

EN-CV DURING LS1: UPGRADE, CONSOLIDATION, MAINTENANCE, OPERATION

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Abstract

The Cooling and Ventilation (CV) Group in the Engineering Department (EN) will be heavily involved in several projects and activities during the long shutdown in 2013 and 2014 (LS1) within a timeframe limited to around twelve months. According to the requests received so far, most projects are related to the upgrade of users' equipment, consolidation work, and the construction of new plants. However, through the experience gained from the first years of the LHC run, some projects are also needed to adapt the existing installations to the new operating parameters. Some of these projects are presented hereafter, outlining the impact that they will have on operational working conditions or risks of breakdown. Finally, EN-CV activities during LS1 for maintenance, operation, and commissioning will be mentioned since they represent a major workload for the Group.

GENERAL OVERVIEW

The projects planned to be carried out during LS1 can be divided into three major activities:

- Consolidation activities: mainly based on a request from EN-CV itself;
- Upgrade activities: requested either from equipment users in order to cope with future needs or by EN-CV in order to match existing thermal loads;
- New projects: requested by equipment users groups.

These activities represent an important workload and the number of projects is equally distributed among them.

At present, around 55 different activities are planned to be carried out by EN-CV during LS1 across CERN's accelerator complex. One third of them consist in major projects that will represent an important workload and require major efforts given the technical complexity, number of plants concerned by each project, amounts involved, and planning constraints. The remaining activities are less complex and are considered closer or comparable to routine work.

However, around 20 projects have already been postponed to a date later than mid-2014 since EN-CV's resources are fully absorbed by approved activities.

LHC PROJECTS

Among the approved projects, the most important ones having a direct impact on the operation of CV installations for the LHC complex are reported in Table 1.

Table 1: List of major CV projects in the LHC

| Project | Location | Work duration (months) |
|--|----------------|------------------------|
| PM32 raising pumps | PM32 | 3 |
| Cooling of the CCC | Bldg. 874 | 12 |
| R2E | Pts 1, 5, 7, 8 | 12 |
| Backup cooling towers for ATLAS & cryogenics | Pts 1, 4, 6, 8 | 3 /Pt |
| Thermosyphon for ATLAS | Pt 1 | 15 |
| Chilled water upgrade | Pt 2 | 12 |
| New pumps in UWs | All UWs | 2 /UW |
| Controls update | SFs, SUs, UW | 12 |
| Ventilation of ALICE L3 | Pt 2 | |
| Backup pump Pt 4 | SF4 | 3 |

Details on some of these projects are given hereunder.

PM32 Raising Pumps

There is a constant water and sand ingress into the LHC tunnel from the underground water table in Sector 34. The water is collected into a basin at the bottom of PM32 where pumps continuously send the water to the surface while the sand cumulates at the bottom of the pit.

The project is justified by the poor conditions of the existing plant that needs refurbishing, by the obsolescence of the control system for which spare parts are no longer available and because the access conditions to the bottom of PM32 were changed last year. In fact, while during the LEP era the basin was independently accessible even during the run of the accelerator, with the LHC this is no longer possible since the basin is located in the helium escape path in case of leak. The sand has to be periodically emptied from the basin and 2 people are sent to transfer the sand out of the basin into special containers.

The system is extremely strategic since, if there is a general failure of the main pumps and of the backup pumps, the Level 3 alarm is triggered within 12 minutes and water overflows from the basin after 3 additional minutes.

The solution is to refurbish the station and modify the bottom of the basin in order to pump water and sand to the surface at the same time, consequently eliminating the need for people to access the basin to remove the sand.

An additional complication is given by the need of keeping the system operational during the whole duration of the work.

CCC Cooling

The CERN Control Centre is presently cooled by a set of air handling units each one dedicated to a specific room. The overall cooling power is insufficient in some of these rooms and the plant is no more redundant for the critical equipment. Moreover, when maintenance work is carried out, the system has to be shut down since there is no parallel plant can keep on providing the necessary cooling; this problem mainly concerns uninterruptible equipment; namely, informatics and telecom racks and the electrical supply.

The work will consist in increasing the cooling power, providing additional redundant units, and creating parallel circuits so that maintenance interventions can be performed without affecting the operation of the Control Centre. A new circuit for water-cooled rack shall also be implemented.

Throughout the whole duration of the work (more than one year), several phases are foreseen to keep on ensuring the cooling of the equipment. However, the final connection to existing pipes and ducts, functional tests, and commissioning (foreseen at the end of 2013) require a general downtime of the plant of one month during which the functioning of the Control Centre will have to be reduced.

Backup Cooling Towers for ATLAS & Cryogenics

Applicable laws on the control of *Legionella* risk require an annual stop of evaporative cooling towers with a complete cleaning and chemical treatment of their primary circuit. In order to comply with this constraint during the years of LHC run, the systems relying on the cryogenic plants have to be stopped for an overall duration of several days to take into account the warming up of the cryogenic systems, the cleaning period and the cool down to the operating temperature.

Installing a 6 MW cooling tower in parallel to the existing ones in LHC Points 1, 4, 6 and 8 will allow CERN to carry-out the mandatory cleaning while keeping the cryogenics operational. Other advantages of such a solution are the possibility of performing full maintenance on the pumping station of the primary circuit for 3 weeks (compared to the 4 days presently allowed for the stop) and to allow the run of the LHC throughout the winter of 2014-2015 when no winter stop is planned.

The work duration is estimated to be about 3 months per point with a total downtime of the cooling system of about 2 weeks.

Chilled Water Upgrade in Point 2

The available cooling power of the chilled water station at LHC Point 2 is presently insufficient to match the existing needs. Therefore, when the external temperature is around 32°C, the system cannot cope with the needed power and temperatures can only be guaranteed for the

ventilation of UX25, the tunnel and counting room in PX24. Moreover, no backup chiller is available for most of the year.

Increasing the cooling power requires additional chillers to be installed and the distribution circuit for the underground plants to be upgraded, including the change of the PM shaft pipeline.

The downtime of the station is estimated to be around 2 months for surface users while 6 months are foreseen for the work in the PM shaft.

ATLAS Thermosyphon

The cooling of the inner detector of the ATLAS Experiment is ensured by a closed circuit using C₃F₈ as a coolant and a set of compressors working in parallel. The operation of these compressors has not been reliable enough in the past years and an extended maintenance every 2 months is mandatory to ensure the proper running of the station.

The project involves creating a cascade of circuits to reach the -70°C operating temperature of the coolant entering the detector. In this circuit no mechanical component is installed (the existing compressors are kept only as a backup solution) and the required pressure at the inlet of the detector is ensured by the weight of the column of fluid between the surface (where the tank and condenser are located) and the underground cavern of the detector. The fluid then goes back to the surface in the gaseous state.

Several advantages in terms of reliability are expected, since the lack of mechanical components reduces the risk of failure as well as the risk of polluting the detector from possible oil droplets. The lack of vibration should also prevent damage to the circuits which result in leaks of the coolant; this represent a cost and environmental impact that is non-negligible. In addition, the overall requested maintenance will be reduced.

In the past years a smaller scale test has been carried out above ground to validate the concept.

Work has already started in 2011, will continue and be completed in 2012, and the plant commissioned in 2013.

New Pumps in UWs

The cooling circuit of each LHC sector is ensured by a single pump located in the UW cavern in the even points of the LHC. For budgetary reasons, the backup pump was not installed.

Another issue affecting the performance of this station is the flow rate that is excessive with respect to the design conditions and to the nominal working point of the installed pumps (from 9 to 38% higher). Even though this does not represent a significant loss in the circuit pressure, the motor of the pumps is very close to the limit and the risk of the motor overheating is very high.

Since there is no request for further increase of the flow rate in the coming years, the work will mainly consist in replacing the pumps and installing backup pumps.

The downtime of the station should be around 2 months, during which no cooling will be possible in the

sector. The impact on the UPS temperature located in the REs has to be carefully evaluated.

MAINTENANCE, OPERATION

Since during LS1 most of the equipment and accelerator components are not supposed to operate, EN-CV shall plan extended maintenance interventions in its stations to compensate the lack of maintenance during the last four years of run, when, because of the constraints imposed by the LHC operation schedule, the available time left for maintenance was insufficient to guarantee an acceptable level of upkeep thus limiting interventions to very basic work (greasing, replacing filters, belt tightening) and repairing faulty components.

Within the 20 months scheduled for LS1, two maintenance rounds are planned for all the equipment that is supposed to be operated during the shutdown period; a single intervention is foreseen, preferably at the end of LS1, for the stations that will not run in 2013.

The extended maintenance of the CV plants, whether it be cooling or ventilation, shall require the complete stop of the stations and operations such as the opening and cleaning of plate heat exchangers, the verification of Doucet filters, etc.

In addition, EN-CV will need to perform an extensive series of functional tests to ensure that the stations will perform correctly during the next few years: these tests include safety tests (e.g. Level 3 alarms) that are already performed periodically, as well as manipulating isolation valves to isolate part of the circuits or working in a degraded mode scenario (one single air handling unit to ventilate several areas in parallel) that cannot be performed during the annual technical stops during the LHC operation years.

The implementation in 2012 of a new preventive maintenance plan for cooling plants with more detailed instruction lists and procedures for performing interventions will bring additional advantages in terms of reliability and performance in the coming years.

CV SERVICES DURING LS1

Although the accelerator equipment is foreseen not be powered during LS1, several CV plants shall continue to run in the same way as during LHC operation years.

All the essential services that are under EN-CV's responsibility shall continue to be operated with possible interruptions to systems that will be subject to consolidation or upgrade work. However, compensatory measures shall be implemented during these stops wherever possible.

The essential services ensured are the following:

- Ventilation of underground and surface premises (tunnel, experimental areas, buildings, etc.);
- Chilled water only for ventilation purposes;
- Compressed air;
- Raising systems;
- Drinking water supplies;
- Fire hydrants network;

- Ventilation in the REs.

It is important to note that the ventilation units dedicated to the cooling of specific equipment (such as the ones in the UAs or service caverns for the experiments) are not planned to operate.

In addition to these plants, CV will operate plants according to users' requests, provided that they match the work foreseen in the same systems. However, until now even though the question has already been raised several times, no request has been made to run the CERN Axion Solar Telescope (CAST) experiment in LHC Point 8 for half of 2013. The author is convinced that several requests will be made in the coming months which might create significant problems in terms of planning and availability if the requests are made after the detailed planning for work and related contracts have already been signed with external contractors.

COMMISSIONING

Another activity that will represent an important workload during 2013 and 2014 is the commissioning of CV stations, especially those needing modification works, as well as the commissioning of users' equipment. As an example, the number of connections and valves to balance in each circuit of one LHC sector is above one hundred (e.g. 137 connections in Sector 12).

It is fundamental to make use of the previously gained experience from the commissioning work that was carried out at the end of the LHC installation project, during which several difficulties were encountered that had an impact on the planning. Given the limited flexibility of the planning during LS1, it will be essential to avoid similar problems. The following issues are the most important to tackle:

- Continuous balancing of cooling circuits following the start-up of the different equipment to be cooled;
- Air management in underground areas during the shutdown period in which the tunnel will be in an open access configuration;
- Balancing the pressure difference between different areas, that can be checked and calibrated only once the whole tunnel and experimental caverns are closed, i.e. at the end of the shutdown;
- Circuit flushing, with a higher risk of filters clogging if a proper flushing has not been previously carried out on each equipment;
- Coordination and phasing of every job in case the circuits need to be drained to avoid the equipment being damaged (e.g. current leads).

FINAL CONSIDERATIONS

EN-CV's involvement during LS1 covers various activities (installation work, maintenance, operation, etc.) and fully employs all the CV staff throughout the whole shutdown. This means that flexibility will not be possible when dealing with new intervention requests or modifications to the work schedule at a later stage. The addition of a new project will result in the cancellation of

other ones but such a decision has to be coordinated at a more general level (where several groups are involved in the same project) and shall comply with the priorities set by CERN's management.

Although LS1 shall start in 10 months from now, CERN procedures require that call for tenders related to the most important projects have to be sent out by May 2012 at the latest; this implies that project definition and detailed planning have to be clarified before this date.

In order to reduce the workload during LS1, part of the work shall already start in 2012, where possible. However, this represents a small part of EN-CV's activity and also depends on other Groups' availabilities (such as the civil engineering work).

As it has already been mentioned in several parts of this paper, the success of the activities foreseen during LS1 will also strongly depend on the general and detailed planning of work for each Point. Maintenance interventions as well as projects, tests, and commissioning will affect or require important downtime of the plants and this should match the cooling needs of the equipment groups for their activities. It is therefore clear that the delay in one activity will have a domino effect on other ones. Finally, any important modifications to the planning have an impact on several contracts with external contractors and might entail important overspending. For all these reasons it is of primary strategic importance that all activities and requests are made in the coming weeks in order to define a feasible and credible planning. Since the number of requests exceeds the resources available in EN-CV, an arbitration process by the LS1 Project Leader will define which requests shall be approved and which ones have to be postponed until after LS1. Late requests cannot be taken into consideration.

The last point that needs to be mentioned is an outlook on 2014 and 2015 in terms of reliability of CV plants: since no technical stop is foreseen around Christmas 2014, the installations will run for two years without any preventive maintenance. It is therefore extremely important that, whenever possible and in agreement with the commissioning and powering planning, EN-CV is allowed to perform preventive maintenance work in all its installations during 2014.