Eaton delivers the power inside hundreds of products that are answering the demands of today’s fast changing world.

We help our customers worldwide manage the power they need for buildings, aircraft, trucks, cars, machinery and entire businesses. And we do it in a way that consumes fewer resources.

Next generation transportation
Eaton is driving the development of new technologies – from hybrid drive trains and emission control systems to advanced engine components – that reduce fuel consumption and emissions in trucks and cars.

Higher expectations
We continue to expand our aerospace solutions and services to meet the needs of new aviation platforms, including the high-flying light jet and very light jet markets.

Building on our strengths
Our hydraulics business combines localised service and support with an innovative portfolio of fluid power solutions to answer the needs of global infrastructure projects, including locks, canals and dams.

Powering Greener Buildings and Businesses
Eaton’s Electrical Group is a leading provider of power quality, distribution and control solutions that increase energy efficiency and improve power quality, safety and reliability. Our solutions offer a growing portfolio of “green” products and services, such as energy audits and real-time energy consumption monitoring. Eaton’s Uninterruptible Power Supplies (UPS), variable speed drives and lighting controls help conserve energy and increase efficiency.
Eaton’s knowledge and understanding of industries, applications, technology and products enables us to offer customers safe, reliable and high performance solutions. We have been part of the Medium Voltage switchgear technology creation and therefore carry what’s needed with us – always!

**Complete MV switchgear solutions**

The series of Eaton Medium Voltage systems offers switchgear and components for applications in distribution networks (substations and transformer stations) and industrial power supplies. These technically high quality systems are air or epoxy resin insulated and are always equipped with circuit-breakers based on proprietary vacuum interrupters.

The medium voltage switchgear systems carrying Eaton’s brand are based on the use of vacuum circuit-breakers combined with solid insulation material. This is an environmentally-friendly technology in comparison with the methods used by many other suppliers, which use SF₆ as an insulation medium.

Eaton thus has a wide range of switching systems and components that offer an environmentally friendly solution for every application. Additionally, Eaton’s global service network provides maximum customer support in all regions of the world.

**Industry leading vacuum and solid insulation technology**

Through more than eighty years of innovation and experience, Eaton has developed environmentally friendly vacuum interrupters capable of reliably switching both normal load currents and high stress fault currents.

Eaton is one of the few companies in the world producing vacuum interrupters and has succeeded in developing world class products with a number of international patents. This has been achieved through company acquisitions over the years of Westinghouse, Cutler-Hammer, MEM and Holec.

To increase the dielectric strength of the vacuum interrupter, Eaton has also designed vacuum interrupters that are encapsulated in epoxy resin material. The medium voltage IEC circuit breaker family utilizes this solid insulation technology that has been catering to a wide range of applications for more than 40 years.
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9. Introduction

9.1. System

The Power Xpert® FMX is Eaton’s single busbar, air insulated medium voltage switchgear up to 24 kV.

The system is a modern, high quality design based on environmentally-friendly aspects and long lasting technology.

Within the system our engineers integrated the best core technologies out of our different current systems. Besides using these core technologies, with an experience of more than a century, they also introduced a new ElectroMagnetic technology for the circuit-breaker.

The product fits well within the rest of the Eaton’s medium voltage product portfolio, being an extension to the Eaton medium voltage products Magnefix, Xiria and SVS and an addition to the MMS double busbar and Power Xpert® UX withdrawable switchgear.

In combination with Eaton’s low voltage switchgears, busbar trunking, UPS products, project management & service capabilities, the FMX can be part of a complete solution to the customer.
9.2. Application

The FMX is ideally suited for application in Main feeder stations, Subdistribution stations, (Process) Industry and Infrastructure projects.

Some applications are:

- Main feeder stations
- Subdistribution stations
- Cement industry
- Mining industry
- Automotive industry
- Petrochemical plants
- Textile, paper & food industry
- Infrastructure projects
- Hospitals
- Food industry
- Data centres

The design philosophy makes the system especially suitable for applications where a reliable, safe and clean environment is necessary.
9.3. Core technologies

Solid insulation using cast resin technology
Epoxy resin (cast resin) is used as high-quality primary solid insulation material around live parts.

By using cast resin technology for solid insulation, Eaton design engineers can shape the parts specifically for optimal insulation, robust construction and cooling purposes.

With many years of experience of design and manufacture of epoxy resin insulated components, we have learned to integrate conductors and vacuum interrupters directly into the moulding, and to make complex shapes. FMX utilises optimal field control through the special design of all primary components.

Electrical field control
With conventional shapes for primary components like busbars and conductors, the electrical field between the and earth, is non-uniformly distributed. In areas with high fields, partial break-through can trigger avalanches resulting in flash-overs. In-depth knowledge of breakthrough phenomena and field steering phenomena and field steering techniques enables us to prevent flash-over completely. The result is a particularly compact design.

Vacuum technology: safe, compact and reliable
Eaton vacuum interrupters consist of a ceramic cylinder, housing a fixed and movable contact. Movement of the contact under vacuum conditions is performed by bellows. A shield surrounding the contacts prevents the insulators from becoming contaminated by metal vapour produced during current produced during current interruption. This shield also ensures good potential distribution over the insulator.

A special feature of Eaton vacuum interrupters is that a large number of parallel arcs are created between the contacts. This “diffuse discharge” is characterised by very low arc voltage and short arc times, resulting in very low arc energy. Contact wear in a vacuum interrupter is therefore virtually negligible. Vacuum interrupters are maintenance free and are certified up to 30,000 operation cycles.
9.4. Innovation

The advantage of an electromagnetic mechanism over a conventional spring operated mechanism

To switch a vacuum interrupter effectively, the driving mechanism has to operate according to a specific force-stroke characteristic (- - -), see the diagram.

A conventional, spring operated mechanism has force-stroke characteristics (- - -) that differ greatly from the required characteristics. The required force-stroke diagram therefore has to be transferred from the spring characteristics, leading to mechanisms that require a large number of links moving at high speed.

An electromagnetic mechanism has a force-stroke diagram (- - -) that already resembles the force-stroke characteristic that is required for vacuum switchgear. Therefore electromagnetic mechanisms can be very simple in their construction. They consist of a minimum amount of parts and can be coupled directly to the vacuum interrupter, because of the favorable force-stroke characteristics. Due to this direct coupling maximum rigidity is reached, which is advantageous for the rate at which contact pressure is reached and the effectiveness of contact breaking.

To summarise, the electromagnetic mechanism has the following advantages:

- Superior reliability due to use of less parts and direct drive with high rigidity
- Cost effective, maintenance free and compact due to the low number of parts
- Tested for a high number of 30,000 switching cycles

Force-stroke characteristics
- as required by vacuum switch
- as offered by a conventional spring operated mechanism
- as offered by an electromagnetic mechanism
Innovative Electromagnetic Mechanism in FMX switchgear

Eaton’s electromagnetic mechanism is based on the idea of separating the magnetic circuits for closing, holding and opening.

The mechanism consists of a permanent magnetic actuator and the basic mechanism in which a drive rod is connected to the vacuum interrupter. The permanent actuator is mono-stable; only the closed position is maintained by permanent magnets. The end position for opening, and therefore the stroke of the actuator, can be chosen at random within certain limits. For this innovative concept, a patent has been granted.

The standard position of the plunger is in the upper position. In this position the circuit-breaker is in the open position.

Closing

To close the circuit-breaker, the closing coil is energised. The current creates a magnetic flux in the yoke, which forces the plunger down. The force on the plunger is directly proportional to this current. When the force on the plunger becomes greater than the counteracting forces of the opening spring, the closing movement starts. When closed, the drive rod is kept in position by permanent magnets.

Opening / tripping

Opening is basically a passive action: the energy stored in the contact pressure spring and the opening spring is released. The release of this energy can be occasioned by an integrated trip coil, or a mechanical lever.

Tripping (opening) the circuit-breaker is done by energising the tripping coil. By this, the magnetic flux of the permanent magnet is partly compensated. As soon as the holding force of the permanent magnet is less than that of the contact pressure spring, the plunger will move to the upper position, consequently opening the contacts in the vacuum interrupters. Due to the force in the contact pressure spring, the required energy for tripping is very low compared to closing the breaker.
Controlling an Internal Arc

An internal arc in switchgear causes an overpressure, together with the release of fire and smoke. By design, vacuum and air/solid insulated switchgear has the least environmental impact after an internal arc event. The impact of an arc is twofold: internal impact (in the switchgear) and external impact (in the switch room).

The overpressure created by an internal arc will, in standard switchgear, be channeled out of the switchgear by means of a pressure relief duct. This duct is normally an additional compartment to the switchgear and therefore increasing the panel dimension. As an alternative to the duct, a complicated and expensive arc channel can be installed, which guides the arc output into the switch room. The FMX is designed in such a way that both impacts are significantly reduced, and therefore in essence no complicated and costly arc channel is needed.

No phase-to-phase short circuits minimises pressure

Within the FMX, all high voltage parts in accessible compartments are single pole insulated. The advantage of this single pole construction is that the only conceivable internal fault is a single-phase short circuit, e.g. due to a cable connection failure (when single-core cables are connected, as is normal practice nowadays).

Integrated compartments reduce pressure

By integrating different compartments, internal arc pressure is significantly reduced because of the volume.

For the FMX panel, cable connection, circuit-breaker and voltage transformers are integrated in one large, metal enclosed, compartment instead of individual small compartments.

The busbar compartment of the switchgear consists of one overall compartment with no extra partitions between panels.

Arc absorber reduces output impact

To minimise the impact of an internal arc in the busbar compartment, the arc is “guided” outside the panel by an arc absorber installed in the rear of the unit. A standard FMX feature is the use of an integrated arc absorber to reduce output into the switch room. By using ceramic blocks with an absorbing surface of 9 m² this absorber breaks up and filters gasses and fire significantly.
Fixed in Philosophy, Flexible in Design

The FMX switchgear is designed based on Eaton’s proven fixed technology. The primary objective of this technology is to increase safety and reliability within a more compact and cost effective housing.

The advantages of a fixed design….

The fixed design contains different features that provide optimal reliability of the switchgear.

Firm connections between breaker and the overall system

Firm and simple interconnection between the breaker and the other fixed system parts (cable and busbar) ensure a robust and reliable system.

Optimal safety by fixed interlocked housing

Optimal safety is realized by integrating all primary parts into a fixed housing. Access to high voltage compartments in the switchgear are prevented by safety interlocks. Within these compartments all primary parts are sealed for live by means of epoxy resin. Operation of the switchgear is very simple and only possible when the high voltage compartments are closed. The operation panels are positioned at the front side of the switchgear and the safety interlocks provide a safe situation for the operator.

Reliable circuit-breaker

The latest design in electromagnetic mechanism is used to control the circuit-breaker. This electromagnetic mechanism and the vacuum interrupters it operates, are both tested for 30,000 full-load operations and 100 short-circuit operations. This number of operations in combination with the simple mechanism design, requires no maintenance and exchange activities on the circuit-breaker. Moreover this maintenance-free fixed design responds to the current lack of technically skilled personnel that will become even worse in future.

Additional flexibility ... control and exchange of circuit-breakers

Despite the fact that the fixed FMX design has all the features that contribute to optimal reliability, some customers still want to have the ability to test, maintain and/or exchange the circuit-breaker very simple and quickly. To meet this market demand the FMX added this flexibility to its fixed design.

Controller for status indication of the mechanism

First of all the FMX is equipped with a “health check” function for testing the quality of the circuit-breaker. By means of a controller the quality of the circuit-breaker mechanism is being checked. The controller is for example checking the opening and closing circuit. The status will be presented on the manual operation panel or remote.

Easy and quick exchange of the circuit-breaker

The FMX circuit-breaker can be exchanged in less than 30 minutes. Only a few steps are necessary to remove the circuit-breaker. This procedure requires a minimal working space in front of the panel. Plugging-in a new breaker can be done in the opposite sequence with minimal effort.

Because the system is based on fixed technology the primary contacts are very simple and robust. The latter will provide that during exchange the contacts will not be damaged. During exchange of the breaker the rest of the switchgear can stay energized and therefore minimizing the impact on the grid. For optimal operator safety we have executed internal arc tests in the busbar compartment and the adjacent panels while the breaker was withdrawn.
9.5. Features and Benefits

Safe in Use
- Compartments protected against penetration by objects
- Capacitive voltage detection system for verification of safe isolation from supply
- Operation only possible with closed cable compartment
- Logical mechanical and electrical interlocks prevent mal-operation
- Cable testing via integrated cable test facility outside high voltage compartments
- Voltage transformers can be (dis)connected from the primary circuit, with closed high voltage compartments
- Smooth contemporary design

Low Total Cost of Ownership
Low initial costs due to:
- Panels minimum 500 mm width
- Cable connection from the front (back to wall arrangement)
- Integrated arc channel with absorbers
- 12 kV and 24 kV panels in the same housing

No costs during service due to:
- Robust design with a minimum number of parts (routine tested in factory)
- Long-life, using epoxy resin as insulation medium
- Maintenance-free circuit-breaker (electromagnetic mechanism and vacuum interrupters)
- No SF₆ pressure checks

Low end of life disposal cost due to:
- Vacuum switching technology
- Solid insulation with air as insulating medium
- Recycling or re-use of materials

User Friendly
- Cable connection and user interfaces for operation on the frontside of the unit
- Ergonomic cable connection height of 750 mm from floor level
- Different cable cone lengths for easy cable connection
- Cable (secondary) entry points on both sides of the low voltage compartment top plate
- Secondary cable terminals positioned at a good reachable height within the low voltage compartment
- Clear and simple, straightforward operation panels
- Facility for (dis)connecting the voltage transformers, easily accessible from the front without entering the HV compartment
- Integrated cable test facility positioned on the manual operation panel
Environmentally Friendly
- Minimised number of components
- Environmentally-friendly materials used in the design
- No use of SF₆-gas for switching and insulation (green switching)
- Energy-efficient production and assembly, with environmentally friendly energy sources
- Minimal number of transition points in the primary design enables low energy loss during operation
- Only re-usable and/or recyclable materials used

Reliable and Safe in Operation
- Complete design certified in accordance with IEC
- Arc fault tested in accordance with IEC 62271-200
- Quality assurance in accordance with DIN EN 9001
- Product quality guaranteed by execution of prescribed routine tests during production
- Single pole insulated primary parts within one compartment
- Separate busbar compartment
- Integrated cable test facility
- Ferro-resonance protected voltage transformers
- Integrated (internal) arc absorbers
10. Product range

10.1. Overview

Circuit-breaker panel (500 or 1000 mm panel)   Busbar sectionalizer panel (1200 or 1325 mm panel)

- Circuit-breaker
- Change-over switch
- 2 cables
- 3 cables
- Capacitive voltage detection system
- Voltage transformer at the cable (disconnectable)
- Voltage transformer at the busbar (disconnectable)
- Current transformer
10.2. Panel description

Circuit-breaker

**Basic panel**
- Low voltage compartment
- Manual operation panel with position indication
- Circuit-breaker (ElectroMagnetic)
- Change-over switch
- Voltage detection system Horstmann WEGA 1.2
- Cable cones
- Cable clamps
- Three-phase busbars
- Auxiliary contact circuit-breaker 1NO + 1NC
- Auxiliary contact change-over switch 1NC (service position), 1NC (earthed position)

**Options**
- Cable test facility
- Protection relay
- Current transformers for protection
- Current transformers for metering
- Core balance current transformers
- Cable side voltage transformers
- Busbar side voltage transformers
- Change-over switch motorized
- Volt meter
- Ampere meter
- Under voltage release
- Second tripping coil
- Auxiliary contacts circuit-breaker 7NO + 7NC
- Auxiliary contacts change-over switch 3NC (service position), 3NC (earthed position)

**Technical data**

<table>
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<td>25</td>
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<td>10000 x</td>
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<tr>
<td>Class</td>
<td></td>
<td></td>
<td>M2, E2, C2</td>
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</table>
Busbar sectionalizer

**Basic panel**
- Low voltage compartment
- Manual operation panel with position indication
- Circuit-breaker (ElectroMagnetic) (right panel)
- Change-over switch (both panels)
- Three-phase busbars
- Door interlocking
- Auxiliary contact circuit-breaker 1NO + 1NC
- Auxiliary contact change-over switch 1NC (service position), 1NC (earthed position)

**Options**
- Voltage detection system Horstmann WEGA 1.2
- Protection relay
- Current transformers for protection
- Current transformers for metering
- Busbar side voltage transformers
- Volt meter
- Ampere meter
- Change-over switch motorized
- Under voltage release
- Second tripping coil
- Auxiliary contacts circuit-breaker 7NO + 7NC
- Auxiliary contacts change-over switch 3NC (service position), 3NC (earthed position)

**Technical data**

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<td>kA</td>
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<tr>
<td>Rated peak withstand current</td>
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<td></td>
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<tr>
<td>Rated short-circuit making current</td>
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<td>10000</td>
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<tr>
<td>Class</td>
<td></td>
<td></td>
<td>M2  , E2  , C2</td>
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</tbody>
</table>
11. Design

11.1. Basic design

The FMX system is modular in construction. This ensures that any panel combination and sequence is possible. In addition, the number of panels capable of being used in an installation is unlimited, as several sections can easily be connected. The panels in the FMX system are compact (min. 500 mm wide), resulting in considerable savings in costs and installation space.

Circuit-breaker panel (example)
1. Protection relay
2. Arc absorber
3. Mimic diagram with push buttons for operation of circuit-breaker and two-position change-over switch
4. Busbar
5. Voltage detection system
6. Two-position change-over switch
7. Vacuum interrupter
8. Manual operation panel with position indicator
9. Current transformers
10. Cable cones
11. Coil and resistor for protection against ferro-resonance
12. Voltage transformers
13. Low voltage compartment (electrical control panel)
14. Vacuum circuit-breaker with electromagnetic mechanism
15. Cable test facility
16. Cable clamps
17. Earth bar
11.2. Vacuum circuit-breaker

Operating sequence
The rated operating sequence of the vacuum circuit-breaker is O – 0.3s - CO – 15s - CO.

There are two alternative rated operating sequences as follows:
O - t - CO - t’ - CO
Unless otherwise specified:
t = 3 min for circuit-breakers not intended for rapid auto-reclosing;
t = 0.3 s for circuit-breakers intended for rapid auto-reclosing (dead time)
t’ = 3 min.

NOTE Instead of t’ = 3 min, other values: t’ = 15 s and t’ = 1 min are also used for circuit-breakers intended for rapid auto-reclosing.

Class
The class of the vacuum circuit-breaker is M2, E2, C2.

The class is defined in the IEC standard IEC 62271-100.

Circuit-breaker class M2:
Frequently operated circuit-breaker for special service requirements and designed so as to require only limited maintenance as demonstrated by specific type tests (circuit-breaker with extended mechanical endurance, mechanically type tested for 10,000 operations). The FMX mechanism is additionally tested for 30,000 operations.

Circuit-breaker class E2:
Circuit-breaker designed so as not to require maintenance of the interrupting parts of the main circuit during its expected operating life, and only minimal maintenance of its other parts (circuit-breaker with extended electrical endurance)

Circuit-breaker class C2:
Circuit-breaker with very low probability of restrike during capacitive current breaking as demonstrated by specific type tests
Switching times
In the table below the switching times of the vacuum circuit-breaker are shown.

**Switching times vacuum circuit-breaker**

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Closing time</td>
<td>70 ms</td>
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<tr>
<td>Opening time</td>
<td>50 ms</td>
</tr>
<tr>
<td>Arcing time</td>
<td>&lt; 20 ms</td>
</tr>
<tr>
<td>Break time</td>
<td>&lt; 70 ms</td>
</tr>
<tr>
<td>Dead time</td>
<td>300 ms</td>
</tr>
<tr>
<td>Total charging time</td>
<td>&lt; 10 s</td>
</tr>
</tbody>
</table>

All above times are exclusive the relays time. This is time is set by IEC on 10 ms.

Switching rate of the vacuum interrupter
In the graphic below the number of operations of the vacuum circuit-breaker are shown.

**Electrical data**
Rated voltage 24 kV
Rated short-circuit breaking current <= 25 kA
Rated normal current <= 2000 A
11.3. Change-over switch

All Eaton MV switchgear have a design in which a 2-position change-over switch is used in combination with a circuit-breaker or a load-break switch. The 2-position change-over switch can have 2 positions. The earthed position and the service position. The change-over switch can only be operated (is interlocked) if the circuit-breaker is switched off. Earthing a cable is done via the circuit-breaker.

Class
The class of the change-over switch is M0, E2.

The class is defined in the IEC standard IEC 62 271-102.

Disconnector class M0
Disconnector having a mechanical endurance of 1000 operating cycles, suitable for applications in distribution and transmission systems fulfilling the general requirements of this standard.

Earthing switch class E2
Earthing switch of class E1 requiring minimal maintenance, capable of an extended number of short-circuit making operations suitable for applications in systems up to and including 52 kV.

Switching times change-over switch

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<table>
<thead>
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<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Closing time</td>
<td>&lt; 20 s</td>
</tr>
<tr>
<td>Opening time</td>
<td>&lt; 20 s</td>
</tr>
</tbody>
</table>

* more contacts are possible (option)
* auxiliary voltage 24/48/60/110/220 V DC & 110/230 V AC

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11.4. Busbars

1. Electrical field screen (cast resin)
2. Branch (aluminium / copper)
3. Busbar (aluminium)

The busbars are positioned in a separate air insulated compartment with IP degree 4X. This compartment is only accessible by means of a tool. The busbars are constructed in such a way that they fully support a compact and air insulated design. The busbars are made of high quality aluminium and are standard designed for 24 kV, 2000 A, 25 kA.

All busbars are protected against corrosion by means of an anodized layer on the surface.

Coupling is realized by means of silver plated copper coupling blocks that are connected inside the C-shape busbar construction. To prevent corrosion penetrox is lubricated between the coupling blocks and the aluminium busbars. See picture for an example how the busbars are coupled.
11.5. Low voltage compartment
The low voltage compartment is equipped with secondary wiring and protection & control equipment as the customer wishes. The external secondary wiring entry for the system is on top of the LV compartment. The panel-to-panel wiring is constructed in such a way that the low voltage compartment can be taken off while the other panels remain in service. The wires of the compartment to be taken off can be easily disconnected by a plug. The customer related terminals are positioned at an easily accessible location.

Dimensions:
- Height: 600 mm (standard). On request higher values are possible
- Width: 500 mm (cover total width of the panel)
- Depth: 500 mm

Secondary wiring
The secondary wiring will be executed with single-core flexible untinned copper wire with heat resistant grey colored pvc insulation. Type H07V2-K. Voltage grade 450/750 V. Operating temperature max. 105 ºC.

Cross section 1.5 mm² for the control circuits and 2.5 mm² for the voltage and current transformer circuits.

The wiring is executed according to our standard for wiring and is marked according IEC 60391 (sub. 3.4.1.a.3). This is a system of marking in which each end of a conductor is marked both with the marking of the terminal to which it is connected and also with that of the terminal to which the remote end is connected. The marking is printed in black characters on the wire (terminal code).

In general only one wire is connected to a terminal or termination point. The connection of two or more wires to one terminal or termination point is only done when the terminal or termination point is designed for this purpose.

The multi-strands conductor ends are not provided with any wire end finishing component for those terminals and termination points which are designed for this method of connection. Wire pin, spade, open tongue and ring tongue terminations, with or without insulation support, are used as far as necessary for the given terminal.

Where necessary, the secondary wiring is connected to terminal strips make Wago with quick type connection for internal wiring and cage-clamp type connection for external wiring. Auxiliary cables for external connections can be connected directly to these terminals.
11.6. Control panels

The FMX unit is equipped with two types of control panel, one for normal operation and one for operation under special circumstances such as in case of there is no auxiliary supply voltage.

1. Electr. push button of 2-position change-over switch to busbar position.
2. Position indicator Circuit-breaker.
3. Electr. push button of Circuit-breaker to ON position.
4. Voltage detection system.
5. Locking slide of 2-position change-over switch.
6. Mechanical position indicator of 2-position change-over switch.
7. Earth position interlocking.
8. Mechanical operating handle Circuit-breaker to OFF position.
10. Interlocking of cable compartment (option).
11. Door cable compartment.
12. Electr. push button of 2-position change-over switch to earth position.
13. Position indicator of 2 position change-over switch.
14. Electr. push button of Circuit-breaker to OFF position.
16. Indication of the status of the controller of the EM mechanical drive.
17. Electr. push button for connection of voltage transformers (option).
18. Electr. push button for disconnection of voltage transformers (option).
19. Mechanical position indicator of disconnector of voltage transformers (option).
20. Locking slide for access openings (option).
21. Access openings for cable testing (option).
Isolating the change-over switch (option)

It is possible to isolate the change-over switch. This can be done by moving the locking slide for the change-over switch in a specific position. Next this position can be padlocked.

**Position:**
1. Hand operation, electrical operation blocked
2. Hand and electrical operation blocked
3. Electrical operation, hand operation blocked

### 11.7. Current transformers

- According IEC 60044-1
- Designed as ring-core, single-pole transformer
- Free of dielectric stress due to earthed layer between HV and LV
- Inductive type
- Terminals in LV compartment

A lot of combinations with a choice for burden, ratio and class are possible for current transformers for protection and measuring depending on the number of connected cables and length of the primary conductor.

#### Electrical data

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated continuous thermal current</td>
<td>Max. 1.2 x rated current (primary)</td>
</tr>
<tr>
<td>Rated thermal short-time current</td>
<td>Max. 25 kA</td>
</tr>
<tr>
<td>Measuring core</td>
<td></td>
</tr>
<tr>
<td>Rating</td>
<td>2.5 VA to 30 VA</td>
</tr>
<tr>
<td>Class</td>
<td>0.2 to 1</td>
</tr>
<tr>
<td>Overcurrent factor</td>
<td>FS 5, FS 10</td>
</tr>
<tr>
<td>Protection core</td>
<td></td>
</tr>
<tr>
<td>Rating</td>
<td>2.5 VA to 30 VA</td>
</tr>
<tr>
<td>Class</td>
<td>5 P or 10 P</td>
</tr>
<tr>
<td>Overcurrent factor</td>
<td>10 to 30</td>
</tr>
<tr>
<td>Insulation class</td>
<td>E</td>
</tr>
</tbody>
</table>
11.8. Voltage transformers

- According IEC 60044-2
- Designed as single-pole
- Free of dielectric stress due to earthed layer around the transformer
- Epoxy resin insulated
- Inductive type
- With disconnection device (motor operated) when testing the cables
- Terminals in LV compartment
- With connection to
  - Cable (Feeders)
  - Busbar (sectionalisers)

The voltage transformers are epoxy-resin insulated.

The primary connections are completely sealed with sleeves.

The primary and secondary windings of the transformers will be star connected. Both neutral points will be earthed. For protection against Ferroresonance a coil and resistor are installed in the tertiary circuit.

Position: voltage transformers connected
Position: voltage transformers disconnected

Cable side solution

1. Single pole insulated (cast resin) parts
2. Disconnecting mechanism
3. Cast resin insulated voltage transformers
4. Resistor + coil

Cable side voltage transformers (Example)
Busbar side solution
Integrated on busbar compartment

1. Disconnecting mechanism
2. Resistor + coil
3. Cast resin insulated voltage transformers
4. Connection bar
5. Busbar

In separate panel

**Primary data*** | **Rated voltage kV**
---|---
Rated Power frequency withstand voltage (r.m.s.) | 28 kV 10 / √3 kV
| 11 / √3 kV
| 38 kV 13.8 / √3 kV
| 50 kV 20 / √3 kV
| 22 / √3 kV
Rated voltage factor: | Un/8h | 1.9
| Un/continuous | 1.2

*Table shows standard values, other values on request.

**Secondary data***

| Rated voltage | 100 / √3 V | 110 / √3 V |
| Auxiliary winding | 100 / 3 V |
| Thermal limit | 300 VA |
| Rating at accuracy class | 0.2 0…10 VA |
| | 0.5 10, 15, 25 VA |
| | 1 10, 15, 25, 30, 50, 60 VA |
| | 3 10, 15, 25, 30, 50, 60, 75, 100 VA |
11.9. Cable connections

Three types of outside cones are available:
- Type C for ratings 630 and 800 A
- Type C for rating 1250 A
- Type F for ratings 1600 and 2000 A

All cones feature:
- Bolted contacts with M16 according to EN 50181
- Cable connection height of 810 mm
- For plastic insulated cables
- Application of T-connectors or cable elbow connectors with bolted contacts
- Surge arrestors can be plugged into the cable T-connector
- For 3x1 or 1x3 cables
- For connection of cables with cross-sections up to 1000 mm²
- For bottom front / rear bottom / rear top cable connection

Maximum connection dept:
- Type C for 630/800 A: 405 mm (for 2 cables per phase or one cable and a plugged surge arrester)
- Type C for 1250 A: 650 mm (for 3 cables per phase or two cables and a plugged surge arrester)
- Type F for 1600/2000 A: 650 mm (for 3 cables per phase or two cables and a plugged surge arrester)

For the dimensions between the phases see the drawings in chapter "Room Planning – Floor openings and fixing points ".

Cable connectors are not included. For 24 kV connections cable connectors with an earthed layer on the outside must be used, for 12 kV connections connectors without an earthed layer might be used also. Both types may not exceed certain dimensions. The cones in the system are according to EN 50181. They can be of the type C and F. Connectors from different suppliers can be installed. Possible suppliers are:
- Euromold
- Tyco Electronics
- Nkt cables
Below some examples of possible cable plugs from Euromold are presented.

**400LB**

Interface C elbow connector
Up to 24 kV – 630 A

**430TB**

Interface C Tee connector
Up to 36 kV – 630 A (800 A)

**400TB**

Interface C Tee connector
Up to 41.5 kV – 630 A (800 A)

**440TB**

Interface C Tee connector
Up to 41.5 kV – 630 A (1250 A)

**430TBM-P2/P3**

Dual/triple cable arrangement
For 430TB
Up to 36 kV – 630 A (1250 A)

**944TB**

Interface F asymmetrical Tee connector
Up to 42 kV – up to 2500 A
11.10. Voltage detection system

Each FMX panel is provided with a voltage detector mounted on the front.

It is connected via internal wiring to capacitive sensors inside the cable connection cones. It shows the presence of the primary voltage on all three phases of the primary cable connected to the cable.

This integrated voltage detecting system (make Horstmann type WEGA 1.2) is used for continuous operation. The condition "voltage present" is displayed by arrows and respectively arrows and dots.

Testing
The display of the detector can be tested by using the piezo-button on the front of the unit. The full functionality can be tested by using the functional tester, available as an option.

Phase comparison is possible by using an external phase comparator in accordance to VDE 0682 part 415, for example the ORION (make Horstmann) which has to be plugged in the earth and test point (LRM system). These test points are accessible after removing the protective cap.

For more details of the voltage detector and the optional test equipment see the technical data sheets WEGA 1.2, Orion 3.0 and Orion Compare.

Electric details

<table>
<thead>
<tr>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated voltage</td>
<td>3 kV ... 36 kV (rated voltage of the switch gear)</td>
</tr>
<tr>
<td>Rated frequency</td>
<td>50 Hz</td>
</tr>
<tr>
<td>Operating temperature</td>
<td>-25°C...+55°C (according to the operating temperature of the switchgear)</td>
</tr>
<tr>
<td>Power supply</td>
<td>generated by the voltage to be tested</td>
</tr>
<tr>
<td>Interface</td>
<td>LRM-System for every phase</td>
</tr>
<tr>
<td>Indication Arrow</td>
<td>Means 'Voltage present'. The display appears in the range of 0.1...0.45 Un.</td>
</tr>
<tr>
<td>Indication Dot</td>
<td>Means that the current flowing through the detecting system fulfills the requirements for integrated voltage detecting systems (VDS) of VDE 0682 part 415. This constant monitoring makes a maintenance test not necessary.</td>
</tr>
<tr>
<td>No indication</td>
<td>All the symbols are turned off in the switchgear condition with all-poles switched off/ disconnected.</td>
</tr>
</tbody>
</table>
Protection and Control with Woodward SEG

The protection and control equipment is located in the low voltage compartment. This compartment is completely separate and has its own access door. There is space on the door for a mimic diagram and equipment such as protection relays, voltage detection systems, meters, etc.

The FMX is standardized for the SEG HighProtec relays series. However the FMX is adaptable for the installation of other brands.

In case more than one relay is required, the low voltage compartment can be extended.

<table>
<thead>
<tr>
<th>Model/housing</th>
<th>B1</th>
<th>B2</th>
<th>B3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Directional feeder protection</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overcurrent &amp; earth fault protection OC&amp;EF protection</td>
<td>MRA4</td>
<td></td>
<td>MCA4</td>
</tr>
<tr>
<td>Voltage &amp; frequency protection</td>
<td>MRI4</td>
<td></td>
<td>MCI4</td>
</tr>
<tr>
<td>Engine</td>
<td>MRI4</td>
<td></td>
<td>MCI4</td>
</tr>
<tr>
<td>Motor protection with voltage</td>
<td>MRMV4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motor differential protection</td>
<td></td>
<td>MCDMV4</td>
<td></td>
</tr>
<tr>
<td>Generator differential protection</td>
<td></td>
<td>MCDGV4</td>
<td></td>
</tr>
<tr>
<td>Transformer differential protection</td>
<td>MRDT4</td>
<td></td>
<td>MCDT4</td>
</tr>
<tr>
<td>Transformer differential protection with voltage measurement</td>
<td>MCDTV4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power differential protection with voltage measurement</td>
<td>MCDLV4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distance protection</td>
<td></td>
<td></td>
<td>MCDZ4</td>
</tr>
</tbody>
</table>
Smart Grids with integrated SASensor® technology
Eaton has a complete automation solution available for FMX medium voltage substations. By integrating SASensor® products from Locamation, the FMX switching system is easy to protect and manage. This makes it possible to easily measure the energy, monitor the power quality, register the digital faults and obtain more accurate data.

Functionality with SASensor®

Basic substation automation functions SASensor® offers e.g. the following functionality:

- Alarm & Event handling
- Protection
- Revenue metering (kWh-measurement)
- Accurate data acquisition
- Remote Control and Local Control (LCD system)
- Power Quality monitoring
- Digital fault registration
- IEC 61850 compliancy
### 11.12. Accessories and spare parts

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>E6046005</td>
<td>Phase sequence indicator type Orion Compare. Simplified version of the Orion 3.0. Used for voltage test and phase sequence test of the voltage detecting unit type WEGA.</td>
</tr>
<tr>
<td>E6046007</td>
<td>Functional tester for WEGA voltage detecting units.</td>
</tr>
<tr>
<td>665868</td>
<td>Cable fixing clamps for primary cables. 36-52 mm single phase cables.</td>
</tr>
<tr>
<td>665997</td>
<td>26-38 mm single phase cables.</td>
</tr>
<tr>
<td>665867</td>
<td>66-90 mm three phase cables.</td>
</tr>
<tr>
<td>E6015230</td>
<td>Voltage detector with LCD screen make Horstmann type WEGA 1.2 3-4.15 kV</td>
</tr>
<tr>
<td>E6015231</td>
<td>6-7.2 kV</td>
</tr>
<tr>
<td>E6015232</td>
<td>10-15 kV</td>
</tr>
<tr>
<td>E6015233</td>
<td>17.5-24 kV</td>
</tr>
<tr>
<td>107926</td>
<td>Padlock, used for padlocking the earth interlock and/or 2-position change-over switch.</td>
</tr>
<tr>
<td>107079</td>
<td>Warning sign, used when a panel is switched ON in earthed position and any further manual operation is not allowed.</td>
</tr>
<tr>
<td>6058923</td>
<td>Operating handle for manual operation of the 2-position change-over switch.</td>
</tr>
<tr>
<td>6054334</td>
<td>3 Test pins for testing the cables</td>
</tr>
</tbody>
</table>
12. Operation & Interlocks

12.1. Operation (change-over switch motorized)

Standard the FMX is operated electrically. For this the auxiliary circuit should be connected to 24/48/60/110/220V DC or 110/230V AC. Before electrical operation make sure that the locking slide (number “5” on page 24) is positioned in motor (M) operation.

<table>
<thead>
<tr>
<th>From service position to earthed position</th>
<th>From earthed position to service position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switch OFF</td>
<td>Switch OFF</td>
</tr>
<tr>
<td>Circuit-breaker</td>
<td>Circuit-breaker</td>
</tr>
<tr>
<td>Switch change-over switch</td>
<td>Switch change-over switch</td>
</tr>
<tr>
<td>Switch ON</td>
<td>Switch ON</td>
</tr>
<tr>
<td>Circuit-breaker</td>
<td>Circuit-breaker</td>
</tr>
<tr>
<td>Earthed position</td>
<td>Service position</td>
</tr>
</tbody>
</table>
12.2. Operation (change-over switch manually)

Switch OFF the circuitbreaker by pushing the red handle (8) downwards. Next keep the red handle (8) down and insert the operation handle.

Switch the change-over switch to a safe position by turning the operation handle clockwise.

By checking the position indicators (6) make sure it is in final position.
12.3. Interlocks

The FMX unit is equipped as standard with interlocks to prevent accidental switching operations. A number of switching positions can also be interlocked with padlocks.

The following interlocks are included in the FMX-installation:

1. It is not possible to operate electrically the 2-position change-over switch when the circuit-breaker is ON.
2. It is not possible to operate the 2-position change-over switch electrically if the mechanical operating handle is used.
3. It is only possible to disconnect the voltage transformers on the cable if the circuit-breaker is in the earthed and locked position.
4. It is only possible to open the cable access openings if the cable is earthed and the earth position interlock is pulled out.
   Note: After opening the cable access openings, the circuit-breaker can be switched to the OFF position to perform cable testing, while the connection to earth is disconnected.
5. It is only possible to open the door of the cable compartment if the circuit-breaker is in the Earthed (locked) position.
6. It is only possible to go to the service position if the cable compartment door is closed.
7. It is only possible to go to the service position if the cable access openings are closed.
8. It is not possible to operate the circuit-breaker and the 2-position change-over switch in Earthed (locked) position.

Earth position interlocking

The earth position interlocking is used to lock the accidental breaking of the cable earthing. Cable earthing can only be done with the circuit-breaker; the circuit-breaker should therefore be locked to secure the cable earthing.

If this padlock is installed, then the following operations are no longer possible:

1. Opening of the circuit-breaker with the electrical push button.
2. Opening of the circuit-breaker with the mechanical operating handle.
3. Opening of the circuit-breaker by the protection relay.
4. Switching the 2-position change-over switch to the busbar position.

The earth interlocking can be applied if:

1. The 2-position change-over switch is in earthed position;
2. The circuit-breaker is ON;
3. The door of the cable compartment is closed.
### 13. Technical data

#### 13.1. Electrical data

<table>
<thead>
<tr>
<th>FMX switchgear system</th>
<th>12 kV</th>
<th>17.5 kV</th>
<th>24 kV</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rated Voltage</strong> (kV)</td>
<td>12</td>
<td>17.5</td>
<td>24</td>
</tr>
<tr>
<td><strong>Lightning Impulse withstand voltage</strong> (kV)</td>
<td>75</td>
<td>95</td>
<td>125</td>
</tr>
<tr>
<td><strong>Power frequency withstand voltage</strong> (kV)</td>
<td>28</td>
<td>38</td>
<td>50</td>
</tr>
<tr>
<td><strong>Rated frequency</strong> (Hz)</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td><strong>Internal arc class</strong></td>
<td>AFL 25 kA - 1 s</td>
<td>AFL 25 kA - 1 s</td>
<td>AFL 25 kA - 1 s</td>
</tr>
<tr>
<td><strong>Loss of service continuity category</strong></td>
<td>LSC2B</td>
<td>LSC2B</td>
<td>LSC2B</td>
</tr>
<tr>
<td><strong>Partition class</strong></td>
<td>PM</td>
<td>PM</td>
<td>PM</td>
</tr>
<tr>
<td><strong>Earthing circuit</strong></td>
<td>kA - s 25 - 3</td>
<td>25 - 3</td>
<td>25 - 3</td>
</tr>
<tr>
<td><strong>Compartment circuit-breaker/cable</strong></td>
<td>Interlock-controlled</td>
<td>Interlock-controlled</td>
<td>Interlock-controlled</td>
</tr>
<tr>
<td><strong>Compartment busbar</strong></td>
<td>Tool-based / non-accessible</td>
<td>Tool-based / non-accessible</td>
<td>Tool-based / non-accessible</td>
</tr>
<tr>
<td><strong>Degree of protection HV compartments (optional)</strong></td>
<td>IP4X</td>
<td>IP4X</td>
<td>IP4X</td>
</tr>
<tr>
<td><strong>Degree of protection LV compartment</strong></td>
<td>IP3XD</td>
<td>IP3XD</td>
<td>IP3XD</td>
</tr>
<tr>
<td><strong>Temperature classification</strong></td>
<td>Minus 5 °C indoor</td>
<td>Minus 5 °C indoor</td>
<td>Minus 5 °C indoor</td>
</tr>
<tr>
<td><strong>Busbar system</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Rated normal current</strong> (A)</td>
<td>2000</td>
<td>2000</td>
<td>2000</td>
</tr>
<tr>
<td><strong>Rated short-time withstand current</strong> (kA - s 25 - 3)</td>
<td>25 - 3</td>
<td>25 - 3</td>
<td>25 - 3</td>
</tr>
<tr>
<td><strong>Rated peak withstand current</strong> (kA)</td>
<td>63</td>
<td>63</td>
<td>63</td>
</tr>
</tbody>
</table>

**Circuit-breaker - incoming feeder and sectionalizer**

| Rated normal current (A) | 1250 - 1600 - 2000 | 1250 - 1600 - 2000 | 1250 - 1600 - 2000 |
| Rated short-circuit breaking current (kA) | 25 | 25 | 25 |
| Rated short-circuit making current (kA) | 63 | 63 | 63 |
| Rated short-time withstand current (kA - s 25 - 3) | 25 - 3 | 25 - 3 | 25 - 3 |

**Circuit-breaker - outgoing feeder**

| Rated normal current (A) | 630 - 800 | 630 - 800 | 630 - 800 |
| Rated short-circuit breaking current (kA) | 25 | 25 | 25 |
| Rated short-circuit making current (kA) | 63 | 63 | 63 |
| Rated short-time withstand current (kA - s 25 - 3) | 25 - 3 | 25 - 3 | 25 - 3 |
| **Class** | E2, C2 | E2, C2 | E2, C2 |
| **Operating cycles at short-circuit current** | 100 | 100 | 100 |
| **Single capacitor bank switching** (A) | 400 | 400 | 400 |
| **Rated line-charging breaking current** (A) | 10 | 10 | 10 |
| **Rated cable-charging breaking current** (A) | 40 | 40 | 40 |

**Mechanism**

| Rated operating sequence | A O- 0.3s - CO- 15s - CO O- 0.3s - CO- 15s - CO O- 0.3s - CO- 15s - CO |
| **Class** | M2 | M2 | M2 |
| **Opening time** (ms) | 50 | 50 | 50 |
| **DC component** (%) | 35 | 35 | 35 |
| **Closing time** (ms) | 70 | 70 | 70 |
| **Number of operations actuator** | 90,000 | 90,000 | 90,000 |
| **Number of operations interrupter** | 30,000 | 30,000 | 30,000 |
| **Auxiliary voltage** (V DC, 110/230 VAC) | 24, 48, 60, 110, 220 | 24, 48, 60, 110, 220 | 24, 48, 60, 110, 220 |

**Mechanism change-over switch**

| Opening time (s) | <20 | <20 | <20 |
| Closing time (s) | <20 | <20 | <20 |
| **Number of operations change-over switch** | 1,000 | 1,000 | 1,000 |
| **Class** | M0 | M0 | M0 |
13.2. Operating conditions

Temperature
The standard service condition for indoor type switchgear is described in IEC 62271-1. The FMX system complies with this specification in the class "minus 5 indoor". Ambient temperature may vary between -5 and + 40 °C. However higher maximum temperatures are allowed when the maximum load current is derated with below formula:

\[ I_{\text{max}} = I_N \times \sqrt{(65 + 40 - \text{Ambient temperature}) / (65)} \]

Height
The rated insulation level is verified by testing with rated values of power frequency withstand voltage and lightning impulse voltage.

The withstand voltage values "across the isolating distance" are valid only for the switching devices where the clearance between open contacts is designed to meet the safety requirements specified for disconnectors.

Because in the system there is only an insulation to earth, it is only necessary to meet the requirement for phase-to-earth and between phases.

<table>
<thead>
<tr>
<th>Insulation level (Phase to earth)</th>
<th>Rated Voltage</th>
<th>12</th>
<th>15</th>
<th>17.5</th>
<th>24</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated Lightning Impulse withstand voltage (peak)</td>
<td>kV</td>
<td>75</td>
<td>95</td>
<td>95</td>
<td>125</td>
</tr>
<tr>
<td>Rated Power frequency withstand voltage (r.m.s.)</td>
<td>kV</td>
<td>28</td>
<td>36</td>
<td>38</td>
<td>50</td>
</tr>
</tbody>
</table>

The rated values are referred to sea level and to normal atmospheric conditions according IEC 62271-1. For site altitudes above 1000 m a correction factor has to take into account depending on the actual site altitude above sea level resulting in choosing a higher level for the lightning impulse withstand voltage and the power frequency withstand voltage.

For installations at an altitude higher than 1000 m, the insulation withstand level of external insulation at the service location shall be determined by multiplying the rated insulation levels by a factor \( K_a \) in accordance with the figure on the next page.

For internal insulation, the dielectric characteristics are identical at any altitude and no special precautions need to be taken. For external and internal insulation, refer to IEC 60071-2.

For low-voltage auxiliary and control equipment, no special precautions need to be taken if the altitude is lower than 2000 m. For higher altitudes, refer to IEC 60664-1.

The altitude correction factor can be calculated from 4.2.2 of IEC 60071-2 with the following equation, which is modified to reflect that no correction is required up to 1000 m:

\[ K_a = e^{m (H - 1000)/8150} \]

Where

- \( H \) is the altitude, in metres
- \( m \) is taken as a fixed value in each case for simplification as follows:
  - \( m = 1 \) for power-frequency, lightning impulse and phase-to-phase switching impulse voltages
  - \( m = 0.9 \) for longitudinal switching impulse voltage
  - \( m = 0.75 \) for phase-to-earth switching impulse voltage
Example:

12 kV switchgear at 2500m altitude.

Result:

Power frequency voltage, lightning impulse and phase-to-phase switching impulse voltages correction:

According to the table a rating must be selected of $1.2 \times 28 \text{kV} = 33.6 \text{kV}$.

Lightning impulse voltage correction:

According to the table a rating must be selected of $1.2 \times 75 \text{kV} = 90 \text{kV}$.

Switchgear with a rating of 17.5 kV has to be selected.
13.3. Shipping data & Dimensions

Shipping data

<table>
<thead>
<tr>
<th>Weight of the heaviest transport unit</th>
<th>Nett (kg)</th>
<th>Gross (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 circuit-breaker 630, 800 A</td>
<td>625</td>
<td>675</td>
</tr>
<tr>
<td>1 circuit-breaker 1250 A</td>
<td>750</td>
<td>800</td>
</tr>
<tr>
<td>1 circuit-breaker 1600 A</td>
<td>900</td>
<td>950</td>
</tr>
<tr>
<td>1 circuit-breaker 2000 A</td>
<td>950</td>
<td>1000</td>
</tr>
<tr>
<td>1 sectionaliser 1250 A</td>
<td>1300</td>
<td>1400</td>
</tr>
<tr>
<td>1 sectionaliser 1600 A</td>
<td>1450</td>
<td>1550</td>
</tr>
<tr>
<td>1 sectionaliser 2000 A</td>
<td>1500</td>
<td>1600</td>
</tr>
</tbody>
</table>

See delivery note for the exact value.
The unit is standard packed in voil.

Provision for lifting is fitted to the top of the unit.

The unit can be handled simply and safely providing that standard lifting equipment is being used.

The installation of the unit includes the following actions:

1. Lifting.
2. Travelling.
3. Preparation prior to installation.
4. Installing the unit.
5. Securing to the floor.
The first 2 actions can be done by the customer.

Action 3-5 should be done by Eaton Service specialists or certified specialists.

Dimensions

<table>
<thead>
<tr>
<th>Unit dimensions</th>
<th>Width (mm)</th>
<th>Depth (mm)</th>
<th>Height (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 circuit-breaker 630, 800, 1250 A</td>
<td>500</td>
<td>1450</td>
<td>2100*</td>
</tr>
<tr>
<td>1 circuit-breaker 1600, 2000 A</td>
<td>1000</td>
<td>1450</td>
<td>2100*</td>
</tr>
<tr>
<td>1 sectionaliser 1250 A</td>
<td>1200</td>
<td>1450</td>
<td>2100*</td>
</tr>
<tr>
<td>1 sectionaliser 1600, 2000 A</td>
<td>1325</td>
<td>1450</td>
<td>2100*</td>
</tr>
</tbody>
</table>

* Per section one arc absorber box of 150 mm should be installed.
13.4. Room planning
The unit has been designed in accordance with IEC 62271-1, refer to the type plate on the unit for the specification. Eaton also imposes additional ambient requirements, see Table 4. If the ambient conditions do not meet the specifications, Eaton cannot guarantee the operation and service life of the unit.

<table>
<thead>
<tr>
<th>Item</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Requirements for the floor and wall of the building</td>
<td>Minimum permissible floor loading 1200 kg/m². The floor must be level and have a smooth finish to ensure that the carrier frame of the unit is evenly supported. Provide cable recesses according to the floor plan. The cable openings in the floor can be sealed to prevent rising damp. Polyurethane with a compact cellular structure can be used for this.</td>
</tr>
<tr>
<td>Requirements for clearances around the FMX</td>
<td>At least 600 mm at the top. This is equivalent to a minimum height of 2700 mm for the operating area. One side minimum 100 mm and the other side minimum 500 mm. Sufficient space should be available at the front and along the entire length of the unit for operational purposes and to be able to work safely, for instance with a voltage probe or earth rod in excess of 800 mm. In accordance with IEC 61936-1.</td>
</tr>
<tr>
<td>Requirements for escape routes</td>
<td>When the unit is installed in an accessible area, escape routes shall be provided according to the local requirements.</td>
</tr>
<tr>
<td>Ambient conditions (IEC 62271-1)</td>
<td>Indoor switchgear and controlgear must comply:</td>
</tr>
<tr>
<td></td>
<td>• The ambient air temperature does not exceed 40 °C and its average value, measured over a period of 24 h, does not exceed 35 °C.</td>
</tr>
<tr>
<td></td>
<td>• The minimum ambient air temperature is −5 °C for class &quot;minus 5 indoor&quot;, −15 °C for class &quot;minus 15 indoor&quot; and −25 °C for class &quot;minus 25 indoor&quot;.</td>
</tr>
<tr>
<td></td>
<td>• The influence of solar radiation may be neglected.</td>
</tr>
<tr>
<td></td>
<td>• The altitude does not exceed 1 000 m.</td>
</tr>
<tr>
<td></td>
<td>• The ambient air is not significantly polluted by dust, smoke, corrosive and/or flammable gases, vapours or salt.</td>
</tr>
<tr>
<td>Ambient conditions (IEC 62271-1)</td>
<td>The conditions of humidity are as follows:</td>
</tr>
<tr>
<td></td>
<td>• the average value of the relative humidity, measured over a period of 24 h, does not exceed 95%;</td>
</tr>
<tr>
<td></td>
<td>• the average value of the water vapour pressure, over a period of 24 h, does not exceed 2,2 kPa;</td>
</tr>
<tr>
<td></td>
<td>• the average value of the relative humidity, over a period of one month, does not exceed 90%;</td>
</tr>
<tr>
<td></td>
<td>• the average value of the water vapour pressure, over a period of one month, does not exceed 1,8 kPa.</td>
</tr>
<tr>
<td></td>
<td>For these conditions, condensation may occasionally occur.</td>
</tr>
<tr>
<td></td>
<td>NOTE 1 Condensation can be expected where sudden temperature changes occur in periods of high humidity.</td>
</tr>
<tr>
<td></td>
<td>NOTE 2 To withstand the effects of high humidity and condensation, such as breakdown of insulation or corrosion of metallic parts, switchgear designed for such conditions and tested accordingly should be used.</td>
</tr>
<tr>
<td></td>
<td>NOTE 3 Condensation may be prevented by special design of the building or housing, by suitable ventilation and heating of the station or by the use of dehumidifying equipment.</td>
</tr>
<tr>
<td></td>
<td>• Vibration due to causes external to the switchgear and controlgear or earth tremors are negligible.</td>
</tr>
<tr>
<td></td>
<td>• Induced electromagnetic disturbances at interfaces of the secondary system, as a result of switching in the high-voltage system, do not exceed 1,6 kV common mode for normal EMC severity class, and 0,8 kV common mode for reduced EMC severity class.</td>
</tr>
</tbody>
</table>

www.eaton.eu

Power Xpert® FMX 605 4036_02 41
For coupling of the installation, there must be a free space at one side of the installation for at least 500 mm.

Depending on national requirements. For breaker exchange or panel replacement control aisle > 1500 mm. Front-front arrangement control aisle > 1500 mm.

Because the system is tested AFL it is not allowed to stand behind the switchgear if the busbars are energized.
13.5. Room planning - Floor openings and fixing points

### Cable panel 630 A – 1250 A
- **Dimension foundation**
- **Left end panel**
- **Middle panel**
- **Right end panel**

### Cable panel 1600 A
- **Dimension foundation**
- **Left end panel**
- **Middle panel**
- **Right end panel**

### Cable panel 2000 A
- **Dimension foundation**
- **Left end panel**
- **Middle panel**
- **Right end panel**

### 1600 A or 2000 A cable panel
- **Dimension foundation**
- **Left end panel**
- **Middle panel**
- **Right end panel**

---

www.eaton.eu
Sectionalizer 630 A – 1250 A

Dimension foundation
630 A or 1250 A sectionalizer
Left end panel

Dimension foundation
630 A or 1250 A sectionalizer
middle panel

Dimension foundation
630 A or 1250 A sectionalizer
right end panel

Sectionalizer 1600 A

Dimension foundation
1600 A or 2000 A sectionalizer
Left end panel

Dimension foundation
1600 A or 2000 A sectionalizer
middle panel

Dimension foundation
1600 A or 2000 A sectionalizer right end panel

Sectionalizer 2000 A

Dimension foundation
1600 A or 2000 A sectionalizer
# 14. Standards

FMX complies with the following international standards:

<table>
<thead>
<tr>
<th>Standard Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEC 62271-1</td>
<td>Common specifications</td>
</tr>
<tr>
<td>IEC 62271-100</td>
<td>Circuit-breakers (E2, M2, C2)</td>
</tr>
<tr>
<td>IEC 62271-102</td>
<td>Disconnectors and earthing switches (E2, M0)</td>
</tr>
<tr>
<td>IEC 62271-200</td>
<td>Metal enclosed switchgear and controlgear</td>
</tr>
<tr>
<td>IEC 60044-1</td>
<td>Current transformers</td>
</tr>
<tr>
<td>IEC 60044-2</td>
<td>Voltage transformers</td>
</tr>
<tr>
<td>IEC 60529</td>
<td>Degrees of protection (IP Code)</td>
</tr>
<tr>
<td>IEC 61850</td>
<td>Communication networks and systems in substations</td>
</tr>
<tr>
<td>IEC 61243-5</td>
<td>Live working - Voltage detectors - Part 5: Voltage detecting systems</td>
</tr>
</tbody>
</table>
15. Quality

Eaton has been meeting the ISO 9001 quality assurance requirements since 1989. This quality assurance system calls for a periodic evaluation of the organizational structure, the assignment of responsibilities and the associated procedures. It also guarantees corrective action and activities when required. This keeps the quality assurance system up to standard and enables adjustments to be made and further development to take place where necessary.

FMX switchgear is manufactured and tested in accordance with the procedures as laid down in ISO 9001-2000. KEMA Registered Quality B.V. checks periodically that these standards are adhered to. In addition, with respect to its integral environmental management system, Eaton Industries (Netherlands) B.V. adheres to ISO 14001.
16. Environment

16.1. Sustainable alternative to SF₆ gas-filled switchgear systems

In the design of Eaton medium voltage systems, only environmentally-friendly materials are used for switching and insulating: clean, dry air as an insulation medium and a vacuum as a switching medium. This design helps the medium voltage switchgear to meet the energy distribution sector’s need for sustainable solutions.

With this complete range of MV switchgear, Eaton provides its customers the opportunity to actively contribute towards reducing global emissions of SF₆ gas.

Only environmentally-friendly materials are used in the medium voltage switchgear systems. At the end of its service life, the switchgear system is easy to dismantle, as the materials used can be identified and the raw materials can be reused. This makes the switchgear easier to recycle and mitigates unnecessary costs, such as environmental taxes, when taking a system out of operation.

Why is the use of SF₆ gas in switchgear systems harmful for the environment?

- **SF₆ is the most hazardous greenhouse gas on the Kyoto list**
  
  SF₆ gas emissions created by switchgear systems in the power distribution network make a significant contribution towards the threat of the greenhouse effect and the climate change associated with it. SF₆ is the most hazardous greenhouse gas on the list of greenhouse gases in the Kyoto protocol and it has a global warming potential of 22,800. SF₆ also remains in the atmosphere for a very long time (3200 years). Global emissions of SF₆ gas in 2011 are estimated as being equivalent to 200 megatons of CO₂.

- ** Leakage of SF₆ gas is unavoidable in practice**
  
  This is because the systems require maintenance during the course of their service life, at which point leaks occur. Leaks also occur when SF₆ gas is produced, when the switchgear systems are manufactured and during dismantling and recycling of the system at the end of its service life. Even “hermetically” sealed systems that do not require maintenance during their service life cause considerable SF₆ emissions at these other stages. Due to the enclosed nature of these systems, it is claimed that the emissions they create as a result of leaks are limited. However, there will always be a certain amount of leakage because in practice, gaskets leaks due to changes in temperature as a result of the day / night and summer / winter cycles. Leaks cannot therefore be ruled out in the long term over the service life of the system (> 30 years).

- **Toxic by-products of SF₆ pose a health risk in public spaces and other locations**
  
  In an open arc, SF₆ dissolves into highly toxic substances (including HF, SF₄, SOF₂ and S₂F₁₀) which are released into the outside air. These toxic substances are also created when switching normally and through partial discharge during normal use. The toxic residues then remain in the housing, which means that special measures are necessary when dismantling and recycling at the end of the system’s service life. In particular, if gas-filled systems are used in public spaces, such as residential areas and shopping centres, this can pose a danger to public health. By-products of SF₆ are also suspected of causing damage to the ozone layer.
16.2. Eaton supports the 'Green Switching' platform

The aim of the 'Green Switching' platform is to play a part in tackling global warming by sharing factual information about alternatives to SF₆ in switchgear systems in energy distribution. The ultimate goal is to eliminate SF₆ emissions from medium voltage switchgear systems. Read more about the facts surrounding the use of SF₆ gas on www.greenswitching.com

16.3. Lowest total service life costs with Eaton medium voltage switchgear

Eaton has provided a clear overview of all costs that may arise during the lifecycle of a switchgear system. We are able to calculate the costs of a MV switchgear system over its 40-year service life in relation to competitors’ systems, on the basis of price levels and cost structure. Calculations show that in all cases the Eaton medium voltage switchgear has the lowest Total Cost of Ownership. Making a choice in favor of quality, reliability and the environment pays off over the service life of the system!

We will be happy to calculate the savings you will make by using Eaton medium voltage switchgear systems in your distribution network.
16.4. Environmental declaration

Supplier

Eaton Industries (Netherlands) B.V.
Europalaan 202
7559 SC Hengelo
The Netherlands

1. In the medium voltage switchgear type FMX there are no poisonous or otherwise hazardous materials nor materials which may or can affect the ozone layer or influence the greenhouse effect.

2. The FMX switchgear contains materials which can be recycled. The epoxy resin can be broken up at the end of its life-cycle. The copper, aluminium and other metal parts can be recycled.

3. At the end of its life cycle the FMX switchgear can be traded in at Eaton.

4. List of materials used for manufacturing a typical FMX circuit-breaker panel (rel. 1.0, 630 A):

<table>
<thead>
<tr>
<th>Metals</th>
<th>[kg]</th>
<th>[kg]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
<td>406.07</td>
<td></td>
</tr>
<tr>
<td>Stainless steel</td>
<td>4.44</td>
<td></td>
</tr>
<tr>
<td>Al</td>
<td>30.33</td>
<td></td>
</tr>
<tr>
<td>Cu</td>
<td>25.84</td>
<td></td>
</tr>
<tr>
<td>Total weight metals</td>
<td>466.67</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Thermoplastic</th>
<th>[kg]</th>
<th>[kg]</th>
</tr>
</thead>
<tbody>
<tr>
<td>PA</td>
<td>1.15</td>
<td></td>
</tr>
<tr>
<td>PC</td>
<td>0.23</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>2.42</td>
<td></td>
</tr>
<tr>
<td>Total weight thermoplastic</td>
<td>3.80</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Elastomer</th>
<th>[kg]</th>
<th>[kg]</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPDM</td>
<td>2.09</td>
<td></td>
</tr>
<tr>
<td>Silicone</td>
<td>0.50</td>
<td></td>
</tr>
<tr>
<td>Total weight elastomer</td>
<td>2.59</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Thermoset</th>
<th>[kg]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Epoxy</td>
<td>17.22</td>
</tr>
<tr>
<td>Total weight thermoset</td>
<td>17.22</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Other</th>
<th>[kg]</th>
<th>[kg]</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO₂</td>
<td>21.04</td>
<td></td>
</tr>
<tr>
<td>Ceramic</td>
<td>31.54</td>
<td></td>
</tr>
<tr>
<td>Total weight other</td>
<td>52.59</td>
<td></td>
</tr>
</tbody>
</table>

Total weight FMX | 542.87
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