

MOBILE SUBSTATIONS

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ABSTRACT

The report describes in Sweden newly developed mobile substations. They are compact, modularised and completely enclosed. The mobile substations are arranged for quick transport on road and prepared for transport in air or on sea.

INTRODUCTION

In a modern society long power outages are unacceptable. After heavy storms have destroyed parts of the distribution network, power companies in Sweden have invested hundreds of millions USD in the distribution networks. Medium voltage overhead lines have mainly been replaced by cables. However also faults in substations may cause major blackouts.

To provide a quick supply of power to customers after a serious fault in a substation, Vattenfall, a European utility, has developed new types of mobile substations. They are easy to move and install. Indoor installation makes fences unnecessary and equipment more reliable. The mobile substations have been designed in cooperation with the Contractor, ABB Power Technologies. One substation for 52/24(12) kV has now successfully been in operation for two years. More of this type is planned and one of another type for 170/52/24(12) kV is ordered.

The complete 52/24(12) kV mobile substation, see figure 1 is built on one 17 meters long trailer with a weight of 43 tons. The trailer can be transported with a speed limit of 80 km/h facilitating a quick contribution after voltage collapse.



Figure 1 52/24(12) kV mobile substation

To provide easy transport the 170/52/24(12) kV mobile substation is split into several parts. These make transport in air possible. The transformer is placed on a trailer and the rest of equipment in containers. Because of the modular design and cable connection, see figure 2 the substation requires a minimum of time at site for installation and commissioning.

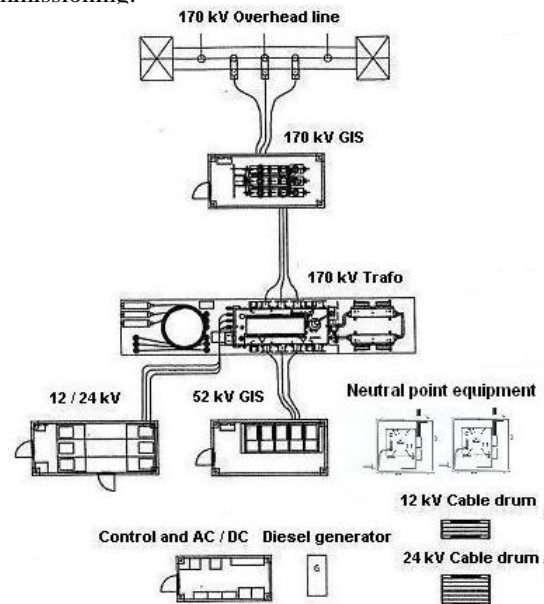


Figure 2 Lay-out of 170/52/24(12) kV mobile substation

BACKGROUND

The purpose of the newly developed mobile substations is mainly to guarantee quick restoration of power supply after a major fault in a substation. However, if required, they can also be used for temporary power supply during maintenance or substation extensions. They can be used in temperatures between 40°C and -50°C. However transports shall not be done at lower temperatures than -35°C because of risk for damages of tyres.

Until now substations in Sweden often have been provided with two transformers of full capacity. One of these is normally in stand-by as spare for automatic connection in case of fault on the operating one, i.e. full transformer redundancy. To reduce the cost, it is possible to replace the second transformer with mobile redundancy, when it is suitable. The northern region of the Swedish utility

Vattenfall Eldistribution AB has developed a new substation concept for a modularised 52/24(12) kV substation with only one transformer [1] and a mobile substation.

The first mobile substation of this type, delivered by ABB, has now been in operation for two years and more are planned to be ordered. The mobile substation is intended to be in operation within 8 hours after a major fault in a nearby substation.

For domestic security of power supply a new type of mobile substation for 170/52/24(12) kV has been invented. The substation is financed by Swedish National Grid to be available in emergency for all Swedish power companies. The substation can also, if decided by National Grid, be used for emergency abroad. If a major fault occurs, the modular design makes it possible to transport and use either the complete substation or only parts of it. The design makes transport on road, at sea or in air possible. The substation shall be installed and ready for operation within two days after coming to site.

One 170/52/24(12) kV mobile substation is ordered from ABB Power Technologies AB and will be delivered to Vattenfall Eldistribution AB in summer 2007.

52/24(12) KV MOBILE SUBSTATION

Description

A new type of mobile substation, called RULLE, figure 3 is developed. The substation is completely enclosed and can be installed without fences. It is assembled and tested in the factory. The substation is built on a 17 meters long and 3,1 m wide trailer. A relatively low weight makes quick transport on Swedish roads possible.

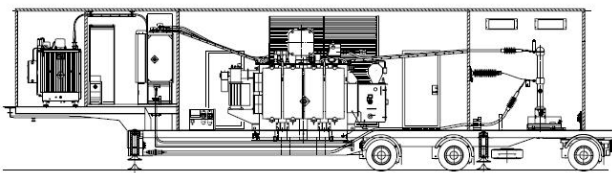


Figure 3 Intersection of 52/24(12) kV mobile substation

Ratings

Transformer power	6,5/4 MVA
Cooling type	ONAF/ONAN
Rated voltage	46±8x1,67%/23(11,5) kV
Highest voltage of equipment	52 kV, 24(12) kV
Short-circuit current 1 sec.	16 kA
Auxiliary power transformer	100 kVA
Neutral reactor 23(11,5) kV is placed in the front of trailer.	

Design

The substation has one transformer of 6,5 MVA, one 52 kV single line connection and two outgoing 24 kV metal-clad

switchgear bays, see figure 4. Electrical connection will be via flexible cables.

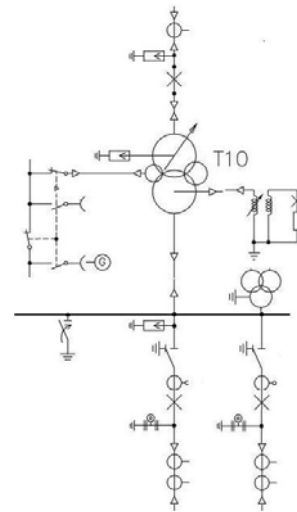


Figure 4 single line diagram

The incoming feeder is equipped with a 52 kV SF6 trolley-mounted circuit breaker. Surge arresters are installed in the same bay. The current transformers are installed around the cables.

There are two outgoing feeders and one incoming in a 24(12) kV switchgear of metal-clad type. The switchgear is equipped with vacuum-type circuit breakers.

The substation has one 5 kVA, 240 V petrol powered emergency generator, to provide electrical power for battery charging and heating of control cabinet during transport at low temperatures, and also for low voltage supply before connecting to the local power supply during installation.

The trailer has an integrated oil-pit of 5,5 m³, for handling of possible oil spill. The volume is enough to take care of the total oil quantity from the power transformer and the neutral point reactor.

A shock detector on the trailer ensures that the electrical equipment is in good shape after transport.

170/52/24(12) KV MOBILE SUBSTATION

Vattenfall Eldistribution AB has ordered, from ABB, delivery of a new type of mobile substation in summer of 2007. The substation is intended to be available in emergency for all Swedish power companies. The substation was required to be designed for transport abroad in an easy manner, also in air. Therefore it is split in modules adapted to transport profiles.

Description

A new type of mobile substation, called BAMSE is developed, see figure 5. It is completely enclosed and can be installed without fence. The substation is modularised with the transformer on a trailer and the other electrical components installed in containers. An advantage is that also part of the substation then can be used in emergency situations. Connections between the different parts of the substation are made with prefabricated cables.

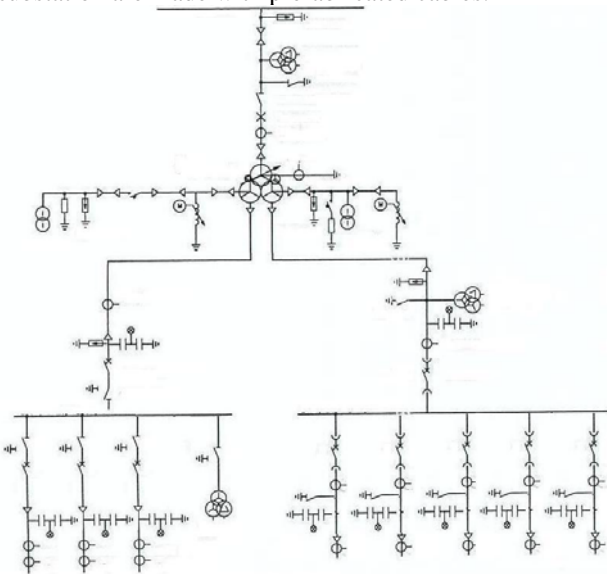


Figure 5 Single line diagram

Trailer

The transformer is placed on a trailer together with the prefabricated 170 kV high-voltage cables on a drum, see figure 6. Cables for 52 kV and 24 kV are placed on separate drums. All cable drums are motor operated.

The trailer has an integrated oil-pit of 5 m³, at site connected to a flat oil-tank of 17 m³ for handling oil-spill.

The trailer has four axles and the total weight is 75,5 tons. It has a speed limit of 80 km/h.

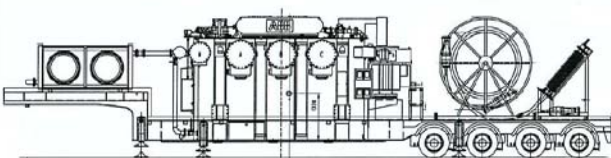


Figure 6 Trailer

Transformer

The transformer is designed for trailer transport on bad roads and is adapted for relevant transport profiles. It is of three-winding type with an equalizing winding. The transformer is provided with an on-load tap changer with vacuum interrupters. HV connections are enclosed for cable connection.

Rated voltage 145± 9x1,67%/46/24(12)/11 kV

Rated power 25/25/25/8,3 MVA
 Connection mode YN/yn/yn/d
 Cooling type ONAF

Reactors connected to 52 kV and 24 kV neutrals are placed in two containers, one for each neutral.

Containers

The electrical equipment, except transformer, is housed in containers. The dimensions are adapted for maximal transportability. They are, except for the neutral equipment, placed on one metre high legs to simplify cable entrance. The walls and roof are made of galvanized steel. The floor has a strong frame to minimize buckling. Doors where cables enter are doubled to be tight against dust, snow etc. All doors are lockable. Containers for switchgears have devices for pressure relief in case of internal arcs.

The trailer as well the containers are all equipped with shock detectors. This is to ensure that all electrical equipment is in good shape after transport.

170 kV switchgear

One switchgear bay is placed in a separate container, see figure 7. The switchgear is SF₆ gas-insulated of ABB type PASS M0.

Rated voltage 170 kV
 BIL 650 kV
 Rated current 2500 A
 Short time current 40 kA

The switchgear is connected to the grid and transformer with cables.

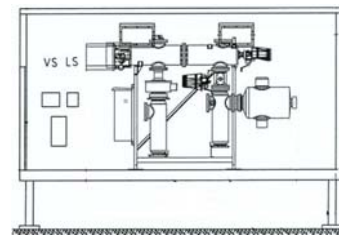


Figure 7 Container with 170 kV switchgear

The switchgear container can be transported without reduction of gas pressure in switchgear.

52 kV switchgear

Three outgoing bays and one incoming are placed in an other container, see figure 8. The switchgear is of AREVA manufacture.

Rated voltage 52 kV
 BIL 250 kV
 Rated current 1250 A
 Short time current 25 kA

The switchgear is of SF₆ gas-insulated type with low

working pressure. Gas from a possible internal arc is led to outside of the container by an exhaust channel.

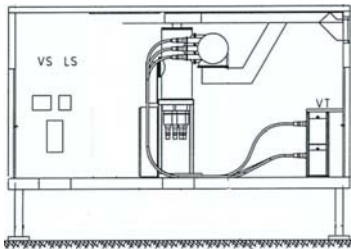


Figure 8 Container with 52 kV switchgear

24(12) kV switchgear

The switchgear is placed in a separate container, see figure 9. The switchgear consists of five outgoing bays and one incoming. It is of type Unigear ZS1, manufactured by ABB.

Rated voltage	24 kV
BIL	125 kV
Rated current busbar	2000 A
Rated short circuit current	25 kA

The switchgear is fully compartmented and equipped with vacuum circuit breakers on trolleys. Also here gas from a possible internal arc is led to outside of the container by an exhaust channel.

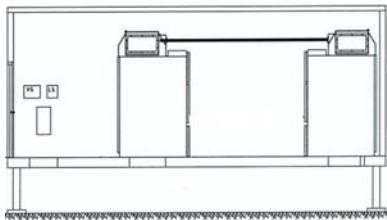


Figure 9 Container with 24 kV switchgear

Control and protection

The equipment for control and protection of the 170kV switchgear is placed in a separate container together with the auxiliary system. An ABB RET670 terminal handles operation and indication. The tap changer control is a part of the same terminal.

The protections for 52kV and 24(12) kV switchgears are placed in the switchgear cubicles, from where also operation and indication is handled.

Individual alarms from different types of equipment are normally transferred to a selected control centre and also to an alarm-unit in the control container. Alarms from 52 kV and 24(12) kV switchgears are visualized on the relay protections. Measuring of power and energy are only done at 24(12) kV outgoing feeders.

Auxiliary

The substation is normally supplied from the auxiliary

winding of the transformer or as an alternative from a local network. A board is installed in the control container for 400 V power distributions to the different parts of the mobile substation. A 44 kVA, 240 V diesel generator is used for supply before the substation is connected to the local a.c system. The aggregate is completely enclosed and transported as a separate unit.

A system for 110 V d.c. is installed in the control container. A cubicle contains main supply, rectifier, fuse boards, batteries and control equipment.

SUMMARY AND CONCLUSIONS

Vattenfall has in Sweden developed new types of mobile substations. The purpose of these substations is mainly to guarantee quick restoration of power supply after a major fault in a substation. However, when required, they can also be used for temporary power supply.

Substations in Sweden often have been provided with two transformers i.e. full transformer redundancy. One of these is normally in stand by. To reduce the cost, it is suggested to replace the second transformer with mobile redundancy in parts of the 52 kV network. A mobile substation is intended to be in operation within 8 hours after a major fault in a nearby substation.

The new types of mobile substations are easy to move and install. Enclosed design makes fences unnecessary and equipment more reliable. The mobile substations have been designed in cooperation with the contractor, ABB Power Technologies. One substation for 52/24(12) kV has now successfully been in operation for two years. More of this type are planned and another one for 170/52/24(12) kV is ordered.

The complete 52/24(12) kV mobile substation is built on a trailer. The trailer can be transported with a speed limit of 80 km/h facilitating a quick contribution after voltage collapse. A mobile substation is intended to be in operation within 8 hours after a major fault in a nearby substation.

The 170/52/24(12) kV mobile substation is split in several parts, to provide easy transport mainly in Sweden but also abroad. The transformer is placed on a trailer and the rest of equipment in containers. Because of the modular design and cable connection, the substation requires a minimum of time at site for installation and commissioning. An advantage is that also part of the substation can be used in emergency situation. The complete substation is intended to be installed and ready for operation within two days after coming to site.

REFERENCES

- [1] W.Lord, L.Ahnlund B.Wallbing-Lövgren, A.Lundvall 2005, "A substation concept for changeable load conditions" *CIRE D 2005*