# CHAPTER 3

# SAFETY ISSUES

## 3.1 GENERAL SAFETY INFRASTRUCTURE

### 3.1.1 Risks

The analysis of the dangers present in the LHC domain has shown that they are similar to those around any other big accelerator facility, with the exception of the omnipresence of helium (He) in the underground areas during operation. The risk analyses performed concerning the latter have demonstrated that serious oxygen deficiency could occur if there is an accidental release of a significant quantity of He in closed areas such as the underground tunnels, tunnel junction chambers or even surface galleries.

In the LHC installations, potential hazardous conditions [1] are associated with:

- Ionising radiation,
- The fact that persons are unfamiliar with the premises and necessary precautions (e.g. visitors),
- Cryogenic liquids in the machine tunnel, technical and experimental caverns,
- Isolation of workers underground in a long and extended tunnel system,
- Limitation to the number of evacuation paths in case of an accident and confinement of volumes underground,
- Space limitation in the safe zones,
- The presence of water in a “mining” environment,
- Flammable or asphyxiating gases in the physics detectors or emanating from cryogenic installations,
- Large amounts of combustible materials,
- Falling objects in high caverns and pits as well as personnel working at height,
- Work in the presence of magnetic fields,
- Electrical risks,
- Laser radiation,
- Pressurized installations and lifting equipment.

Once the LHC is operational most of these risks will be permanently present. The radiation issues are treated in the next chapter.

*Preventive Measures*

Preventive measures [2] aim to reduce the frequency or the probability of an accident. CERN has its own regulatory documents for safety which establish the rules to follow for the construction, installation and utilization any equipment in order to protect people and equipment from the risks listed above. These documents are based on European and host state regulations. They are mainly in the form of Safety Codes, Safety Instructions and Safety Notes and translate the CERN safety policy into rules applicable for specific domains such as chemicals, radiation, flammable gas, fire prevention, electricity, lifting devices, pressurized vessels and so on. All of the details concerning the preventive measures for the LHC machine and premises can be found in [3] and [4].

*Protective Measures*

Protective measures may be applied collectively or individually and aim to reduce the gravity of an accident as much as possible. Automated safety systems reduce human intervention to a minimum and therefore they ensure collective protection in an autonomous and reliable way.

*Training and Information*

Training is mandatory before access to a zone which has safety risks. The skills and techniques learned during the mandatory training sessions and evacuation drill exercises have to be refreshed regularly and access permission is withdrawn from personnel who have not followed the refresher training.

Information is provided on panels at relevant places like access points to the underground installations to inform people about the risks, the individual protection systems which they need, the state of the equipment, alarms and other information relevant to safety.

### 3.1.2 Alarms

LHC safety alarms are classified in three levels according to their importance:

**Level-3**: These are generated in the case of an accident or a serious abnormal situation. They warn of danger to human life, property or to the environment. These alarms trigger an immediate response by the Fire and Rescue service.

**Level-2**: These are generated in the case of incorrect operation of equipment or an abnormal situation. They trigger an immediate intervention by the technical service concerned.

**Level-1**: These are generated by an equipment or installation fault. They trigger an intervention by the technical service concerned.

The CERN safety alarm monitoring system (CSAM) transmits the level-3 alarms with high priority though redundant pathways which use differing transmission methods to the safety control room for immediate intervention by the CERN Fire Brigade (FB). The quality and the precision of information which is transmitted are crucial to ensure fast and efficient interventions. This information is also sent to the accelerator and technical control rooms.

### 3.1.3 Safety Systems which Generate Level-3 Alarms

Level-3 alarms are generated by the following systems:

- Smoke (fire) detectors,
- Flammable or toxic gas detectors signalling serious leaks,
- Emergency calling system,
- Emergency stop button (electrical power),
- Oxygen deficiency detection system,
- Water leak (flooding) detectors,
- Activation of evacuation signals,
- Call from a lift (trapped occupants),
- “dead man” devices.

The important features of these systems are described in the following paragraphs.

*Smoke (fire) detection*

The LHC automatic fire detection system (AFD) is composed of detectors located in strategic areas and uses detectors of various kinds chosen for the most efficient fire detection. Theses detectors are connected to control systems which are located in service areas where their status can be monitored. A repeater screen is installed in the SY surface building of the site.

The AFD system’s main functions are to:

- Generate Level-3 alarms when smoke or fire is detected and transmit them via CSAM to the Fire Brigade for immediate action,
- Notify the Technical Control Room (TCR), via the CSAM, of any internal faults that might occur, so that corrective action can be undertaken,
- Trigger any necessary ancillary equipment or safety actions like activate buzzers or cut the power.

In the arcs of the LHC there is no need for a fire detection system since the fire risk in these regions is negligible. The control chassis which are located under the cryostats might have been considered as potential fire hazards, but they have lateral panels which limit thermal propagation to the adjacent chassis, appropriate electrical protection and are also thermally protected if the installed power is greater than 500W. A fire detection system is installed in the underground zones where electrical equipment is concentrated (for example the UJ, UA, RR, RE, US, RF zones together with the experimental areas).

In the surface buildings, fire detection is installed if the group responsible for the building and/or the Safety Commission has requested such a system to protect equipment and/or people.

*Flammable gas detection system*

An automatic alarm system, known as a *sniffer*, which uses air sampling through perforated or branched tubes detects the presence of flammable gases. It provides an analogue value corresponding to the gas concentrations and the appropriate pre-alarms and alarms are generated accordingly.

There is no gas detection system in the main tunnel as there are no flammable gases in these regions. However, a gas detection system is installed in the experimental caverns where flammable gases are used in the experimental detectors.

Flammable gas detectors are also installed in all gas buildings (SG, SGX), located at the different access points of the LHC where gases for use in the experiments are stored.

*Oxygen deficiency detection system*

The LHC oxygen deficiency alarm system (ODH) is composed of numerous detectors, located in selected areas to detect low oxygen levels. These detectors are connected to control racks located in service areas where their status can be monitored. The system will transmit alarms if low oxygen levels are detected. If the machine is in access mode the system will trigger the LHC emergency evacuation system in the relevant zones. A repeater screen is installed in the SY surface building of the site.

Oxygen deficiency detectors are installed in the upper part of each enlargement or alcove, including the experimental caverns. Flashing panels are installed in these areas to provide a visual warning to personnel**.** In the curved part of the tunnel an ODH detector is mounted every 285m on the ceiling. The addition of a flashing light to these detectors is still under discussion. In surface areas ODH detectors are installed in the galleries linking the SD and SH/SHM buildings.

*Flood detection system*

Water level detectors are installed in the retention pits which concentrate all drainage flow at the lowest points of the different LHC sites before pumping it up to the surface. In normal conditions, only one pump is running. When the second pump starts to run, a level-2 alarm is generated. When the 2 pumps are running at full speed, a level-3 alarm is generated and sent to the Fire Brigade indicating a risk of flooding. Finally, a level-3 alarm is generated when the float indicates a high water level in the sump.

The LEP flood warning infrastructure has been extended to cope with the new underground caverns. Retention pits are located at each even point and at the lowest point in the tunnel.

*Emergency phone system*

The «red telephone» system installed for the LEP machine has been kept and upgraded. When off the hook, the red telephone allows vocal communication with the rescue service and at the same time identifies the place of origin of the call. A telephone is installed every 280m in the tunnel. Red telephones are also installed in the experimental caverns and in the non pressurized part of the accessible pits. Certain areas, such as the lift shaft and emergency staircases have an air pressure which is slightly higher than the other areas so that smoke cannot infiltrate. These can be used as a “safe haven” in the event of fire.

*Evacuation System*

The evacuation system consists of push buttons and warning sirens, fixed at 1.5 m above the floor. It takes the form of a “manual call-point” of break-glass type set either surrounded by the standard CERN square plate with the inscription “Evacuation” or near the corresponding evacuation pictogram. The action of breaking the glass triggers the sirens of the corresponding areas.

The role of this emergency evacuation system is twofold: to warn people of a serious situation that could put their lives in danger (emergency evacuation) and to serve as the last reminder to rapidly evacuate the area before injection of high energy particle beams (beam imminent warning). Two different and identifiable signals, 10dB over the ambient noise, are produced. All occupants of the underground areas will have been to the safety training sessions where it was explained what to do when they hear them.

The push buttons and sirens can be found all around the facility, in the machine and transfer tunnels, in the technical galleries, experimental caverns, and in some surface buildings. About 300 emergency evacuation buttons and 400 sirens are installed underground.

*Emergency stop system (AUG)*

The emergency stop system is usually known by its French acronym AUG, which stands for Arrêt d'Urgence Générale. The system allows someone to cut electrical power in a given area during emergencies. Two different systems exist: general and local emergency stops. The general emergency stop only generates a level-3 alarm when activated. The activation of a general or local emergency stop (red panel, break the glass type) cuts off all power sources except those related to safety installations which are clearly marked. In relevant places, it kills the circulating beams and prevents any injection of beams.

The electric network is organized in sectors which generally cover a building or a precisely delimited underground area. A network of general emergency stops equips each of these sectors.

## 3.2 PROTECTION OF PERSONNEL IN THE TUNNEL

### 3.2.1 Equipment Needed to Access Underground

In some cases, collective protection systems cannot provide all the necessary guarantees for safety and have to be reinforced by individual protection measures and/or extra means of prevention. Training and safety information panels provide all the relevant information about the way to behave when accessing the different zones.

People who wish to access the tunnel must wear a reliable mobile communication system and have an oxygen mask. They must also wear a personal radiation dosimeter (film-badge), an operational dosimeter, an access card, a token in case of supervised access. The operational dosimeter will provide immediate readout of the radiation dose whereas the dosimeter is usually only read after several weeks.

To access the experimental zones, the same equipment is necessary but a safety helmet is mandatory. The oxygen masks will be provided on a self service basis in the experimental caverns, unlike the tunnel where individuals have their own.

Safety information is generally given at the entrance doors to the surface buildings or galleries. This information varies according to the specific dangers, for example, noise protection is required for compressor buildings, or ODH monitors for galleries where helium is present.

### 3.2.2 Escape Routes

Pictograms showing the directions and distances to the nearest exits to be used for evacuation are available every 50 m in the machine tunnel, in the caverns and galleries around the access pits and in the experimental areas.

## REFERENCES


[1] Memorandum TIS/GS/WW-ac (2001-10) and Annex, *"Safety requirements for LHC underground works-Access conditions"*, July 16, 2001

[2] Systèmes généraux de sécurité du LHC, EDMS 346512

[3] Rapport définitif de sûreté du LEP, édition 1994

[4] Rapport préliminaire de sûreté du LHC, 1999