Environmental aspects and impacts of CERN

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Abstract

CERN – the European Organization for Nuclear Research – is the World’s largest accelerator laboratory for high-energy physics experiments. The particle accelerators and their experimental areas are installed on two main sites and a number of smaller experimental sites. They are located in Switzerland, in the Canton of Geneva, and in France, in Pays de Gex. The poster describes environmental aspects and impacts of CERN and the technical methods used to deal with them. An example of nearly all environmental aspects and impacts to be considered in accelerator research centers like CERN is given.

The main objective of CERN is to develop, build and operate high-energy particle accelerators. Because high-energy particle beams are a source of ionizing radiation and radioactive substances, there are radiological aspects to be taken into account. Penetrating particles, mostly of photons, muons and neutrons, can go through shielding structures and reach the environment. To ensure that regulatory limits fixed for radiation levels in the environment will not be exceeded, computer simulations are carried out before commissioning new or modifying existing facilities and a network of dose rate monitors with on-line readout is installed on the sites and at some reference points. This network is completed with about 160 passive dosimeters. During interactions of particle beams with matter, radioactive nuclei are produced. The greater part of the produced radionuclides remains contained in the accelerator components, therefore, generating radioactive waste. Some radionuclides may, however, be carried over into the environment via circulating fluids, such as cooling water and ventilated air. Compared with a nuclear power plant, radioactive waste produced at CERN is much less dangerous, as it is non-contaminating, has low specific activities and contains mostly short-lived radionuclides that emit only beta and gamma radiation with low radiotoxicity. Radioactive waste is temporarily stored on the CERN sites allowing for the radioactive decay of the short-lived radionuclides. After this cooling and conditioning time, if still radioactive, the waste is handed over to the Swiss and/or French competent agencies NAGRA and ANDRA, respectively.

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All ventilation and drainage outlets from which radioactive substances are likely to be released into the environment (e.g. exhausts of accelerator tunnels) are equipped with online monitoring stations and automatic samplers. These allow for stopping any operation leading to too high radioactive releases and enable CERN to calculate the activities released into the environment during a definite time, usually one month. With the help of environmental dispersion models, the effective dose the members of the public due to releases of radioactive substances is evaluated and compared with the regulatory limit as required by the Euratom Directive 96/29. This dose makes usually about 1% of the strict limit of 0.3 mSv/year fixed by the CERN Radiation Safety Manual. Number of samples from all environmental matrices are taken and analyzed to verify the validity of the dispersion models in use.

There are numerous activities that support the accelerator operation. These activities, which are carried out respecting the European Directives and regulations in the Host States, have some conventional environmental aspects and impacts. The first activity is related to usage and treatment of cooling water. Accelerator components like magnets are supplied with cooling water that must fulfill strict requirements concerning its mineral content. Often demineralized water must be used. Demineralized water is produced by using ion exchangers, which in turn have to be regenerated by using acids and bases. There is, therefore, a risk of an unintentional release of acid or basic water into the watercourses around the CERN sites. For early detection of such events, all water release points are equipped with pH sensors, which generate alarms in the CERN Technical Control Room if pH values out of the range permitted by the regulations in force are detected. The water used in the regeneration process is neutralized and released as industrial wastewater into sewers. The use of biocides for keeping up the biological quality of cooling water in secondary cooling circuits is strictly controlled. Although cooling water in the biggest accelerator, the Super Proton Synchrotron (SPS), is recycled in a closed circuit, some cooling water from the Proton Synchrotron Complex is released into the site drainage continuously. To detect any accidental release of too warm water, the above-mentioned water monitoring stations are equipped also with temperature probes. In addition, the CERN Safety Commission (SC) carries out weekly inspections of watercourses receiving water from CERN.

Another environmental aspect related directly to the operation of accelerators is the transformation and consumption of electricity. Over the years, CERN has eliminated all PCB-containing electrical equipment and components. The levels of non-ionizing radiation resulting from the use of electricity are continuously monitored.

There are also some industrial activities carried out on the sites, which require the use of dangerous or toxic substances. These include, for example, electroplating, production of printed circuit boards, degreasing of accelerator components, etc. All such activities are under the strict control of the Organization based on the Swiss OPAM classification. Water resulting from these activities is not released into the
environment but into sewers as industrial wastewater. When necessary, air filters are installed at ventilation outlets, otherwise air is recycled. Special wastes generated by these activities and other activities are redirected towards competent companies in the Host States.

As for any organization, there are environmental aspects related to commonplace activities. These comprise collection and elimination of household waste, banal industrial waste with recycling, upkeep of green areas, heating and civil engineering. For the elimination of all kinds of commonplace waste, CERN subcontracts competent and certified companies from the Host States, which have the necessary permissions to carry out such activities. Since 1996 CERN heats its premises exclusively with natural gas.

Civil engineering has been particularly topical during the construction of the Large Hadron Collider (LHC), the new big CERN project, a particle accelerator that should start operating in 2007. These activities included excavation of underground caverns and tunnels. The main environmental aspects of this type of civil engineering include earth spoil, enhanced traffic, noise and production of concrete. Excavated soil contained occasionally natural hydrocarbons that needed to be treated and disposed of specifically. Traffic has been limited to working hours. Noise has been carefully monitored and noise barriers were erected when necessary. Decantation basins and neutralization plants have been installed on the major civil-engineering worksites and watercourses receiving water from these sites and they have regularly been inspected by SC.

The LHC will be equipped with a state-of-the-art environmental monitoring system called RAMSES that will be used for radiation and radioactivity. It will also integrate other variables such as physicochemical parameters of discharged water, levels of non-ionizing radiation as well as ultrasonic anemometers. The latter will provide online site-specific wind and atmospheric turbulence data for calculations of pollutant dispersion. Two monitoring stations for ozone and nitrogen oxides are already operated by CERN. They are observing the LHC-preoperational levels and trends of these noxious gases potentially produced by radiolysis in accelerator areas. RAMSES will be later extended to all CERN sites.

Thanks to the regular surveillance, corrective actions and environmental awareness of the CERN Management and Staff, the environmental impact of CERN has been negligible over the years.