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## NEW GAS INSULATED SWITCHGEAR (GIS) FOR ALL MEDIUM VOLTAGE APPLICATIONS

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### KEY WORDS

Gas insulated switchgear; vacuum switching; sensor and conventional technology; modular system; customer oriented; high flexibility; factory assembled and tested

### SUMMARY

The new metal clad single busbar GIS type ZX1, based on the predecessor product with the same name, completes the successful ZX switchgear family. For all market segments worldwide there is now a new ZX1 existing with a high flexibility of switchgear configurations in metal clad single busbars applications with alternatively use of digital bay control and protection technology with sensors or conventional protection units and instrument transformers.

### NEW MEMBER OF THE ZX FAMILY

The MV GIS family ZX of ABB Calor Emag Mittelspannung GmbH, Germany [1], has been revised and has become even more suitable for the needs of all customers. One result is this new metal clad GIS for single busbar applications.

With rated voltages from 12 kV to 40.5 kV, rated short circuit currents up to 31.5 kA and rated currents up to 2000 A, the new ZX1 covers a wide market segment.

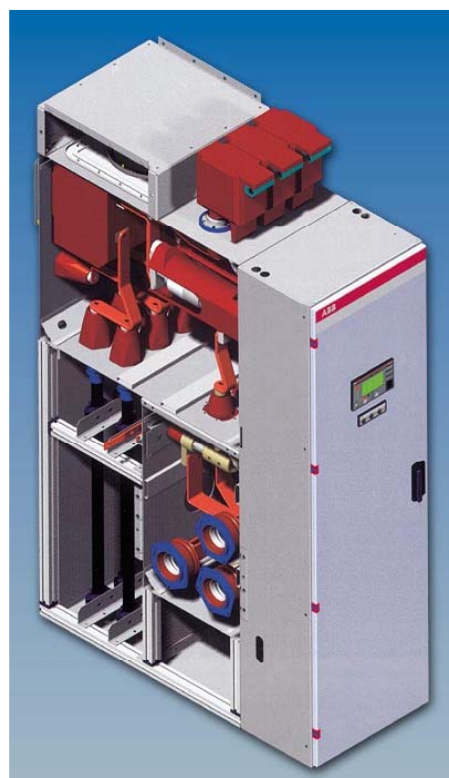
The modular system characterises itself through a compact construction with high performance. It combines future solutions with progressive and reliable concepts and technologies such as gas tight switchgear technology with protection- and insulation gases, vacuum circuit breaker technology, digital bay control and protection units, as well as sensor- and plug-in-technology.

The factory assembled, primary- and secondary, type tested switchgear, contains all maintenance free active components, such as switching- and measuring devices, in a stainless steel enclosure protected by insulation gas. Because of this all these components are protected against

ageing and environmental influences. The gas tight modules (cubicles) might be combined according to customer requirements and are connected by means of plug-in technologies. Gas handling will be avoided outside the manufacturing plant. This is reducing erection time on site and will avoid failures caused by gas handling and working inside the high voltage compartments. The test of gas-tightness can be carried out using the original pressure direction in the factory, what is not possible on site, with a high and reproduceable accuracy.

### MODULAR CONCEPT WITH HIGHER FLEXIBILITY

The modular cubicles of the ZX1 panels provide a maximum amount of flexibility. Through different



*Picture 1: Panel 1250 A with a block CT and a disconnectable PT*

combinations of the compact modules for circuit-breaker- and busbar-compartments there is a solution for almost all specified requirements on the world market. One of the reasons for the high flexibility is the arrangement of the circuit breaker compartment above the busbars. The advantage is that the circuit breaker compartment is highly variable and suited for the specific needs almost independently from the neighbour panel (e.g. equipment like power voltage transformers (PT's), current transformers (CT's) and sensors, which define the requested volume of the cubicle). It can have different depths and heights, what is only possible if the busbar compartment with the fixed position for the busbar is placed under the circuit breaker compartment.

Therefore almost every individual panel of a switchboard can be manufactured so that it complies with customers requirements using combinations of existing standard modules.

Even customer specific order related design is easier and less expensive.

The different modules allow optional future oriented or conventional technologies for metering, control and protection as well as position indication.

The future oriented sensor technology uses Rogowski-coils for current- and resistive dividers for voltage metering and proximity switches for position indication in combination with digital bay control- and protection technology (REF 542plus). In the conventional equipped panels instrument transformers (CT's and PT's), auxiliary contacts, conventional measurement- and protection technology is used. By the use of hybrides (sensors with additional CT) it is possible to use a combination of both technologies.

Through the well known plug-in solution of the ZX family between busbar compartments and the established cable connections size 2 and 3 for the power cables, also this switchgear is going to be delivered as a factory assembled, complete tested system. This guarantees constantly high and reproducible test results.

The separate modules have been developed by using the newest construction principles. Complete development in 3D-CAD (3-dimensional Computer Aided Design) as well as integrated calculation systems are used. Mechanical calculation tools for the judgement of the strength of the compartments and electric field analysis for the dimensioning of resin and silicon-rubber components as well as for the vacuum bottles, the circuit-breaker and 3-position-switch design are used.

The panel consists of two gas filled main cubicles - the busbar compartment (1) and the circuit breaker compartment (2). As switching device the well known vacuum circuit breaker (3) comes in action [2], [3]. One or two cables per phase, over the inner cone plugs (size 2 or 3) can be connected to the circuit breaker compartment at currents up to 1250 A.

Up to four parallel cables can be used in feeders up to 2000 A. It is also possible to use surge arresters (at the cable position) as well as plug-in voltage transformers (placed on top of the panel and connected with a switch-off mechanism, see picture 1).

The rod-type 3-position-disconnector (4) in the busbar compartment secures, through its simple construction with a minimum number of components, a maintenance-free operation.

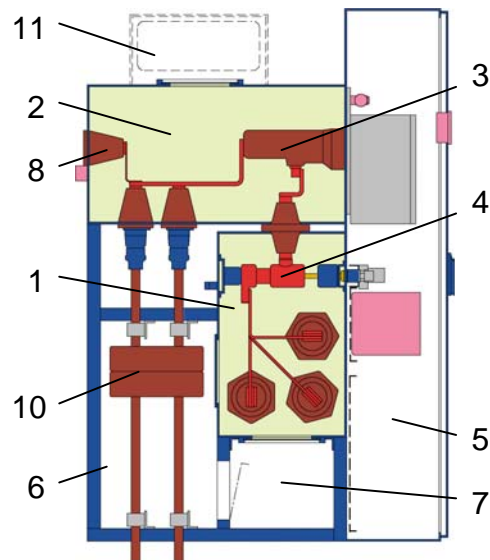
Both of the gas compartments are being supervised through gas density switches so that the necessary gas amount, independently from the temperature and the assembling height, is secured.

The low voltage compartment (5) is located in front of the core modules, with enough space for assembling also sizeable secondary components.

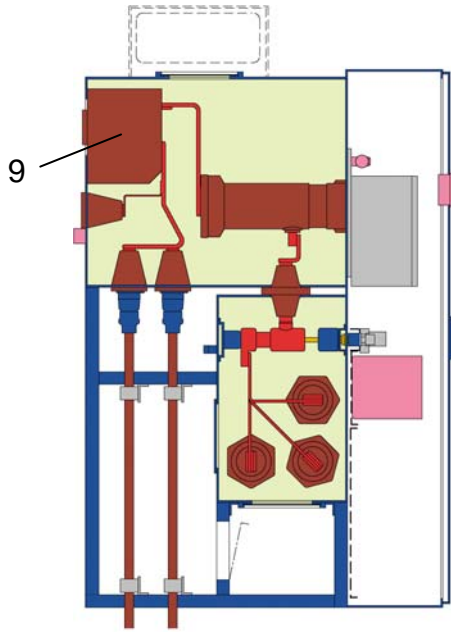
The base frame (6), made of aluminium profiles with optional covers, secures through its construction a safer and more precise standing position of the panel. There is also the pressure relief duct for the busbar compartment (7) integrated.

The result of the circuit breaker compartment arrangement is a comfortable installation of the cable with a high cable fixing point of 1250 mm. This makes it possible to use the panel where only cable trenches are available and no cable cellars can be used. For new substations this gives the possibility to save money for the costs of the building.

The easily accessible test socket with a voltage indication system (8) is located on the back of each panel. No additional covers have to be removed to have access. The socket itself is a standard cable socket size 2 which can be connected to a wide range of testing plugs for voltage and



Picture 2: A cut-through a panel 1250 A with ring core CT



**Picture 3:** A cut-through of the cubicle 1250 A with block CT.

current testing or for earthing equipment. The secondary wiring of the transformers are comfortable accessible, either for bloc transformers (picture 3, item 9), ring type transformer (10) or sensors. Above the circuit

breaker cubicle a pressure relief duct (11) might be installed on request. It would provide in connection with the duct of the busbar cubicle the highest level of personal safety. In that case the pressure relief ducts will be connected at the end of the panel line in a special end cover which is releasing the plasma in a common absorber on top of the last two panels. Optional it is possible to have a duct to release outside the building. By the use of plasma diverters the plasma is released to the back of the panels, where no access to the back of the switchgear is required by the customer.


The performance spectrum of the switchgear will be, at the end stage for up to 40.5 kV rated voltage, rated short circuit currents up to 31.5 kA and rated currents up to 2000 A (2500 A are under development).

The modules of the sectionaliser, riser and busbar metering panels are also optimised, when it comes to function and space requirements.

Sectionaliser panels are available with none, one or two CT's, one on each side of the circuit-breaker. To avoid additional metering panels a busbar metering can be included in the sectionaliser and/or the riser panel.

Metering panels are available with and without busbar earthing switches.

For the connection of two lines of panels there is a solid insulated bus duct available.



### SINGLE-BUSBAR GIS PANEL

Rated voltage	kV	12	24	36/40,5
Rated busbar current	A	...2000 <sup>1)</sup>	...2000 <sup>1)</sup>	...2000 <sup>1)</sup>
Rated feeder current	A	...2000 <sup>1)</sup>	...2000 <sup>1)</sup>	...2000 <sup>1)</sup>
Rated short-time current, 3 s	kA	...31,5	...31,5	...31,5
Rated short-circuit breaking current of the circuit breaker	kA	...31,5	...31,5	...31,5
Rated short-circuit making current of the circuit breaker	kA	80	80	80

<sup>1)</sup> 2500 A under development

**Picture 4:** Ratings of the ZX1 panel

## CONTROL- AND PROTECTION TECHNOLOGY

Through the described modular system it is possible to carry out a wide spectrum of control and protection concepts. An optimal solution provides the modern, for the panels designed, digital bay control and protection unit REF 542*plus*.

It takes care in connection with position switches and



**Picture 5:** Bay control and protection unit REF 542*plus* (operation unit)

current- and voltage sensors of all the necessary tasks like

- protection
- control,
- interlocking,
- measurement,
- communication to the substation level and
- monitoring.

The integrated operation unit is, based upon the modular concept of the REF 542*plus*, located separately from the control unit. This makes it possible to install the display ergonomically and to place the central unit at a reasonable place considering all wiring. It is reducing the amount of cables connected to the door. The design of the REF 542*plus* is already prepared for many future technologies:

The REF 542*plus* is integrated with future technologies like a real webserver.

Different options exist for local control, monitoring and parameter settings: notebook with browser or separable operation unit.

The time synchronisation is possible with a GPS (Global Positioning System) module.

As a network interface different field busses and Ethernet connections are also available.

Alarms to the operating personnel as messages, disturbances or protection reactions are possible to be send via SMS or e-mail.

For the use of a more conventional protection concept different current transformers might be installed in each panel. The voltage transformers are developed to operate as plug-in components above the circuit breaker. Therefore the concept is open for the use of most different customer specific protection components and counters. It is also under certain conditions possible to combine both solutions.

## INTERNAL ARC PROTECTION

The sensor for monitoring the insulation gas has an additional functionality. Transient pressure surges (caused by internal arc faults) are tripping a switch in the sensor. Together with overcurrent signals a rapid shutdown of the incoming feeders is possible. This represents a high level solution for even greater operator and switchgear safety, as the effects of an arc fault are extensively limited by rapid shutdown (approx. 100 ms).

Irrespective of the above, the active arc protection plays an important role in avoiding internal faults and ensuring the reliability of power supplies. The unreduced functionality of the maintenance-free live components under inert gas throughout their service lives makes an essential contribution to this.

## THE PRODUCTION PROCESS

The modular system of the new ZX1 also makes most modern process working possible, so that it allows a modularity in the production line too. The individual modules can be pre-assembled in advance and will be combined later to a complete switchgear. This opens new state of the art concepts with parallel working production steps, which leads to strongly shortened production times.

Here the production of the welded cubicles has a special meaning. These are made of stainless steel and are joined together through laser welding plants. The required narrow production tolerance will be covered through state of the art laser-cutting machines. Both machines are, through geometry independent lasers, extremely flexible and they allow a high level of variation.

The laser welding technology characterises itself through a high process speed as well as through an extremely clean production, which makes additional finishing work unnecessary. The thermal deforming of the housings is very small, what keeps the high quality of the laser cutted shapes of sealing surfaces without additional treatment.

All introduced optimised potentials are only usable when suitable methods are followed by all individual process steps of the production. Within the scope of a detailed process reflection the possibilities of failures by the individual process steps are discovered and solved. Under

the use of statistic methods the individual process steps becomes an optimised, reliable production- and test strategy.

## CONCLUSIONS

The new optimised gas insulated switchgear combines progress- and future orientated concepts and technologies with market oriented solutions.

The use of vacuum circuit breakers secures unlimited mechanical and electrical functionality during the whole lifetime. For determining current and voltage signals there are the options to put in alternatively sensors but also conventional transformers. In combination with the computer controlled, digital bay control technology the operation will be easier and safer as well as engineering, production and commissioning.

The installation time on site will be minimised due to the plug-in technology.

The benefit of the ZX1 switchgear concept characterises itself through almost unlimited flexibility, a high standardisation level, high personal- and switchgear safety, supply reliability, maintenance free as well as through economy and low life cycle costs.

These advantages will be assured through extensive operation experience. Since 1995 are already several thousands switchgears of the ZX family disturbance free and reliable in use [4].

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