

# SAFETY GUIDE FOR EXPERIMENTS



LSC

*Laboratorio Subterráneo de Canfranc*

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ANNEX I. LSC Flowchart

ANNEX II. Contact List example

ANNEX III. Work Permit example

ANNEX IV. Process Procedure template

ANNEX V. Action Plan template

# **1 SAFETY ORGANISATION FOR EXPERIMENTS**

This chapter gives a view of Safety Organization concerning the experiments and the collaborations between the Laboratory and the Experiments.

## **1.1 THE EXPERIMENT COLLABORATION**

All Institutes and guest members that are going to present and/or realize an experimental apparatus of any size in the Laboratorio Subterráneo de Canfranc (LSC) must contact the Prevention and Protection Service (PPS). They are also bound to respect the safety laws concerning the activities and the equipment used in Laboratories.

## **1.2 PREVENTION AND PROTECTION SERVICE**

In the Laboratories, the PPS is responsible for training courses and safety briefings and all the activities concerning Safety and, above all, rules and procedures.

## **1.3 TECHNICAL DIVISION**

These Areas are composed of different services, as it is shown in the flowchart at ANNEX I. They cooperate with the PPS for all the activities concerning Safety.

## **1.4 THE GROUP LEADER IN MATTERS OF SAFETY (GLIMOS)**

The whole responsibility of each aspect of the Safety of the Experiment belongs to GLIMOS (Group Leader in Matters of Safety). He is a member of the Experiment Collaboration and external experts can help him. He has the duty to apply all the rules suggested by the experts. For more information see the chapter 3.4 and 16.

## **1.5 RESPONSIBILITIES**

The organizational structure we are describing shows all the responsibilities in matter of safety from a hierarchical point of view.

## **1.6 PREVENTION AND PROTECTION SERVICE (PPS) DUTIES**

The PPS duty is to assist the Laboratory Director in safety matters.

The PPS has to:

- ✓ supervise safety.
- ✓ inform all internal and external collaborators.
- ✓ train all internal and external collaborators.
- ✓ make sure of a high level of safety.
- ✓ make sure, in particular, of the application of rules and industrial standards where possible.
- ✓ verify the application of the ALARA principle (as low as reasonably achievable) to reduce hazard, if some of those rules and standards cannot be applied.

The PPS has also some executive functions in matters of:

- ✓ protections from radiations.
- ✓ prevention and fire control.
- ✓ control of chemical contamination dangers, together with the Chemistry Service.
- ✓ medical prevention.
- ✓ first aid.

The responsible staff at LSC about safety is:

José Luis Rubió

E-Mail: jlrubio@lsc-canfranc.es

Phone: 974 373 474

Silvia Borjabad

E-Mail: sborjabad@lsc-canfranc.es

Phone: 974 373 474

### **1.7 LABORATORIES SAFETY DOCUMENTS**

The PPS Department has an archive with all the documents of Labs concerning safety.

### **1.8 THE CONTACTS LIST**

It is a contact sheet with the names and phone numbers of those people having particular responsibilities in an experiment. The poster must show the schemes of the experimental apparatus plants and it must be placed on the experiment plants or in the laboratory. An example is shown at ANNEX II.

### **1.9 THE WORK PERMIT**

It deals with an official paper to be used by all the companies/collaborations/consultants involved in any installation both in the underground and in the external labs. This document will not be required to regular members of the Collaboration with experiments installed at LSC. An example is shown at ANNEX III.



## **2 SAFETY MEASURES FOR EXPERIMENTS**

This chapter describes the safety rules and procedures to be applied during the whole life of the experiments.

### **2.1 GENERAL CONSIDERATIONS ON THE SAFETY FOR EXPERIMENTS**

An experiment may vary during its development, commissioning and data taking. Hardware and configuration may be modified. Collaborators and responsibilities within the Collaboration may change too. That is why safety measures have to predict and follow these changes during the whole experiment phase.

More specifically, after the initial installation phase, a strict supervision is required to keep those safety measures on plants so that everything can proceed together with the experiment development. One of the main needs is the elimination and/or reduction of every serious hazard for people, including those who are not very informed about the experiment and its hazards. Since it is impossible to realize any riskless activity, the possible consequences must be reduced to the minimum by suitable safety measures and planned human interventions.

### **2.2 PURPOSE OF SAFETY MEASURES**

As a basic rule, safety rules must be considered an essential part of each experiment project. Safety procedures should be sent to the PPS in a written form since the beginning of the experiment. The safety precautions adopted should be included in the proposal, so that any plant and apparatus design will be evaluated in a safe way. These procedures will be in force and updated during the experiment until its decommissioning.

The decommissioning of any experiment apparatus is certainly very important, complicated and dangerous. As the cost connected to the decommissioning might be not negligible, they have to be estimated since the beginning of each experiment.

### **3 PREPARATION PHASE OF AN EXPERIMENT**

#### **3.1 LETTERS OF INTENT AND PREPARATION OF PROPOSAL**

The physics case of any Collaboration proposing an experiment must be submitted and approved by the LSC Director based on the LSC Scientific Committee recommendations. Any new Collaboration working at LSC has to make sure that all the procedures are executed according to the safety rules in force. On the basis of the information received from the experiment collaboration members, the Laboratory will contact the authorities dealing with safety, since during the proposal preparation. This management will allow a first evaluation of the following factors:

- ✓ the experiment feasibility from a safety point of view.
- ✓ the possible dangers.
- ✓ the costs of safety measure.
- ✓ the responsibilities sharing between Laboratory and experiment collaboration members.

All that will help prevent any future disagreeable misunderstanding.

#### **3.2 APPROVAL OF AN EXPERIMENT**

After the approval of an experiment from a scientific point of view, the experiment technical details are considered by the Laboratory (Technical Division and Prevention and Protection Service).

Before installation and operation on an apparatus the Collaboration should provide to the Laboratory the following documentations.

1. Description of apparatus
2. Technical drawing
  - P&ID (piping and instrumentation drawing)
  - Design layouts of equipment
3. Description of operation mode
4. Risk analysis (report from the Collaboration on the identification, description and assessment of most critical risk scenarios for the apparatus to be in operation)
  - Failure mode, effect and critical analysis (FMECA)
  - HAZard and OPerability (HAZOP) analysis review
  - Fault Tree Analysis (FTA)
  - Top event probability calculations
5. Summary of results (for each hazard event identified provide probability/year)
6. Risk evaluation criteria (ALARP matrix: for each hazard event identified provide the classification of risk as unacceptable, tolerable and acceptable)
7. The Collaboration should provide references about the authors of the risk analysis

The above documentation, approved by the Collaboration, is reviewed by the Laboratory. The Director gives authorization on the basis of the internal review process. Based on the above documentation and operation procedures the Director will approve activities on the equipment.

The approval of particularly hazardous equipment can be given only after an exhaustive study on safety. This study should show a satisfying application of safety rules. The approval of every single part of the experiment can be assured only after evaluations and tests that satisfy all the rules.

Later on, within the approval, formal contacts will be established between the different LSC commissions and the experiment collaborators in order to discuss all the aspects of safety.

### **3.3 SAFETY MEASURES COSTS**

The survey of experiment costs must be based on a very detailed plan including all measures and means needed for safety. The collaborators must budget both every prevention measure (including labour costs for safety maintenance) and the apparatus decommissioning costs.

### **3.4 GLIMOS ELECTION**

As soon as an experiment has been approved, the experiment Spokesperson will be asked to propose a candidate for GLIMOS. The elected candidate must be submitted and approved by the LSC Director, assisted by the PPS

If there is no GLIMOS, all the responsibilities fall on the Spokesperson.

The GLIMOS candidate should be approved soon enough to start treating all the aspects of safety since the proposal preparation. In particular, it could be useful to consider and discuss alternative techniques to optimize safety, efficiency and costs.

In many experiments there is also a Technical Coordinator, who deals with all technical activities coordination, and a Site Manager during busy installation periods. The name of the Technical Coordinator and that of the Site Manager should be reported to the PPS.

GLIMOS can designate a person assigned to safety SLIMOS (Shift Leader in Matter of Safety), to assist him/her both in safety matters and all aspects concerning tests, laboratory activities and safety courses. Their names must be communicated to the Direction and the PPS.

If the designated GLIMOS can't keep on doing that activity, either he/she or the Spokesperson has to inform the Direction or the PPS in advance and propose a new candidate for GLIMOS to be approved by the LSC Director, assisted by the PPS.

The GLIMOS must report regularly to the Laboratory Director on safety issues about activities at the Laboratory he/she is dealing with for the Collaboration.

### 3.5 ASSEMBLY AREA

The Collaboration must present to the LSC a request of space needed for the preparation and installation. The Collaboration is fully responsible in matter of safety of all spaces needed and obtained from the Laboratory.

### 3.6 GASES, LIQUIDS, CRYOGENIC LIQUIDS

The Collaboration must indicate and communicate to the PPS all combinations of flammable or cryogenic gases and liquids used during the experiment or just stored in their areas.

- It is necessary to have a list of all the flammable liquids and cryogenic substances, storage tanks and circulation systems of those products (information about type, amounts and location are requested).
- In case of gas rooms, the Collaboration must specify clearly both the total volume of the flammable gases combination and the number of rooms, as shown in the following examples:  
Volume= (number of rooms) x (volume of each room)

#### 3.6.1 OTHER CHEMICAL SUBSTANCES

The Collaboration must also:

- ✓ indicate the probable or maximum quantity of toxic and/or noxious substance, such as: dangerous metals (Beryllium, Sodium and Uranium), paints, solvents, additives, resins, glues, plastics, electrical or thermal insulation materials, dielectric fluids or convectors.
- ✓ include anything used in the experiment which might cause a significant danger, and also almost unknown substances, especially if not commonly used in other experiments.
- ✓ include also those substances that, even though they are considered safe, may be dangerous in case of fire or imply a hazard during the preparation process.
- ✓ indicate moderately dangerous materials, especially when used in unusual quantities or in inaccessible areas.

In order to optimize the study and prevention phase, it is absolutely mandatory to present a safety schedule of all materials used in the experiment that might be source of danger. This schedule must be updated if case of changes/modifications.

### 3.7 ELECTRICAL SYSTEMS

The Collaboration must indicate to the PPS and the Technical Division all electrical components and a complete description of the installation, including Voltage and Intensity of the circuits. All the commercial electrical components must have the proper homologation including the electromagnetic compatibility homologation.

The Collaboration must also indicate and communicate to the PPS the power required.

### **3.8 LIFTING AND HANDLING**

The use of the LSC crane and fork-lift is only allowed to Laboratory staff. Any activity which includes this equipment must be coordinated with the Laboratory. The Laboratory staff will make an effort to adapt to special requests from the Collaboration and give support outside “standard” working hours.

All the LSC lifting and handling equipment operations, used during the preparation, the installation and the activity, must be requested in advance to the PPS and the Technical Division, by the Collaboration.

All these tasks will be done under safe conditions and in coordination with the Laboratory, experiment collaborators and external companies (if necessary).

### **3.9 VACUUM AND PRESSURE TANK AND COMPONENTS**

The Collaboration must indicate to the PPS and the Technical Division all pressure tanks and components under the Spanish rules. As regards the vacuum and pressure tanks and components, keep in mind that at present there is no homologation for tanks already approved outside the EU (USA, for example); in order to be clearer, a pressure tank already tested in USA can't operate in Spain, so, you have to get the CE Mark before to start the operation.

Indicate material, density and area of what is considered the most fragile wall of the tank.

### **3.10 USE OF RADIATION SOURCES**

The Collaboration must inform the PPS and the Technical Division about everything concerning:

- ✓ Type and intensity of particle beams, purpose of use.
- ✓ Radioactive source type and activity, purpose of use.
- ✓ Wavelength areas and laser power, purpose of use.
- ✓ RF frequency ray and microwave emitters of the possible components of the experiment system.

A request of use for this equipment and a schedule must be submitted to the LSC Director.

### **3.11 OTHER DANGERS**

Other dangers not elsewhere specified must be indicated.

## **4 TOPICS FOR A SAFETY DISCUSSION**

Here is a list of the possible topics of discussion in matters of safety.

### **4.1 GENERAL CONSIDERATIONS**

- ✓ Schedule
- ✓ Safety planning
- ✓ Laboratories and workshops (necessary areas, considering material storage and temporary worksites, too).
- ✓ List of authorized collaborators.

### **4.2 DETECTOR**

- ✓ Identification of a Technical Coordinator
- ✓ Identification of the GLIMOS
- ✓ Description of the experiment systems and components
- ✓ Description of all the plants and system in the experimental apparatus. Above all, a complete description of the plants dealing with flammable, toxic and/or noxious gasses or liquids is needed.

### **4.3 MECHANICAL ENGINEERING**

- ✓ Name of the Responsible
- ✓ Structural Engineering, pressure/depression tanks
- ✓ Detailed descriptions of the safety issues concerning the structural project
- ✓ Project parameters
- ✓ Evaluation/Calculus relation of the system in the seismic field.

### **4.4 GASES, FLUIDS AND TOXIC MATERIALS**

- ✓ Name of the Responsible.
- ✓ Flammable gases and liquids
  - Gases/Liquids
  - Proportions
  - Quantity of hydrocarbon
  - Equivalent hydrogen
- ✓ Gas or liquid dispersion
  - Limits
  - Conditions of detection
- ✓ Cooling of detector component
  - Means
  - Operations: valves and switches
- ✓ Cryogenic fluids
  - Fluid

- ✓ Flux diagrams
  - Flammable gasses and liquids
  - Cryogenic liquids
- ✓ Storage
  - Construction phase
  - Systems in use
- ✓ Toxic products
  - Products
  - Quantity
- ✓ Dangerous waste management
  - Products
  - Quantity

#### **4.5 ELECTRICAL SAFETY**

Here below is a list of all the information an experiment must communicate to the LSC Technical Division before starting the installation.

- ✓ Name of the Responsible
- ✓ Industrial Electricity
  - Voltage, frequency, power
  - Local emergency stops
  - Materials
- ✓ Electricity and Electronics in detectors
- ✓ Low Voltage
  - Electrical protection of circuits and equipment
  - Thermic protection of circuits and equipment
  - Breakdown signal
  - Static electricity
- ✓ High Tension
  - Energy stored in joules
  - Indication of HT presence
  - Inaccessibility, links, protection devices
  - Safety rules
  - Overtension test and insulating materials
  - Insulating materials rating
  - Radiation damages
- ✓ Electricity and Electronics in counting rooms
  - Counting rooms
  - Numbers of nets
  - Total lost power
  - Auxiliary circuits

- Ventilation
- Emergency switches for equipment
- Fire detection, abnormal temperature detection, alarms.
- ✓ Type of circuits
  - Net power
  - Ventilation, cooling
  - Thermic protection
  - Emergency switches
  - Alarms: action and transmission
- ✓ High tension feeders
  - Type of voltage
  - Indication of HT presence
  - Safety rules

#### **4.6 RADIATIONS (RADIATION SCHEDULE)**

Here below is a list of all the information an experiment must communicate to the LSC Technical Division before starting the installation.

- ✓ Name of the Responsible
- ✓ Radioactive sources
- ✓ Tests
- ✓ X-rays
- ✓ Classes
- ✓ Staff and material protection

#### **4.7 PROTECTION OF THE EXPERIMENTAL AREAS**

- ✓ The experiment configuration
- ✓ Access
- ✓ Fixed and movable fire systems
- ✓ Alarms
- ✓ Danger signals and the *contact list*

#### **4.8 HAZARD ANALYSIS**

Although it basically depends on the experiment complexity, an analysis of hazards and/or used technologies can already be made in the initial discussion on safety.

It will have to follow the rules in force and it must be completed in the initial phase of the experiment so that it becomes effective. The Laboratory will approve the experiment taking into account all the safety aspects before releasing the approval.



## **5 EXPERIMENT ASSEMBLING PHASE**

### **5.1 SAFETY PROGRESS MEETINGS**

After the initial discussion, some meetings should be regularly held to analyse every aspect of the experiment safety. The number and the frequency of these meetings depend on the size, the complexity and the problems of the experiment itself.

In order to ensure their effectiveness, these meetings should have a small number of permanent members:

- Site Manager
- GLIMOS
- Possible external consultants
- One PPS member
- Technical Division members (Services at the Laboratory)

Additional members can be added under specific request. Minutes of the meeting must be recorded and submitted to the Laboratory. The PPS member is on charge to write down minutes. The PPS responsible will call for meetings.

### **5.2 INSPECTIONS**

Since the construction phase, it might be necessary and/or useful to inspect all facilities in the construction area (workshops, laboratories, etc...) according to safety rules, in order to avoid any possible future problem.

## **6 EXPERIMENT SET UP**

### **6.1 APPROVAL OF EQUIPMENT**

The PPS and the Technical Division must review every part of the equipment. The Collaboration, before any installation, should present the list of items to be installed in order to review with the LSC any possible issue concerning safety and underground installations and activities.

### **6.2 PREPARATION OF THE EXPERIMENT AREA**

The Laboratory and the GLIMOS basically are responsible for the experiment area setting-up. In this phase they have to decide all the safety measures needed and the person responsible for them.

### **6.3 TRANSPORT OF EQUIPMENT**

The Collaboration must inform the PPS and the Technical Division about the deliveries to the underground facilities, providing details about materials, type, volume, weight, dimensions, schedule...

If the material to transport is radioactive and/or dangerous some special rules and access protocol must be respected.

If the material to transport needs heavy and /or big volume transport vehicles, also some special rules and access protocol must be respected.

For more details about this matter, see Chapter 14.

### **6.4 INSTALLATION**

The Laboratory and the Site Manager and the GLIMOS look after the set up in the designed area.

The GLIMOS must verify the existence and the perfect operation of all structures regarding safety. If in the experiment area a compressed air distribution system is available, all experiments must use it under safe conditions.

### **6.5 SAFETY COMMISSION AND USERS DEPARTMENT**

Before every new experiment, especially the big dimension and long-life ones, a working group must be formed. It should be essentially composed of:

- GLIMOS
- Anybody involved in the experiment who could bring specific expertise
- One PPS member and a Technical Division member.

## **7 SHORT-TERM EXPERIMENTS**

### DEFINITION

An experiment must satisfy two conditions to have simplified safety measures:

- It must have a small set up of irrelevant danger.
- It must forecast one or two weeks of duration as well as the same decommissioning time.

### SIMPLIFIED PROCEDURES

Even though a GLIMOS is always required, many operations can be simplified or even neglected. Before the experiment starts, there should be an inspection to decide the Safety level required and the possibility to simplify some procedures.

## **8 INSPECTIONS AND TESTS (SAFETY)**

This chapter shows different types of inspections and tests to be done in the experiment phases related to safety.

### **8.1 PRE-COMMISSIONING INSPECTIONS:**

These inspections deal with:

- Newly arrived or built facilities.
- New installations.

Facilities or installations that have been sensibly modified. They are normally requested by GLIMOS and then organized together with the PPS. The number and the experience of people involved and invited are strictly related to the problem at issue.

### **8.2 SCHEDULED INSPECTIONS**

There must be an inspection before the experiment becomes effective. The GLIMOS is expected to organize between the Collaboration and LSC such an activity.

The people involved in the inspection, will be selected according to the tasks and their complexity.

### **8.3 ANNUAL INSPECTIONS**

The annual inspections must check the complete safety conditions in the experiments, the laboratories and the workshops.

The following people have to participate:

- GLIMOS
- Site Manager
- Any other member having any responsibility within the experiment safety or anybody who might give useful information.
- A PPS member who also drafts the inspection proceeding.
- Specialists or experts if required.

After any of these inspections, the GLIMOS have to prepare report with the results and conclusions. These reports have to be submitted to the Laboratory.

## **9 PERIODIC INSPECTIONS (OPERATION)**

The periodic inspections deal with facilities and particular systems such as elevators, tanks, security valves and fire systems. These inspections will have to check that they all are in accordance with the rules in force.

### **9.1 PREPARATION OF AN INSPECTION**

The inspection must clear up the general safety conditions. In this phase the various aspects concerning safety (including budget, staff safety and so on) should be discussed, studied.

The following people have to participate:

- GLIMOS
- Site Manager
- Any other member having any responsibility within the experiment safety or anybody who might give useful information.
- A PPS member
- Technical division related to the inspection.
- Specialists or experts if required.

### **9.2 INSPECTION REPORTS**

The PPS member of the Commission must draft the inspection reports. These reports have to be distributed to all those who need the information on safety that are contained there. The report is approved by the Collaboration spokesperson or Project Coordinator and LSC.

### **9.3 URGENT MEASURES**

If, during an inspection, a situation turns out to be dangerous, the PPS member in charge has the authority to immediately stop the experiment activities.

### **9.4 FOLLOWING REPORTS**

The suggestions in those reports should be put into practice as soon as possible. If there is any disagreement, the GLIMOS has to inform the author of that report immediately and arrange a discussion.

## **10 SAFETY EQUIPMENT AND MEASURES FOR EXPERIMENTS**

### **10.1 SAFETY SYSTEMS**

All safety procedures of an experiment in operation or commissioning mode should take into account possible maintenance or other activities on equipment under Laboratory control. Any possible interference should be considered in advance. The PPS should be informed about maintenance operations. Maintenance operations are under the responsibility of the Collaboration.

Safety systems concerning an experiment are directly requested to the GLIMOS. Some common safety facilities, such as, for example, the general extinguishing systems, are directly set up in the Laboratory. The Laboratory takes care of maintenance for these general safety facilities. New facilities or improvements/modifications in the LSC can be requested as needed by each Collaboration.

Generally, in every experimental area and its neighborhood, the following indications should be evident:

- Displays and danger signals concerning:
  - magnetic fields.
  - ionizing beams and radiations.
  - ultraviolet and electromagnetic radiations.
  - high intensity noises.
  - flammable gasses and liquids.
  - toxic and caustic chemical substances.
  - helmets or other personal protections to put on.
  - high voltage
  - cryogenic substances
- Other labels, posters and projects:
  - the *contact list* with the names and phone numbers of people to call in case of need;
  - flammable gasses poster with the name of employed people in gas systems set up.
  - evacuation signals.
  - flammable gas detectors
  - oxygen detectors
  - alarm installations
  - fire extinguishers
  - main switches and emergency switches
  - personnel protective equipment (PPE)
  - emergency exits
  - emergency lights
  - self-breathing personnel equipment
  - first aid equipment.

## 10.2 SAFETY PROBLEMS IN THE UNDERGROUND SITES

Experiments in the underground areas might imply high risk. In addition they deal with the great difficulty of underground laboratory evacuation in case of accident.

The main hazard is caused by the high concentration of probable dangers in a too small area. As a consequence of that, all the indications and rules provided by the Laboratory must be fully respected. Particular attention must be given to the following factors:

- ✓ Materials used in the experiment. Smoke is probably more dangerous than the fire itself or heat. That's why only suitable materials must be used. In fact, in case of fire, they should not exhale toxic or caustic smokes.
- ✓ The quantity of flammable gasses and/or liquids in the tunnel must be reduced to the minimum. However the minimum experimental needs should be taken into account.
- ✓ All the people working in the Laboratory must be informed on safety rules, hazards, alarms and emergency exits. All information must be given just before the access. For more details see Chapter 15.
- ✓ Emergency exits, self-breathing personnel equipment and fire extinguishers must be clearly indicated and free from any kind of obstacle.

## 10.3 EXPERIMENT OPERATIVE PHASES

The safety measures depend on the experiment operational status. There can be two phases of operating conditions: data taking and upgrade/modification. Besides them, there can be some intermediate steps. Activities carried out on the experimental underground site in any phase of the experiment must be approved after some “standard” documents which describe the purpose, procedure and operators have been submitted to the LSC Director. These documents are provided by the PPS and the templates are shown at ANNEX IV and ANNEX V.

## 10.4 SAFETY MEASURES IN THE EXPERIMENT AREAS

The areas where the experiments take place have a number of safety facilities. They basically deal with the protection of the area, infrastructure used and/or the experiment staff.

## 10.5 SAFETY EQUIPMENT IN THE EXPERIMENT AREAS

For safety reasons in the experiment areas some specific equipment must be set up such as the following:

- Fire walls and doors
- Fire manual or automatic equipment
- Emergency ventilation
- Emergency exits
- Remote gasses distribution where it's possible
- Safety detectors

- Standard alarm systems
- Evacuation alarms, emergency switches, red telephones.

Facilities do not necessarily have the same equipment in all areas.

## 10.6 GENERAL SYSTEMS

Safety signs for users must be present underground. This is responsibility of the Laboratory or of the Collaboration depending on the infrastructure. For Collaboration infrastructures safety signs installations must be agreed with the PPS.

## 10.7 SAFETY EQUIPMENT

Besides the facilities above mentioned, there should always be some equipment in the experiment area, such as:

- First aid equipment.
- Self-breathing personnel equipment.
- Signals, labels, posters indicating:
  - ✓ emergency exits.
  - ✓ fire extinguishers.
  - ✓ emergency switches and valves.
  - ✓ flammable gasses and liquids present there with their quantity.
  - ✓ a *contact list* with the names of some people in charge for safety.

## 10.8 BUDGET FOR SAFETY

The Personnel Protective Equipment (PPE) for operators and researchers in the underground site is under the responsibility of the Collaboration.

## 10.9 MAINTENANCE

Regular maintenance of equipment under control of experimental collaboration must be performed. The PPS should be informed of such operations.



## **11 EXPERIMENT DECOMMISSIONING PHASE**

### **11.1 GENERAL COMMENTS**

General safety conditions must be kept also after the end of an experiment. To decommissioning operations we apply the same rules and procedures as for installation activities.

### **11.2 HAZARDS**

Hazards that can occur during the decommissioning are mainly the following:

- Fallings.
- Falling of objects or materials.
- Limited spaces.
- Damages to adjoining plants.

Hazards regarding materials that are being wasted:

- Radioactivity.
- Toxicity.
- Electricity.

Hazards due to handling or transport.

### **11.3 RESPONSIBILITIES**

The GLIMOS responsibility concerning staff and material safety continues also after the decommissioning phase.

### **11.4 PRECAUTIONS**

According to the type of system to be disassembled, necessary safety measures must be taken both for staff and material.

A suitable operational project should be planned in advance:

- ✓ periods and duration of the different activities.
- ✓ work conditions and equipment required.
- ✓ how to transmit the information needed by the dismantling staff.
- ✓ how to set up the preliminary measures to take before the dismantling phase begins.

There could also be the possibility of a change in the operative plan if anything unexpected happens.

Safety measures for expected dangers:

- ✓ use specific signals, barriers, road signs etc., to bound the dismantling area.
- ✓ turn off or close all operative plants.
- ✓ check that the all the plants have been turned off.
- ✓ respect all the procedures activated according to the nature of materials.

- ✓ define an area accessible to people and machines.
- ✓ make sure that the staff is qualified.
- ✓ avoid any increasing of garbage inside the experimental area and/or the accumulation of any useless objects.
- ✓ keep the accesses and the emergency exits free from obstacles.
- ✓ inform in detail the entire staff on the hazards that can be met, on the operative plan and its possible changes.

## **12 ALARMS**

For details see the “Plan de Autoprotección”.

## **13 SAFETY MEASURES IN LABORATORIES (LAB 780, LAB 2400, LAB 2500 AND EXTERNAL BUILDING) AND WORKSHOPS**

### **13.1 BUILDINGS, LABORATORIES AND WORKSHOPS FOR DANGEROUS ACTIVITIES**

All the buildings and/or the areas where laboratories and workshops are placed must respect all criteria in matter of safety.

### **13.2 ELECTRICITY, ELECTRONICS, AND HIGH VOLTAGE**

The Technical Division in charge of the electrical plants must check that all areas have:

- Local emergency shutdown buttons that interrupt the power supply to all the local plants.
- Separated ground connections.
- Switchboards of electrical tests in HV equipment and/or facilities must follow these rules:
  - ✓ the HV test area must be identified and separated from the other work areas.
  - ✓ access doors must be opened with a lock key and easy to be opened from the inside towards the outside.
  - ✓ the names of people in charge, and of those who have the permit to enter, should be clearly shown on the access doors.
  - ✓ danger signals and labels signaling HV.
  - ✓ safety equipment including: rescue poles, extinguishers etc...It has to be tested in the area.

### **13.3 FLAMMABLE GASES**

Set-up working with flammable gasses must not be set in crowded buildings. All the areas, in which large quantities of flammable gas are handled, must be provided with control boards. Flammable gas bottles always have to be stored outside the laboratories in special suitable cabinets according to the regulations.

### **13.4 THE TWO PERSON RULE**

Working underground requires the presence of a second person who might help and intervene in case of accident or emergency.

### **13.5 SAFETY EQUIPMENT: DANGER SIGNALS AND LABELS**

The GLIMOS and the PPS must look after the correct distribution and maintenance of warning signals, labels and any other indication on safety equipment in the experiment area and the set-ups and workshops, respectively.

### **13.6 STANDARD SAFETY EQUIPMENT**

If necessary, the standard safety equipment can be completed by other instruments as needed.

### 13.7 SPECIAL DANGER EQUIPMENT

Sometimes it may be necessary to complete the Safety Equipment, especially under the following situations:

- ✓ In areas where electrical or electronic facilities are developed or tested.
- ✓ In areas where there is a HV apparatus.
- ✓ If chemical substances are used in a laboratory, the latter must be supplied with an eye-washing shower.
- ✓ The use of flammable gasses and/or liquids is severely restricted:
  - the laboratory must have suitable ventilation.
  - flammable gas storage is never allowed in the laboratory.
  - electrical equipment must be placed out of range of flammable gasses.
  - there must be a regular pressure reducer.
  - in pre-established places there must be flammable gas detectors perfectly functional.

### 13.8 WORK SUPERVISION: INSTRUCTIONS ABOUT DANGEROUS MATERIALS

The nature of danger and hazards as well as the safety measures and procedures must be clear to all those involved in the project. The GLIMOS is responsible for sharing the information.

### 13.9 INSPECTIONS

All the laboratory are liable to inspections of different kinds:

- ✓ INSPECTIONS: when new laboratory or workshops are set up.
- ✓ ANNUAL INSPECTIONS: every year, laboratories, workshops and departments are subjected to a technical revision (safety audit).
- ✓ PERIODIC INSPECTIONS: They deal with special kinds of facilities: fire equipment, equipment for flammable gas treatment etc...

Sometimes it may be necessary to inspect some equipment and/or device already in an operating mode, to check if they are in accordance with the rules in force.

All inspections in the Laboratory as well as in any experiment area should take into account possible interferences.

## **14 ACQUISITIONS, SHIPPING, STORAGE AND WASTE MANAGEMENT**

Acquisition, shipping, storage and waste management could create a number interferences and/or dangerous situations due to different materials and tasks at issue.

There are some particular rules on this topic that have to be absolutely respected.

The Chemistry Service, the PPS and the Safety System Service must be always informed when dangerous materials and/or substances get into the Laboratory. These Services will take the suitable and appropriate safety measures and cautions.

In theory and in practice, dangerous materials could not be purchased, stored or be sold off without proper controls.

The following substances can be ordered only if approved by the Chemistry Service and the PPS:

- ✓ oils
- ✓ solvents
- ✓ degreasing agents
- ✓ sprays
- ✓ paints
- ✓ resins
- ✓ adhesives.

In any case, all these materials, with their necessary safety schedules, must be strictly controlled.

The orders for the fire-fighting team equipment must be approved by the PPS so that they can check that everything is in accordance with the rules in force.

### **14.1 ACQUISITION**

Most of the equipment used in laboratories is produced by the Collaboration and/or the LSC Technical Division themselves. Some other components are bought from external companies. Responsibilities in matter of safety always fall on the producers.

### **14.2 SHIPPING**

The Collaboration must communicate in large advance the shipping to the PPS and the Technical Division, providing detailed information and tracking number, if possible.

The dangerous materials shipping (for example: large amount of chemicals, compressed gasses or cryogenic substances) must absolutely follow the laws of the country they come from and it must always

be accompanied by its Safety Data Sheets. As regard as dangerous goods transport, the ADR regulation should usually be followed.

In case of large vehicle shipping, some restricted limits have to be followed to access to the underground facilities.

### **14.3 RECEPTION**

As regard as the delivering of devices, plants, components, facilities to the LSC, the Collaboration must communicate in large advance their arrival to the PPS and the Technical Division, providing some detailed information and the schedule. The PPS and the GLIMOS of the experiment at issue have the capability and the authority to check the correspondence of those facilities to the rules in force.

As for dangerous materials, the Collaboration is bound to inform about the arrival of the expected quantities as well as their location and the possible storage duration in the laboratories.

### **14.4 STORAGE**

In all cases of long time storage, all the materials, the containers, as well as the restricted area must be signaled, so that even the untrained people and visitors may know the possible dangers. Take care that signs do not fall down during transport or that they are not spoiled by water coming from the cave rocks.

### **14.5 WASTE MANAGEMENT**

#### **Chemical substances, oils, drill lubricants and contaminated labware.**

The Laboratory is declared as “Minor Dangerous Waste Producer” by the local government and is authorized to manage a list of dangerous wastes. So, the Collaboration must inform and report to the PPS and the Chemical Service the dangerous wastes to be managed by the Laboratory.

Even though the removal of chemical substances does not apparently involve any danger, it will surely show some difficulties concerning, for instance, the environment and the sewer system protection.

In order to make the operations easier, all the experimental collaborations, as well as all the companies and people working in the underground labs, the full respect of the procedures established by the Chemistry Service is absolutely mandatory. It is mandatory to respect the following rules:

- In general, users are bound to label these containers with the name of the product and its storage date.
- Do not combine different chemical substances because it could be very dangerous.
- Small quantities of chemical products, oil, drill lubricant, contaminated labware must be put in sealed containers.

- If solvents exceed 20 liters they could be put in proper safety cans.
- Higher quantities of solvents and/or oil could be put in separated metal tanks.
- Water solutions such as acids or alkali exceeding 50 liters could be put in big plastic containers.
- It's strictly forbidden to pure any kind of dangerous products through the sanitary ware of the WC, the perimeter channel inside the pool (Hall A) and the drain system.
- All dangerous waste products have to be stored under safe conditions in the defined Waste Storage Room/Area.

### **Batteries**

The different types of batteries used in the experiment must be put in proper boxes with clear labels on them. However they must never be put in the bins. If there is a large quantity, those batteries will stored in the defined Waste Storage Room/Area.

### **Rubbish**

Any type of rubbish (cans, boxes, papers, containers) can become a danger. So, it is mandatory, to look out that they do not obstruct emergency exits, self-breathing personnel equipment and fire extinguishers and they are not close to heat sources. In any case, it is forbidden to leave useless flammable materials near the experimental area. Everybody must communicate any possible flammable material presence to the PPS.

### **Electrical and electronic equipment.**

The different types of electrical and electronic equipment (RAEEs) to be managed as waste in the experiment must be put in proper boxes with clear labels on them. These equipment will be stored in the defined Waste Storage Room/Area. They must never be put in the bins.



## **15 TRAINING COURSES**

The best safety conditions can be reached only if everybody knows the possible dangers, consequences of accidents, precautions and what to do in case of emergency. In order to reach this safety level, the Direction and the PPS will organize courses and practical demonstrations concerning safety in the Laboratory.

The PPS arranges for the organization of these courses, takes care of spreading off all the information and trains the users and the staff of the Laboratory.

### **15.1 SAFETY COURSES**

It is compulsory to attend safety courses including practical demonstrations for all experiment collaborators and the LSC staff.

As for external companies, all those having a contract with 2-3 working days or more into the underground facilities will have to attend a course on the dangers that can occur in this kind of areas to obtain the access.

Some other courses are the following:

- Courses on the dangers of restrained areas and machines. The permit to work with lifting (except the LSC crane) means will be given by the Director
- Courses on the use of calibration radiation sources.

### **15.2 PRACTICAL DEMONSTRATIONS AND EXTERNAL COURSES**

The Laboratory will hold seminars, courses and practical demonstrations on the dangers of the different activities with the help of external companies too.

## **16 GROUP LEADER IN MATTER OF SAFETY (GLIMOS)**

Since the experiment Collaborations are composed of teams from different countries and places, it is necessary to have a safety person responsible who is *super parties* and has the authority to operate.

### **16.1 THE GLIMOS**

That is why the GLIMOS has been created. She/he has the authority needed to operate in safety matters.

### **16.2 DUTIES**

GLIMOS has a central and important role in the organization of an experiment; don't forget she/he is the experiment responsible in matter of safety. In spite of this, according to Spanish laws, the responsible for all the operations in the LSC is always the lab Director. Therefore, the GLIMOS must report to the LSC Director regularly on issues concerning safety of installations and operations at LSC. The GLIMOS will review all procedures submitted by the Collaboration to the LSC for operations.

### **16.3 QUALIFICATIONS**

The GLIMOS must have a perfect knowledge of every aspect of the experiment as well as of the staff involved. She/he will have the time and authority required in order to operate.

### **16.4 THE SIZE OF THE PROJECT**

#### ***16.4.1 LARGE EXPERIMENTS***

In case of large experiments, the GLIMOS cannot work alone. That is why she/he can designate one or more linkmen who help him with his job. However, these linkmen do not relieve the GLIMOS from all responsibilities.

#### ***16.4.2 SHORT-TERM AND SMALL TESTS AND EXPERIMENTS***

In case of small experiments and tests (or that do not exceed one or two weeks), safety measures can be reduced, always regarding what the real hazards are. In any case, these Experiments will have to elect a GLIMOS too.

### **16.5 WHAT GLIMOS CAN DO**

The GLIMOS can

➤ designate:

- a substitute to be approved by the Lab Director.
- the Linkmen, according to the experiment needs.
- a SLIMOS ("Shift Leader In Matter Of Safety"), if the activity requires it. Up to now, the LSC do not provide for a SLIMOS, but this figure can be easily found in the experiment shift leader (or coordinator).

- inform the authorities in charge on the following topics:
  - conditions, systems and safety plants in the experiment areas.
  - safety conditions in the nearby experiments, with particular attention to alarms and how to eventually behave.
  - designations and substitutions.
  - incidents and accidents.
  - possible variations on the experiment.;
  - systems changes.
  - conditions of an eventual gas system.
- start:
  - testing new materials.
  - safety valve maintenance and test.
  - safety training of the experiment staff.
  - evacuation practices.
  - first aid courses (one or more experiment members should attend them).
- participate to:
  - all the important meetings on the experiment.
  - the experiment inspections.
  - the tests on experiment alarms or the area at issue.
  - evacuation practices.
  - fire practices.
- ensure:
  - that everybody in the Collaboration:
    - knows and respects safety rules;
    - is conscious of her/his own duties and of all the possible dangers;
    - knows emergency exits;
    - pays attention to any sign that can avoid a possible incident;
    - works in safety conditions;
    - knows where the first aid kit is;
    - knows where the *contact list* is and makes sure that this can be clearly seen;
    - that nobody works alone when there is a possible real danger;
    - that nobody acts in an unsafe way.

The GLIMOS also has to ensure:

- that the Collaboration owns and uses the safety material.
- that she/he will check safety in tests together with a linkman.

## 16.6 GLIMOS BEHAVIOUR IN CASE OF EMERGENCY

Before an emergency, the GLIMOS has to know:

- the experiment lay-out and where it has been set up.
- how many people are generally present in the experiment.
- the main hazards.
- where these hazards can be found.
- where the collaborators work and how to evacuate them quickly.
- the experiments nearby and their possible dangers.
- the position of emergency exits and the control of their availability.
- the perfect conditions of alarms.
- what the safety equipment conditions are.
- the rules in force.
- the initial phases in an emergency status.
- the evacuation procedures.
- the alarms procedures.
- the organization of First Intervention team in the Laboratory and Fire Service and the Safety Service in the Control Center Somport Tunnel

During an emergency the GLIMOS has to:

- call the Control Center Somport Tunnel and LSC External Building to mobilize the first intervention team (fire staff ).
- organize first aids to injured, together with the first intervention team.
- evacuate the area, if necessary.
- help the first intervention team giving all the information on the experiment system and its hazards.
- be at disposal.

After an emergency the GLIMOS has to:

- check the conditions of safety systems, plants and facilities.

## **17 SOME GOOD RULES FOR USERS**

### **17.1 PERSONNEL PROTECTIVE EQUIPMENT (PPE)**

- ✓ Wear personnel protective equipment as established, according to Spanish laws.
- ✓ Pay attention to alarm signals.
- ✓ Follow the Medical Service instruction from your Institute/Company/Collaboration as regards the required medical tests (blood test, and so on).
- ✓ Follow the TWO PERSON RULE.
- ✓ Take the necessary precautions when working at a certain height.

### **17.2 KNOW YOUR WORKING ENVIRONMENT**

- ✓ Know how to alert the First Intervention team in the Laboratory and Fire Service and the Safety Service in the Control Center Somport Tunnel.
- ✓ Know the position of the emergency switchboards and how to activate it.
- ✓ Know the exact meaning of alarm signs.
- ✓ Know how to stop gas and water generators in case of need.
- ✓ Know the position of the fire extinguishers (both fixed and movable) and self-breathing personnel equipment.
- ✓ Ask GLIMOS and her/his collaborators to explain what has not been understood and discuss with them what does not seem to be clear or safe.

### **17.3 DO NOT CAUSE INCIDENTS**

- ✓ Do not start dangerous activities if you are not able to do, for example if you are very tired.
- ✓ Read the instruction carefully before using any new or unfamiliar equipment.
- ✓ Do not leave any equipment, which could fall down or cause damages.
- ✓ Do not obstruct the areas near the ventilation systems of the equipment, for example computers.
- ✓ Fasten gas bottles.
- ✓ Do not smoke in any area.
- ✓ Do not obstruct emergency exits or accesses to the extinguishers and self-breathing personnel equipment.
- ✓ Do not park cars outside the parking bays and where they might interfere with the fire brigade intervention.

In spite of all attentions, it might happen to be involved in an incident. In this case it will be necessary to limit the consequences.

- ✓ Stay calm, because it is important to act quickly but it is fundamental to act effectively.
- ✓ Alert to Control Center Somport Tunnel (974-37-35-24) and the LSC External Building (974-37-35-05) using the phones distributed with set-function keys.
- ✓ Try to apply all that has been learnt in the safety and emergency courses.

## 17.4 HOW TO ALERT THE FIRE BRIGADE

For all the emergencies call

### Control Center Somport Tunnel (974-37-35-24)

When making an emergency call, it's mandatory to provide the information below:

- Place of the emergency
- Type and magnitude of the emergency
- Personnel affected
- Predictable evolution and propagation, if possible.

The Control Center Somport Tunnel will always be automatically alerted by:

- General emergency stops.
- Evacuation alarms
- Fire alarms.

Once arrived at the area at issue, the fire brigade will be responsible for the operations but they will need cooperation from everybody.

## 17.5 PREMONITIONS

Sometimes an incident may be a warning. It is always useful to pay attention to any strange "warning non standard sign" coming from facilities and equipment, such as:

- inexplicable changes of current and voltage.
- abnormal temperatures.
- strange noises.
- strange odors.
- abnormal data from detectors.
- people's unusual behavior.

Any "warning non standard sign" must be checked with the Site Manager and reported to the GLIMOS and/or SLIMOS.

## **18 CHEMICAL SAFETY**

In the Laboratory many chemical products are used. They usually have different degrees of danger. Their dangers are not always easily recognizable and sometimes their effects on health are delayed.

### **18.1 CHEMICAL HAZARDS**

An updated list of the chemical products, gases and cryogenic substances used and storage as well as their safety data sheet (SDS) will be available in the Emergency Documents RED BOX at the entrance of the Laboratory.

The safety data sheet provides workers and emergency personnel with procedures for handling and working with that substance in a safe manner and includes important information such as physical data, toxicity, health effects and so on.

### **18.2 CHEMICAL SUBSTANCES CONTAMINATION**

Dangerous and toxic substances could pass through our body in different ways:

- inhalation: breathing vapors or dust
- ingestion: getting confused with drinks and toxic liquids or by contained food
- absorption: through skin or wounds, causing allergies, infections, corruptions or poisonings
- injection: doing a false movement while handling a syringe

### **18.3 EFFECTS ON METABOLISM**

When there is just a suspicion of poisoning it may be useful to go to the health center. In fact it is possible that some chemical products, once they're metabolized, are more toxic than the original ones. Thus, a ready medical intervention can help to avoid serious health problems.

## **19 MEDICAL SUPERVISION**

Duty and aim of the Protection and Prevention Service (PPS) concerning medical supervision are to:

- protect staff's health.
- research and identify the causes that may undermine workers' health and hygiene.
- arrange for a first medical covering in case of emergency.

Furthermore, advices can be given and exams at the Jaca Hospital can be organized through the Protection and Prevention Service (PPS)

### **19.1 APTITUDE TO WORK**

Some medical exams are compulsory:

- at the moment of employment.
- at regular intervals.
- in accordance with the kind of activity that is being developed.
- after an absence from work for illness longer than 21 days
- in case of change of work by reason of health.
- at the moment of retirement.

### **19.2 MEDICAL SUPERVISION**

Other exams can be suggested:

- regular blood tests, according to the kind of activity done.
- hearing tests.
- sight tests.
- breathing test.

The medical schedule is very important. It allows getting a complete view concerning the staff conditions and it will be very useful in case of health problems.



## **20 DANGERS IN THE EXPERIMENT HALLS**

The main worries of safety in the experimental areas are:

- ionizing radiations.
- flammable products.
- high voltage.
- people or things that can fall down.
- an excessive quantity of flammable material.
- careless chemical or radioactive materials handling.
- mess, confusion in the experimental areas.

### **20.1 ACTIVITIES INADAPTED TO LOCAL EQUIPMENT**

Sometimes we are tempted to do some activity which local structures are not suitable to. Thus, before starting, be sure that all safety measures are perfectly working. However, in any case, the GLIMOS must be informed.

### **20.2 ACCESS PATHS**

The main problem in the experiment area is that users usually fill all the available areas with the equipment required for the experiment. Thus it should be employed only the quantity of materials sufficient to the activities to do. However the staff must be ready to evacuate for the intervention of the emergency teams. Besides, the access paths, the evacuations roots and the emergency exists must be free from obstacles.

### **20.3 CONFINED SPACES**

A limited space is an area where there is a danger of air contamination or which it is difficult to evacuate from. If you need to get into one of these areas, you have to inform the PPS and GLIMOS/SLIMOS that has been trained for this case too and it will be perfectly able to take the suitable precautions.

### **20.4 FALSE FLOORS**

Many counting rooms and electronic shelters have false floors: many thick cables have been placed under them. They are usually out of reach and clearly indicated, but one of the floating floors might be opened, and this would cause a real danger. Every opening must be signaled and the area protected with a barrier that must be kept there 'til the end of the operation.

### **20.5 LIFTING AND HANDLING EQUIPMENT**

This type of equipment can be dangerous, when not used in accordance with safety measures. To avoid any kind of hazard, remember the following considerations:

- the equipment must be properly designed and built.
- all the equipments must be approved by the Laboratory.
- the facilities can be used only by those who have a permit.

- the heavy masses lifting and handling must be in agreement with the other activities in the area.
- the objects must never be lifted more above than it is necessary and never above people.

## **21 SAFETY IN THE UNDERGROUND AREAS**

### **21.1 UNDERGROUND EXPERIMENT AREAS**

Underground areas may have some problems that are less important on the surface. Consequently, safety rules and measures are much more rigid underground and must be more strictly respected.

### **21.2 GENERAL CONSIDERATIONS**

Much attention must be paid to safety signals in the experiments in the gallery. In fact, incidents hardly ever occur with no premonitions. Thus, every single signal of danger must be taken into great account, to avoid all the possible hitches.

## **22 CHEMISTRY**

The use of particular chemical substances may expose to hazard those people who are not used to work with extremely dangerous materials.

### **22.1 TOXICITY CLASSIFICATION**

Toxic materials are divided into classes of toxicity. For any further information users are bound to refer to the Chemistry Service. However all toxic substances must be handled with care.

### **22.2 LABELLING**

The containers of toxic products will have to be clearly labelled with:

- names of contents.
- toxicity class.
- main dangers of products.
- first aid instructions.

### **22.3 MEDICAL CONTROL**

Those people who often handle chemical substances must regularly undergo a medical examination. The Medical Service from your Institute/Company/Collaboration will decide when these checkups will be necessary, in accordance with the medical schedule, which is always to be updated.

### **22.4 CHEMICAL HAZARDS**

It is impossible to give a complete list of dangerous chemical products. Here below it is a list of products commonly used by Laboratories for experimental systems, so that to have a rough idea of what the hazardous substances are:

- **ASBESTOS:** it is a mineral fiber, resistant to warmth and used as insulating. It can cause serious illnesses if inhaled but only if it is worked to produce asbestos powder.
- **EPOXY RESINS:** they are used for several objects. Their preparation can cause serious skin irritations and their vapors must not be inhaled.
- **LEAD:** it is largely used as a radiation protection. It is not dangerous as a solid metal but it may become a poison if it is inhaled or if it penetrates bodies.
- **METHYLAL:** it is used as quenchers. It is highly flammable and its vapors have narcotic effects. It must be stored in the original metal tank in a steel wardrobe.
- **PCB:** under the name of Clophen, Pyralene or Askarel, it has been used as a component of dielectric lubricants in transformers and condensers.
- **PLASTIC MATERIAL:** it is used for scintillators and light guides. It burns easily and produces a thick smoke.
- **SOLVENTS:** Solvents such as benzene or carbon tetrachloride are so toxic that they are forbidden for general use. All solvents are toxic and some are highly flammable.

- **SULPHUR HEXAFLUORIDE:** it is used as an insulating for HV systems, like steam rooms. It is a n inert gas and it is not toxic if it is pure. Electrical discharges and warmth dissociate it in lower sulphur fluorides, hydrogen fluoride and metal fluorides. All of them are highly toxic.
- **TMAE** is used as a photoionizing agent in RICH chambers. It is as toxic as gasoline is. We do not know much about its effect in the long term but it does not seem to be cancerogenous. Since it is rarely used we do not have enough data.

As already pointed out, the above list is not complete. At the moment of the proposal of any experiment, the Collaboration is bound to indicate all the dangerous substances used in the experiment system. Laboratory users can and must refer to the Chemistry Service and the PPS for further information about this.

## **23 GASES AND LIQUIDS USED IN LABORATORIES**

This chapter will deal with some fluids commonly used in the particle detectors.

Gases are mainly compressed gas stored in the experiment area or supplied by the LSC general gas distribution system and liquids are liquefied gases (cryogenic liquids).

### **23.1 DEFINITIONS OF SOME TERMS**

- **FLASH POINT:** it is the minimum temperature at which a liquid produces vapors sufficient to create a flammable mix with the air close to the liquid surface.
- **LEL (Lower explosive limit):** it's the lowest concentration of combustible gas or its vapor in the air, which a flame can spread at. Under this level, the mix is too light to burn. The energy produced by the combustion of a particle is dispelled before it can activate another particle so to produce a flame.
- **UEL (Upper explosive limit):** it's the maximum concentration of combustible gas or its vapors in the air, which a flame can spread at. Above this concentration, the mix is too rich to burn. That means that oxygen exhausts in the combustion of a particle and there is not enough left to burn the next particle.
- **FLAMMABILITY RANGE:** it's defined by LEL and UEL.
- **SELF-COMBUSTION TEMPERATURE:** it's the lowest temperature to start or to cause self-combustion in a flammable mix without adding any energy from an external source.

### **23.2 IGNITION**

LEL in the air is at 4% for hydrogen and between 1.3% and 5.3% for other gases. On the other hand VEL is 14% for hydrogen and between 8% and 14% for other gases.

The energy needed to light an explosive mix is very low. A spark of only two microvolts might be sufficient for hydrogen/air near the stoichiometric concentration for ignition. Opening an unprotected electrical equipment might easily cause an ignition.

Flammable gases most used in revealing rooms have a self-combustion temperature between 300° and 600°. In this way any incandescent object might burn these rooms if the mix with the air were explosive.

The use of any flammable liquid must be discussed with the PPS.

### **23.3 DENSITY**

The standard air density is about 1.3 g/l. If compared to this value hydrogen and methane are lighter than the air, ethane is similar while propane and isobutane are heavier. Densities of liquefied gases are typically 200/800 times higher than those of their corresponding gases.

### 23.4 STORAGE

Gas containers (cylinders and/or tanks) must store in a ventilated and well illuminated area away from sources or sources of exceed heat, open flame or ignition. The Gases Storage Room in the Laboratory is the suitable and define place for this storage.

Every gas container must be identify by proper labels and secured with a fastener or similar.

Flammable products must be stored outside the laboratories in special suitable gas cabinets protected from tampering by unauthorized personnel.

### 23.5 SOME REMARKS ON LABORATORIES CONSTRUCTION

The following formula calculates the lowest volume required by an area (with the solid walls) to avoid explosive pressure in case of ignition:

$$V_{lab} = \frac{20000 \times V_{esc}}{LEL}$$

Where  $V_{lab}$  is the minimum volume of the laboratory;  $V_{esc}$  is the volume of the flammable part of the gas come out that remains inside the laboratories in concentrations superior to LEL.

### 23.6 FLAMMABLE GASES/LIQUIDS AREAS

The areas with flammable gases/liquids in the experiment are decided by the GLIMOS. They are those places where flammable gases or liquids are stored or used. In each area there must be tables with the names of the gases/liquids and the person in charge. Smoking, fire and sparks are strictly forbidden.

In the case of activities producing sparks (grinding or welding) these operations will have to be arranged with maximum caution (separating plates). They must also be communicated in advance to the PPS and must be done at the presence of one or two people responsible for emergency.

### 23.7 PURGING OF GAS SYSTEM

Purging is an important procedure that it is often over looked in many gas processes. This is very suitable before initial and subsequent system start-ups to remove contaminants such as air and water vapor.

Purging usually consist of simply flowing the service gas through the system and venting. However when the gas is toxic, corrosive or otherwise hazardous, purging by this method is not practical and safe.

Before filling the facilities with flammable gas it is compulsory to flux them carefully using an inert gas to remove every trace of oxygen. If it were possible vacuum pumping might be an even more effective method to eliminate oxygen.

All these purging operations must be done only by qualified experts.

### **23.8 GAS BOTTLES**

Sometimes it happens that cylinders are filled with a pressure higher than the one used in tests. This is very dangerous indeed. It is safer to consult the pressure test of each cylinder and check its correct pressure.

### **23.9 GAS DISTRIBUTION**

The gas distribution system in an experiment is generally divided into two phases. The first one is from the store to distribution boards and the second from these boards to the rooms.

If the plants are very small the first phase can be made up of local gas cylinders. If not, the LSC general gas distribution system may be more or less centralized, in accordance with topographic, economical and historical circumstances. In the centralized systems many experiments are fed by a common pipe system and connections distributed in any experimental rooms in the laboratory.

### **23.10 MAINTENANCE OF GAS EQUIPMENT**

The main gas systems should be run by a qualified staff. Some others especially in smaller tests and experiments will be under the direct responsibility of the user, even though the latter can be helped and **receive suggestions from the qualified staff.**

### **23.11 FLAMMABLE GAS DETECTORS**

These detectors are used to check the concentration of flammable gases in the atmosphere. All the laboratories using large quantities of flammable gases must have detectors. The most common detectors gauge ohmic resistance change of a wire due to catalytic oxidation. There are three types of detectors: manual, portable and automatic position version

Other physical principles can be used for gas detection. One is based on the infrared spectrometer, is more sensible and specific for a certain gas and less subject to pollution.

Gas detectors are set up to give a first warning from 10% to 20% LEL and the alarm from 20% to 40% LEL (pre-alarm and alarm thresholds).

All the detectors in laboratories, workshops and assembly rooms should be linked to the safety room.



## **23.12 INERT FLUIDS AND GASES**

### **23.12.1 HAZARDS AND PRECAUTIONS**

Inert gases are neither flammable nor toxic but they can dilute the oxygen in air, leading to death by asphyxiation if breathed long enough. There are no specific rules for inert gases.

The typical inert gases used in experiments are: helium, nitrogen, argon and carbon dioxide. Carbon dioxide and nitrogen are not proper inert gases but they are hardly used in laboratories. As cryogenic liquids, they are used for cooling inert atmospheres, calorimeters etc...

### **23.12.2 LEAKAGE**

In case of leakage, during a transport or an accidental break of pipes, the main hazard with cryogenic liquids is people's injuring or damages to materials due to the cooling effect.

### **23.12.3 THERMAL EXPANSION**

At a temperature superior to its boiling point, the evaporated cryogenic liquid will spread with a factor going from  $10^2$  to  $10^3$  depending on the type of liquid.

### **23.12.4 LACK OF OXYGEN**

The normal concentration of oxygen in the air is 20,9%. For a normal vital support the concentration needed is 19.5%, limiting to 7% the increase of inert gases in the air. When oxygen goes below 17% there can be serious breathing problems; if it goes below 12% life is in danger. Below 5% death comes after a few minutes.

The danger, in these cases, is that people do not perceive the reduction of oxygen concentration in the air and then they cannot take the suitable safety measures in time.

Notice that staying in an environment containing more than 5% of carbon dioxide may cause serious breathing problems.

## **24 FIRE PREVENTION AND FIRE FIGHTING**

Prevention and fire control are essentially experts' duties. However it is everybody's duty to participate actively.

### **24.1 FIRE CLASSIFICATION**

Fires are classified in the following way:

- **CLASS A:** fires of solid fuels that start thick flames.  
Ex.: Wood, coal, paper, hard plastic, straw, textile materials.  
Characteristics: deep fire and flames.
- **CLASS B:** fires of liquids or melted solids.  
Ex.: gasoline, grease, resins, paints, tar, soft plastics.  
Characteristics: flames.
- **CLASS C:** gas fires.  
Ex.: acetylene, methane, propane, butane, hydrogen.  
Characteristics: flames.

Fire started from gas leaks can be put out by stopping gas supplies. If this is not possible it will be necessary to try to limit the fire where it is possible to cool the area environment. However, never try to put fires out with extinguishers or water before closing gas supplies: there would be explosion hazards.

- **CLASS D:** metal fires.  
EX.: Al, Mg (as well as their alloys Na, K, Li, U)  
Characteristics: deep fire, possible emissions of heated fragments.
- **CLASS E:** Sometimes fires of HT electrical systems (engines, transformers, magnets, control panels) are grouped in only one class (class E). Fires are usually a combination of class A and class B plus electricity hazards for rescuers.

### **24.2 FIRE DEVELOPMENT**

Fires usually spread out in four phases and detectors are programmed to find some typical effects of one or more phases.

- **INITIAL PHASE:** invisible smoke, no flames and little warmth. Invisible combustion (but sometimes perceivable by smell). This phase sometimes develops slowly.
- **FIRE WITHOUT FLAMES:** smoke but no flames and little warmth.
- **FLAMES:** visible flames, more warmth, little smoke, in particular with liquids or gases.
- **WARMTH:** fires produce a large quantity of flames, warmth, smoke and toxic gases.

The passage from one phase to another can be very fast.

## **25 PREVENTION**

### **25.1 DEVICES AND INSTALLATIONS**

The basic principle of protection is to prevent the development of fire and smoke by building fire and smokeproof floor, walls and doors in different fire sector defined in the Laboratory. In areas where flammable materials are stored fireproof walls and doors must be installed. Also the cable passages between different fire sectors must be covered with special materials, such as silicone and rock wool that permit a proper protection.

### **25.2 SELECTION OF MATERIALS**

Every time it is possible, non-flammable materials should be used. Among the materials that can burn you'd better to use materials retarding fire and with a low rate of smoke hazards and toxic and corrosive emissions. The choice, if not indicated by precise laws, will turn out to be a compromise among: fireproof characteristics, electrical and mechanical properties and resistance to gases, chemical materials or radiations.

Plastic materials must not contain halogen, nitrogen, antimony, sulphur and phosphor.

### **25.3 THE FIRE PERMIT**

Many fires are caused by activities made using hot tools when:

- grinding and cutting (incandescent sparks and fragments can be produced).
- welding or cutting electricity and oxyacetylene.
- warming up by a blow lamp or a propane lance.

The *fire permit* is issued to few expert people in using such equipment, so that they will be the only ones able to use all the dangerous facilities. Most part of this kind of activity is usually done by external companies. To reduce to the minimum the hazard of incidents it is PPS aim to regulate these kinds of activities by issuing the *fire permit*.

So, all activities concerning the *fire permit* must be reported in large advance (at least one month) to the PPS.

### **25.4 FIRE DETECTORS**

There are many kinds of detectors. There can be single or linear unit models.

#### **25.4.1 SINGLE DETECTORS**

- THERMICAL DETECTORS: they are sensible to fire warmth. They are programmed to start at determined temperatures that are generally between 50° and 70°.
- THERMAL GRADIENT DETECTORS: they are more sophisticated. They can react both to a sudden increase of temperature ( $vt > 9^\circ/\text{min}$ ) and to a fixed temperature between 50° and 70°;

- **FLAME DETECTORS:** they are sensible to flames light, generally at the infrared threshold of the visible spectrum, but sometimes at the ultraviolet threshold. The traditional frequency of flames is set between 5 and 30 Hz;
- **SMOKE DETECTORS:** a smoke detector system produces a signal when the beam of a photocell is obscured by smoke. Another system perceives the light produced by Tyndall effect in a photocell that normally does not receive light. This system works better with white smoke.
- **IONIZING DETECTORS:** ionizing systems perceive the invisible production of a combustible and then it can signal fire in the initial phase.

#### **25.4.2 LINEAR DETECTORS**

There are three types of linear detectors.

- **Pipes with holes along their whole length (VESDA).** The air to check is aspirated by a fan through these holes and it is sent to detectors where it is analyzed from a molecular point of view. This type of system is very effective because it is able to determine the initial phase of a fire. Cells can be optic, ionizing or a combination of both.
- **Thermosensitive cable:** a sensitive cable is set in raceways containing power electrical cables. When the cables are on fire (and consequently temperature increases) the thermosensitive cable goes haywire. The short circuit is signaled to a panel connected to the cable through an alarm.
- **Infrared detectors:** they can be used to survey big areas. In high hazard areas combinations of systems can be used. This solution will definitely reduce false alarms hazard.

#### **25.5 AGENTS AGAINST FIRE**

Here are some extinguishing agents. Many of them can be used against electrical system fires with a higher than 1000 volts voltage.

- **WATER** has many good properties of cooling and penetration that help the reignition of a deep fire.
- **POWDER B** (sodium bicarbonate) or **POWDER AB** (ammonium monobasic phosphates) are powdered agents used against fires of type AB and B.
- **AGENTS D** are used against metal fires when the use of other substances like water might be dangerous. These agents can be: sodium chloride, graphite or other powders in special mixes for each metal.
- **FOAM** puts fires out forming a cover over the flaming material surface. It also prevents a reignition by cooling them. Water, powder and foam can cause big secondary damages to facilities (above all electrical systems).
- **CARBON DIOXYDE** acts cooling and stopping the oxygen feeding. To stop fire the oxygen concentration must be inferior to 6% corresponding to a carbon dioxide concentration at 70% in the air mix. In this case there is also a danger of asphyxia in the fire areas.
- **NITROGEN** is not used to put fire out till it is not possible to liquefy it to the temperature of the room. Sometimes it is used to keep the oxygen rate low in the air.

- HALON: systems already existing are now being dismantled because of problems caused to ozone. The extinguisher agent was very effective and not much toxic for users but it is not available anymore, unless by a ministerial derogation.

## 25.6 FIRE FIGHTING AGENTS FOR FIXED INSTALLATIONS IN THE LABORATORY

Extinguishing Agents	Classes of Fire		
	a) Solid	b) Liquid	c) Electrical
Powder ABC	+-	+	+-
Powder B	-	++	-
CO2	-	+	+-

## 25.7 FIRE FIGHTING AGENTS FOR PORTABLE EXTINGUISHERS IN THE LABORATORY

Extinguishing Agents	Classes of fire				Safety Distance <1000 V
	a) Solid	b) Liquid	c) Metal	d) Electrical	
Powder B	-	++	-	+-	1mm
Powder ABC	+	+	-	+	1mm
Carbon Dioxide	-	+	-	+-	1mm

Symbols key: ++: very good; +: good; +-: sufficient; -: insufficient

## 25.8 REPLACEMENTS FOR HALON

Halon is excellent to fight fires, but it has a devastating influence on the environment. In fact it destroys the ozone belt. But other components and techniques can be set up:

- CFC or HCFC compounds have a few light effects on ozone. They put fires out by a chemical action, as well as halon, but they cannot replace halon in the existing systems without modifications.

- INERT GASES: put fires out excluding oxygen. Some gases are not immediately dangerous for people but unfortunately they must be used in great quantities.
- HI-FOG is a thick water steam that puts fires out by cooling. It does not damage facilities.
- HIGH EXPANSION FOAM puts fires out in two ways. It stops oxygen and it cools facilities. It causes no further damages to the system.
- INERGEN is a mix of nitrogen, argon and CO<sub>2</sub>. It fills up the area in a few minutes with an invisible and odorless gas without causing any breathing problem.

### **25.9 FIRE FIGHTING MEANS AT EXPERIMENTS**

- Portable fire means that can be used by everybody:
  - Carbon dioxide
  - Powder ABC
  - Powder B

### **25.10 USE OF PORTABLE EXTINGUISHERS**

They should be put in places easily accessible and close to the experiment area. Move quickly when using them but do not run. Remember that an extinguisher has a limited duration that goes from 40 to 100 seconds for liquids or foams and from 10 to 25 seconds for powder and carbon dioxide.

Do not use fire equipment against gas fires before closing the erogators to avoid the hazard of an explosion.

### **25.11 NON AUTOMATIC AND AUTOMATIC FIRE EXTINGUISHING SYSTEM**

Consider these systems when justified by the following factors:

- hazards of fires with dangers for people and/or system stabilities.
- inaccessibility of manual systems.
- delays in replacing facilities.

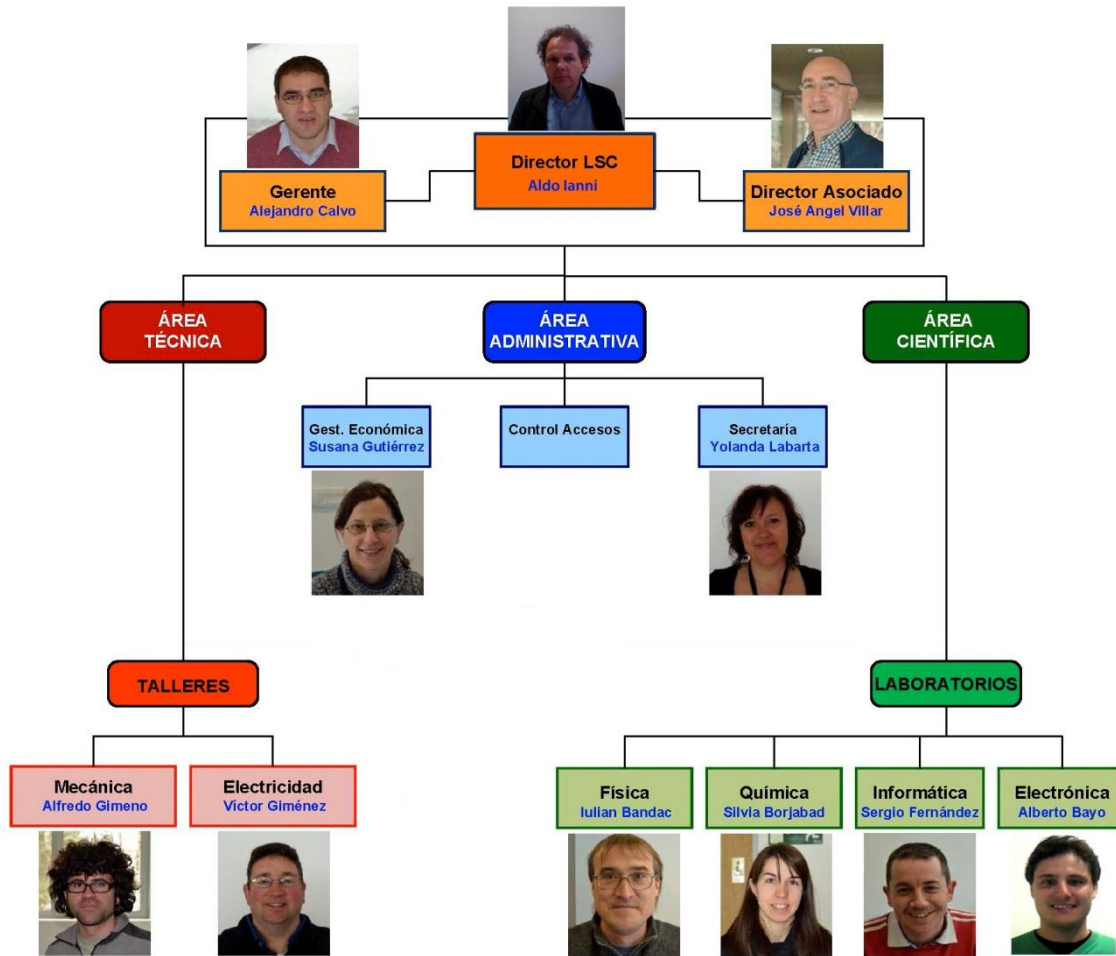
In the Laboratories the following systems can be found:

- carbon dioxide points of exits.

The LSC carbon dioxide system is installed in Hall A, Hall B/C and same electrical rooms. The system works automatically connected to detectors, and also manually. Any area works independently from the other ones. The system has sound and lighting alarms at the entrance of each area and also duplicated in the parking area.

In some cases some special systems can be created to protect all the facilities.

ANNEX I.  
LSC Flowchart





ANNEX II.  
Contact List template

# CONTACT LIST TEMPLATE

NAME	AREA	PHONE	E-MAIL
Ianni, Aldo	Director	+34-974-373-474	<a href="mailto:aianni@lsc-canfranc.es">aianni@lsc-canfranc.es</a>
Villar, Jose Angel	Joint Director	+34-974-373-474	<a href="mailto:jvillar@lsc-canfranc.es">jvillar@lsc-canfranc.es</a>
Calvo Vinacua, Alejandro	Financial Manager	+34-974-373-474	<a href="mailto:acalvo@lsc-canfranc.es">acalvo@lsc-canfranc.es</a>
Labarta Hernández, Yolanda	Director's Secretary	+34-974-373-474	<a href="mailto:ylabarta@lsc-canfranc.es">ylabarta@lsc-canfranc.es</a>
Gutierrez Dencausa , Susana	Admin/Accounts	+34-974-373-474	<a href="mailto:sgutierrez@lsc-canfranc.es">sgutierrez@lsc-canfranc.es</a>
Borjabad Sanchez, Silvia	Chemist	+34-974-373-474	<a href="mailto:sborjabad@lsc-canfranc.es">sborjabad@lsc-canfranc.es</a>
Bandac, Iulian	Physicist	+34-974-373-474	<a href="mailto:ibandac@lsc-canfranc.es">ibandac@lsc-canfranc.es</a>
Gimeno Iñiguez, Alfredo	Mechanics Technician	+34-974-373-474	<a href="mailto:fredi@lsc-canfranc.es">fredi@lsc-canfranc.es</a>
Gimenez Lalaguna, Victor	Electrics Technician	+34-974-373-474	<a href="mailto:vgimenez@lsc-canfranc.es">vgimenez@lsc-canfranc.es</a>
Fernandez Royo, Sergio	Tec. Informático	+34-974-373-474	<a href="mailto:sfernandez@lsc-canfranc.es">sfernandez@lsc-canfranc.es</a>
Bayo Martínez, Alberto	Tec. Físico-Electrónico	+34-974-373-474	<a href="mailto:abayo@lsc-canfranc.es">abayo@lsc-canfranc.es</a>

ANNEX III.  
Work Permit template



# WORK PERMIT TEMPLATE

Description of work

--

Location of Work

Building	Floor	Room	Location
Date required	Valid From (time)		To

Contact Details (method of Contact)

Mobile Phone	Site telephone	Co. Office No.
Estates Project Officer	Estates Help Desk	Security

Potential Hazards	<input type="checkbox"/> Oxygen enrichment <input type="checkbox"/> Oxygen depletion <input type="checkbox"/> Toxic Gas <input type="checkbox"/> Explosive Gas <input type="checkbox"/> Bio Hazard <input type="checkbox"/> Poor lighting <input type="checkbox"/> Heat <input type="checkbox"/> Noise <input type="checkbox"/> Tripping/falling/striking objects <input type="checkbox"/> Other- provide details				
Control Measures	<input type="checkbox"/> Hazard / equipment Isolated <input type="checkbox"/> Department staff informed <input type="checkbox"/> Protective equipment required				
Other Identified Hazards	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 40%;"></th> <th style="width: 60%;">Controls Measures</th> </tr> <tr> <td style="height: 40px;"></td> <td></td> </tr> </table>		Controls Measures		
	Controls Measures				

Person entering work area


Permit issued by	Date	Time
Permit Received by	Date	

Permit cancellation (Estates Dept.)

Name	Date	Time

ANNEX IV.  
Process Procedure template

# PROCESS PROCEDURE TEMPLATE

## TITLE

**Process Procedure Number:** EXPName-XXX - Rev. X

**Last Revision Date:** DATE

### Procedure Author(s):

Name Sign

Name Sign

### Reviewed by:

Name Sign

Name Sign

### GLIMOS (Revised and Approved):

Name Sign

### Last Revised and Approved by:

Name Sign

Position: Spokesperson / Project Coordinator

**Procedure validity:** For Example (from Revision Date to End of Project)

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## 2. Revision History

Revision number	Date	Author(s)	Reason	Sections Updated / Modified
Number	Date	Names / Acronym	Text	Specify

Add one after another, in chronological order all the reviews

## 3. Personal authorized to carry out the process

Operators
Name

Add every authorized person

## 4. Purpose

Brief description of purpose of the procedure

## 5. Used Facilities / Parts of the experiment / New equipments / Reference Documents

List the Used Facilities, Parts of the experiment, New equipments, ... Please clarify in the list the requests to LSC Technician Division.

List also the Reference Documents:

- Previous approved Procedures
- Any Manual
- Any rules or technical document
- .....

Please list the names of the Reference Documents (if internal) or permanent link to external documents.

## 6. Distribution list

Include the list of persons / departments / areas who will receive the document.

On the side of the LSC, you have to consider the following potential recipients:

- ✓ LSC Prevention and Protection Service (SPP).
- ✓ LSC Technical Division.
- ✓ LSC Director Office

## 7. References

If appropriate, include any reference such as: Laws, Rules, LSC procedures.....

## 8. Hazards in Operations & Safety Instructions

### A. Introduction

Include a brief introduction of the safety considerations.

### B. Hazards descriptions

Please consider and describe the hazards in the following areas (if appropriate):

- Process work area
- Gases, liquids, cryogenic liquids
- Other chemical substances
- Electrical Systems
- Lifting and Handling



- Vacuum and Pressure tanks
- Radiations
- Other Dangers

### **C. Safety Instructions**

Include all general safety instructions to be carried out during the process as well as safety and/or emergency rules, Personal Protective Equipments (PPE) and so on.

### **D. Description of possible failures**

If the procedure implies any failure in/or the equipment /facilities, describe here this situation and the corrective actions to take.

### **E. Recommended major safety equipment**

Describe the major safety equipment.

### **F. External and Environmental Impact (if appropriate)**

Describe the possible External and Environmental Impact

## **9. Procedure**

### **A. Description of the operations**

A brief description of the procedure

### **B. Operating Procedure**

- Steps of operations
- Operators check list including Prerequisites and Operative procedure (see the Check list template in the Annex I – modify it as appropriate)
- Diagrams and/or pictures

The Check list will be filled and signed with name and date, every time the procedure is performed.

## **10. Operations and Shifts Requirements**

Include any requirement information such as:

- Responsible for the operations on behalf of the Collaboration: Task Manager.
- Number of people present during the activity
- Persons to whom report before work
- .....

As a reminder, laboratory staff and their contact details are:

Phone: +34 974 373 474  
 Fax: +34 974 373 475  
 General support e-mail: [support@lsc-canfranc.es](mailto:support@lsc-canfranc.es)

NAME	POSITION	E-MAIL
Ianni, Aldo	Director	<a href="mailto:aianni@lsc-canfranc.es">aianni@lsc-canfranc.es</a>
Villar, Jose Angel	Joint Director	<a href="mailto:jvillar@lsc-canfranc.es">jvillar@lsc-canfranc.es</a>
Calvo Vinacua, Alejandro	Financial Manager	<a href="mailto:acalvo@lsc-canfranc.es">acalvo@lsc-canfranc.es</a>
Labarta Hernández, Yolanda	Director's Secretary	<a href="mailto:ylabarta@lsc-canfranc.es">ylabarta@lsc-canfranc.es</a>
Gutierrez Dencausa , Susana	Admin/Accounts	<a href="mailto:sgutierrez@lsc-canfranc.es">sgutierrez@lsc-canfranc.es</a>
Borjabad Sanchez, Silvia	Chemist	<a href="mailto:sborjabad@lsc-canfranc.es">sborjabad@lsc-canfranc.es</a>
Bandac, Iulian	Physicist	<a href="mailto:ibandac@lsc-canfranc.es">ibandac@lsc-canfranc.es</a>
Gimeno Iñiguez, Alfredo	Mechanics Technician	<a href="mailto:fredi@lsc-canfranc.es">fredi@lsc-canfranc.es</a>
Gimenez Lalaguna, Victor	Electrics Technician	<a href="mailto:vgimenez@lsc-canfranc.es">vgimenez@lsc-canfranc.es</a>
Fernandez Royo, Sergio	Computers Technician	<a href="mailto:sfernandez@lsc-canfranc.es">sfernandez@lsc-canfranc.es</a>
Bayo Martínez, Alberto	Physicist-Electronics Technician	<a href="mailto:abayo@lsc-canfranc.es">abayo@lsc-canfranc.es</a>
Rubió Martínez, José Luis	Safety Technician	<a href="mailto:jlrubio@lsc-canfranc.es">jlrubio@lsc-canfranc.es</a>

## ANNEX I

### CHECK LIST TEMPLATE

#### *PREREQUISITES (If appropriate)*

- Item nº1
- Item nº 2
- Item nº3
- .....
- ....
- Item nº N

#### *OPERATIVE PROCEDURE*

- Item nº1
- Item nº 2
- Item nº3
- .....
- ....
- Item nº N

Date: \_\_\_\_\_

Signed: \_\_\_\_\_

ANNEX V.  
Action Plan template

# ACTION PLAN TEMPLATE

## TITLE

**Last Revision Date:**

**Author(s):**

**Reviewed by:**

**GLIMOS (Revised and Approved):**

**Last Revised and Approved by:**

**Plan validity:**

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## 2. Operators

Operator	Task manager	Approval	Date started	Date ended
Name	Name	Names / Acronym	Date	Date

Add every person. Task manager is the on site responsible for the Collaboration

## 3. Description

Make references to the approved procedures

## 4. General request for LSC support

- LSC technical support
- Courses: Safety, person in charge, clean room
- LSC services requests (forms): Clean room, pure measurements
- LSC deliveries
- Others

## 5. Schedule

- Days
- Personnel
- Tasks
- Working Hours

Include a detailed plan reporting daily personnel at work, tasks. Indicate approximate working time to allow LSC Personnel to get organized to give support if appropriate. Use the following template, modify it as appropriate.



	Day 1	Day 2	.....	Day N
Operator 1	Task (from X am to X pm)	Task (from X am to X pm)	.....	Task (from X am to X pm)
Operator 2	Task (from X am to X pm)	Task (from X am to X pm)	.....	Task (from X am to X pm)
	.....	.....	.....	
Operator N	Task (from X am to X pm)	Task (from X am to X pm)	.....	Task (from X am to X pm)