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MONITORING THE WASTEWATER OF LEP

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Abstract

Along the LEP sites CERN is discharging water of differing quality and varying amounts into the local rivers. This wastewater is not only process water from different cooling circuits but also water that infiltrates into the LEP tunnel. The quality of the discharged wastewater has to conform to the local environmental legislation of our Host States and therefore has to be monitored constantly. The most difficult aspect regarding the wastewater concerns LEP Point 8 owing to an infiltration of crude oil (petroleum), which is naturally contained in the soil along octant 7–8 of the LEP tunnel. This paper will give a short summary of the modifications made to the oil/water separation unit at LEP Point 8. The aim was to obtain a satisfactory oil/water separation and to install a monitoring system for a permanent measurement of the amount of hydrocarbons in the wastewater.

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1 INTRODUCTION

The main part of the Large Electron Positron collider (LEP) and the related installations are water-cooled. There are different water circuits for the varying demand of users in terms of water temperature, water quality, pressure and flow rate. The sewage, which has to be discharged from LEP, comes from the open raw-water circuit, the water treatment, tunnel infiltration, water leaks and condensation.

2 SEWAGE CIRCUITS

For the discharge of the above sewage the following circuits have been installed at LEP.

2.1 Discharged-water circuit *(Réseau eau rejet)*

The consumption and discharge of raw water depends mainly on the energy requirement of LEP and the time of year; there is however a permanent discharge of raw water all year round. This is mainly because of

- automatically flushed filter units for the primary water circuit,
- measurement of the conductivity in an open analysing circuit,
- evaporation losses and associated deconcentration of the primary water which has to be compensated,
- minimum flow rate of the raw-water supply pumps for the primary water circuit.

The discharged water arrives at LEP Point 1 from where the water is discharged into the river 'Nant d'Avril'. A permanent monitoring of the radiation, the pH and the temperature is done.

2.2 Basin for neutralization *(Fosse de neutralisation)*

The demineralized water for the LEP cooling circuits is produced in building 378 at the Meyrin site and is afterwards distributed from there to all LEP points. The equipment to produce demineralized water and the demineralizer, which are installed in each demineralized water circuit to ensure the quality of the water, have to be recycled periodically. This is also done in building 378. Demineralized water is collected here in a basin for neutralization, where the pH value is continuously monitored. Before the basin is discharged, the water will be treated to set the pH value between 6.5 and 8.5. The basin has a volume of about 60 m^3 and is discharged about once a month directly to the purification station at Peney, Switzerland.

2.3 Used-water circuit *(Réseau eau usée)*

The used water from the sanitary stations is discharged like the normal domestic sewage. Raw water is added to the collecting pit for used water to facilitate the pumping of the viscous used water from the underground area to the surface.

2.4 Clear-water circuit (*Réseau eau claire*)

The designation 'CLEAR WATER' does not relate to the quality of the water. The clear-water circuit is in fact the drainage-water system for the LEP tunnel and it collects all the water from the LEP tunnel.

- About 64 m^3/h spills into the drainage system due to the open cooling circuits of the sixteen ‘alveoles’ along the LEP tunnel.
- The infiltrated water of the LEP tunnel has also to be evacuated by the drainage system. The exact amount of infiltration cannot be determined. In general, we estimate an infiltration of up to 4 m^3 per hour. This value is not at all applicable for LEP octant 2–3. There is an infiltration of approximately 70 m^3 per hour. To evacuate this huge amount of water, a special drainage system to LEP Point 32 has been installed.
- The water, which is to be evacuated owing to modifications or maintenance of one of the LEP underground water circuits, is also collected via the drainage system. This could be raw water, primary water, demineralized water or mixed water.
- Small amounts of leakage and condensation water also spill into the drainage systems.

This water is pumped from each underground cavern of the LEP tunnel to the surface and then discharged into the local rivers. TIS-TE is taking monthly samples from the rivers for analysing the pH, temperature, conductivity and concentration of dissolved oxygen. TIS-RP is taking once-a-year samples of water, sediments and plants at the river inlets to measure the radioactivity.

3 LOCAL ENVIRONMENTAL LEGISLATION OF OUR HOST STATES

Although most of the water of LEP is discharged into French rivers, CERN adheres to the much tighter Swiss law [Ordonnance sur le déversement des eaux usées (RO 1975 2403)]. The slight differences in the French law [Les normes de rejet (Arrêté du premier mars 1993)] are also fully applied by CERN whenever this law indicates stricter monitoring than the Swiss law (Table 1). The Swiss law defines limit values for more than 50 parameters and, obviously, it is not possible to survey them all continuously. Hence most of the processes are monitored according to their specific use by taking into account the major risks. In most cases a permanent measurement of the pH and the temperature is adequate. Owing to the specific use at CERN the radiation of the discharged water has also to be monitored.

Table 1

Differences in Swiss and French law of some limit values

Parameter	Swiss law	French law
pH	6.5–8.5	5.5–9.5
Temperature	25°C [30°C]	30°C
Concentration of dissolved oxygen	6 mg O_2/l	
Concentration of hydrocarbons	10 mg/l	15 mg/l
Radiation		

4 LEP POINT 8

The monitoring of the discharged clear water of LEP Point 8 is different from all the other LEP points. A more detailed description of the situation at LEP Point 8 is therefore necessary.

4.1 Infiltration of water and petroleum

In the two LEP octants 6–7 and 7–8 there is also an infiltration of petroleum (natural crude oil), which is naturally contained in the soil. Naturally occurring petroleum is complex and variable in chemical composition. Its colour ranges from light greenish brown to black. It may be fluid or so viscous as to be nearly solid.

4.2 Consistency of the oil

The analysis was done by SHELL in 1988. The sample consisted of a mixture of

- 10% volume of sediments (sand, etc.),
- 40% volume of water,
- 50% volume of hydrocarbons.

The mixture indicated the following values:

- density of 0.972 kg/ dm^3,
- kinematic viscosity of 568 cSt (centistokes) by 50ºC [1cSt = 10^{-6} m^2/s = 1 mm^2/s],
- 0.27% weight of sulphur.

The phase of hydrocarbons showed

- 70% volume distilled by a temperature lower than 370ºC, and can be seen therefore as light oil;
- 30% volume has to be considered as heavy oil.

This analysis shows that the raw petroleum is to be considered as very heavy (bitumen) with a very high inflammation point.

4.3 Emulsion

An emulsion is an intimate mixture of two liquid phases, such as oil and water, in which the liquids are mutually insoluble and where either phase may be dispersed in the other. An oily waste emulsion, in which oil is dispersed in the water phase, may contain any of various types of oil in a wide range of concentrations. Violent mixing and shearing of oily wastewater in transfer pumps disperses these minute oil droplets throughout the water.

4.4 Treatment methods

Oil separation and removal can be divided into two processes: gravity separation of free, nonemulsified oil and chemical treatment and separation of emulsified oil. Oily waste is typically a combination of free, nonemulsified oil, stable emulsified oil and insoluble solids. Settable-free oils and insoluble solids are physically removed from wastewater by gravity separation. Such gravity separators cannot remove soluble impurities nor break emulsions.

Gravity separators depend on density differences to provide the buoyant force that causes the droplets of free oil to rise to the surface. Theoretically, oil droplets rise linearly as predicted by 'Stokes'[1] law; in practice, turbulence and short-circuiting usually disturb the separation pattern.

$$v_g = \frac{d^2 * (\delta_w - \delta_o)}{18\eta} * g \qquad (1)$$

ν_g - liquid droplet rise velocity [m/s] d - particle/droplet diameter [m]
δ_w - water density [kg/m^3] δ_o - oil density [kg/m^3]
η - dynamic viscosity [kg/(m*s)] g - gravity [9.81 m/s^2]

The above expression shows that the sedimentation of a particle (droplet) is determined by the physical characteristics of the particle/droplet in the continuous phase. The main factors that affect the design of an oil-water separator are accordingly

- Flow rate (average, maximum, and minimum).
- Specific gravity of the oil.
- Viscosity of oil.
- Operating temperature,
- Fluid characteristics: % of free oil, % of soluble oil, diameter of oil globules, and extent of mechanical emulsion.
- Identification of other contaminants present in feed stream.

4.5 Modifications made to the water–oil separation unit at LEP Point 8

The crude oil comes mainly along the lowest point and the two alveoles RE 78 and RE 82. To diminish the amount of clear water to treat at the water-oil separation unit, the two cooling circuits for the alveoles RE 78 and RE 82 have been modified. The primary-water circuit is now a closed demineralized-water circuit. The main modifications have been made to the decantation basin.

- Cleaning and discharge of more than 20 m^3 of oily sedimentation from the decantation basin.
- Increasing the capacity of the basin, by building up each restraining wall by 50 cm, to handle higher flow rates by maintaining the water quality.
- Installation of a new filter system (mousse de polyuréthane floquée) with a ten times larger filter surface.
- Installation of an oil skimmer that can be moved from one chamber of the decantation basin to the other to skim the oil from the water surface. This oil skimmer reduces the cleaning of the decantation basin almost to zero.
- Seven new overflow holes (siphons), adjustable in height, have been installed which can also be used to drain the surface water.

[1] Stokes, Sir George Gabriel (1819-1903); British physicist and mathematician noted for his studies of the behaviour of viscous fluids.

- The oil, which is collected via an oil skimmer and via the siphons into the collecting channel, is discharged by ORTEC for incineration.
- For a constant measurement of the quantity of hydrocarbons in the sewage leaving the decantation basin, a photometer is installed in the SUX 8 building. The measurement is a continuous analysis of the fluorescence of the water and a continuous comparison with a chemical source (quinine sulphate) of fluorescence, which corresponds to 100% of crude oil. The photometer calibrates itself continuously. The results of the analysis are transferred to the LabVIEW control system. The 'Département des travaux publics de Genève' is also taking samples once a month. The latest results have shown that their analyses are in agreement with the measurements of the photometer.
- A valve of DN 400 has been installed on the outlet of the decantation basin, which will close if the amount of hydrocarbons exceeds the allowable maximum of 10 mg of hydrocarbons per litre of water, to avoid sewage spill into the river 'Nant du Gobé'.
- The constant monitoring of the water quality allowed us to create different alarm levels.

Today the water–oil-separation unit consists of two oil separators and a decantation basin, equipped with an oil skimmer, seven overflow holes (siphons), three vertical and one horizontal filter that allow a satisfactory oil/water separation. The entire water–oil-separation unit is a static process based on separation per gravity, which means that changes in the flow rate will effect the quality of the separation directly.

4 CONCLUSION

Throughout the years of LEP experiments there hasn't been any law-breaking incident due to the discharge of LEP wastewater. With regard to LHC, the wastewater which has to be discharged will be far less than today because almost all cooling will be done in closed circuits. Nevertheless the monitoring of the discharged clear water will be extended because of the higher expected radiation for the LHC.

Concerning LEP Point 8, the infiltration of crude oil will continue indefinitely. Hence the monitoring of the sewage and the installations has to be maintained properly to guarantee a satisfactory oil/water separation.

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