Pushing GIS limits to new horizons

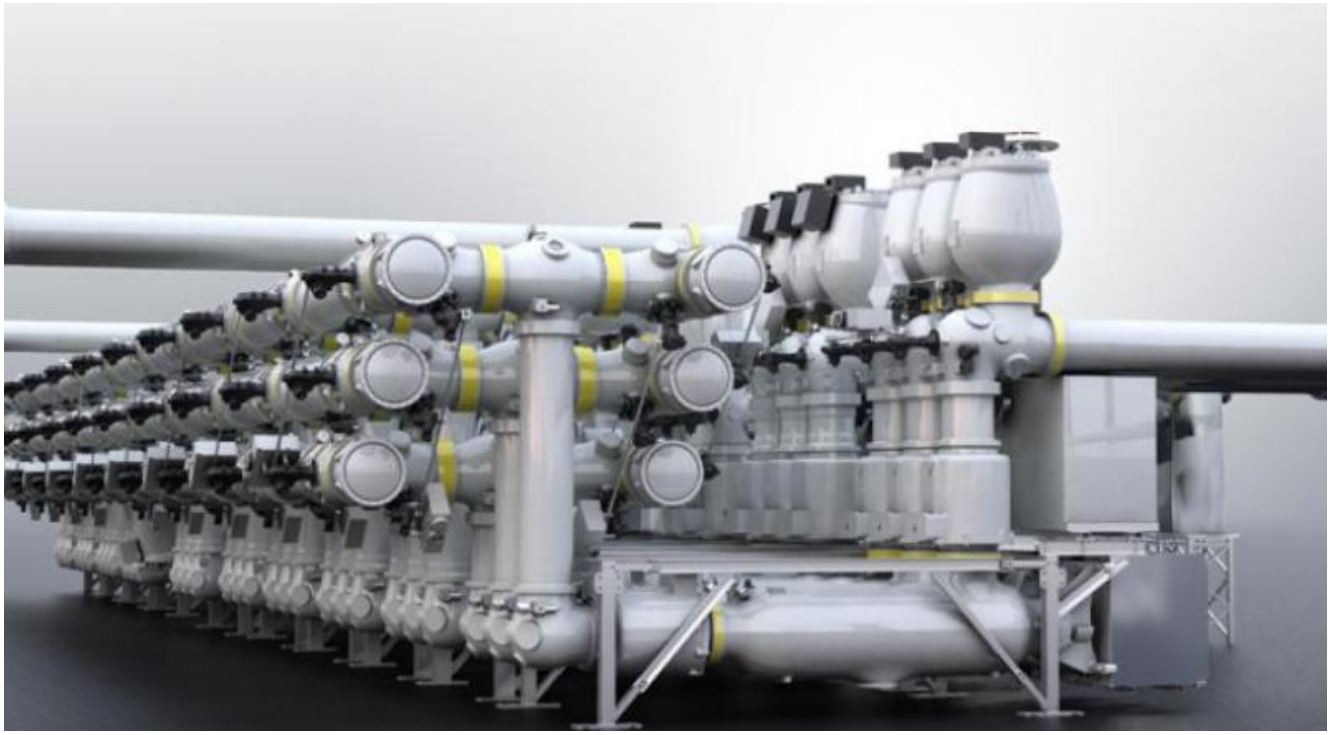
Thinking of solutions with several advantages

08/16/2014 - 3.11 pm

CLEAN GRID GIS SF_6

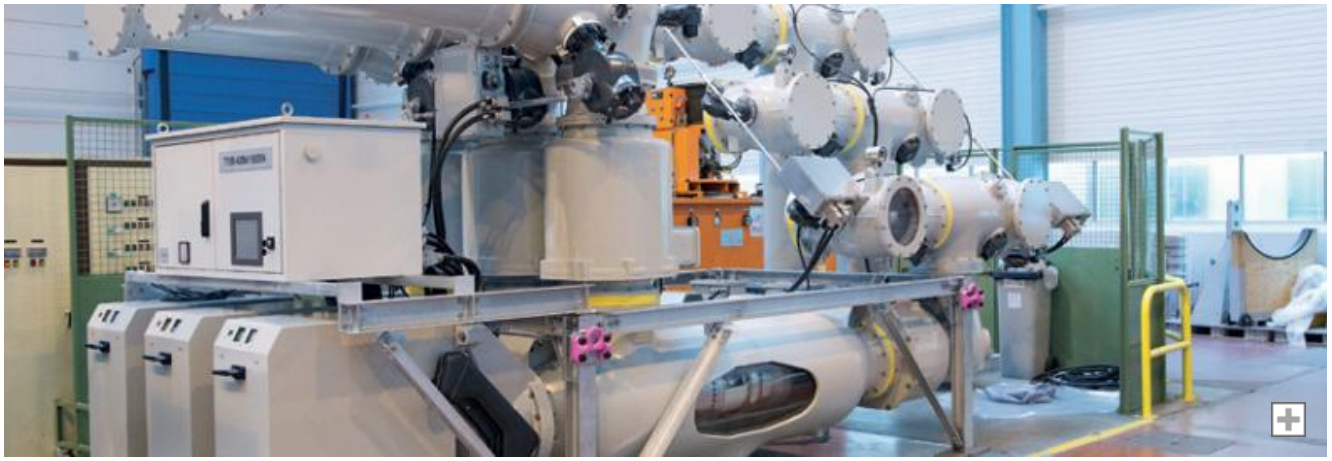
To meet the tough duties of 420 kV/63 kA gas-insulated substations (GIS), Alstom teams have developed a new single-chamber, double-motion circuit breaker. It demonstrates major improvements in size, cost and environmental impact.

Post a comment



High voltage circuit-breaker (CB) technology has advanced greatly since its introduction. Several interrupting principles have been developed to enhance performance and reduce operating energy. Among the various CB technologies Alstom has in its portfolio, gas-insulated substations (GIS) offer several advantages compared with air-, oil- or vacuum-insulated approaches. One is compactness, which explains why GIS are often chosen when space is limited and land is costly. As this becomes more significant with population growth and the trend of urbanisation, equipment compactness has become a key factor. “When dealing with high voltages such as 245 kV, the solution was originally to use 2 breaking chambers in series, each chamber taking half of the voltage. Then we developed a single chamber, but with high operating energy,” explains Jean-Baptiste Jourjon, Alstom’s GIS R&D group manager. “Advances in design then made possible the use of a single SF_6 chamber or ‘single break’, but with a low energy operating mechanism.” Subsequently, the same principles were extended to even higher voltages such as 420 kV, i.e. beginning with 2 chambers in series and then, to improve compactness, moving to a single chamber via the ingenious “double-motion” technology. This permits a drastic reduction in the

operating energy of the opening mechanism (see sidebar - box 4), allowing the adoption of a commonly used spring mechanism.



1 Getting up to 420 kV/63 kA

A “single-break” product rated up to 420 kV had been developed previously, but it was limited to 50 kA short-circuit current. It was a very large “puffer”-type circuit breaker with a high-energy hydraulic mechanism, so it was too large and too costly for today’s markets. Building on the self-blast double-motion technology that already existed for the 245 kV/50 kA range, Alstom’s engineers rose to the challenge of designing and constructing a new class of interrupter that could accommodate

the most demanding mechanical and dielectric constraints of the 420 kV/63 kA GIS duty cycle, yet be compact, cost-effective, reliable, safer and more environmentally friendly.

« Designing and constructing a new class of interrupter that could accommodate the most demanding constraints. »

However, pushing the technology to increase both the rated voltage and the short-circuit current up to these targets seemed a very serious challenge, especially in the context of size limitations. “We had to establish new criteria, first to optimise the sizing of the interrupter (dielectrics, mechanics, pressure and thermal withstand, etc.), and also because the known rules for lower voltages did not work when applied to 420 kV,” says Jourjon.

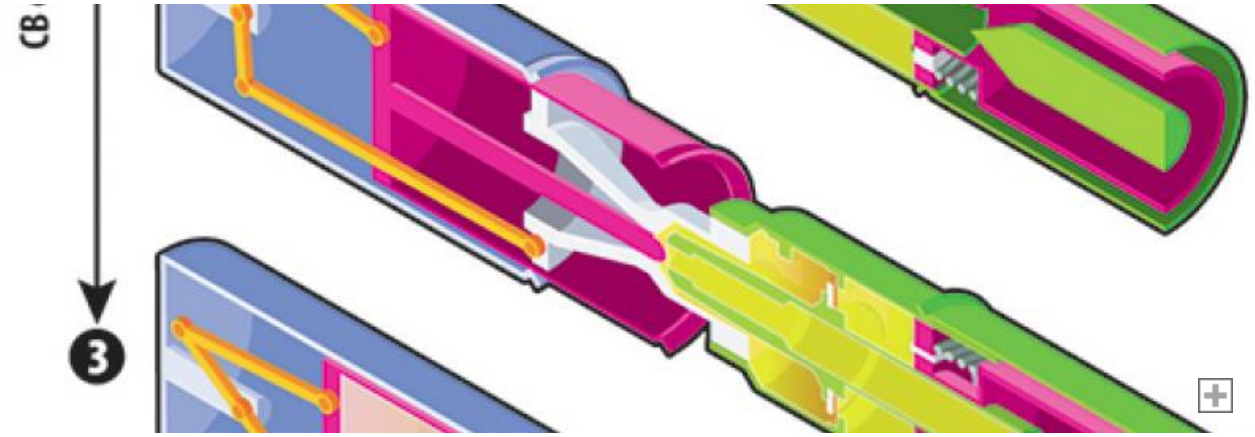
2 __ 40 % footprint reduction

After some years of simulations, model optimisation and tests on full-scale prototypes, the teams came up with a solution: the T155-CB3 single-break (or single chamber) interrupter, which is much smaller than the existing single-motion, double-break technology (2 interrupters in series) and which provides significant advantages:

- a 40 % reduction in opening energy;- lower environmental impact with 40 % less SF_6 mass;
- a 38 % mass reduction for one full pole with mechanism;
- phase width reduced from 900 to 700 mm;
- a 34 % height and 40 % footprint reduction;

- and the possibility of a full three-phase bay integration with common points and disconnectors in a single package.

“With this single-chamber approach, the cost is dramatically reduced, as well as the environmental impacts,” says Jourjon. These include reduction of mass, meaning less use of material (aluminium), and SF_6 reduction, which is important for global warming. In addition, complete bay shipment reduces the carbon footprint of transport to site.



3 __ Great interaction between product lines

Throughout the 5 years of development, the Alstom R&D departments working in both gas- and air-insulated switchgear product lines, in collaboration with the Research Centre in Villeurbanne, all worked closely together on this ambitious technical project.

« It also achieves a breaking time below two cycles at 60 Hz. »

The aim was to maximise the knowledge-sharing of the experts, conceive and compare various technical options, and to benefit from standardised solutions whenever possible. “It also allowed

us to incorporate industrial aspects early in the development process, to avoid the issue of a sophisticated technical solution that works but would not be cost-effective and would be difficult to manufacture in volume," points out Jourjon.

4 __A complete redesign of the whole GIS

The T155-CB3 "single-break" interrupter manages to reach 420 kV/63 kA switching and breaking performance with only one interrupting unit per phase and with low-energy spring mechanism for both energy storage and actuation. It also achieves a breaking time below 2 cycles at 60 Hz, which means a higher level of protection for the equipment in case of fault currents. Breaking performance covers 420 kV systems globally, including 60 Hz networks. The compactness of this new circuit breaker led to a complete redesign of the whole GIS, with a new arrangement of the components (disconnectors, etc.) enabling complete bay assembly at the factory and full bay shipment to site. This means that all major components are tested (including optional embedded low voltage control cabinet) and sealed at factory, a further guarantee for a high level of quality and customer satisfaction.

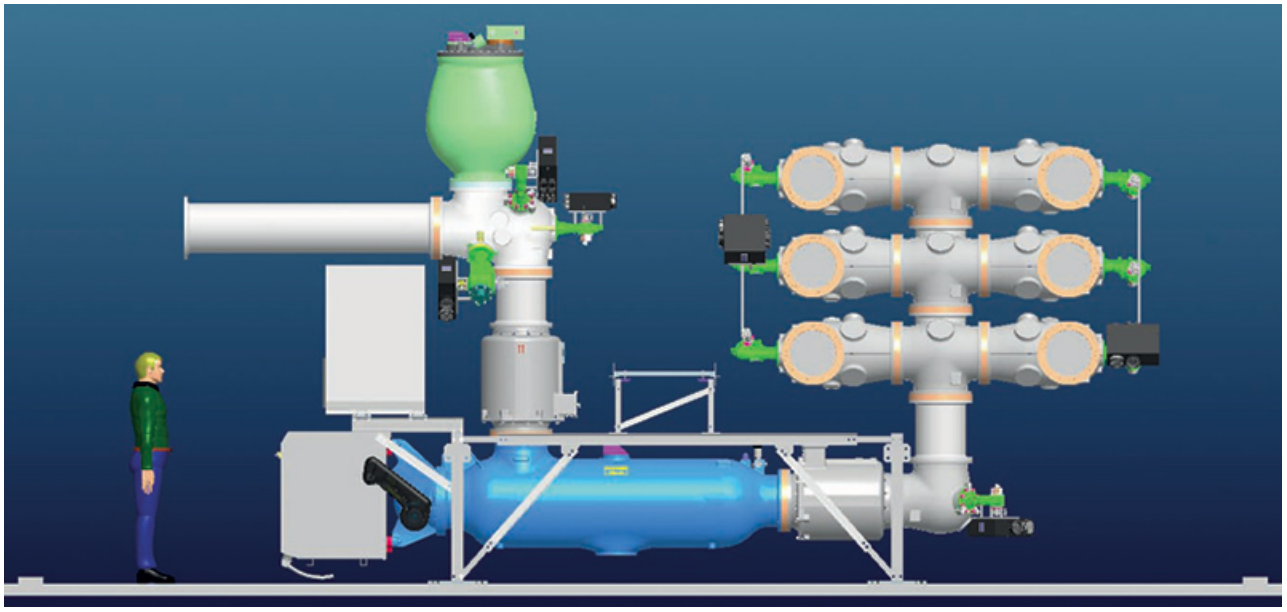
« It has a premium performance. »

In addition, full bay shipment reduces erection time by 30 %. Jourjon stresses: "The T155-CB3 is designed for easy accessibility with integrated gangways, and the specific gas partitioning ensures maximum availability in case of maintenance. So despite its lower cost (and size), it has very much a premium performance. It also offers comprehensive monitoring solutions and is ready for the full digital substation."

Single-break, double-motion principle

AC short-circuit current interruption involves blowing insulating gas through the electrical arc.

A piston moved by the operating mechanism increases gas density and generates an overpressure between the arcing contacts. As a consequence, gas flows through the arcing area, which cools down the arc and prevents its re-ignition after a current zero. The new Alstom T155-CB3 circuit breaker uses SF_6 self-blast technology, where the arc energy contributes to overpressure generation without affecting the mechanism's operating energy. At 63 kA, overpressure can reach up to 120 bar, which a spring mechanism could not withstand if the pressure were applied directly to the moving piston. For the 420 kV rating, very fast moving contacts are needed to withstand the recovery voltage between terminals following current interruption. To reduce operating energy and allow the use of its standard spring-driven FK3-6 mechanism, Alstom developed a double-motion technique that consists of displacing the two arcing contacts in opposite directions using a linkage lever system (see figure), instead of displacing one contact as in traditional designs. The speed requirement from the operating mechanism is therefore halved. This means that the energy necessary for the opening spring is reduced by around 40 %.



T155-CB3 single chamber 420 kV / 63 kA Interrupter: efficient, compact and easily accessible

RATE THIS ARTICLE

COMMENTS

SIGN UP FOR OUR NEWSLETTER

LEARN MORE

EXPERTS

Jean-Baptiste Jourjon

Alstom's GIS R&D group manager

SEND A MESSAGE TO OUR EXPERTS