Safety and availability in GIS

Service Continuity

Jessica Ponce de Leon | Head of Sales for AMERICAS, ABB Switzerland Ltd.
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

Market leader with more than 25,000 bays installed worldwide

Driving technology and innovation since 1965

Complete range of GIS 52 kV to 1200 kV
GIS ABB

Factory Network

- Hanau, Germany: GIS 52 kV to 170 kV
- Zurich, Switzerland: GIS 245 kV to 550 kV
- Dammam, Saudi Arabia: GIS 66 kV to 420 kV
- Vadodara, India: GIS 52 kV to 420 kV
- Xiamen, China: GIS 66 kV to 800 kV

GIS service centers
ABB GIS

A lot of "first time"
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 (SF₆) 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
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.
In every gas compartment (in every closed space between orange marks) you must find one. We only show some of them here.

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

Valve

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

Absorber

- 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

Enclosure

Barrier insulator

Support insulator

Support insulator

Barrier insulator

Aluminum or copper conductor

Density Monitor

...and cabling to LCC

Pressure Relief Device

Absorber

Valve
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...

- 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

...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 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

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 (number of busbars, sequence of feeders, number and position of disconnectors...)
- Gas compartment: partitioning, configuration and design, number of gas compartments, additional gas buffer compartments
- Additional isolating links...
- Physical arrangement of components
- Facilities for dismantling
- 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.
- Provision for on-site dielectric test (GIS and interfaces)
- Necessity to carry out on-site dielectric tests after maintenance or repair
- Provision for future extensions: buffer gas compartments, appropriate disconnect facilities for extensions without de-energization of complete GIS
- 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

- SF₆ operating pressure
- SF₆ 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.
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 extendable 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 maintenance/repair concept
- Provide a detailed method statement in case of repairs
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

<table>
<thead>
<tr>
<th>Feeder or part of the substation</th>
<th>Maintenance</th>
<th>After failure until repair</th>
<th>Repair or replacement of a busbar disconnector after failure</th>
<th>Dielectric test</th>
<th>Extension</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>→ See Annex F.3.1</td>
<td>→ See Annex F.3.2</td>
<td>→ See Annex F.3.2</td>
<td>→ See Annex F.3.4</td>
<td>→ See Annex F.3.3</td>
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<table>
<thead>
<tr>
<th></th>
<th>Service continuity</th>
<th>Accepted duration (days 2)</th>
<th>Service continuity</th>
<th>Accepted duration (days 2)</th>
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<th>Accepted duration (days 2)</th>
<th>Service continuity</th>
<th>Accepted duration (days 2)</th>
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<tbody>
<tr>
<td>LINE-1</td>
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<td>LINE-2</td>
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<td>BUSBAR SEPARATION</td>
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<tr>
<td>BUS COUPLER</td>
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<td>LINE-3</td>
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<td>LINE-4</td>
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<tr>
<td>EXTENSION “RIGHT”</td>
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## Documentation for enquiries and tenders

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

<table>
<thead>
<tr>
<th>Requirement</th>
<th>User requirements</th>
<th>Supplier proposals</th>
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</thead>
<tbody>
<tr>
<td>Single line diagram</td>
<td></td>
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</tr>
<tr>
<td><strong>Requirements for service continuity during maintenance, repair, extension and on-site testing</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>General arrangement drawings of substation layout</td>
<td></td>
<td></td>
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<tr>
<td>Foundation loading</td>
<td></td>
<td>Supplier information</td>
</tr>
<tr>
<td>Gas schematic diagrams</td>
<td></td>
<td>Supplier information</td>
</tr>
<tr>
<td>List of type test reports</td>
<td></td>
<td>Supplier information</td>
</tr>
<tr>
<td>List of recommended spare parts</td>
<td></td>
<td>Supplier information</td>
</tr>
</tbody>
</table>
GIS designs for Service Continuity

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 differential pressure during operation and maintenance, repair)
  - Routine tests in production: safety factor of 2
Service Continuity Concept

LSC-X
Service Continuity Concept

LSC-3
Service Continuity Concept

LSC-1
GIS designs for Service Continuity
ABB solution
Repair cases
ABB Solution

Basic rules

- 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
Repair cases
LSC-1, 230kV GHORASHAL

- SF₆ 680kPa (abs)
- SF₆ 530kPa (abs)
- SF₆ 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

- SF₆ 680kPa (abs)
- SF₆ 530kPa (abs)
- SF₆ 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
Case 1 - Busbar Disconnector/Earthing Switch replacement

Replace faulty component
**Case 1 - Busbar Disconnector/Earthing Switch replacement**

GIS parts which may remain in service

<table>
<thead>
<tr>
<th></th>
<th>After fault until revision</th>
<th>During revision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Busbar disconnector replacement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Busbar BB1</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>Busbar BB2</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Affected feeder</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>Feeder on the left of the faulty bay</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Feeder on the right of the faulty bay</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>
## Case 2 - Circuit-breaker replacement

De-energize and earth faulty section

- **SF₆ 680kPa (abs)**
- **SF₆ 530kPa (abs)**
- **SF₆ 120kPa (abs)**
- **Air amb. pressure 100kPa (abs)**
- **Energized**
- **De-Energized**
- **Faulty component**
- **Earthing (MES, FAES or temporary earthing device)**

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Case 2 - Circuit-breaker replacement

Gas handling
Case 2 - Circuit-breaker replacement

Replace faulty component

- SF\textsubscript{6} 680kPa (abs)
- SF\textsubscript{6} 530kPa (abs)
- SF\textsubscript{6} 120kPa (abs)
- Air amb. pressure 100kPa (abs)
- Energized
- De-Energized
- Faulty component
- Earthing (MES, FAES or temporary earthing device)
Case 2 - Circuit-breaker replacement

GIS parts which may remain in service

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<th>After fault until revision</th>
<th>During revision</th>
</tr>
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<tbody>
<tr>
<td>Busbar BB1</td>
<td>✓</td>
<td>✓</td>
</tr>
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<td>Busbar BB2</td>
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GIS designs for Service Continuity
Other solutions in the market
Examples
Let's take test!

DBB Switchgear. Observations & consequences?

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

Substation example from the 60's
Arrangements and Configurations

Double Busbar Scheme – High risk example

Negative example

Double BB without partition insulators

Critical gas-zones
Arrangements and Configurations

Double Busbar Scheme – Positive example

Double BB without partition insulators

Positive example
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

- 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
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Contact Information

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