Guidelines
on
Basic Safety Requirements
in Laboratories
dealing with Aerosols

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Foreword

Billions of aerosols are produced every year fulfilling the high safety standards put in place in production. The continuous success of aerosol products also results from the fact that relevant innovations and the high level of consumer satisfaction are achieved.

This revised FEA *Guide on Basic Safety Requirements in Laboratories dealing with Aerosols* targets all the laboratories where aerosols are handled, whether it will be in the early stages of product development or later-on in production quality laboratories.

When a high level of training for all parties involved and awareness about the hazards and requirements is achieved, the prerequisites for safe laboratory works are given. It is about coworkers' safety and therefore a mandatory paper for supervisors and laboratory workers.

Latest information about the changes in CLP or Directives about safety at work are incorporated as well as useful practical instructions are compiled.

It is my pleasure, as President of the European Aerosol Federation, to introduce the revised edition and to thank you, the experts from the European aerosol industry and National Associations who have compiled that excellent paper, for the fantastic work done.

This Guide is recommended by FEA as a practical contribution to high safety standards in daily laboratory operations.
This Guide, of course, does not supersede national enforcement of the legislation.

Rolf Bayersdörfer
FEA President
October 2016

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Chapter 1

Purpose of this Manual

The purpose of this manual is to prompt and promote an awareness of the potential hazards in the various operations encountered in laboratories engaged in the development or testing of aerosol products.

This guide provides advice on many aspects of safety in the aerosol laboratory. However, it is not possible to predict every set of circumstances in every laboratory. It is also the responsibility of management to ensure that risk assessments are suitable and sufficient for the purpose, and apply the results of the risk assessment.

It is not sufficient to present a copy of this guide and rely on this as the site risk assessment.

Notes:

a. Official national legislation must ALWAYS be respected and takes priority over these guidelines.
b. The design and construction of machinery, installations and buildings should always be in line with the appropriate EN standards.

Chapter 2

Glossary of Terms

For the purposes of these guidelines:

Aerosol dispenser or *Aerosol* – a non-reusable[1] container made of metal, glass or plastic and containing a gas compressed, liquefied or dissolved under pressure, with or without a liquid, paste or powder, and fitted with a release device allowing the contents to be ejected as solid or liquid particles in suspension in a gas, as foam, past or powder or in a liquid state (according to Aerosol Dispensers Directive 75/324/EEC). In practice it can be stated that an aerosol is a product that is dispensed from an aerosol container by a propellant.

Compressed gas – within the purpose of these guidelines it refers to CO_2, air, N_2 and N_2O.

Conductive – capable of discharging electricity to a ground.

Cylinder – normally a portable cylindrical container from about 0.5 to 61 litres.

Explosion – the effect of a rapid combustion of a flammable gas/air within a confined space.

Flammable gas – a gas capable of forming flammable or explosive mixtures in air.

Flammable limits – the spread between the *lower explosive limit* (LEL) and the *upper explosive limit* (UEL). Gas/air compositions in this range are flammable or, if confined, explosive.

Flammability – a flammable substance is easily ignited and capable of burning.

Flash point – the temperature at which, under prescribed test conditions, a substance emits vapours that can be ignited in air. Flash point temperature may differ according to the method of testing.

Gas detection system – the apparatus used to sense the concentration of aerosol propellant gases in air at various key points.

Gas level – the concentration of aerosol propellant gases in air, as measured by gas sensors and indicated as a percentage of the *lower explosive limit* (LEL).

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[1] Although it is stated as non-reusable, it should be noted that empty aerosol cans are recyclable.

General ventilation – a ventilating system designed to cover the entire gas house of aerosol propellant vapours; normally designed with a low and high flow rate of air.

Good Laboratory Practice (GLP) – a set of principles that provides a framework within which laboratory studies are planned, performed, monitored, recorded, reported and archived.

Grounded – electrical connection to the earth of fixed installed equipment, machines, piping, etc.

Hazard – the ability of a situation to cause harm to man, facilities or the environment.

Hood – an enclosure surrounding a hazardous substance emission point providing local ventilation and exhaust.

Intrinsically safe – safe by its design due to special low potential electrical circuits.

Liquefied propellants – within the purpose of these guidelines it refers to hydrocarbon propellants (propane, butane), hydrofluorocarbons (HFCs) or dimethyl ether (DME).

Local Exhaust Ventilation (LEV) – a system that uses extract ventilation to prevent or reduce the level of airborne hazardous substances from being breathed by people in the workplace.

Minimum Ignition Energy (MIE) – the minimum energy that can ignite a mixture of a specified flammable material with air or oxygen, measured by a standard procedure.

Occupational Exposure Limit (OEL) – a generally legally-enforceable limit on the amount or concentration of a chemical to which workers may be exposed.

Personal Protective Equipment (PPE) – an equipment designed to protect employees from serious workplace injuries or illnesses resulting from contact with chemical, radiological, physical, electrical, mechanical, or other workplace hazards. Besides face shields, safety glasses, hard hats, and safety shoes, PPE includes a variety of devices and garments such as goggles, coveralls, gloves, vests, earplugs, and respirators.

Purging – Replacement of hazardous materials from a piping system or machine by inert gas (for maintenance, emergencies or changing propellants).

Risk – the likelihood that a particular hazard will actually cause harm.

Safety Data Sheet (SDS) – Document which presents information on a substance/mixture: identification of the substance/mixture and of the company/undertaking, hazards identification, composition/information on ingredients, first-aid measures, fire-fighting measures, accidental release measures, handling and storage, exposure controls/personal protection, physical and chemical properties, stability and reactivity, toxicological information, ecological information, disposal considerations, transport information, regulatory information and other information.

Source of ignition – heat, flame, static electricity or lightning with sufficient energy to ignite a flammable substance.

Sprinkler system – an overhead piping system to provide large quantities of water – activated when a fire triggers a detection device.

Static electricity – an electrical charge (stationary or moving), developed by frictional forces and normally capable of being discharged to a conductive and grounded surface.

Vapour pressure – the pressure exerted by a vapour that is in equilibrium with its solid or liquid form.

Ventilation air volume – ventilation capacity to maintain the gashouse or local ventilation enclosure below hazardous level.

Venting – allowing the safe escape of hazardous materials from a piping system or machine (for maintenance, emergencies or changing propellants).

Chapter 3

Relevant Directives

3.1. Aerosol Dispensers

- Council Directive of 20 May 1975 on the approximation of the laws of the Member States relating to aerosol dispensers (75/324/EEC)

3.2. Safety at Work

- Council Directive 89/391/EEC of 12 June 1989 on the introduction of measures to encourage improvements in the safety and health of workers at work (‘OSH Framework Directive’)
- Council Directive 89/654/EEC of 30 November 1989 concerning the minimum safety and health requirements for the workplace (first individual directive within the meaning of Article 16 (1) of Directive 89/391/EEC)
- Council Directive 89/656/EEC of 30 November 1989 on the minimum health and safety requirements for the use by workers of personal protective equipment at the workplace (third individual directive within the meaning of Article 16 (1) of Directive 89/391/EEC) (which will be repealed from 21 April 2018)
- Council Directive 90/269/EEC of 29 May 1990 on the minimum health and safety requirements for the manual handling of loads where there is a risk particularly of back injury to workers (fourth individual Directive within the meaning of Article 16 (1) of Directive 89/391/EEC)
- Council Directive 90/270/EEC of 29 May 1990 on the minimum safety and health requirements for work with display screen equipment (fifth individual Directive within the meaning of Article 16 (1) of Directive 89/391/EEC)
- Commission Directive 91/322/EEC of 29 May 1991 on establishing indicative limit values by implementing Council Directive 80/1107/EEC on the protection of workers from the risks related to exposure to chemical, physical and biological agents at work
- Council Directive 92/58/EEC of 24 June 1992 on the minimum requirements for the provision of safety and/or health signs at work (ninth individual Directive within the meaning of Article 16 (1) of Directive 89/391/EEC)
- Council Directive 92/85/EEC of 19 October 1992 on the introduction of measures to encourage improvements in the safety and health at work of pregnant workers and workers who have recently given birth or are breastfeeding (tenth individual Directive within the meaning of Article 16 (1) of Directive 89/391/EEC)

- Council Directive 94/33/EC of 22 June 1994 on the protection of young people at work
- Council Directive 98/24/EC of 7 April 1998 on the protection of the health and safety of workers from the risks related to chemical agents at work (fourteenth individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC)
- Directive 1999/92/EC of the European Parliament and of the Council of 16 December 1999 on minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres (15th individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC)
- Commission Directive 2000/39/EC of 8 June 2000 establishing a first list of indicative occupational exposure limit values in implementation of Council Directive 98/24/EC on the protection of the health and safety of workers from the risks related to chemical agents at work
- Directive 2003/10/EC of the European Parliament and of the Council of 6 February 2003 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise) (Seventeenth individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC)
- Directive 2004/37/EC of the European Parliament and of the Council of 29 April 2004 on the protection of workers from the risks related to exposure to carcinogens or mutagens at work (Sixth individual Directive within the meaning of Article 16(1) of Council Directive 89/391/EEC) (codified version)
- Commission Directive 2006/15/EC of 7 February 2006 establishing a second list of indicative occupational exposure limit values in implementation of Council Directive 98/24/EC and amending Directives 91/322/EEC and 2000/39/EC
- Directive 2009/104/EC of the European Parliament and of the Council of 16 September 2009 concerning the minimum safety and health requirements for the use of work equipment by workers at work (second individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC)
- Commission Directive 2009/161/EU of 17 December 2009 establishing a third list of indicative occupational exposure limit values in implementation of Council Directive 98/24/EC and amending Commission Directive 2000/39/EC
- Regulation (EU) 2016/425 of the European Parliament and of the Council of 9 March 2016 on personal protective equipment and repealing Council Directive 89/686/EEC (which shall apply from 21 April 2018, with the exception of Articles 20 to 36 and Article 44 which shall apply from 21 October 2016; and Article 45(1) which shall apply from 21 March 2018)

3.3. Machines and Electrical Equipment

- Directive 2006/42/EC of the European Parliament and of the Council of 17 May 2006 on machinery, and amending Directive 95/16/EC (recast)
- Directive 2014/34/EU of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of the Member States relating to equipment and protective systems intended for use in potentially explosive atmospheres (recast)

3.4. Hazardous Substances and Mixtures

- Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC
- Regulation (EC) No 1272/2008 of the European Parliament and of the Council of 16 December 2008 on classification, labelling and packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1907/2006

Chapter 4

Design and Good Working Practices for the Laboratory

4.1. Introduction

In addition to the special precautions necessary for the filling, evaluation and handling of aerosols, general principles of *Good Laboratory Practice* (GLP) must be applied. Laboratory safety must be considered when compiling Company Health and Safety policies.

When considering safety issues, all relevant legislation and codes of practice must be considered. Seek guidance in accessing the latest legislative requirements and codes of practice.

The following is a brief introduction to some of the guiding principles – it should be read in conjunction with the latest legislation and codes of practice.

4.2. Risk Assessments of Tasks / Operations and Practical Advice

All actual or potential dangerous tasks, operations or processes that occur in an aerosol laboratory, should be subject to a risk assessment: this is a legal requirement of Management.

Risk assessment should be undertaken by competent individuals, who are familiar with the task, operation or process that is being assessed. The assessment should be performed from a position of safety.

4.2.1 Undertaking Risk Assessments

4.2.1.1. All risk assessments should be uniquely identified; the person undertaking the assessment and date of the assessment should also be recorded.

4.2.1.2. Identify: (i) the task being assessed,
(ii) the person(s) potentially at risk,
(iii) the hazards involved and
(iv) the factors involved.

4.2.1.3. Identify the type of potential injury that may be reasonably foreseen as a consequent of the factors identified. The potential injuries/severity should be classified High (H), Medium (M) or Low (L).

Typically:
High (H): An injury that can reasonably result in a person not being able to attend work for a period of 7 days or more, e.g. fatality, fractures, burns, tissue damage, hospital in-patient treatment etc.

Medium (M): An injury that can reasonably result in a person not being able to attend work for a period of longer than 1 day but less than 7 days, e.g. sprains, strains, hospital outpatient treatment etc.

Low (L): An injury that may not require first aid treatment and which would not reasonably expect to result in any lost time from work, e.g. minor bruising, lacerations, minor burns etc.

4.2.1.4. Identify the probability or likelihood of an event occurring that could result in the injury that has been identified. The probability should be classified High (H), Medium (M) or Low (L).

Typically:
High (H) Certain – no doubt
Likely – to be expected
Probable – no surprise

Medium (M) Even chance – could happen
Possible – but usual
Unlikely – but could occur

Low (L) Highly unlikely – though conceivable
Almost unlikely – possible in extreme circumstances
Almost impossible – barely feasible

4.2.1.5. Once the potential injury and probability have been determined, it is possible to determine the risk. Risk is a result of the severity of potential injury combined with the probability of that injury occurring.

		INJURY/SEVERITY		
		High (H)	Medium (M)	Low (L)
PROBABILITY	High (H)	**HIGH (H)**	**HIGH (H)**	**MEDIUM (M)**
	Medium (M)	**HIGH (H)**	**MEDIUM (M)**	**MEDIUM (M)**
	Low (L)	**MEDIUM (M)**	**MEDIUM (M)**	**LOW (L)**

4.2.1.6. Based on the risk assessment, determine what control methods are in place to control the risk and whether they are adequate.

4.2.1.7. Identify any proposed control measures that could be implemented, to control the risk and determine whether they would be adequate.

4.2.2 Practical Guidance / Control Methods for Laboratories, Post- Risk Assessment

The following gives some general advice on control methodology for flammable and inhalation risks determined after concluding a risk assessment. Of course these are just two potential hazards within an aerosol laboratory. Clearly many other potential risks exist and some are specific to a laboratory and / or the types of products being processed. Each and every risk identified must be addressed, without delay.

The priority for the management of potential risks must always be:
- removal of the hazard
- find a safer alternative
- physical containment of the hazard
- personal protection

4.2.3 Flammable Risks

4.2.3.1. If the risk assessment identifies that any raw material is flammable, then it is important to examine the preparation area and processing equipment to be used to ensure that the risk of vapour ignition is eliminated.

4.2.3.2. Flammable materials should be handled and processed in a flame proof area. Special attention should be given to materials with very low flash points. Vapour loss from the vessels being used for processing should be minimised by, for example, using closed containers or by maintaining low temperatures during the operation. The risk of an electrical discharge, from processing equipment, should be minimised by using appropriately rated equipment.

4.2.3.3. It should be remembered that flammable materials may be ignited by static discharges from surfaces or any unearthed apparatus, and from clothing (particularly silk or nylon) worn by the operative. All apparatus should be earthed and earthing points provided for operatives, especially when very low flash point liquids are being handled. Also, shoes and flooring should be suitably conductive to prevent build-up of static charge.

4.2.3.4. Ventilation / extraction in the preparation area should be designed to prevent the build-up of flammable mixtures in the atmosphere. Attention should also be given to the storage during processing of any flammable ingredients and of the finished product concentrate and / or finished aerosols.

4.2.3.5. The necessary fire fighting equipment should be available and its correct use understood before any laboratory activity commences.

4.2.4 Inhalation Risks

4.2.4.1. Where a potential inhalation hazard is identified then safeguards must be taken to prevent a build-up in the laboratory atmosphere. Atmospheric concentrations of all materials should always be kept as low as possible and the *occupational exposure limit* (OEL) must not be exceeded.

4.2.4.2. Minimising vapour losses from the apparatus, i.e. by using suitably closed containers or maintaining low temperature during manufacture can prevent build-up of hazardous vapour in the atmosphere. Adequate ventilation / air extraction must be provided where there is any possibility of unacceptable vapour loss so that the levels in the work area are maintained well below the OEL.

4.2.4.3. Where a mixture of materials is being handled, with more than one potentially hazardous material, ventilation control should be calculated on the air flow required to maintain all materials below their respective OEL.

4.2.4.4. It is important to ensure that any vapour is extracted away from the operative and not drawn towards them. If other people are in the work area, then equally they must not be exposed to dangerous levels, which might occur through air circulation patterns carrying vapours away from the operator, but towards them.

4.2.4.5. Consideration should also be given to the amount of product to be manufactured where hazardous materials are to be used; for example, minimising the batch size to reduce the risk of over-exposure.

4.2.4.6. In any situation where the OEL is likely to be exceeded then if possible the work programme has to be redesigned to avoid the situation (e.g. substituting with less hazardous ingredients). If this is not possible and the possibility of exceeding the OEL continues to exist, then suitable, properly maintained *personal protective equipment* (PPE) must be used.

4.2.4.7. Where powdered materials are to be used during manufacture, protection must be provided to prevent inhalation of powder particles, via the use of, e.g. local extraction. Care must be taken, when handling such materials, to prevent powder "fly" and to notify others in the same work area of the potential problem, so that they can adopt the appropriate protective measures.

4.3. Personnel

Health and Safety highlights the responsibility of individuals for their own safety and that of others. Management has a responsibility to support staff to recognise individual responsibilities and to act responsibly. The aim should be to foster a safety culture by promoting and encouraging training, good working practices and regular auditing. Focus of attention must be on prevention of accidents, via a rigorous process of risk assessments.

Legislation requires a management structure of competent persons to be in place to cover safety. Where justified by staffing levels, it is advisable to appoint a single person to act as a focus for safety in the laboratory. This person should be an experienced laboratory worker who can advice on safety, experimental operations and laboratory organisation, whilst assisting management in maintaining a high standard of housekeeping.

Management should be conversant with the local legislation regarding notification of accidents and dangerous occurrences that covers the reporting of major accidents and fires. A central record of all accidents and “near misses” must be kept and reviewed at regular intervals by management and safety representatives, in order to identify trends and areas of vulnerability and take precautions against reoccurrence. Every effort must be made to avoid accidents and if they occur reporting is essential.

All new starters, whether permanent, contract or temporary employees, must be given training in safe working practices in addition to job related hazards, prior to commencement of operations in the laboratory. The requirements of this induction training should be documented and once completed records maintained to confirm its completion and understanding by both the employee and employer.

Prior to commencing new experimentation or operation, a full risk assessment must be performed. The risk assessment must consider, for example, Directive 98/24/EC (chemicals) and 90/269/EEC (manual handling) requirements. Based on the outputs from risk assessments, a safety protocol should be devised, in addition to a technical assessment, covering all potential hazards, preventative and protective measures to be taken.

Regular safety audits/inspections of the laboratory should be undertaken, by appropriately trained personnel. These should cover all aspects of safety and housekeeping. Current practices should be identified and compared to company policies and procedures. In addition to measurable factors, the safety culture within the laboratory should be monitored. The utilisation of personnel from outside the laboratory, to review practices, can add an independent dimension to the audit process.

As non-laboratory personnel may be required to work in the laboratory, for example maintenance contractors, procedures in the form of a “Permit to Work” system should be in force to ensure that such work can be undertaken without exposing the individual(s) to risk. Attention must be given to the levels of training and supervision necessary in these circumstances.

Lone working in the laboratory is to be discouraged. If it is essential to work alone, appropriate risk assessments must be undertaken and preventative protocols followed for example the use of lone worker pagers.

4.4. *Laboratory Design*

Design of a laboratory is dictated by a number of factors. Of paramount importance is the need to design out risk. The following list, whilst not exhaustive, should be considered:

- Local, national and regional legislation.
- Industry best practice.
- Scope of the work being undertaken.
- Size of the laboratory.
- Number of personnel likely to occupy the laboratory – both now and in the future.
- Location of fixed benches and equipment.
    - Free access with no obstructions.

- Location of fume hoods.
- Location, size and what will be stored
    - Aerosols must be stored in appropriately labelled well-ventilated areas. The areas should contain gas detectors and sprinkler systems and should be able to contain a fire for a time period agreed with insurers and fire authorities.
    - Storage racking should be appropriate for goods to be stored, with due consideration being given to Manual Handling regulations.
    - All materials and products should be appropriately labelled, due consideration needs to be given.
- Piped services, for example, water, propellants, compressed air, steam must be clearly identified with a tag or indelible label.
- Where flammable materials are handled the design and specification of all electrical equipment and fittings must be in accordance with current legislation. The necessity to eliminate the possibility of electrical or electrostatic discharge is paramount.
    - Intrinsically safe componentary and connectors must be employed.
    - Mobile phones / pagers, except intrinsically safe, should be excluded.
    - Nylon clothing, for example nylon reflective jackets, should be excluded.
    - Due consideration of the Chemical Agents Directive and ATEX (Explosive Atmosphere) Directive 1999/92/EC.
- Lighting should enable clear visibility in all areas.
- General ventilation should, ideally, be achieved via a purpose designed forced air system.
- Appropriate *local exhaust ventilation* (LEV) will be necessary, as defined in risk assessments.
- Flooring should be of good integrity and non-slippery.
    - When operating in an environment where flammable materials are handled, consideration should be given to reducing any potential build of electrostatic charge between the soles of the shoes / boots and the flooring.
- Fire / smoke detection systems and alarms should be selected after consultation with insurers and the fire authorities.
    - Regular maintenance and testing of such systems is essential.
- Sprinkler systems should be selected after consultation with insurers and the fire authorities.
    - Regular maintenance and testing of such systems is essential.
- Escape routes should be designed in conjunction with fire authorities. Escape routes and fire doors must be identified with appropriate signage.
- The laboratory design should ensure there is an appropriate “non laboratory” area to allow personnel to eat / drink etc.
- Throughout the laboratory there should be appropriate signage. The signage should:
    - identify hazards and preventative / precautionary actions
    - indicate restricted access, as appropriate
    - storage areas and precautions necessary
- Gas detectors / alarms must be employed in any area where hydrocarbon gases are employed.

4.5. *Personal Protection*

The priority for the protection of personnel shall always be:

- removal of the hazard
- find a safer alternative

- physical containment of the hazard
- personal protection

The choice of *personal protective equipment* (PPE) to be employed, in a given situation, should result from risks assessment prior to starting the process / operation. PPE must bear CE mark in accordance with Directive 89/656/EEC until 20 April 2018 and Regulation (EU) 2016/425 from 21 April 2018.

Personnel must dress suitably for working in the laboratory, for example clothing must not be too loose, nor must it be easily ignited and long hair should be controlled. A laboratory coat or other suitable protective clothing and approved safety footwear shall be worn.

Personal protection is required in most laboratories, depending on the nature of the chemicals and processes involved. The aim should be however to eliminate the need for PPE by controlling the hazard at source. Reference should be made to the Personal Protective Equipment and other relevant Health and Safety regulations.

Issue and control of PPE should be done following a risk assessment of all chemicals and processes involved.

4.5.1 Eye Protection

Eye protection should always be mandatory in laboratories. The type of eye protection, for example spectacles, goggles, facemask, laser goggles, will be determined by risk assessments.

The wearing of contact lenses in the laboratory may cause problems, in the event of contamination. Prescription lenses can be fitted into frames of safety goggles or spectacles.

4.5.2 Hand Protection

The choice of gloves or other hand protection to be used in a given situation should result from risk assessments prior to starting the process / operation. If it is not possible to obtain suitable hand protection, then the basic process should be re-evaluated.

4.5.3 Footware

The choice of foot protection to be used in a given situation should result from risk assessments prior to starting the process / operation.

In addition to providing protection from chemical and physical hazards, the footware should incorporate conductive soles between 5×10^4 and 10^8 Ω (ohm).

4.5.4 Respiratory Protection

Inhalation of materials that may be irritant, toxic or harmful must be avoided. The need for respiratory protection should be determined from risk assessments prior to starting the process / operation.

4.6. Visitors

All visitors should be as well protected as those working in the laboratory and should be made aware of safety protocols. Care should be taken by everyone who normally works in the laboratory to ensure that a visitor is not placed in danger through ignorance or a lack of *personal protective equipment* (PPE).

4.7. Safety Equipment

It is essential to provide appropriate safety equipment for both protective and emergency use. The emphasis should be on safely designed operations that minimise the need for safety equipment. The quality and type of equipment needed will be dependent on the type of work undertaken.

The following are some of the more common type of safety equipment – the list is not exhaustive:

4.7.1 Preventative Equipment

Shields and Guards – machinery with moving parts must be well guarded. Suitable shielding must also be used for operations that present potential hazards.

Fumehoods / local exhaust ventilation (LEV) – when a risk of contamination of the laboratory atmosphere is present, additional ventilation must be provided to ensure that exposure to hazardous materials does not occur.

Signs – Permanent and temporary signs should be available to indicate hazards and escape routes.

4.7.2 Emergency Equipment

Fire Fighting – In conjunction with the local fire authorities, suitable fire fighting equipment should be deployed for the particular hazard. Fire extinguishers should be kept in an obvious location and properly signed. Regular inspections of the appliances are essential, with defective equipment being replaced immediately.

First Aid Provision – There is a specific need for trained First Aid personnel to be present at all relevant times and for the employer to provide adequate First Aid provisions for employees.

Eyewash / Shower Systems – Sterile eyewash bottles and / or a purpose built, regularly tested, eyewash station should be strategically placed in the laboratory. Depending on the nature of the material being handled, it may be appropriate to deploy emergency showers to remove any contamination from clothing or the skin.

Spill Kits – Suitable materials for the handling of spillages of hazardous materials should be available.

Chapter 5

Processing Ingredients (Formulation)

Evaluation of the physicochemical properties and health effects of the potential ingredients is an important part of the development process. The resulting understanding will enable the development of strategies to control these hazards during preparation of the proto-type product formulation. Consideration should be given to whether any hazardous by-products or intermediates may be formed or whether impurities in the raw materials pose hazards during the manufacture or storage of the finished aerosol. CLP Regulation (EC) No 1272/2008 lists 16 physical, ten health and two environment hazard classes that should be considered, it is reproduced in Appendix 1.

5.1. Risk Assessment

Health and Safety are important considerations for the laboratory and irrespective of whether a proposed change is a new ingredient, a new process method or a completely new product: There is always a possibility of creating new risks to health or safety. From a regulatory perspective, the REACH Regulation (EC) No 1907/2006 requires health and safety risk assessments of potential hazards which may arise during the handling of raw materials, their mixing and processing into finished aerosols.

It is always more efficient to identify potential hazards at the design stage of the development process and take preventative actions to control any risks rather than to retro-fit expensive engineering solutions on a long lead-time to control the hazards. Special attention needs to be paid to raw materials that are new to the laboratory. Therefore before any aerosol product concentrate is prepared a risk assessment of the toxicological and physiochemical properties according must be conducted. Assessments should result in a document that is used to inform the operator and colleagues in the area, of the hazards likely to be encountered, the methods to be used and in case of an accident, the subsequent actions to be taken. The ingredients and the method of processing selected should be designed so that the risk of any of the hazards occurring is eliminated or reduced to a minimum.

In a chemical risk assessment Risk = Hazard × Exposure

Hazard: The way in which a substance or preparation may cause harm i.e. a physical injury and/or damage to health, property or environment.
Exposure: The extent to which the likely recipient of the harm is exposed to – or can be influenced by – the hazard.
Risk: The probable rate of occurrence of a hazard causing harm; and the degree of severity of the harm.

It follows that risk may be reduced either by:

- Choosing an alternative raw material which fulfils the same purpose but significantly reduces the risk during processing.
- Using a control measure to reduce exposure, for example using a fume cupboard during development work.

However, the hazardous nature of any substance should not be considered in isolation as the process and the people using the substance will often dictate the controls needed to minimise risk.

In many cases a simple risk assessment will be sufficient, but it may be necessary for a more detailed investigation.

5.2. Physical Hazards

The CLP Regulation (EC) No 1272/2008 defines 16 classes of physical hazards, these are: Explosives, Flammable gases (including chemically unstable gases), Aerosols, Oxidizing gases, Gases under pressure, Flammable liquids, Flammable solids, Self-reactive substances and mixtures, Pyrophoric liquids, Pyrophoric solids, Self-heating substances and mixtures, Substances and mixtures which in contact with water emit flammable gases, Oxidising liquids, Oxidising solids, Organic peroxides and Corrosive to metals (see § 11.1.1. for definitions of each hazard class). Risk assessments should include consideration of all categories for each ingredient of any proposed new formulation. In particular because a significant number of the ingredients used in aerosol formulations are either flammable gases or flammable liquids it is important that the potential flammability of the ingredients, intermediates, product concentrates and finished aerosols is considered at an early stage of development.

The main sources of hazard data are the suppliers' *safety data sheets* (SDS). Alternatively a risk assessment based on historical data of product composition information for similar systems can help identify those aerosol products where flammability is a concern. For example although compressed gases tend to be non-flammable the incorporation level is usually low, so an alcohol-based product propelled with carbon dioxide may still contain approximately 95% flammable materials. Through careful selection of raw materials, propellant type and concentrate/propellant ratio the product formulator has the ability to influence the flammability risk during manufacture. As a consequence it is essential that the flammability hazards and the risks associated with a product are fully evaluated during the development process.

When powders are transferred, be aware of their potential to build up static electricity by friction and take appropriate measures to prevent dust explosions!
Where powders are being handled, ensure there is adequate dust extraction. In dust filters, all conductive parts, conductive filter cloth support baskets, clamps, straps, etc. should be grounded.

5.2.1 Practical Steps for the Laboratory

If the risk assessment shows that any raw material is flammable, then it is important to examine the preparation area and processing equipment to be used to ensure that the risk of vapour ignition is eliminated. Flammable materials should be handled and processed in a flame proof area. Special attention should be given to materials with very low flash points. Vapour loss from the vessels being used for processing should be minimised by, for example, using closed containers or by maintaining low temperatures during the operation. Ventilation/extraction in the preparation area should be designed to prevent the build-up of flammable mixtures in the atmosphere. Attention should also be given to the storage during processing of any flammable ingredients and of the finished product concentrate and/or aerosol.

It should be remembered that flammable materials may be ignited by static discharges from surfaces or any unearthed apparatus, and from clothing (particularly silk or nylon) worn by the operative. All apparatus should be earthed, especially when very low flash point liquids are being handled. Also, shoes and flooring should be suitably conductive to prevent build-up of static charge.

The necessary fire fighting equipment should be available and its correct use understood before preparation of the formulation begins.

5.3. Health and Environmental Hazards

The CLP Regulation (EC) No 1272/2008 lists 10 health and 2 environmental hazard classes: Acute toxicity, Skin corrosion/irritation, Serious eye damage/eye irritation, Respiratory or skin sensitisation, Germ cell mutagenicity, Carcinogenicity, Reproductive toxicity, Specific target organ toxicity — single exposure, Specific target organ toxicity — repeated exposure, Aspiration hazard, Hazardous to the aquatic environment and Hazardous to the ozone layer. These hazard classes have a number of categories to reflect either mode of action or the varying degrees of hazard (see § 11.1.2. for additional information).

Aerosol propellant, solvent and any dusty material in the formulation, e.g. silica, aluminium salts, paint pigments, should be regarded as potentially hazardous materials. Therefore before preparation of a new formulation, a toxicological evaluation of the ingredients should be carried out to provide appropriate medical advice in case of an accident. The results of the assessments should also be used to prescribe the appropriate *personal protective equipment* (PPE) to be worn and the working procedures to be followed by operatives. Assessments should be recorded – whether formal or informal. Depending on local legislation, data from personal exposure to toxic material may need to be retained for more than 30 years after the date of measurement.

All ingredients should be subjected to a chemical risk assessment before use, with consideration given to both the short term and the long term exposure levels on a time weighted average basis. As required by the assessment, appropriate methods of working should be utilised to prevent exposure by ingestion, inhalation, or by the dermal routes.

5.3.1 Practical Steps for the Laboratory

5.3.1.1. Inhalation

Where a potential inhalation hazard is identified then safeguards must be taken to prevent a build-up in the laboratory atmosphere. Atmospheric concentrations of all materials should always be kept as low as possible and the OEL must not be exceeded at any time.

Minimising vapour losses from the apparatus, i.e. by using suitably closed containers or maintaining low temperature during manufacture can prevent build-up of hazardous vapour in the atmosphere. Adequate ventilation/air extraction must be provided where there is any possibility of unacceptable vapour loss so that the levels in the work area are maintained well below the OEL.

Where a mixture of materials is being handled, with more than one potentially hazardous material, ventilation control should be calculated on the air flow required to maintain all materials below their respective OEL.

It is important to ensure that any vapour is extracted away from the operative and not drawn towards them. If other people are in the work area, then equally they must not be exposed to dangerous levels, which might occur through air circulation patterns carrying vapours away from the operator, but towards them.

Consideration should also be given to the amount of product to be manufactured where hazardous materials are to be used e.g. in minimising the batch size to reduce the risk of over-exposure.

In any situation where the OEL is likely to be exceeded, the work programme should be redesigned to avoid the situation (e.g. substituting with less hazardous ingredients). If this is not possible and the possibility of exceeding the OEL continues to exist, then suitable, properly maintained respirators must be used.

Where powdered materials are to be used during manufacture, protection must be provided to prevent inhalation of powder particles. Care must be taken, when handling such materials, to prevent powder "fly" and to notify others in the same work area of the potential problem, so that they can adopt the appropriate protective measures.

5.3.1.2. Dermal or Skin Contact

As part of the chemical risk assessment data should be consulted to discover if any of the materials has any hazardous dermal properties. If a hazard of this type is identified, precautions must be taken to ensure that skin contact is prevented, i.e. by suitable clothing, gloves etc. The correct method of treatment must be understood in case of accidents and suitable treatment facilities must be available.

5.3.1.3. Ingestion

It is important to ensure that raw materials are not transferred accidentally:

- into areas where food or drink is consumed
- to the operative's mouth, due to contaminated hands, or clothing worn during and after the handling operation.

Chapter 6

Propellants

There are many regulations referring to the storage, handling and safe use of propellants, in particular hydrocarbons and dimethylether. It is not the intention of this Chapter to reiterate the total content of all these regulations; they are sometimes country dependent and therefore the responsibility of the user. Of course users have a duty to read and comply with them.

This Chapter focuses on the practicalities of propellant handling on a laboratory scale and on the description of good practices.

The best source of information, other than these regulations, in any instance of uncertainty with respect to the safe handling of any propellant, is your supplier.

6.1. Storage and Handling

6.1.1 General

The laboratory must at all times be maintained in a tidy and organised condition and must never be allowed to become a general storage area for propellants. It is imperative that the minimum quantity of propellant sufficient to meet immediate needs of laboratory work should not be exceeded. The main storage compound must be located in a safe area away from any pit or drain, well enclosed and remote from access by unauthorised persons and safeguarded from vandalism. The area must be well ventilated and separated from any source of heat or possible leakage of flammable solvents or fuel. Flammable, non-flammable and compressed gas propellants must be segregated from each other in storage, both as full and "empty" containers according to the local provisions. Each propellant must be clearly labelled for identification and safe use. Furthermore the storage facilities might fall under the ATEX Directive 1999/92/EC (depending on the amount stored, risk inventory and measures taken) and should be protected according to this legislation.

6.1.2 Propellant Packages

Propellants used in the laboratory will usually be contained in gas cylinders or conventional aerosol containers. As propellant cylinders are pressure vessels it is essential that they are correctly handled.

- They must never be dropped or otherwise damaged by rough handling.
- They must never be rolled along the ground in view of the risk of damage by stones or sharp objects.

- Before cylinders are moved, any regulator must be removed first and the protective valve dome (if supplied) must be securely fitted. It is advisable that a trolley specifically designed for transportation of such cylinders is used.
- Cylinders must be securely chained in the in-use or storage position.
- Cylinders must not be stored on their sides.

The filling of cylinders from large containers e.g. bulk manufacturing supply or storage tanks is forbidden. It is also forbidden to use cylinders as mixing vessels to prepare propellant blends.

If a cylinder is overfilled, any slight increase in temperature could result in the container becoming liquid full. Further temperature increase will develop hydraulic pressure at a rapid rate which can deform or rupture the container violently. It is known that when a cylinder is liquid full, any degree temperature rise will cause an additional pressure rise of 3 bar! For the same reason, unless non return valves are fitted, liquefied gas propellant cylinders must never be manifolded together.

Where non-standard propellant blends are required, this should be accomplished by multi-shot filling each propellant constituent individually using equipment designed solely for that purpose. Start with the propellant having the lowest intrinsic pressure and work towards that having the highest so that the likelihood of back flush into the supply container in each case is minimised.

For certain applications, it may be necessary to further increase the pressure within the reservoir container by the addition of a compressed gas. Under no circumstances must the developed pressure be allowed to exceed the maximum safe working pressure of that container. Always consult suppliers' literature prior to attempting such an action. Whenever a cylinder is over-pressurised, a relief device must be fitted into the gas supply line to safeguard that container in the event of failure of the pressure regulator. This device must be sufficient in size to vent the full flow of gas safely to atmosphere.

Heating of any pressurised container for whatever purpose deemed necessary should only be attempted with extreme caution. Such heating should only take place within an industry-recognised water bath. Any aerosol so treated should be securely restrained in a wire cage to protect the operator in case of failure of the container.

The water bath should be fitted with a safety thermostat, in the event of failure of the primary thermostat. Under no circumstances should direct heat be supplied by naked flames, radiant electric heaters or live steam.

Never allow people to bend over the water bath to look if the aerosol cans leak. If an aerosol can explodes in a water bath (e.g. due to temperature limit failure or damaged can) the force of the explosion will be rather severe and may cause serious injuries due to the impact of the can and/or the hot water!

Never use hot tap water to increase the pressure of the aerosol container (e.g. for better transfer purposes) because this might lead to uncontrolled increase of pressure and possible failure of the can. If propellant transfer from one to another container is difficult it is advised to cool the receiving aerosol can in order to facilitate the transfer.

A cylinder which has held aerosol propellant and is apparently empty will still contain propellant vapour and must be handled as if it was full. The valve must never be left open as air may enter, and in the case of the propellant being flammable, may form an explosive mixture.

The net contents of a liquefied gas propellant cylinder can only be established by check weighing. The reading on a pressure gauge may be misleading and, in any case, only indicates the internal pressure and not the level of contents.

For disposal of empty aerosols, special measures have to be taken which are mentioned in Chapter 10 *Disposal*.

6.1.3 Propellant Handling

All propellants which may be used in the laboratory will have different chemical and physical properties, e.g. solvency power and vapour pressure. All equipment, pipework and in particular seals used to handle propellant must be capable of withstanding all possible chemical properties of the propellant and must have an adequate safe working pressure commensurate with the physical properties of the propellant involved. Attention is drawn to the particularly aggressive nature of dimethylether (‘DME’) in this respect.

All propellants must at all times be treated respectfully and should only be handled in well ventilated areas like a fume cupboard. In view of their low boiling points, suitable precautions should be taken by the use of appropriate protective clothing to avoid spraying liquid or vapour onto the skin and particularly into the eyes; as freezing of tissues or eye fluids could result. Long term exposure to the liquids may result in skin complaints.

Temporary propellant pipework must be avoided. Where flexible pipework is installed, it must be inspected at regular intervals for possible damage due to chafing. If plastic pipework is used this should be braided and reinforced, and its chemical compatibility with the propellant must be ascertained. Prior to the maintenance of filling equipment, it is imperative that the entire system is vented in a safe and controlled manner and thereafter purged with an inert gas e.g. nitrogen. If plastic (non conductive) pipework is used, earth continuity must be ensured. In practice it will be very difficult to avoid the build-up of static electricity with plastic (non-conductive) pipework when handling propellants (or e.g. when a leakage occurs). Therefore the system should be carefully checked by an expert in the field of static electricity before operation, and wherever these plastic connections can be avoided they should be replaced by conductive parts.

In a laboratory where many different propellants may be employed it is imperative that a *suitable* venting facility should be included which is capable of the safe discharge of propellant to a well ventilated location outdoors. *Suitable* means also that the exhaust facility should never be able to act as an ignition source for the relieved gases (design should be according to the appropriate ATEX Directive 2014/34/EU guidelines[2]).

To minimise propellant losses when frequent changeovers of propellant are made, pipework must be kept to a minimum. Self sealing quick release hose couplings should be employed.

At the end of each operation the propellant supply must be isolated at the cylinder valve and the pump safety shut-down valves.

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[2] Guidance available at: http://ec.europa.eu/growth/sectors/mechanical-engineering/atex/index_en.htm

6.2. Propellant Systems

For the purpose of this document aerosol propellants can be segregated into the following categories:

- Non flammable liquefied gas propellants e.g.

  Hydrofluorocarbon HFC-134a (1,1,1,2-tetrafluoroethane, HFA-134a)

  Hydrofluoroolefin HFO-1234ze (1,3,3,3-tetrafluoropropene)

- Flammable liquefied gas propellants e.g.

  Hydrocarbons (Propane, Butane, Iso-butane)

  Dimethyl ether ('DME')

  Hydrofluorocarbon HFC-152a (1,1-difluoroethane, HFA-152a)

- Compressed soluble and insoluble gases e.g.

  Air, Nitrogen (N_2), Carbon Dioxide (CO_2), Nitrous Oxide (N_2O).

Atmospheric concentrations must be kept to a minimum and must never be permitted to exceed the recommended OEL (where applicable).

Inhalation of very high concentrations of gas or vapour, even for short periods, must be avoided as this can cause unconsciousness or even death. This is not only valid for the flammable propellants but also for e.g. nitrogen which is sometimes considered as "not dangerous at all" but can cause even death if circumstances are bad! Anyone suffering from the effects of inhalation of vapour must be moved to the open air and kept rested. Medical advice should be sought.

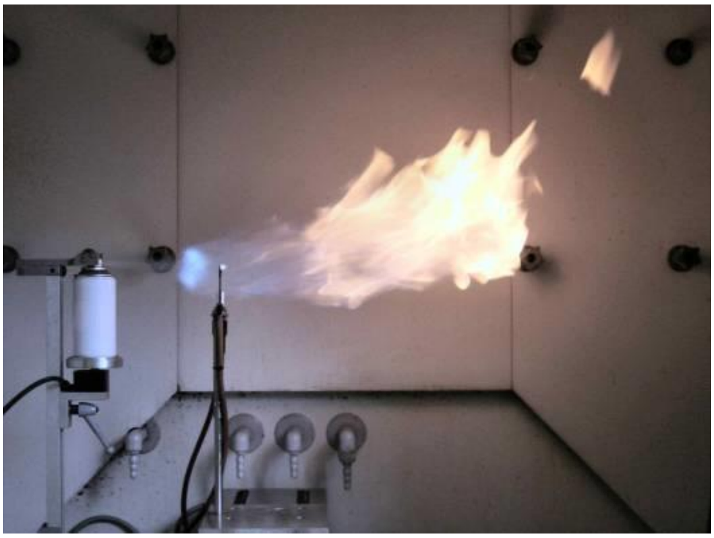
6.2.1 Non Flammable Liquefied Propellants

Following major studies undertaken to research alternative fluorocarbon propellants, hydrofluorocarbon HFC-134a is used as replacement for non-flammable *chlorofluorocarbon* (CFC) propellants which were used before 1989. More recently, HFO-1234ze has been designed to substitute HFC-134a.

These two propellants are unique insofar that it is the only permitted liquefied propellants which are non-flammable. However HFO-1234ze exhibits flame limits at temperatures in excess of 28˚C. It is also very important to consider the fact that, under exceptional circumstances, e.g. at temperatures above 400°C, they may contribute to a fire and like HFC-152a *hydrofluoric acid* (HF) and *carbonyl fluoride* (COF_2) may be released in a fire which is highly corrosive (HF) and toxic (COF_2) and therefore will "attack" equipment. More important is that HF and COF_2 in smoke are very dangerous for people in the vicinity of such a fire. These effects can be mitigated by proper fire suppression measures similar to those for hydrocarbons.

HFC-134a has a low boiling point and generates high pressure when used as sole propellant (4.9 bar at 21ºC; 13.2 bar at 50ºC). Mixing with solvents or other propellants allows for reduction of the vapour pressure as appropriate.

6.2.2 Flammable Propellants



This group of propellants comprises:

- Blends of aliphatic hydrocarbons (Propane, butane, iso-butane)
- Dimethylether (‘DME’)
- HFC-152a.

All these materials form flammable mixtures in air and as such all safety procedures outlined in Chapter 4 *Design and Good Working Practices for the Laboratory* must be strictly adhered to.

6.2.2.1. Hydrocarbon Propellants

This major group of propellants is produced mainly from mixtures of propane, n-butane and iso-butane (iso-pentane is also used) to give specific vapour pressures as required by the aerosol formulator. Because hydrocarbons originate from natural sources they contain small quantities of other volatile hydrocarbons such as ethane, propylene and pentane, together with a low level (not more than 2%) of unsaturated hydrocarbons. Mixtures with different pressure, depending on the required application, can be obtained via the supplier.

6.2.2.2. Dimethylether (‘DME’)

DME is supplied as a pure chemical compound. Because of its unique properties of high miscibility with water and high solvency power it is possible to formulate aerosol products that are totally non-flammable when sprayed. Nevertheless, the same stringent precautions must be taken when handling this propellant.
As mentioned, this propellant has exceptionally strong solvency power which might result in damage of elastomeric seals and couplings and the hazard of consequent leaks. This property must be considered during the course of design of any equipment likely to come in contact with it. Advice from appropriate suppliers must always be sought.

6.2.2.3. HFC-152a (Difluoroethane)

Hydrofluorocarbon HFC-152a is also supplied as a pure chemical compound. This propellant has Global Warming Potential (GWP) of 124[3] and can replace HFC-134a in some applications, which are prohibited in the F-gases II Regulation (EU) No 517/2014.

Hydrofluorocarbon HFC-152a is also used in products (e.g. hairsprays) which are produced in Europe specifically for the US-market, to comply with U.S. EPA[4] or CARB[5] VOC[6] standards in consumer products.

6.2.2.4. Physical Properties of Flammable Propellants

For the physical properties of the different propellants it is referred to the *safety data sheet* (SDS) of the propellants as available via the respective suppliers.

6.2.2.5. Specific Precautions for the Handling of Flammable Propellants

At no time must any source of ignition e.g. matches, lighters or electronic equipment such as calculators, mobile phones and communicators, be brought into a room designed for either storage or filling of flammable propellant gas unless they are certified as being intrinsically safe. In this respect it is worthwhile to mention that the Minimum Ignition Energy (MIE) of flammable gases is well below 1 mJ which makes it easy to ignite a flammable cloud with a broad scale of ignition sources.

Storage facilities for all flammable gas propellants must be designed to give adequate ventilation in order to prevent any build up of gas to critical levels. Wherever possible it should be located externally to main buildings and have natural ventilation. Storage at basement level is forbidden by legislation and should anyhow be avoided due to the possibility of accumulation of the heavy vapours.

All gas-filling rooms must have adequate ventilation maintained at all times. In the event of a leak where the propellant concentration exceeds 20% of the *lower explosion limit* (LEL), the air flow rate should be increased. At higher LEL level (mostly 40% LEL is used) it is advised to stop all gas supply. These measures have to be according to the risk assessment for the gas-filling room and to comply with local legislation.

All gas detectors must be regularly calibrated to ensure correct functioning at all times. It is imperative that the detectors are so designed that they are not desensitised by any other material that may be used in this area.

Any electrical equipment that is operated in the storage or filling area must be totally flame-proofed and "Ex" rated according to the ATEX Directive 2014/34/EU zoning and classification.

Spark proof tools must be used when appropriate e.g. where there is a risk of flammable atmospheres. It is proven that sparks originating from tools are capable of igniting sensitive flammable mixtures.

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[3] Source: F-gases II Regulation (EU) N°517/2014, Annex I

[4] U.S. EPA: U.S. Environmental Protection Agency

[5] CARB: California Air Resources Board

[6] VOC: Volatile Organic Compound

The build-up of static charges represents a significant hazard in the filling of flammable gas propellants. All equipment must be adequately earthed. Earthing should regularly be checked (e.g. by a certified external company).
Clothing worn by personnel should be selected to minimise similar hazards.
One of the most important items regarding static electricity are shoes and floors. They should be suitably conductive to prevent build-up of static charge. In general a maximum resistance to earth of the combination of operator and floor of $10^8\ \Omega$ is considered as being safe to avoid build-up of static electricity to dangerous levels.

6.2.2.6. Mixtures

Whenever filling of mixtures of flammable and non-flammable gases is carried out all precautions that would be taken for flammable gases alone must be maintained.

6.2.3 Compressed and Dissolved Gases

A number of compressed gases have found application as aerosol propellants. The commonest in use are:

- Insoluble e.g. Air, Nitrogen (N_2)
- Soluble e.g. Carbon Dioxide (CO_2), Nitrous Oxide (N_2O).

These propellant gases may be used as the sole propellant or alternatively as an overpressurising agent.
It is imperative that the pressure regulator fitted to any cylinder is correctly chosen for the gas being used and that it is also regularly inspected and maintained according to the manufacturer's instructions.
Gas cylinders may be fitted with or without diptubes. It is essential that the correct type of cylinder is used with any filling equipment. Failure to do so may result in the equipment being subjected to pressures above that for which it was designed. This could lead to personal injury.
Overfilled or overpressurised aerosol containers must be treated with caution and disposed of according to the methods described in Appendix 5 *Handling of Defective Containers*.

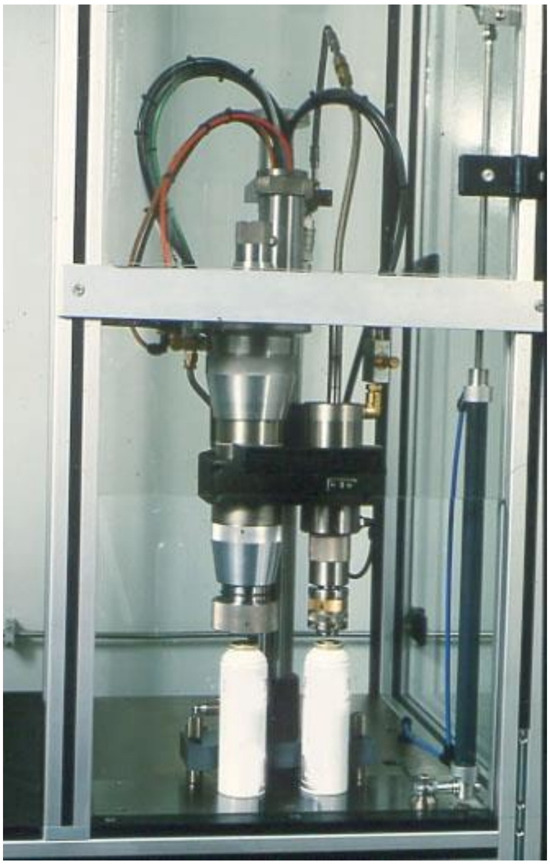
6.3. Increase in volume for evaporating propellants

The transfer from liquefied propellant to gas is instantaneous and results in a volume increase of 250-350 times (depending on the type of propellant used). Mixing with air to the *lower explosion limit* (LEL) results in an even bigger flammable gas cloud.

As a rule of thumb it can be stated that a release of 100 ml of liquefied propellant results in a flammable gas cloud of 1000-1500 litre!

Chapter 7

Aerosol Filling



Among the various aspects of aerosol production, the gassing stage presents one of the greater hazard areas to personnel, since it involves pressurised systems. Particular care must be taken to prevent leakage and regular maintenance of all gassing equipment is essential.

The possible rupture of faulty or overfilled aerosol containers is another hazard, which must be considered. Aerosol propellants are, generally, flammable and therefore present the additional risks of fire or explosion.

Laboratory gassing techniques, particularly transfer filling, will often bring the operator into close proximity with these potential hazards.

Therefore all personnel involved in gassing aerosol containers must exercise maximum care and use all appropriate safety equipment. Eye protection is of particular importance during filling operations.

Smoking must not be permitted at any time.

7.1. Strength of Container

An aerosol laboratory usually stocks a wide range of empty containers of varying construction, size, strength, and material. The container should be chosen carefully to match the formulation being filled. The strength of the container, in terms of deformation and burst test pressure, must always be adequate for the intended contents. Stored empty containers should be identified as to their pressure rating.
Information on these aspects is covered by the Aerosol Dispensers Directive 75/324/EEC.

Particular attention should be paid to container strength when using glass containers. Refer to § 7.5.7 of this Chapter.

7.2. Control of Filling Quantities

It is essential that laboratory personnel control maximum fill levels to avoid the danger of dispensers becoming liquid full and bursting, due to hydraulic pressure when subject to a temperature rise. Maximum safe fill levels for various types of container are covered in the Aerosol Dispensers Directive 75/324/EEC.

Note, however, that whilst the maximum fill requirements are defined in volume terms, they are most easily controlled by check weighing and the knowledge of the product density (See standard FEA 605 *Filled aerosol packs – Measurement of the density of aerosol formulations*).

7.3. Concentrate Filling & Container Sealing

Filling concentrate into aerosol containers in the laboratory should be subject to the same precautions described in Chapter 5 *Processing Ingredients (Formulation)*. The following measures should also be taken where appropriate:

- Before filling, examine the empty containers, and valves for defects. Reject where necessary.
- When concentrate has been filled, valves should be crimped / swaged in place as soon as possible to avoid loss of contents, contamination, or the "pick-up" of water vapour or oxygen. Also, uncrimped cans are prone to spillage.
- Crimp dimensions must be checked at frequent and regular intervals to avoid drifting from target and to detect any malfunction of equipment.

It is important that crimp/swage dimensions are within the appropriate tolerances.
If necessary the crimper must be adjusted accordingly, following agreed protocol.
Dispose of containers with incorrect crimp/swage dimensions as soon as possible.
Refer to Chapter 10 *Disposal*.

7.4. Can Purging

Purging is the removal of air from the container headspace prior to fixing the valve in place. It is done to maintain container pressure within safe limits and for technical reasons associated with product stability and spray characteristics.
Complete removal of all air in the pack is not necessary and in some instances could prove detrimental to corrosion performance as some systems need a small amount of air as stabiliser. The usual practice is to remove about half the volume of air in the pack before the valve is crimped into position.

When pressure filling, the problem of excess entrapped air occurs if no provision is made to displace the air. With this method, concentrate displaces its own volume of air before the valve is in position. After crimping, the propellant is pressure-filled through the valve which compresses the remaining trapped air above the liquid, thereby increasing the pressure within the pack, perhaps to a dangerous level.

Transfer (or equilibrium) filling can be difficult if excess air is present. The attainment of full fill weights can be slow or impossible and occasional reverse flow back into the transfer line/container can lead to contamination.

It should be noted that whilst purging is normally desirable in the interests of general product quality, there are applications when the presence of air is beneficial. These depend entirely on the formulations involved and it is not practicable to quote specific examples. Propellant purging has certain limitations, for instance, if the concentrate is particularly cold or is a good solvent for the purging propellant, evaporation will be slow and purging may be relatively inefficient. The choice of purging propellant depends on the formulation and packaging in question and should be made with these factors in mind. Whilst purging with flammable propellants should be avoided, if absolutely necessary, adopt the safety precautions in § 7.5.3 *Transfer Filling* below.

When a laboratory is working for a particular production unit, the method in use in that unit must be reproduced in the laboratory.

7.5. Gassing

In the laboratory environment, gassing may be achieved in several ways:

- Using conventional aerosol filling equipment (§ 7.5.2)
- Transfer filling (§ 7.5.3)
- Cold filling (§ 7.5.5)
- Burette Filling (§ 7.5.6.)

7.5.1 General

Eye protection must be worn during gassing operations. Also, the equipment must be properly guarded. A chemical risk assessment must be carried out and the appropriate personal protective equipment provided and used.

Gassing should take place in an area segregated from the main laboratory area. A separate specialised gassing room is ideal. Most aerosol propellants are flammable; therefore, the area must be flameproof.

All conventional liquefied propellants have vapours heavier than air, which should be remembered when designing extraction systems for the gassing area.

The main features of gassing room design are discussed in Appendix 2.

7.5.2 Pressure Filling

7.5.2.1. All Propellants

It is strongly recommended that automatic or semi-automatic filling equipment should be supplied with a primary enclosure with mechanical ventilation.

There must be an established Gassing Room procedure, fully understood by all personnel, covering both routine operation and the necessary actions in the event of an emergency. A risk assessment of the gassing operation should have been carried out.

- No one should be allowed to work alone at any time when gassing aerosols.
- Appropriate measures must always be taken to prevent propellant leakage.
- As the equipment in a laboratory may be used in an intermittent fashion, careful maintenance is necessary to ensure freedom from both propellant and air leaks, which may develop even when machinery stands idle.
- When a machine is used for several different propellants, the propellant last in use should be indicated on the machine. Better still a diary of use should be maintained.
- All seals must be appropriate to the propellant in use. Particular care must be taken when using DME.
- When changing propellant, turn off the propellant supply, and discharge unused propellant from the equipment by controlled discharge to the outside atmosphere, preferably via the extraction system. An alternative is filling into suitable aerosol containers, with subsequent disposal. Refer to Chapter 10 *Disposal*.

7.5.2.2. Propellant Filling (Flammability Issues)

Most aerosol propellants are flammable; therefore, gassing requires a purpose built facility. The following points are worthy of special note in addition to the comments given in § 7.5.1 and § 7.5.2.1:

- The gassing room must be flameproof.
- The main features of gassing room design are discussed in Appendix 2 *Some Features of Gassing Room Design.*

- All the conventional liquefied flammable propellants have vapours heavier than air and this feature must be noted during the design of any air extraction system.
- Laboratory staff and other personnel entering the gassing room should check that the following items are not on their persons: all possible sources of ignition, including watches, mobile phones, radios, calculators, paging devices, matches and lighters.
- Because of the need to minimise the generation of static electricity, clothing should be cotton or cotton/polyester rather than silk, nylon or other synthetic fibres. Synthetics that melt when exposed to flame should be avoided.
- For the same reason flooring material and footwear should also be carefully selected to avoid the possibility of spark generation. Anti-static shoes should be used. Working alone in the laboratory must not be allowed. Inexperienced people should not be allowed to work unsupervised.
- Before entering the gassing room, check that the ventilation systems and gas detection systems are operating.
- Discharge personal static electricity by touching earthing points just before entry.
- Activation of the gas detectors, failure of the extraction system or the gas detection equipment should automatically shut down the gassing operation and isolate the propellant supply. All personnel should leave and follow the agreed emergency procedure.

  Where automated systems are not installed, regular checks are essential to ensure that both the extraction/ventilation and gas detection equipment are operating. Again, in the event of high gas levels being indicated or any equipment failure, the gassing operation must be terminated immediately with manual isolation of the propellant supply and evacuation of all personnel following the agreed emergency procedure.

- A post evacuation procedure should be laid down and clearly understood by all personnel. The reason for the high gas level or equipment failure should be established by a qualified person before allowing re-entry and resumption of work.
- In a situation where leaking propellant has become ignited, e.g. from a leaking joint, do not attempt to extinguish it. Instead, isolate the propellant supply at source if it is safe to do so.
- Before any maintenance is carried out, all equipment and lines used for flammable propellants should be purged with a non flammable gas such as nitrogen. All equipment should be serviced/inspected at regular intervals by trained personnel. The intervals should be decided by the needs of each laboratory, taking advice from the equipment manufacturers, the maintenance department etc.
- Do not allow cleaners, engineers etc., free access to the gassing room. There should be a well defined "Permit to Work" system established as described in Chapter 4 *Design and Good Working Practices for the Laboratory*. Supervision by laboratory personnel is strongly recommended.

7.5.3 Transfer Filling

This is a technique widely used where small numbers of cans are involved or where it is impractical to employ normal gassing equipment.

Essentially, an aerosol container is gassed in this way by transferring propellant from another aerosol container containing propellant only, using an adaptor to link the two valves. The technique relies on the pressure difference between the two containers to ensure transfer of propellant.

Safety procedures must be as strict as for pressure filling operations, in particular the following precautions should be applied to transfer cans and transfer fillings:

- Any propellant filling operation conducted in a laboratory must have safety equipment, such as proper ventilation system, electrical classification, gas detectors, etc.
- Pressure performance of transfer containers must be suitable for the vapour pressure of the propellant concerned.

  Also because of the high solvency characteristics of DME the valve components and gasket material of the aerosol must be carefully selected.

  DME can interact with the material of a PET aerosol.

- Transfer cans should not be refilled, principally because continued re-use will eventually cause the valve to malfunction, with subsequent, potentially dangerous, loss of propellant.
- Transfer cans must not be overfilled. If they become liquid full they could burst, if the temperature rises, due to hydraulic pressure.
- To assist in the transfer of the propellant, the recipient container may be cooled.
- Only valves specifically designed for transfer filling, or standard valves with suitable adaptors, must be used on transfer cans.

- Filled transfer containers should be water bath tested.
- Transfer cans should be clearly labelled. Refer to § 7.7 *Container Testing*.
- When transfer filling, wear eye protection and gloves. A safety assessment should have been performed before any work is carried out. It is recommended that transfer filling is done under the same conditions as normal gassing.

7.5.4 Compressed and soluble gas propellants

High-pressure compressed and soluble gas propellants are introduced into aerosol cans by a variety of filling methods. For example: “Through-the-valve” propellant fillers, “under-the-cup” fillers or gasser-shakers.
Connecting a pressure regulated propellant cylinder directly to the machine is a common method to perform laboratory work. Special care must be used to prevent bulging and bursting of the container.

- Cylinders of high-pressure compressed and soluble propellant gases must be secured at all times to prevent them from falling over. Cylinder transportation carts should be used for moving cylinders.
- Regulated pressures should be less than the rated pressure of the aerosol container.
- With CO_2 and N_2O it needs to be guaranteed that only vapour is drawn from the cylinder or tank. Even a very small amount of liquid may immediately rupture the container. Failure of the vaporizer system could also result in liquid propellant entering into the system.
- Changing between compressed gasses (Nitrous oxide/Oxygen) requires cleaning of the pipe and filling equipment to remove all traces of compounds, which could react with N_2O or Oxygen.
- Mixtures of N_2O and flammable propellants are potentially explosive. It is recommended using two separate feeding systems. Cleaning procedures should be executed with special care.
- Compressed and soluble gas propellants by itself are not flammable and do not require explosion-proof filling rooms. However, properties of the product concentrates and other considerations may qualify for the use of explosion-proof equipments.
- Ventilation is required to prevent accumulation of propellant gases in closed rooms.

Health and hazards:

- Nitrogen is a gas without warning odour. The release of excessive amounts in non-ventilated areas can be life threatening.
- Exposures to significant concentrations of CO_2 must be avoided through ventilation. Check for maximum allowable concentration on the workplace (safety data sheet).
- Carbon dioxide can be trapped in liquid form inside hoses and pipes and can even form dry ice clogging the system. A sudden release can cause serious injury to personnel.

7.5.5 Cold Filling

This technique involves the chilling of liquefied gas propellant below its boiling point in order to fill the propellant into open top containers prior to swaging on the valve.
As it can give rise to a high level of propellant vapour in the atmosphere**, IT MUST NOT BE USED WITH FLAMMABLE PROPELLANTS**. Considering that most aerosol propellants are flammable this technique is virtually obsolete and cannot be recommended. Also, this method is not suitable for compressed gas propellants.

7.5.6 Burette Filling

Pressure filing with burettes presents an especially hazardous potential and the use of this technology should be avoided.

In any way, glass burettes without a pressure certificate shall not be used – burettes with cracks should be removed from the laboratory. Only burettes with correctly working and regularly calibrated nitrogen pressure regulators should be used. The burette should be properly installed and secured. Safety glasses must be worn all the time working with a glass burette.

7.5.7 Filling of Glass/Plastic Aerosol Containers

Three types of (non metal) containers are handled in laboratory work:

- Aerosol compatibility tubes. These bottles are designed to be reusable and have an opening for a 25.4 mm valve. The tubes are supplied with a plastic safety shield which must always be in place during use.
- Conventional production glass bottles, either plastic coated or uncoated with an opening for 10/15/20 mm valves. These containers must not be reused. Plastic coated bottles should be used in preference to uncoated ones.
- Plastic aerosols. Compatibility between the plastic container and its contents needs to be assessed. Also, as with glass aerosol containers, these must not be reused.

Safe handling requirements:

- Ensure that the strength of the container is sufficient for the formulation to be packed. Note that glass containers are very easily damaged, and even the mild abrasion caused by bottles rubbing together in transit can weaken the bottle sufficiently to cause failure. Therefore, examine all bottles carefully for flaws before use, paying particular attention to the neck area. Reusable containers also need special care in examination.
- Take special care in controlling fill levels, as the internal volume of glass/plastic bottles is subject to wider variation than metal containers. Particularly with glass and plastic containers the product should not be allowed to foul the surface on the neck, as this could lead to leakage when the propellant is filled.
- There are special precautions to note when sealing the valve on to the container:

(A) Conventional crimping of glass bottle valves. Take care that the crimp is not too tight or too shallow. This can weaken the bottle neck.

(B) The use of a two-piece screw coupling and valve assembly. This is the usual means of sealing reusable compatibility tubes and also is a common feature of experimental test kits.

The couplings consist of a collar, either nylon or metal, which seats on the neck of the bottle, and a retaining piece, always of metal, which screws down over the valve on to the collar. These couplings are reusable, and are paired, so it is important that both parts of the coupling are kept together when not in use. Couplings should be examined before use, for any damage to the thread. Check that the correct (outer) sealing gasket is in place on the valve and ensure that the coupling is securely screwed down before filling with propellant. Check also that the correct internal gasket has been selected. Some propellants (i.e. DME) can have an adverse effect on gasket material.

NOTE: Care should be taken when disposing of the contents. Completely depressurise any reusable glass containers before attempting to unscrew the couplings. Refer to Chapter 10 *Disposal*.

- Propellant filling of bottles in the laboratory is usually by transfer. It should be carried out using face protection, and at any sign of leakage, filling must be stopped and the container emptied with care. If the point of leakage is the screw coupling, do not tighten during the filling operation, but empty the bottle and start the whole operation again.
- Filled glass or plastic containers must not be subjected to thermal or mechanical shock, although water bath testing must be carried out.

7.6. Overfilled Containers

Overfilled containers present a hazard (see § 7.2 *Control of Filling Quantities*) and must be disposed of as quickly as possible using the techniques described in Chapter 10 *Disposal*, with due regard to all necessary safety precautions.

7.7. Container Testing

All filled containers must be water bath tested using a method no less stringent than laid down in the Aerosol Dispensers Directive 75/324/EEC.

Samples of filled containers should be checked for pressure, weight, and crimp dimensions. Any samples failing to meet the pre-determined standards should be disposed of with due attention to safety precautions. Refer to Chapter 10 *Disposal*.

7.8. *Sample Storage & Labelling*

Filled containers should be provided with overcaps to prevent accidental discharge.
Samples retained in the laboratory must be clearly identified, defining the contents, to all personnel concerned. If the aerosols present a particular hazard with respect to toxicity/irritancy or flammability, this should be emphasised on the label.

Samples made for use outside the laboratory must carry labels showing appropriate warnings/cautions as laid in the Aerosol Dispensers Directive 75/324/EEC or the CLP Regulation (EC) No 1272/2008.

Examples:

- Extremely flammable aerosol (+ flame pictogram and signal word ‘Danger’)
- Pressurised container: May burst if heated.
- Keep away from heat, hot surfaces, sparks, open flames and other ignition sources. No smoking.
- Do not spray on an open flame or other ignition source.
- Do not pierce or burn, even after use.
- Protect from sunlight. Do not expose to temperatures exceeding 50ºC.
- Keep out of reach of children.

The label should also show the name and address or trade mark of the person responsible for filling the aerosol dispenser.

Code markings enabling the filling batch to be identified should be displayed on the container.

Specific precautionary labelling may be appropriate for certain aerosols such as oven cleaners, etc.

Chapter 8

Laboratory Storage of Aerosol Products

The majority of aerosols that may be found in the laboratory represent examples of prototype formulations and/or packaging specifications. These may be employed in a wide range of testing procedures. Of particular importance are those that are destined for compatibility testing where the risk of failure of the container due to corrosion may be significant.

In every situation great care must be paid to the storage of any containers to minimise the risk associated with the release of flammable gases.

8.1. General Guidelines for All Stored Aerosols

8.1.1 Numbers of samples retained in the laboratory

The quantity of samples required for testing will depend on many factors including available space, formulation variants, container specifications etc. Although precise numbers should be kept to a minimum on grounds of safety, they should nevertheless be sufficient to provide accurate and statistically meaningful results.

8.1.2 Labelling

All packs stored in the laboratory must be clearly and indelibly marked.

The label must identify the contents together with the following information:

- Flammability of contents
- Toxic nature of ingredients
- Date of manufacture
- Reference code for more comprehensive information

8.1.3 Water Bath Testing

All aerosol samples, whether for storage testing or for any other evaluation must be water bath tested using a method no less stringent than that laid down in the Aerosol Dispensers Directive 75/324/EEC.

All leaking or otherwise faulty packs must be immediately disposed of safely. Refer to Chapter 10 *Disposal*.

8.1.4 Packing

Irrespective of being stored upright or inverted, it is recommended that all aerosol containers being storage tested should be fitted with overcaps to prevent accidental discharge of the contents. It is recommended to use carton boxes for packing; in the event that an aerosol container starts leaking, the contents will be absorbed by the carton. Also the leaking aerosol container will be easy to detect.

8.2. Long Term Aerosol Testing

A stability test programme is undertaken to establish the suitability for use of a package (formulation and container) over extended periods under normal conditions.

In recent years there has been an increasing tendency to centralise filling in one country and then export filled units to all the territories concerned both within Europe and beyond. As such, there is a greater need to consider corrosion rates in both warmer (Mediterranean and tropical) and cooler (Scandinavia and some Eastern European countries) markets.

In order to reach a decision in a short time scale the practice of storing samples at elevated temperatures (40ºC or even 45ºC) has become a common practice. It should be emphasised that such "accelerated" testing may give misleading results - and has been known to do so on many occasions - and consequently, this method cannot be recommended as a safe substitute for long term storage under the conditions normally prevailing in the intended country of sale.

All samples stored for this purpose must be examined at regular intervals. Any container exhibiting severe deterioration or leakage should immediately be removed from storage and, after any examination (CAUTION!), be disposed of safely. Refer to Chapter 10 *Disposal*.

8.2.1 Ambient Temperature Storage

All samples must be stored away from sunlight and remote from any source of direct heat or ignition. It is advisable that they are placed in liquid proof trays which will retain the product in the event of leakage. In view of the possibility of the build up of flammable gasses arising from leakage, the storage area should be designated a flameproof area and be adequately ventilated.

8.2.2 Elevated Temperature Storage

Practically all elevated temperature storage rooms or cabinets re-circulate the air within them. As a result, any flammable vapour which may arise from leaking cans may be drawn over heating elements/lights etc. For this reason it is strongly recommended that all elevated temperature storage areas should be flameproof and a gas detection system installed.
If non-flameproof units have to be used, these must be fitted with either a blow-out panel or have a magnetically latched door to vent any explosion that may occur.
Great care must be taken in the siting of such equipment to ensure that any such occurrence does not present a hazard to workers. Non-flameproof units cannot be recommended.
Once the temperature has been correctly set, the controls must be sealed to prevent any accidental or deliberate maladjustment of the settings.
As a further safeguard, all ovens must be fitted with a safety override thermostat or thermal fuse which will operate in the event of a failure in the primary circuit. A thermometer should be fitted which must be easily visible to enable monitoring on a regular basis.
All samples must be adequately spaced to allow air circulation and prevent "hot spots" which may lead to possible rupture of containers.

8.3. Disposal of Samples

On the termination of each test programme all samples still remaining must be removed from storage. These should be disposed of safely and in accordance with the procedures described in Chapter 10 *Disposal*. Also, there should be regular auditing of storage rooms/areas to remove old samples.

Chapter 9

Testing of Filled Aerosols

The testing of aerosols covers both routine testing of existing products for compliance to standards and development work. Although the hazards may be known for existing products and the necessary precautions well rehearsed, complacency must not lead to unsafe short cuts. In either case the fundamentals of good laboratory practice have to be observed.

9.1. General

Prior to any testing, all aerosols should have passed adequate safety checks.
Particular care should be taken that those who handle aerosols only occasionally, e.g. analysts, should apply the same standards of sampling and disposal as does the aerosol technologist.
Whenever spray testing is being undertaken, the test areas must be adequately ventilated to minimise exposure of personnel to products. The Occupational Exposure Standard of the materials being handled must never be exceeded and extractions/ventilation systems designed to cope with the burden of spray testing should be installed. It is always preferable to carry out spray testing in a purpose designed fume cupboard.
In quality control laboratories where spray testing is a regular feature of the daily work, continuous monitoring of atmospheric concentrations of the aerosol contents might need to be considered.
After testing is complete, dispose of unwanted packs safely using the methods given in Chapter 10 *Disposal*.

9.2. Specific Tests

Refer to the FEA and/or CEN standards for details regarding the actual way of performing the tests.

9.2.1 Spray Tests

When carrying out spray tests to determine particle size, discharge rate, product residue and spray pattern, ensure that there are no naked flames or sources of ignition in the vicinity. (Flammability tests are discussed later).
Use continuous ventilation/extraction. Inhalation of sprays should always be avoided.

Do not spray into the laboratory atmosphere if this can be avoided and ensure there is no residual contamination of surfaces, especially the floor.

9.2.2 Pack Tests (vacuum, pressure and crimp values)

Normally, these present little hazard, but beware of peripheral discharge around the stem during pressure checks. (A cloth round the stem will not affect results, but does reduce the ferocity of this discharge). Do not pressurise containers following vacuum checks since even a partial loss of vacuum can create a higher than normal pressure after filling. Remove the actuator prior to crimp/swage checks to avoid accidental actuation.

9.2.3 Flammability Tests

Drum and flame ignition distance tests all involve an ignition source.

- The main hazards are fire, uncontrolled explosion and the possible toxic nature of thermally degrade components from the products on test.
- Never work alone and have the fire fighting and breathing apparatus at hand. Inform the site safety or fire officer of your intention to operate these tests.
- Ventilate the area thoroughly between each test and clean down at the end of the testing to ensure that residual toxic materials are removed. Use appropriate safety measures and equipment during the cleaning.
- Make sure that no unnecessary materials which could spread fire are close by (cloths, paper towels, clothing). Arrange the testing such that it is not a hazard to other areas in the laboratory.
- Take precautions to avoid burns. Be aware of the fact that direct contact with evaporating propellants can also cause frost blisters!
- Take care to avoid setting off fire detection systems inadvertently during flammability testing.
- Ensure adequate avoidance of build-up of static electricity during the tests by means of applying adequate earth connection.
- Provide a safety shower and eye-shower in direct vicinity of test area to be able to act quickly when being exposed to flames but also when exposed to evaporating propellant.
- Be aware of “unexpected” effects because they have also to be tested in alternative orientations which can lead to other effects than expected.

- If products have to be tested with the Enclosed Space Ignition Test (ESIT) pay extra attention to personal protection. Wear protective clothing to be protected from flames escaping from the vessel, especially from the hole at the back of the vessel (so called “flash-back” from the product). Also pay extra attention to your respiratory system because large amounts of irritating materials may be dispersed into the air. The most ideal situation would be a test setup which can be operated remotely.

9.2.4 Specialised Tests

Corrosivity, electrostatic build-up, storage etc. come into this category and each has its own particular hazards in addition to those already mentioned. For example, storage trials may result in perforated cans with uncontrolled leaks of propellant or concentrate. Ensure that this cannot cause vapour to build up or personnel to be sprayed with product. Electrostatic tests can result in sparks capable of igniting flammable vapours (for an extensive overview of safety measures related to static electricity, see the CENELEC code CLC/TR 50404:2003). Various other standard tests are widely used. Consider carefully the hazards which may occur and take heed of any cautions given in associated standards including the relevant Personal Protective Equipment Regulations. Opened cans have sharp (and contaminated) edges and suitable gloves should be worn during their handling. Ensure opened cans are not left where they will constitute a hazard. Refer to Chapter 10 *Disposal*.

9.2.5 Product Analysis

Product analysis involves extracting part or all of the contents and an examination of the components of the package. Be very cautious if dealing with unknown products - consider the most likely chemicals involved and the propellant system in use. Always work in an area with fume extraction and remember that even depressurised packs may still emit gas and vapours for a long while after. Do not put extracted product into sealed containers because pressure build-up is likely.

Chapter 10

Disposal

Important Note

ALL LEGAL REQUIREMENTS REGARDING WASTE DISPOSAL HAVE TO BE FOLLOWED! KNOWLEDGE OF LOCAL REGULATIONS IS IMPORTANT!

IT IS THE LEGAL RESPONSIBILITY OF THE WASTE PRODUCER TO ENSURE THAT THE DISPOSER IS TOLD OF ALL KNOWN HAZARDS. SPECIFIC REGULATORY DOCUMENTATION IS REQUIRED FOR THIS PURPOSE.

All raw material suppliers must, by law, supply up-to-date Health and Safety data on their products. These data contain information on special disposal requirements.

10.1. General

When the various aspects of aerosol work described in the previous chapters have been completed, there will always be some aerosol containers in a filled, pressurised condition that must be disposed of.

It is very important to remember that, unlike the consumer, who will be throwing away a single used container, the laboratory technician has to dispose of many unsatisfactory containers, some of which may be having high internal pressure or fill, severe corrosion (including obnoxious or dangerous corrosion by-products) or containing toxic materials. As an added complication, relatively large amounts of flammable or highly flammable materials may also be present.

European Health and Safety Laws require that management provide a safe work place. Personnel are responsible for ensuring that they work in a safe way and also that they do not endanger those working around them. Additionally, regulations require that every process is evaluated for potential hazards including the generation and initial handling of waste materials.

There are statutory regulations concerning the materials and quantities which may be allowed to enter the sewage system. Details must be obtained from local water authorities.

It is most important that laboratory procedures are set up to ensure that *hazardous* containers, products or other materials are not allowed to find their way into the domestic general waste disposal system.

The best and safest means of disposing of any form of special waste generated in the aerosol laboratory is either by arrangement with a specialist disposal company or, for those laboratories attached to a suitable factory facility, by liaison with factory management, to have the waste dealt with in the factory system. Disposal should be carried out regularly to avoid a large build-up of potentially hazardous waste in the laboratory.

Finally, aerosols consist of both the product and the container. Make due allowance for both of these when setting up the disposal system.

10.2. Personnel and Hazards

Every aerosol package/product combination should be assessed for disposal hazards on its particular properties. The disposal aspect of any laboratory activity should be included in the Risk Assessment of this activity. Selection of *personal protection equipment* (PPE) must be based on the results of this Risk Assessment. The use of selected PPE is mandatory for personnel. If circumstance will require special PPE like breathing apparatus, then these items must be used and maintained in a satisfactory manner.

Everyone dealing with disposal must be properly trained to understand, recognise and handle the hazards involved. The particular hazards will most commonly include loss of pressure, release of toxic materials and degreasing agents (solvents), surfactants, highly flammable and/or suffocating vapours and large volumes of foam. Additionally, opened containers present very sharp edges capable of inflicting a severe injury.

PPE used during disposal operations must be resistant to all product(s) involved. As an example, leather gloves, which may give excellent protection against raw metal or glass edges, will usually not prevent chemicals from soaking through to the hands. Residual contamination of gloves, that cannot easily be removed, will also occur.

10.3. Disposal of Filled Containers

For the reasons stated above, filled containers must not enter domestic general waste systems. Small amounts of filled cans should be de-pressurised and emptied completely before being disposed of (see the following sections on depressurisation and disposal of contents and also Appendix 5 *Handling of Defective Containers*).

When more than a few dozen cans are involved, this may be difficult to control. Arrangements should then be made with a specialist disposal company or, in the case of those laboratories attached to an aerosol filling facility, factory management, to remove intact containers from the laboratory for disposal. This should be done on a regular basis to prevent large numbers of filled containers from building up.

10.4. Defective Containers

Filled containers suspected of being hazardous because of over-pressurisation, over-filling, and leakage should be made safe/de-pressurised immediately and not retained for routine disposal. In particular, take special care when dealing with excess pressure or fill. Containers should be subjected to the minimum possible movement and protected from external physical damage and high temperature until they can be discharged under controlled conditions. In particular, face and hand protection should be used at all times when handling such containers and the use of wire mesh cages or similar restraining devices should be encouraged in order to reduce the chances of injury by container rupture.

Limited "first aid" may be applied to these situations by actuating the aerosol valve to reduce the fill level, but this will only reduce the pressure of containers propelled by compressed gases or the hydrostatic pressure generated when a container is completely liquid full. It is strongly recommended that this actuation should, if possible, be carried out remotely and the container certainly should NOT be hand held during this operation (See Appendix 5 *Handling of Defective Containers* for suggested methods). Cooling the container (without inducing too rapid a change in temperature) will also help to reduce excess pressure, although this is rather limited in the case of compressed gases. Once any immediate hazard has been dealt with, the container should be depressurised and then disposed of with its contents as described in the following sections.

10.5. Depressurisation

Puncturing of full aerosol containers is a highly hazardous operation and should be avoided if at all possible.

Aerosol containers should normally be depressurised by totally discharging the contents through the valve.

Discharge through the valve does not result in a rapid pressure loss but is slow and presents the problem of how to contain and control the large volumes of spray produced. The use of this method should, however, be used if an uncontrolled discharge is considered too dangerous or if glass bottles are involved.

If necessary, containers can be emptied by controlled puncturing. This is fast to carry out but involves rapid pressure release, although it is possible with most products to minimise this hazard by cooling the can first to reduce the internal pressure. (See Appendices 6 *Puncturing of Aerosol Containers* and *7 Puncturing of Aerosols Containing High Foaming Products* for recommended methods of puncturing).

Any discharge operation has to be carried out in a safe, controlled fashion! The operator must be adequately protected from any discharged materials and hazards resulting from the discharge (fires, explosions!).

Therefore, when a flammable or highly flammable liquid or vapour is involved, the operation has to be carried out in the complete absence of ignition sources. Additionally, discharge is likely to

cause high concentrations of hazardous vapour and/or spray so that suitable extraction/ventilation should be used. A flameproof fume cupboard is ideal for this purpose.
Adequate extraction is vital and the cupboard door should be kept closed as far as it is practical during the whole operation.

If any dispersed powder formulations, e.g. anti-perspirants, talc or metal powders, are to be depressurised, additional precautions (earthing!) should be taken to prevent the build up of static charges on the container which could result in ignition.

Glass aerosol containers should be treated with great care during depressurisation and, obviously, no attempt should be made to puncture them. The contents of glass bottles should always be sprayed off!

Discharged solid or liquid materials have to be collected and disposed observing legal obligations.

10.6. Disposal of Container Contents

After depressurisation, the contained product is not automatically safe. Aspects still to be considered are the possible toxicity or flammability of the concentrate and the fact that the concentrate will most likely still contain propellant – in either the dissolved or emulsified form.

With respect to toxicity, flammability and solids content, the restrictive sewage regulations (mentioned above) have to be observed. The remaining concentrates may either not be allowed to be sent down the domestic drain, or only after considerable modification or dilution!

Because of these limitations, the laboratory may accumulate waste concentrates which have to be stored and disposed of in a safe manner. Here again, two aspects are involved. The concentrates may still contain propellant which must be controlled and removed, and there is also the possibility of hazardous interaction between two or more concentrates coming into contact.

Liquid waste containers should not be sealed as retained propellant may easily generate unsafe pressures inside them. A controlled relief system is essential.

As for the disposal of filled containers, the best means of waste disposal is by arrangement with a specialist waste disposal company or through an established factory disposal system. Again, this should be done regularly to avoid the build up of large quantities of waste within the laboratory.

10.7. Emptied Containers

In many cases, aerosol containers are opened to investigate product/container compatibility. When a detailed examination is intended, the container, usually metal (tinplate or aluminium) has to be opened sufficiently to become essentially a flat sheet. This can produce raw metal edges which are extremely sharp and which can inflict a severe cutting injury. Additionally, metal slivers can be produced which may enter the flesh. Hand protection is therefore vital when carrying out this operation. If open specimens are to be retained, the sharp corners should be removed and the raw edges covered with adhesive tape. Even if the can is washed and dried, it may still be contaminated with product and this may cause complications in the event of a cut.

When disposing of cut or disassembled cans, it has to be assured that janitors/cleaners are aware of the hazards described above. Ideally, cans should be rinsed and placed in a suitable disposal container that does not require re-opening and is marked as such. It is recommended that glass aerosol containers, even when empty, should be treated with care and that a specific, separate glass disposal system is used.

10.8. Disposal of Raw Materials

After completing a particular project within the laboratory, raw material samples may remain for which there is no immediate use.

Recommended shelf lives and material hazards have to be observed! Every new sample must be marked with the date of receipt, the shelf life and the hazard symbol as described in the Safety Data Sheets. A regular survey must be carried out and sample stocks sorted to identify out-of-date or faulty materials (some materials may not turn out to be as stable as first expected) which should then be disposed of safely.

As mentioned at the beginning of this Chapter, material suppliers are required by law to supply Health & Safety data in a Safety Data Sheet including a section on disposal. This information must be applied to the disposal of raw materials from the laboratory. These materials must not be treated as unimportant small quantities which can be thrown into the domestic waste disposal system. They may be highly toxic and/or flammable in their concentrated, pure form (as opposed to their usual diluted form in a finished product) and could result in a major hazard in a situation where no warning or protection exists.

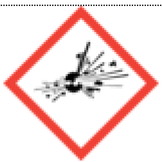
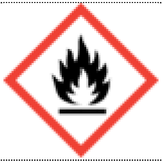
As always, the best means of waste disposal is by arrangement with a specialist waste disposal company or through an established factory disposal system. This should be done regularly to avoid the build up of large quantities of waste within the laboratory.

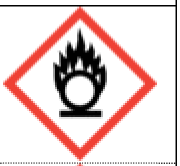
Appendices

11.1. Appendix 1 – CLP Hazard Classes

11.1.1 Physical Hazards

Hazard Classes	**Definitions**	**Possible pictograms**
Explosives	An explosive substance or mixture is a solid or liquid substance or mixture of substances which is in itself capable by chemical reaction of producing gas at such a temperature and pressure and at such a speed as to cause damage to the surroundings. Pyrotechnic substances are included even when they do not evolve gases. A pyrotechnic substance or mixture is a substance or mixture of substances designed to produce an effect by heat, light, sound, gas or smoke or a combination of these as the result of non-detonative self-sustaining exothermic chemical reactions.	
Flammable gases (including chemically unstable gases)	Flammable gas means a gas or gas mixture having a flammable range with air at 20 °C and a standard pressure of 101.3 kPa. A chemically unstable gas means a flammable gas that is able to react explosively even in the absence of air or oxygen.	
Aerosols	Any non-refillable receptacles made of metal, glass or plastics and containing a gas compressed, liquefied or dissolved under pressure, with or without a liquid, paste or powder, and fitted with a release device allowing the contents to be ejected as solid or liquid particles in suspension in a gas, as a foam, paste or powder or in a liquid state or in a gaseous state.	
Oxidizing gases	Any gas or gas mixture which may, generally by providing oxygen, cause or contribute to the combustion of other material more than air does.	

Hazard Classes	Definitions	Possible pictograms
Gases under pressure	Gases which are contained in a receptacle at a pressure of 200 kPa (gauge) or more at 20 °C, or which are liquefied or liquefied and refrigerated. They comprise compressed gases, liquefied gases, dissolved gases and refrigerated liquefied gases.	
Flammable liquids	A liquid having a flash point of not more than 60 °C	
Flammable solids	A solid which is readily combustible, or may cause or contribute to fire through friction. Readily combustible solids are powdered, granular, or pasty substances or mixtures which are dangerous if they can be easily ignited by brief contact with an ignition source, such as a burning match, and if the flame spreads rapidly.	
Self-reactive substances and mixtures	Self-reactive substances or mixtures are thermally unstable liquid or solid substances or mixtures liable to undergo a strongly exothermic decomposition even without participation of oxygen (air). This definition excludes substances and mixtures classified as explosives, organic peroxides or as oxidising.	 
Pyrophoric liquids	A liquid substance or mixture which, even in small quantities, is liable to ignite within five minutes after coming into contact with air.	
Pyrophoric solids	A solid substance or mixture which, even in small quantities, is liable to ignite within five minutes after coming into contact with air.	
Self-heating substances and mixtures	A liquid or solid substance or mixture, other than a pyrophoric liquid or solid, which, by reaction with air and without energy supply, is liable to self-heat; this substance or mixture differs from a pyrophoric liquid or solid in that it will ignite only when in large amounts (kilograms) and after long periods of time (hours or days).	
Substances and mixtures which in contact with water emit flammable gases	Substances or mixtures which, in contact with water, emit flammable gases means solid or liquid substances or mixtures which, by interaction with water, are liable to become spontaneously flammable or to give off flammable gases in dangerous quantities.	

Hazard Classes	Definitions	Possible pictograms
Oxidising liquids	A liquid substance or mixture which, while in itself not necessarily combustible, may, generally by yielding oxygen, cause, or contribute to, the combustion of other material.	
Oxidising solids	A solid substance or mixture which, while in itself is not necessarily combustible, may, generally by yielding oxygen, cause, or contribute to, the combustion of other material.	
Organic peroxides	Organic peroxides means liquid or solid organic substances which contain the bivalent -O-O- structure and may be considered derivatives of hydrogen peroxide, where one or both of the hydrogen atoms have been replaced by organic radicals. The term organic peroxide includes organic peroxide mixtures (formulations) containing at least one organic peroxide. Organic peroxides are thermally unstable substances or mixtures, which can undergo exothermic self-accelerating decomposition. In addition, they can have one or more of the following properties: (i) be liable to explosive decomposition; (ii) burn rapidly; (iii) be sensitive to impact or friction; (iv) react dangerously with other substances.	 
Corrosive to metals	A substance or a mixture that is corrosive to metals means a substance or a mixture which by chemical action will materially damage, or even destroy, metals.	

11.1.2 Health Hazards

Hazard Classes	Definitions	Possible pictograms
Acute toxicity	Acute toxicity means those adverse effects occurring following oral or dermal administration of a single dose of a substance or a mixture, or multiple doses given within 24 hours, or an inhalation exposure of 4 hours.	 

Hazard Classes	Definitions	Possible pictograms
Skin corrosion/irritation	Skin Corrosion means the production of irreversible damage to the skin; namely, visible necrosis through the epidermis and into the dermis, following the application of a test substance for up to 4 hours. Corrosive reactions are typified by ulcers, bleeding, bloody scabs, and, by the end of observation at 14 days, by discolouration due to blanching of the skin, complete areas of alopecia, and scars. Histopathology shall be considered to evaluate questionable lesions. Skin Irritation means the production of reversible damage to the skin following the application of a test substance for up to 4 hours.	 
Serious eye damage/eye irritation	Serious eye damage means the production of tissue damage in the eye, or serious physical decay of vision, following application of a test substance to the anterior surface of the eye, which is not fully reversible within 21 days of application. Eye irritation means the production of changes in the eye following the application of test substance to the anterior surface of the eye, which are fully reversible within 21 days of application.	 
Respiratory or skin sensitisation	Respiratory sensitiser means a substance that will lead to hypersensitivity of the airways following inhalation of the substance. Skin sensitiser means a substance that will lead to an allergic response following skin contact.	 
Germ cell mutagenicity	A mutation means a permanent change in the amount or structure of the genetic material in a cell. The term 'mutation' applies both to heritable genetic changes that may be manifested at the phenotypic level and to the underlying DNA modifications when known (including specific base pair changes and chromosomal translocations). The term 'mutagenic' and 'mutagen' will be used for agents giving rise to an increased occurrence of mutations in populations of cells and/or organisms.	

Hazard Classes	**Definitions**	**Possible pictograms**
Carcinogenicity	A substance or a mixture of substances which induce cancer or increase its incidence. Substances which have induced benign and malignant tumours in well performed experimental studies on animals are considered also to be presumed or suspected human carcinogens unless there is strong evidence that the mechanism of tumour formation is not relevant for humans.	
Reproductive toxicity	Reproductive toxicity includes adverse effects on sexual function and fertility in adult males and females, as well as developmental toxicity in the offspring. The definitions presented below are adapted from those agreed as working definitions in IPCS/EHC Document No 225, Principles for Evaluating Health Risks to Reproduction Associated with Exposure to Chemicals. For classification purposes, the known induction of genetically based heritable effects in the offspring is addressed in Germ Cell Mutagenicity (section 3.5), since in the present classification system it is considered more appropriate to address such effects under the separate hazard class of germ cell mutagenicity.	
Specific target organ toxicity — single exposure	Specific target organ toxicity (single exposure) is defined as specific, non lethal target organ toxicity arising from a single exposure to a substance or mixture.	 
Specific target organ toxicity — repeated exposure	Target organ toxicity (repeated exposure) means specific, target organ toxicity arising from a repeated exposure to a substance or mixture.	

Hazard Classes	Definitions	Possible pictograms
Aspiration hazard	‘Aspiration’ means the entry of a liquid or solid substance or mixture directly through the oral or nasal cavity, or indirectly from vomiting, into the trachea and lower respiratory system. Aspiration toxicity includes severe acute effects such as chemical pneumonia, varying degrees of pulmonary injury or death following aspiration.	

11.1.3 Environmental Hazards

Hazard Classes	Definitions	Possible pictograms
Hazardous to the aquatic environment	‘acute aquatic toxicity’ means the intrinsic property of a substance to be injurious to an aquatic organism in a short-term aquatic exposure to that substance. ‘chronic aquatic toxicity’ means the intrinsic property of a substance to cause adverse effects to aquatic organisms during aquatic exposures which are determined in relation to the life-cycle of the organism.	
Hazardous to the ozone layer	Substance hazardous to the ozone layer means a substance which, on the basis of the available evidence concerning its properties and its predicted or observed environmental fate and behaviour may present a danger to the structure and/or the functioning of the stratospheric ozone layer.	

11.2. Appendix 2 – Some Features of Gassing Room Design

This appendix is not an attempt to produce a specific design for zoned gassing rooms or gassing areas, since local conditions of each company will differ enormously. Instead, it is hoped that the following list of recommendations will help in the design of new facilities or the upgrading, as necessary, of existing installations.

Many of these recommendations are intended to ensure the safe handling of flammable propellants. They should, therefore, be carefully considered for any laboratory, even where the handling of flammable propellants is restricted to the occasional cylinder.

	Essential Features	**Desirable Features**
Overall nature of the gassing area The area should be zoned.	A designated area intended only for the filling of concentrate, crimping and gassing. If not a separate room, then some form of screening is required a) to define the area and b) to intensify local ventilation.	Special room with brick breeze-block walls. Fire resistant doors. Blast panels Viewing windows (to see in) made of laminated or suitably re-inforced material.
Ventilation	Adequate ventilation to cope with losses whilst gassing or in the event of a major leak. The exhaust outlet should be positioned in the open air in such a way that the exhaust cannot build up or affect personnel, equipment or other sections of the plant. Allow for replacement air to ensure efficient ventilation.	Permanent background ventilation to cope with very slow leaks. Extra ventilation should be used while gassing and operate automatically when detection indicates that vapour concentrations are approaching 20 -25% of the LEL or when permanent background ventilation fails.
Gas Detectors	An approved system is required whenever flammable propellants are filled regularly.	
Position of Extractors and gas detectors	Extractors and gas detectors should generally be near the floor - all propellant vapours are heavier than air. The primary enclosure should also have a gas detector.	Several at various positions around the filling area.
Balances: other equipment. All lighting & electrics.	Wherever flammable propellants are used, equipment in the area should be flame-proof. (Mechanical balances are accurate enough to control filling weights.)	

	Essential Features	**Desirable Features**
Electrostatics	When flammable propellants or concentrates are used all equipment must be earthed.	Provide personal earthing points at the entrance to the gassing area. Also, shoes and floors should be suitably conductive to prevent build-up of static charge.
Propellant (stock)	Quantities stored in the gassing area should be minimised - See Chapter 6 *Propellants*.	Separate storage area - See Chapter 6 *Propellants*.
Propellant (for day-to-day use)	As above	Ideally, propellants should be stored outside the laboratory and piped into the gassing area.
Propellant supply pipework	This should be checked regularly for leakage, and, in the case of flexible hoses, for abrasion and weak points where cracks might occur. Easy accessibility, particularly to joints is a prime requirement.	Where possible should be stainless steel. Flexible piping should be reinforced (braided).
Shut off valves	Shut off valves should be close at hand, irrespective of whether propellant is piped into the gassing area or individual cylinders are used close to the gassing machines.	Automatic shut off valves coupled with line failure and linked to gas detection system.
Crimpers, Gassing machines	Suppliers should be consulted about installation, use and operator training.	
Signs	Entrance area and doors should carry prominent "No Smoking" signs.	Gassing equipment should carry signs indicating which propellant is in use and which was used last.
Escape Route	These must be clearly indicated and never obstructed, even momentarily. External doors should be fitted with crash bars.	
Fire Extinguishers	Consult local Fire Authority.	

11.3. Appendix 3 – Control of Laser Equipment

The measurement of particle size distribution from sprayed products can involve the use of laser equipment.

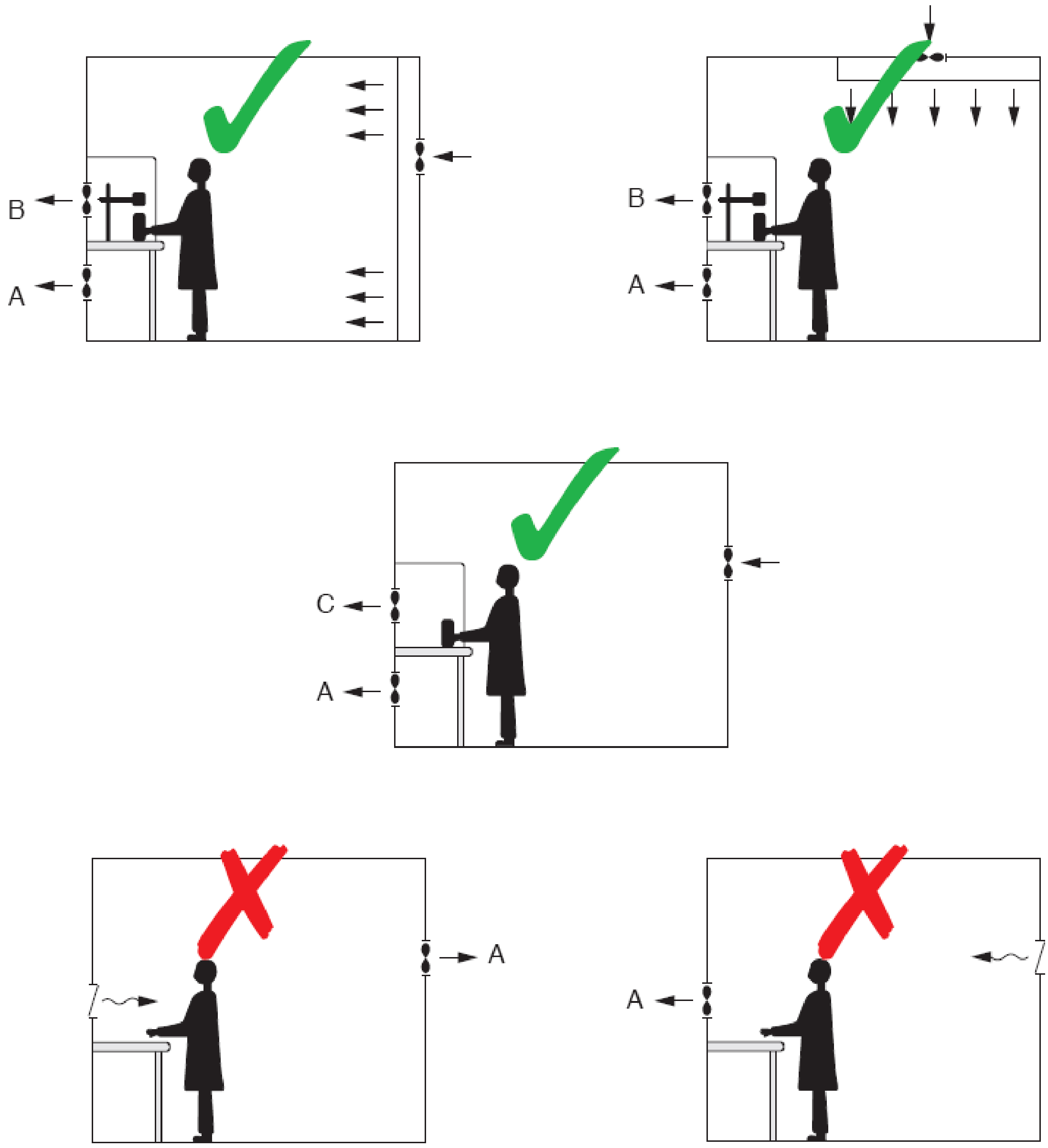
Several international standards have attempted to provide guidelines for the safe operation of laser based equipment, the latest of which is **EN 60825:1992 (Radiation Safety of Laser Products)**. This document classifies lasers into several hazard categories.
Many pieces of equipment regularly used within the aerosol industry for the determination of droplet or particle size distribution operate using open cavity lasers which fall into the Class 3A/B categories, and are required to be used with all due attention to safe operating procedures.

In order to operate safely, the following guidelines should be followed:

- Only operators fully trained in safe use of the equipment and familiar with EN 60825 should have authorised access to laser based instrumentation.
- Laser based equipment must be contained within a purpose designed enclosure/room with physical separation from non-operating personnel.
- Any windows present should be fitted with opaque blinds.
- Laser warning labels **MUST** be attached to any entrance door(s) and to the laser equipment itself.
- It is advised that the operation of such laser equipment is controlled overall by a resident, fully trained Safety Officer.
- All operators should be provided with laser safety goggles complying with **DIN 58215**.
- Power supply to the laser must be provided **ONLY** by operating a removable key. When the equipment is not in use, the operating key must be kept in secure (locked) storage and be available only to designated operators.
- Access to the laser **MUST NOT** be permitted to unauthorised personnel whilst the laser is in use. Ideally, entrances to the laser area should be fitted with interlock systems, such that the laser is immediately switched off if the door is opened. If this is not possible, for whatever reason, a Code of Practice should be set up and agreed which will clearly satisfy the legislation related to health and safety at work. Whatever is decided, the exit situation with respect to a fire or similar emergency must be fully considered.

11.4. Appendix 4 – Ventilation Air Flow Design

VENTILATION/EXTRACTION SYSTEMS



A = ROOM VENTILATION SYSTEM
B = MACHINE ENCLOSURE EXTRACTION SYSTEM
C = FUME CUPBOARD EXTRACTION SYSTEM

11.5. Appendix 5 – Handling of Defective Containers

The three types of defective container giving the greatest cause for concern are those which are overfilled (i.e. hydraulically full containers), those which contain propellant at a pressure exceeding the safe working pressure for that particular container, and leakers.

All possible precautions should be taken to protect the operator when handling these types of containers. Eye and face protection, protective gloves and clothing should be worn as defined in the Risk Assessment.

11.5.1 Overfilled Containers

The most common reasons for overfilled containers are miscalculation of filling weights, use of the wrong container size or "double shot" filling.

Hydraulic cans are those which are completely filled with liquid and which may be distended from their normal shape. The pressure within may be very close to the burst strength of the container (including the strength of the valve swage), and may be more than 14 bar. Very rapid increases in pressure will occur with a very slight rise in temperature.

The overriding priority is to remove some of the liquid so that a headspace is introduced. In the moment when the headspace is created, the internal pressure will drop to approximately the intrinsic pressure of the propellant system.

The following method is suggested when a hydraulic situation is detected. Before any filling is attempted, manufacture a small rig which can operate through the filling guard and, by a suitable lever arrangement, can depress the valve stem/actuator and discharge some of the container contents within the confines of the machine guards. If the dome has inverted on the container, it may well have fallen over, but this does not matter provided that the container can be moved into a corner of the machine guarding and the valve actuated there. The method may be messy but it does afford a fairly high degree of safety for the operator.

If overfilled containers are found after filling, for example in the water bath, they should be placed immediately into safety cages (such as those used for water bath testing), the cages placed in a spray booth or fume cupboard and the valves actuated using a wooden rod until sufficient product has been removed. Since their rupture can cause serious injury, overfilled containers should not be touched by hand.

ON NO ACCOUNT SHOULD HYDRAULIC CONTAINERS BE LEFT IN THE OVERFILLED CONDITION FOR MORE THAN THE ABSOLUTE MINIMUM TIME. PUNCTURING HYDRAULIC CONTAINERS IS DEFINITELY NOT RECOMMENDED, A VIOLENT DISCHARGE CAN OCCUR AND THE CONTAINER MAY RUPTURE OR BECOME A PROJECTILE!

11.5.2 Overpressurised Containers

These may occur for at least four major reasons:

- Use of the wrong propellant or propellant blend.
- Overfilling with compressed gases such as nitrogen or carbon dioxide.
- Gaseous corrosion products such as hydrogen.
- Overfilling with high pressure liquefied gas.

Overpressurised containers are far less obvious than hydraulic ones and they represent a very good reason for keeping and using a good pressure gauge.

If overpressurised containers are detected, they should be placed immediately into safety cages, the cages placed in a spray booth or fume cupboard and the valves actuated using a wooden rod until they are empty.

Where overpressure is the result of internal corrosion, solid corrosion products may also be present and may block the valve. If this should occur, then the container may be punctured INSIDE THE SAFETY CAGE using the maximum amount of caution; but this should be the last resort! Pressing the actuator/stem repeatedly may clear the blockage and should always be tried first! NO ATTEMPT SHOULD BE MADE TO CLEAR THE BLOCKAGE BY THE INJECTION OF MORE PROPELLANT!

11.5.3 Leakers

Great care should be taken when handling leaking containers, particularly if the reason for the leakage is not apparent. *They may be overpressurised or overfilled and on the point of rupture!* All the precautions noted above for overpressurised containers should be followed and, in addition, precautions taken to protect the operator from any spray/jetting that might be coming from the area of leakage. This can sometimes be assisted by holding the container in a position so that the point of leakage is above the gaseous contents of the container rather than below the liquid level.

11.6. Appendix 6 – Puncturing of Aerosol Containers

The puncturing of aerosol containers is potentially one of the most dangerous operations carried out within the laboratory and all possible safety precautions must be taken at this time! It should be avoided whenever possible!

If it is decided to carry out this operation the company should carry out a special risk assessment considering the points below.

Ideally, the operation should be carried out in a fume cupboard, ensuring that the cupboard is suitable for use with flammable or highly flammable materials and/or toxic materials. If a fume cupboard is not available, then puncturing should only be attempted in an area where there is a free flow of air and where no ignition sources are present, e.g. outside or on the roof of a building (Wind conditions have to be taken into consideration!).

The operator must be adequately protected from spray or fumes by the use of face and eye protection and suitable gloves and clothing. The operator and the aerosol container to be punctured have to be adequately earthed. This can be achieved by attaching an earth wire with a clip to the aerosol container and the operator with a wrist-strap.

Note: The clip must be in contact with bare metal to ensure good electrical contact. This method is not suitable for the discharge of glass bottle aerosols which must be fully discharged through the valve!

11.6.1 General

For most products, the safest place to puncture the container is in the headspace and the most convenient way is to make a small hole in the base of the valve cup. If this hole is made on the side away from the operator and behind the boss head as the operator sees it, this gives added protection as the boss head will tend to prevent any discharge being directed towards him. If the operation is done carefully, the product concentrate can usually be retrieved in an uncontaminated form for evaluation.

11.6.2 Method

Do not shake or otherwise agitate containers prior to puncturing. This helps to minimise propellant incorporation within the concentrate and will help to prevent foaming when the internal pressure is reduced.

During controlled puncture of a container the loss of the liquid contents usually cannot be avoided. The puncture should be in the head space to minimise any such losses. In the case of high foaming products, the container should be left undisturbed for as long as possible before puncturing to minimise foam production. The container should stand in a tray to collect the foam produced.

"Jetting" of the product from the puncture has to be avoided, for instance by placing an inverted beaker over the container, which directs the product into a drip tray. This practice could cause obliteration of solvent soluble labelling which may present identification difficulties if the can is to be retained for any reason.

With the ventilation/extraction on (check before starting) and the cupboard screen pulled down as far as is practical (to increase airflow in front of and thus help protect the operator) the puncturing operation should be carried out as follows:

Ensure that the can is earthed (see above).

Using a large brass spike (at least 10 cm long) and a spark-proof (or wood) striker or rubber headed mallet, make a small hole in the valve cup in the position described above, keeping the spike firmly in the hole when it has been formed.

By moving the spike in the hole, propellant will be heard escaping. Allow this to continue - with gentle movement of the spike - until the initial pressure has been released. If any concentrate is released, turn the spike back to restrict the propellant flow and hold it closed for a few moments. The release of propellant should be controlled in this way until the pressure has fallen sufficiently to give a gentle, continuous escape of vapour with some frosting appearing on the outside of the container.

The container should then be left in the fume cupboard with the screen down for some time, perhaps several hours, to allow most of the propellant to discharge. It is important to place a notice on the cupboard warning that propellant discharge is under way.

When all obvious discharge has ceased, open the container (CAUTION, point the opened can away from you!), inside the fume cupboard, collecting the contents in a beaker. Retain the concentrate within the fume cupboard until stirring with a spatula or glass rod produces no further release of propellant.
Specific devices exist to remove the valve.

It should be noted that, as most propellants are heavier than air, any headspace in the beaker is liable to be rich in propellant vapour and this should be allowed to remove before taking the beaker out of the cupboard.

The puncturing operation contains an element of skill which can only be achieved with experience. It is recommended that it is practised using low pressure non-flammable, low toxicity products during operator training sessions (even an empty container with valve could be used to start with) until the requisite skill level has been achieved.

NOTE
When more than one container has to be punctured, great care must be taken in puncturing subsequent containers as:

- Any shock may cause uncontrolled release of propellant in already punctured containers and
- The atmosphere in the vicinity of already punctured containers may contain flammable vapours.

11.7. *Appendix 7 – Safe Disposal of Residual Concentrate*

Any product concentrate from a previously pressurised container will present several potential hazards to a laboratory operator, depending upon both the propellant used and the make-up of the product concentrate.

Immediately after depressurisation, and for some time afterwards, the concentrate will contain propellant to an extent depending upon the total formulation. This propellant may be dissolved or emulsified into the concentrate and may not be easily removable. It is essential that, if this concentrate has to be stored for any length of time before disposal, any propellant released during this storage period must be controlled - especially if it is flammable. For this reason, the waste container must be stored where local fume extraction is permanently available or, alternatively, in the open. This is also relevant if the concentrate is capable of giving off other vapours which are either flammable or toxic.

It is also important that waste concentrates are not kept in fully sealed containers as retained propellant may build up an unacceptable pressure leading to rupture or severe uncontrolled discharge on opening - though they should be enclosed as far as is practical. One solution to the problem is to use a venting cap such as a carbon dioxide trap of the type used in home brewing kits (a "U" tube partially filled with water) which will act as a pressure relief valve.

Due consideration must also be given to the possible interaction of product concentrates (i.e. halogenic and non-halogenic solvents) and care must be taken when storing waste concentrates to ensure that they will not interact in any detrimental manner. Many combinations may give rise to precipitation, which may not be hazardous, but the precipitates should not be allowed to build up and should be removed when the waste vessel is emptied. It should be noted that if the waste container is intended for re-use, then it must be cleaned out thoroughly when it is emptied to prevent accidental contamination or interaction when re-used.

Water Authorities will usually issue regulations as to what materials may be allowed to go to drain. These will be enshrined in a "Consent" issued to your company which will specify exactly what you may send down the drain. It is essential that you meet this Consent for two reasons: failure may lead to the creation of dangerous conditions within the sewage system and can also result in heavy surcharges or even prosecution.

Examination of Consents will probably indicate that many water based product concentrates and a limited quantity of "solvent" (with some specific restrictions such as insecticides and pesticides) can be sent down the domestic sewage system but note must be taken of the maximums allowed. Suspended solids, chemical oxygen demand and a pH range are likely to be specified. As a matter of good practice, ensure that discharges are an order of magnitude less than the consent allows. Usually you are charged for what you discharge – so the smaller the quantity, the lower the sewage charge!

Note that most products contain a number of components and it is the level of the least acceptable one which must be controlled most closely.