

COMPACT HIGH VOLTAGE SWITCHGEAR SOLUTIONS

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1 Key Words

Compact solutions, Service concepts, High voltage switchgear, Air-insulated switchgear, Gas-insulated switchgear, Highly-integrated switchgear, Life-cycle costs.

2 Abstract

The aim of this article is to point out the availability of attractive state-of-the-art high-voltage switchgear solutions which have been designed to cater to the changing trends in the procurement and implementation patterns of the utilities which in turn have been influenced by the new trends in the world-wide energy market.

A factor common to most of these high-voltage switchgear solutions is the notable emphasis on the compactness of dimensions. It has however to be kept in mind that "Compactness" is a relative terminology, dependent upon the type of switchgear with which a particular "Compact Solution" is being compared. The choice and feasibility of a particular Compact Solution is further related to the techno-commercial boundary conditions and requirements.

This article shall also focus on the availability of highly efficient and cost decreasing service strategies which enable utilities to synergise their know how as a user

with the competence and experience of the supplier of the switchgear system. It will be shown with the help of implemented substations how the replacement of complete bays, modules or separate poles (depending on voltage level and type of module) of an installation in case of unscheduled maintenance is possible within a couple of hours

3 Introduction

The world-wide energy market is changing rapidly. The drivers for this change incorporate not only the deregulation of energy markets which is synonymous with the ever-increasing degree of competitiveness but a vast array of other factors which call for a number of requirements including: the integration of the substations in harmony with the landscape, reduction of environmental impact, reduction of space requirements, reduction of erection & commissioning times, enhancement of availability & reliability, reduction of maintenance and, last but not least, emphasis on overall feasibility, especially from the LCC (Life Cycle Cost) point of view.

The recent past has witnessed a growing demand for compact solutions for indoor as well as outdoor applications. It has been noted that in addition to their small space requirement, many compact solutions offer standardised as well as interchangeable switchgear modules catering thereby to the clients' needs for flexibility. The fact that different kinds of available solutions like the *HIS (Highly Integrated Switchgear)* which is an *exclusively registered trademark*, are delivered as pre-fabricated modules, reduces the overall erection & installation time dramatically in comparison to a conventional (AIS) substation where individual components have to be procured, handled, installed, commissioned and maintained separately. Another advantage of pre-fabrication is the reduced risk of faulty installation at site.

4 Characteristics of a Highly-Integrated Switchgear (HIS)

The Highly Integrated Switchgear (HIS) is a state-of-the-art compact GIS solution for indoor as well as outdoor applications. Besides providing optimal solutions for new GIS substation installations including certain standard configurations like H/ T/ In-Out schemes; its strength lies in offering highly flexible solutions for extensions and/or retrofit programs of outdoor as well as indoor type conventional (AIS) substations.



Fig. 1: Installation of a 145kV HIS substation as a space saving and reliable solution for the extension of an existing AIS substation

Being thoroughly encapsulated and at earth-potential, the HIS is safe-to-touch and is fully suitable for outdoor use. Corrosion-resistant cast aluminium enclosures, fully encapsulated contact systems & operating linkages with self-lubricating motor-operated mechanisms as well as other design and manufacturing features like an ambient temperature-withstand capability fully suited to

hostile negative and positive temperatures; have enabled a practically maintenance-free, operating life of at least 40 to 50 years for the HIS.

All components like circuit-breakers, disconnectors, earthing switches and current/ voltage transformers are accommodated in compressed gas-tight enclosures, thus rendering the switchgear extremely compact. The usage of one common type of self compressing interrupting units and spring operated drives up to 420/ 550 kV increases flexibility and reliability of the equipment.

Therefore, like mentioned above, it provides optimal techno-economic solutions for sites where space is limited, especially in cases involving increasingly complex site-approval procedures. As an example, two 145 kV HIS bays can be easily accommodated in the space available for one outdoor conventional bay. Similarly, a 420/ 550 kV HIS in 1.5 circuit breaker configuration could need as less as 20% space as compared to its AIS counterpart. Depending upon the application, HIS substations are sometimes up to 90% smaller than AIS substations due to the complete encapsulation of all devices.

The space-saving is accompanied by significant savings in the number of foundations, gantries, secondary wiring and other equipment, sometimes in the range of 60% to 90%. Analyses of such savings form part of the LCC (Life Cycle Cost) approach depicted in Fig. 2. For more details about this approach, Reference [1] mentioned at the end of this article can be consulted.

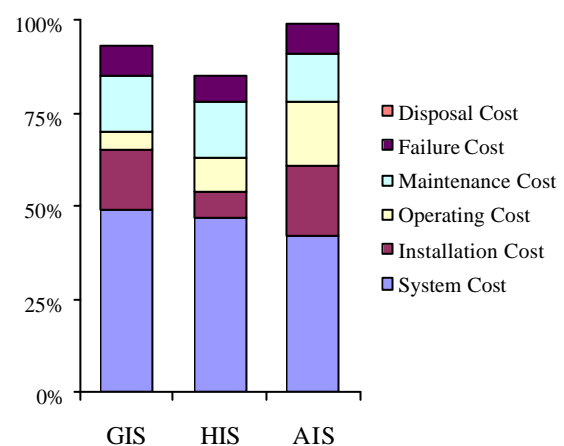


Fig. 2: Comparison of cost structure of LCC of GIS, HIS, AIS of a 145kV sample substation

5 Innovative Service Concepts for HIS substations

HIS - as an integrated modular switchgear - is easy to install. The pre-fabricated and pre-tested HIS modules will be installed and commissioned within a few days. Due to the fact that the technology of HIS is based on the well proven GIS technology, the service intervals are significantly higher than for comparable AIS substations. The first major overhaul i.e. the first inspection where the serviced bay has to be de-energised and the gas compartments have to be opened, is scheduled only after 25 years. In addition, the reliability of fully encapsulated technology is significantly higher than conventional outdoor technology.

The modular design of the HIS enables implementation of innovative service concepts. It is possible to replace complete modules within a minimum period of time in case of failure. It is possible to exchange a complete 420/ 550kV circuit breaker pole within 4 hours including all gas works and re-energising work.

Consequently, the operating utility does not have to maintain service personnel capable of detecting failures and carrying out repair work. The strict separation of the gas compartments by gas-tight bushings makes it easy to exchange any active module independent of the other components of the switchgear.



Fig 3: Complete 420/ 550 kV circuit breaker pole with C.T., V.T., disconnectors, earthing switches in separate gas compartments

6 HIS for 145kV rated voltage application

The 145kV HIS is characterised by a completely three-phase encapsulated, one-level design which is ideal for implementation of a simple substation layouts like H/ T/ In-Out schemes. Every active component is segregated from the next component, which increases the reliability and operator-friendliness.



Fig. 4: Example of a 145kV HIS-substation in H-arrangement with 5 circuit breakers in Germany

The 145kV HIS substation shown in fig. 4 connects two 31.5 MVA transformers supplying energy to an German industrial area with two 145kV XLPE supply cables. The transformers are connected by SF6/outdoor bushings with compound insulators. A sectionalising circuit-breaker is installed between the transformer bays allowing the transformers to be connected selectively. The entire installation took only six weeks to complete. The HIS occupies a 340 sq m plot of land equivalent to approximately only 30 % of the space needed for a comparable air-insulated switchgear installation with transformers



Fig. 5: Example of a 145kV HIS-substation in H-arrangement with 3 circuit breakers placed on the rooftop of the transformer building in China

Figure 5 shows an existing 145kV AIS substation in China being extended by two additional overhead line connections by implementing an HIS solution. The substation is located in a densely populated area with stringent space constraints. The flexible and compact design of HIS made it possible to place the substation on top of the control building. The H-arrangement with 3 circuit breakers covers a surface area of 240 sq m

7 HIS for 420 kV/550kV rated voltage application

The 420/ 550 kV HIS switchgear is based on a single-pole design with single-pole drives for the circuit breaker and disconnectors. The complete switchgear including the operating systems of the disconnectors is encapsulated. The single phase encapsulation is necessary due to the requirement for high insulation clearing distance for this voltage level.



Fig. 6: Installed Single In/Out-bay of a 420kV HIS-substation in Spain

The busbar is available in conventional (AIS) as well as in encapsulated (GIS) design. By using an encapsulated (GIS) busbar, significant savings in space can be realised.

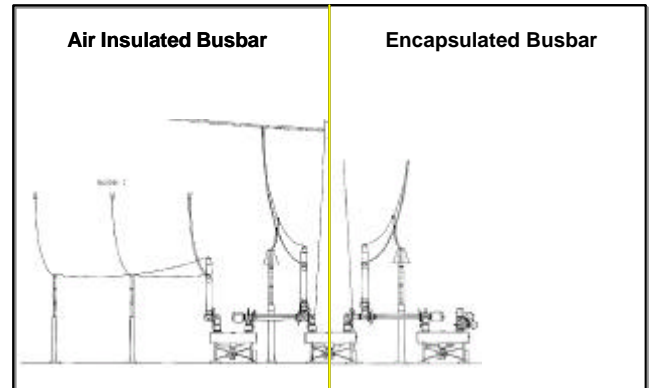


Fig. 7: 420/ 550 kV HIS – Busbar Solutions for One-and-a-Half CB Arrangement

The comparison of one diameter of a 420/ 550 kV, 1.5 circuit breaker arrangement shows that by using HIS technology, space can be saved up to 70% with the conventional (AIS) busbar. With an encapsulated (GIS) busbar, the length of such an arrangement can be reduced from approximately 200m to only 20m resulting in a space-saving of 90% in comparison with the original conventional (AIS) layout.

8 Conclusion

Compact high-voltage switchgear solutions like the HIS enhance the availability and reliability in operation by benefiting from the decisive characteristics of GIS technology. Their characteristics including their flexible modular structure and the usage of pre-fabricated and pre-tested units facilitate project-planning and reduce erection & installation times.

HIS technology makes unrestricted use of the well-established technologies that are continuously being improved for the past almost 40 years and have proven their reliability in connection with GIS circuit breakers, Dead Tank circuit breakers and outdoor circuit breakers. Well-established manufacturing and logistic processes keeping the core technologies for critical manufacturing steps tightly under control, guarantee the high product quality of the HIS. Consequently, the design properties of an HIS system contribute to high life-cycle benefit, high operating safety, long service life and high reliability and availability of this technology

9 References

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