Overview of the LEP1 cryoplants PA4/PA8 supplying ALEPH/DELPHI solenoids and QS0s - Problems encountered in 1999, solutions & cures for next year

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Abstract

The two plants supply LHe to the superconducting solenoids of the ALEPH / DELPHI detectors and to the superconducting QS0s of the LEP accelerator, installed before the collision points. A brief description of the cryogenic installations is given, before the operation statistic and the problems encountered, during this year's physics run, are discussed. Finally a list of preventive and corrective shutdown maintenance actions is presented, to avoid similar problems during the LEP physics run 2000.

1 OVERVIEW OF A LEP1 CRYOPLANT

All liquid helium, required for the cooling of the accelerator (SC cavities, SC QS0), is provided by four 18 kW cryoplants, installed in the even points and operated under the responsibility of LHC/ACR. The only exemption are the QS0s of LEP PA4 and PA8, which are connected to a Sulzer TCF200 helium refrigerator (800 W at 4.5 K entropy equivalent) also supplying the superconducting solenoids of the ALEPH and DELPHI detectors. These two installations are operated under the responsibility of LHC/ECR. Figure 1 shows a schematic overview of the cryoplant.

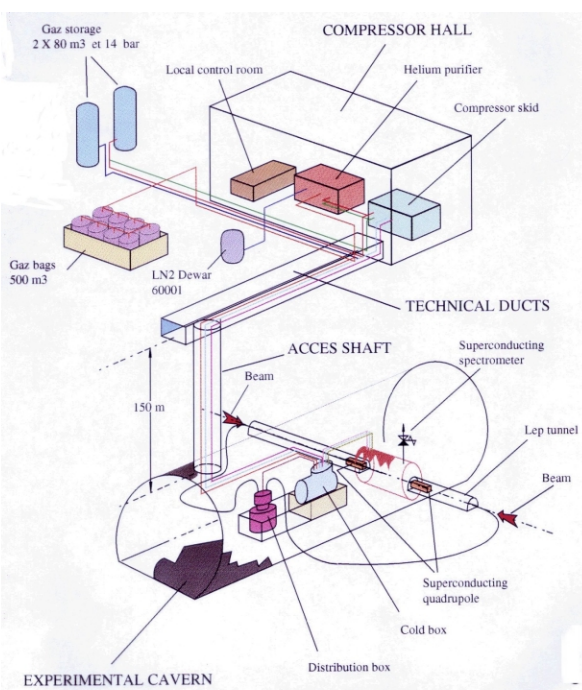

Figure 1: Overview of LEP1 cryo plant.

In the following the 1999 LHC/ECR cryogenics operation campaign is summarised, in particular the performance obtained with the two LEP1 cryoplants.

2 OPERATION STATISTICS 1999

2.1 Helium cryogenics operated under the responsibility of LHC/ECR

During the 1999-operation campaign in total 12 cryoplants were in operation. Figure 2 shows a geographical overview of the installations, which can be subdivided into two categories: Cryogenics for SPS/LEP experiments (7 plants) and Cryogenics for LHC test facilities (5 plants). Operation statistics have been established over the last 8 years for the cryoplants supplying SPS/LEP experiments and during the last two years for the LHC test facilities. The installations are also geographically grouped in three zones and each zone is controlled from a dedicated cryo control room with its own operation team.

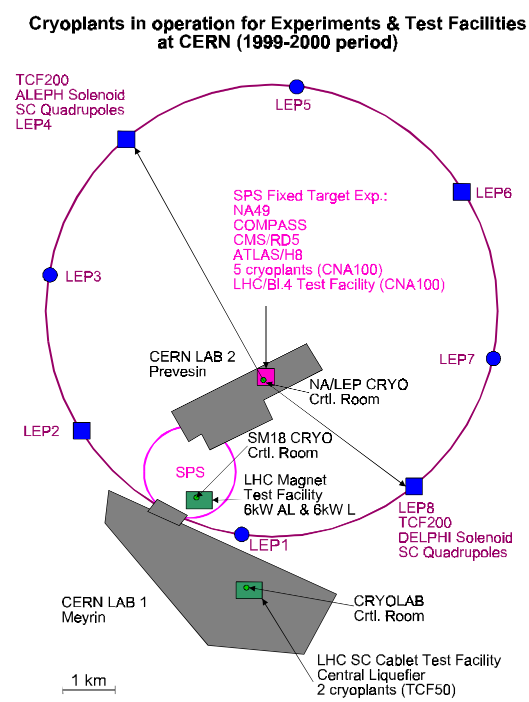

Figure 2: Geographical overview of cryoplants in operation for experiments & test facilities.

2.2 *Cryogenics operation for LEP/SPS experiments*

In the 1999 operation campaign cryogenics to 6 physics experiments has been provided including also the experiment ALEPH (LEP PA4), DELPHI (LEP PA8) and their associated superconducting quadrupoles. In total 24’226 hours of running time have been accumulated, during which 14 MW*hour (total accumulated cooling by 6 plants running for SPS/LEP experiments) of cooling power at 4.5 K have been provided to the superconducting magnets.

The evolution over the last 8 years of the total running time and fault rate for the LEP/SPS cryogenics is shown in figures 3 & 4. While the total running time remained constant at around 45’000 hours during the first 4 years it has decreased since 1997 to around 25’000 hours. This represents the fact that some of the SPS experiments have been stopped and the cryoplants were transferred to supply test facilities for LHC in the West Area & North Area. Also in 1995/96 the two dedicated liquefiers for the QS0’s in LEP PA2 and PA6 were transferred to the North Area and the QS0 were connected to the 12 kW LEP2 installations.

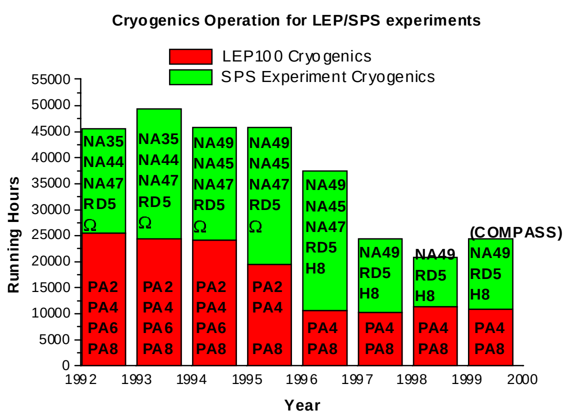

Figure 3: Total running hours of LEP/SPS experiment cryogenics over past 7 years

The fault rate is calculated as the ratio of the accumulated number of hours the helium production was stopped during LEP physics and total running time. The trend over the past 8 years shows, that the fault rate after some initial problems in 1992 had stabilised around 3 per thousand hours, but during the past two years it has raised to 4.75 per thousand hours. This increase is related mainly to two major cold box blockages occurring at the LEP1 cryoplants, one of which happened last year in LEP1 PA4 causing around 160 hours of LEP down time. Complete lists of incidents as well as the corrective and preventive maintenance actions taken are discussed more in detail in the following chapters.

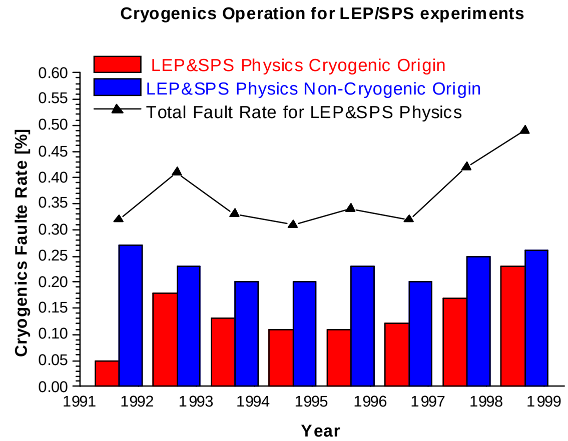

Figure 4: Accumulated fault rate of LEP/SPS experiment cryogenics over past 7 years.

2.3 *Cryogenics operation for LHC test facilities*

The cryogenics for LHC test facilities includes the two 6 kW @ 4.5 K cryoplants at SM18, two 450 W @ 4.5 K liquefier at CERN Meyrin site (bldg. 163, 165) and another 450 W @ 4.5 K refrigerator installed at CERN Prevesin site (bldg. 892). The installations have totalled 27167 hours of running time during which 50 MW*hour of cooling at 4.5 K were provided to the various LHC test facilities.

During last year over 300’000 litres of liquid helium were distributed to 35 clients using movable Dewars with capacities between 200 to 1’000 l. Also more then 400’000 m^3 of helium gas were recovered and re-purified from the LHC test facilities with a loss rate of less then 2.5%. In addition around 3’200 t of liquid nitrogen were distributed to 20 large storage tanks (capacities: 6’000–50’000 l) in operation on the various CERN sites.

3 MAIN PROBLEMS ENCOUNTERED DURING 1999 LEP1 CRYO OPERATION

3.1 *LEP1, PA4*

The total running time for ALEPH was 5015 hours with in total 170 hours of liquid helium production stop during LEP physics.

162 hours have a cryogenic origin, which means they were provoked by failure of equipment, for which the maintenance is done under responsibility of LHC/ECR. This was due to a cold box blockage with water, which necessitated two stops of helium production to regenerate and clean the helium circuits.

During the LEP physics run 3 electric power cuts caused in total 4 hours of ALEPH down time to recover nominal conditions. Also 7 quenches of the QS0s in PA8 were observed. All had a non-cryogenic origin and could be recovered fully automatically within 35 - 40 minutes, causing in total only 4 hours of QS0 downtime.

3.2 LEP1, PA8

This plant accumulated in total 5646 hours of running time with only 33 hours stop of liquid helium production during LEP physics.

The only stop with cryogenic origin (4 hours) was due to the mechanical failure of a sliding valve installed in the main helium compressor. Another stop (6 hours) was needed to re-align the compressor during the LEP accelerator setup, but did affect the LEP physics run.

During LEP physics one electrical power cut caused a DELPHI stop of 21 hours to recover nominal conditions, but did not affect QS0 operation. The only QS0 downtime last year was caused by in total 11 quenches with non-cryogenic origin. The fully automatic quench recovery took in average 40 minutes and therefore caused 8 hours of LEP accelerator stop.

4 CORRECTIVE AND PREVENTIVE LEP1 CRYO MAINTENANCE TASKS

During the past 8 years a detailed preventive maintenance plan has been established for all cryogenic installations. It specifies for all equipment in operation the maintenance to be performed as well as the service intervals. Despite the shortest shutdown interval since start-up of LEP1 cryogenics, all preventive maintenance tasks were scheduled and have been performed before the re-start in February 2000.

Apart from the preventive maintenance, two major other actions had to be taken during the LEP1 1999/2000 shutdown.

4.1 Protection for BREOX oil

During the 1999 run two major incidents with leaks in the oil circuits of the main helium compressors happened, provoking a stop of plant operation and causing a potential risk of environment pollution. Ageing of material (welding) due to elevated local vibrations, when the compressors are operated in certain configurations, have been traced as the origin. At present a study, how to decrease the vibrations is on going. In parallel measures were taken to detect a BREOX oil leak faster and to avoid BREOX oil getting outside the compressor hall.

The first incident (SM18) showed, that the already existing oil leak detection system, using level and pressure measurements in the oil separators of the compressors is not rapid enough (40-50 min.), in case of a small leak declaring on a pressurised (6-8 bar) helium-oil circuit. In such a case the BREOX-helium mixture is distributed in form of a hot mist into the whole compressor hall and attacks chemically all PVC containing components (cable isolation). While the leak repair can be done fairly rapidly (4-5 hours), the cleaning of all components in the compressor hall, exposed to the amount of BREOX (200 l) scattered during the 40 min. before de-pressurisation, takes several days. Therefore an additional optical smoke/vapour detection system has been tested and will be installed before the LEP physics run 2000 on top of the LEP1 compressors and connected to the hardware interlock chain. With this system, the appearing of BREOX oil mist around the compressor can be detected within 2 minutes including the triggering of an automatic stop and de-pressurisation.

The second incident (LEP2, PA4) showed that in case of big BREOX leaks (full fracture of a pipe), where the liquid oil is flowing on the floor of the compressor hall, there is a potential pollution risk of the surrounding environment via the water evacuation systems and technical galleries below. Therefore all LEP1 and LEP2 compressor halls were inspected to identify all points where oil could get outside and at present the modifications are done by ST to seal them.

4.2 LEP1, PA4 water leak search

Following the blockage of the LEP1, PA4 cold box the 25th of September 1999 stopping the LEP accelerator and ALEPH, a series of actions were taken. The various compressor and cold box regenerations performed during the LEP physics run, the technical stop and at the beginning of the shutdown showed that in total between 2.5 and 4 Kg of water had been trapped in the first heat exchanger, provoking the complete loss of refrigeration power. No air was found, excluding the possibility for an atmospheric origin of the water

During the shutdown all water/helium heat exchangers (2 installed on the compressor, 1 installed on each turbine), representing the only points in the whole helium cooling circuit where an intake of pure water could happen, have been leak tested by LHC/VAC. All have been certified to be leak tide at least down to 10^{-8} mbar l sec^{-1}. Also the two turbines itself have been leak tested and found to be tide down to 10^{-9} mbar l sec^{-1}.

The two 80 m^3 helium buffers, supplying the pure helium gas to the compressor were analysed and no detectable quantity of water could be found. The helium cooling circuits (including the storage Dewar) of the QS0 have been warmed up to 300 K with pure helium gas and the analysis of the return gas showed no residual water.

The thermal shield of the solenoid, supplied with cold helium gas from the cold box during the run, as well as the main helium cooling circuit (including storage dewar) have been warmed up electrically to a temperature of 250 K. Then they have been rinsed with pure helium gas up to ambient temperature with a water analyser connected to the return without seeing any detectable water concentration.

Together with the detailed analysis of the alarm/event lists and the plant performance just before the blockage, it could be shown that the whole LEP1, PA4 cryoplant was and is absolutely leak tide and ready for nominal operation in LEP’s last physics run.