PASS M0
Innovative solutions for distribution substations up to 170 kV
The concept

In the today’s changing market, the substation is becoming more and more a key element to meet end users requirements successfully and economically. Many existing substations have outlived their operational life and a one-to-one replacement of conventional AIS components like circuit-breakers and disconnectors is not economically advisable; completely new substations have to meet tough requirements in terms of occupied space, environment and availability. Substations extensions require high flexibility on primary equipment, to cope with already existing control systems, lack of available space, limited down time.

PASS M0 is the ideal primary equipment to meet all the above scenarios and it is the result of a different thinking; think for the performance of the substation as a complete system.

PASS M0 switchgear limits the number of equipment to what is really necessary to assure the best functionality of the bay; its modular design assures all the possible substation layouts can be realized.

The flexibility

PASS (Plug And Switch System) is based on ABB extensive experience in manufacturing both airinsulated switchgear (AIS) and gas-insulated switchgear (GIS).

PASS can also be thought as “Performance And Save Space”: any substation layout can be met while making efficient use of available space. Performance is guaranteed by the wealth of experience in research and development, manufacture and operation of switchgear which constitute the basis of ABB know-how.

The key characteristic of PASS is its compact and modular design which encompasses several functions in one module, as for example:

- Bushings for connection to one or two BusBar systems
- One circuit-breaker
- One or more combined disconnector/earthing switches
- One current transformer

Fig. 1
PASS M0 in its standard configuration (Single BusBar):
1: Combined disconnector/earthing switch
2: Circuit-breaker
3: Current transformer.
PASS is equivalent to a high voltage bay. In PASS M0 all live parts, excluding BusBars, are encapsulated in a grounded aluminium tank which is filled with pressurised SF6 gas. Each pole has its own enclosure, to increase availability and safety. The enclosures are of casted and welded aluminium construction.

Using standardised components, the addition of a secondary BusBar system to PASS M0 is straightforward.

As the picture Fig. 3 shows, with such a configuration PASS M0 is a complete High Voltage substation in incoming/outgoing configuration:

- the first bushings are connected to the power transformer;
- the second bushings are connected to the outgoing line;
- the third bushings are connected to the incoming line.

Therefore there is no traditional BusBar, i.e. the BusBar is realized within the PASS M0 by means of the first and second bushings.

PASS M0 in this configuration is a really breakthrough as system concept (patented) for distribution substation.
General description

Circuit-breaker
The PASS M0 circuit-breaker is a single pressure interrupter operating on the well-established self-blast principle.

The energy for interrupting currents is partly supplied by the arc itself, thereby reducing the energy requested from the operating mechanism of about 50% compared with a conventional puffer-type circuit-breaker.

Combined Disconnector/Earthing Switch
PASS M0 is equipped with a three pole operated combined disconnector/earthing switch. The operating principle (patented) is based upon the rotary motion of the contact which can be closed on the BusBar, earthed or left in the neutral position.

The mechanism is composed of minimal number of mechanical components and it is intrinsically reliable, and maintenance free. This modular design can be applied to PASS M0 in Single BusBar configuration, Double BusBar configuration and on all the bushings: BusBar or line sides.

All the combinations are possible.
In both cases, Single BusBar and Double BusBar, the position of the combined disconnector/earthing switch is clearly indicated at all times by an indicator which is mechanically coupled to the shaft. In addition to this, a visual confirmation is possible by means of a view port in the enclosure.

The disconnector/earthing switch may, in an emergency, be operated manually by means of a crank.

Current Transformer
PASS M0 is equipped with a conventional current transformer, to meet customer requirements, e.g. for retrofitting. Several combinations of cores for protection and measurements with different burdens are available. Up to 5 cores can be fitted into the current transformer.

Bushings
Overhead lines and BusBars are connected to the PASS M0 by air bushings. The main insulation is compressed SF6-gas. The insulator consists of an epoxy impregnated fibreglass tube with silicon rubber sheds. The flanges are heatshrunk and glued onto the tube making an extremely strong and gastight joint. The silicon rubber sheds are cast onto the tube and chemically bonded to it, thus allowing no moisture or contamination to enter between them. The silicon rubber sheds are hydrophobic and give very good rain and pollution performance. The main features are:

SF6 Gas System
The compact design of the PASS M0 module is due to the excellent insulation qualities of SF6 gas. Its dielectric strength in a homogeneous field is about 2.5 times greater than that of air at the same temperature and pressure. The design of the live components is such that the field distribution is as homogeneous as possible, which allows the intrinsic strength of the insulating gas to be utilized most efficiently.

- high safety (crack and explosion resistant)
- low weight
- excellent pollution and rain performance
- sandstorm resistant
- maintenance free.

SF6 gas pressures of the PASS M0 module at 20 °C
- Filling pressure .................. 680 kPa (abs)
- First alarm level .................. 620 kPa (abs)
- Nominal insulation pressure (blocking pressure) .............. 600 kPa (abs)

Filling pressure is about 15% higher than the nominal insulation pressure. This guarantees sufficient gas density over a long operational period. To ensure minimum gas loss during operation all enclosures, connections and valves are subjected to severe gas-tightness tests in the factory.

Gas density control
Each PASS M0 pole builds a single gas compartment. Since the dielectric strength of the switchgear and the breaking capacity of the SF6 circuit-breaker depend on the density of the SF6 gas, a gas density relay is installed to control gas density and detect leakage.
Over-pressure relief
To protect against excessive over-pressure due to unlikely internal arc faults a metal rupture-diaphragm (rupture disk) is installed. When a predetermined overpressure is reached, the rupture disk will break open and relieve the pressure which would otherwise cause the enclosure itself to rupture. Deflectors in front of the diaphragms ensure the safety of personnel.

Support structure
The support structure for the PASS M0 module is hot-dip galvanised and painted for protection against corrosion. It is designed in such a way to offer the maximum support and robustness while keeping civil works at minimum.

Integration with secondary system
PASS M0 is equipped with a conventional process coupling: e.g. auxiliary contacts for circuit-breaker and disconnector/earthing switch positions and relay outputs for signalling (e.g. SF6 lock out).
This conventional interface allows the PASS M0 to be connected with any control and protection system, thus enabling retrofitting and upgrading of already existing substations.
Once installed in the field, two multipolar cables from the local control cubicle are the only items to connect PASS M0 to the control and protection system.

Environmental impact and Life Cycle Cost
PASS M0 is kind to the environment. Global life cycle cost and impact on the environment were considered during PASS M0 design since beginning. Compared to a conventional air insulated solution which implements the same functions, PASS M0 meets the following targets:
- SF6 reduced by 80%
- maintenance cost reduced by 38%
- space reduced by 70%
- total life cycle cost less than 60%

Compared to a conventional 5 bays H layout air insulated substation, the global life cycle cost for PASS M0 is estimated to be more than 30% lower (see diagram on page 28).
Moreover PASS M0 has been subject to the LCA (Life Cycle Assessment), a study that covers all environmental aspects during the whole life of the product. In this regard, EDP (Environmental Product Declaration) provides a quantitative and verified description of the environmental performance of PASS M0, viewed from a comprehensive life cycle perspective.

Transportation
No special arrangements are needed for shipping and transportation. PASS M0 fits into a standard truck container and does not require any packaging. Once on site a simple 30° rotation of the outer poles is needed for the final layout of PASS M0.
The following pictures show PASS M0 145 kV in Single and Double BusBar configuration in transportation and operation positions. The compactness in both positions is self-evident.
Fig. 7A
PASS M0 145 kV SBB
Transportation Position.

Fig. 7B
PASS M0 145 kV SBB
Operation Position.

Fig. 7C
PASS M0 145 kV DBB
Transportation Position.

Fig. 7D
PASS M0 145 kV DBB
Operation Position.
Manufacturing and Quality Assurance

Manufacturing

PASS M0 is born from the wealth of experience in research and development, manufacturing and operation of switchgears within ABB Power Technologies in Lodi. Parts which are not directly manufactured are supplied by other ABB companies. The choice of materials, suppliers, sub-assemblies and working procedures is governed by the internal standard quality assurance programs, which meet the requirements laid down by ISO 9001 and 14001.

On-site assembly

A PASS M0 module is equivalent or almost equivalent to a complete bay. It allows the installation of substations in a short period of time: each bay can be unloaded from the trailer and directly installed on the platform foundation (extremely small). The on-site erection of PASS M0 modules is simplified since PASS M0 is assembled in the factory before the shipment. The installation of a PASS M0 requires about a few hours with a crew of two (not including gas handling).

Standards

PASS M0 meets the requirements set out in the following documents:
- IEC (all relevant standards - see technical data)
- ISO 9001 and 14001.

The enclosure complies with the following standard for pressure vessels:
- CENELEC EN 50052.

Quality handbooks and inspection plans can be provided to the customer on request.

Quality assurance testing

Type tests

All type tests specified by the relevant IEC standards have been passed. Tests can be repeated on request at customer’s expense. Copies of certificates and reports can be provided on request.

Routine tests

Before leaving the factory all PASS M0 units are subject to the following routine tests:
- AC High voltage test;
- dielectric tests on auxiliary control units;
- pressure tests of the enclosure according to CENELEC-EN 50052 1986 TC 17C WG MPE. The enclosure is tested at double the design overpressure for one minute. This test also meets the requirements of IEC 60517;
- gas tightness;
- mechanical functional test of all moving parts;
- test of all equipment and accessories;
- AC high voltage test with PD measurement.

These tests ensure perfect functionality of all components before they leave the factory. A test report is produced for all tests. If so required customers can attend routine testing having received invitations well in advance.

On-site testing

After final assembly or commissioning of the substation, the following tests are made:
- mechanical functional testing of circuit-breaker, and combined disconnector/earthing switch;
- testing of SF6 gas-tightness;
- random sampling of moisture content in individual components;
- checking and functional testing of control and auxiliary equipment.

After completion of these tests a handover report is completed.
**General Ratings**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated frequency</td>
<td>50/60 Hz</td>
</tr>
<tr>
<td>Rated voltage</td>
<td>170 kV, 2/3/123/145/170 kV</td>
</tr>
<tr>
<td>Rated current</td>
<td>2500 A (1)</td>
</tr>
</tbody>
</table>

**Max. test voltage:**

a) Phase to ground:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated short time power frequency withstand voltage, 1 min</td>
<td>325 kV, 140/230/275/275 kV</td>
</tr>
<tr>
<td>Rated lightning impulse withstand voltage 1.2/50 µs</td>
<td>750 kV, 325/550/650/650 kV</td>
</tr>
</tbody>
</table>

b) Across isolating distance (circuit-breaker, disconnector):

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated short time power frequency withstand voltage, 1 min</td>
<td>375 kV, 160/265/315/315 kV</td>
</tr>
<tr>
<td>Rated lightning impulse withstand voltage 1.2/50 µs</td>
<td>860 kV, 375/630/750/750 kV</td>
</tr>
</tbody>
</table>

**Rated short time withstand current (3 s)**                                  | 40 kA                                                                |
| **Rated peak withstand current**                                            | 100 kA                                                               |

**Ambient temperature**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min. (2)</td>
<td>-25 °C, -30 °C</td>
</tr>
<tr>
<td>Max.</td>
<td>+55 °C</td>
</tr>
</tbody>
</table>

**Gas loss per year**                                                        | < 1%                                                                |

**Weight**

<table>
<thead>
<tr>
<th>Single BusBar</th>
<th>1900 kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Double BusBar</td>
<td>2150 kg</td>
</tr>
<tr>
<td>Incoming - outgoing</td>
<td>2300 kg</td>
</tr>
</tbody>
</table>

**SF6 pressures (20 °C) (absolute values)**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filling pressure</td>
<td>700 kPa, 680 kPa</td>
</tr>
<tr>
<td>First alarm level</td>
<td>660 kPa, 620 kPa</td>
</tr>
<tr>
<td>Nominal insulating pressure (blocking pressure)</td>
<td>640 kPa, 600 kPa</td>
</tr>
</tbody>
</table>

(1) Up to 3150 A, on request.
(2) Lower temperatures can be reached by a gas mixture on request.

**Circuit-breaker**

Single interrupter, type LTB-D

- Rated short circuit breaking current ........................................... 40 kA / 50 Hz
- Rated short circuit breaking current ........................................... 40 kA / 60 Hz
- Rated short circuit making current (close and latch) .................... 100 kA pk.
- Line charging switching .............................................................. 63A
- Cable charging switching .............................................................. 160A
- Drive ....................................................................................... 3 poles spring operated / Single pole
- Type ......................................................................................... BLK 222 / BLK 82
- Rated operating sequence ....................................................... O-0.3 s-CO-1min-CO
- Opening time ............................................................................... <=25 ms
- Breaking time (50 Hz) ................................................................... <=47 ms
- Breaking time (60 Hz) ................................................................... <=44 ms
- Closing time ............................................................................... <=42 ms
- Rated supply voltage of auxiliary circuits .................................. 110VDC (typical)
**Disconnector/Earthing Switch**

Drive .............................................................................. 3 poles motor operated
Rated supply voltage of auxiliary circuits ......................... 110VDC
Switching time from line to earth .................................................. 5.5 s

Emergency manual operation possible (hand-crank).
Contact position visible through porthole.

**Current Transformer**

Type ........................................................................................................ ring CT
Measurement class ........................................................................... 0.2/0.5/1.0
Protection class .............................. meets all requirements
IP code (IEC 60144) .................................................................................. IP 54

- **Current Transformer (example)**
  - Current ratio .......................................................... 300-600/1-1-1 A
  - Cores ....................................................................................................... 3
  - Accuracy class .......................................................... 10 VA, cl. 0.2, FS<10
  - Burden ............................................................. 20 VA, 5P20 / 20 VA, 5P20
  - Rated continuous current ............................................................... 1.2 IN A

**Bushings**

Type ................................................................. composite insulator
Rated voltage ................................................................. 145kV / 170 kV
Arching distance ................................................................. 1304mm/1633 mm
Creeepage distance ................................................................. 4670mm/5462 mm
Max. permissible static mechanical force ........................................... 1000 N/1000 N

**Standards**

PASS switchgear is produced according to the following standards:
- For pressure vessel construction: ......................... CENELEC EN 50052
- For quality assurance: ................................................... ISO 9001, 14001

For switchgear and associated equipment:
- High voltage switchgear ............................................................. IEC 60694
- SF6 switchgear ................................................................. IEC 62271-203
- Bushings ................................................................................... IEC 60137
- Current transformers ........................................................ IEC 60044-1
- Disconnect/earthing switch .................................................. IEC 62271-102
- Circuit-breaker ............................................................... IEC 62271-100
Substation layouts with PASS M0 innovative solution

PASS M0 IOS

The cooperation with Enel in Italy originated a completely new system concept - patented - for distribution substations. The principle is to use components for double BusBar system for a Single BusBar substation configuration.

PASS M0 for Double BusBar fits very well in this concept and it is used as a complete HV substation.

No traditional BusBar are used, i.e. the BusBar is inside the PASS M0 (see single line diagram fig. 9).

Customer requirements in terms of current and voltage detection and measurements are fulfilled by non conventional sensors on board of PASS M0. Conventional current transformer is also available.

PASS M0 used in this configuration presents a lot of advantages for customer:

- reduction of occupied space;
- reduced environmental impact (more and more a critical factor in highly populated and highly industrialized countries);
- reduction of losses due to smaller MV networks (HV can be brought closer to the end user and the number of HV substations can be substantially increased);

Fig. 9

1. Single line diagram (PASS M0 IOS substation, ENEL).
2. PASS M0 Double BusBar Fed-through.
Fig. 11A
PASS M0 IOS 145-170 kV
Transportation Position.

Fig. 11B
PASS M0 IOS 145-170 kV
Operation Position.

- reduction of short circuit current (benefits for all the equipment);
- easy installation;
- reduced commissioning time of the whole substation;
- substation is completely transportable (three pieces: HV switchboard PASS M0, power transformer, MV feeders);
- reduced life cycle cost.

Fig. 12
Fed-through S/S The total substation area including high voltage equipment, transformer, medium voltage equipment and control cubicles is ~40m x 18m only.
Some applications

*H scheme single BusBar substation*

The drawing below shows a H scheme Single BusBar indoor substation, composed by 2 incoming feeder bays and 2 trafo bays. It also presents a coupling bay. There is a PASS M0 for each bay (total 4). The switchyard area is 16mx22m.

![H scheme Single BusBar indoor substation](image13.png)

**Single BusBar with coupling bay**

The drawing below shows a substation Single BusBar with 6 feeder bays, 2 trafo bays and 2 spare bays for future expansions. A bus coupler bay is present. There is a PASS M0 for each bay (total 11). The switchyard area is 14mx34m.

Notice that PASS M0 can be moved in order to fulfill the BusBar phase distance.

![Single BusBar with coupling bay, top view](image14.png)
Fig. 15
Transformer and line bays.

Fig. 16
Coupling bay, section view.
PASS M0 variant

Fig. 17 A - PASS M0 SBB with GIS VT's.

Fig. 17 B - PASS M0 IOS.

Fig. 17 C - PASS M0 DBB.

Fig. 17 D - PASS M0 DCB.
PASS M0 SBB with additional Current Transformer.

PASS M0 SBB cable ends.

PASS M0 DCB cable ends and bushing.
Fig. 21
Mobile Substation in transport condition.

Fig. 22
Mobile Substation in operating condition.
**PASS M0 132/20 - 25 MVA**

![Diagram of Mobile Substation in transport condition.](image1)

**Fig. 23** Mobile Substation in transport condition.

![Diagram of Mobile Substation in operating condition.](image2)

**Fig. 24** Mobile Substation in operating condition.
PASS M0 Railway Mobile Substation

Fig. 25
Mobile Substation for Italian railway in transport condition.

Fig. 26
Mobile Substation for Italian railway in operating condition.
**LCC - Life Cycle Cost** (examples from OSCAR)

**Customer needs:**
- feed energy to S/S A, B, C
- minimum space
- maximum availability on S/S B
- cost.

**Customer solution:**
- conventional Double BusBar system.

**PASS M0 solution:**
- PASS M0, Single busbar
- same functionalities
- reduced space occupation
- reduced cost.

**Life Cycle Cost comparison**

**INITIAL COST:**
engineering, civil works, components, secondary equipment, space acquisition, erection, spare parts, etc.

**FIXED COST:**
Operation and maintenance.

**VARIABLE COST:**
repairing, power interruption, energy interruption.
Fig. 29 Component details.

A2. Gas connection.
A3. Density sensor.

B1. Position indication combined disconnector.

C1. Combined disconnector drive.
C2. Transmission shaft.

D1. Circuit-breaker operating mechanism.