RESUM

Aquest projecte consisteix a estudiar la situació actual de la gestió dels residus especials generats als laboratoris de la Facultat de Ciències de Base (FSB) de l'Escola Politècnica Federal de Lausana (EPFL) i en la posterior millora d'aquesta gestió tot modificant algunes de les eines disponibles i creant-ne de noves. Ha estat desenvolupat per tal d'assegurar el total compliment de la legislació vigent en matèria de residus especials, per tal de reduir el risc per a la salut de totes les persones que hi entren en contacte des del moment en que són generats i per tal de minimitzar, en la mesura del possible, l'impacte que aquests tindran en el medi ambient.

En primer lloc, i abans de millorar el programa de gestió de residus de la Facultat, ha estat necessari realitzar un anàlisi en profunditat de la situació actual. Per a aquest fi ha sigut imprescindible estudiar la legislació vigent relativa als residus especials, entendre com s'organitza l'EPFL en general i la FSB en concret, procurar tenir una visió global i específica de tot el cicle de vida d'aquests residus i, finalment, conèixer i entendre les qualitats i les carències de les eines actuals.

Una de les carències detectades ha estat la manca d'informació disponible sobre les incompatibilitats entre residus i amb els contenidors on han de ser dipositats. El coneixement de les incompatibilitats és crucial per a gestionar de manera correcta els residus i, sobretot, per tal d'evitar riscs per a les persones que hi entren en contacte. És per això que s'ha treballat el tema en profunditat i s'ha resumit la informació per tal de posar-la a disponibilitat de tots els col·laboradors de la FSB. A més a més, s'ha actualitzat el taulell "Gestió de residus especials a la FSB" i s'ha modificat les etiquetes dels residus especials per tal d'homogeneïtzar-ne la llengua i realitzar algunes correccions.

Un dels pilars del projecte ha estat la creació d'un llibret que sintetitza tota la informació relativa a la gestió de residus especials generats a la FSB d'una manera clara i visual, i que especifica la millor manera d'etiquetar i d'empaquetar cada tipus de residu. També s'ha creat un programa informàtic que proporciona aquesta mateixa informació després de respondre un seguit de preguntes per tal d'identificar el residu generat. A més, s'ha recopilat informació sobre el tipus i la quantitat de residus especials generats per cada grup de recerca que a la llarga pot resultar molt valuosa per a millorar-ne la seva gestió.

CONTENTS

1. GLOSSARY

Activity: Number of disintegrations per unit time. The unit of activity is the becquerel (Bq); 1Bq = $1s^{-1}$.

CO_2-equivalent: Unit describing the amount of global warming that may be caused by a given type and volume of greenhouse gas using the functionally equivalent amount or concentration of carbon dioxide (CO_2) as a reference. To ensure better comparability, greenhouse gas emissions other than CO_2 (CH_4, N_2O, HFCs, PFCs and SF_6) are converted into CO_2-equivalents according to their global warming potential (GMP). One kilogram of CH_4 corresponds to 21 kg of CO_2 and one kilogram of N_2O is equivalent to 310 kg of CO_2.

Disposal of waste: The recovery or deposit of waste in a landfill as well as the preliminary stages of collection, storage and treatment. Treatment is any physical, chemical or biological modification of the waste.

Disposal company: Any company that receives waste for disposal and any collection station operated by the township, by the municipality or by an individual they have mandated.

Effects: Air pollution, noise, vibrations, radiation, water pollution or other interference in water, soil pollution, modifications of the genetic material of organisms or modifications of biological diversity caused by the construction and operation of installations, by the handling of substances, organisms or waste, or by the cultivation of the soil.

Emission: The release of pollutants, noise, radiation and similar phenomena from natural or anthropogenic (man-made) sources, e.g. plants and installations.

Incompatible chemicals: Chemical substances that should not be stored near each other because any contact between them would cause a dangerous reaction leading to an explosion, fire and/ or production of hazardous new substances.

Ionizing radiation: Radiation that has sufficient energy to eject electrons from an atomic shell (ionisation).

Management of radioactive waste: Activities whereby radioactive waste is prepared for surrender to the federal collection centre.

Nanoparticle: Microscopic particle measuring less than 100 nanometres (nm).

Organism: Any cellular or non-cellular biological entity capable of replication or of transferring genetic material. Mixtures and articles containing such entities are also regarded as organisms.

Radioactive waste: Waste that emits radioactive substances or radioactively contaminated materials which are not reused.

Radioactivity: Spontaneous disintegration of nuclides, accompanied by the emission of ionising radiation.

Radionuclide: Nuclide that disintegrates spontaneously, emitting radiation.

Remitting company: Any company or public utility that delivers its waste to another operating site or a third party.

Special waste: Waste whose environmentally sound disposal requires special technical and organisational measures due to its composition and physicochemical or biological properties.

Substances: Natural or manufactured chemical elements and their compounds. Preparations (mixtures, blends and solutions) and articles containing such substances are also regarded as substances.

Waste: Any moveable material disposed of by its holder or the disposal of which is required in the public interest.

2. PREFACE

During the lasts decades there has been a major environmental and health concern for the problems that waste and, specially, special waste generated. This concern, born in the most economically developed countries, forced to face the problem of environment contamination and its consequent adverse on public health.

Experience has shown that, in order to achieve the proper management of special waste, it is necessary to develop an infrastructure to help taking the more appropriate actions. A proper management of waste is the one that takes into account the processes of sorting, packaging, labelling, storage, transport and final treatment, all without causing negative impacts on the environment or on the living beings and, if possible, with a reduced cost. The damage that an incorrect management can cause to the environment and to human health, therefore to workers health, can be of enormous importance.

It is the responsibility of the waste producer's entity to comply with the current legislation of the country where it is emplaced. It is for this reason that each entity should develop internal rules indicating the protocol to be followed in this regard.

In teaching and research activities a great amount of products are handled, and several processes involving generation of waste, mainly special waste, are effectuated. Although the volume of the waste produced in the laboratories is small, there is a large variety of them.

The laboratory should, in order to have good work conditions, include a waste management plan to allow an adequate health and environment protection. It should not be forget that laboratory wastes are dangerous substances or dangerous mixtures whose inadequate identification or storage would be an added risk for the laboratory.

2.1. ORIGIN OF THE PROJECT

It is well known, for years now, how necessary it is to correctly manage the waste that is generated. In particular, properly managing special wastes is vital in order to avoid them damaging the environment and human health.

Swiss government is aware of this issue, as it is shown by the large investment allocated to research and to the implementation of programs related to special waste management. Swiss legislation does also very strictly regulate all the lifecycle of this type of waste, from its generation to its final valuation or disposal.

For all these reasons, in the Faculty of Basic Sciences (FSB) of the Federal Polytechnic School of Lausanne (EPFL), the Occupational Safety and Health department (SST) has, between its main objectives, the task of implementing and maintaining a special waste management program that must regulate all special waste that it is generated in the FSB laboratories. This program shall ensure that the current legislation is complied and shall minimize the risk that these wastes may have for collaborators health and for the environment.

3. INTRODUCTION

3.1. OBJECTIVES OF THE PROJECT

Due to the changes in the legislation, the continuous increase of knowledge about the subject, and the constant evolution of the research conducted at the Faculty of Basic Sciences (FSB) of the EPFL (and thus the evolution of the special wastes generated there), it is necessary to periodically review the special waste management program of the faculty and, if necessary, modify it.

The main objective of this project is, therefore, the improvement of this management by modifying some available tools and creating new ones after, obviously, having made a thorough review of the current situation.

In concrete, these tools shall be modified or created in order to:

- Ensure that the Swiss legislation related to special waste management is being complied.
- Reduce the risk that special waste can generate for those who come into contact with them from the moment they are generated.
- Reduce, to the extent possible, the impact that these wastes have on the environment.
- Reduce the economic costs associated with the treatment and disposal of special wastes.

3.2. SCOPE OF THE PROJECT

This project consists on studying the situation of the management of special wastes that are generated in the FSB laboratories of the EPFL, and on the subsequent improvement of the already available tools and the creation of new ones. It is developed in order to ensure that the current legislation is complied, in order to reduce the risk to health of the ones that come into contact with special wastes and to minimize, to the extent possible, the impact that these ones have on the environment.

The project does not include, however, the implementation of these tools or the study of how these ones will affect, in the medium and long term, the quality of the management of special waste generated in the FSB laboratories.

4. ANALYSIS OF THE CURRENT SITUATION

Before improving the special waste's management of the Faculty of Basic Sciences of the EPFL by modifying and creating new tools it has been essential to thorough review the current situation.

That is why it has been necessary to make a meticulous study of the current legislation regarding special waste management, to learn about the organisation of the EPFL in general and of the FSB in particular, to have a global and a specific vision of the special waste's lifecycle and, finally, to know and understand how the already available tools work.

4.1. LEGAL CONTEXT IN SWITZERLAND

4.1.1. SWISS LEGISLATIVE PROCESS

In its various federal acts and their correspondent ordinances, the Swiss Confederation sets out both the goals of environmental protection and the instruments and measures that are used to achieve these goals **[1]**. The cantons essentially have the task of making these goals reality. The Confederation is responsible for implementing legislation in specialized sectors. In addition, it supervises whether the cantons are carrying out their tasks in accordance with the law. Both at the lawmaking stage and during implementation, the Confederation and the cantons work closely with the private sector.

ACTS AND ORDINANCES

The legal principles of environmental protection are laid down in acts of Parliament **[2]**. In addition, the Federal Council issues ordinances, which add detail to the provisions contained in the acts. The preparatory work for acts and ordinances is carried out by the Federal Administration. In this it works closely with the cantons, political parties and business and environmental groups. In Switzerland, a well established system of consultation procedures and hearings allows the knowledge and experience of experts and the views of the implementing authorities and political decision-makers to be exploited in the lawmaking process.

KEY ROLE OF THE CANTONS IN THE IMPLEMENTATION

Written law becomes effective when it is applied at a practical level. The responsibility for this is first and foremost of the cantons, which thus play a crucial role in the environmental protection. Individual cantons organize the implementation of the law in different ways, in particular in the extent to which they delegate tasks to the communes or take care of those tasks themselves.

Figure 4.1 below represents the Swiss legislative process and the implementation of its laws:

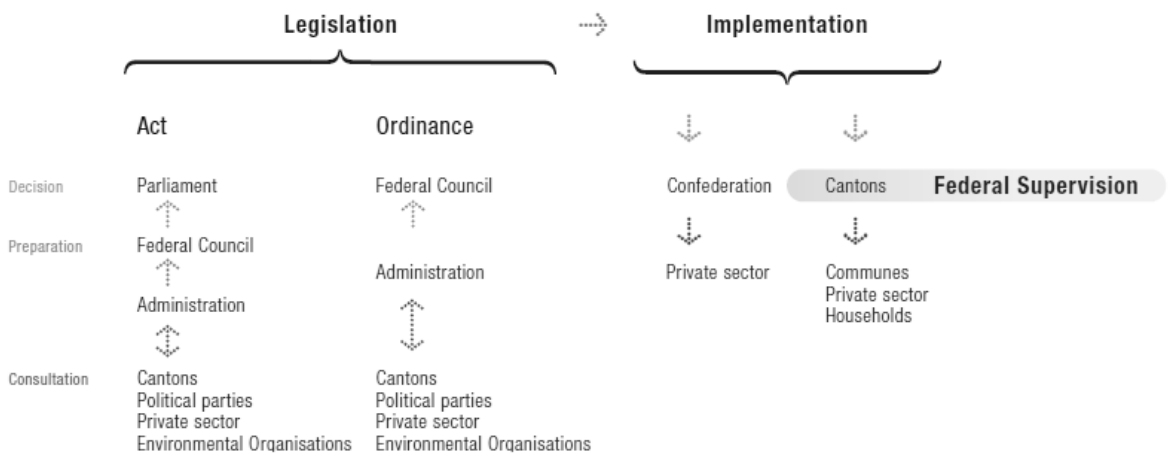


Figure 4.1. Representation of the Swiss legislative process and the implementation of its laws

4.1.2. SWISS LEGISLATION CONCERNING THE DISPOSAL OF SPECIAL WASTE

Knowledge of the Swiss legislation concerning special waste has been essential for the understanding of the work that is being done by the SB-SST group and for the proper development of the project.

Wastes containing chemical products or biological material are regulated by the Federal Act on the Protection of the Environment (LPE, ref. 814.01) and, more precisely, by the Ordinance on special wastes movement (OMoD, ref. 814.610). Every waste concerned by OMoD is classified with a six digits identification code listed in the DETEC Ordinance concerning lists of wastes' movements (LMoD, ref. 814.610.1). Treatment of biological waste is described in the Ordinance on Handling Organisms in Contained Systems (OUC, ref. 814.912). Moreover, wastes containing radioactive sources are regulated by the Radiological Protection Act (LRaP, ref. 814.50) and its ordinance (ORaP, ref. 814.501).

LEGISLATION CONCERNING ALL TYPE OF WASTE

- **Summary of the Federal Act on the Protection of the Environment (LPE), ref. 814.01**

The Federal Act on the Protection of the Environment is the cornerstone of Swiss environmental law. It regulates several key areas of environmental protection and contains general provisions that apply to all aspects of environmental protection. The detailed provisions are contained in the various ordinances of this act.

The key areas of this act are environmental protection, the issues of protection against emissions, substances that are hazardous to the environment, organisms, waste (including the remediation of contaminated sites) and the soil.

The act says that the putting into circulation of substances for uses where, when handled correctly, they, their derivatives or waste may present a danger to the environment or indirectly endanger people is prohibited. To this end, the manufacturer or importer is responsible for their own self-regulation.

In relation to waste, this Act says that:

- the production of waste should be avoided wherever possible;
- waste must be recovered wherever possible;
- waste must be disposed of in an environmentally compatible way and, insofar as this is possible and reasonable, within Switzerland.

And that the Federal Council may:

- prohibit placing products intended for once-only, short-term use on the market if the benefits of such use do not justify the harm to the environment that they cause;
- prohibit the use of substances and organisms that considerably hamper disposal or the disposal of which may represent a danger to the environment;
- require manufacturers to avoid the production of waste where there is no known environmentally compatible process for its disposal.

In relation to their treatment, the Act says that waste must not be burned other than in incineration plants.

LEGISLATION CONCERNING THE DISPOSAL OF CHEMICAL WASTE

- **Summary of the Ordinance on the Movement of Wastes (OMoD), ref. 814.610**

This Ordinance is intended to ensure that waste will only be delivered to appropriate disposal companies.

It governs:

- the movement of special wastes and other wastes subjected to control, inside Switzerland;
- cross-borders movements of all type of wastes;
- movements of hazardous waste between third countries, insofar as a Swiss company organizes or participates in these movements.

In relation to the delivery of waste within Switzerland, the Ordinance indicates that, before returning waste, their holder is required to check whether they are special wastes or other wastes subjected to control. The holder is only authorized to return special waste, or other wastes subjected to control, to an authorized centre.

The remitting company is not authorized to mix or dilute special waste before returning them. It is only authorized to ad adjuvants to special waste with the agreement of the disposal company if this adjuvant reduces the hazards of transport, and does not complicates the elimination.

In order to return special waste, the remitting company is required to use tracking documents and to write on them all the information required.

The remitting company is required to provide the transporter and the disposal company the information about the origin, the composition and the properties of the waste if these details are necessary to protect the environment, the staff or the facilities of the disposal company, or to eliminate waste in an environmentally friendly way.

In addition, the remitting company is required to provide the following information on the packaging used to transport special waste:

a. the mention “déchets spéciaux”, “sonderabfälle”, “rifiuti speciali”;
b. the code of the waste or its designation according to the waste list;
c. the number of the tracking document.

LEGISLATION CONCERNING THE DISPOSAL OF BIOLOGICAL WASTE

- **Summary of the Ordinance on Handling Organisms in Contained Systems (OUC), ref. 814.912**

The Ordinance on handling organisms in contained systems is intended to protect human beings, animals and the environment, as well as biological diversity and its sustainable use, from hazards or harm caused by handling organisms, their metabolic products and wastes in contained systems. It regulates the handling of organisms, in particular genetically modified, pathogenic or alien organisms, in contained systems.

It also indicates that the management of biological wastes must be organized by the BioSafety Officer as part of its program of biological safety. This one has to ensure that the measures are respected, especially for:

- Inactivation and decontamination methods
- Collection and elimination of liquid and solid wastes

In order to assess the risk determined, organisms must be allocated to one of the following groups

- Group 1: organisms whose occurrence presents no risk or a negligible risk
- Group 2: organisms whose occurrence presents a low risk
- Group 3: organisms whose occurrence presents a moderate risk
- Group 4: organisms whose occurrence presents a high risk

Also in order to assess the risk, the planned activity must be allocated to one of the following classes:

- Class 1: activities with no risk or a negligible risk
- Class 2: activities with a low risk
- Class 3: activities with a moderate risk
- Class 4: activities with a high risk

LEGISLATION CONCERNING THE DISPOSAL OF RADIOACTIVE WASTE

- **Summary of the Radiological Protection Act (LRaP), ref. 814.50**

The purpose of this Act is to protect people and the environment against dangers from ionizing radiation.

The Act applies to all activities, installations, events and situations that may involve an ionizing radiation hazard, and in particular to;

- the handling of radioactive substances and of installations, equipment and articles containing radioactive substances or capable of emitting ionizing radiation;
- events that may lead to an increase in environmental radioactivity.

The term “handling” covers extraction, manufacturing, processing, distribution, installation, use, storage, transport, disposal, import, export and transit, and any other form of transfer to a third party.

Only duly qualified persons shall be permitted to carry out activities that may involve an ionizing radiation hazard. The licence holder or the persons in charge of an enterprise are responsible for ensuring compliance with the radiological protection regulations. For this purpose, they are required to appoint an appropriate number of experts and to provide them with the necessary powers and resources. All persons working in an enterprise are required to support the management and the experts with regard to radiological protection measures.

In relation to radioactive waste, the Act indicates that:

- radioactive waste emans radioactive substances or radioactively contaminated materials which are not reused;
- radioactive substances are to be handled in such a way that as little radioactive waste as possible is generated;
- radioactive waste arising in Switzerland must, as a general rule, be disposed of in this country.

On-site, radioactive waste must be handled and stored in such a way as to minimize releases of radioactive substances to the environment.

The Federal Coucil shall specify the conditions under which low-level radioactive waste may be discharged to the environment. Radioactive waste that is not to be discharged to the environment must be suitably retained or securely contained, possibly in solidified form, collected and stored at a site approved by the supervisory authority while awaiting surrender or export.

- **Summary of the Radiological Protection Ordinance (ORaP), ref. 814.501**

The Radiological Protection Ordinance dictaminates that people handling ionizing radiations must undergo radiological protection training and continuing education in line with their activities and responsibility.

The training must ensure that such persons:

- are familiar with the basic rules of radiological protection;
- learn appropriate working methods;
- can apply the radiological regulations relevant to the activity concerned;
- are aware of the risks of radiation exposure which may arise from malpractice;
- are aware of the health risks involved in working with ionizing radiation.

As introduced in the Radiological Protection Act, experts must demonstrably have undergone training in radiological protection, including an examination, which is appropriate to their activities and responsibilities and recognized by the supervisor authority, and have knowledge of radiological protection legislation.

In relation to radioactive waste, the Ordinance states that it may only be discharged to the environment with a license and under the supervision of the license holder. Only low-level radioactive waste may be discharged to the environment.

Waste exclusively containing radionuclides with a half-life of 60 days or less must be stored at the sites where it arises until its activity is lower than its Exemption Limit (EL). The activity must be verified in an appropriate manner immediately prior to disposal of the waste. The license holder must ensure that labels, hazards symbols or other markings drawing attention to radioactivity are removed after the activity has decayed and before the material is disposed of as inactive waste.

Radioactive waste not arising as a result of the use of nuclear energy must be surrendered, following any treatment that may be required, to the federal collection centre, the Paul Scherrer Institute (PSI). The PSI shall take receipt of radioactive waste subject to mandatory surrender and be responsible for stacking, treatment and interim storage.

4.2. GENERAL INFORMATION AND ORGANIZATION OF THE EPFL

4.2.1. INFORMATION ABOUT THE EPFL

The EPFL is one of the two Swiss Federal Institutes of Technology. It has the status of National School since 1969. Since then, the school has grown in many dimensions and has become one of the most famous European institutions of science and technology. The EPFL has three core missions: training, research and technology transfer.

EPFL is located in Lausanne in Switzerland. Its main campus brigns together over 11.000 persons, students, reserchers and staff. Daily interactions amongts students, researchers and entrepreneurs on the campus give rise to new scientific, technological and architectural projects.

With over 350 laboratories and reserch groups, EPFL is one of Europe's most innovative and productive scientific institutions. The School's promotes trans-disciplinary research and partnerships with other institutions. It continuously combines fundamental research and egineering.

The EPFL is composed of 5 Schools, 2 Colleges, 1 Transdisciplinary Entity, 24 Institutes and more than 340 laboratories. There are almost 10.000 students of over 125 nationalities and about 5.500 staff members.

Faculties of the EPFL are shown in the Table 4.1 below:

Table 4.1. Faculties of the EPFL and its subjects of study

FACULTIES	SUBJECTS OF STUDY
Architecture, Civil and Environmental Engineering (ENAC)	Architecture Civil Engineering Urban Planning
Computer and Communication Sciences (IC)	Computer Science Communication Systems
College of Humanities (CDH)	Human and Cultural Studies Area and Cultural Studies
Basic Sciences (SB)	Chemistry Mathematics Physics
Life Sciences (SV)	Bioengineering Global Health Cancer Neuroscience Brain Mind & Blue Brain

Engineering (STI)	Electrical Engineering Mechanical Engineering Materials Science and Engineering Microengineering Bioengineering
Management of Technology (CDM)	Management of Technology Technology and Public Policy Financial Engineering

4.2.2. FACULTY OF BASIC SCIENCES

The Faculty of Basic Sciences is responsible for teaching and research in chemistry, mathematics, physics and related domains. A growing emphasis has been developing in fields at the interface between traditional disciplines, both within and outside of the School. The interaction with the Faculty of Life Sciences is particularly strong, as evidenced by jointly appointed professors, collaborative projects and shared infrastructure.

Table 4.2 represents the subject of study of the institutes of the FSB:

Table 4.2. Subject of study of the Insitutes of the FSB

SUBJECT OF STUDY	INSTITUTE
Chemistry	Institute of Chemical Sciences and Engineering (ISIC)
Mathematics	Mathematics Institute of Computational Science and Engineering (MATHICSE) Mathematics Institute for Analysis and Applications (MATHAA) Mathematics Institute for Geometry and Applications (MATHGEOM)
Physics	Institute of Physics of Energy and Particles (IPEP) Institute of Condensed Matter Physics (ICMP) Institute of the Physics of Biological Systems (IPSB) Institute of Theoretical Physics (ITP)

4.2.3. OCCUPATIONAL SAFETY AND HEALTH SERVICE

The Occupational Safety and Health Service (SB-SST) is a support for researchers and students of the School of Basic Sciences (SB) as well as for the hosts in the building. The Faculty of Basic Sciences decided to create this service in order to implement management as regards Occupational Safety and Health. The objectives of the SB-SST aim to the daily involvement of each individual as regards SST by setting means for prevention such as support, training and inspections as to the program MICE **[3]**. Figure 4.2 below shows which are the four components of the MICE concept:

M anagement	-	organization of safety means
I nformation	-	and basic complementary training
C ontrol	-	laboratory visits, audits, danger detection
E mergency	-	logic support in case of incidents, specialists' contribution

Figure 4.2. Schema of the program MICE

The person in charge of the SST Service (MER Dr. Thierry Meyer) has a delegation of responsibility from the Faculty of Basic Sciences, and therefore authority as regards to occupational safety and health on the persons in charge of institutes and units.

ORGANISATION OF THE SB-SST

The Occupational Safety and Health Service (SB-SST) was created to support institutes, centres sections and research units of the FSB as well as its collaborators in their tasks related to health and safety.

The SB-SST is directly in contact with the FSB institutes, laboratories and collaborators through the building supervisors and the safety delegates. The SB-SST also cooperates with other EPFL services, mainly the DSPS (Safety, Prevention and Health Domain) and the DII (Real State and Infrastructure Department), in order to implement protective and precautionary measures adapted to each laboratory. The Figure 4.3 below represents how SB-SST is organised:

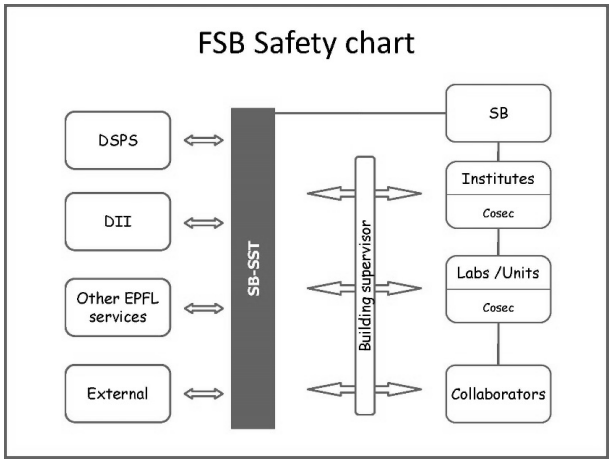


Figure 4.3. SB-SST organisation

As it can be seen below, the responsibilities of both the Supervisor and the Safety Delegate of each unit are thoroughly specified by the EPFL **[4]**:

Responsibilities of the unit's Supervisor

In his unit, the professor or head of service sets up an organisation capable of:

- ensuring the good working practices recognised in his/ her domain;
- improving safety conditions by systematic risk identification;
- taking into account the development of safety-related knowledge and practices;
- establishing specific safety instructions and practical safety training linked with his/ her unit's activity;
- encouraging the commitment of colleagues who are members of the fire-fighting and first aid teams. This especially involves permitting them to attend training sessions and intervene in the event of an emergency (this activity forms an integral part of their job description).

In the absence of any clearly defined delegation, the professor assumes the tasks of the COSEC.

Missions of the unit's Safety Delegate (COSEC)

Under the direct supervision of the unit's Supervisor, the unit's Safety Delegate (COSEC) works closely with the SB-SST and the DSPS. The responsibilities of the COSEC include functions related to the unit's activity. These may be extended to include several units, an institute, a building, centres or other particular infrastructures and functions in accordance with the list of basic tasks.

Basic tasks of the unit's Safety Delegate (COSEC)

1. Contact person for occupational health and safety in his unit(s).

2. Organise training and information concerning occupational health and safety for new employees and guests of the unit.

3. Distribute safety information among the unit's staff.

4. Pass on safety information concerning the unit to the School Safety Coordinator (CSF).

5. Inform the Head of unit/section and the CSF regarding safety-related problems and incidents.

6. Be acquainted with alarm systems, building evacuation procedures and emergency equipment (extinguisher, safety shower, eyewash station, etc.) and inform the unit's staff.

7. Coordinate the creation and updating of «door safety datasheets» for the safety of his unit(s).

8. Check periodically the presence and state of personal protective equipment (first aid kit, masks, gloves, safety glasses, eyewash station, etc.) and the unit's emergency equipment and organise its maintenance with the Safety, Prevention and Health Domain (DSPS).

9. Ensure that safety regulations are complied with within the unit and in the event of non-compliance consult the CSF.

10. Check that modifications requested concerning safety for the unit are implemented.

11. Organise the announcement of events and participate in meetings and specific training sessions organised by the CSF or DSPS.

12. Impose emergency measures to eliminate any imminent danger (e.g. stop an experiment) of which he is aware.

SB-SST ACTIVITIES

In order to manage safety and health at work, the SB-SST team is involved in various activities:

- securing the workplace to prevent accidents
- organisation of specific courses to acquaint the collaborators with basic safety rules, specific dangers attached to his or her activities and the behaviour to adopt in case of accident
- laboratory visits to identify the hazards and suggest precautionary measures
- checking that the safety measures are in place and that the safety rules are respected

If there is an accident, the SB-SST analyses the facts and the behaviour of the collaborators directly or indirectly implied, and determines if the precautionary and emergency measures functioned correctly. Complementary measures could be required by the SB-SST if necessary.

4.2.4. CHEMICAL STORES

Chemical stores are essential elements in the EPFL as they maintain a wide range of basic chemicals, solvents, gases and apparatus for chemistry and biochemistry. In addition, chemical stores are responsible for safety equipment, courier services, and ordering chemicals and equipment. What is more, special waste collecting points at the EPFL are also found in the chemical stores.

The FSB has two chemical stores, one for the CH and PH buildings and one for the BCH building. All special waste from FSB laboratories must be collected at one of these stores. It is the producer's responsibility to only bring to the store waste that has been thoroughly deactivated and neutralized (explosives, organometallic compounds, etc.) and that does not present any risk for storage, transport and treatment. Both stores are equipped with locals to storage special waste in the most secure way. They have also all the material that can be needed to correctly label it.

4.3. SPECIAL WASTE'S LIFECYCLE

It is essential for the producers of special waste to have in mind that there is a long process from the generation of waste until its disposal. This long process involves a large number of people. That is why it is essential to treat the waste, from the very beginning, carefully and with respect to its associated danger. It is also clear that the better the waste is treated in all steps, the easier it will be to limit its impact on the environment.

Over their life-time, wastes generated in the laboratories of the Faculty of Basic Sciences of the EPFL go through different stages. Figure 4.4 below gives an overview of this lifecycle:

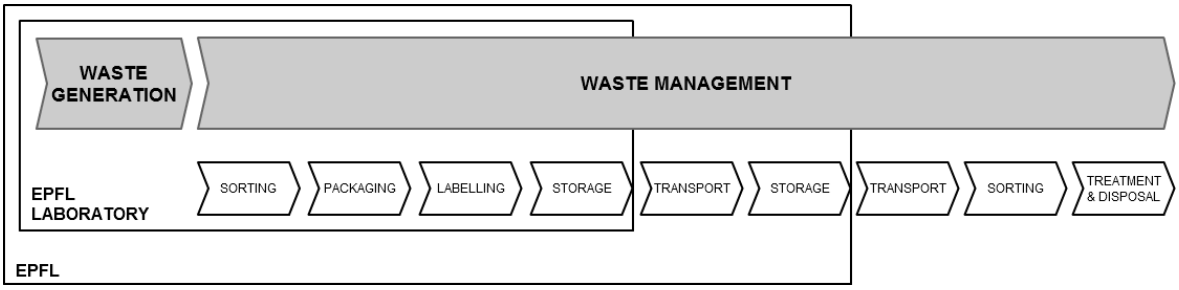


Figure 4.4. Schema of the lifecycle of the special waste that is generated in the FSB laboratories

4.3.1. WASTE GENERATION

According to Swiss law, in Switzerland the producer is responsible for his/ her wastes until the end of the recycling process or destruction. He is not authorized to dilute them before elimination unless it is for safety reasons. In addition, any company providing special waste to another operating site is considered as a "Remitting Company" and is subjected to well-defined rules.

The safety delegate (COSEC) of the unit is responsible for checking that the rules are carefully respected. Every special waste must be eliminated no later than two months after its production. Material contaminated by either chemicals or biologics is also considered as special waste.

At the FSB, special waste is mainly generated in the laboratories used for research purposes, as its activity is very high. Nevertheless, some of it is also generated in the laboratories used for educational purposes.

Special waste that is generated at the EPFL is classified as:

- chemical,
- biological and/ or
- radioactive waste.

4.3.2. SORTING AND PACKAGING

In the FSB laboratories the principles to follow start with sorting out at the source so that the waste is assigned as early as possible. To the possible extent, substances have to be kept in their original packaging. The container must be adapted in terms of size and material to avoid incompatibilities.

Waste must be properly and neatly labelled, and then brought to the respective storage areas. Chemical incompatibilities must be respected. All biological wastes are deactivated either by chemical deactivation or by autoclaving.

To secure the packaging, this latter must comply with the following indications:

- In order to obtain the adapted conditioning a distinction has to be made between special waste (chemical, biological, radioactive) and contaminated material waste. Solids must also be distinguished from liquids.
- Only waste containers provided by the stores will be accepted.
- Containers must be made of materials which are chemically and mechanically resistant to the waste and with size adapted to the disposal stream (two months maximum).
- The colour code (Table 4.3) shall be respected:

Table 4.3. Container's colour code

			
Green bottles for special waste	White can for aqueous solutions or containing acetonitrile	Blue can for halogenated solvents	Yellow can for non-halogenated solvents

- These containers should be filled up to 80% maximum to avoid splashing, spilling and overpressure.
- Reuse of used containers for waste is prohibited except for organic solvents which will be spilled in to recovery containers.
- Each unit's individual wastes will not be mixed. They will remain in their original container.
- Unless specific recommendation, liquids must be poured into plastic containers which are sealed with a secured cap (that is to say, equipped with a pressure relief valve) (Figure 4.5).

Figure 4.5. Security cap equipped with a pressure relief valve

The use of glass containers in prohibited unless the liquid waste to be removed is still in its original glass container, or if there is an incompatibility issue. This can be the case of strong acids such as nitric acid or still sulphuric acid at high concentrations (> 60%). It is also forbidden to use food packaging whatever the chemical, waste or not.

4.3.3. LABELLING

Each waste that is generated in the EPFL must be identified by the producer with a label indicating:

- the content
- the OMoD code
- the hazard(s) pictogram(s)
- the name of the producer
- the group to which it belongs
- the date of the waste's generation

Ideally, the appropriate container will be prepared in advance with its label. Blank or pre-filled labels are available at the stores (Figure 4.6). By default, each label must contain at least one pictogram. To avoid misinterpretation, it is forbidden to write acronyms on labels. It is only after that that the container can be transported to the chemical store.

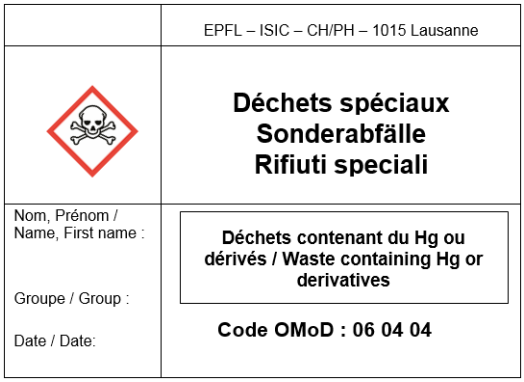


Figure 4.6. a) Labels available in CH/ PH store, b) Pre-filled sample label

4.3.4. STORAGE IN THE LABORATORY

After being sorted, packaged and labelled, special waste is stored in the laboratory. Waste can be stored in it during maximum two month. Specifically, cans with liquid waste must be stored in retention trays (even if they are in fridges or freezers), and all organic solvents must be put in ventilated places and keep tightly closed to prevent evaporation of volatile. In particular, flammable waste must be put in ventilated and fireproof cabinets, and toxic waste in ventilated and locked cabinets.

Figure 4.7 shows the correct places were special waste can be stored:

Figure 4.7. a) Closed cans in retention trays in a ventilated place, b) Ventilated and fireproof cabinet

Pending the collection of waste, it is essential to respect the safety requirements by identifying the containers, respecting the place where they have to be stored and assessing the potential risks. In all cases, learning about storage incompatibilities between products and being ensured that the containers are compatible with the contents is essential. This is also vital for safe transportation of the waste until its final destruction step.

4.3.5. TRANSPORT TO THE STORE

The FSB collaborators must transport the generated waste from the laboratory to the corresponding store in a completely safe manner. In fact, the risks of carrying not well-sealed bottles, tripping or unexpected door openings are not negligible. That is why, baskets, buckets or carts available in stores must be used for all transports (Figure 4.8).

Figure 4.8. Containers and cart available for the transport of special wastes

4.3.6. STORAGE IN THE STORE

For security reasons, auto-reactive or unstable waste must be deactivated in the laboratory where they were produced. Only after that they can be brought to the stores.

In laboratories, waste solvents are poured in special containers according to their nature. Once these filled, they are brought to the store and are emptied in suitable recovery containers. The nature and quantities of special waste must be reported in the dedicated solvent sheet at the stores. Special waste, other than solvents, being brought to the store has to be overhanded to the person in charge.

The personal of the store latter collect these wastes and are the only ones authorized to hand them over to external companies for destruction. Before the transport company arrives, the responsible of the store groups the waste containers according to their compatibility, and puts them into pallets.

4.3.7. TRANSPORT TO THE SORTING COMPANY

The transport of special waste is a delicate step that requires strict protocols set by national and international agreements (Federal Ordinance and European Agreement). Theses strict rules aim to prevent the maximum risk of accidents, and its consequences for the environment and the population.

As it is regulated in Swiss law, in order to return special waste, the remitting company (in this case, the EPFL) is required to use tracking documents and to write on them all the information required. The remitting company is required to provide the transporter and the disposal company the information about the origin, the composition and the properties of the waste if these details are necessary to protect the environment, the staff or the facilities of the disposal company, or to eliminate waste in an environmentally friendly way.

Those tracking documents are essential for the safe transportation of the waste until its final destruction step, as they describe the name of the remitting company, its address, the code of the waste according to the legislation, the amount of waste, the date of shipment, the name and address of the disposal company, and the name of the transporting company among others.

Figure 4.9 below shows an example of a special waste tracking document generated at the EPFL:

1. REMITTING COMPANY:

any company or public utility that delivers its waste to another operating site or a third party.

- **name**
- **adress**
- **OMoD's identification number**
- **telephone number**

2. DESCRIPTION OF THE WASTE:

according to the DETEC Ordinance concerning the lists of wastes' movements (LMoD, ref. 814.610.1), and clarifications to ensure a safe disposal and to protect the environment if necessary.

- **description according to the wastes' list**
- **OMoD code**
- **weight**
- **number of packages**
- **shipping date**
- **signature of the remitting company**

3. DISPOSAL COMPANY:

any company that receives waste for disposal and any collection station operated by the township, by the municipality or by an individual they have mandated.

- **name**
- **adress**
- **OMoD's identification number**
- **contact person**
- **telephone number**

4. TRANSPORTER:

- **name**
- **adress**
- **type of transport:**
  1. road
  2. rail
  3. waterway
  4. combined transport
- **delivery date**
- **registration number of the road vehicle**
- **signature of the transporter**

Number and barcode of the tracking document

DOCUMENT DE SUIVI POUR LES MOUVEMENTS DE DÉCHETS SPÉCIAUX EN SUISSE

N°: AA01745082

1 ENTREPRISE REMETTANTE

Nom: EPFL

Adresse: PL- DII Intendance
Bâtiment CE 1 017
Station 10
1015 Lausanne

N° d'identification OMoD: 5 6 3 5 0 0 0 1 1

Personne de contact: Jacques Gremaud

N° tél.: 021 693 76 57

2 DESCRIPTION DES DÉCHETS

Description selon la liste des déchets, et précisions si elles sont nécessaires pour assurer la sécurité de l'élimination et pour protéger l'en

[ds] Solvants, liquides de lavage et liqueurs mères organiques halogénés (teneur en chlore > 2 %)

Code des déchets: 0 7 0 1 0 3

Poids: 60 kg

Quantité:[1)2)] litres

Transport de grandes quantités:[3)] oui ☐

Type d'emballage:[1)4)] 2 bidons de 25l

Marchandises dangereuses selon ADR/SDR ou RID/RSD ☒oui ☐non

Remarques (p.ex. précisions relatives à l'ADR/SDR):[1)]

Nombre d'emballages (colis): 2

Date d'expédition: 04.12.2013

Signature de l'entreprise remettante:

3 ENTREPRISE D'ELIMINATION

Nom: Cridec SA

Adresse: ZI Les Portettes
1312 Eclépens

N° d'identification OMoD: 5 4 8 2 0 0 0 0 1

Personne de contact: Alexandre Humair

N° tél.: 0218660300

Poids: kg

Signature de l'entreprise d'élimination:
(après contrôle et réception des déchets)

Date de réception des déchet

Procédé d'élimination:
(voir au verso)

Date de livraison des déchets:

4 TRANSPORTEUR (Nom, adresse)

UNIL
1015 Lausanne

Type de transport:[5)] 1

Date de livraison: 04.12.2013

Numéro d'immatriculation du véhicule routier: VD 3512

Signature du transporteur:

5 TRANSBORDEMENT ET TRANSPORT PAR UN CENTRE LOGISTIQUE (ann. 1, ch. 1.2, let. b, OMoD)

2. Transporteur (nom, adresse):	3. Transporteur (nom, adresse):	Centre logistique (nom, adresse):
Type de transport:[5)]	Type de tranport:[5)]	
Date de livraison:	Date de livraison:	Date de livraison:
Immatriculation du véhicule:	Immatriculation du véhicule:	Date du réacheminement
Signature:	Signature:	

Autres transporteurs ou autres centres logistiques ? oui ☐
(Joindre une liste comprenant les indications les concernant, ainsi que leur signature)

1) A ne remplir que si l'on n'utilise pas le document de bord prévu par les prescriptions sur les marchandises dangereuses
2) Indication supplémentaire en litres, si les prescriptions sur la marchandises dangereuses l'exigent
3) Utilisation restreinte selon l'annexe 1, ch. 2.1, let. b, OMoD
4) Désignation des colis selon les prescriptions sur les marchandises dangereuses
5) 1 Route 2 Rail 3 Voie navigable 4 Transport combiné

Version: 3 A conserver par l'entreprise remettante

Figure 4.9. Example of a special waste tracking document

4.3.8. SORTING

Chemical waste produced at the EPFL is assigned to a company specialized in the treatment and the recycling of special waste: CRIDEC SA from Eclépens. Otherwise, radioactive waste that cannot be neutralized on site is handed out to the Paul Scherrer Institute (PSI) in Villigen, the Swiss center for the retreatment of this kind of wastes.

SORTING AT CRIDEC

CRIDEC SA is headquartered in Eclépens, in Vaud canton. Since 1986, the company recovers almost all special waste defined in the list of the Ordinance on the Movement of Wastes (OMoD). Only radioactive, explosive and infectious waste is not supported. Between the moment when they are identified as special wastes and the moment when they are eliminated or valued, wastes that are supported by CRIDEC are the subject of a constant attention and vigilance. Thus, according to their characteristics, these wastes can be recycled, distilled, regenerated, stabilized, neutralized or used as fuel or as a substitute.

Once it arrives to CRIDEC, collaborators have to collect, identify (at their laboratory of analysis) and sort special waste. Then it is grouped and conditioned to allow its valuation and its final processing. In the laboratory, several tests are performed in order to check that the waste is correctly identified in its label. Some unknown wastes may also be received, and that is why it is extremely important to perform these tests properly.

These tests are executed following a rank of priorities. First, the most important thing is the security of the laboratory's staff. That is why CRIDEC does not accept any infectious, radioactive or explosive waste. Then, the next priority is the preservation of the environment. For that reason CRIDEC's aim is to valorize the maximum of waste that is possible. It is evident that the financial part is also important, but always after the former ones.

Figure 4.10 shows waste before and after being sorted at CRIDEC :

Figure 4.10. Waste before and after being sorted at CRIDEC

SORTING AT PSI

The Paul Scherrer Institute (PSI) **[5]** is the largest national research centre in Switzerland. Apart from doing research, PSI manages some of the wastes from medicine, industry, and research throughout Switzerland on behalf of the government. The EPFL charges PSI with the collection, treatment and interim storage of their radiological waste in accordance with the Swiss legislation on radiological protection and the ordinance on radioactive waste. Waste collection is organized, including the inspection of the waste before shipment and its preparation for shipment according to these rules. Waste producers have to declare their waste in advance. Waste is conditioned at PSI and, after the final conditioning, waste packages are stored on-site in a dedicated interim storage facility.

4.3.9. TREATMENT AND DISPOSAL

TREATMENT AND DISPOSAL AT CRIDEC

One of the most common questions asked about waste in general, and special waste in particular, concerns to its fate once delivered to collection centres. In order to avoid any economic and energetic loss, centres as CRIDEC must develop techniques and provide infrastructures to valorise the residual qualities of these wastes.

CRIDEC's most used valorisation system is the transformation of organic waste to fuel for the cement kilns, mainly those of Holcim Suisse SA, CRIDEC's main energetic partner. This production of solid substitution fuel is a mix of soiled absorbents, oils, glues, varnishes and inks with a carbon support. This solid substitution fuel is used as a fuel in the Holcim cement industry. As this industry is very near to CRIDEC's company, the ecological impact is reduced.

Once these organic wastes have been burned, a part from energy, also ash is obtained. For each tone of waste about 300 kg of ash are generated. After cleaning it, these are reduced to 30 kg. Then, the ash is mixed with cement and it is poured into a sealed discharge. Every day, CRIDEC's staff takes a litter of water within and outside the site to control that there is no filtering.

Some special waste cannot be valued. In these cases, High Temperature Incineration (HTI) is proven a reliable solution for its management. A typical special waste high temperature incinerator consists of a rotatory kiln (primary combustion chamber), an afterburner (secondary combustion chamber), connected to an air pollution control system, all of which are controlled and monitored.

The HTI process can eliminate many different types of wastes in any forms, including:

- solids (powder, pastes, resins, sludge)
- liquids (aqueous, solvent, slurry)
- packaged wastes (boxes, tubs)
- bulk wastes
- laboratory chemicals
- reactive wastes

TREATMENT AND DISPOSAL AT PSI

Each waste collection is an individual task because there is little consistency among wastes with respect to the nuclide and material composition. Waste has to be sorted by the producers into types and classes. The largest quantities are delivered by industry and are well defined with respect to their material properties. Smaller quantities, but with complex material properties, are passed from the universities to PSI. In total, the waste can contain over fifteen different nuclides.

Based on the declaration of the producers and the results of an inspection, waste is sorted at PSI into groups for further treatment. After being sorted or preconditioned, waste is treated in the waste management facilities when needed. The majority of waste is solidified with cement or imbedded in concrete. Then it is ready to be stored.

Radioactive waste in Switzerland is stored in deep geological repositories. The principal objective of these repositories is to protect human and the environment both in the short term and in the long term. Experts throughout the world agree that storage in rock layers deep below the earth's surface is the only way to guarantee safe disposal over the necessary lengthy period of time. In Switzerland,

long-term safety will be guaranteed by passive barriers. Monitoring and recoverability are foreseen in the plans for deep geological repositories.

In contrast to an end-storage facility, the deep geological repository concept embodies the principle of recoverability. Deep geological repositories have to guarantee permanent protection for humans and the environment, but they also have to meet the requirement of recoverability imposed by society.

4.4. AVAILABLE TOOLS

During the last years the SB-SST group has developed some very useful tools related to waste management that are of great interest for all the collaborators and students that work in the FSB laboratories. Some of these tools are also used by other members of the EPFL. These many tools aim to help managing the waste that is generated in the FSB laboratories in the most effective and safe way. Below there is a description of each one of these tools.

4.4.1. SAFETY MANUAL

This manual addresses the basic questions related to hazards encountered in the various activities in the scientific and technical environment of the FSB and their safety answers. It aims to encourage the reader to adapt his/ her behaviour according to the dangers to which he/ she is confronted. It also describes the principal existing operational rules in the Faculty.

It is published in bilingual mode, French and English, to comply with the majority of the languages spoken on the EPFL site, and it is available in all FSB laboratories and in the SB-SST website.

The chapters of the manual that are related to the project are:

- Chapter 6: Working with chemical substances
- Chapter 7: Working with biomaterials – Biosafety
- Chapter 8: Working with nanoobjects

And specially:

- Chapter 16: Disposal of special wastes

Even if it is a very useful tool, it has to be taken in account that it was written in the year 2009 and some of the information that contains has become outdated.

4.4.2. SPECIAL WASTES' MANAGEMENT FLOWCHART

The "Management of special wastes at the FSB" chart is a tool that helps to classify the different categories of chemical wastes. It describes how to separate the different types of chemical wastes according to Swiss law. This can be extremely helpful for EPFL collaborators as in Switzerland the

waste producer is responsible and avoids mixing different wastes, and must sort them according to their physicochemical properties and toxicity and according to the law.

There is minimum one “Management of special wastes at the FSB” chart in every laboratory of the FSB. These ones can be printed in DIN A4, DIN A3 and/ or DIN A2, depending on the users’ preference. This chart is also available on-line at the SB-SST webpage.

4.4.3. SB-SST WEBPAGE

A large amount of useful information can be found in the SB-SST webpage such as a brief explanation of the different types of existing hazards and the prevention that must be taken against them, information about the type of wastes that are produced at the FSB and how to manage them and their incompatibilities, information about the existing training programs, a glove selection guide for protection against chemicals, and publications related to safety and health, among others.

4.4.4. SAFETY TRAINING

Introductory safety training is compulsory for every collaborator of the FSB. This training addresses the general safety information and the use of fire extinguishers. A part from this training, free and optional complementary trainings can also be done. There is a course about chemical hazards and one about biological hazards, among others. Both of them contain an explanation about waste management.

There is also a specific course about special waste management at the FSB, which develops the basics rules concerning waste, the procedures applied at the FSB and the correct way to use the “Management of special wastes at the FSB” chart. These trainings are very useful to deepen in this issue and to resolve any existing doubt. This is possible because these courses are conducted periodically and in small groups.

4.4.5. FEEDBACK FROM VISITS

The SB-SST group is particularly concerned with the care taken in running the laboratories of the Faculty. It is well known that risk of accidents increases strongly when, among others:

- the working place is not held with care
- the safety equipment is not worn

- the rooms are encumbered and the ground strewn with obstacles
- products are wrongly stored or labelled
- special waste are kept too long

That is why each laboratory is systematically visited twice a year by the SB-SST team. After each visit a report is issued and sent to the person responsible for the laboratory. This report indicates the elements that have to be corrected. These reports are very useful for collaborators because they indicate, between others, if waste is wrongly stored and/ or labelled, which happens in some occasions.

Table 4.4 and 4.5 and Figure 4.11 and 4.12 show some examples of remarks that have been indicated in the last reports (year 2013 – 2nd round) with indications about some changes that shall be done in the laboratories in order to improve waste management and the security of the collaborators.

REMARKS CONCERNING STORAGE

Table 4.4. Examples of remarks concerning storage

CATEGORY	MISTAKE	CORRECTIVE MEASURE
Retention trays	Absents	Put the waste into retention trays
Bins	Not clear	Bins are overfilled
Bins	Waste not properly stored	Different bins for soiled glass and for other soiled materials
Storage period	Full container	Empty the solvents container
Storage location	Non-ventilated place	Put the container into a ventilated cabinet an into a retention tray

Figure 4.11. a) Overfilled bin, b) Soiled glass bin with papers in it, c) Flasks without a retention tray

REMARKS CONCERNING LABELLING

Table 4.5. Examples of remarks concerning labelling

CATEGORY	MISTAKE	CORRECTIVE MEASURE
Labels	Non-readable/ erased	Change the labels
Labels	Absents	Put labels on the flasks
Bins	In bad conditions	Redo the labels on the bins for waste

Figure 4.12. Non-readable and missing labels

It may seem that what these visits expect to change are only little details without much relevance. Nevertheless, these improvements can prevent some accidents to happen in the laboratory, and also latter, during the transport and the final treatment of the waste.

Correctly labelling waste, for example, can avoid incompatible wastes getting mixed, fact that would generate undesired reactions. These reactions can lead to:

- an explosion or fire due to the creation of a flammable and potentially explosive gas mixture
- poisoning of people due to the vent of a toxic product
- pollution of the environment due to the flow of hazardous material
- property damages (deformation or rupture due to overpressure, accelerated corrosion,…)

The rule that states that all cans with liquid waste must be stored in retention trays is essential to prevent the contact between the waste and the collaborator in the case of a spillage or a leakage. What is more, avoiding overfilling the bins reduces the possibility of tripping.

4.4.6. FEEDBACK FROM ACCIDENTS

If there is an accident the SB-SST experts analyse the facts and the behaviour of the collaborators directly and indirectly implied and determine if the precautionary and emergency measures functioned correctly. With all this information a report is written. This report includes, among others, an analysis by the SB-SST team which includes an approximate assessment of the property damage and longer-term measures that have to be taken, and some reminders about what should have been done to avoid the accident. These reminders are extremely useful for all collaborators, not only for the ones that had the accident. That is why feedback reports from accidents at the FSB are available for everyone.

EXAMPLE OF FEEDBACK GIVEN AFTER AN ACCIDENT

An example of the analysis of a real accident that could have been extremely harmful is developed below:

- **Description of the event**

Chemical waste composed by 1 litter of mixture of sulphuric acid and hydrogen peroxide packaged in a glass bottle and then in a cardboard box filled with absorbent and porexpan chips, prepared and disposed in a waiting zone before being sent to the treatment plant has had, during the weekend of the 26 to the 28 May 2012, a chemical reaction that caused, inside the cardboard box, an explosion of the glass bottle, which caused a leak of acid and stained the floor of the room CH F0 498.

- **Property damages**

Dirty and soiled floor by the acid.

- **Immediate measures**

After discovering this incident immediate action had been taken in order to absorb the liquid acid and put the bottles that were in the same cardboard box in a safe place after having checked their condition. Everything has returned to normal after a deep cleaning; only some traces still remain on the ground that was attacked by the acid.

- **Analysis by the SB-SST team**

Approximate assessment of property damage:

In the CH F0 498 storage room, the explosion and then the flow of a piranha solution (a mixture of hydrogen peroxide and sulphuric acid) stained a wood transport pallet and the ground underneath. Despite cleaning, ground will remain marked at this place.

Longer-term measures:

- Do not bring unstable mixtures to the store; neutralize them in the laboratory where were created. The responsible collaborator was asked to come and neutralize the second bottle of unstable mixture in the chapel of the store.
- Piranha solution must be prepared gradually as needed. If it has to be stored, it must be poured into glass bottles (appropriate materials than can contain this solution). These bottles must be sealed with a secured cap equipped with a pressure relief valve and be stored in ventilated areas where there are no other substances.
- The person bringing waste to the store must ensure that the label on the container describes the waste (OMoD code included) and the name of the producer is therein too.

Analysis:

A collaborator has prepared two glass bottles of one litter each filled with a highly reactive solution: the piranha solution (a mixture of hydrogen peroxide and sulphuric acid that generate peroxymonosulphuric acid).

$$\mathrm{H_2SO_4 + H_2O_2 \rightarrow H_2SO_5 + H_2O} \quad \textbf{(3.1)}$$

This highly exothermic preparation generates a big amount of energy that easily brings the solution up to 120 ºC and therefore to boil, generating gas emissions. Thinking that the mixture was not highly reactive any more, the two bottles were taken to the CH/ PH store in order to be sent to the treatment plant. The collaborator stated that the plastic bottle caps should not be hermetically screwed in case of some gas emissions would still be generated. After one week the bottles were screwed back to be packed in one cardboard box ready to be shipped. A week later, as a result of the pressure that was created inside, one of the two bottles exploded during the weekend (Figure 4.13-a). This resulted in the flow of the solution outside the cardboard box. It has been removed by an

absorbent for acids (Figure 4.13-b) and then the floor has been cleaned. Due to its corrosive nature, the solution has definitely marked one part of the ground of the CH F0 498 room (Figure 4.13-c). Waiting for the treatment, the second bottle was placed in a chapel and its cap was replaced for one with a pressure relief valve. It was by means of the tracking label that it had been possible to trace to the source of the problem and perform an effective intervention.

Figure 4.13. Accident with H_2SO_4 and H_2O_2: a) Bottles and cardboard box, b) Absorption of the acid, c) Final traces

This accident could have been much more harmful than what it was at the end. First, the glass bottle could have exploded while being transported to the store. This could have generated not only property damages, but it could have also harmed the person who brought it to the store, and students, teachers and collaborators who were near him at that moment.

Another possibility would have been that the accident happened during the week, when the store was open. The room of the store where the waste is stored is often frequented by EPFL collaborators, because it is the area where they leave their waste and where they can find all the material available to label them. In addition, store staff is often in the room in order to help them and to control that everything is in order. For that reason, if the explosion would have occurred at that moment, the most probable would have been that one or more people had been affected.

5. IMPROVEMENT OF SPECIAL WASTE'S MANAGEMENT

5.1. INCOMPATIBILITY STUDY

One of the main pillars of the management of special waste is the in-depth knowledge of their incompatibilities with other substances and with the containers that will contain them. Collaborators and students of the FSB of the EPFL have some knowledge about these incompatibilities, and use the information available in the SB-SST website to solve their doubts.

However, there have been several cases of doubts and even some accidents due to waste incompatibility. In addition, during the visits of the laboratories done by the experts of the SB-SST team, it has been detected that some wastes were stored in containers that could, in the medium or long term, degrade.

It is for all these reasons that, both being crucial for the proper management of the waste, and more importantly, for the safety of all the people that interact with it, a section related to all this incompatibilities is included in the project. Besides, a more schematic, simple and visual abstract has also been created in order to make this valuable information available to all the collaborators and students, and to be able to make them aware of the importance that this issue has for their own safety and the one of those who work with them. This deepen research has also been useful to update the information related to incompatibility between chemicals that is available on the SB-SST web site.

5.1.1. INCOMPATIBILITIES BETWEEN CHEMICALS

Incompatible chemicals lead to undesired chemical reactions when mixed. This usually refers to substances that will react to cause an imminent threat to health and safety through an explosion, fire, and/or formation of toxic materials.

Even everyday chemicals have incompatibilities. For example, containers of bleach have a warning not to mix it with ammonia because, when mixed, these substances generate the toxic gas chloramine (NH_2Cl) and hydrazine (N_2H_4), which could cause serious injuries or death.

Description of the reaction:

Bleach decomposes to form hydrochloric acid, which reacts with ammonia to form toxic chloramines fumes.

- Formation of the hydrochloric acid:

$$NaOCl \rightarrow NaOH + HOCl \quad \textbf{(5.1)}$$

$$HOCl \rightarrow HCl + O \quad \textbf{(5.2)}$$

- Then the ammonia and the chlorine gas react to form chloramines, which is released as a vapour:

$$NaOCl + 2HCl \rightarrow Cl_2 + NaCl + H_2O \quad \textbf{(5.3)}$$

$$2NH_3 + Cl_2 \rightarrow 2NH_2Cl \quad \textbf{(5.4)}$$

If ammonia is present in excess (which could or could not be, depending on the mixture) toxic and potentially explosive liquid hydrazine may be formed. While impure hydrazine tends not to explode, it is still toxic, and it can boil and spray hot toxic liquid.

$$2NH_3 + NaOCl \rightarrow N_2H_4 + NaCl + H_2O \quad \textbf{(5.5)}$$

Other examples of incompatibilities include the reaction of alkali metals such as sodium or potassium metal with water. In this case, products are extremely basic sodium or potassium hydroxide (corrosive), hydrogen gas (explosive) and a lot of heat (exothermic reaction). Heat generated is so great that the hydrogen generated will usually ignite.

COMPATIBILITY CLASSIFICATION AND STORAGE RECOMMANDATIONS

There is not a perfect method of determining chemical compatibility. The reasons for this are varied and include:

- Many chemicals belong to more than one hazard class. This can lead to confusion as to which class is appropriate for the chemical in question.

  Examples: Nitric acid is both an acid and an oxidizer; Benzoyl chloride is a combustible liquid, a corrosive, and a lachrymator.

- The hazard class that is most important can change depending on factors such as quantity of material, and other chemicals in the storage area.
- Not all chemicals in a given class are compatible.

Example: Sodium dichloroisocyanurate and calcium hypochlorite are both oxidizers and belong to no other class of chemical, yet the mixing of these two materials can lead to the formation of nitrogen trichloride, a shock sensitive explosive.

- The sheer number of exceptions to any classification scheme prevents listing all of them in a convenient reference table.

Relying solely on compatibility classification schemes might provide false sense of security and it is important that those working with chemicals and those responsible for using and maintaining chemical storage facilities are familiar with the limitations of the classification system and the properties of the materials they are working with.

The following guidelines are provided for the safe storage of special waste in accordance with their hazard classes:

Acids

- Segregate acids from reactive metals such as sodium, potassium, magnesium, etc.
- Segregate oxidizing acids (ex. nitric acid) from organic acids, flammable and combustible materials.
- Segregate acids from chemicals which could generate toxic or flammable gases upon contact, such as sodium cyanide, iron sulphide, etc.
- Segregate acids from bases.

Bases

- Segregate bases from acids, metals, organic peroxides and easily ignitable materials.

Solvents (flammable and halogenated solvents)

- Segregate from oxidizing acids and oxidizers.
- Keep away from any source of ignition (heat, sparks or open flames).

Oxidizers

- Store in a cool, dry place.
- Keep away from combustible and flammable materials.
- Keep away from reducing agents such as zinc, alkali metals, and formic acid.

Water reactive chemicals

- Store in a cool, dry place away from any water source.
- Make certain that a class D fire extinguisher is available in case of fire.

Pyrophoric substance

- Store in a cool, dry place making provisions for an airtight seal.

Peroxide forming chemicals

- Store in airtight containers in a dark, cool, and dry place.
- Periodically test for the presence of peroxides.

Organic peroxides

- Store in area such as a refrigerator where the temperature will remain below the self accelerating decomposition temperature.

Table 5.1 shows combinations of some of the more commonly encountered chemicals that should be avoided **[6]**. Before mixing any chemicals, we should refer to this partial list and the chemicals' SDS (Safety Data Sheet).

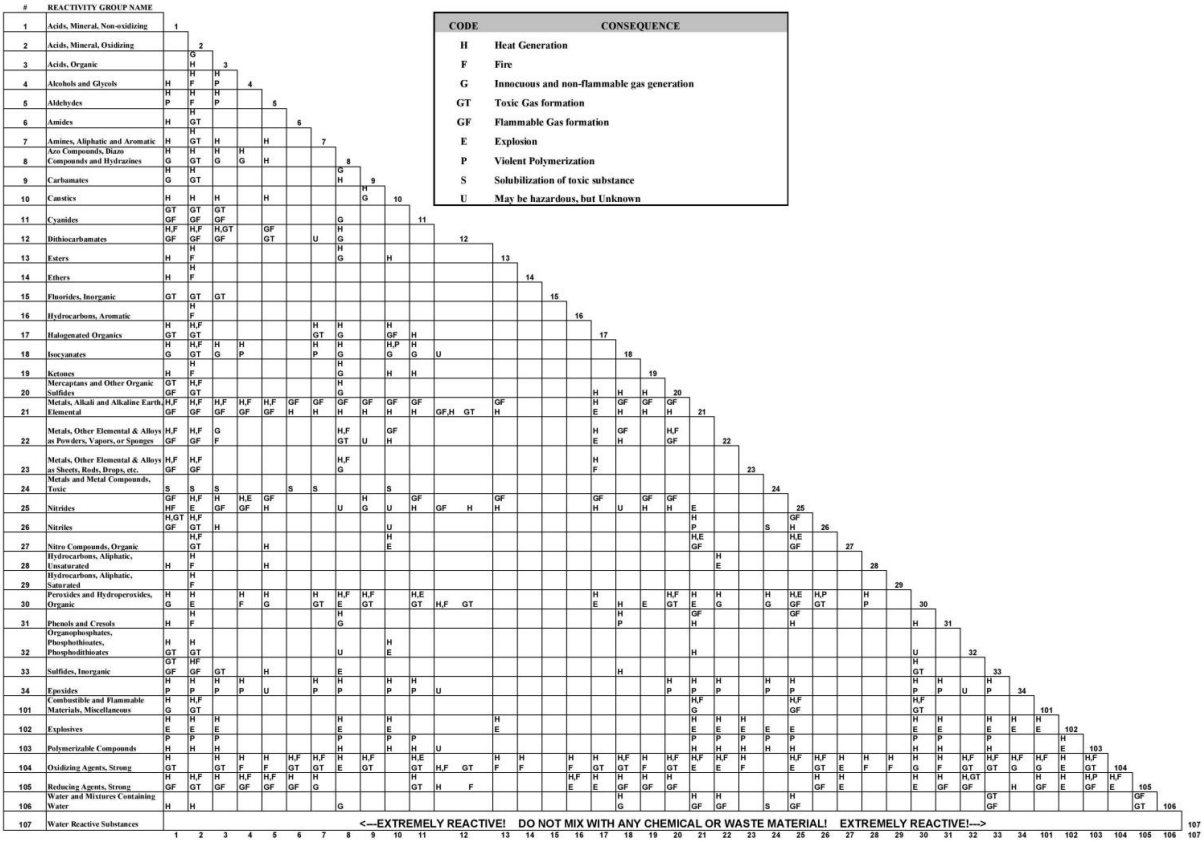
Table 5.1. Incompatibilities between chemical substances

Chemical	Formula	Incompatibility	Kind of incompatible reaction
Acetic acid	$C_2H_4O_2$	CrO_3, $KMnO_4$, H_2O_2	Rapid oxidation
Acetone	C_3H_6O	HNO_3, H_2SO_4	Rapid oxidation
		CrO_3	Rapid oxidation
Acetylene	C_2H_2	Ag^0, Hg^0, Cu^0, Mg^0	Explosive acetylides
		F_2, Cl_2, Br_2, I_2	Rapid oxidation
		O_2, O_3, $(NO)_x$, etc.	Rapid oxidation
Alkali metals	Cs^0, Rb^0, K^0, Na^0, Li^0	Water	Exothermic formation alkaline hydroxide with hydrogen release
		Halogens (F_2, Cl_2, Br_2)	Formation of halide (explosive reaction)
		Alkyl halides (CCl_4, CH_2Cl_2, etc.)	Exothermic reaction
		Carbon dioxide (CO_2)	Combustion
		Sulphur (S_8)	Exothermic reaction
Ammonia	NH_3OH	Silver nitrate, silver oxide, etc.	Formation of explosive silver nitride (AgN_3)
		Bromine	Formation of explosive nitrogen tribromide

		Alkyl sulphates (dimethyl-, diethyl-)	Extremely exothermic reaction
Bromine	Br_2	Unsaturated compounds (olefins, etc.)	Exothermic bromination
		Aldehydes, ketones	Exothermic bromination
		Esters (diethyl oxides)	Combustion
		Metals (Al^0, Hg^0, Ti^0, etc.)	Exothermic formation of bromide
		Ammonia, ammonium hydroxide	Formation of explosive nitrogen tribromide
Chlorine	Cl_2	Organic materials (rubber, etc.)	Exothermic chlorination
		Hydrazines	Formation of hydronitric acid
		Ammonia	Formation of explosive nitrogen trichloride
		Phosphorus	Exothermic chlorination
		Silicones	Exothermic reaction
Chromic acid	CrO_3	Flammable liquids (alcohols, ketones, acids, etc.)	Rapid oxidation
		Sulphur (S_8)	Spontaneous combustion
Mercury	Hg^0	Solid $KMnO_4$	Combustion
		Acetylene	Formation of mercury acetylide (explosive)
		Ammonia	
		Br_2, Cl_2	Formation of halide
		Sulphur (S_8)	Exothermic reaction
Nitric acid	HNO_3	Organic combustible materials (cotton, wood, etc.)	Rapid oxidation (combustion)
		Alcohols (methanol, ethanol, ethylene glycol)	Formation of nitric esters (rapid oxidation)
		Ketones	Rapid oxidation
Hydrogen Peroxide	H_2O_2	Combustible organic materials (fats, etc.)	More or less rapid oxidation according to the concentration of H_2O_2
		Alcohols (methanol, ethanol, glycerol, etc.)	
		Acetone	Formation of explosive cyclic peroxides
Perchloric Acid	$HClO_4$	Organic combustible materials (wood, paper, cotton, etc.)	Formation of perchloric esters (rapid oxidation)
Phosphorus	P_4	Oxygen, air	Spontaneous combustion
		Oxidizing compounds ($KClO_3$, $KMnO_4$, etc.)	Explosive reaction
		$MgClO_4$	Explosive reaction
		F_2, Cl_2, Br_2	Combustion

Potassium permanganate	$KMnO_4$	H_2SO_4 HCl Acetic acid	Exothermic reaction Exothermic reaction (combustion)
Sodium Hypochlorite	NaOCl	Acids Alcohols (methanol, etc.)	Dichlore compound release Formation of unstable alkyl hypochlorite
Strong mineral Bases	NaOH, KOH	Water Strong acids	Exothermic dissolution Exothermic neutralization
Strong mineral Acids	HCl, H_2SO_4, HNO_3	NaOH, KOH, HONH4 NaOCl	Exothermic neutralization Dichlore compound release
Sulphur	S_8	Alkali metals (K^0, Na^0, etc.) CrO_3	Exothermic reaction Spontaneous combustion
Sulphuric acid	H_2SO_4	Water + fuming sulphuric acid $KMnO_4$ $KClO_3$ Polymerizable compounds (acrylonitrile, cyclopentadiene, etc.) Nitrated compounds (nitromethane, nitrobenzene, etc.)	Violent reaction Formation of $HMnO_4 + Mn_2O_7$ Formation of ClO_2 Explosive polymerization Exothermic reaction

There are also some charts that can be used to decide whether a chemical is compatible with another one or not. Besides (Figure 5.1) there is, as an example of a very detailed chemical compatibility chart, the US Environmental Protection Agency's (EPA) one:



CODE	CONSEQUENCE
H	Heat Generation
F	Fire
G	Innocuous and non-flammable gas generation
GT	Toxic Gas formation
GF	Flammable Gas formation
E	Explosion
P	Violent Polymerization
S	Solubilization of toxic substance
U	May be hazardous, but Unknown

#	REACTIVITY GROUP NAME	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	101	102	103	104	105	106	107
1	Acids, Mineral, Non-oxidizing	1																																								
2	Acids, Mineral, Oxidizing		2																																							
3	Acids, Organic		G H	3																																						
4	Alcohols and Glycols	H	H F	H P	4																																					
5	Aldehydes	H P	H F	H P		5																																				
6	Amides	H	H GT				6																																			
7	Amines, Aliphatic and Aromatic	H	H GT	H		H		7																																		
8	Azo Compounds, Diazo Compounds and Hydrazines	H G	H GT	H G	H G	H			8																																	
9	Carbamates	H G	H GT						G H	9																																
10	Caustics	H	H	H		H				H G	10																															
11	Cyanides	GT GF	GT GF	GT GF					G			11																														
12	Dithiocarbamates	H,F GF	H,F GF	H,GT GF		GF GT		U	H G				12																													
13	Esters	H	H F						H G		H			13																												
14	Ethers	H	H F												14																											
15	Fluorides, Inorganic	GT	GT	GT												15																										
16	Hydrocarbons, Aromatic		H F														16																									
17	Halogenated Organics	H GT	H,F GT					H GT	H G		H GF	H						17																								
18	Isocyanates	H G	H,F GT	H G	H P			H P	H G		H,P G	H G	U						18																							
19	Ketones	H	H F						H G		H	H								19																						
20	Mercaptans and Other Organic Sulfides	GT GF	H,F GT						H G									H	H	H	20																					
21	Metals, Alkali and Alkaline Earth, Elemental	H,F GF	H,F GF	H,F GF	H,F GF	H,F GF	GF H	GF H	GF H	GF H	GF H	GF H	GF,H GT	GF H				H E	GF H	GF H	GF H	21																				
22	Metals, Other Elemental & Alloys as Powders, Vapors, or Sponges	H,F GF	H,F GF	G F					H,F GT	U	GF H							H E	GF H		H,F GF		22																			
23	Metals, Other Elemental & Alloys as Sheets, Rods, Drops, etc.	H,F GF	H,F GF						H,F G									H F						23																		
24	Metals and Metal Compounds, Toxic	S GF	S H,F	S H	H,E	GF	S	S		H	S	GF		GF				GF		GF	GF				24																	
25	Nitrides	HF	E	GF	GF	H			U	G	U	H	GF H	H				H	U	H	H	E				25																
26	Nitriles	H,GT GF	H,F GT	H							U											H P			S	GF H	26															
27	Nitro Compounds, Organic		H,F GT			H					H E											H,E GF				H,E GF		27														
28	Hydrocarbons, Aliphatic, Unsaturated	H	H F			H																	H E						28													
29	Hydrocarbons, Aliphatic, Saturated		H F																											29												
30	Peroxides and Hydroperoxides, Organic	H G	H E		H F	H G		H GT	H,F E	H,F GT		H,E GT	H,F GT					H E	H	E	H,F GT	H E	H G		H G	H,E GF	H,P GT		H P		30											
31	Phenols and Cresols	H	H F						H G										H P			GF H				GF H					H	31										
32	Organophosphates, Phosphothioates, Phosphodithioates	H GT	H GT						U		H E											H									U		32									
33	Sulfides, Inorganic	GT GF	HF GF	GT		H			E										H												H GT			33								
34	Epoxides	H P	H P	H P	H P	U		H P	H P		H P	H P	U								H P	H P	P		H P	H P					H P	H P	U	H P	34							
101	Combustible and Flammable Materials, Miscellaneous	H G	H,F GT																			H,F G				H,F GF					H,F GT					101						
102	Explosives	H E	H E	H E					H E		H E			H E								H E	H E	H E	E	E					H E	H E		H E	H E	H E	102					
103	Polymerizable Compounds	P H	P H	P H					P H		P H	P H	U									P H	P H	P H	P H	P H					P H	P H		P H			H E	103				
104	Oxidizing Agents, Strong	H GT		H GT	H F	H F	H,F GT	H,F GT	H E	H,F GT		H,E GT	H,F GT	H F	H F		H F	H GT	H,F GT	H F	H,F GT	H,F E	H,F E	H F		H,F E	H,F GT	H E	H F		H G	H F	H,F GT	H,F GT	H,F G	H,F G	H E	H,F GT	104		
105	Reducing Agents, Strong	H GF	H,F GT	H GF	H,F GF	H,F GF	H GF	H G				H GT	H F				H,F E	H E	H GF	H GF	H GF					H GF	H E				H E	H GF	H,GT GF		H	H GF	H E	H,F GF	H,F E	105		
106	Water and Mixtures Containing Water	H	H						G										H G			H GF	H GF		S	H GF								GT GF							GF GT	106	
107	Water Reactive Substances	<—EXTREMELY REACTIVE! DO NOT MIX WITH ANY CHEMICAL OR WASTE MATERIAL! EXTREMELY REACTIVE!—>																																								107
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	101	102	103	104	105	106	107

Figure 5.1. EPA's chart illustrating incompatibilities between chemicals

This chart is not the one that has been used to illustrate chemical incompatibilities in the abstract available for collaborators and students, as it is quite complex and contains a great amount of information. Instead of this one, a more schematic and visual one is used (Figure 5.2):

								acid	base	
	+	-	-	-	-	-	-	-	-	-
	-	+	-	-	-	-	-	-	-	-
	-	-	+	-	O	+	-	-	-	+
	-	-	-	+	-	-	O	O	O	O
	-	-	O	-	+	+	-	-	-	+
	-	-	+	-	+	+	-	-	-	+
acid	-	-	-	O	-	-	+	-	-	-
base	-	-	-	O	-	-	-	+	-	-
	-	-	+	O	+	+	-	-	-	+

Figure 5.2. Chart used in the abstract to illustrate incompatibilities between chemicals

5.1.2. INCOMPATIBILITIES WITH THE CONTAINERS

Packaging must be designed in order to ensure that the waste that it contains can cause no risk for humans or for the environment during the storage and the transport process. This includes being selected to withstand:

- Physical properties of the content: including corrosion, oxidation, and the dissolution pressure.
- Storage conditions: as weather resistance, sterilization, freezing, light, etc.

When choosing the best container, taking into account the composition of the cap should not be forget. It is usually at this point that the weakness of storage is found.

Packages designed to contain the waste are made primarily of thermoplastic materials. The more commonly used products are: polyethylene, polyvinyl chloride (PVC) and polypropylene, as pure polymers or copolymers with other resins. When choosing the type of package the volume of waste produced and the available space to temporarily store it in the laboratory has to be taken in account. Potential incompatibility between the container and the waste (ex. bromoform or carbon disulphide with containers made of HDPE) should be noted. Some recommendations concerning the use of polyethylene containers are summarized in the following Table 5.2 **[7]**:

Table 5.2. Recommendations concerning the use of polyethylene containers

Bromoform Chloroform Carbon sulphide	Do not use.
Butyric acid Benzoic acid Bromine Bromobenzene Dichlorobenzenes	Do not use for storage periods longer that one month.
Amylchloride Ethers Acid halides Nitrobenzene Perchlorethylene Trichloroethane Trichlorethylene	Do not use the product at temperatures above 40ºC.

For certain organic solvents such as chloroform, bromoform, diethyl ether, etc., it is recommended to refer to the Safety Data Sheet (SDS). Frequently, the reuse of the original containers is the best solution.

CONTAINERS USED TO STORAGE SPECIAL WASTE

EPFL chemical stores are the ones that provide the collaborators with the different containers that are available to storage waste. In relation to waste containers, stores of the CH/PH and BCH buildings work primarily with the Swiss company Semadeni AG. The stores offer a wide range of options for storing generated waste in order to be able to provide collaborators with the most suitable container for each case.

Nevertheless, cans available at Semadeni AG **[8]** do not have a secured cap. This one is essential in the cases when some gas emissions are generated into the can, as it is equipped with a pressure relief valve. That is why these secured caps are acquired in the Swiss company FAUST SA. Containers for the storage of special waste, and their correspondent covers, available in CH/ PH and BCH stores are listed in the Table 5.3 below:

WHITE CAN	
	**Stackable standardized container - hard polyethylene (HDPE)** Natural colour. Stackable. Dimensions corresponding to the standard for pallets. Easy handling thanks to the handle hollow. Good resistance to chemicals and acids. Complete emptying possible through the hollow handle in the bottom of each container. UN homologation for the transport of dangerous goods. Capacity: 5, 10 l
In the EPFL, it is usually used for the storage of liquid biological waste (with or without chemical substances), for aqueous solutions (which can be acid, basic or neutral), for liquid paint waste, and occasionally for radiological waste.	
BLUE CAN	
	**Discharge can – hard polyethylene (HDPE)** Blue colour. Robust and resistant to chemicals. Stacking and provided with a practical hollow handle and an air vent. Capacity: 10 l

In the EPFL, it is used for the storage of halogenated solvents.	
YELLOW CAN	
	**Discharge can – hard polyethylene (HDPE)** Yellow colour. Robust and resistant to chemicals. Stacking and provided with a practical hollow handle and an air vent. Capacity: 10 l
In the EPFL, it is used for the storage of non-halogenated solvents.	
GREEN BOTTLE	
	**Bottle for toxic substances – hard polyethylene (HDPE)** Packaging for toxic substances. Robust, bright green colour, cylindrical, with four flat surfaces, fluted, with a skull printed on it and with a trilingual inscription: GIFT – POISON – VELENO. With a vertical translucent tape over the entire height of the bottle allows the exact level control, which is a considerable advantage for decanting. It is made of good quality material with excellent chemical resistance. Capacity: 0.5, 1 l
In the EPFL, it is mostly used for the storage of toxic waste, as it is the case of liquid chemicals with cyanides, mercury or its derivatives, or with nanoparticles. It can also be used for liquid radioactive waste, and for liquid biological waste (with or without chemical substances).	
BOTTLES FOR SOLID AND POWDER WASTE	
	**Wide neck bottle - hard polyethylene (HDPE)** Natural colour. Tight-fitting lid, plastic handle. Capacity: 5 l
	**Wide-mouth bottle, square - hard polyethylene (HDPE)** White. Squared shape, convenient and compact. Very strong, with a large opening, inner seal (LDPE) and red screw cap. Capacity: 1 l

	**Wide-mouth bottle with green cap - hard polyethylene (HDPE)** Natural/ translucent colour, with a screw polypropylene cap (PP). Capacity: 0.1, 0.2 l
In the EPFL, these bottles are mostly used for the storage of solid or powder waste, as it is the case of solid waste with nanoparticles or used silica.	
WHITE BUCKET	
	**Evacuation bucket - hard polyethylene (HDPE)** Bucket for solid waste disposal. White colour, round, very solid, with UN homologation. It includes a sealed lid and a metal handle. Capacity: 5 l
In the EPFL, it is used for the storage of large quantities of radioactive waste, unstable/ auto-reactive waste, solid chemical waste with nanoparticles, used silica, contaminated absorbent and big amounts of material contaminated with toxic chemicals.	
YELLOW BUCKET	
	**Yellow container - polypropylene (PP)** Squared plastic container for storage use. Resistant to temperatures from -20ºC to 80 ºC. It has two handles. Capacity: 60 l
In the EPFL, it is mostly used for the storage of glassware contaminated with chemicals. It can also be used for storing unstable/ auto-reactive waste.	
BUCKET FOR NEEDLES AND SYRINGES	
	**Rigi-box opti-safe disposal box - polypropylene (PP)** Yellow colour, thick-walled (1.7 mm). Safety box for the elimination of cannulas, scalpels, pipettes, syringes and other objects with long stem. Boxes with UN homologation. Capacity: 3, 6 l
In the EPFL, it is used for used syringes and needles disposal.	

RETENTION TRAY	
	**Laboratory tray - polypropylene (PP)** White. Resistant and not deformable. Rounded corners and very smooth surface making cleaning easy. Resistant to most acids, bases and solvents. Temperatures of use from -20 ºC to +130 ºC. Suitable as retention tray for aggressive substances. Size: 180x230x42 mm; 250x310x65 mm; 310x370x75 mm; 420x520x120 mm; 535x635x140 mm; 650x845x160 mm
In the EPFL, all cans with liquid waste must be stored in retention trays.	
SECURITY CAP	
	**Black PE cap with PTFE membrane and PE safety ring**

Table 5.3. Available containers for the storage of special waste

Through the list of chemical resistances **[8]** it has been possible to confirm that all these containers are compatible with the special wastes that are intended to contain.

5.2. IMPROVEMENT OF THE AVAILABLE TOOLS

Some of the already available tools concerning special waste management developed by the SB-SST group needed to be improved due to the evolution of the research in the FSB laboratories and the constant work done by the SB-SST experts and the other collaborators of the FSB.

5.2.1. IMPROVEMENT OF THE SPECIAL WASTES' MANAGEMENT FLOWCHART

The "Management of special wastes at the FSB" chart is a tool that helps to classify the different categories of chemical wastes. It describes how to separate the different types of chemical wastes according to Swiss law. This can be extremely helpful for collaborators as in Switzerland the waste producer is responsible and avoids mixing different wastes, and must sort them according to their physicochemical properties and toxicity and according to the law.

There is minimum one "Management of special wastes at the FSB" chart in every laboratory of the FSB. These ones can be printed in DIN A4, DIN A3 and/ or DIN A2 depending on the users' preference. This chart is also available on-line at the SB-SST website. This tool is used not only in the FSB laboratories but also increasingly in the FSV (Faculty of Life Sciences) ones.

This chart is subject to constant change because, firstly, the work done in the EPFL laboratories is constantly evolving and this means that new wastes are generated, so new doubts concerning the management of these ones are generated too. There are also some types of waste, especially toxic and dangerous waste, which lately are generated in fewer occasions. Furthermore, the fact that so many people of different environments use it generates proposals for improvements that may be useful to all users.

This is why a comprehensive review of the chart has been done. This has led to generate a number of different versions as the time passed, as a result of several meetings and discussions with the collaborators of the laboratories, the experts in chemistry, biology, physics and radioactivity of the SB-SST group, and with the workers of CRIDEC, the sorting and disposal company of the majority of the wastes produced by the EPFL laboratories.

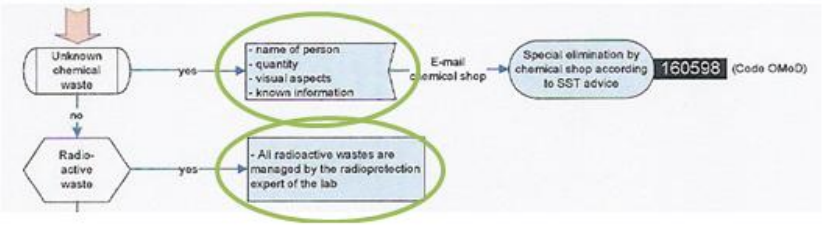
CHANGES MADE TO THE FLOWCHART

Global changes

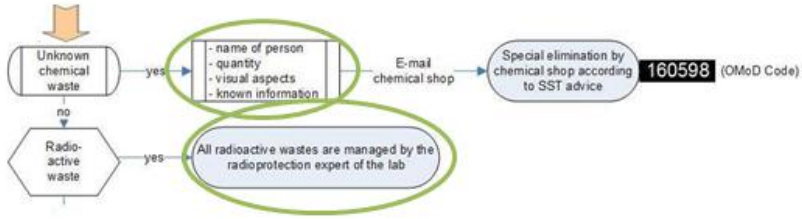
At first sight some possible improvements are already detected. First, the major complain of the laboratories' staff is that the chart looks overcharged and is not visually appealing enough. Moreover, initially it can also be seen that, in some parts of the chart, symbols corresponding to flowcharts are not correct. Finally, some OMoD codes are not visible enough as the colours used have not enough contrast.

- **Homogenization of the symbology corresponding to a flowchart:**

BEFORE:

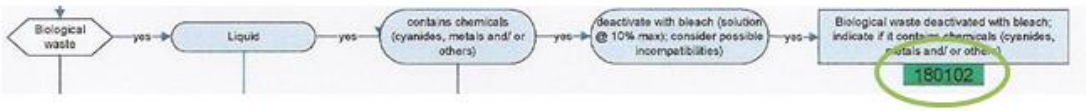


AFTER:

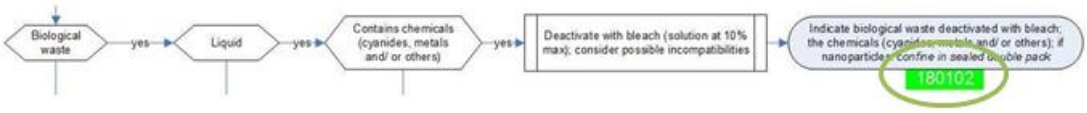


- **Modification of some colours used to distinguish some OMoD codes:**

BEFORE:



AFTER:



- **Although there was the intent of lighten the chart, it has been very difficult because all the information contained in it is essential for the proper management of the produced waste.**

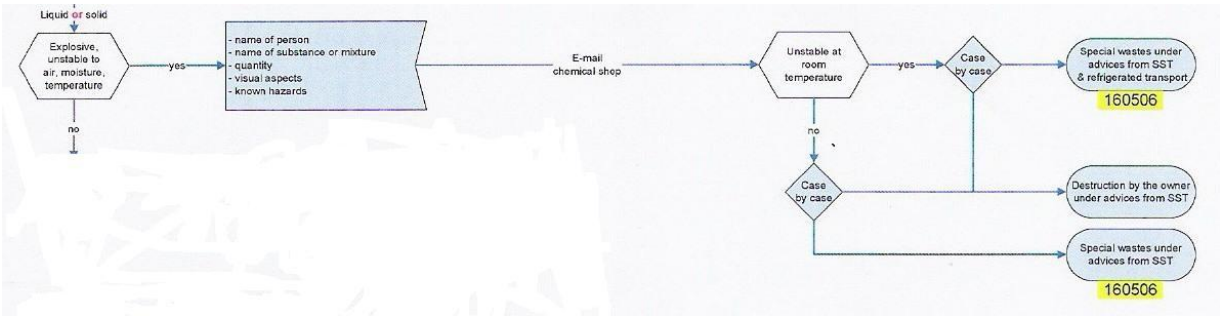
Specific changes

Some changes in the content of the "Management of special wastes at the FSB" chart have also been performed as a consequence of the comprehensive review that has been done after several meetings and discussions with the collaborators and experts of the SB-SST group and the workers of CRIDEC.

- **Explosive, reactive to air, moisture, thermally unstable**

BEFORE:

Initially, the chart gives information about the indications that the label must contain. Then, it indicates that an e-mail must be sent to the chemical shop, and then, independently of the choice, it indicates to contact the SB-SST group.

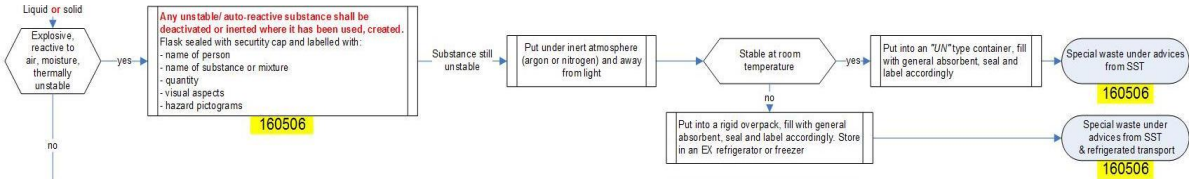


AFTER:

First, the chart emphasizes the need to deactivate or inert this waste where it has been created and/ or used. This information is given initially because the waste should be deactivated as soon as possible and whiteout being carried from one place to another in order to avoid any additional risks.

Secondly, if the collaborator does not know how to deactivate the waste, the chart continues giving indications in order to guide him or her in this process.

In addition, information about how to pack the waste is given. There is also information about how to deactivate the waste that is instable at room temperature. It is in this moment, once the waste is deactivated or inert, when the SB-SST group should be contacted in order to give indications about how to continue.



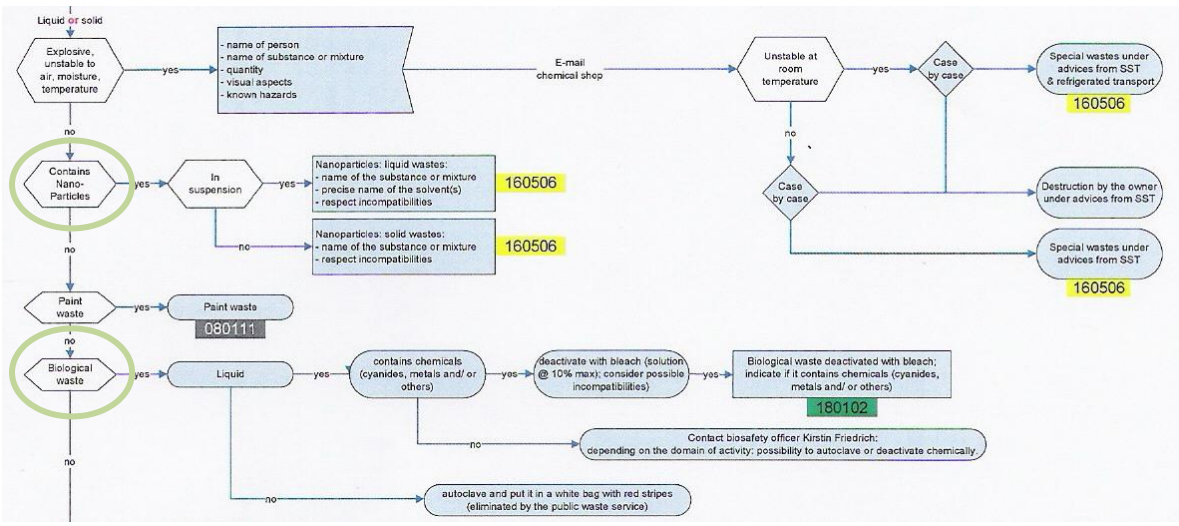
- **Biological waste and waste that contains nanoparticles**

BEFORE:

The order of appearance of these wastes in the flowchart is:

1. Explosive, unstable to air, moisture, temperature
2. Contains nanoparticles
3. Paint waste
4. Biological waste

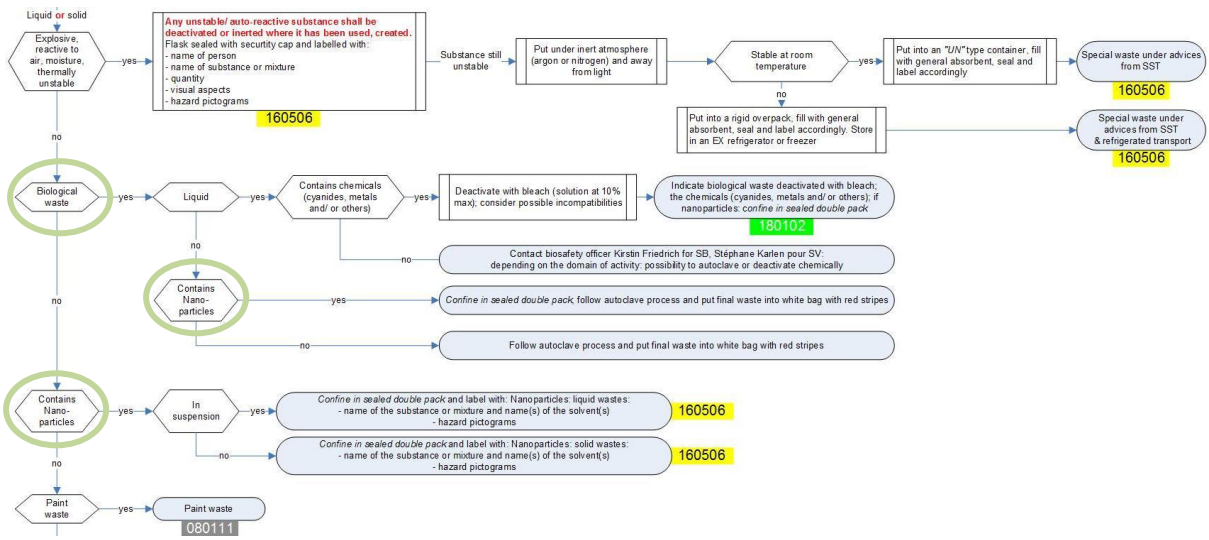
Therefore, biological waste containing nanoparticles is treated as nanoparticles waste.



AFTER:

After contacting CRIDEC, and asking them about this subject, they said that, for their workers' health, they consider that biological wastes are more dangerous than the ones that contain nanoparticles. They asked the EPFL to label biological waste containing nanoparticles as a biological waste (with its descriptive and OMoD code). However, this waste must be confined in a sealed double pack as all other waste that contains nanoparticles.

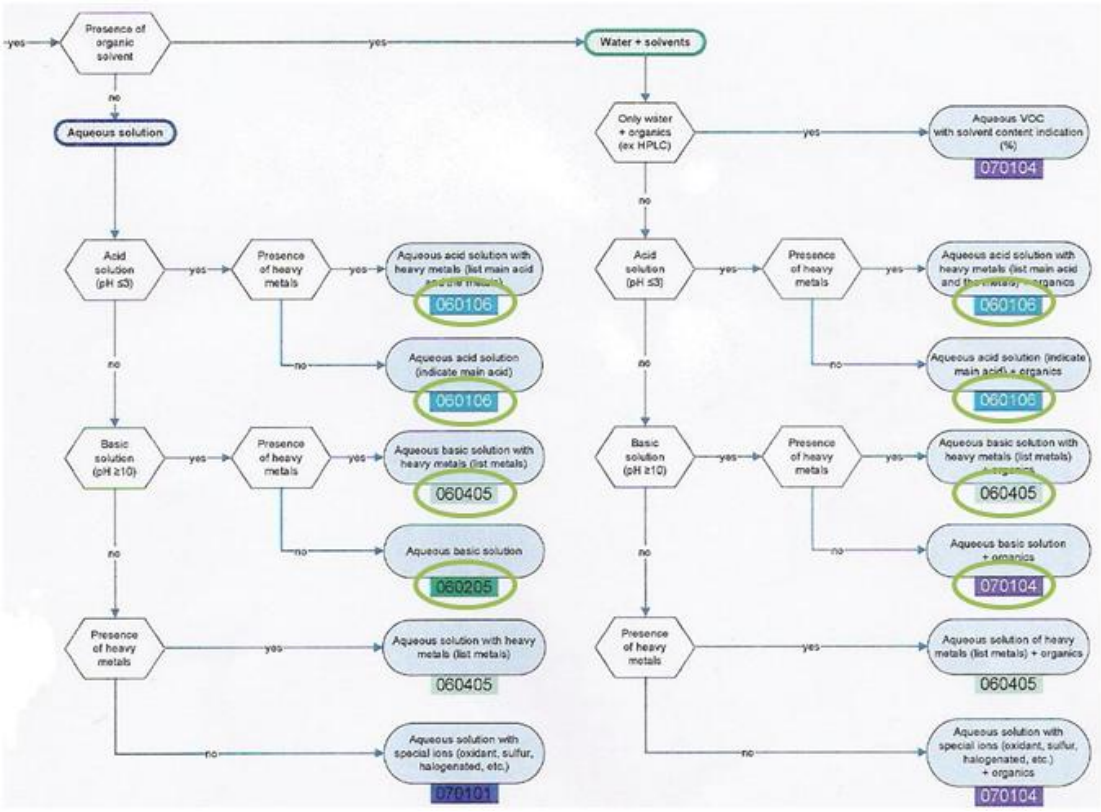
That is why a modification of the position of biological waste in the chart is done. Biological waste is now placed before waste that contains nanoparticles. Additional information is given about the way that the biological waste that contains nanoparticles shall be packed, both in the case of solid waste and liquid waste.



- **Acid and basic waste**

BEFORE:

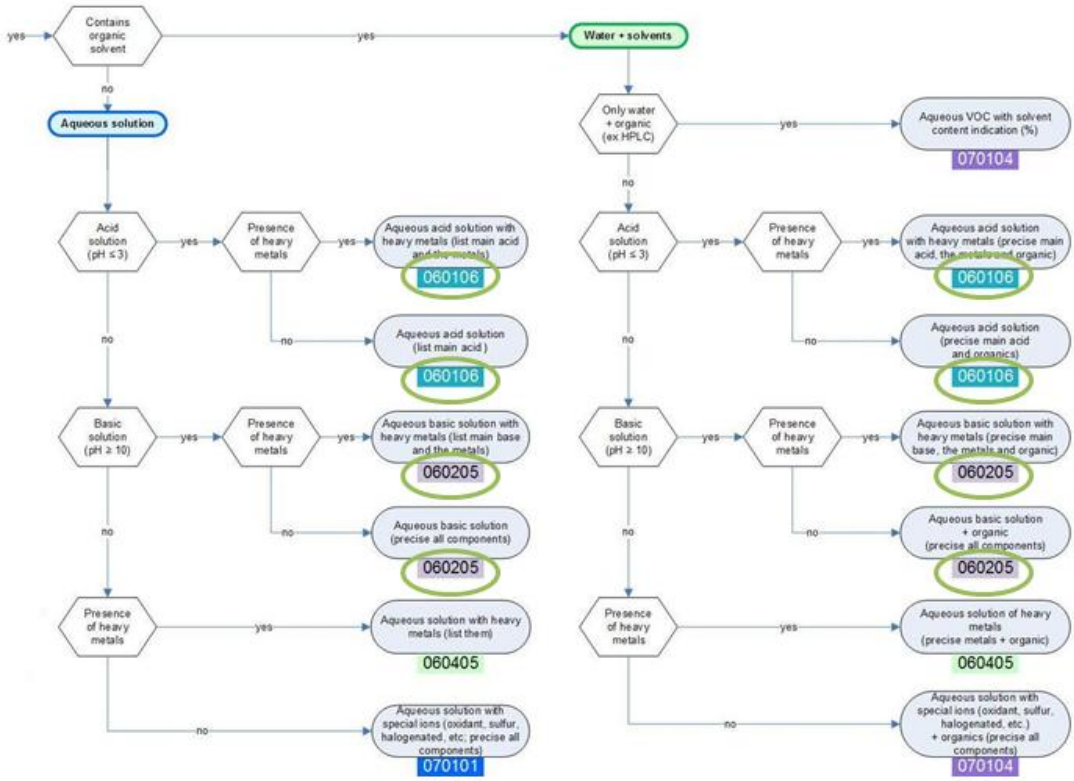
There is an inconsistency with the OMoD codes assigned to acid and basic wastes containing heavy metals. On the one hand, acid wastes, whether or not containing them, have the acids OMoD code assigned. On the other hand, basic wastes have different codes depending on if they contain or they do not contain heavy metals.



AFTER:

After contacting CRIDEC, the final conclusion is that, even if it would be interesting for CRIDEC's workers to distinguish between waste that contains or not heavy metals, for both the EPFL collaborators (in order to avoid storing in a close position acid and bases wastes) and the emergency personnel (in case of a possible accident), the more reasonable decision is to distinguish, by using the OMoD codes, between acid and basic waste.

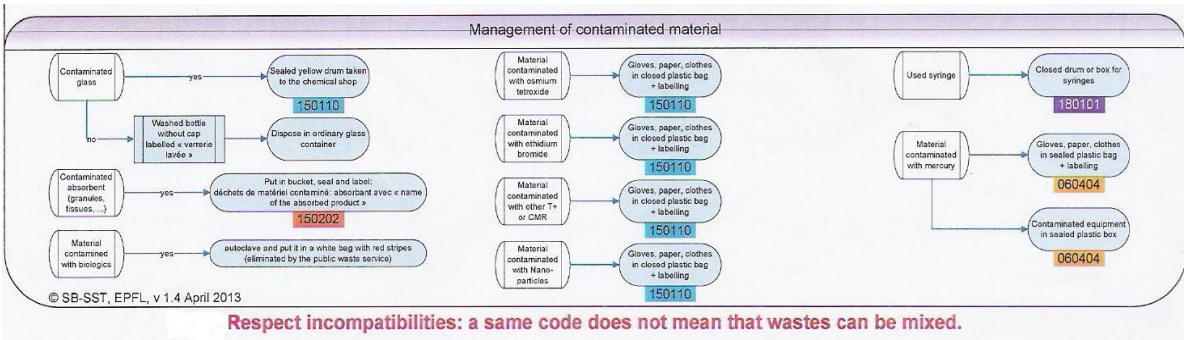
However, in order to help CRIDEC's workers to sort the waste in the most efficient way and to affect the environment as little as possible, the label shall specify if the waste contains or not heavy metals. In the affirmative case, the label must list these metals.



- **Contaminated material**

BEFORE:

The part of the flowchart that contains information about the management of contaminated material is very full and not visually appealing enough. In addition, information about materials contaminated by other toxics used outdated symbology.

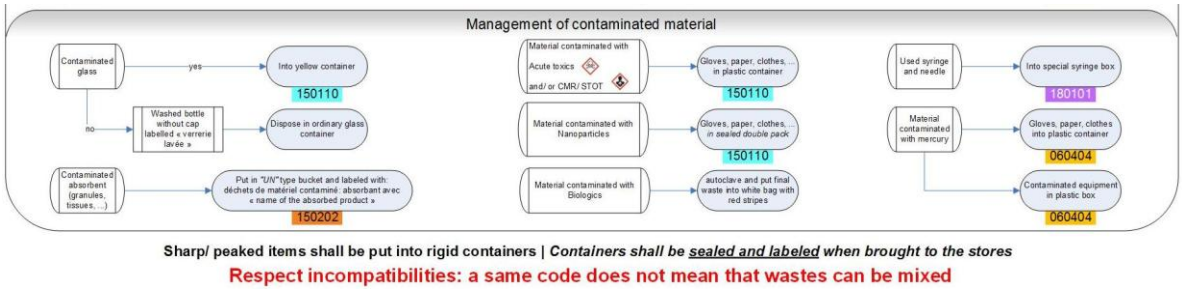


AFTER:

In order to make the chart more visual, and due to the fact that the use of osmium tetroxide and ethidium bromide has decreased a lot, three cells have been united and now there is only one for all material contaminated with acute toxics and/ or CMR[1]/ STOT[2]. In addition, the symbology has been outdated (acute toxics instead of T+) and two hazard pictograms have been added.

Moreover, a recommendation that says that sharp or peaked items shall be put into rigid containers has been added at the bottom of the chart. This information is important to avoid piercing plastic bags. It has also been added a reminder that says that all containers shall be sealed and labeled before being brought to the stores.

Finally, minor changes have also been made. First, needles must be disposed in the same container that syringes. Secondly, material contaminated with nanoparticles shall be double packed.



Below there is the full image of the "Management of special wastes at the FSB" chart after all the modifications, both in the English version (Figure 5.3) and in the French version (Figure 5.4):

[1] Carcirogenic, Mutagenic, toxic to Reproduction

[2] Specific Target Organ Toxicity

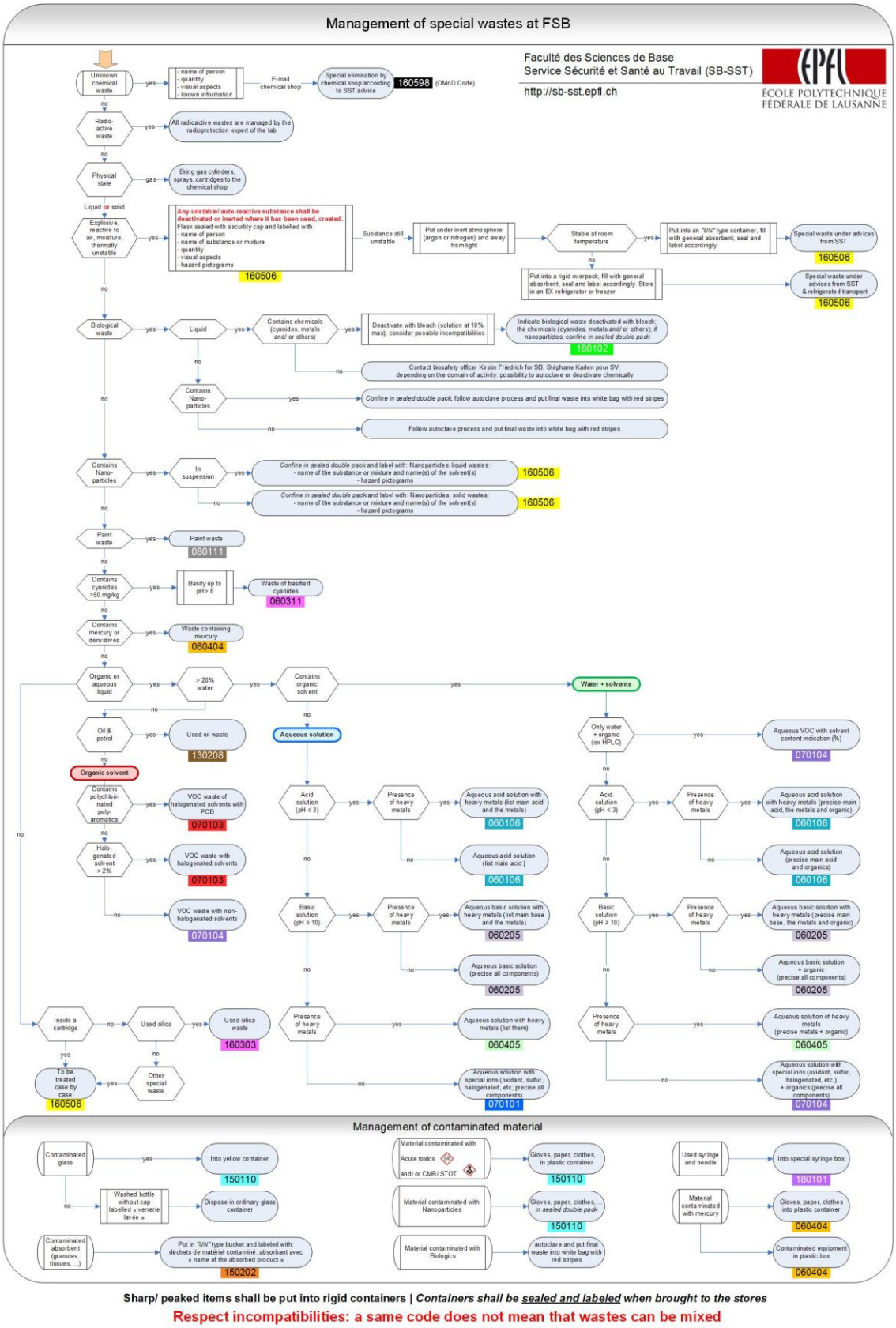


Figure 5.3. "Management of special wastes at the FSB chart" after the modifications. English version

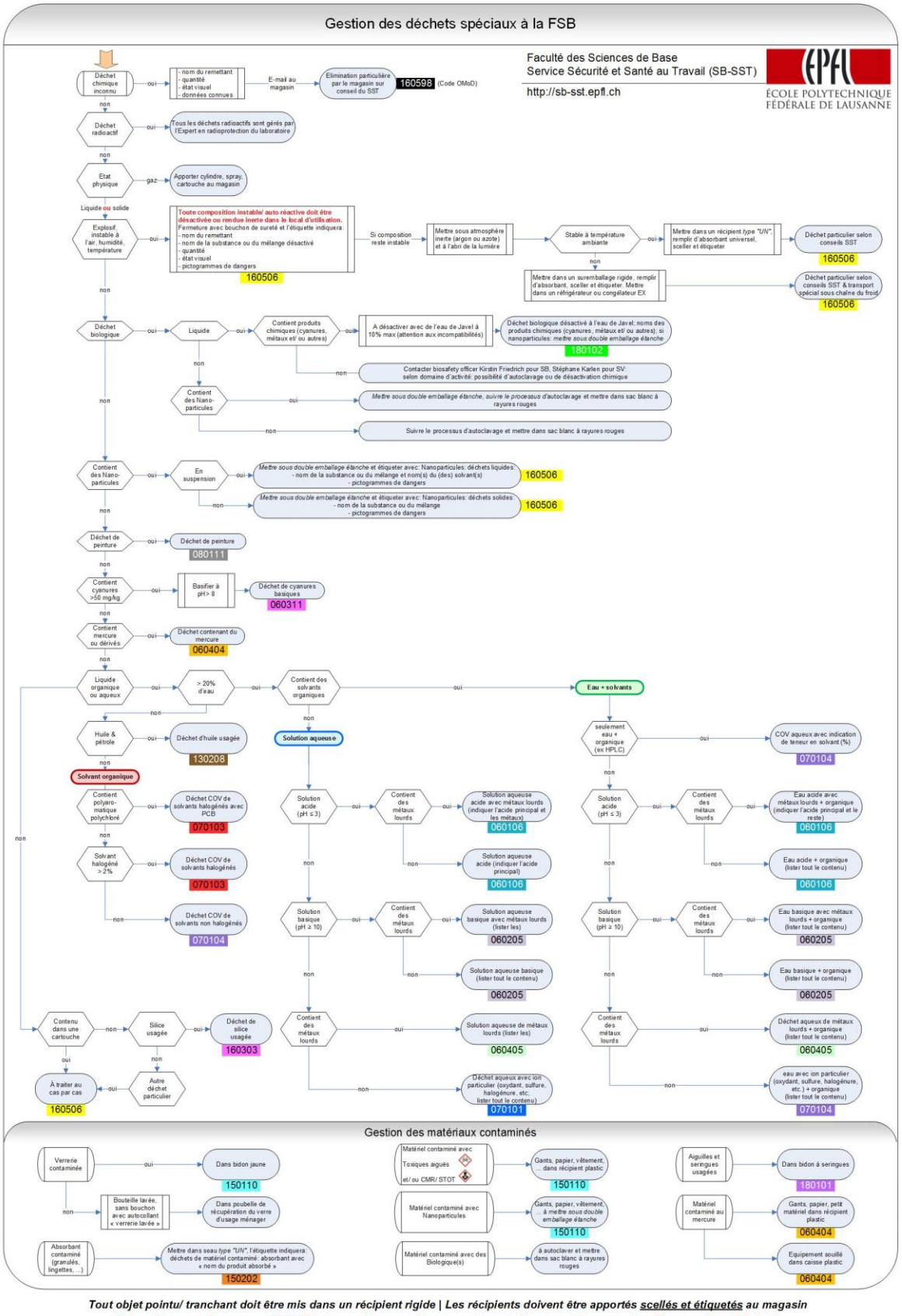


Figure 5.4. "Management of special wastes at the FSB" chart. French version

5.2.2. IMPROVEMENT OF SPECIAL WASTES' LABELLING

For years, the EPFL has been working to ensure that all waste generated in their laboratories is properly labeled before being delivered to the transport company. This is extremely important for the preservation of the EPFL collaborators and the employees of the transport and disposal company's health, and to cause the minimum impact on the environment.

Although the SB-SST group has made a great effort to raise awareness of the importance of correctly labelling the generated waste, after a review of the labels available at the chemical stores it has been observed that there is certain incoherence between these ones.

To start with, in the available labels, the language used to describe the waste is, in some cases French, in others English, and in other cases both of them. What is more, after consulting the experts in chemistry of the SB-SST group and the information provided by the European Chemicals Agency (ECHA) **[9]** it has been verified that some of the labels contained pictograms that were not the most adequate to illustrate the hazards that the waste had.

CHANGES MADE TO THE LABELS

- **Homogenization of the languages:** all the labels are written in French and English. Only the reference "Déchets spéciaux" is written in French, German and Italian as it is specified in the Ordinance on the Movements of Wastes OMoD (ref. 814.610).
- **Addition of the name of the producer of the waste:** it is considered necessary as it can be very useful in case of a possible doubt, irregularity or accident, as the producer of the waste is the person that has more information about the content of the container and the possible hazards that it may involve.
- **Creation of new labels**: in order to be able to give more specific information in certain cases.
- **Correction of some hazard pictograms:** in accordance with the CLP (Classification, Packaging and Labelling) Regulation described by the ECHA.

The regulation described by the ECHA according to the substances and mixtures classified for more than one hazards is summarized below:

1. **For physical hazards**, if the label carries the pictogram of on an exploding bomb (explosive), then the pictogram of a flame (flammable) and the pictogram of a flame over a circle (oxideizer) are optional...

mandatory optional optional

... except in cases where more than one pictogram is compulsory, namely for substances and mixtures classified as self-reactive or as organic peroxide.

2. **For physical and health hazards**, if the label carries the pictogram of a flame (flammable) or the one with skull and crossbones (toxic), then the pictogram of a gas cylinder is optional:

or

mandatory mandatory optional

3. **For health hazards**, if the label carries the pictogram with skull and crossbones, then the one with an exclamation mark shall not appear:

4. **For health hazards**, if the label carries the corrosion pictogram, then the one with an exclamation mark should not be used for skin or eye corrosion...

... but still has to be used for other hazards.

5. **For health hazards**, if the label carries the pictogram concerning health hazard for respiratory sensitisation, then exclamation mark shall not be used for skin sensitisation or for skin or eye irritation...

... but still has to be used for other hazards.

The Table 5.4 below shows some examples of the modifications that have been made in order to homogenize and improve the available wastes' labels:

Table 5.4. Examples of improved labels

HOMOGENEIZATION OF THE LANGUAGES	
BEFORE	**AFTER**
EPFL – ISIC – CH/PH - 1015 Lausanne **Déchets spéciaux** **Sonderabfälle** **Rfiuti speciali** Groupe : Date : **Déchet biologique désactivé à l'eau de javel MAX 10%** **(AVEC indication si cyanures et/ou méteaux lourds)** **Code LMoD : 18 01 02**	EPFL – ISIC – CH/PH – 1015 Lausanne **Déchets spéciaux** **Sonderabfälle** **Rifiuti speciali** Nom, Prénom / Name, First name : Groupe / Group : Date / Date: **Déchet biologique désactivé à l'eau de Javel MAX 10% / Biological waste desactivated with bleach MAX 10%** **Code OMoD : 18 01 02** Indication si cyanures, métaux lourds et/ou autres / Indication if cyanide, heavy metals and/or other.

CORRECTION OF HAZARD PICTOGRAMS	
BEFORE	**AFTER**
EPFL – ISIC – CH/PH – 1015 Lausanne **Déchets spéciaux** **Sonderabfälle** **Rifiuti speciali** Groupe : Date : **Déchets liquides aqueux contenant des cyanures** **Code LMoD : 06 03 11**	EPFL – ISIC – CH/PH – 1015 Lausanne **Déchets spéciaux** **Sonderabfälle** **Rifiuti speciali** Nom, Prénom / Name, First name : Groupe / Group : Date / Date: **Déchets de cyanures basiques / Basic cyanide waste** **Code OMoD : 06 03 11**

CREATION OF NEW LABELS TO BETTER SPECIFY THE CONTENT

BEFORE

	EPFL – ISIC – CH/PH - 1015 Lausanne
	**Déchets spéciaux** **Sonderabfälle** **Rfiuti speciali**
Groupe : Date :	**Acides concentrés – Concentrated acids pH<3** **Code LMoD : 06 01 06** Conserver à l'écart des bases et des solvants/Keep away from bases and solvents

AFTER

	EPFL – ISIC – CH/PH – 1015 Lausanne
	**Déchets spéciaux** **Sonderabfälle** **Rifiuti speciali**
Nom, Prénom / Name, First name : Groupe / Group : Date / Date:	**Acides pH ≤ 3 / Acids pH ≤ 3** **Code OMoD : 06 01 06** Conserver à l'écart des bases et des solvants / Keep away from bases and solvents

	EPFL – ISIC – CH/PH – 1015 Lausanne
	**Déchets spéciaux** **Sonderabfälle** **Rifiuti speciali**
Nom, Prénom / Name, First name : Groupe / Group : Date / Date:	**Acides pH ≤ 3 avec métaux / Acids pH ≤ 3 with metals** **Code OMoD : 06 01 06** Liste des métaux lourds en solution (PAS DE MERCURE) / List of the heavy metals in solution (NO MERCURY) Conserver à l'écart des bases et des solvants / Keep away from bases and solvents

5.3. CREATION OF NEW TOOLS

During the last years the SB-SST group has developed some very useful tools related to waste management that are of great interest for all the collaborators and students that work in the FSB laboratories. However, up to now, no tool that compiles in one document all the information corresponding to the management of special waste generated in the laboratories of the FSB has been created.

That is why the main goal of this project has been the creation of a new leaflet, written in English and in French, which collects all this information and which does specify the best way to package and label each type of waste. Based on this leaflet, and in order to create the most useful tool for every situation and every user, a computer program that allows obtaining the same information by means of some simple questions has also been designed.

Besides, within any waste management program is essential to know the nature, the amount and the storage location of these ones. The FSB, hitherto, has not made any compilation of this information. It is for this reason that, using the tracking documents for the movements of special wastes in Switzerland and with the information given by the COSECs (unit's Safety Delegate) of some research groups of the FSB, a set of information that may be useful to improve the control of the waste has been generated.

5.3.1. LEAFLET ABOUT THE MANAGEMENT OF SPECIAL WASTE AT FSB

This leaflet has been created in order to answer all the questions that may be generated during the different steps of the management of special waste (Figure 5.5). It describes the rules to follow for a safe waste and material disposal while respecting the environment.

Figure 5.5. Steps of the waste management

The leaflet summarizes the FSB rules related to waste management and includes primordial information about incompatibilities between chemicals. However, the main body of this document is a detailed explanation of the process of packaging, labelling and storage of each type of special

waste. These wastes are ordered according to their level of dangerousness, considered by SB-SST experts and CRIDEC's workers.

The leaflet about the management of special waste at FSB is considered a valuable tool that should be in all FSB laboratories and that will lead to a considerable improvement in the management of special waste. This will reduce the risk of accidents, both at the university and during the transport and subsequent waste disposal.

In addition, it has been written trying to highlight the fact that waste is not a final product, but that it follows a long process and pass through many hands since it is generated, and that a small initial error can affect on a large scale afterwards in the process.

This leaflet is available at **Appendix A.1**.

5.3.2. COMPUTER PROGRAM CONCERNING THE MANAGEMENT OF SPECIAL WASTE AT FSB

This program has been designed to guide the collaborator that has generated a waste, through a series of simple questions that are answered with a yes or a no, to all the information relevant to its packaging, labeling and storage. These questions follow the order of the "Management of special wastes at FSB" chart.

The computer program has been designed but is no yet available. However, **Appendix A.2** shows, graphically, how it works and the information that can be obtained from it.

5.3.3. DATA CONCERNING THE NATURE AND THE AMOUNT OF SPECIAL WASTE GENERATED AT FSB

As it has already been said before, within any waste management program is essential to know the nature, the amount and the storage location of these ones. With the tracking documents for the movements of special wastes in Switzerland and with the information given by the COSECs (Unit's Safety Delegate) of some research groups of the FSB the following information has been obtained.

INFORMATION OBTAINED FROM THE TRACKING DOCUMENTS

Swiss law requires the remitting company (in this case, the EPFL) to generate tracking documents for all the wastes that are delivered to the transport company. The law, moreover, obliges to preserve these documents at least during one year.

Since tracking documents specify the nature and the amount of delivered waste, these documents (Figure 5.6) can be very useful in order to know the quantity of waste generated by all the laboratories of the CH/ PH building (tracking documents kept in the CH/ PH store) and by the BCH ones (tracking documents kept in the BCH store).

2 DESCRIPTION DES DÉCHETS

Description selon la liste des déchets, et précisions si elles sont nécessaires pour assurer la sécurité de l'élimination et pour protéger l'en

[ds] Déchets contenant d'autres métaux lourds

Code des déchets: 0 6 0 4 0 5

Poids: 30 kg

Quantité:[1) 2)] litres

Transport de grandes quantités:[3)] oui ☐

Type d'emballage:[1) 4)] 5 cartons

Marchandises dangereuses selon ADR/SDR ou RID/RSD ☒oui ☐non

Remarques (p.ex. précisions relatives à l'ADR/SDR):[1)]

Nombre d'emballages (colis): 5

Date d'expédition: 04.12.2013

Signature de l'entreprise remettante:

Figure 5.6. Part of the tracking document that contains the information about the nature and the amount of waste, and the shipping date

It has been possible to obtain the tracking documents of the year 2013 of the BCH store and the ones of the year 2012 and 2013 of the CH/ PH store. In order to have a global and visual idea of the information, charts representing the amount of each type of generated waste depending on the different months of the year have been created. These charts are available at **Appendix A.3** of this project.

The information obtained through these documents can be very useful as it gives an overview of the production of special waste in the FSB laboratories, which until now was not known. Furthermore, this information may also be useful for the firefighters and the emergency staff of the EPFL. In the case of an accident (for example a fire or an explosion) in the local of storage of special waste, the emergency staff would be able to prepare in a better way, both to solve the problem (for example choosing the best type of fire extinguisher) and to protect themselves the most efficiently way. This information concerning the nature and the amount of waste stored could appear on the sheet door

of the special waste storage locals of the stores. In that way, the information would be visible all time.

INFORMATION OBTAINED FROM THE COSECS OF THE RESEARCH UNITS

In order to obtain specific information about the waste generated by each research group, some COSECs (Security Coordinators) have been asked about the nature and the approximate amount of waste regularly generated in their laboratories. This information is also available at **Appendix A.3** of this project.

This information would be considerably interesting as it might give an idea about the level of danger of each laboratory, taking in account, among others, the type and the amount of waste that is temporarily stored in it. However, the information that has been collected is only indicative as it is very difficult to determinate accurately the quantity of waste generated in each laboratory every month. In some occasions one type of waste is generated only for a period of time. This is due to the constant evolution of the research.

FUTURE WORK

Both in the case of the information obtained through the tracking documents and the one obtained talking to the COSECs of each research group, no decisive conclusions can be taken. The data is not complete neither regular. This is due to the continuous evolution of the research and that some projects finish and others begin constantly.

In the long term, information of all the tracking documents generated from now on should be collected. In addition, concrete information about the generation of special waste in each group should be compiled by the COSECs of the FSB. Then, an analysis of the consistency of all this information over the time should be done.

6. ENVIRONMENTAL AND SOCIAL IMPACT

The aim of this project is to improve and develop tools in order to ameliorate the management of the special waste generated at the FSB of the EPFL. By improving the management of these wastes (chemical, biological and radioactive) from the moment of their generation in the FSB laboratories the risk of accidents and affectation to all the people which come in contact with them throughout their lifecycle decreases. The same happens with the impact that these wastes will have on the environment.

6.1. ENVIRONMENTAL IMPACT

It is undeniable that the generation of waste, and of special waste in particular, gravely affects the environment. It is for this reason that any effort made to reduce this impact, although it is in a small scale, is transcendental. The SB-SST group works year after year in order to contribute in the best way that is possible in this cause, and in order to ensure that special waste generated in the laboratories of the FSB is treated with the utmost of care and according to the current legislation. This will help to reduce the impact that it can cause to the environment.

If there is a slightest doubt about the nature of the waste, and in order to avoid any risk, this one must be burned in a high temperature incinerator (HTI). This implies that waste that could probably be valorised or incinerated at a lower temperature is burnt at high temperature. The high temperature incineration is the process that affects the environment to a greater extent.

Moreover and even worse is the case of wrongly labelled waste. This could imply that waste would be burned at temperature lower than the necessary. This could generate the release of gases with hazardous unburnts. This situation would be extremely critical for the environment.

Thanks to the improvement of the existing tools and the creation of new ones in order to manage special waste that is generated at the FSB there will be an amelioration of the way this one is sorted and labelled. This will reduce the possibility of making one of the errors mentioned above and will increase the possibility to recycle or valorise these wastes.

Increasing the amount of wastes that can be recycled or valorized also implies decreasing the volume of the ones that must be incinerated. This leads to a reduction of the production of CO_2 that will be

released to the atmosphere. The Figure 6.1 below shows the order of magnitude of the impact (in kg CO_2 eq.) of the treatment of 1 kg of special waste at CRIDEC versus the displacement of a medium class car per 1 km (data from the year 2009) **[10]**:

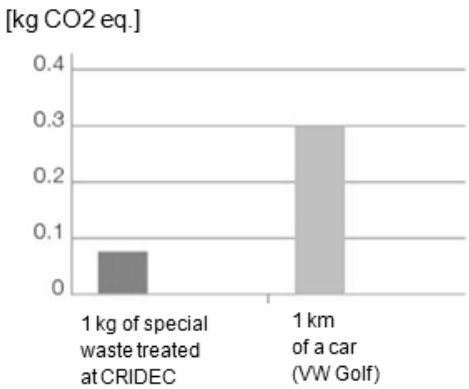


Figure 6.1. Order of magnitude of the impact of the treatment of 1 kg of special waste at CRIDEC vs the displacement of a medium class car per 1 km

It is for all these reasons that it is so important to label the waste with the maximum information and accuracy from the moment when it is generated, in order to avoid having any doubts or making any errors that may involve serious consequences for the environment.

6.2. SOCIAL IMPACT

When improving the management of special waste that is generated at the FSB laboratories, the risk of accidents and affectation to the health of all the people who come in contact with them decrease.

6.2.1. IMPACT ON THE EPFL COMMUNITY

This improvement of the special waste management affects mainly the FSB collaborators that work doing research in its laboratories. Both the leaflet about the management of special waste at FSB and the computer program developed after it explain the rules concerning the correct packaging, labelling, storage at the laboratories and safe transportation to the chemical stores. In addition, they also summarize the chemical incompatibilities using a visual chart and some reminder sentences, and detail, step by step, the proper conditioning of each type of waste.

All this information helps collaborators to know the best way to manage special waste in order to decrease the risks that this may have for their health and safety. In particular, this risk decreases as

they know now which wastes must be stored separately according to their reactivity, and which are the containers that better support each waste. Moreover, the process to follow to stabilize unstable or auto-reactive waste is detailed in the leaflet in order to increase the safety when using it. Finally, the risk of having an accident when transporting special waste from the laboratory where it has been generated to the chemical store is also reduced as the leaflet gives specific information about the safer way to do it.

These improvements are also beneficial for students, as the leaflet will also be available in all the laboratories used for educational purposes, and they will therefore be influenced by all the ameliorations mentioned above.

Furthermore, thanks to the information given about where to throw each waste, the EPFL's cleaning staff would avoid some risky situations due to contaminated sharp items that were sometimes found in the ordinary bin. In the past there had been some cases of cleaning staff that had been injured with a needle or a syringe that was in an ordinary been. This caused not only the injury but also a possible contamination due to its previous content.

6.2.2. IMPACT ON THE TRANSPORT COMPANY'S STAFF

The improvement of the labeling of special waste at the FSB (more specific information, correct hazard pictograms, all written in French and English) will help workers to have more knowledge about the content and the associated risks of the wastes that they are transporting. This will help to improve safety when transporting special waste and will give them valuable clues to help them react more efficiently in the case of having an accident. It will also be extremely helpful for firefighters in the case that this happens.

6.2.3. IMPACT ON THE SORTING AND DISPOSAL COMPANY'S STAFF

The fact of having improved the sorting, the packaging and the labeling of special waste generated at the FSB that has to be sorted and processed by the sorting and disposal company implies a high improvement for the safety of their workers.

First of all, depositing this waste in compatible containers prevents from an accidental spillage and, thus, avoids the contact of this waste with a member of the staff. What is more, if waste is properly identified some risky situations can be avoided, for example an unexpected release of gas effluviums

when opening the waste container. Finally, the better the sorting is done, the fewer tests will have to be done in the laboratory of the sorting company, fact that will facilitate the work of their employees.

6.2.4. IMPACT ON THE SOCIETY

To start with, as mentioned before, improving the management of special waste leads to a reduction of the negative impacts that these ones will have on the environment. This is beneficial not only for Swiss habitants, but for all humanity in general. However, it must be taken into account that due to the small amount of special waste generated in the FSB compared to all special waste generated by the industry, this decrease will be almost imperceptible.

7. ECONOMIC ANALYSIS

The aim of this project is the improvement of the available tools and the creation of new ones in order to improve the special waste management generated at the FSB laboratories. These tools are mostly documents in paper or computer support that represent no or very small economic cost.

7.1. COSTS ASSOCIATED WITH THE DEVELOPMENT AND IMPLEMENTATION OF THE TOOLS

The main cost of this project is the retribution of the person in charge of its development. Considering a salary of 30 €/hour and taking into account that the engineer in charge of the project worked 40 hours per week during 5 month, this cost represents 24000 €. The work done by the SB-SST team is part of its job and is included in their salary.

In relation with the cost associated to the improvement of the available tools, information concerning chemical incompatibilities needs only to be posted on the SB-SST website. Moreover, the implementation of new labels will be done gradually once the old ones start to run. From now on, when one type of label is finished, chemical store's staff will print the new version ones. That is why this change does not involve any additional charge for the SB-SST department.

Finally, the modification of the "Management of special wastes at the FSB" chart involves uploading the new version on the website and also printing and distributing it to all the FSB laboratories. This implies no additional costs either, as a reprinting of the charts is already planned every 6 month – 1 year due to its periodically modification as a result of the evolution of the research and the fact that the copies of the laboratories deteriorate with the time pass.

Regarding the creation of new tools, the situation is the same as mentioned above. Both the work done by the SB-SST collaborators and the programming task done by an EPFL programmer are part of their competences and do not imply an increase in their economic reward.

However, there is a cost associated to the leaflet. This one must be printed and distributed to all FSB laboratories, either in the English version, the French version, or both of them. This cost is proportional to the number of laboratories that FSB has, and depends on the number of spent sheets

and the amount of ink that is used to print the leaflets. However, it is difficult to estimate this cost in a more or less precise way. Nevertheless, this cost is almost negligible compared to the overall printing expenses of the SB-SST department, as this department generates a great amount of documents every year, for example the ones created to illustrate the courses, advising documents relating to security, and labels for chemicals and waste.

7.2. COSTS ASSOCIATED WITH THE MAINTENANCE OF THE TOOLS

In order to keep the management of special waste tools updated it is necessary to review their contents minimum once a year and modify them if necessary. Concerning the economic costs, this maintenance does only involve the possibility of having to reprint some tools after updating them. As mentioned above, this cost would be insignificant in comparison to the overall costs of the SB-SST department.

7.3. SAVINGS ASSOCIATED WITH THE IMPROVEMENT AND THE CREATION OF TOOLS

The improvement of the available tools and the creation of new ones involves, in the medium and long term, a better management of special waste generated at the FSB laboratories. This may implicate a reduction of the cost associated to its disposal, as CRIDEC (the sorting and disposal company) increases the price of its services when waste is mislabeled, that is to say, when the information written in the label concerning the nature of the waste (pH, consistency, chemical composition, etc.) does not match with the results obtained by the tests done in their laboratories. All this information is specified in the Terms and Conditions document of CRIDEC **[11]**.

CONCLUSIONS

This project consists on studying the management of special wastes that are generated in the FSB laboratories of the EPFL, and on the subsequent improvement of the already available tools and the creation of new ones. It has been developed in order to ensure that the current legislation is complied, in order to reduce the risk to health of the ones that come into contact with special wastes and to minimize, to the extent possible, the impact that these ones have on the environment.

During the development of the project it became clear that all FSB collaborators are very aware of the importance that the proper management of special wastes has, and that the FSB management program has a high level of effectiveness. Nevertheless, due to the changes in the legislation, the continuous increase of knowledge about the subject, and the constant evolution of the research conducted at the FSB (and thus the evolution of the special wastes generated there), it has been necessary to modify it.

This project has allowed to thorough review the special waste management program of the FSB and therefore to have a general idea of its weaknesses. It has been detected, for example, that the possible incompatibility between different wastes was an issue that generated several doubts among collaborators. It has also been seen the need to summarize all available information about sorting, packaging, labelling and storage of special waste in a single document. That is why one of the fundamental parts of this project has been the development of a leaflet that summarizes all this information, which has required to work closely with all the SB-SST experts and with the CRIDEC, the main sorting and disposal company.

7.4. FUTURE WORK

In the near future, the implementation of the tools that have been modified and the ones that have been created must be done. The new version of the "Management of special wastes at FSB" chart must be printed and distributed to all FSB laboratories both in its English version and in its French version, and the chemical store's staff should print the new version of the labels once the old ones start to run.

Regarding the implementation of the new tools, the leaflet about the management of special waste at FSB should be printed, in English and in French, and distributed to all FSB laboratories as well. In addition, the programming of the computer program should be finished as soon as possible in order to make it available for all the collaborators.

In the mid and long term, information of all tracking documents generated from now on should be collected. In addition, concrete information about the generation of special waste in each group should be compiled by the COSECs of the FSB. Then, an analysis of the consistency of all this information over the time should be done.

Finally, the SB-SST department should periodically review these tools in order to maintain them updated as the legislation and the research done in the FSB laboratories evolve.

ACKNOWLEDGEMENTS

First, I would like to thank Dr. Francesc Recasens. Without his help and support the realization of this project would not have been possible. Thanks for his time and dedication.

I would also like to express my gratitude to MER Dr. Thierry Meyer for trusting me and supporting me from the moment we met, and giving me the opportunity to work in the Occupational Health and Safety (SST) team of the Faculty of Basic Sciences (FSB) of the EPFL. This has enabled me to learn from him and his team and to grow both professionally and personally.

Thanks to Dr. Sebastian Brückner for always being willing to help me and to solve all the doubts that have arisen during the development of the project. And thanks to all the collaborators and PhDs of the SST team as well (Dr. Kirstin Friedrich, Dr. Amela Grosso, Dr. Valeria Granata, Mrs. Nadia Baati and Mr. David Plüs) for giving me their valuable advices and helping me feel at home.

I would also like to thank all the teachers that I have had, both in the *Escola Infant Jesús* and in the UPC University. The first taught me how satisfactory it is to work hard for what you want, and the latter provided me with all the knowledge necessary to be a chemical engineer.

Finally I would like to express my gratitude to my friends for being with me in the good and not so good times, and to my parents and my partner for giving me their unconditional support.

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