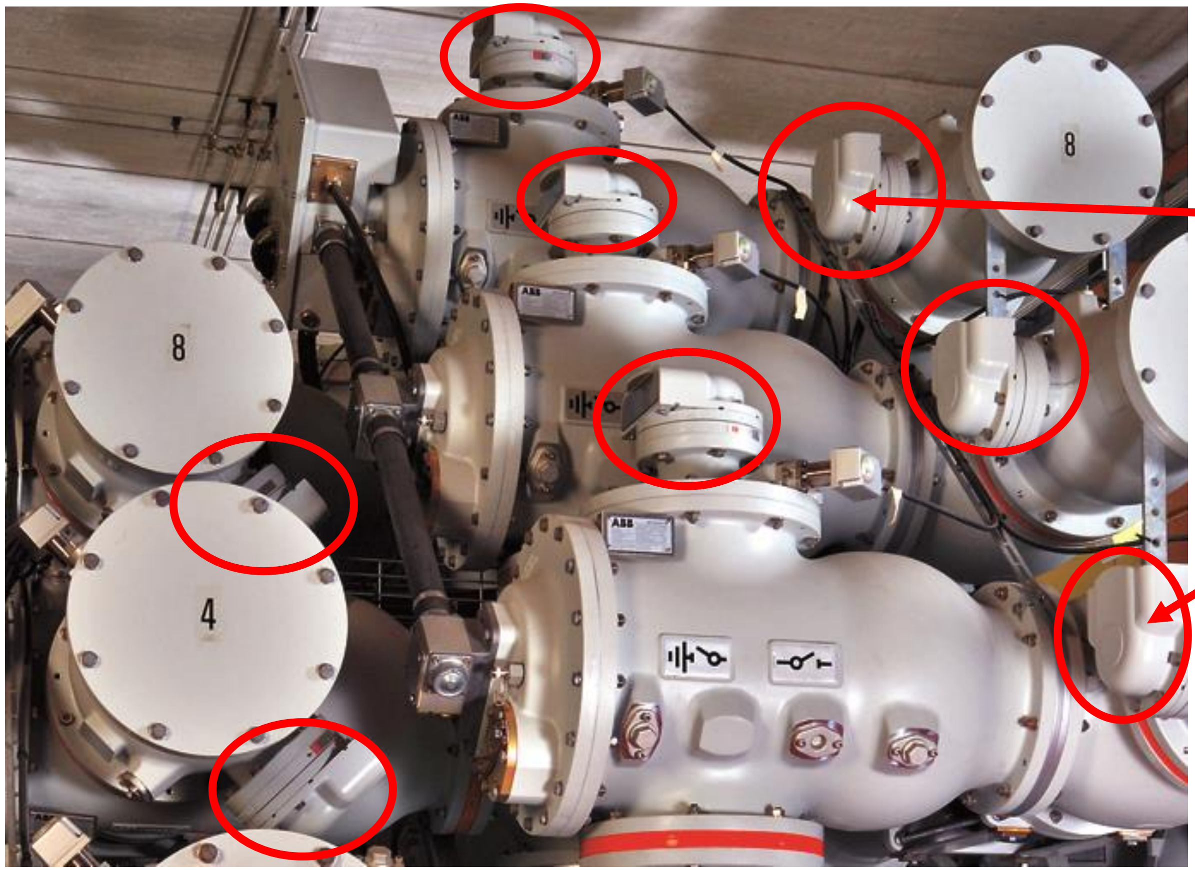


Note the cabling to the Local control cubicle

In every gas compartment (in every closed space between orange marks) you must find one. We only show some of them here

Gas compartment

Pressure relief device



In every gas compartment (in every closed space between orange marks) you must find one. We only show some of them here

Gas compartment

Valve

- Every gas compartment must have its own valve for the proper gas handling

Gas compartment

Absorber

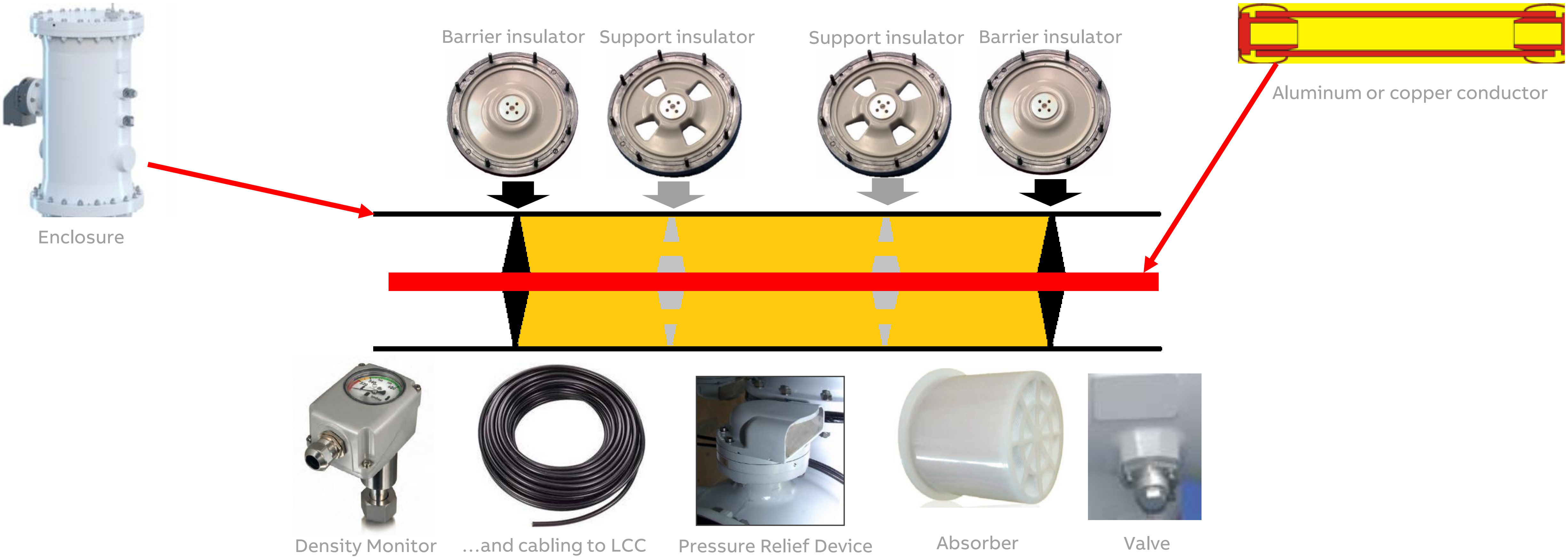
Adsorber (Circuit-breaker)

Adsorber (Other compartments)

- Each gas compartment is equipped with an absorber to remove moisture and decomposition products out of the gas
- Molecular sieve grade 5A is used as absorbing medium
- Easy access for exchange, if maintenance inside gas compartment required.

Gas compartment

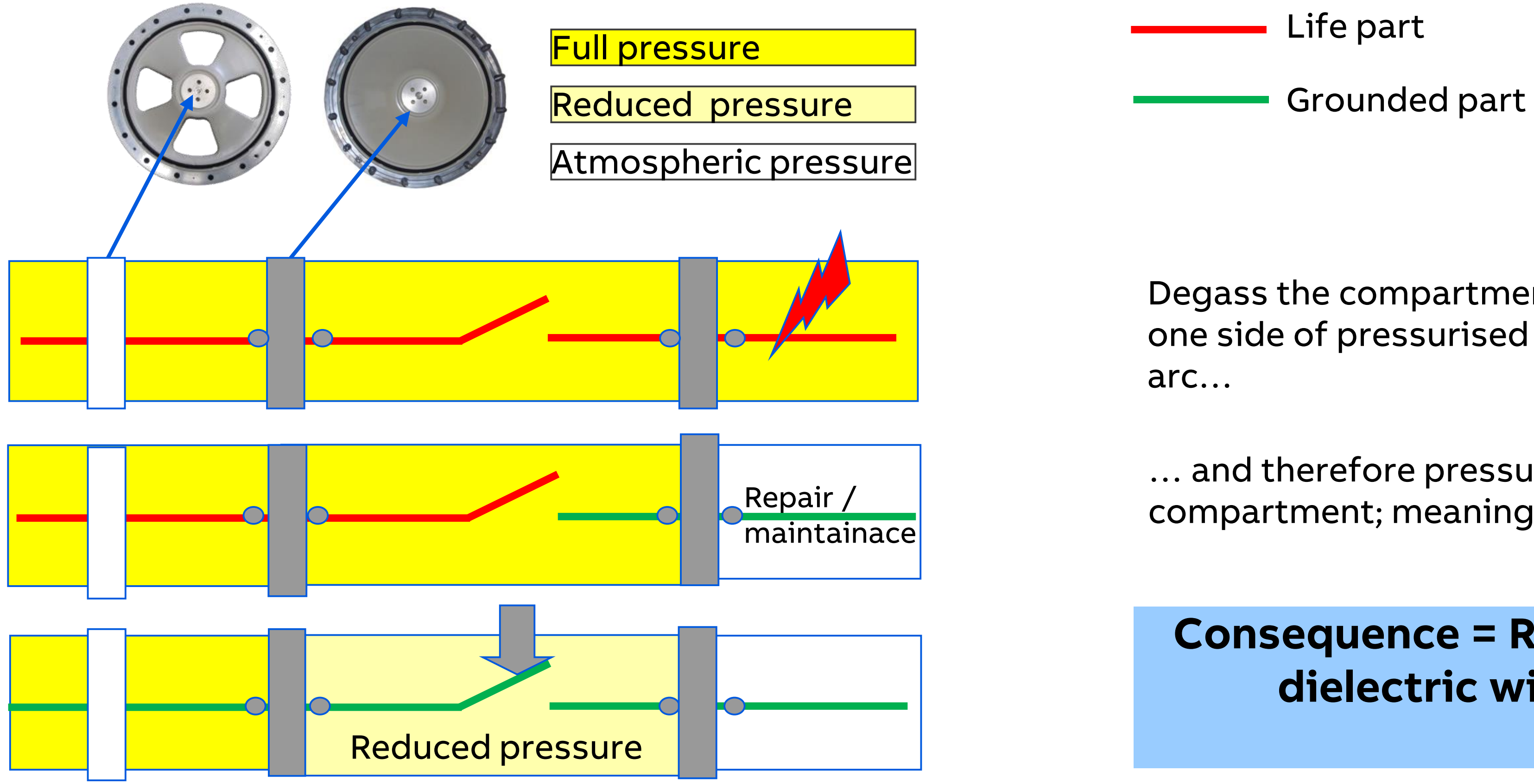
Components



Safety and availability in GIS Service Continuity

Service continuity

Safety rules have to be considered



Degass the compartment.. safety rules would prohibit working on one side of pressurised gas barrier which has been exposed to an arc…

… and therefore pressure will have to be reduced in the adjacent compartment; meaning…

Consequence = Reduced pressure means reduced dielectric withstand capability of the gas compartment…..

Service continuity

What happens if…

Q

M	a GIS gas compartment must be opened for maintenance
R	a GIS component must be repaired after a flashover
E	GIS is extended by a bay or more
T	part of the GIS must be tested with High-voltage on site

e.g.

…a GIS gas compartment must be opened for maintenance

- replacement of a CB interrupter due to wear
- replacement of a gas sealing system due to leakage
- replacement of a saturated humidity adsorbent

Service continuity

What happens if…

A

A part of the substation (or the entire substation) must be taken off line for Maintenance/ Repair/ Extension/ Test

The extend of the shutdown depends on … multiple factors.

Safety and availability in GIS International Standards

What IEC says about this?

Gas segregation and service continuity

IEC 62271-203 – ed 2.0, recommendations – Annex F


IEC 62271-203

Edition 2.0 2011-09

INTERNATIONAL STANDARD

NORME INTERNATIONALE

High-voltage switchgear and controlgear –
Part 203: Gas-insulated metal-enclosed switchgear for rated voltages above 52 kV

Appareillage à haute tension –
Partie 203: Appareillage sous enveloppe métallique à isolation gazeuse de tensions assignées supérieures à 52 kV

Background:

- Reliability of GIS is generally very good
- Maintenance and failures can cause long outages
- Bad experience with some GIS designs
- European users wanted to have recommendations in IEC standard regarding Service Continuity

Service continuity in GIS - Factors

IEC 62271-203 – ed 2.0, recommendations – Annex F

In order to achieve required service continuity the following factors may be considered among others:

Single line diagram	Single line diagram (number of busbars, sequence of feeders, number and position of disconnectors…)
Gas compartment	Gas compartment: partitioning, configuration and design, number of gas compartments, additional gas buffer compartments
Isolating link	Additional isolating links…
Physical arrangement of components	Physical arrangement of components
Facilities for dismantling	Facilities for dismantling
Design of partitions	Design of partitions: whether the design allows or disallows working in a compartment with the adjacent under full pressure. In addition working conditions and procedures are to be considered in order to avoid injuries to persons or damage to partitions.
Provisions for onsite dielectric testing	Provision for on-site dielectric test (GIS and interfaces)
Necessity of on-site dielectric testing	Necessity to carry out on-site dielectric tests after maintenance or repair
Provisions for future extensions	Provision for future extensions: buffer gas compartments, appropriate disconnect facilities for extensions without de-energization of complete GIS
Availability of spare parts	Availability of spare parts, tools and skilled staff

GIS partitioning

Annex F – Examples of Partitioning – Example 1

In some arrangements the two busbar-disconnectors are separated by only one partition. In Figure F.1. the removal of the gas compartment partition at 'A' may require both busbars of a double busbar substation to be de-energized, with the loss of all feeders on that section of busbar for the duration of the repair.

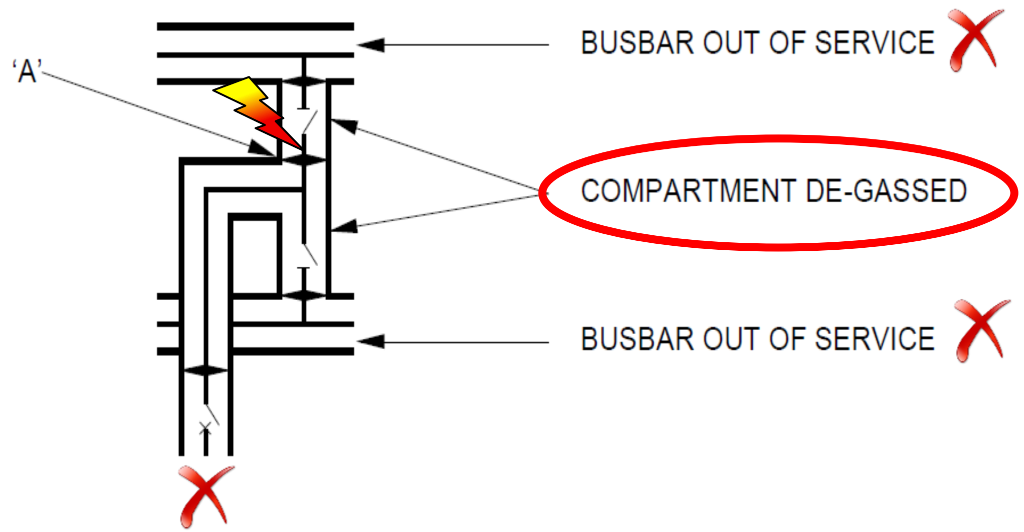
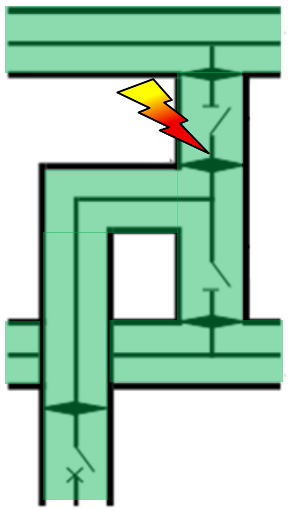


Figure F.1 — Impact due to the removal of common partition between busbar-disconnector

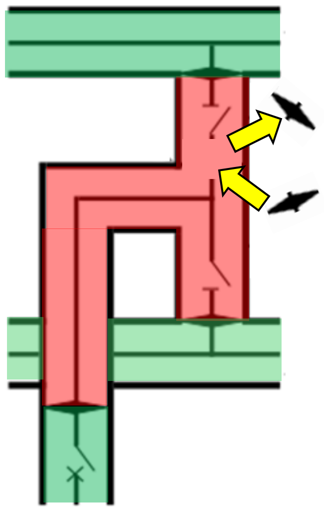
GIS partitioning

How partitioning may affect service continuity

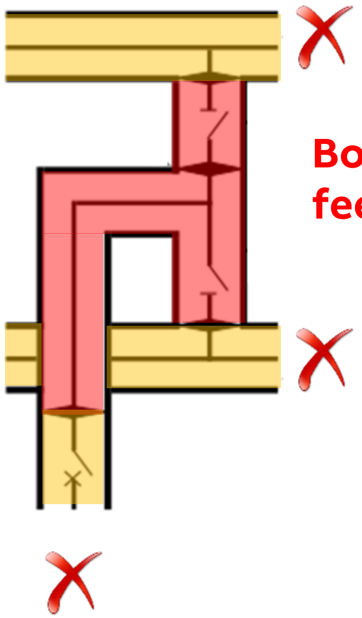
Repair of partition insulator



Between fault and repair, the compartment needs to be de-energized



Pressure in the adjacent compartments may be reduced during repair for safety reason



Both busbars and all feeders are out of service

SF_6 operating pressure

SF_6 reduced pressure

De-gassed atmospheric pressure air

GIS partitioning

Annex F – Examples of Partitioning – Example 2

In Figure F.2 the removal of the disconnector, including its partitions, at ‘B' requires the compartments of the adjacent disconnectors to be de-gassed. This causes the loss of the associated feeders for the duration of the repair.

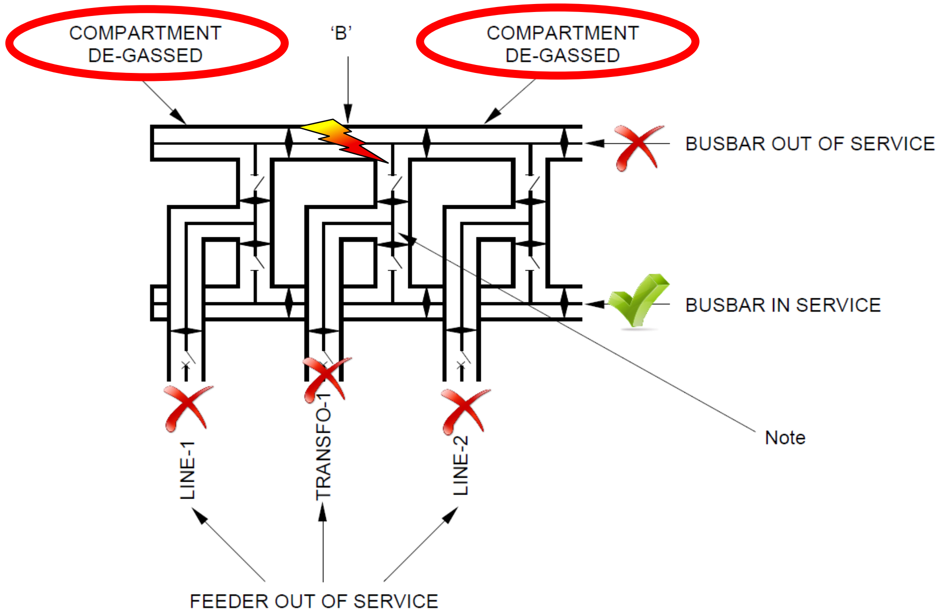


Figure F.1 — Impact of GIS partitioning on service continuity

GIS partitioning

Annex F – Examples of Partitioning – Example 3

In the case study, the removal of the disconnector at ‘D’ in SECTION-3 requires only the outage of the faulty feeder and not of the adjacent feeders. See Figure F.6.

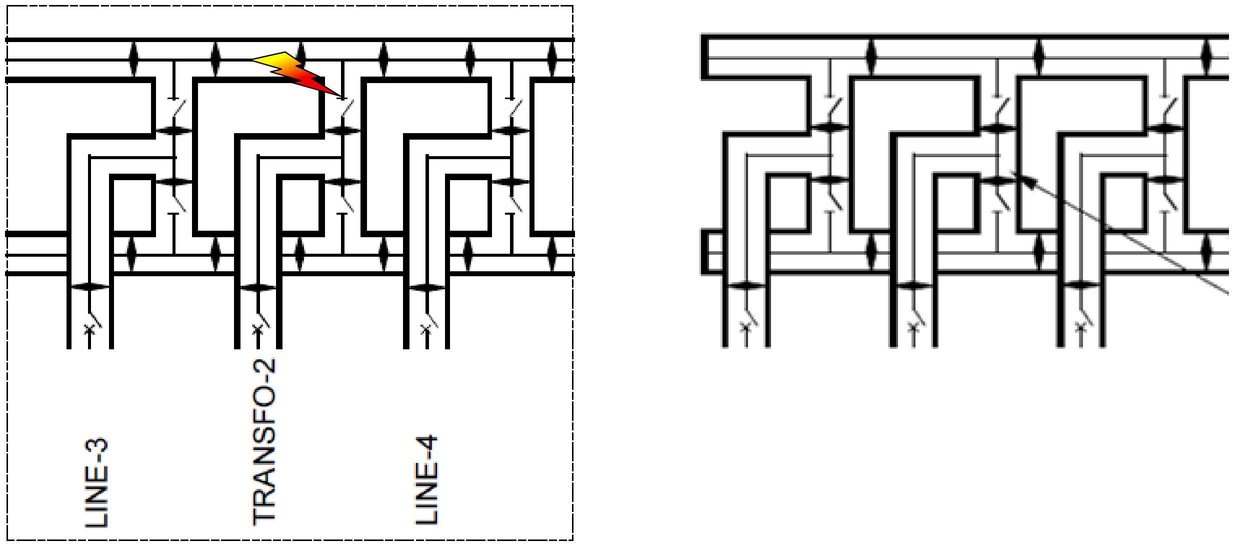


Figure F.6 — Impact of GIS partitioning on service continuity

GIS partitioning

Annex F – Examples of Partitioning – Example 3

In the case study, the removal of the disconnector at ‘D’ in SECTION-3 requires only the outage of the faulty feeder and not of the adjacent feeders. See Figure F.6.

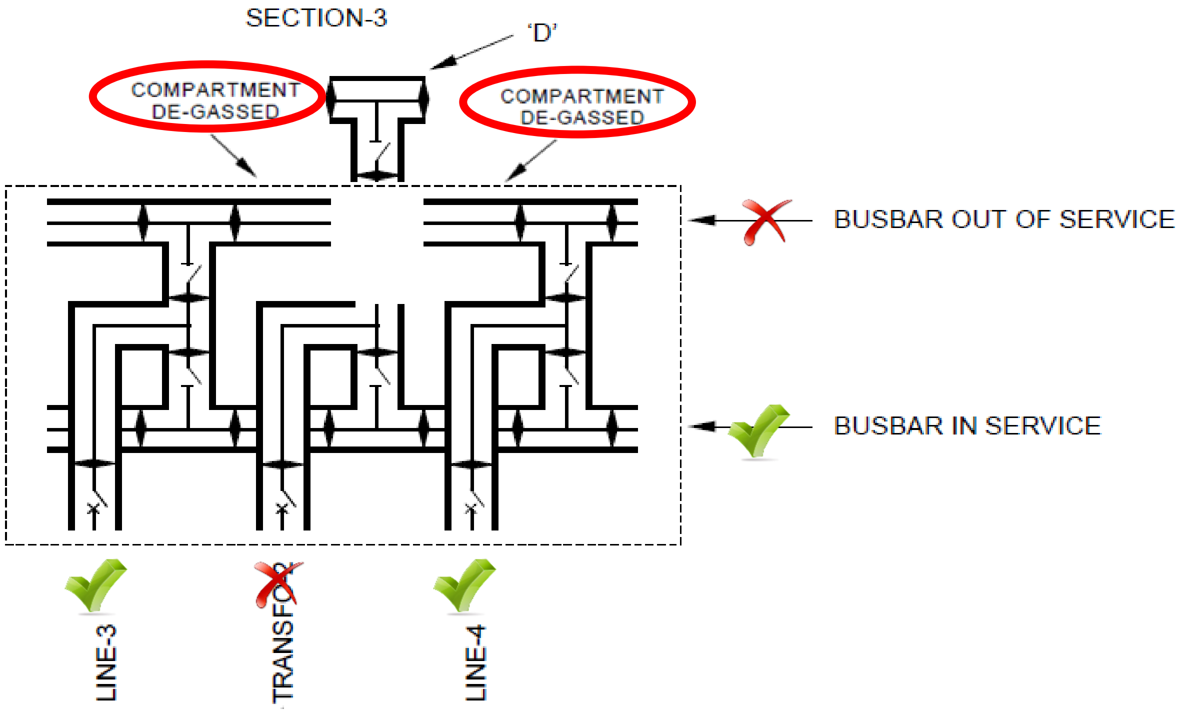
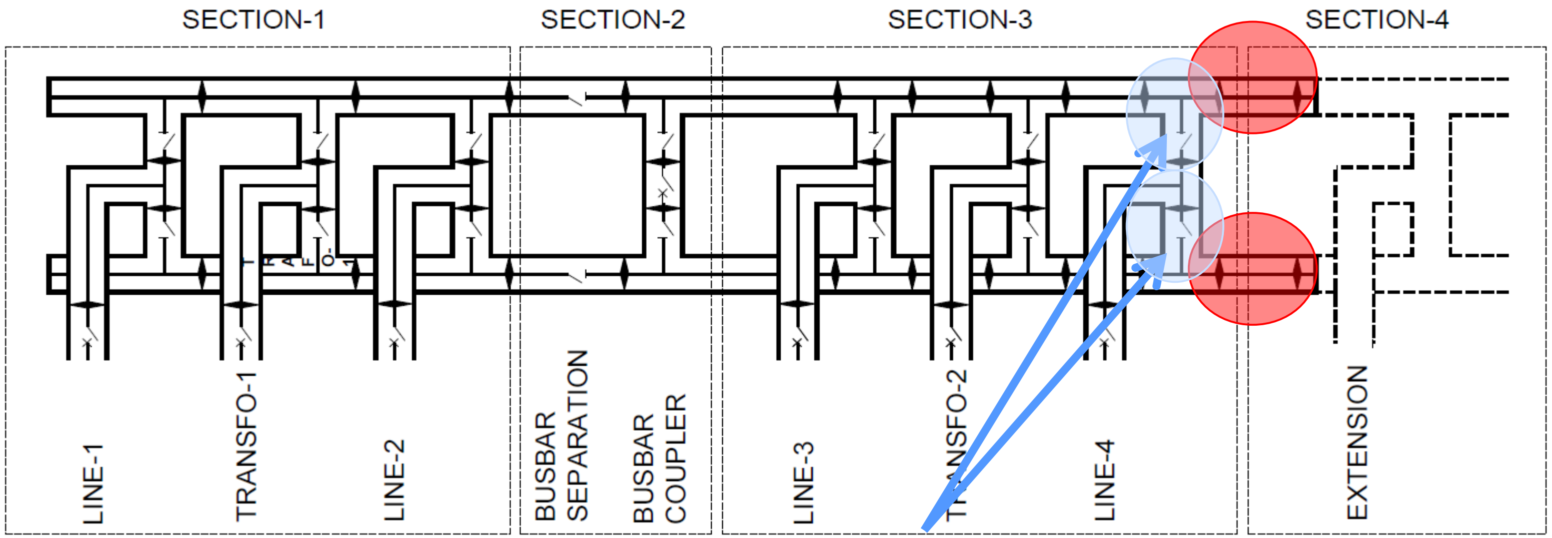


Figure F.6 — Impact of GIS partitioning on service continuity

GIS partitioning

Annex F – Examples of Partitioning – Example 4

In the example the substation has a total number of six feeders, four line and two transformer feeders. The busbars are divided by a busbar separation and linked with a coupler. A future extension is planned at the right side of the substation



Buffer compartments to avoid de-gassing of disconnector compartments and loss of Line 4

User defines requirements on service continuity

IEC 62271-203 – ed 2.0, recommendations – Annex F

It is the responsibility of users to define a strategy of maintenance relatively to the impact on service continuity and, it is the responsibility of manufacturers to design and define partitioning in order to fulfil users need.

The service continuity requirements should achieve an appropriate balance between equipment cost and the criticality of the substation in the user´s network.

The user may define some general statements that allow a quantitative assessment of the service continuity during maintenance, repair or extension. The following general statements are given as examples:

- At least one line and transformer-feeder must remain in service during maintenance and repair
- Maximum one busbar and one feeder permitted out of service during maintenance and repair
- The power flow must be maintained between specified feeders during extension

User defines requirements on service continuity

Remarks

Users

Our customers should specify:

- Circuit, possible with optimized feeder sequence*
- Service continuity requirements
  - How many feeders adjacent to a faulty feeder/busbar segment may be out of service during repair?

    e.g. DBB all, 5, 3, 1?
  - Shall HV testing of feeders/busbars be possible without shutdown?
  - Shall the substation be extandable without shutdown?
  - OHS procedures for working on pressurized partitions

Manufacturers

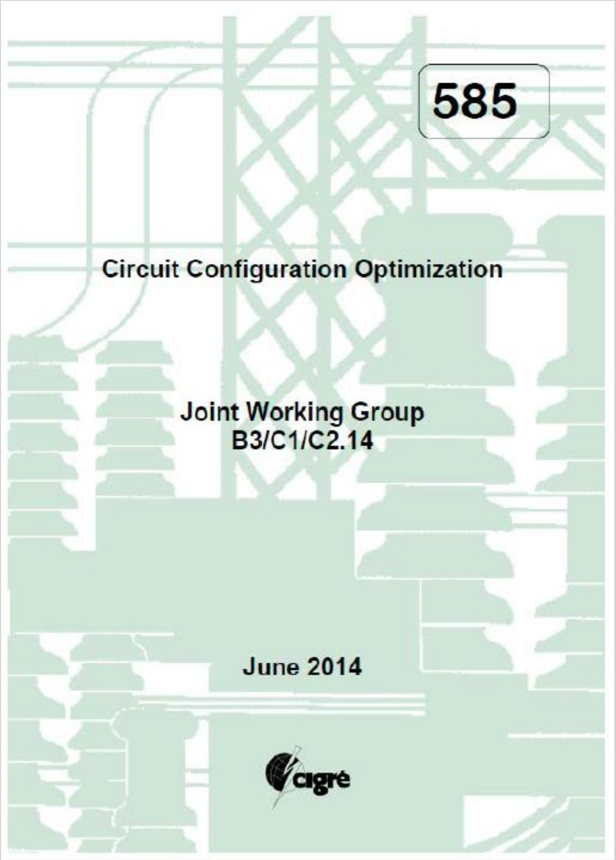
We:

- Design partitioning schemes and layouts according to customer requirements and ABB OHS rules
- Provide a maintanence/repair concept
- Provide a detailed method statement in case of repairs

* CIGRE brochure

Design considerations

Circuit



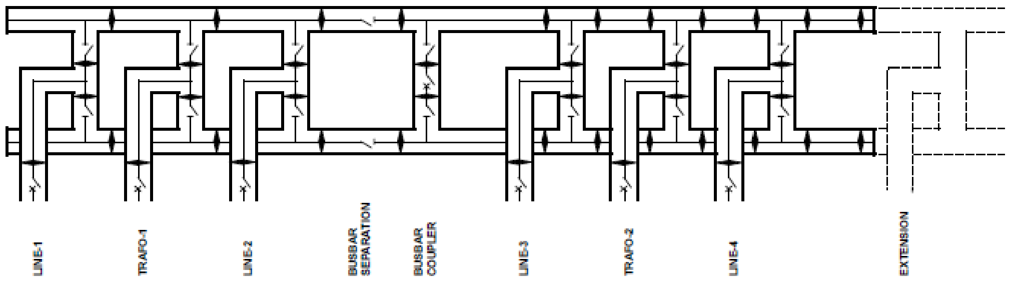
Highly recommended:

Cigre brochure TB585, Circuit Configuration Optimization

- Compares availability and repair of all common circuits in an easy to understand methodology
- Contains also maintenance considerations for GIS DBB systems

Example for detailed service continuity requirements

IEC 62271-203 – ed 2.0, recommendations – Annex F



Feeders or part of the substation	Maintenance → See Annex F.3.1		After failure until repair → See Annex F.3.2.1		Repair or replacement of a busbar disconnector after failure → See Annex F.3.2.2		Dielectric test → See Annex F.3.4		Extension → See Annex F.3.3	
	Service continuity 1)	Accepted duration (days) 2)	Service continuity 1)	Accepted duration (days) 2)	Service continuity 1)	Accepted duration (days) 2)	Service continuity 1)	Accepted duration (days) 2)	Service continuity 1)	Accepted duration (days) 2)
LINE-1										
TRAFO-1										
LINE-2										
BUSBAR-SEPARATION										
BUS-COUPLER										
LINE-3										
TRAFO-2										
LINE-4										
EXTENSION “RIGHT”										

Documentation for enquiries and tenders

IEC 62271-203 – ed 2.0, recommendations – Annex F

		User requirements	Supplier proposals
Single line diagram			
Requirements for service continuity during maintenance, repair, extension and on-site testing			
General arrangement drawings of substation layout			
Foundation loading		Supplier information	
Gas schematic diagrams		Supplier information	
List of type test reports		Supplier information	
List of recommended spare parts		Supplier information	

GIS designs for Service Continuity
ABB solution

Service continuity concept

ABB solution

Service continuity concept

There are 3 levels of service continuity:

LSC-X

- More than 3 feeders may be out of service simultaneously.
- All busbars may be out of service for a certain time.

LSC-3

- No more than 3 feeders may be out of service simultaneously.
- And at least one busbar has to be in service.

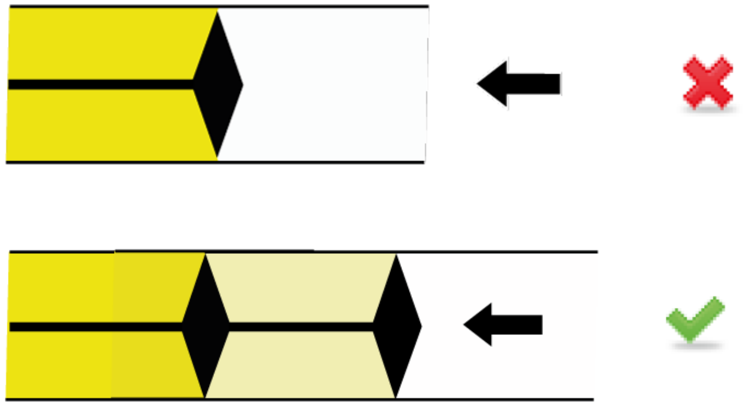
LSC-1

- No more than 1 feeder may be out of service simultaneously.
- And at least one busbar has to be in service.

Service continuity + Safety for personnel

Key benefits

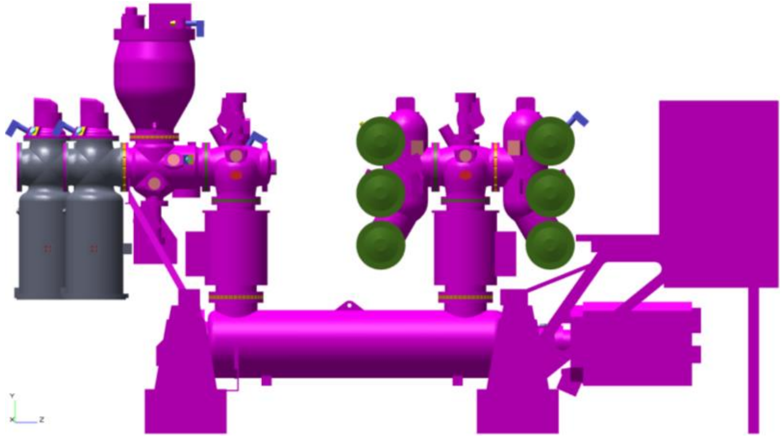
Service Continuity Concept [SCC]

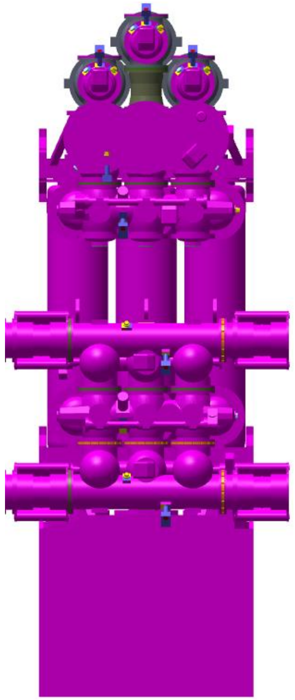


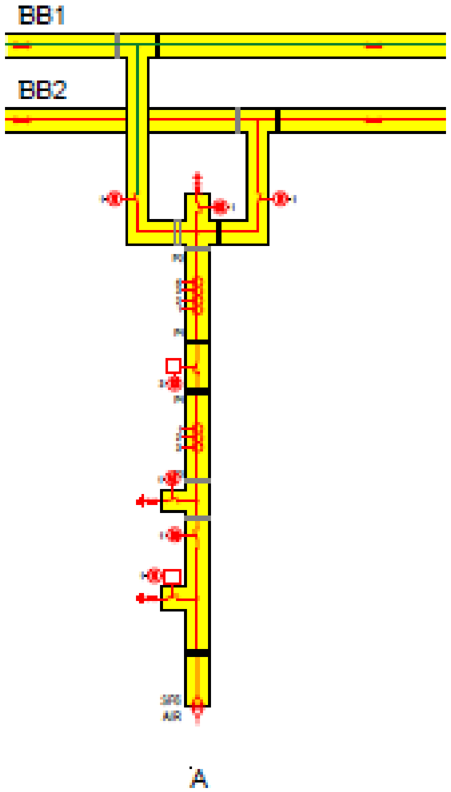
- Partition insulators are designed according to IEC62271-203
  - Bursting pressure type test: safety factor of 3 (referring to maximum diferential pressure during operation and maintanence, repair)
  - Routine tests in production: safety factor of 2

Service Continuity Concept

LSC-X

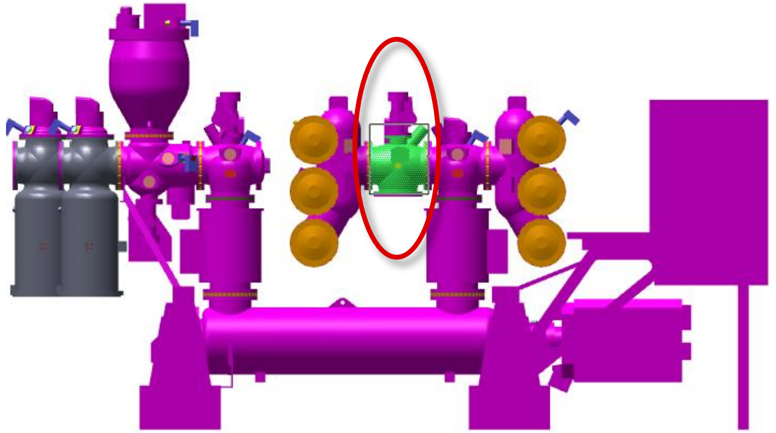


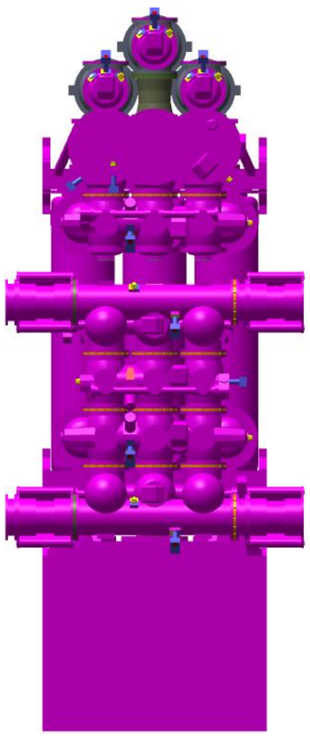


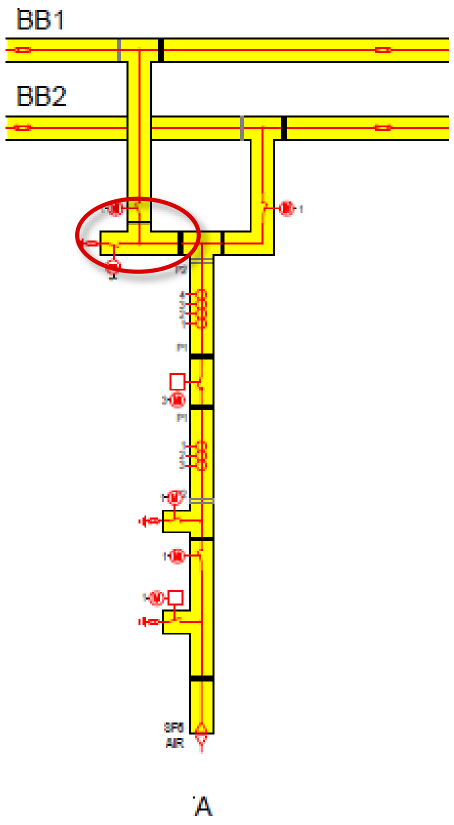


Service Continuity Concept

LSC-3

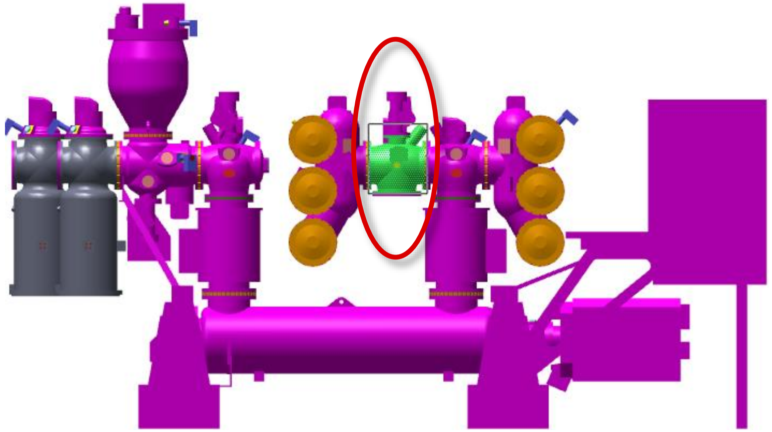


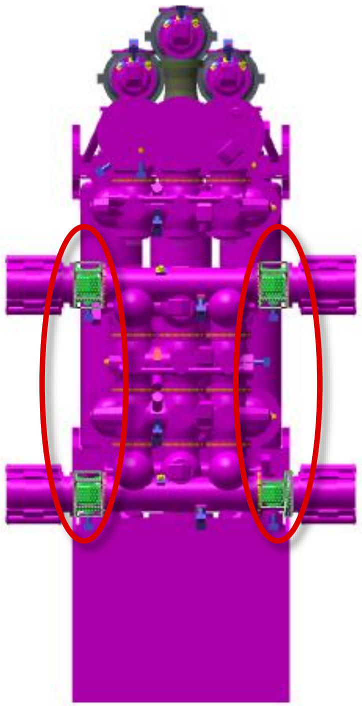


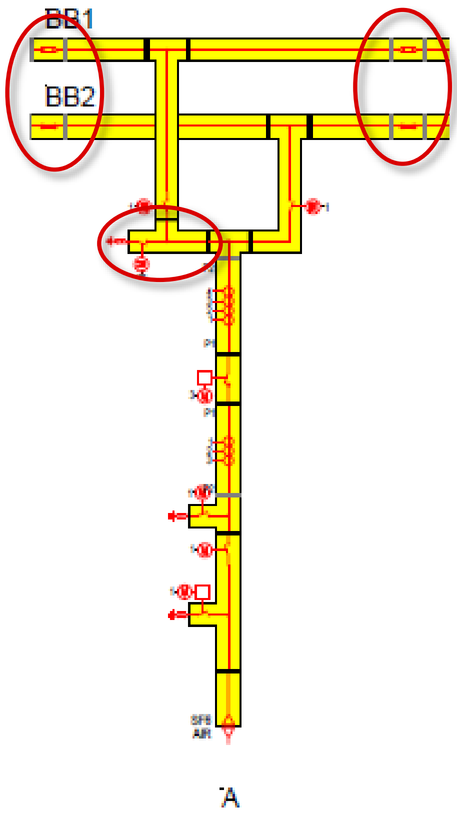


Service Continuity Concept

LSC-1







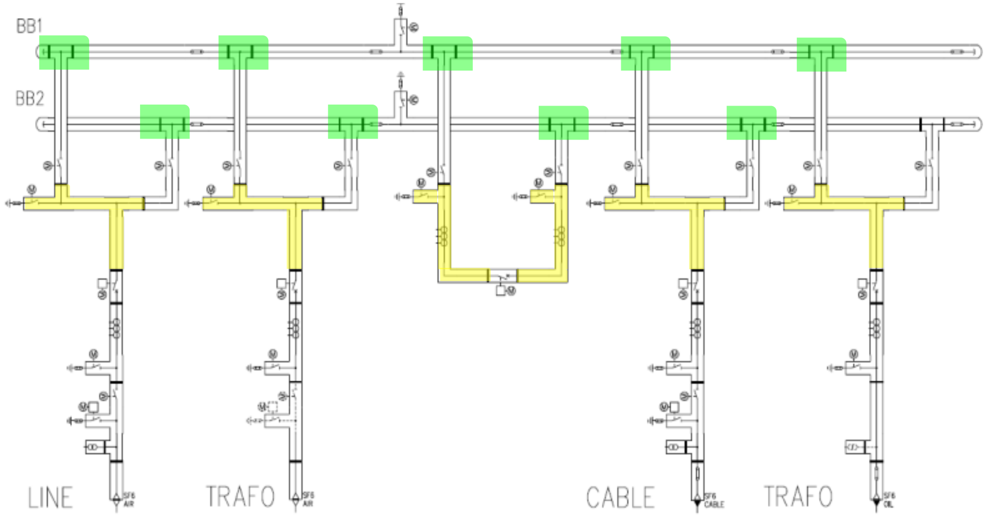
ABB

GIS designs for Service Continuity
ABB solution
Repair cases

ABB Solution

Basic rules

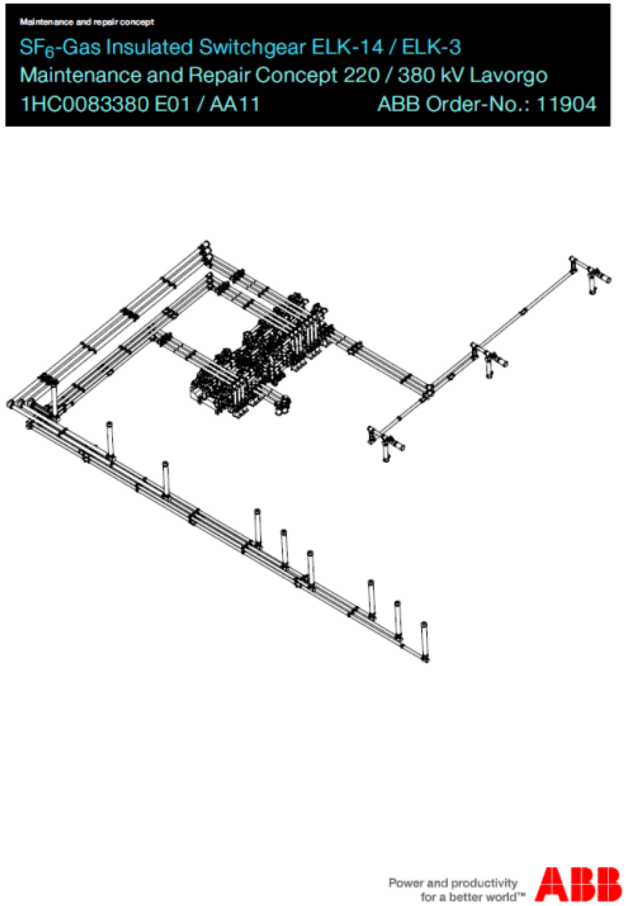
Double BB with partition insulators



- Bay-wise gas segregation, to avoid outages of complete busbars
- Buffer compartment between busbar disconnectors to avoid shutdown of complete substations
- Buffer compartment between circuit breaker and busbar disconnector, to remain both busbars in Service in case of maintenance or repair
- Make strategic spares available

Maintenance and repair concept

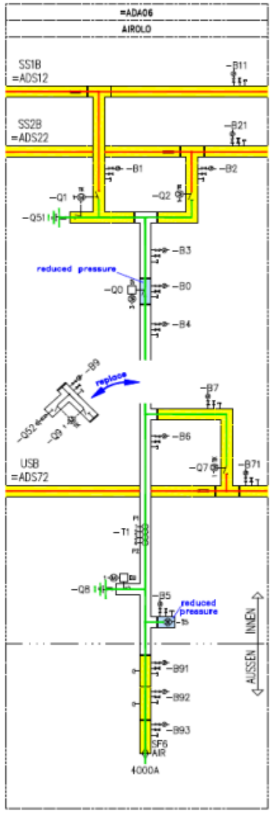
Repair cases

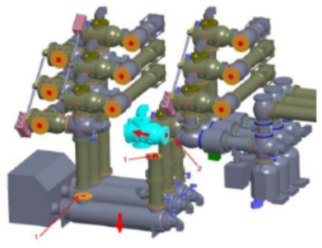

Maintenance and repair concept

SF_6-Gas Insulated Switchgear ELK-14 / ELK-3
Maintenance and Repair Concept 220 / 380 kV Lavorgo
1HC0083380 E01 / AA11 ABB Order-No.: 11904

Power and productivity for a better world™ ABB

SF_6-Gas Insulated Switchgear ELK-14 / ELK-3
5 Description of the inspection and repair cases





GIS Parts which may remain in service

	In service	Out of service and earthed
Busbar SS1	☒	☐
Busbar SS2	☒	☐
Busbar US	☒	☒
Affected feeder	☐	☒
Adjacent feeder left	☒	☐
Adjacent feeder right	☒	☐
Bus coupler	☒	☐

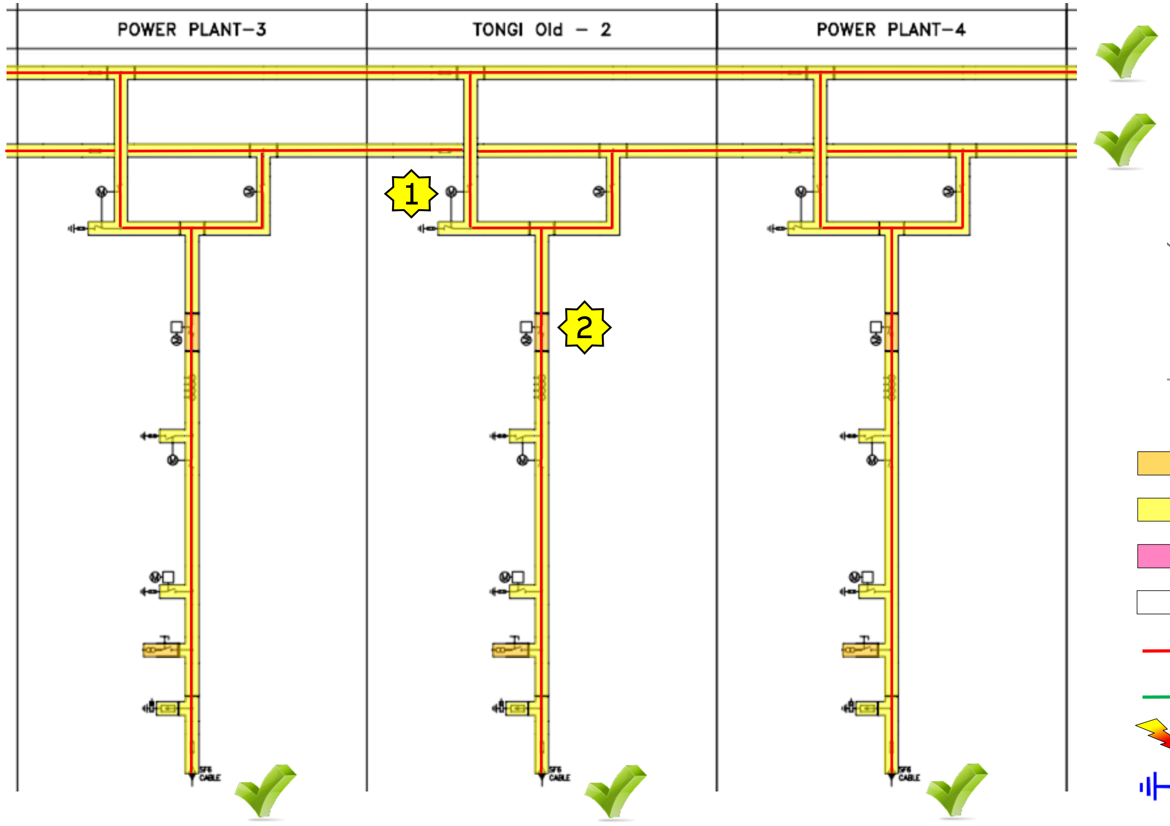
Legend for gas schematic diagram

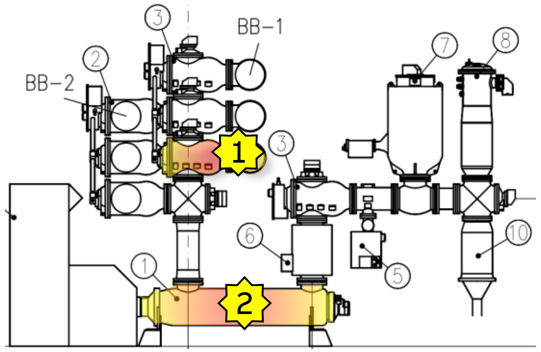
- In service
- Out of service and earthed
- Ambient pressure (air)
- SF_6 (max 530 kPa)
- SF_6 (680 kPa)

Fig. 4: Gas schematic diagramm and 3D view for step01-26 (Case 02 - Exchange of the exit disconnector and earthing switch with removing enclosure)

Repair cases

LSC-1, 230kV GHORASHAL





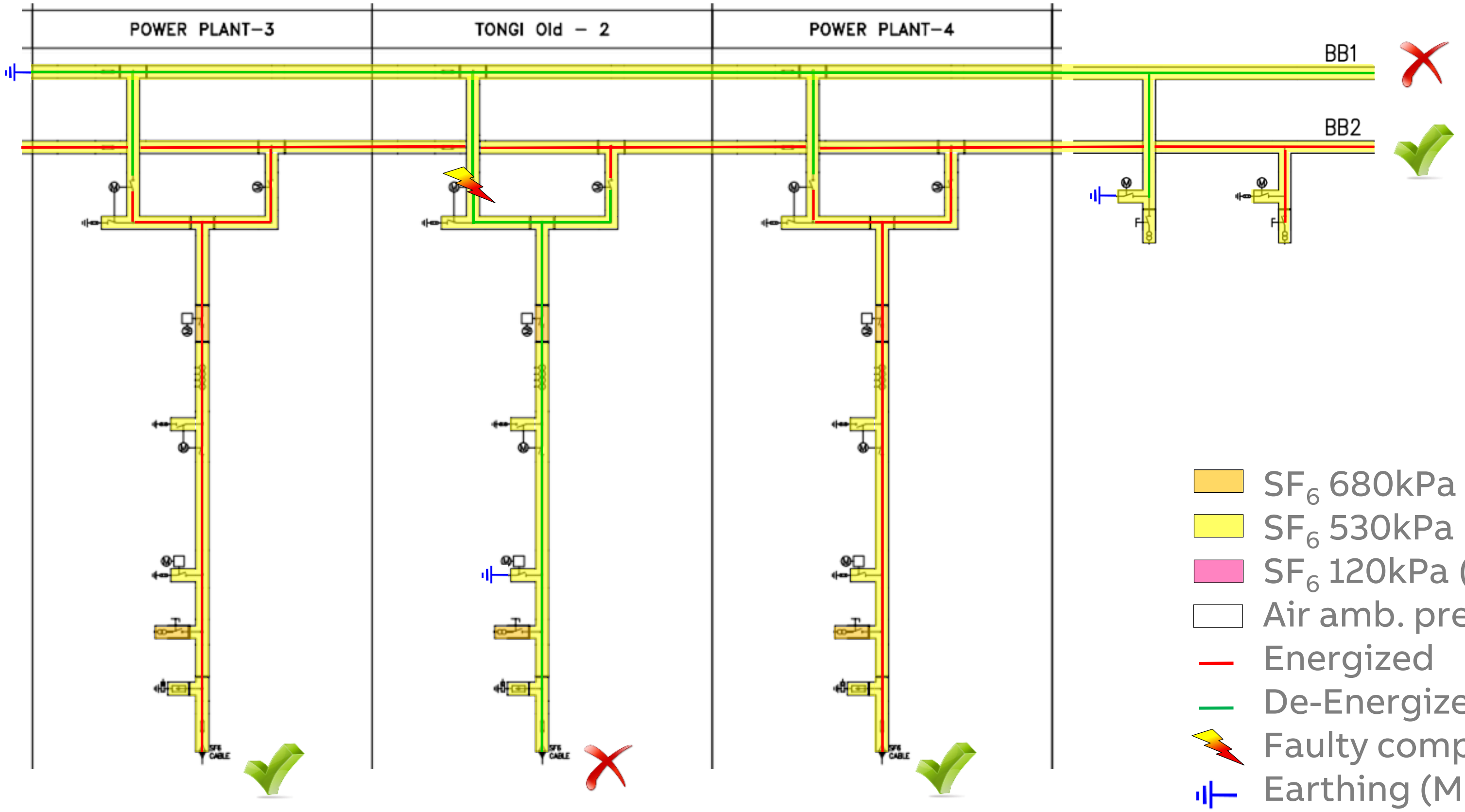
- SF_6 680kPa (abs)
- SF_6 530kPa (abs)
- SF_6 120kPa (abs)
- Air pressure 100kPa (abs)
- Energized
- De-Energized
- Faulty component
- Earthing (MES, FAES or temporary earthing device)

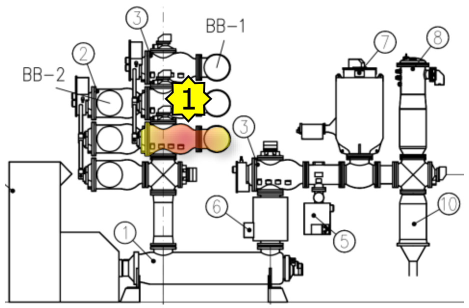
1 Busbar Disconnector-Earthing Switch

2 Circuit-Breaker

Case 1 - Busbar Disconnector/Earthing Switch replacement

De-energize and earth faulty section

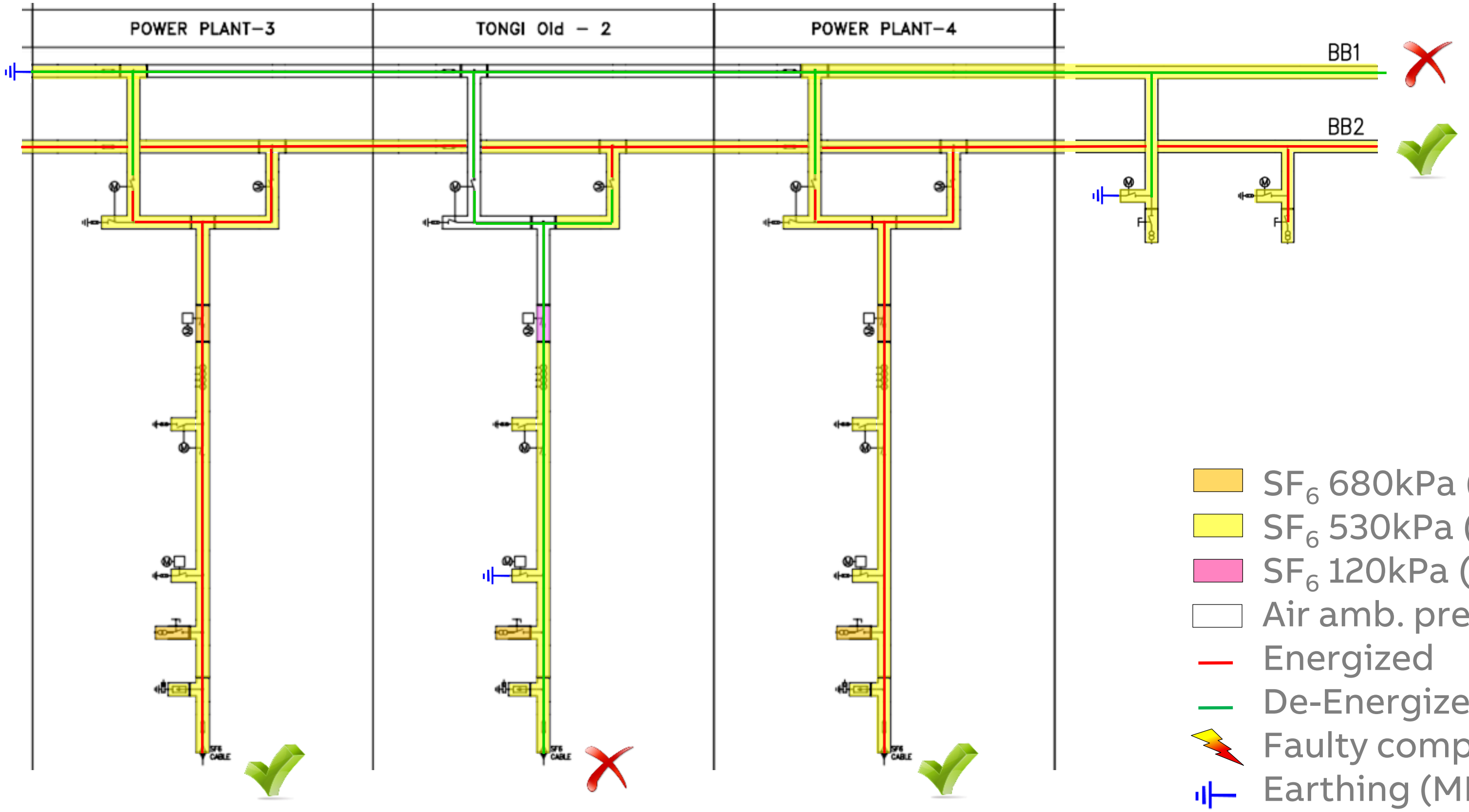


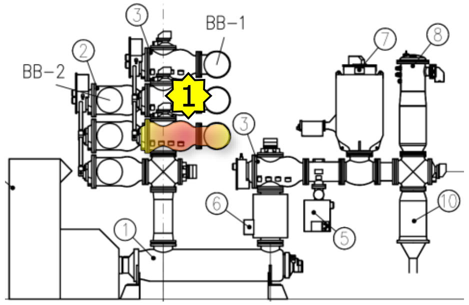


- SF$_6$ 680kPa (abs)
- SF$_6$ 530kPa (abs)
- SF$_6$ 120kPa (abs)
- Air amb. pressure 100kPa (abs)
- Energized
- De-Energized
- Faulty component
- Earthing (MES, FAES or temporary earthing device)

Case 1 - Busbar Disconnector/Earthing Switch replacement

Gas handling

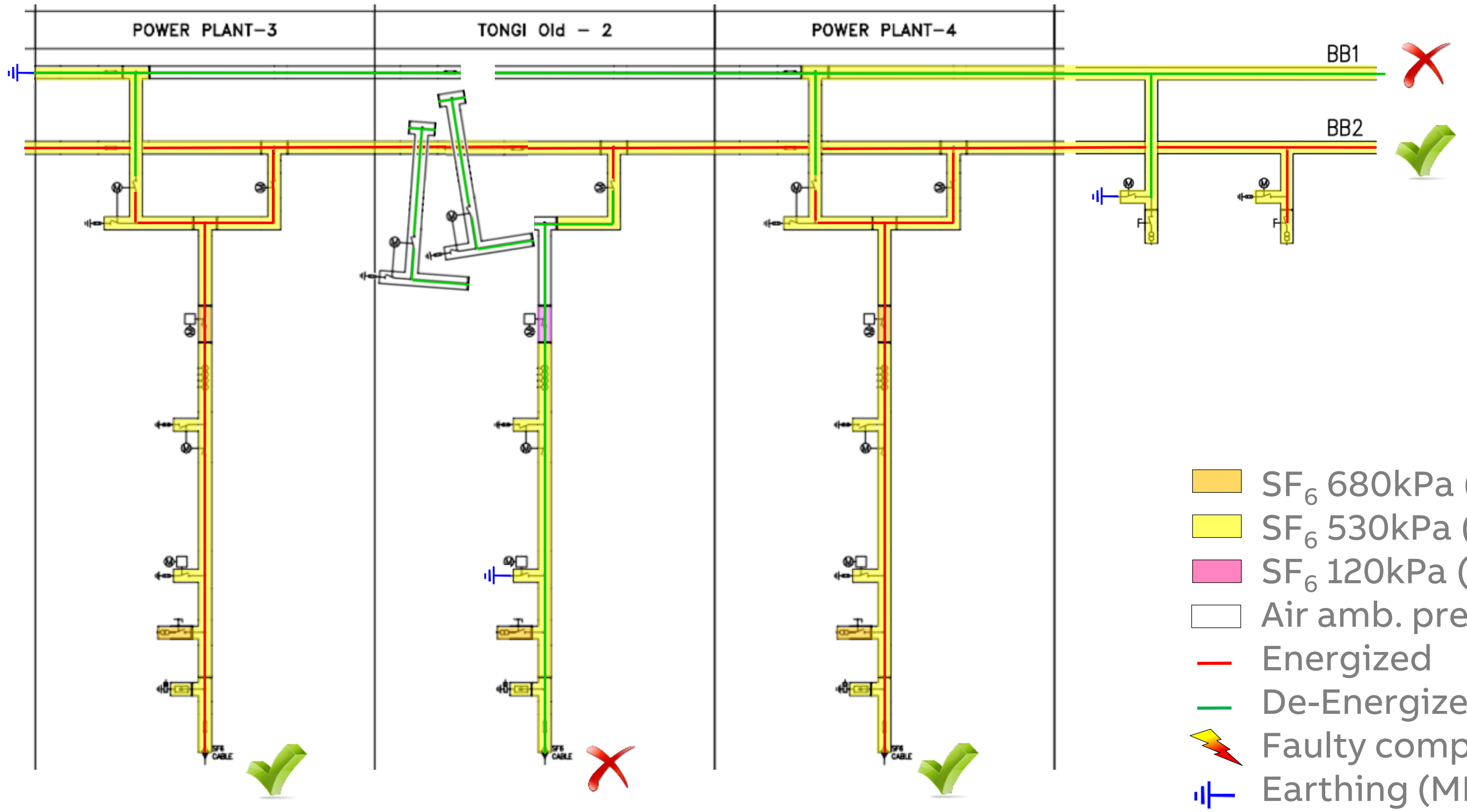


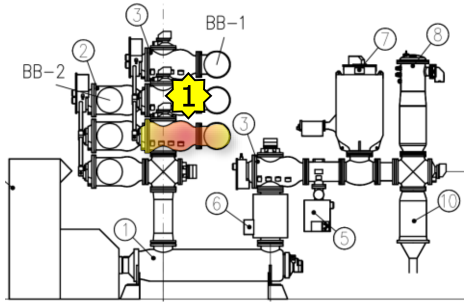


- SF_6 680kPa (abs)
- SF_6 530kPa (abs)
- SF_6 120kPa (abs)
- Air amb. pressure 100kPa (abs)
- Energized
- De-Energized
- Faulty component
- Earthing (MES, FAES or temporary earthing device)

Case 1 - Busbar Disconnector/Earthing Switch replacement

Replace faulty component





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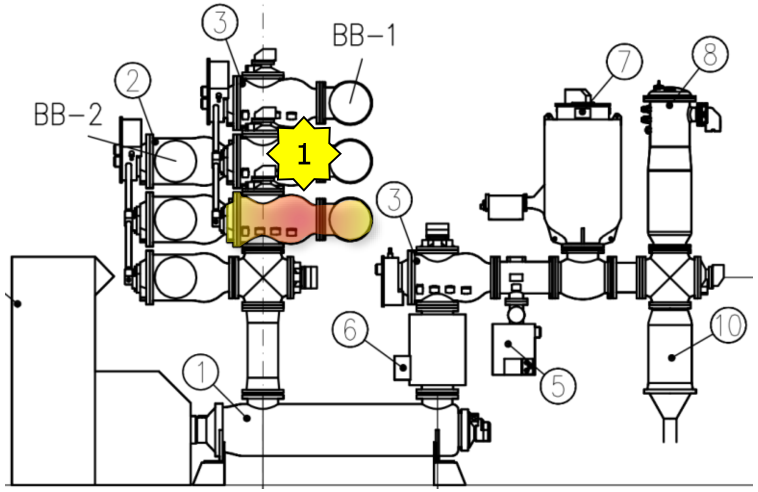
Case 1 - Busbar Disconnector/Earthing Switch replacement

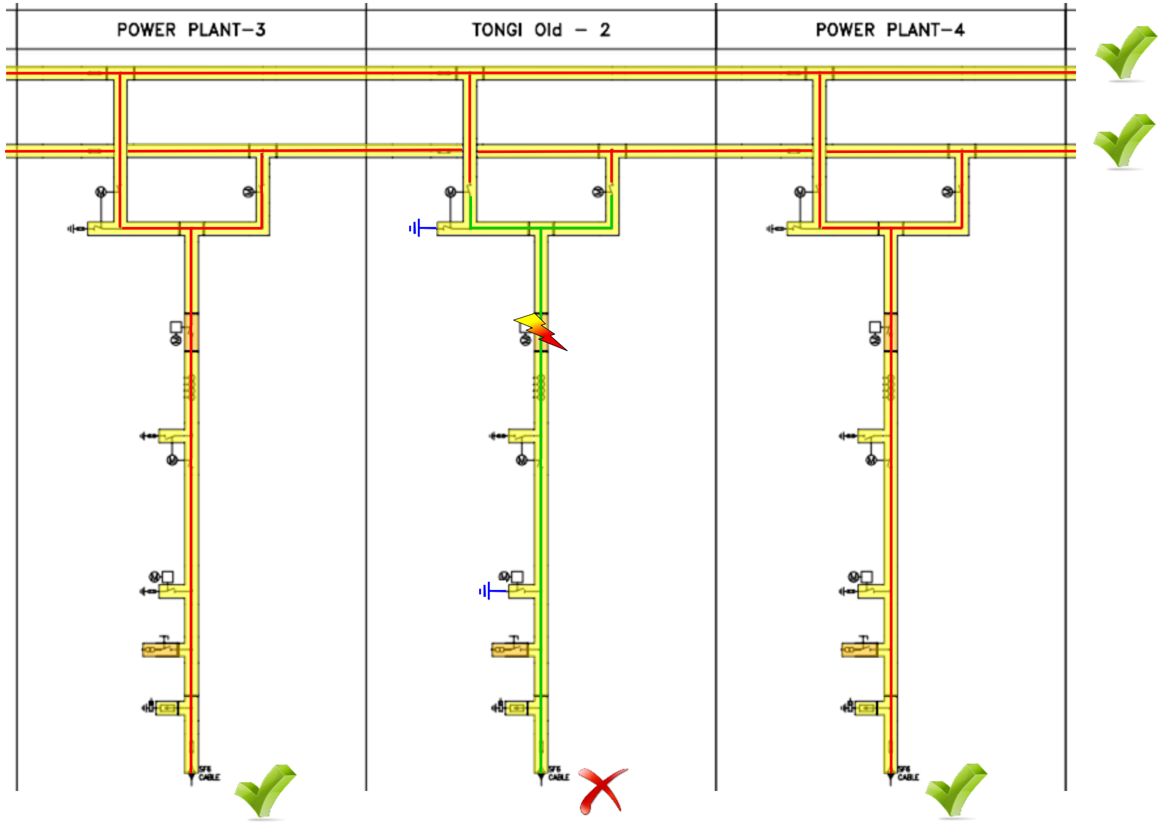
GIS parts which may remain in service

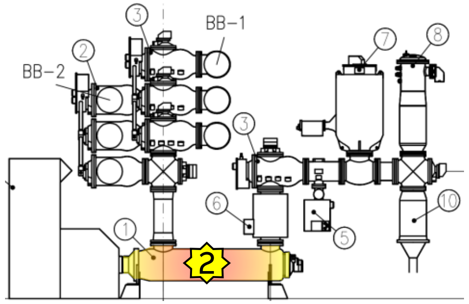
Busbar disconnector replacement	After fault until revision	During revision
Busbar BB1	✗	✗
Busbar BB2	✓	✓
Affected feeder	✗	✗
Feeder on the left of the faulty bay	✓	✓
Feeder on the right of the faulty bay	✓	✓



Case 2 - Circuit-breaker replacement

De-energize and earth faulty section





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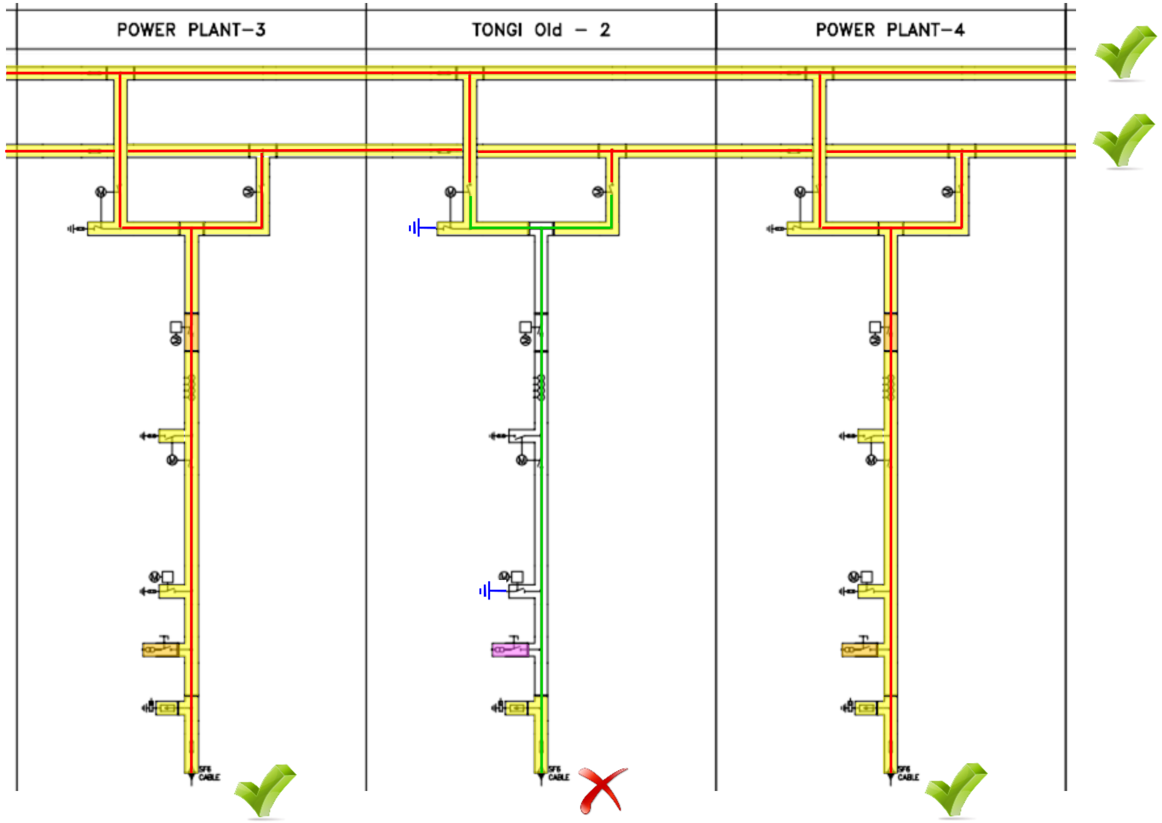
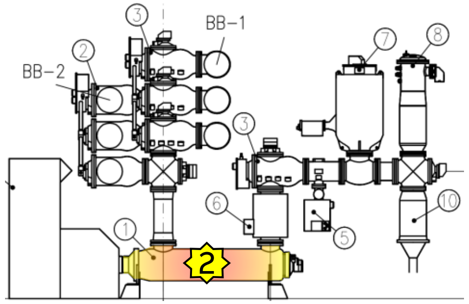
Case 2 - Circuit-breaker replacement

Gas handling





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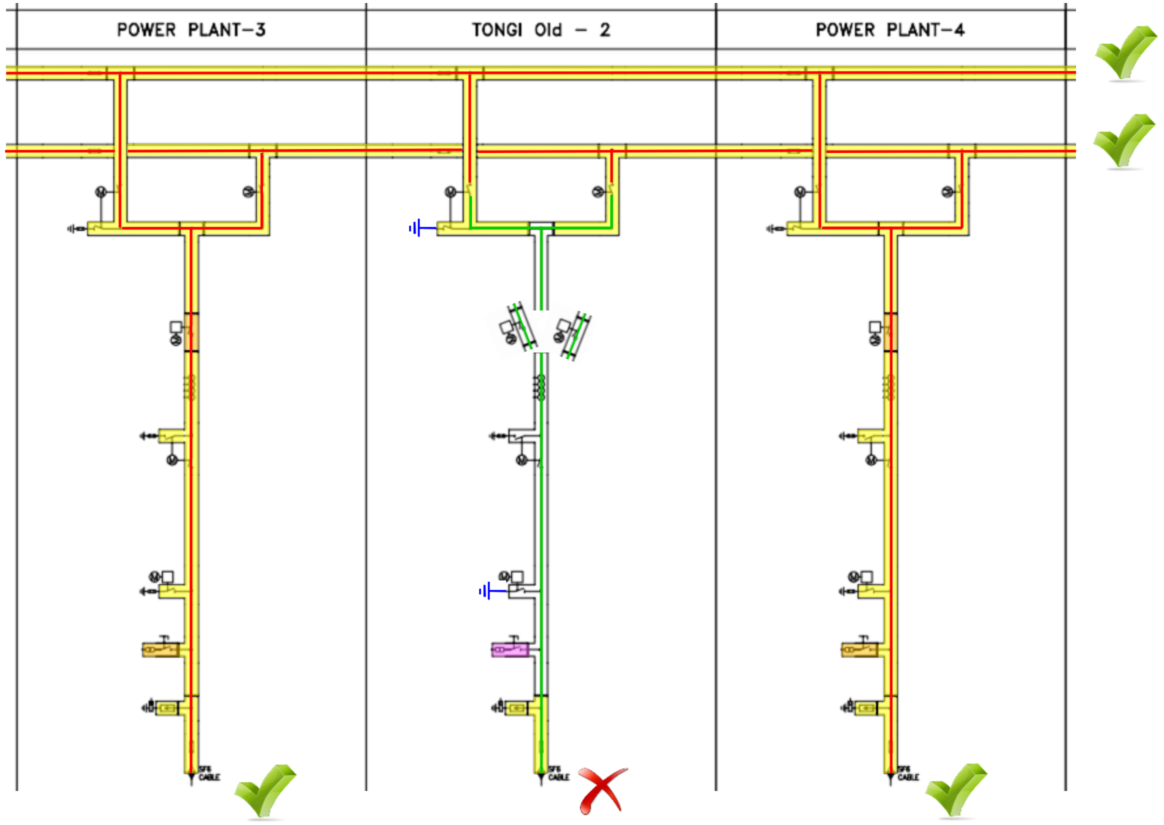
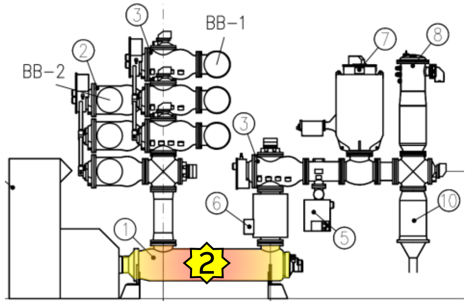
Case 2 - Circuit-breaker replacement

Replace faulty component





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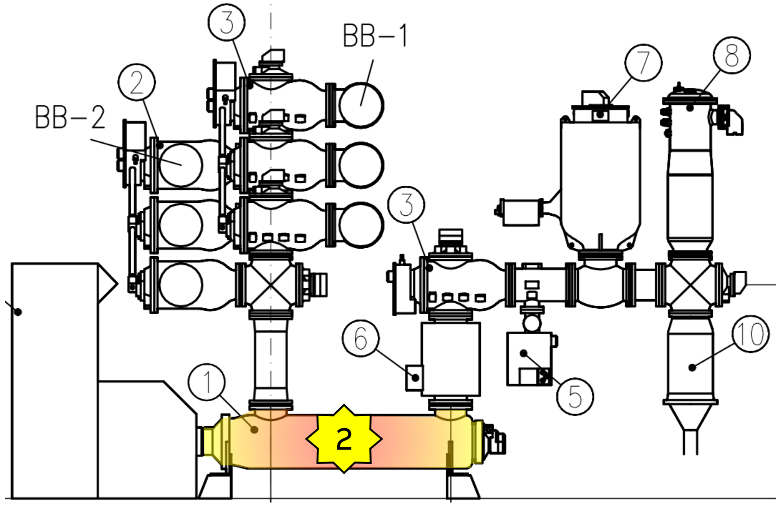
Case 2 - Circuit-breaker replacement

GIS parts which may remain in service

Circuit-breaker replacement	After fault until revision	During revision
Busbar BB1	✔	✔
Busbar BB2	✔	✔
Affected feeder	✘	✘
Feeder on the left of the faulty bay	✔	✔
Feeder on the right of the faulty bay	✔	✔

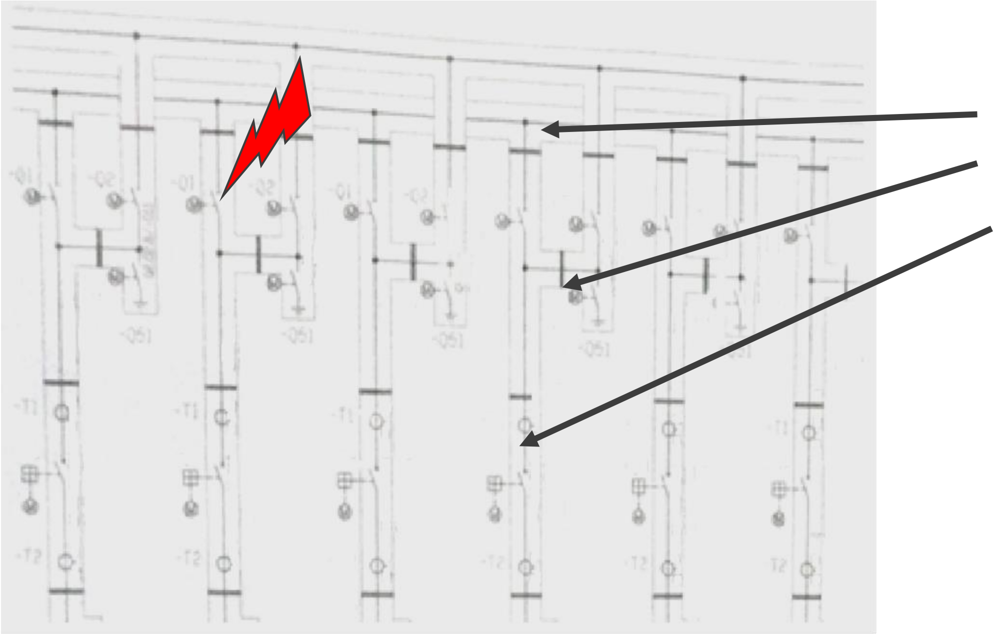


GIS designs for Service Continuity
Other solutions in the marktet
Examples

Lets take test !

DBB Switchgear. Observations & consequences ?

Negative example


Substation example from the 60's

Observations

- No bay-wise gas segregation
- No buffer compartment between both busbar disconnectors
- CTs inside CB compartment

Consequence

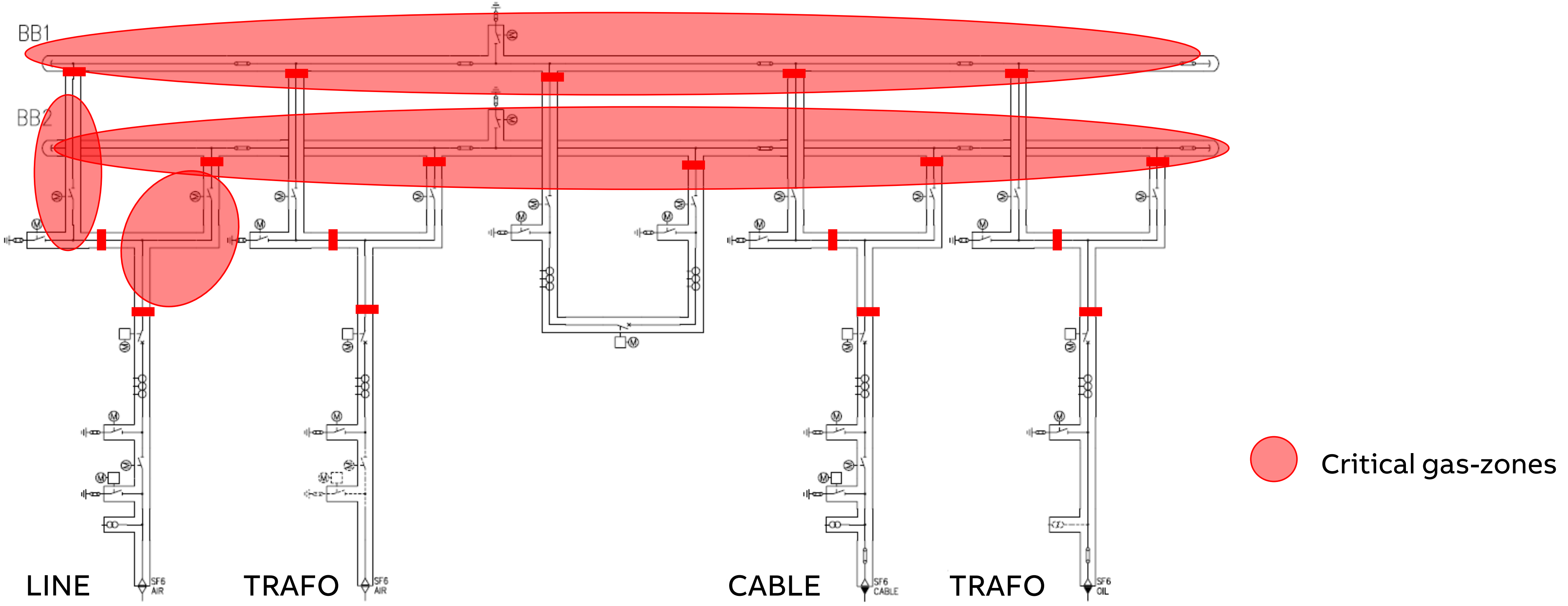
- Failure in one BB disconnector will lead to a complete shutdown of the substation
- Failure in a busbar, will cause:
  - long repair time
  - big environment impact

Arrangements and Configurations

Double Busbar Scheme – High risk example

Negative
example

Double BB without partition insulators

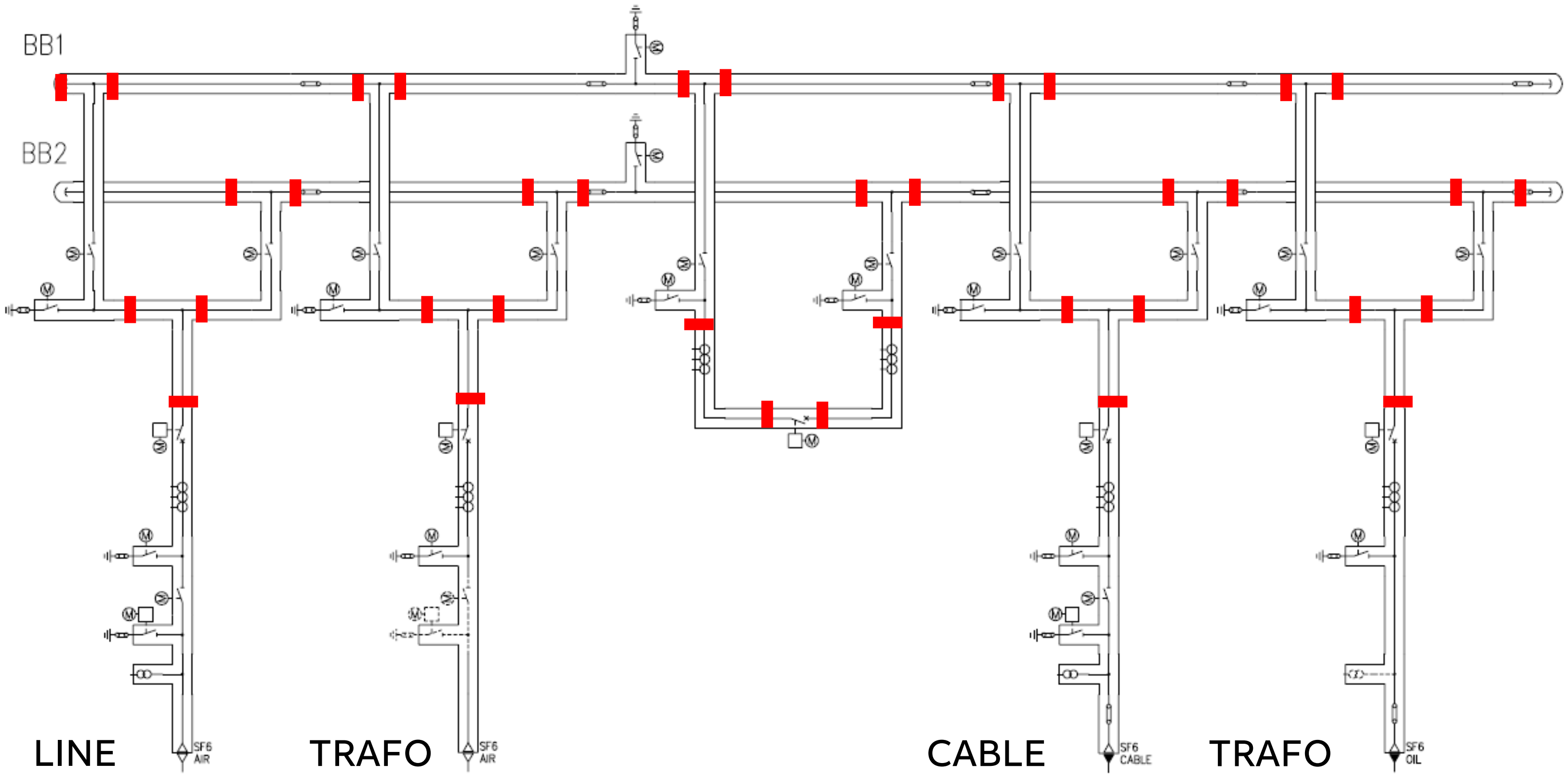


Arrangements and Configurations

Double Busbar Scheme – Positive example

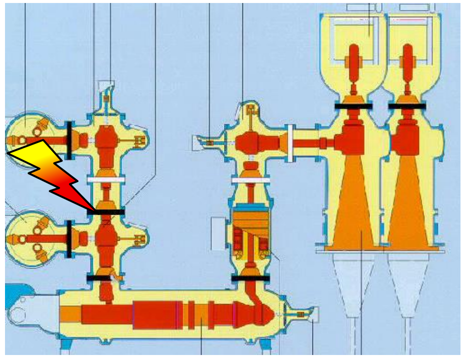
Positive example

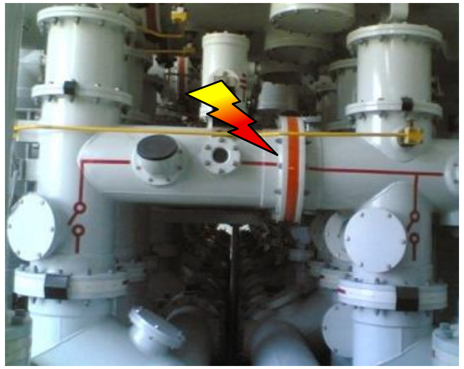
Double BB without partition insulators

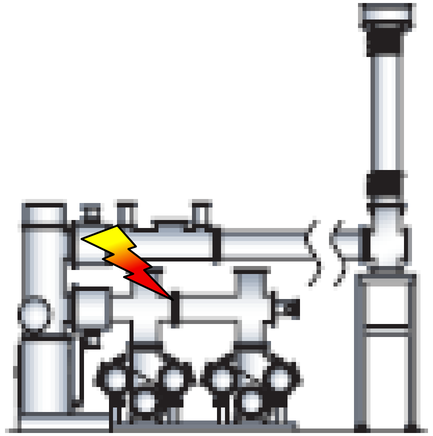


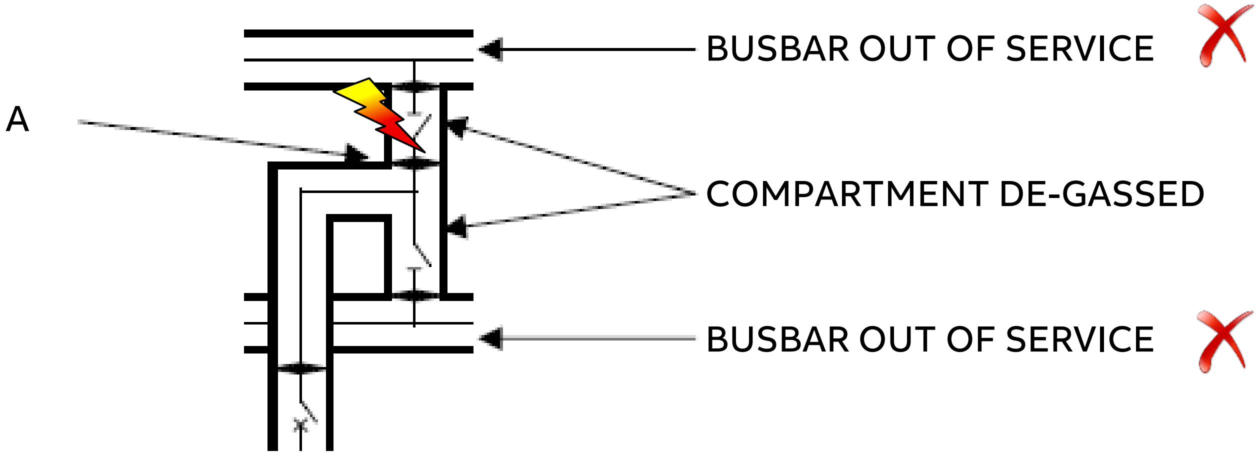
Other solutions in the market

Examples









Conclusions

User defines requirements on service continuity

Users

responsibility to define strategy of service continuity

→

Manufacturers

responsibility to design and define partitioning

→

User may define general statements:

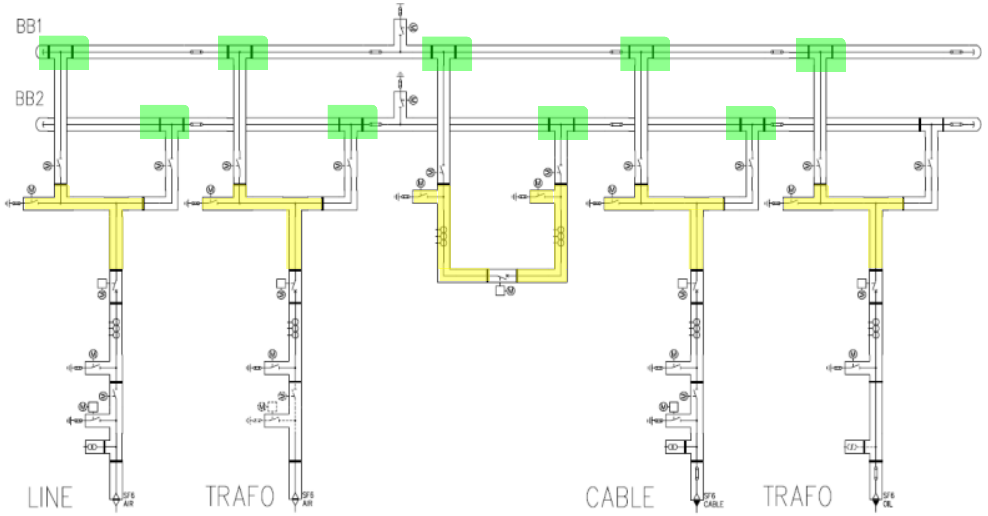
- At least one feeder must remain in service
- Maximum one busbar out of service
- Maintain power flow during extensions

What customer invests now, customer will safe in the future!

Service Continuity

Basic rules

Double BB with partition insulators



- Bay-wise gas segregation, to avoid outages of complete busbars
- Buffer compartment between busbar disconnectors to avoid shutdown of complete substations
- Buffer compartment between circuit breaker and busbar disconnector, to remain both busbars in Service in case of maintenance or repair
- Make strategic spares available

Contact Information

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