A new facility at Romanche Gavet, currently under construction on the Romanche river, just outside the Oisans area, replaces six old power plants. The specific feature of this run-of-river facility is to have a very limited impoundment and very long short-circuited stretch. To secure access to the river, EDF has opted for unprecedented technology in France: energy dissipators.

This new facility will replace five dams and six old power plants on the Middle Romanche river. Most of these plants, in operation during the construction of the new facility, go back almost a hundred years. After studies conducted by the Hydroelectric Engineering Centre (CIH) of EDF, it was decided to replace them by one single, more efficient facility to optimise the head flow. (See Figure 1)

This new facility, consisting of a dam, a 9.3 km long headrace, an underground plant and a few external buildings, operates the same stretch of river as all the current six plants put together. More efficient, it is used to produce 35% more energy with the same head flow. This production gain corresponds to the average consumption of a town with a population of 60,000.

More environmentally-friendly, it clears the landscape of old equipment (plants, dams, penstocks, inlets, channels, etc.), it restores ecological continuity by removing river obstacles such as dams and uses plant engineering techniques to ensure the stability of the banks.

Sharing uses of water and securing the short-circuited stretch

The construction of a new facility offers the opportunity to factor in other uses of water (fishing, tourism, white water sports, etc.) and improve river safety. For that, it is necessary to raise the prefectural order currently in force, which prevents access to the short-circuited stretch of the Romanche. On the old facilities, there are no systems to delay the opening of the dams when a turbine does an emergency shutdown. This shutdown causes major flow variations in the river and can generate a risk for people present in the bed of the river.

Fig. 1. Diagram of the facility as a whole. Upstream, the Livet dam can impound part of the water of the Romanche in the headrace (dotted line). This 9.3 km headrace is built by two tunnel boring machines from the Les Ponants adit and links the dam to the Gavet plant located downstream. Excess water, or at least the instream flow, is poured into the short-circuited stretch (in blue), a natural stretch of the river between the dam and the plant.
Dissipating to ensure a time delay

On the new facility, the dam capacity is not enough to store all the upstream flow in the case of a sudden shutdown of the turbines. As the flows impounded can reach 50 m$^3$/s, it is no longer possible to open the valves of the dam to immediately release non-turbined water without putting people in the bed of the river at risk. Such a flow would cause extremely strong and excessively rapid rising waters. It must therefore be possible to perform a warning release to notify anyone present in the river of an impending rise of the waters. Moreover, the short-circuited stretch is long (approximately 10 km) and it is important to consider the time to propagate this warning release. To delay the opening of the dam gates while performing this warning release, it is therefore necessary to dissipate the value of the flow crossing the turbines when these are shut down. This warning release, agreed between EDF and the State as part of the licence agreement, consists of releasing only 10 m$^3$/s for a duration of 40 minutes. This flow is added to the in-stream flow which is 3.83 m$^3$/s. After these 40 minutes, EDF can then switch the entire river flow into the short-circuited stretch.

An innovative technical choice

It has therefore been decided to continue to impound the water in the dam to lead it downstream, at the level of the plant. There, a dedicated penstock, connected to vertical armoured wells, offers a way to bypass the plant and its turbines and lead the water taken from the river to the energy dissipators located on the plant’s restoration platform. They will dissipate the hydraulic energy instead of the turbine. This system is exclusively used in the case of emergency shutdowns. For scheduled shutdowns of the turbines, the warning release at the dam is programmed simultaneously with the decline of turbined flows. Finally, the dissipators have an operating time that corresponds to the time needed to perform the warning release.

Conventional energy dissipation systems usually rely on cone jet technology. This could not be applied at Gavet as it would have required space that is not available given its location at the foot of a cliff on a very narrow natural platform. The technical underground dissipation technique was also envisaged but it would require excessive excavation work. A multi-jet dissipation system was therefore finally chosen for Romanche Gavet.

This technology, although tried and tested since the 1990s in Italy at a single site, is innovative as it has experienced an interesting technical breakthrough since 2009 under the impetus of D2FC Energy Valves who design and manufacture this equipment. It is currently found in three Canadian facilities, in Albania, Columbian, Jordanian plants and soon, in France, at Romanche Gavet. This technical choice is therefore both innovative and linked to the geographic context of the new facility.

High performance equipment

Each dissipator can dissipate 0 to 25 MW. There are four dissipators, making it possible to dissipate all the power of the flow impounded at the dam. A dissipator weighs 30 tonnes, measures 8 m tall x 1.20 m in diameter and is placed at the bottom of a 6 m diameter x 7 m tall pit (see Figure 2). A barrel valve located at its lower end is activated by a hydraulic valve and releases water through submerged nozzles at the bottom of the inundated pit.

Dissipation occurs by combining back-pressure (position at the bottom of the pit) and a physical phenomenon called Von Karman vortices, i.e. a flow in alternated, energy-consuming vortices. When a dissipator operates at full flow, the water overflows into the pits in a one-meter high wave, then joins the river. At the bottom of the dissipating pits, a second pit, called the damping pit, closed by a 1.20 m high spillway wall, helps to absorb the shock once the water has been restored to the river.

The pit into which the dissipators release water are fitted with a 3 m high shield at their base, corresponding to the active part of the dissipator (see Figure 3).

Each dissipator has a security system consisting of a 900 mm ball valve. These valves are connected to a manifold, itself linked to the dissipators’ penstock. All this equipment is sized to resist Maximum Instant Operating Pressure which, at Gavet, is equal to a 347 m water column, equivalent to 34.7 bars where the operating pressure is 27 bars.

Downstream from the ball valve, an outfall (conical element of the penstock) reduces the 900 m diameter to 120 mm of the body of dissipators while reducing the speed of the water flow.

Reactive equipment

In case of an emergency shutdown of one or several turbine generators, the flow is cut off at the turbine by closing the distributor that supplies the turbine wheel with water, then by closing the ball valve supplying the generator. At the same time as this shutdown, one or several ball valves on the dissipator are opened simultaneously.
followed by the opening of the dissipators themselves for a value equal to the flow run by the turbines of the generator or generators during shutdown. All this equipment is steered by a control system consisting of PLCs that ensure real-time steering.

In the event of an emergency shutdown of the generators linked to a mains fault, the hydraulic plant that activates the dissipator valve remains operational, as the energy needed to move it is stored in the oleo-hydraulic accumulators’ battery.

Closely-monitored production

D2FC Energy Valves, which designs, manufactures and installs this equipment is a French company headquartered near Pécamp in Normandy. The construction materials come from German and Italian steel plants but are made and assembled in France. The pits and machine tools are made in the Grenoble area, at Pont de Claire and the hydraulic plants in Toulouse. A subsidiary of the company, D2FC Services, located near Grenoble at Fontaine, assembles the machinery on site.

The production of such equipment, on which the safety of the facility depends, undergoes a large number of tests and inspections. Tests are also performed by the company which has its own quality engineer but also under the supervision of EDF materials inspectors and outside auditing organisations. Inspections are conducted on the basic materials to guarantee the quality of steel and welding during assembly. Pressure tests are conducted to ensure perfect watertightness and pressure-resistance of the various parts. Finally, the anticorrosion paint coating is tested to guarantee sustainability.

The different assembly phases

The assembly of the dissipators is part of the phasing of the construction of the building housing them. It was firstly necessary to build the foundations to install the pits. Their armoured reinforcements, delivered in two parts in autumn 2015, were firstly welded then sealed to the concrete of the structure. Their installation required very precise altimetric mapping and horizontal positioning as the whole system then needed to be linked to the penstock installed once the armoured wells were completed.

The pits were concreted at the same time as the elevation of the building (33 m long x 18 m x 18 m h.) between late 2015 and early 2016. To concrete the pits without affecting their roundness, six batches of concrete (50 cm x 3 m h.) were needed as stress on the reinforcements was high. The armoured tanks were also solidly supported internally and six external removable stiffening rings (hoops) were used to maintain the geometry of the pits.

In May 2016, the manifold (see Figure 4) was installed on its supporting concrete blocks and pillars. Then, in March 2017,
New hydroelectric facility in Romanche-Gavet

Adapted civil engineering

Reinforcement and concreting of the pits and walls of the building are calculated according to the great stress to which they will be subjected during the operation of the dissipators. The bottom slab is 1 m thick over 450 m². 2,400 m³ of concrete surround the tanks and 320 tonnes of iron framework were needed for the whole building.

To reduce potential vibrations on the inner wall of the building, crossed by offtakes of the dissipators, shock-absorbing devices were installed on an offtake flange. Likewise, the bases of the dissipator in the pits were mounted on silentblocs to reduce vibrations. Stress linked to the weight of the operating dissipator is mainly vertical, at around 30 tonnes, while the stress on the wall crossing is 168 tonnes (see Figure 7).

The bend of the penstock is concreted and the end of the dispatcher (manifold) is also held in a concrete block to ensure stability of the upstream part of the dissipators.

Priming tests

In early 2018, dry runs will be conducted on the hydraulic plants. Water testing of the whole dissipation system may only be conducted with the priming of the facility scheduled in 2019. Because they are indispensable to the safety of the facility, the dissipators will be among the first equipment to be water-tested, just after testing of the watertightness of the headrace and operation of the ball valves.

Once the reinforced wells are built and the 276-m penstock installed in its tunnel, the bend joining up with the dispatcher could be concreted and all the welds between the different parts (manifolds and ring spools of the ball valves) will be completed.

Fig. 7. Cross-section of a dissipator in its pit. On the top, the wall crossing where stress can reach 168 tonnes. On the bottom, the base of the dissipator, where stress is around 30 tonnes, is mounted on a silentbloc to lower vibration levels. © D2FC (zoom to be extracted from attached JPEG)
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