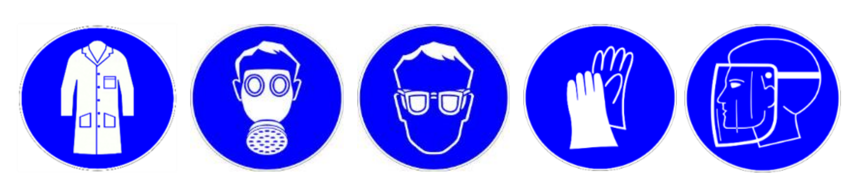

# A Health and Safety Guide for Material Testing Laboratories in the Road Construction Industry

## Manual 38 November 2024

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This document is prepared for the sole purpose of making the information contained herein available to operators of Materials Testing Laboratories in the Road Construction Industry. It is a reference document to assist with making informed decisions in connection with the Health and Safety requirements associated with the activities of Materials Testing Laboratories as applicable.

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# LIST OF COMPANION SABITA MANUALS AND DVDs

| | |
|---|---|
| **Manual 1** | *Technical guidelines: Construction of bitumen rubber seals* |
| **Manual 2** | *Bituminous binders for road construction and maintenance* |
| **Manual 3 & 4** | *(Withdrawn)* |
| **Manual 5** | *Guidelines for the manufacture and construction of hot mix asphalt* |
| **Manual 6** | *(Withdrawn)* |
| **Manual 7** | *SuperSurf – Economic warrants for surfacing roads* |
| **Manual 8** | *Guidelines for the safe and responsible handling of bituminous products* |
| **Manual 9** | *(Withdrawn)* |
| **Manual 10** | *Bituminous surfacing for low volume roads and temporary deviations* |
| **Manual 11** | *Labour enhanced construction for bituminous surfacings (This manual has been withdrawn and consolidated with Manual 12)* |
| **Manual 12** | *Labour Absorptive Methods in Road Construction using Bituminous Materials* |
| **Manual 13** | *LAMBs – The design and use of large aggregate mixes for bases* |
| **Manual 14** | *(Superseded by TG2)* |
| **Manual 15 & 16** | *(Withdrawn)* |
| **Manual 17** | *Porous asphalt mixes: Design and use* |
| **Manual 18** | *Appropriate standards for the use of sand asphalt* |
| **Manual 19** | *Guidelines for the design, manufacture and construction of bitumen rubber asphalt wearing courses* (CD) |
| **Manual 20** | *Sealing of active cracks in road pavements* |
| **Manual 21** | *(Superseded by TG2)* |
| **Manual 22** | *Hot mix paving in adverse weather* |
| **Manual 23** | *Code of practice: Loading bitumen at refineries* |
| **Manual 24** | *User Guide for the Design of Hot Mix Asphalt* |
| **Manual 25** | *Code of practice: Transportation, off-loading and storage of bitumen and bituminous products* (CD) |
| **Manual 26** | *Interim guidelines for primes and stone pre-coating fluids* |
| **Manual 27** | *Guidelines for thin hot mix asphalt wearing courses on residential streets* |
| **Manual 28** | *Best practice for the design and construction of slurry seals* |
| **Manual 29** | *Guide to the safe use of solvents in a bituminous products laboratory* |
| **Manual 30** | *A guide to the selection of bituminous binders for road construction* |
| **Manual 31** | *Guidelines for calibrating a binder distributor to ensure satisfactory performance* |
| **Manual 32** | *Best practice guideline and specification for warm mix asphalt* |
| **Manual 33** | *Design procedure for high modulus asphalt (EME)* |
| **Manual 34** | (A) *Guidelines to the transportation of bitumen and* (B) *Bitumen spill protocol* |
| **Manual 35/TRH8** | *Design and use of Asphalt in Road Pavements* |
| **Manual 36 / TRH21** | *Use of Reclaimed Asphalt in the Production of Asphalt* |
| **Manual 37/TMH5** | *Sampling Methods for Road Construction Materials* |
| **Manual 38** | *A Health and Safety Guide for Material Testing Labs in the Road Construction Industry* |
| **Manual 39** | *Laboratory Testing Protocols for Binders and Asphalt* |
| **Manual 40** | *Design and Construction of Surfacing Seals* |

## Technical guidelines

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|---|---|
| **TG1** | *The use of modified binders in road construction* |
| **TG2** | *Bitumen stabilised materials* |
| **TG3** | *Asphalt reinforcement for road condition* |

## DVDs

| | |
|---|---|
| **DVD100** | *Test methods for bituminous products* |
| **DVD200** | *Training guide for the construction and repair of bituminous surfacings by hand* |
| **DVD300** | *Manufacture, paving and compaction of hot mix asphalt* |
| **DVD410** | *The safe handling of bitumen* |
| **DVD420** | *Treatment of bitumen burns* |
| **DVD430** | *Working safely with bitumen* |
| **DVD440** | *Firefighting in the bituminous products industry* |
| **DVD450** | *Safe loading and off-loading of bitumen* |

## PREFACE TO THE THIRD EDITION

This document was produced in answer to concerns expressed by Organisations that operate Materials Testing Laboratories in the Road Construction Industry. The main concern was that operators of material testing laboratories may not be in full compliance with applicable Health and Safety Legislation and/or that, the arrangements for addressing Health and Safety risk and hazards in the "*workplace*" do not conform to acceptable standards.

SABITA was approached to assist in this regard and hence took the initiative to development this Health and Safety best practice guide for a typical Materials Testing Laboratory. Since the publication of the Second Edition, specific feedback from Laboratory operators has highlighted concerns with regards to health and safety issues in connection with distillation of Toluene. Hence, after consultation with relevant stakeholders, it was decided to revise this guideline to include more detailed discussion and recommendations for establishing and managing the hazards and effects associated with the distillation of Toluene.

## SCOPE AND OBJECTIVES

The intended audience of this guide is primarily Bituminous and Asphalt Materials Testing laboratories. However, in response to interest shown by other interested parties, the scope has been extended to include laboratories active in the broader Road Construction Industry. The scope therefore covers, but is not limited to, the work processes and associated activities of laboratories including permanent commercial and production facilities as well as project or site facilities, that deliver services in the following categories:

1. Bituminous and Asphalt Materials Testing;
2. Aggregate Testing;
3. Soils and Gravel Analysis and Testing;
4. Concrete Analysis and Testing;
5. Rock Testing;
6. Geotechnical Testing;
7. Field investigations.

The primary objectives of this guide are as follows:

- To provide Laboratory Managers with a framework to facilitate a program for establishing a Risk Management Plan, that will ensure a safe and healthy working environment;
- To help the Laboratory to comply with applicable Laws, Regulations and Local Authority By-laws;
- To facilitate the training of laboratory personnel;
- To provide a basic inspection *aide memoir* to facilitate inspection of work places where hazardous chemical agents are used.

## GLOSSARY OF TERMS AND ABBREVIATIONS

| | | |
|---|---|---|
| **Acute toxicity** | : | Adverse health effects occurring within a short time period of exposure to a single dose of a chemical or as a result of multiple exposures over a short time period, e.g. 24 hours. |
| **Auto ignition** | : | The auto ignition temperature of a substance is the temperature at or above which a material will spontaneously ignite (catch fire) without an external spark or flame. |
| **Auto ignition temperature** | : | The minimum temperature required to initiate or cause self-sustained combustion of material in the absence of any external source of energy. (Values may change significantly with geometry, gas/vapour concentration, and presence of catalyst.) Any ignition source must be at a temperature of, or greater than, the ignition temperature of the specific substance. |

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| **Barrier cream** | A topical compound for limiting or preventing contact with irritants such as allergens, parasites, or toxins. |
| **BLEVE** | Boiling Liquid Expanding Vapour Explosion**.** Instantaneous release and ignition of flammable vapour upon rupture of a vessel containing flammable liquid above its atmospheric boiling point. |
| **Boil-over** | The rapid increase in volume caused by the presence of water in hot bitumen and the subsequent overflow from a container. |
| **CARC** | CARC: denotes carcinogenicity, which is based on GHS categorisation, including category 1A, 1B<br>Any agent or mixture which induces cancer or increases its incidence, classified by GHS as:<br>(a) Category 1: known or presumed human carcinogens;<br>(b) Category 2: suspected human carcinogens |
| **CEO** | Chief Executive Officer - in relation to a body corporate or an enterprise conducted by the State, means the person who is responsible for the overall management and control of the business of such body corporate or enterprise; |
| **Chronic toxicity** | Adverse health effects resulting from repeated daily exposures to a chemical for a significant period. |
| **Contact dermatitis** | Inflammation of the skin due to exposure to a substance that attacks its surface. |
| **Combustible** | A combustible material is a solid or liquid than can be easily ignited and burned. |
| **Corrosive** | A substance that chemically attacks a material with which it has contact (body cells, materials of construction). |
| **Due diligence** | Applied to occupational health and safety, due diligence means that "employers" shall take all reasonable precautions, under the particular circumstances, to prevent injuries or incidents in the "workplace". |
| **Employer** | Employer as defined in the OHSA means any person, institution or organisation, including government who employs and provides work to an employee, and supervises, remunerates or tacitly or expressly undertakes to remunerate such employee for services rendered by such employee. |
| **Ergonomics** | A scientific discipline concerned with the fundamental understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimise human well-being and overall system performance |
| **Exothermic reaction** | A chemical reaction in which heat is released and, unless temperature is controlled, may lead to runaway conditions. |
| **Flammable liquid** | "Flammable liquid" means any liquid which produces a vapour that forms an explosive mixture with air, and includes any liquid with a closed-cup flash-point of less than 55 °C. |
| **Flammable limits/range** | A flammable vapour mixed with air will only ignite/explode if the mixture is in the flammable range. The minimum and maximum percentage gas concentrations, which can be ignited, constitute the lower and upper limits respectively. The flammable limits and the flammable range are also known as the Explosive Limits and the Explosive Range respectively. |

**Flash point** : The lowest temperature required to raise the vapour pressure of a liquid such that vapour concentration in air near the surface of the liquid is within the flammable range, and as such the air/vapour mixture will ignite in the presence of a suitable ignition source, usually a flame.

**Fume** : Airborne solid particles (usually <0.1 µm) that have condensed from the vapour state.

**GHS** : The Globally Harmonized System of classification and labelling of chemicals, a guidance document developed by the United Nations for standardizing and harmonizing the classification and labelling of chemicals globally, as may be updated from time to time, commonly known as the UN Purple Book.

**Hazard** : The inherent property of a substance capable of causing harm (e.g. toxicity, radioactivity, flammability, explosivity, reactivity, instability). In a broader context anything that can cause harm, e.g. electricity, oxygen-deficiency, machinery, extreme temperature.

**Hazardous waste** : Any waste that contains organic or inorganic elements or compounds that may, owing to the inherent physical, chemical or toxicological characteristics of that waste, have a detrimental impact on health and the environment.

**HRA** : Health Risk Assessment as contemplated in the RHCA

**Ionizing radiation** : The transfer of energy in the form of particles or electromagnetic waves of a wavelength of 100 nanometres or less or a frequency of 3 × 1015 hertz or more capable of producing ions directly or indirectly.

**LEL/LFL** : Lower (Explosive or Flammable) Limit. The minimum concentration of a gas, vapour, mist or dust in air at a given pressure and temperature that will propagate a flame when exposed to an efficient ignition source. Generally expressed as % by volume for gases and vapours, and as mg/m$^3$ for mists or dusts.

**LPG** : Liquefied Petroleum Gas. Petroleum gas stored or processed as a liquid in equilibrium with vapour by refrigeration or pressurization. The two LPG’s in general use are propane and butane.

**OEL** : Occupational Exposure Limit. A limit value set by the Minister for a stress factor in the workplace as revised from time to time by notice in the Government Gazette.

**OEL-ML** : Occupational Exposure Limit – Maximum Limit (Table 2 of RHCA)

**OEL-RL** : OEL-RL: Occupational Exposure Limit – Restricted Limit (Table 3 of RHCA)

**OHSA** : Occupational Health and Safety Act, as amended.

**Oxidizing agent** : Compound that gives up oxygen easily or removes hydrogen from another compound. It may comprise a gas, e.g. oxygen, chlorine, fluorine, or a chemical which releases oxygen, e.g. a nitrate or perchlorate. A compound that attracts electrons.

**PPM** : Parts Per Million

**Percutaneous absorption** : Absorption via the skin, e.g. due to local contamination or a splash of chemical.

**Pyrophoric substance** : A material that undergoes such vigorous oxidation or hydrolysis (often with evolution of highly-flammable gases) when exposed to atmospheric oxygen or to water, that it rapidly ignites without an external source of ignition. This is a special case of spontaneous combustion.

**RHCA** : Regulations for Hazardous Chemical Agents

**Reasonably practicable** : Practicable having regard to-

(a) the severity and scope of the hazard or risk concerned;
(b) the state of knowledge reasonably available concerning that hazard or risk and of any means of removing or mitigating that hazard or risk;
(c) the availability and suitability of means to remove or mitigate that hazard or risk; and
(d) the cost of removing or mitigating that hazard or risk in relation to the benefits deriving therefrom;

**Risk** : Risk means the probability [Likelihood] that personal injury, illness or the death of an employee or any other person, damage to property or the environment will occur.

**Risk Assessment** : The process of evaluating the risks to employee health and safety, as well as the environmental aspects, from workplace hazards. It is a systematic assessment of all aspects of work that considers:

*(a)* a complete hazard identification;
*(b)* identification of all who may be affected by the hazard and how a person may be affected;
*(c)* identification of environmental aspects;
*(d)* the analysis and evaluation of the hazards; and
*(e)* prioritisation of risks;

**SABITA** : Southern African Bitumen Association

**SDS** : Safety Data Sheet/s. Safety Data Sheets are an essential component of the **GHS** and are intended to provide comprehensive information about a substance or mixture for use in workplace chemical management.

**Solvents** : Liquids that dissolve other substances. Chemical solvents are used widely in industry: e.g. by pharmaceutical makers to extract active substances; by electronics manufacturers to wash circuit boards; by paint makers to aid drying. For civils laboratories toluene is a solvent used for extraction of hard-to-remove material from aggregate.

**Source of ignition** : Typical ignition sources in a laboratory include but are not limited to the following: Heat/flame devices, sparks from electrical switch gear, static electricity buildup, friction, hot surfaces, matches/cigarette lighters, cellular phones. These all have the potential for sufficient energy to ignite flammable vapours and gases.

**Substance** : Includes any solid, liquid, vapour, gas or aerosol, or combination thereof.

**Volatility** : The tendency and ability of a substance to vaporise at normal ambient temperature. Volatile hydrocarbons are usually in the low boiling point substance range.

**Volatile solvents** : Volatile solvents are liquids that vaporise at room temperature. These organic solvents can be inhaled for psychoactive effects and are present in many domestic and industrial products such as glue, aerosol, paints, industrial solvents, lacquer thinners, petrol, and cleaning fluids.

**Workplace** : Workplace means any premises or place where a person performs work in the course of employment.

**UEL** : Upper Explosive or Flammable Limit**.** The maximum concentration of gas, vapour, mist or dust in air at a given pressure and temperature in which a flame can be propagated.

# CONTENTS

## 1. INTRODUCTION

The concept of "Due Diligence" is a generally accepted Business Principle, although its practical application is not always well understood. Exercising Due Diligence could prevent liability under the Occupational Health and Safety Act and is a defence available to companies or individuals charged under the Occupational Health and Safety Act.

To be able to prove Due Diligence, an accused (employer) must be able to prove that they took all reasonable precautions to prevent an incident from occurring. In practical terms and in the context of the Occupational Health and Safety Act, cognisance must be taken of the definition of ***"Reasonably Practicable"***, a term which is used extensively throughout the Act and Regulations. In order to prove Due Diligence, an "*employer*" must be able to demonstrate that **as far as is reasonably practicable**, a working environment that is safe and without risk to the health of his or her employees is provided and maintained.

Considering the above, and in particular the meaning of ***"Reasonably Practicable",*** it is a reasonable assumption that Due Diligence means, that merely complying with Legislative requirements, IS NOT always adequate to provide and maintain a working environment that is safe and without risk. Cognisance must be taken of best practice information and guidance available and reasonably accessible, in connection with relevant Health and Safety risks and hazards in the workplace.

This guide therefore recommends, over and above minimum arrangements for legal compliance, relevant best practice guidance to assist employers with demonstrating Due Diligence.

## 2. REGULATORY REQUIREMENTS

The principal piece of Legislation that governs Health and Safety in the workplace is The Occupational Health and Safety Act (Act No. 85 of 1993) as amended. It is a requirement that a copy of the Act shall be readily available at the workplace.

> **Administrative Regulation 4.** ***'Every employer with five or more persons in his employ shall have a copy of the Act and the relevant regulations readily available at the work place: Provided that, where the total number of employees is less than five, the employer shall, on request of an employee, make a copy of the Act available to that employee.'***

Also, a number of Regulations made under the Act, could be applicable to your operations. The various Acts and Regulations are freely available and can be downloaded from the relevant Government websites and specifically the Department of Employment and Labour at the following link http://www.labour.gov.za/documentcenter.

The general requirements of the Act (*or any other relevant Act*) and relevant Regulations will not be discussed in any detail in this guide however, specific sections from the Act and/or applicable Regulations will be referenced, and if necessary, briefly discussed later to inform on the minimum expectations to comply with relevant regulatory requirements.

# 3. CONTROL FRAMEWORK FOR LABORATORY HEALTH AND SAFETY

## 3.1 Suggested Framework

It is not the intention to discuss a comprehensive Environment, Health and Safety Management System in this guide. Ideally an organisation should consider establishing a System based on an internationally recognised standard such as SANS 18001 or ISO 4500.

However, it is recognised that not all organisations have the resources, especially the financial means, to implement and maintain such systems. Therefore, the suggested control framework in Figure 1 below is proposed as a bare minimum to assist laboratories to demonstrate HSE Due Diligence. The suggested framework will ensure legal compliance and also includes best practice for Hazard Analysis and Hazard Control.

**Figure 1 - Suggested Laboratory HSE Control Framework**

### 3.1.1 Health and Safety Policy and Commitment

A Health and Safety Policy is not mandatory in accordance with the OHSA, unless the Chief Inspector directs an employer in writing to prepare a written policy concerning the protection of the health and safety of his employees at work. However, it is considered best practice for organisations to prepare and display a written HSE Policy. The purpose of the policy is to express the employer's commitment to health and safety. It should include a statement regarding the responsibilities of the employer, supervisors and other workers. A policy broadly states what the employer intends to do about commitment and support for health and safety in the workplace. An example of an HSE Policy is appended to this guide as Appendix 1.

### 3.1.2 Health and Safety Standards

Standards are designed to ensure that HSE systems and control measures are adequate, reliable and consistently perform the way they are intended to. The OHSA and other relevant Acts and Regulations encompass the minimum workplace HSE Standards.

In addition, other standards adopted by organisations enhance the HSE management efforts and establish common values that define safety and quality requirements. In the laboratory HSE control framework the Health and Safety Standards provide the basis for consistent application of processes and procedures necessary to assure the quality of the Risk Management Plan. It is recommended that, at a minimum, laboratory management should consider developing workplace specific written standards that include, but are not limited to the following:

» Hazard Identification and Risk Assessment (Examples are - A generic list of Hazards that could be inherent to the workplace activities and tasks; A Risk Assessment Matrix to classify and prioritise risk);
» A best practice Hazard Analysis technique (Example - The BowTie Methodology);
» A standard for Incident Notification, Investigation, Reporting and Follow-up;
» An HSE Communication standard;
» An Energy Isolation standard;
» A standard for Storage and Handling of Hazardous Substances;
» An HSE Audit Plan.

### 3.1.3 Workplace Specific Risk Management Plan

It should be noted here that the OHSA is under revision and the Occupational Health and Safety Amendment Bill has already gone through the “public comments” phase. It is expected that the revised OHSA will become effective in the not-too-distant future (2025). The Bill proposes some significant changes with regard to the process to be followed for **Risk Assessment** and also provides for a mandatory **Risk Management Plan** to be established. Although it is expected that the current proposed change in this regard will likely be enacted as is, it would be highly presumptuous to assume this.

However, regardless of the ultimate provisions of the Amended Act, the elements of the Risk Management Plan recommended in this guide are considered to be best practice and include some of the proposed changes to the Act.

#### 3.1.3.1 Risk Assessment and Hazard Analysis Process

It is important to note that the Act is very explicit in stating that the Risk Assessment SHALL BE WORKPLACE SPECIFIC. A workplace specific Baseline Risk Assessment (BRA) should be conducted to assess and prioritise risk of all aspects of work. The BRA process should consider the following:

a) A complete hazard identification (HAZID);
b) Identification of all who may be affected by the hazard;
c) How the person/s may be affected (Consequences); and
d) The assessment, evaluation and classification (prioritising) of the risks (LOW, MEDIUM, HIGH).

Once the Baseline Risk Assessment is completed, the systematic analysis of the identified (priority) hazard/s is performed using a methodology such as BowTie, or a similar technique, including the following steps:

i. Clearly define/describe the HAZARD;
ii. Determine the TOP EVENT (initiating event) that could release the HAZARD;
iii. Determine the potential CONSEQUENCES of the TOP EVENT (who/what may be affected);
iv. Determine the potential THREATS (causes) that could lead to the TOP EVENT;
v. Develop BARRIERS (controls) for each THREAT. BARRIERS are aimed at *preventing* the TOP EVENT;
vi. Develop controls to mitigate the CONSEQUENCES *(recovery measures)*;
vii. Document the results of the analysis in a Hazard Register.

### 3.2 Considerations for Developing Controls

OHSA Section 8. 2. (b) clearly states that the duties of an employer to employees include *"taking such steps as may be reasonably practicable to eliminate or mitigate any hazard or potential hazard to the safety or health of employees, **before resorting to personal protective equipment**"*.

In practice, it is a generally accepted rule that the Hierarchy of Controls is applied when developing controls for workplace hazards. Figure 2 below shows the steps in the Hierarchy of Controls.

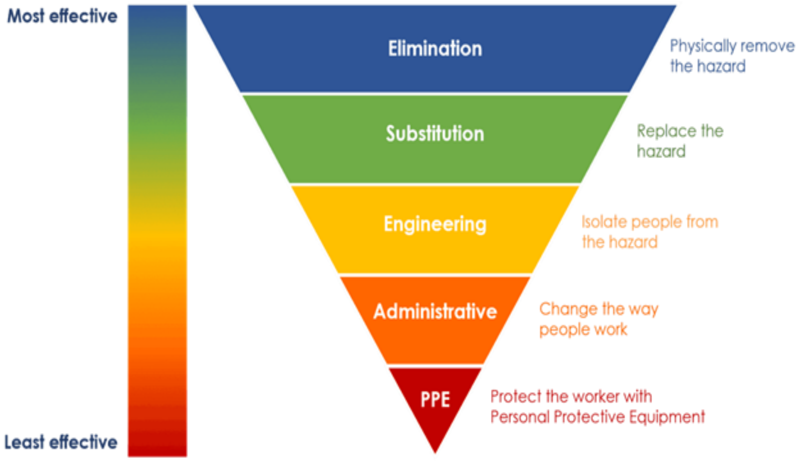


**Figure 2 - The Hierarchy of Controls**

Risks should be reduced to the lowest reasonably practicable level by implementing preventative measures, in order of priority. This is what is meant by a hierarchy of control. The list below sets out the order to follow when developing controls for the hazards you have identified in your workplace. Consider the headings in the order shown - DO NOT simply jump to the easiest control measure to implement: -

i. **Elimination** - Redesign the job or substitute a substance so that the hazard is removed or eliminated;

ii. **Substitution** - Replace the material or process with such as will reduce the severity of the hazard;

iii. **Engineering controls** - Enclosure, Isolation, Ventilation. For example:
   - » Enclosure - Machine guarding prevents workers from coming into contact with dangerous parts of machines;
   - » Isolation - Move a hazardous job to a part of the workplace where fewer people will be exposed;
   - » Ventilation - Local exhaust ventilation to remove hazardous airborne contaminants such as dusts, gases, vapours and fumes, etc., and general ventilation for keeping the workplace comfortable.

iv. **Administrative controls** - These are all about identifying and implementing the procedures needed to work safely. For example:
   - » Limited time exposure to hazards;
   - » Written operating procedures;
   - » Health and Safety rules for employees;
   - » Alarms, Safety Signs, Warning systems, etc;
   - » Health and Safety Training.

v. **Personal protective clothes and equipment** - Only after all the previous measures have been tried and found ineffective in controlling risks to a reasonably practicable level, must personal protective equipment (PPE) be used.

For example:

- Where you cannot eliminate the risk of a fall, use fall arrest equipment to minimise the distance and consequences of a fall (should one occur);
- Where exposure to physical agents cannot be reduced to an acceptable level, use items of clothing such as heat and chemical resistant gloves, aprons, eye and face protection and, suitable respiratory and hearing protection equipment, etc.

### 3.3 Hazard Communication

Hazard communication in the workplace is a vitally important process and the OHSA clearly places a duty on the employer to ensure effective communication in Section 8. (General duties of employers to their employees) and Section 13. - (Duty to inform). The arrangements for Hazard Communication should be documented in the laboratory HSE Communication Standard. Typical documentation and processes to comply with the minimum requirements include, but are not limited to:

- A documented Baseline Risk Assessment;
- The Hazard Register;
- Hazard Control Sheets;
- Standard Operating Procedures and Task Instructions (Included here are the manufacturer's operating instructions. ***Steps should be taken to ensure that these are clearly understood to ensure that the proper operating and safety procedures outlined in the owner's manual supplied with the equipment or apparatus are carried out. These are legally binding documents and the precautionary measures prescribed therein must be adhered to*****)**
- Employee HSE Induction and task specific HSE Training Programs;
- HSE Tool Box Talks;
- Symbolic Safety Signs and Chemical Hazards Pictograms as required by the GHS;
- Safety Data Sheets in the prescribed GHS format **<u>MUST</u>** be readily available;
- Arrangements for communicating with HSE Representatives;
- HSE Committee minutes;
- Inspection/Audit Reports, etc.

A selection of some best practice examples for elements of the Risk Management Plan, are appended to this guide:

- An example of a qualitative Risk Assessment Matrix - Appendix 2;
- A Hazard Register - Appendix 3;
- A Hazard Control Sheet - Appendix 4;

### 3.4 Monitoring, Reporting and Corrective Action

OHSA Section 8. (1) and (2) (a) states that an employer "shall provide and maintain" systems of work that are safe and without risk to the health of employees. This clearly means that an employer shall cause the safe systems of work to continue working as intended. This cannot happen if the implementation of the Risk Management Plan is not monitored, and regularly reviewed to ensure conformance with standards.

Regular laboratory HSE Inspections, periodic Audits and Management review of the Risk Management Plan must be performed. It is recommended that a laboratory HSE Audit Plan is developed, implemented and that the plan execution is closely monitored by management. Besides regular workplace inspections and periodic Internal Audits it is recommended that a comprehensive management review of the Risk Management Plan be conducted at least once per year to ensure continued suitability of the plan.

# 4. GENERAL CONSIDERATIONS FOR CONTROL OF LABORATORY HAZARDS

## 4.1 Regulatory requirements

Regulatory requirements establish the MINIMUM STANDARDS for workplace Health, Safety and Environmental management and conformance with these requirements will provide a solid foundation to build on in pursuit of continuous improvement. Some of the most important regulatory requirements that are applicable, but not limited, to the activities of a typical Materials Testing Laboratory are as follows:

**Table 1 - Regulatory scope, reference and key requirements**

| Regulatory scope | Regulatory Reference | Key Requirements |
|---|---|---|
| General workplace HSE administration | General Administrative Regulations, 2003; | • Copy of the Act must be available<br>• Health and safety committee meeting minutes to be kept for at least 3 years<br>• Arrangements for selection and designation of HSE Representatives<br>• Reporting of incidents and occupational diseases and recording and investigation of incidents |
| Hygiene and ventilation of facilities provided for employees in the workplace | Facilities Regulations, 1988;<br>Parts F, O, P and Q of the National Building Regulations; | Provision and maintenance of:<br>• Sanitation<br>• Personal facilities for safekeeping<br>• Change-rooms (where prescribed)<br>• Dining-rooms (where prescribed)<br>• An adequate supply of drinking water |
| Control of the physical environment in workplaces | Environmental Regulations for Workplaces, 1987<br>Note that a new set of regulations the Draft Physical Agents Regulations were published for comments in October 2022. These regulations have however not yet been promulgated. | • Thermal requirements<br>• Lighting<br>• Windows<br>• Ventilation<br>• Housekeeping<br>• Precautions against flooding<br>• Fire precautions and means of egress |
| Exposure of persons to Hazardous Chemical Agents (HCA) at the workplace. | Regulations for Hazardous Chemical Agents, 2024<br>**Note that the new RHCA Regs. have not yet been promulgated at the time of publication but it is expected that the proposed changes will become effective soon.** | • Classification of Hazardous Chemical Agents<br>• Information and training<br>• Duties of persons who may be exposed to HCA<br>• Assessment of potential exposure<br>• Air monitoring<br>• Medical surveillance<br>• Respirator zone demarcation<br>• Record keeping<br>• Making Safety Data Sheets available<br>• Control of exposure to HCA<br>• Personal protective equipment and facilities<br>• Maintenance of control measures<br>• Prohibition of certain acts by |

| | | |
|---|---|---|
| | | employees<br>• Labelling, packaging, transportation and storage<br>• Disposal of HCA<br>• Occupational exposure limits (OEL) for HCA in the workplace |
| Exposure of any person at the workplace to noise at or above the noise-rating limit | Noise-induced Hearing Loss Regulations, 2003 Note that the NIHL Regulations are under review and draft regulations were published for comments in October 2022 but are yet to be promulgated at the time of publication. | • Information and training<br>• Duties of persons who may be exposed to noise<br>• Assessment of potential noise exposure<br>• Noise monitoring<br>• Medical surveillance<br>• Noise zone demarcation<br>• Control of noise exposure<br>• Record keeping<br>• Hearing protective equipment<br>• Maintenance of control measures |
| Operation of certain machinery used in a workplace | Driven Machinery Regulations, 2015 | • Guarding of moving or revolving components of machinery<br>• Operation of circular saws<br>• Safeguards for mixing, agitating and similar machines<br>• Washing machines, centrifugal extractors, etc. |
| Safety, safe use and maintenance of electrical installations | Electrical Installation Regulations, 2009 | • Responsibility for electrical installations<br>• Certificate of compliance for electrical installations |
| Safety in connection with electrical machinery used in the workplace | Electrical Machinery Regulations, 2011 | • Personal protective equipment<br>• Work on disconnected electrical machinery<br>• Electrical control gear<br>• Switchboards<br>• Electrical machinery in hazardous locations<br>• Portable electric tools<br>• Portable electric lights |
| Operation, repair, modification, maintenance, inspection and testing of pressure equipment | Pressure Equipment Regulations, 2009 | • Duties of users<br>• Pressure equipment marking<br>• Pressure and safety accessories<br>• Inspection and test<br>• Records<br>• Access<br>• Gas reticulation equipment and systems<br>• Transportable gas containers<br>• Fire extinguishers |
| Requirements for various activities that could be performed, or conditions that could prevail in a workplace | General Safety Regulations, 1986 | • Personal safety equipment and facilities<br>• Intoxication<br>• Display of substituted notices and signs<br>• Admittance of persons<br>• First aid, emergency equipment and procedures |

| | | |
|---|---|---|
| | | • Use and storage of flammable liquids<br>• Work in elevated positions<br>• Stacking of articles<br>• Use of ladders<br>• Minimum contents of a First Aid Box |
| General requirements in connection with the use of machinery | General Machinery Regulations, 1988 | • Safeguarding of Machinery<br>• Operation of Machinery<br>• Working on Moving or Electrically Alive Machinery<br>• Devices to Start and Stop Machinery<br>• Reporting of Incidents in Connection with Machinery |
| Management of hazardous waste generated in a workplace | National Environmental Management: Waste Act, 2008 - Waste Classification and Management Regulations, 2013 | • Waste Classification<br>• Safety Data Sheets<br>• General waste management requirements<br>• Waste treatment<br>• Waste Disposal to Landfill<br>• Records of waste generation and management<br>• Waste Manifest System |
| Ergonomics in a workplace | Ergonomics Regulations, 2019 | • Information, instruction and training<br>• Duties of persons who may be at risk of exposure to ergonomic risks<br>• Ergonomic risk assessment<br>• Risk control<br>• Appendix 1 - Explanatory Notes to Ergonomics Regulations 2019 |

## 4.2. Generic best practice guidance for controlling chemical hazards in the laboratory

### 4.2.1 Hazard communication for chemicals used in the laboratory *(i.e. fostering a grasp of the characteristics of the chemicals in use)*

Laboratory personnel who handle chemicals should be familiar with the general characteristics, use and storage guidelines, PPE requirements, and health hazards associated with the chemicals they work with on a routine basis. Laboratory management must ensure that on- the-job training is conducted on specific tasks involving the use of chemicals. An important part of the training curriculum shall be knowledge and understanding of the labels that should be fixed to chemical containers.

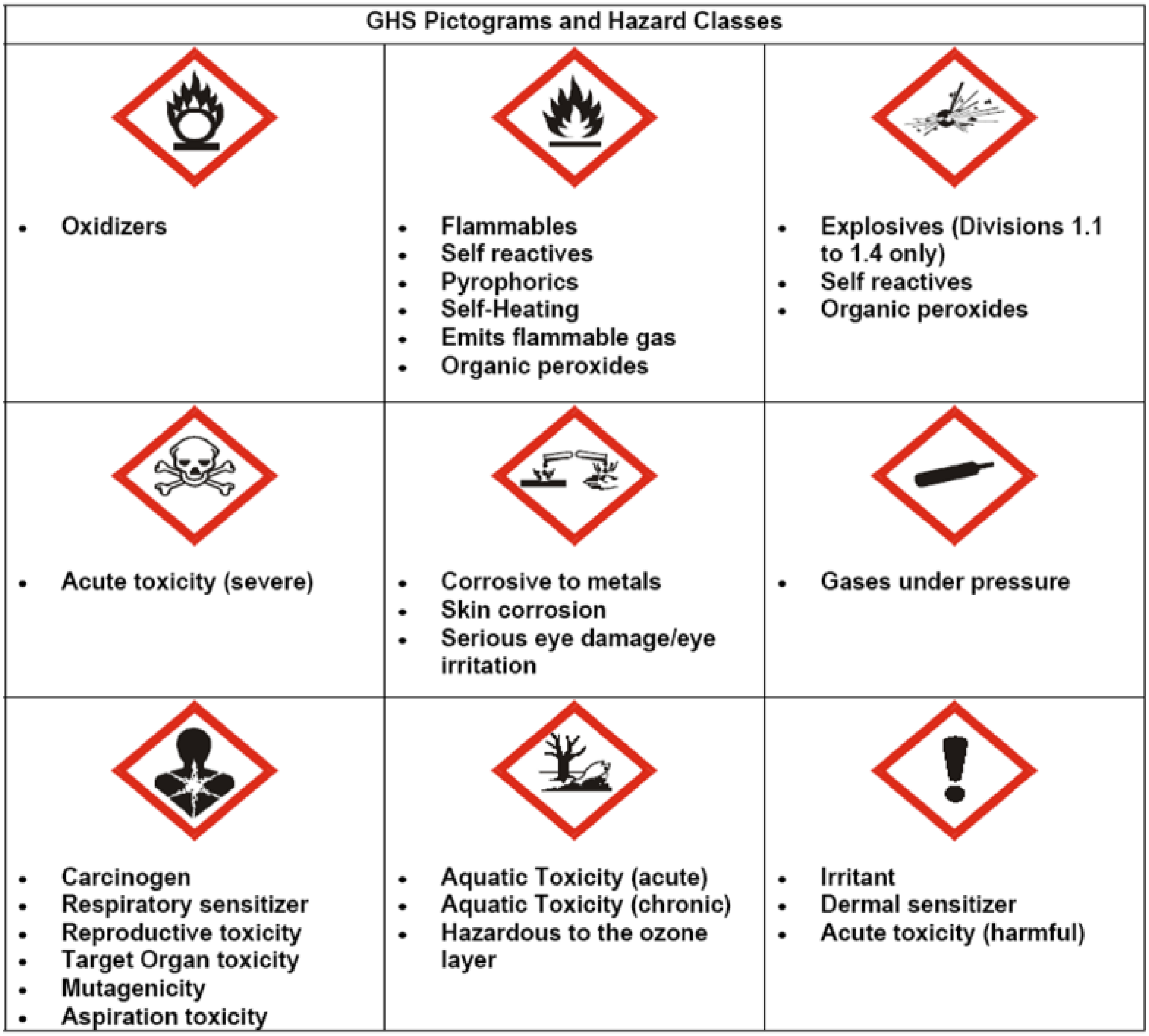
Most laboratory chemicals will fall within one of the following groups or categories:

☐ Flammables and Explosives
☐ Oxidizers
☐ Corrosives
☐ Reactive
☐ Toxins
☐ Compressed Gas

In general, chemicals within these categories will react similarly and will have similar properties. Of course, many chemicals can fit into more than one category and in this case a decision would have to be made as to what is the most significant characteristic of that chemical.

**NOTE ON CHANGES IN PACKAGING AND LABELLING REQUIREMENTS:**
One of the objectives of the Draft Regulations for Hazardous Chemical Agents is to align the requirements with the Globally Harmonized System of Classification and Labelling of Chemicals (GHS). A copy of the GHS can be downloaded at the following link:
http://www.unece.org/fileadmin/DAM/trans/danger/publi/ghs/ghs_rev07/English/ST_SG_AC10_30_Rev7e.pdf

A significant change in requirements is that the symbols on labels have changed and the new labels will replace ALL previous labels. It is also recommended that, where possible, the symbols should be inserted in the relevant sections of an SDS. See Figure 3 below for the GHS Pictograms and Hazard Classes.



GHS Pictograms and Hazard Classes

| | | |
|---|---|---|
| Oxidizers | Flammables<br>Self reactives<br>Pyrophorics<br>Self-Heating<br>Emits flammable gas<br>Organic peroxides | Explosives (Divisions 1.1 to 1.4 only)<br>Self reactives<br>Organic peroxides |
| Acute toxicity (severe) | Corrosive to metals<br>Skin corrosion<br>Serious eye damage/eye irritation | Gases under pressure |
| Carcinogen<br>Respiratory sensitizer<br>Reproductive toxicity<br>Target Organ toxicity<br>Mutagenicity<br>Aspiration toxicity | Aquatic Toxicity (acute)<br>Aquatic Toxicity (chronic)<br>Hazardous to the ozone layer | Irritant<br>Dermal sensitizer<br>Acute toxicity (harmful) |

**Figure 3 - GHS Pictograms for packaging and Labelling**

### 4.2.2 General Chemical Storage Requirements and Guidelines

- Ensure all containers of hazardous chemicals are properly labelled with the identity of the hazardous chemical(s) and appropriate hazard warnings;
- All chemicals should be dated upon receipt in the laboratory and on opening;
- All chemicals should be stored according to their hazard class and not in strict alphabetical order *(Storing chemicals in alphabetical order will often result in incompatible chemicals being stored next to one another. Check the container labelling or the relevant product SDS if you are not sure of the hazard class)*;
- Chemicals should be stored no higher than eye level and never on the top shelf of a storage unit. Shelves should not be overstocked and each shelf should have an anti-roll lip;

- Liquids should be stored in unbreakable or double-contained packaging, or the storage cabinet should have the capacity to hold the contents if the container breaks;
- Flammable liquids should be stored in an approved, dedicated flammable liquid storage cabinet or flammable liquid store if the volume exceeds 40 ℓ of Class 1 (flash point of < 37° C) and 200 ℓ of class II and III liquids (flash point > 37° C). ***(Consult with the local authority (Fire Department) in your area for flammable liquid storage requirements);***
- Store acids in a dedicated acid cabinet. Nitric acid may be stored in the same cabinet but only if it is kept isolated from all other acids;
- Do not store chemicals near heat sources such as ovens, Bunsen burners or steam pipes. Also, do not store chemicals in direct sunlight;
- Do not use laboratory benches as permanent storage for chemicals;
- Inspect your chemicals routinely for any signs of deterioration and for the integrity of the label;
- Do not store chemicals on the floor, especially chemicals in glass containers;
- Do not use fume hoods as a permanent storage location for chemicals, with the exception of particularly odorous or volatile chemicals that may require ventilation;
- Do not store excessive amounts of chemicals in a laboratory. *(Buying chemicals in bulk quantities has more disadvantages than advantages: limited work space, creation of a serious fire hazard, and disposal costs of unused chemicals that are often higher than the initial purchase costs);*
- First aid supplies, emergency phone numbers, eyewash and emergency shower equipment, fire extinguishers, spill clean-up supplies and personal protective equipment should be readily available and personnel trained in their use;
- Only compressed gas cylinders that are in use and secured in place shall be kept in the laboratory. All others, including empties, shall be kept at the compressed gas cylinder storage area for the laboratory;
- Be on the look-out for unusual conditions in chemical storage areas, such as:
  - *Improper storage of chemicals*
  - *Leaking or deteriorating containers*
  - *Spilled chemicals*
  - *Temperature extremes (too hot or cold in storage area)*
  - *Lack of or low lighting levels*
  - *Blocked exits or aisles*
  - *Trash accumulation*
  - *Fire equipment blocked, broken or missing*
  - *Lack of information or warning signs ("Flammable liquids", "Acids", "Corrosives", "Poisons", etc.)*

### 4.2.3 Safe disposal of hazardous chemicals waste

**What is Hazardous Waste?**

Hazardous waste is a waste that contains organic or inorganic elements or compounds that may, owing to the inherent physical, chemical or toxicological properties of that waste, have a detrimental impact on health or the environment.

**General disposal guidelines**

- Hazardous chemicals **MUST NEVER** be poured down the drain;
- Generally, ensure that all hazardous chemical waste is classified as waste and disposed of in accordance with the National Environmental Management: Waste Act, no 59 of 2008 and the Waste classification and management regulations, 2013 ***(It is recommended that laboratory management establish a Waste Disposal Procedure and ensure that these requirements are adhered to);***
- It is very important that hazardous waste is segregated into the proper categories. Different hazardous wastes have different disposal methods. Segregate waste wherever possible. Avoid mixing within, as well as, between categories. As a guide the four characteristics **Flammability, Corrosivity, Reactivity, and Toxicity should be considered** to segregate hazardous waste for disposal.

- All waste must be appropriately labelled and packaged for the particular waste category. For example: Corrosive waste should be placed in non-metallic containers and liquid waste must be placed in leak-proof containers with a screw-top or other type of secure lid;
- A specific storage area must be allocated for temporary storage of hazardous waste with strictly controlled access to this area;
- Accumulation of large quantities of hazardous waste in the laboratory should be avoided. Hence, waste must be regularly removed for disposal at an approved waste disposal facility;
- It is highly recommended that a reputable waste management organisation is used to collect and dispose of hazardous waste. A certificate of safe disposal, at an approved waste disposal site, should be included as part of the contractual obligation of the subcontractor.

### 4.3 The importance of good housekeeping in the laboratory

The great Mr. Henry Ford was once asked the question:

*"What would you do if you were called upon to take charge of a business that had failed?"*

His quick answer was:

*"No business I know of ever went to the wall without first accumulating a vast pile of dirt. The dirt and all that goes with it, untidy thinking and methods, helped to cause that failure. The first thing I would do would be to clean that business up."*

**What does good housekeeping mean?**

According to Harry Mayer's "First Law of Good Work" it is all about order in the workplace and he cites the following definition of order:

**A PLACE IS IN ORDER WHEN THERE ARE NO UNNECESSARY THINGS ABOUT, AND WHEN ALL NECESSARY THINGS ARE IN THEIR PROPER PLACES. "NO" IN THIS SENTENCE MEANS NONE!! NOT ANY!! NOT - EVEN - ONE.**

Good housekeeping practices have numerous positive benefits, such as:

- Clean, clutter-free and spill-free work areas;
- Decreased fire hazards;
- Awareness for tripping and related hazards;
- Proper waste management and control of hazardous substances;
- Better hygienic conditions leading to improved health;
- More effective use of space and improved employee morale;
- Improved productivity and better control over what can go wrong.

**Basic housekeeping rules for a laboratory**

It is recommended that a Laboratory Housekeeping Checklist be used as a prompt for regular inspections of workplaces. Such checklist could include the following items:

**General directives:**

- Organise bench tops with large equipment at the back and progressively smaller equipment toward the front. Leave sufficient space to perform your work safely and to avoid reaching over items that can easily get knocked over, such as graduated cylinders or flasks;
- Put away any clean glassware that is not being used. Avoid accumulating large amounts of dirty dishes on laboratory benches and by sinks. Clean them when your testing is done. Never leave glassware in the sink because it can easily break;
- Regularly check glassware for star cracks, chips, or cracks, and promptly discard or repair any unsafe glassware;
- Discard disposable pipets and pipette tips immediately after use;
- Properly secure and label all containers of chemicals/experimental intermediates;
- Keep drawers and cabinets closed when not in use;
- Promptly clean up spilled chemicals, silica gel, and any other powdered materials to eliminate respiratory hazards;
- Remove any equipment or clutter that interferes with access to emergency equipment such as eyewash stations, safety showers, and fire extinguishers;
- Floors should be free of hazards. Never leave carelessly discarded objects, dropped objects, or spilled material on the floor;

- Always keep tables, chemical hoods, floors, aisles, and desks clear of all material not being used;
- There should always be two clear passageways to exits;
- There should always be clear space around safety showers or eyewashes, fire extinguishers, and electrical controls;
- Sink traps and floor drain traps should be filled with water at all times to prevent the ingress of sewer gases into the laboratory;
- Keep any frequently used bench apparatus well away (at least 50 mm) from any edges and secured whenever possible;
- Clean work areas upon completion of a test or at the end of each day;
- Keep bench tops and bench liners free of visible contamination;
- Reduce the risk of slips, trips, and falls by cleaning up liquid or solid spills immediately, keeping doors and drawers closed and passageways clear of obstructions;

**Storage:**

- Do not store chemical containers on the floor;
- Sharp or pointed tools should be properly sheathed or stored;
- Clothing should be hung in proper locations and not draped over equipment or benches;
- Do not store excess cardboard boxes, equipment boxes, Styrofoam, etc. under laboratory benches, on shelves, or above shelves/cabinets throughout the laboratory. This can be a safety as well as a fire hazard;
- Less commonly used equipment should be kept in designated storage areas;

## 4.4 Compressed Gases

### Hazards of compressed gases

Compressed gases are hazardous due to the high pressure inside cylinders. Knocking over an unsecured, uncapped cylinder of compressed gas can break the cylinder valve; the resulting rapid escape of high-pressure gas can turn a cylinder into an uncontrolled rocket or pinwheel, causing serious injury and damage. Poorly controlled release of compressed gas in the laboratory can burst reaction vessels, cause leaks in equipment and hoses or result in runaway chemical reactions. Compressed gases may also have flammable, oxidizing, dangerously reactive, corrosive or toxic properties. Inert gases such as nitrogen, argon, helium and neon can displace air, reducing oxygen levels in poorly ventilated areas causing asphyxiation.

### Safe handling, storage and transport of compressed gas cylinders:

- All gas cylinders, full or empty, should be securely supported using suitable racks, straps, chains or stands;
- When cylinders are not in use or are being transported, remove the regulator and attach the protective cap;
- An appropriate cylinder cart should be used for transporting cylinders. Chain or strap the cylinder to the cart;
- Verify that the regulator is appropriate for the gas being used and the pressure being delivered;
- Do not rely upon the pressure gauge to indicate the maximum pressure ratings; check the regulator's specifications;
- Do not use adaptors or adhesive tape to attach regulators to gas cylinders;
- Never bleed a cylinder completely empty; leave a residual pressure;
- Do not lubricate the high-pressure side of an oxygen regulator;
- Do not expose cylinders to temperature extremes;
- Store incompatible classes of gases separately.

## 4.5 Guidance on providing appropriate and suitable PPE

In Section 3.2 of this guide, the OHSA Section 8. 2. (b) requirements and Hierarchy of Controls was discussed and it was clearly stated that PPE should be the last resort when developing hazard controls.

However, it is also a fact that in many cases the exposure to the potential consequences of hazardous exposure cannot be totally controlled by applying the first four steps of the Control Hierarchy and therefore PPE should be used to supplement or augment other means of hazard control, to further minimise the risk of injury.

Issues affecting use of PPE include discomfort and inconvenience, and unsuitable or poorly maintained equipment. It is vital that problems caused by inadequate selection, fit and maintenance do not undermine the effectiveness of the equipment. This requires careful consideration of PPE requirements w.r.t suitability, quality, comfort of the wearer, management's commitment and willingness to enforce the use of PPE.

Establishing an effective PPE program is in itself an extensive subject and it is not the intention to discuss it in any great detail in this guide. Instead, a very brief summary of the key requirements for PPE in a materials testing laboratory is provided below and it is highly recommended that management consider establishing a formal PPE standard to at least ensure compliance with regulatory requirements.

### Determining the need for PPE

The first step in the process is to determine the need for and the type of PPE required to protect workers from the residual risk of a particular hazard. This is done as part of the workplace Hazard Analysis and should be documented in the hazard register under Mitigating Controls.

### Types of personal protective equipment

PPE is generally grouped in the following categories, with examples, based on the type of protection afforded by the equipment:

- Respiratory protection - disposable, cartridge, air-line, half or full face;
- Eye protection – spectacles, goggles, shields, visors;
- Hearing protection – earmuffs and plugs;
- Hand protection – gloves and barrier creams;
- Foot protection – shoes, boots, metatarsal guards;
- Head protection – helmets, caps, hoods, hats;
- Working from heights – harness and fall arrest devices;
- Skin protection – hats, sunburn cream, long sleeved clothes.

### Selecting the most appropriate and suitable PPE

Determining the most appropriate and suitable item of PPE for a particular application requires very careful consideration. In practice, it is often found that the PPE used in the workplace is not effective simply because the selection process is flawed and by and large the decisions are often based on "convenience" and "cost saving" considerations to the detriment of the persons whom are supposed to be protected.

Typical examples of incorrect selection or application of PPE are:

- Using a standard "dust mask" to protect against inhalation of toxic chemical vapours or using a filter type face mask with the incorrect filter;
- A very common PPE mistake in a laboratory is the reliance on latex for all purpose use. Latex gloves do not provide adequate chemical protection from organics, solvents, toxics, acids, or bases. The best choice for all purpose use is nitrile gloves;
- Regular glasses are not safety glasses. Safety glasses must be worn over prescription glasses;
- Using common ear plugs when earmuffs are required for noise protection. Hearing Protection Devices have different ratings based on the level of protection required (The measured noise level) and the employees' Personal Attenuation Rating (PAR). It is sometimes necessary to wear a combination of hearing protectors for adequate protection.

Above examples are but a few of the common misconceptions and mistakes associated with application of PPE and, if you are not certain of the most suitable item to select, the appropriate course of action should be to consult with a reputable PPE supplier for the correct selection and application based on your risk assessments.

### General laboratory dress code

It is recommended that laboratory managers establish a standard dress code that should apply to all laboratory employees and visitors whilst present on laboratory premises. This dress code is the minimum requirement over and above the prescribed PPE that may be required for specific tasks. As a minimum the following items of clothing and protection is recommended:

- **Clothing:** Long pants or skirts and closed toed shoes, and tie back long hair (hair nets). Shorts, short skirts, sandals, loose clothing, or dangling jewellery should not be allowed;
- **Laboratory coat:** All laboratory workers and visitors should wear fully buttoned laboratory coats or overall jackets at all testing areas where hazardous materials are handled. It is recommended that laboratory coats made from 100% cotton and which cover the arms are used;

- **Eye protection and gloves:** It is recommended that laboratory personnel and visitors either wear, or have readily available (in the laboratory coat pocket), suitable safety glasses and gloves;

## 5. MATERIALS TESTING LABORATORY SPECIFIC HAZARDS

This section provides examples of typical hazards that are likely to be encountered in a materials testing laboratory included in the scope of this guide. It is by no means suggested that the list is complete; however, it does represent an illustration of information acquired through visits to relevant laboratories as well as information received from representatives of materials testing Laboratories and reliable sources on the Internet.

The aim of this section is to provide information that will assist laboratory managers with hazard identification and defining potential effects. It is highly recommended that laboratories compile a similar laboratory -specific list to facilitate the Hazard Identification process within own operations. The information is presented in Table 2 below:

**Table 2 - Examples of typical Hazards, Potential Consequences and Recommended Control Measures**

**Notes:**

**[1] Specific Regulatory requirements for laboratory Hazards are not included in the column for Recommended Controls. Refer to Section 4: Table 1 under General Considerations for control of laboratory Hazards**

| HAZARD GROUP | HAZARD DESCRIPTION / SOURCE | POTENTIAL CONSEQUENCES | RECOMMENDED CONTROLS [1] |
|---|---|---|---|
| **Hot Fluids** | Liquid Bitumen @ ± 210°C/Paddle Tip Blender | Severe burns to body when handling sample containers. | Wear appropriate PPE to protect against very high temperatures. Refer to Section 3 for PPE requirements. |
| **Hazardous Chemical Agents:**<br>**Toxic Liquids**<br>**Flammable Liquids**<br>**Toxic Gases**<br>**Flammable Gases**<br>**Compressed gas** | Trichloroethylene/Rotary Evaporator<br>*(The current OHSA RHCA OEL (Maximum Limit) for Trichloroethylene is 20 ppm with a CARC and SKIN notation)* | Acute effects include irritation to Skin and Eyes, dizziness, headaches, sleepiness, incoordination, confusion, nausea, unconsciousness, and even death.<br>Long term effects:<br>**Suspected human carcinogen:** The International Agency for Research on Cancer classifies Trichloroethylene as a human carcinogen.<br>. | ***Consider eliminating the hazard by changing to a safer alternative for Trichloroethylene. Research conducted in the USA suggests that such alternatives are available.***<br>Generally, Loss of Containment is the Top Event (initiating event) for all incidents associated with hazards involving liquids. Control measures for these hazards should therefore focus on preventing Loss of Containment and promptly dealing with leaks and spillages to prevent an escalation of consequences. |
| | Toluene/ Centrifuge Extractor /Distillation unit and Bulk storage (200ℓ drums)<br>*(The current OHSA RHCA OEL (Restricted Limit) eight-hour TWA for Toluene is 40 ppm with a SKIN and OTO notation)* | Highly flammable. A vapour mixture within the flammable range will easily ignite if a source of ignition is present.<br>Causes skin irritation.<br>May cause drowsiness or dizziness.<br>May cause damage to organs (central nervous system, liver, heart) through prolonged or repeated exposure. | See addendum to this document for detailed recommendations for storage of Toluene and safeguards during Toluene distillation. |

| | | | |
|---|---|---|---|
| | 10% Methane, Balance Gas Argon (P-10) used in XRF spectroscopy. | Extremely flammable and asphyxiant gas mixture. Can ignite if an external source of ignition is present. Exposure to very high concentrations could lead to unconsciousness and even death in unventilated areas. | Follow the rules of safe handling and storage of compressed gases in Section 4.4 of this guide and ensure that regular leak tests are performed on connections, hoses, and hose fittings.<br>Emergency response should include elimination of ignition sources in the immediate proximity. |
| | Hydrogen/Gas Chromatograph and storage cylinder | Highly flammable. Loss of containment (gas leak) from tubing or valve could result in ignition/fire and severe burns to persons in close proximity. | |
| **Pressure Hazards** | • High pressure equipment 2.10 MPa -Pressure Aging Vessel/ /Compressed Dry Air;<br>• High speed rotating equipment-Centrifuges | Air supply hose failure or "over-pressure situation" in apparatus and supply cylinder; Failed mechanical parts can result in release of flying objects and hazardous chemicals | Ensure that built-in "over-pressure" (fail safe) mechanisms are properly maintained and, if possible, are periodically tested for proper operation. |
| **Dynamic Situation Hazards** | Personnel moving at same level (Slips, Trips and Falls). Caused by cluttered passageways, differences in floor height, slippery floors, etc. | Slips, trips & falls make up majority of general industry incidents. The most common injuries reported are;<br>- Head, hip and pelvis injuries<br>- Sprains & strains<br>- Bruises & contusions<br>- Fractures<br>- Abrasions & lacerations | Refer to Section 3 for housekeeping requirements. |
| **Hot Surfaces** | • Hot plates & gas burners;<br>• Vacuum Degassing Oven/ ± 170°C; and<br>• Heating ovens/± 110°C - 170°C | Burns when unprotected skin contacts extremely hot surfaces or open flames. | Refer to Section 3 for PPE requirements. |
| **Electricity** | Low Voltage (LV) >30 -750V Electricity supply to laboratory equipment | Injuries including electrical shock, burns, and falls due to electrical shocks and burns. | It is highly recommended that an Energy Isolation Procedure, that includes isolation of electrically operated equipment, is established. A policy of |

| | | | |
|---|---|---|---|
| | | Sparks from electrical equipment can ignite flammable materials.<br>Too much current flowing through a wire can cause a power cord to overheat and start a fire. | "inspect before use" should also be in place for all portable electrical equipment. |
| **Electromagnetic Radiation** | Exposure to microwaves (high frequency radio waves) leaking from conventional microwave ovens used in laboratory tests | Long exposures to very high levels of microwave energy can be absorbed by the body and produce heat in exposed tissues, resulting in severe tissue damage. | It is recommended that the condition of seals around microwave oven doors are inspected at least monthly and that the oven is periodically checked for radiation leaks. |
| **Ionizing Radiation** | Exposure to X-Rays (*Radiation scatter)* from hand-held XRF Units | All radiation, if received in sufficient quantities, can damage living tissue. Exposure to unacceptable high dosage of radiation may result in acute or chronic effects that can ultimately be fatal. | Ensure that XRF unit operators are adequately trained and that an operator's manual and/or training manual is conveniently available to ensure continued safe operation.<br>Where high frequency use of XRF equipment is the order of the day it is recommended that operators wear an appropriate personal dosimeter to monitor exposure. Monitoring radiation exposure with dosimeters provides an indication of the working habits and working conditions of the XRF user and may be a way to identify whether the XRF analyser is being properly used. |
| **Asphyxiants** | Helium gas (He) used in XRF spectroscopy. An inert gas and displaces air. It can be an asphyxiant when inhaled instead of normal air. | Exposure to an Oxygen depleted /deficient atmosphere (<19%) resulting from leakage of compressed gases or spillage of volatile liquids.<br><br>Even situations with slight oxygen deficiencies (at or below 19 % of oxygen concentrations) may cause a momentary loss of coordination. | Ensure that any signs of gas leakage and spillage of volatile or toxic liquids are dealt with immediately and that the workplace is properly ventilated to ensure prompt dissipation of vapour. Regularly perform leak tests on gas lines and connections.<br>With regards to ventilation, ensure that the provisions of the Environmental Regulations for Workplaces, 1987 and the requirements of SANS 10400-O:2011 Edition 3 Part O: Lighting and ventilation, are adhered to and installations are properly maintained. |

| | | | |
|---|---|---|---|
| **Toxic Solids:**<br>**Silica, crystalline** | Respirable crystalline silica dust (Quartz) -exposure above the recommended limit *RHCA OEL-ML)* $0.1^{(R)}$ $mg/m^3$ during geotechnical laboratory tests. | Inhaling respirable crystalline silica over long periods can cause silicosis, a debilitating and potentially fatal lung disease. | Where local exhaust ventilation is impractical or not completely effective, technicians should wear suitable breathing apparatus (face mask) with an appropriate filter when handling samples. |
| **Corrosive Substances** | Contact with corrosive liquids used in laboratory tests and cleaning of apparatus (Sulfuric/ Hydrochloric/Nitric Acid) | Chemical burns to Hands, Eyes, Face and other exposed Skin areas. | Refer to Section 3 for PPE requirements. |
| **Ergonomic Hazards** | Ergonomic stressors in the laboratory include static and/or awkward postures and repetitive movement. Manual handling, workplace design and poor body positioning are other potential issues.<br>These stressors occur when using hoods, microscopes, when pipetting, poor seating arrangements, using computers, etc. | Typical common repetitive strain injuries include Carpal Tunnel Syndrome, Raynaud’s Syndrome (“white finger”), Trigger Finger, Tendinitis, etc.<br>Lower back problems can result from continuous and long-term awkward posture. | Refer to Section 3 for minimum Regulatory requirements. |
| **Physical Agents:**<br>**Noise** | Noise ≥85dBA - Intermittent Noise/ Continuos Noise/Impulsive Noise from various items of laboratory equipment | Exposure above the limit can lead to Noise Induced Hearing Loss. | Refer to Section 3 for Regulatory and PPE requirements. |

| | | | |
|---|---|---|---|
| **Heat Stress** | Human body temperature >37°C - Heat radiation from laboratory equipment (could be up to 1100°C), combined with very hot ambient temperatures, in poorly ventilated or confined areas | Dehydration of the body which can, in extreme cases, lead to heat exhaustion. | Refer to Section 3 for Regulatory requirements.<br>Heat stress is one of the hazards that should be addressed in an organisations Health Risk Assessment and it is a minimum requirement that a Registered Occupational Hygiene practitioner must assist with an evaluation of the workplace where heat stress has been identified as a hazard.<br>This issue seems to be specifically prevalent in remote laboratory where proper design specifications are not followed. Refer to the provisions of the Environmental Regulations for Workplaces, 1987 and the requirements of SANS 10400-O:2011 Edition 3 Part O: Lighting and ventilation for the minimum specifications for facilities which, due to conditions of high temperature, may be dangerous to safety or health. |
| **Environmental Aspects: Surface Water, Soil and Groundwater, Hazardous Waste** | Liquid and Solid hazardous waste generated from Laboratory processes e.g. Toluene, Trichloroethylene, Methanol, etc. and contaminated gloves, paper towels, rags, vermiculite or "kitty litter" used to clean up chemical spills, etc. | Improper disposal could result in:<br>- Bodily injury and health risks to ignorant and innocent 3rd parties<br>- Environmental pollution<br>- Severe reputational damage<br>- Liability claims | Refer to Section 3 for general chemicals handling requirements. |

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14. Code of Good Laboratory Working Standards, University of York, UK, 2019;
15. Health and Safety in Chemical Industries, a pamphlet published by the Department of Labour, South Africa (Undated);
16. Laboratory Safety Manual, McGill University, Montreal, Quebec, Canada as updated February 2, 2017.

## LIST OF APPENDICES

1. Laboratory Health and Safety Policy and Commitment
2. Example of a qualitative Risk Assessment Matrix
3. Example Hazard Register
4. Example of a Hazards Control Sheet

### ADDENDUM

Recommendations for safe storage, handling and distillation of Toluene at Material Testing Laboratories in the Road Construction Industry

**Appendix 1 - Example Laboratory HSE Policy**

[Logo]

# LABORATORY HEALTH SAFETY and ENVIRONMENTAL POLICY

## XYZ HSE Aspirations

*XYZ aspires to achieve an HSE performance that is exemplary in its field of expertise and which is consistently equal to, or better than the performance of competitors engaged in corresponding activities.*

## XYZ Commitment to HSE

*XYZ is committed to:*

- *pursue the goal of no harm to people, which includes the local communities*
- *protecting the environment*
- *use energy resources and materials efficiently to provide products and services*
- *manage HSE matters with the diligence accorded to any of its other critical business activities*
- *play a leading role in promoting best practice in our industry*
- *promote a culture in which all XYZ employees share this commitment*
- *transparency in the reporting of our HSE performance*

*In this way, we aim to have an HSE performance we can be proud of, be a good neighbour and, earn the confidence of customers, business partners and the society at large.*

## XYZ HSE Policy

*XYZ shall:*

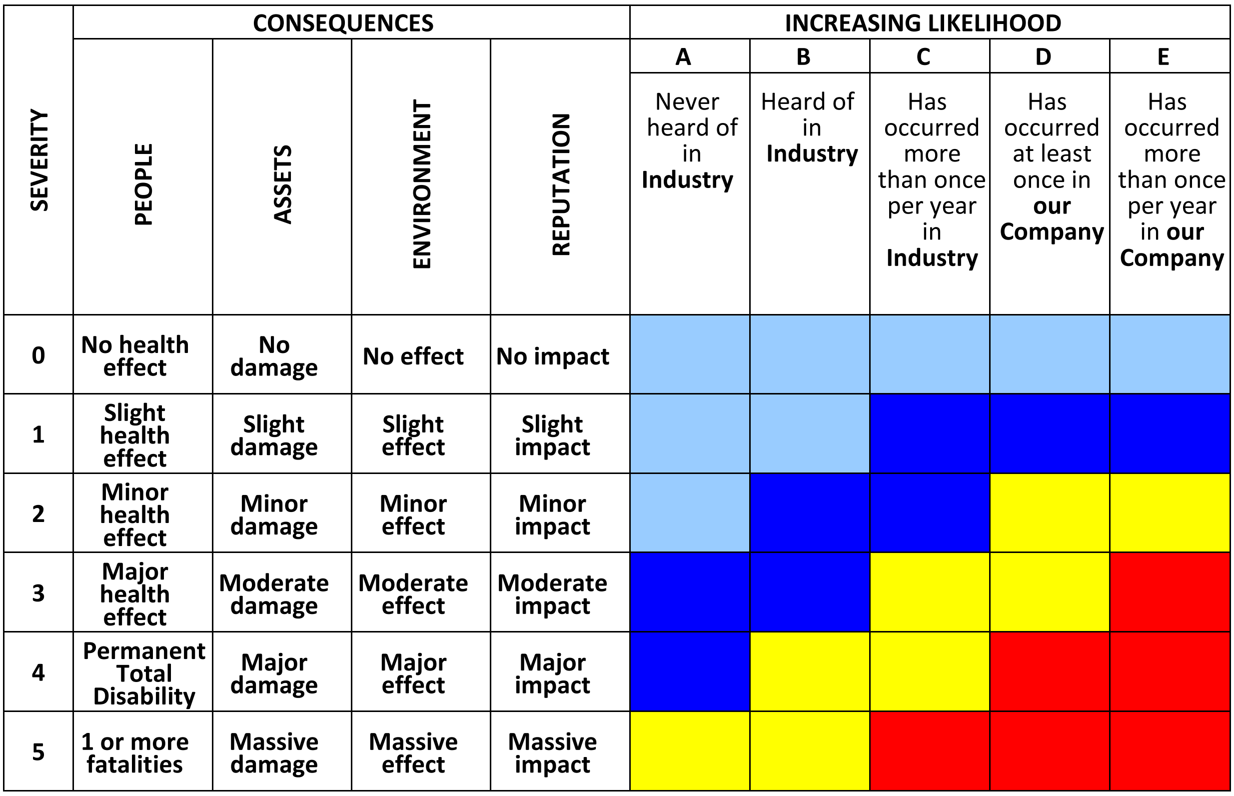
- *have a systematic approach to HSE management designed to ensure compliance with the RSA Laws and Regulations and relevant local and international industry standards*
- *conduct activities in a manner designed to minimise HSE risks to a level which is As Low as Reasonably Practicable (ALARP)*
- *set targets for continuous HSE performance improvements*
- *measure, appraise and report performance as required by interested parties*
- *hold appropriately empowered line management staff accountable for HSE performance*
- *empower all our employees to refrain from actions that are considered a threat to HSE*
- *require contractors to manage HSE in line with this policy*

*XYZ will implement this policy through a documented Risk Management Plan in respect of, every risk identified for all aspects of work in our operations, and be subjected to periodic audits to verify compliance.*

This HSE Policy was approved on the [..] day of [.....] 20.. by:

J Doe
Laboratory Manager, XYZ

## Appendix 2 - Example Qualitative Risk Assessment Matrix



| SEVERITY | CONSEQUENCES | | | | INCREASING LIKELIHOOD | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | A | B | C | D | E |
| | PEOPLE | ASSETS | ENVIRONMENT | REPUTATION | Never heard of in **Industry** | Heard of in **Industry** | Has occurred more than once per year in **Industry** | Has occurred at least once in **our Company** | Has occurred more than once per year in **our Company** |
| **0** | **No health effect** | **No damage** | **No effect** | **No impact** | ░ | ░ | ░ | ░ | ░ |
| **1** | **Slight health effect** | **Slight damage** | **Slight effect** | **Slight impact** | ░ | ░ | 🟦 | 🟦 | 🟦 |
| **2** | **Minor health effect** | **Minor damage** | **Minor effect** | **Minor impact** | ░ | 🟦 | 🟦 | 🟨 | 🟨 |
| **3** | **Major health effect** | **Moderate damage** | **Moderate effect** | **Moderate impact** | 🟦 | 🟦 | 🟨 | 🟨 | 🟥 |
| **4** | **Permanent Total Disability** | **Major damage** | **Major effect** | **Major impact** | 🟦 | 🟨 | 🟨 | 🟥 | 🟥 |
| **5** | **1 or more fatalities** | **Massive damage** | **Massive effect** | **Massive impact** | 🟨 | 🟨 | 🟥 | 🟥 | 🟥 |

## Appendix 3 - Example Hazard Register

| Hazard No | Activity/Location | Hazard/Top Event | Threats | Controls | Potential Consequences considered for RAM rating | Worst Case Inherent Risk Potential | | | | Administrative controls required to demonstrate compliance or achievement of ALARP |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | P | A | E | R | |
| | | | | | | 3E | | | | |
| HSE/01 | **Activity:**<br>Handling hazardous chemicals during testing procedures<br><br>**Location:**<br>ABC test room using CCB test apparatus | **Hazard:**<br>Toxic and corrosive liquids -<br><br>**Top Event:**<br>(1) Loss of containment;<br>(2) Exposure to toxic vapours (Inhalation) | • Workers not aware of or ignore the hazards;<br>• Containers left open after decanting;<br>• Slippery glass container drops and breaks<br>• Vapour in the breathing zone of worker;<br>• Workers handle liquid with unprotected hands; | • Hazard communication: Ensure workers are fully aware of the hazards associated with the substances they use (SDS for products must be available in the relevant workplace)<br>• Substitute hazardous liquids with less hazardous products;<br>• Keep containers closed when not in use;<br>• Where compatible, use plastic or metal containers to store hazardous liquids<br>• Provide adequate ventilation (a constant flow of air) to extract or diffuse any toxic vapours in a work area;<br>• PPE - Wear suitable breathing apparatus and chemical resistant gloves when handling toxic and corrosive substance; | Contact with corrosive liquid Major health effect - laboratory technicians sustain serious burns to hands, arms and face | **Comments:**<br>A similar incident recently occurred in our company | | | | Hazard Control Sheet<br><br>Site MERP<br><br>Product SDS's<br><br>Workplace inspections and reports<br><br>Employee training records |

## Appendix 4 - Example Hazard Control Sheet

**Cautionary note: This sheet contains information resulting from a GENERIC Risk Analysis of the activity under assessment. Users shall exercise caution and conduct further task specific Hazard Analysis to ensure that ALL potential Hazards and Threats are identified and appropriately assessed.**

| | |
|---|---|
| **HAZARD Control SHEET No**: HCS/01/2018 | **Page 1 of 2** |
| **Hazard Group:** Toxic and corrosive liquids | **Location**: Materials Testing Laboratory |

**Assessment of hazard**

**Top event/s:** (1) Loss of containment; (2) Exposure to toxic vapours (Inhalation)

**Potential Consequence/s**: (1) Contact with corrosive liquid: Major health effect - Laboratory technicians sustain serious burns to hands, arms and face (2)

| **Risk ranking (Worst case scenario):** | | | |
|---|---|---|---|
| | **P** | **3** | **E** |

**Threats:** Workers not aware of or ignore the hazards; Hazardous liquid spills in work area; Vapour in the breathing zone of worker; Workers handle liquid with unprotected hands;

| **Controls:** | **HSE Critical Task** | **Responsible Position** |
|---|---|---|
| **1.1 Control in design** | | |
| ❖ Hazard Communication Standard | General HSE induction | Laboratory manager |
| ❖ Adequate exhaust ventilation installed | Approved standard | Engineering Contractor |
| ❖ Emergency shower and eye wash facility installed in close proximity to where incidents are likely to occur | Facility designed to approved standard and appropriately placed | Laboratory manager/Consultant |
| **1.2 Control in operation** | | |
| ❖ Hazard communication: Workers are fully aware of the hazards associated with the substances they use - (SDS for products are available in the Laboratory i.e., in the relevant workplace) | Workplace induction and on-the-job training | Laboratory supervisors |
| ❖ Exhaust ventilation activated before commencement of task | Follow approved task procedure | Laboratory technician |
| ❖ Handle containers with suitable slip resistant gloves | Follow approved task procedure | Laboratory technician |
| ❖ PPE - Wear suitable breathing apparatus, chemical resistant gloves, eye and face protection when handling toxic and corrosive substance - Refer to PPE standard | Inspect PPE before use | Laboratory technician |
| **1.3 Control in maintenance** | | |
| ❖ Routine inspection and maintenance of ventilation systems and emergency shower and eye wash facility | Planned maintenance schedule | Laboratory maintenance technician |
| ❖ | | |
| ❖ | | |
| ❖ | | |
| ❖ | | |
| **1.4 Recovery measures** | | |
| ❖ Emergency shower and eye wash facility accessible and operational | Regular inspections to ensure integrity of equipment | Laboratory technicians/H&S Reps |
| ❖ Medical emergency reaction plan - 1st Aid kits and trained responders available on site | Inspections to ensure of 1st Aid box is stocked as required | 1st Aid responders/H&S Reps |

**References**

**Legislation:**

Regulations for Hazardous Chemical Agents, 2024; General Safety Regulations, 1986 (Minimum contents of a first aid box)

**Industry Standards:**

(Example, SANS Standards and other relevant standards for ventilation systems and emergency shower and eye wash facilities)

| | |
|---|---|
| **Revision:** Original | |
| **HAZARD Control SHEET No: HCS/01/2018** | **Page 2 of 2** |

## Determination of ALARP

| **ADDITIONAL RISK REDUCTION MEASURES FOR CONSIDERATION** | **IS THE MEASURE CREDIBLE / PRACTICABLE? (Yes / No)** | **ARE DISPROPORTIONATE RESOURCES REQUIRED TO IMPLEMENT? (Yes / No)** |
|---|---|---|
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | | |
| 5. | | |

| | | |
|---|---|---|
| **Is the Risk ALARP? – Y/N** | | |

**Comments:**

1.

| **METHOD USED (X)** | | **TEAM MEMBERS** | |
|---|---|---|---|
| | | **Expertise** | **Name** |
| | **Experience/Judgment** | **HSE:** | |
| | **Cost-Benefit** | **Engineering:** | |
| | **Quantitative Assessment** | **Operations:** | |
| | **Other** | **Other:** | |

| | |
|---|---|
| **Management approval** | I approve that the barriers listed above manage the risk to ALARP; and (where necessary) additional actions have been identified and included in the Remedial Action Plan.<br>**Sign:** **Designation:** **Date:** |

# **Addendum:** Recommendations for safe storage and handling of Toluene at Material Testing Laboratories in the Road Construction Industry

**Compiled by:** Anton Ferreira, H&S Consultant to SABITA with valuable contributions by the following persons:
Danny de Villiers - Group HSE Projects Manager, Raubex Group Limited
Barry Pearce - Learning Matters etc cc

**ADVISORY NOTE TO EMPLOYERS, LABORATORY MANAGERS AND USERS OF TOLUENE**

**This guidance was developed in response to concerns raised by industry stakeholders that the health safety and environmental aspects associated with the storage and handling of Toluene at Material Testing Laboratories are not adequately managed and/or controlled. In particular, the distillation of liquid binder/Toluene residue has been highlighted as a notable concern and a potential hazardous operation.**

**Whilst Toluene is the hazardous chemical in the scope for this guide, it is important to note that the hazards, and recommended controls will generally be applicable to other GHS Category 1 and 2 flammable liquids used in Laboratories. Users of this guide should also refer to the *Guide to the safe handling of solvents in a bituminous products laboratory, SABITA Manual 29 September 2010* for further comprehensive general guidance.**

**The advice given, and recommendations made, in this guide are largely based on global Industry Best Practice and the experience of the author however, employers/laboratory managers/users MUST ENSURE that, in the first instance, due regard is given to the relevant requirements of the Occupational Health and Safety Act (Act No. 85 of 1983 as amended) and applicable Regulations made under the Act. The main health and safety legislation relevant to sites handling flammable liquids is outlined below and other relevant health and safety legislation is listed in paragraph 4.**

## Main health and safety legislation

i. **General Safety Regulations, 1986**
  - Use and storage of flammable liquids - Regulation 4. (1), (2), (3), (6), (7), (8), (9), (10) & (11).

ii. **Regulations for Hazardous Chemical Agents, 2021**
  - Regulation 3. Information, instruction and training;
  - Regulation 4. Duties of persons who may be exposed to hazardous chemical agents;
  - Regulation 5. Assessment of exposure;
  - Regulation 6. Air monitoring;
  - Regulation 8. Respirator zone;
  - Regulation 10. Control of exposure to hazardous chemical agents;
  - Regulation 11. Personal protective equipment and facilities;
  - Regulation 12. Maintenance of control measures;
  - Regulation 14A. (d) Safety Data Sheet;
  - Regulation 14B. (d) Labelling of hazardous chemical agents;
  - Regulation 14C. (4) Packaging of hazardous chemical agents;
  - Regulation 15. Disposal of hazardous chemical agents.

iii. **Electrical Machinery Regulations, 2011**
  - Regulation 9. Electrical machinery in hazardous locations

iv. **Note: Also take cognisance of Fire Safety By-Laws within the jurisdictions of the relevant Local Authority.**

# 1. Introduction

Toluene has, mainly due to occupational hygiene considerations, replaced Benzene and Methylene Chloride as the primary solvents traditionally used in laboratory Test Methods. Whilst Toluene is considered a "safer" alternative to Benzene and Methylene Chloride, it is very important for laboratory operators to understand that no solvent is ever "completely safe." The inherent hazardous properties and characteristics of solvents demands strict adherence to health safety and environmental precautions.

***Note that for tests in Material Testing Laboratories (binder extraction), Toluene is commonly used in combination with Ethanol (85%Toluene/15%Ethanol mixture). However, because Toluene is the dominant component in the mixture and, because the hazardous properties of the two solvents are largely similar, the focus for purposes of this guide shall be on Toluene*.**

# 2. Understanding Toluene - Overview of properties and characteristics

## 2.1 Physical properties

Toluene (also known as methylbenzene, phenylmethane, or toluol) is a hydrocarbon compound obtained primarily by distillation from crude petroleum. It is a clear, colourless, liquid with a sweet, pungent, benzene-like odour. Toluene vapour is heavier than air (± 3 times heavier) and may accumulate in low-lying areas. Toluene is lighter than water and, spilled Toluene, will therefore float on water which may be present in the immediate environment.

## 2.2 Chemical characteristics and associated hazards

Toluene is a volatile liquid readily producing flammable and toxic concentrations at ambient temperatures ≥ 20 °C. ***Toluene is highly flammable*** with a flash point of 4 °C and its flammable limits are: Lower- 1,1 vol% and Upper- 7,1 vol% *(very similar to petrol)*; therefore, ***it is a significant fire hazard*** at room temperature if flammable vapour mixtures exist in the presence of ignition sources.

## 2.3 GHS Hazardous classification and OEL

**Toluene:** Flammable liquid: Category 2 (Flash point < 23 °C and initial boiling point > 35 °C);
OEL RHCA: OEL (Restricted Limit) eight-hour TWA for Toluene is 40 ppm with a SKIN and OTO notation.
**Ethanol:** Flammable liquid: Category 2 (Flash point < 23°C and initial boiling point > 35°C);
OEL RHCA: OEL (Restricted Limit) for Ethanol is OEL-STEL/C 2000ppm.

## 2.4 Health Effects of exposure to Toluene

### Exposure routes

The major route of human exposure is through inhalation and smaller amounts can be rapidly absorbed via the skin.

### Acute and Short-Term Health Effects

- Contact can irritate the skin and eyes;
- Inhaling Toluene can irritate the nose and throat causing coughing and wheezing;
- Toluene may affect the nervous system causing trouble concentrating, headaches and slowed reflexes. Higher levels can cause dizziness, light-headedness and passing out.

### Chronic Health Effects

- Prolonged or repeated exposure can cause drying and cracking of the skin with redness and a skin rash;
- Repeated exposure may cause liver, kidney and brain damage;
- Toluene may damage the developing foetus in pregnant women.

### Other health effects

- Toluene and toluene-containing volatile substances are indicated as the most commonly abused solvents with a demonstrative addictive potential in humans. It has a high addictive potential for adult employees in direct contact with the substance;
- Research has shown that inhaled toluene *(from 1000 ppm to 2000 ppm)* is an ototoxic solvent and in combination with other physical workplace stressors *(i.e. noise)* can contribute to hearing loss.

## 2.5 Environmental effects

Toluene has moderate acute (short-term) toxicity on aquatic life and moderate chronic (long-term) toxicity to aquatic life.

### 2.6 Compatibility and reactivity with other chemical agents

**Warning: Toluene reacts violently with strong oxidants.**

Toluene is not compatible with OXIDIZING AGENTS (such as PERCHLORATES, PEROXIDES, PERMANGANATES, CHLORATES, NITRATES, CHLORINE, BROMINE and FLUORINE); METAL SALTS; and STRONG ACIDS (such as HYDROCHLORIC, SULFURIC and NITRIC).

## 3. General recommendations for controlling the hazards and effects associated with storage and handling of Toluene

### 3.1 What must be controlled?

In order to effectively control the hazards, we need to clearly understand WHAT could give rise to unwanted Toluene incidents in a typical Materials Testing Laboratory and therefore we need to understand the causal sequence of incidents. Using BowTie Methodology[1] here follows a brief description of the trigger events [Top Events] and potential causes of Toluene incidents *(The hazards and effects have already been identified in paragraph 2. above)*:

### 3.2 Trigger event/s

- **I.** Loss of containment; and
- **II.** Exposure to toxic vapour.

### 3.3 Potential threats/causes (unsafe acts and/or conditions) that can lead to the trigger events and recommended controls to prevent trigger events

**I. Threat:** Lack of awareness of the hazardous properties of Toluene

**Preventive Controls**

- GHS compliant Toluene and Ethanol Safety Data Sheets are available and on file at the distillation room;
- ALL Toluene containers are clearly and correctly labelled in accordance with GHS requirements;
- Person's handling/using Toluene are properly trained & deemed competent in its use and are able to interpret and understand the labelling.

Figure 1 below shows examples of typical GHS Labelling that may be used for Toluene.

**Flammable liquid**

- **Respiratory Sensitizer**
- **Target Organ Toxicity**
- **Aspiration Toxicity**

**Irritant (skin and eye)**
**(Not mandatory)**

**Toxic to aquatic environment**
**(Not mandatory)**

**Figure 1: GHS danger pictograms for labelling Toluene containers. Note that pictograms 1&2 are mandatory.** *(Image source: Public domain)*

**II. Threat:** Potential sources of exposure to Toluene not clearly identified and documented

**Preventive Controls**

- A baseline risk assessment has been performed, documented and is available at the workplace.

**III. Threat:** Ambient/Personal exposure levels not known

**Preventive controls**

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[1] The bow tie risk management methodology is a diagrammatic illustration of the hazard, the undesirable event, the trigger events/threats and potential outcomes, and the risk controls put in place to minimise the risk. A BowTie Diagram for Toluene hazards has been developed and is available, upon request, from SABITA.

- Measurement of airborne concentrations of Toluene vapour is conducted (by an AIA[2] (Approved Inspection Authority)} to determine personal and ambient exposure levels.

IV. **Threat:** Lack of, or non-compliance with, safe work procedures for handling of Toluene

**Preventive controls**

- Based on exposure monitoring results, *(if exposure exceeds OEL)* conduct detailed task specific hazard analysis;
- Task specific safe work procedures established for storage/handling/use of Toluene;
- Provide suitable and adequate information, instruction and training (as contemplated in the Regulations for Hazardous Chemical Agents) to all persons involved with storage/handling/use of Toluene;
- Monitor compliance with procedures.

V. **Threat:** Malfunctioning or failure of laboratory equipment

**Preventive controls**

- Laboratory equipment/systems, in which Toluene is used, is fit for purpose and installed and maintained in accordance with manufacturers specifications;
- Toluene processing equipment *(i.e., Centrifuge extractor; Toluene distillation unit)* is regularly inspected to ensure ongoing safe operation.

VI. **Threat:** Inadequate zoning, process separation and/or ventilation of hazardous areas

**Preventive controls**

- As far as is reasonably practicable, Toluene processing activities are isolated/separated from other operational areas;
- Hazardous area classification/zones, for Electrical Equipment and Respiratory Protection, is determined and zoning indicated with appropriate signage. *(Based on the results of measurement of airborne concentrations of Toluene vapour in the work location)*;
- Mechanical Exhaust Ventilation (MEV) is installed where adequate natural ventilation is not possible. ***(Note: Toluene vapour is heavier than air and will accumulate on the floor and therefore extraction systems should also be low to the ground)***;
- MEV is installed and maintained in accordance with approved standards as recommended by an AIA.

VII. **Threat:** Inadequate/unsuitable Toluene storage and decanting facilities

**Preventive controls**

- Open-topped cans and buckets ARE NOT used for handling or storing Toluene;
- Toluene quantities ≥ 200 ℓ is ALWAYS stored in metal containers (i.e. 210 ℓ drums) and in a flammable liquid store complying with local authority by-laws;
- Smaller quantities of Toluene (≤ 20 ℓ) are stored in a suitable flammable liquid cabinet;
- Toluene kept in the laboratory for testing purposes is stored in suitable metal containers (i.e. jerry cans) and quantities shall not exceed the daily consumption threshold levels;
- Spill trays, drip cans and other means to contain spillages should be provided where decanting or dispensing is carried out;
- Decanting or transfer from one container to another is carried out in a designated, well-ventilated area;
- ALL components of the decanting system *(containers, taps, syphon pumps, valves, funnels, spouts, spill containment, etc.)* must be made of metal;
- To prevent the generation and discharge of static electricity during decanting, containers must be adequately bonded and earthed.

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[2] The DoEL maintains a list of AIA for Occupational Health & Hygiene. Follow the link below for an updated list: https://www.labour.gov.za/DocumentCenter/Publications/Occupational%20Health%20and%20Safety/AIA%20list%20May_2023.pdf

**Figure 2:** Metal jerry can and spout suitable for storage and dispensing small quantities of flammable liquids (Image source: *Public domain)*

VIII. **Threat:** Irresponsible management of and/or disposing of Toluene waste

**Preventive controls**

- NEVER put waste liquid into public drains or watercourses;
- Use metal containers with leak-proof caps/lids to collect and store Toluene waste in a flammable liquid store;
- Do not overfill the waste containers. Leave at least 10% empty space in the container to allow for expansion and safe transportation;
- Containers with binder/Toluene residue earmarked for recycling are clearly labelled in accordance with GHS requirements;
- ALL waste materials (not fit for recycling or not reusable) that have or may contain Toluene is collected in suitable containers, properly labelled and disposed of in accordance with the requirements of Regulation 15 of the Hazardous Chemical Agents regulations.

## 3.3 Recovery controls to mitigate or prevent escalation of potential consequences if trigger event/s do occur

I. **Potential consequence:** Flammable vapour mixture ignites and fire causes injury to workers and property damage

**Recovery Controls**

- Suitable/adequate secondary containment (i.e., bunding, drip trays) is installed at Toluene storage and handling facilities to prevent uncontrolled spread of spilled liquid;
- Eliminate potential sources of ignition in hazardous areas;
- Sufficient number and correct type of portable fire extinguishers are deployed at hazardous areas;
- Fire extinguishers are regularly inspected and maintained in good working order;
- Laboratory operators have been trained in use of appropriate fire extinguishers.

II. **Potential consequence:** Acute health effects - Contact with liquid Toluene can irritate the skin, eyes, nose and throat. Inhaling high concentrations of vapour can cause dizziness, light-headedness, passing out and death.

**Recovery Controls**

- Operators must wear suitable chemical resistant gloves and safety goggles when decanting or cleaning up Toluene spillage;
- Operators wear half-face respirator with an organic vapour filter in case of significant Toluene spillage with likelihood of high vapour concentrations.

III. **Potential consequence:** Chronic health effects - Repeated long-term exposure to toxic vapour (inhalation) may cause liver, kidney and brain damage and can damage the developing foetus in pregnant women.

**Recovery Controls**

- Pregnant women are not permitted to perform tasks where there is a likelihood of exposure to Toluene vapour;
- Based on exposure monitoring results, obtain the opinion of an occupational medicine practitioner to determine whether it is necessary to conduct medical screening of employees.

# 4. Specific recommendations for safe distillation of Toluene in a laboratory

## Legislation specific to storage and handling of flammable liquids on construction projects:

**Construction Regulations, 2014**

Regulation 25. Use and temporary storage of flammable liquids on construction sites;
Regulation 27. Housekeeping and general safeguarding on construction sites;
Regulation 29. Fire precautions on construction sites.

## Brief Background to this section

Laboratory operations in a typical materials testing laboratory involve, amongst others, extraction and recovery of binder from asphalt samples for various analytical purposes. Depending on the specific test methods used, a selection of solvents is required for the binder extraction processes. The extracted liquid binder inevitably results in potentially hazardous "waste streams" with the solvent remaining in the binder/Toluene residue. Toluene (in combination with Ethanol) is most commonly used in binder extraction processes and distillation of the binder/Toluene residue is the method of choice for recycling Toluene.

Because of the potentially staggering costs of solvent usage, it makes business sense for companies to recycle and reuse solvents. Some sources claim that, provided the distillation process is done correctly and all contaminants are removed, solvent may be distilled/recycled/reused indefinitely. *(See list of references #9)*

## 4.1 Scope and purpose of this section

The general recommendations for controlling the hazards and effects associated with storage and handling of Toluene is covered in Section 3 of this document. In this section specific recommendations are made to ensure that the risks associated with the operation of a Toluene distillation system are managed to "as low as is reasonably practicable". In the paragraphs that follow, brief discussions and recommendations are made under the following headings:

- i. The most significant risk associated with Toluene distillation;
- ii. Location, size and construction material of the distillation room;
- iii. Minimum requirements for ventilation in the distillation room;
- iv. Safe operation of the distillation system;
- v. PPE requirements;
- vi. Storage of flammable liquids and general housekeeping in the distillation room;
- vii. Hazardous area classification and electrical equipment;

Note that cognisance is taken of the fact that there may be constraints with regards to location and building infrastructure in a typical field laboratory. However, notwithstanding these constraints, the recommendations made here should be considered as the ABSOLUTE BARE MINIMUM STANDARD for setup and operation of a Toluene distillation system which ensures legal compliance.

## 4.2 The most significant risk associated with Toluene distillation

The solvents contained in the residual binder earmarked for recycling are both classified as HIGHLY FLAMMABLE and have flashpoints of 4 °C (Toluene) and 11 °C (Ethanol) respectively. The initial boiling points of 78,5 °C (Ethanol) and 110 °C (Toluene) means that the distillation temperature must be set at least ≥ 110 °C which is way above the flashpoints of the solvent mixture. This combination of flammability and high temperatures presents, under "ideal circumstances and conditions", **a significant risk of fire or explosion if the necessary controls are not in place and adhered to.**

## 4.3 Location, size and construction material of the distillation room

Typical distillation units used in laboratories are relatively small and compact and do not take up much floor or bench space *(See Figure 3 below)*. However, as will be seen later on, careful planning is required to ensure that the unit is located such that some of the costly engineering controls may be avoided and that the unit can be operated with minimum risk to operators, the surrounding laboratory facility and the environment.

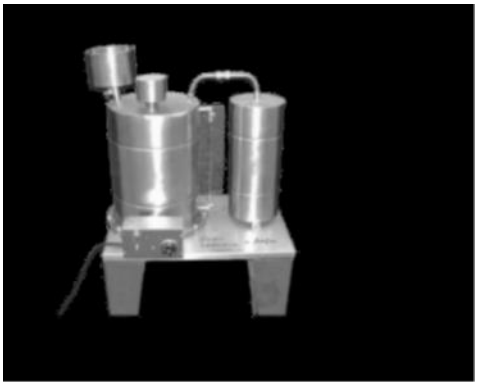

**Figure 3:** Example of a distillation unit used for recovery of Toluene in a laboratory
Image source: *Operating Manual, CLE Solvent Recovery Distillation Unit, Page 1, supplied by Cape Laboratory Equipment, Pty*

Consider the following for optimum placement of the distillation unit:

- In a room with minimum floor space of 3 m$^2$ (2 m long x 1,5 m wide) and a ceiling height of not less than 2,4 m;
- The room should preferably be a freestanding structure at least 3 m away from other buildings however, if the room is located within a multi-room building, the wall against which the unit will be placed must be an outer wall;
- The room should have walls constructed of non-combustible material (bricks or steel sheeting) and hardstand floor surface (preferably concrete);
- Provide a sturdy base (constructed with non-combustible material) at a suitable height above floor level) to accommodate the distillation unit;
- Provide a sturdy and robust shelf, constructed with non-combustible material, at a comfortable height for temporary storage and decanting of the liquid to be distilled in the distillation device;
- The room should have a door (preferably with steel cladding on the inside) that can be locked when distillation is not in process;
- The room must be fitted with an inspection window of strengthened and shatterproof glass that cannot be opened;
- The room should be provided with adequate lighting with a Minimum Maintained Illuminance Value of 500 Lux;
- Affix appropriate hazard warning signs to the external face of the door.

## 4.4 Minimum requirements for ventilation in the distillation room

General Safety Regulation 4. (3) requires that the distillation room is *"to be fitted with an efficient intake and exhaust ventilation system to remove any vapour therefrom and to prevent its recirculation in a manner which may lead to the contamination of any other workplace or the creation of a fire or explosion hazard"*.

Efficient ventilation is a **KEY CONTROL** for reducing exposure to flammable and toxic vapours. GSR 4. (6) (b) expressly requires that the ventilation system is to be ***"kept in operation during working hours [in this case during distillation] as well as for at least the period of time thereafter that may be necessary to clear the vapour from the atmosphere of the room, cabinet or enclosure to below 25 % of the lower explosive limit of that vapour"***.

Considering that the LEL of Toluene is 1,1 vol%, this means that effectively **almost ALL** the hazardous vapour must be removed from the atmosphere. These stringent requirements also means that natural ventilation of a distillation room will (almost certainly) not be sufficient to comply with the regulations. A properly designed and applied mechanical exhaust ventilation system is therefore required.

There are unfortunately no one-fits-all solutions for proper ventilation and therefore designing an efficient ventilation system is best left to a reputable professional ventilation services provider. Therefore, no specific recommendations are made in this guide. It is however prudent to highlight some common misconceptions, and mistakes made, in connection with workplace ventilation:

## Common misconceptions and mistakes

- The natural ventilation in the room is adequate to remove harmful concentrations of gas or vapour;
- Wall/floor/ceiling mounted fans (blowers) and an open window will be sufficient to “flush” the area of gas or vapour;
- A very common error is installing exhaust fans in incorrect positions as can be seen in the pictures below; *(Pictures supplied by Raubex Group Limited)*

**Figure 4:** Even if these fans are of sufficient capacity to clear vapours from the atmosphere, a negative effect would be that the harmful vapours are actually drawn up and through the breathing zone of the operator

Toluene vapour concentrations liberated from binder recovery processes are HEAVIOUR THAN AIR and will accumulate at floor level. ALWAYS ensure that exhaust ventilation is installed at a suitable height above floor level BEHIND the distillation unit and other ventilation aids such as air bricks (in freestanding rooms) should be installed in outer walls at approximately 150 mm above floor level.

## 4.5 Safe operation of the distillation system

### 4.5.1 Placement of the distillation unit

In a permanent laboratory it may be ideal to operate a distillation unit in a purpose designed LEV ***capturing hood***. However, provided that threshold quantity levels and the use of approved containers for Toluene stored in the room are strictly controlled, an LEV Hood is not considered to be necessary for field laboratories. It is therefore recommended that the still, preferably, be placed in a freestanding room on a suitable surface and height above floor level as described in paragraph 4.3 above.

### 4.5.2 Rules for operation of the still

It is recommended that the following rules be adopted and clearly displayed in close proximity to the unit:

- **BEFORE** entering the distillation room:
  - Still operator ensures that the **appropriate protective clothing is worn and that other PPE is available** in the room to be used as and when necessary. *(See PPE requirements in 4.6 below)*;
  - **Switch on** the exhaust ventilation system and ensure that the exhaust ventilation system is in operation for the **DURATION OF THE DISTILLATION PROCESS PLUS 1 HOUR AFTER** the still has been switched off;
- Follow the manufacturer’s instructions, for equipment setup and pre-start checks ***(Refer to the manufacturer’s operating manual or instructions if in any doubt);***
- After starting the distillation process the operator **MUST REMAIN IN ATTENDANCE** in the room for **at least 30 minutes** to ensure that the unit is operating correctly and that there are no signs of liquid leaking from the unit;
- Thereafter the still operator **MUST VISIT** the distillation room **at least once in every hour** whilst distillation is in progress to check if all is well **and specifically** to check that the binder/Toluene mixture does not drop below the minimum level in the sight glass;
- In order to minimise the likelihood of a still explosion, the still operator must be in attendance during the anticipated final 30 minutes of distillation to ensure that the still does not run dry;
- The still operator, or a competent relief operator, shall remain on site during the distillation process. Stills **MUST NEVER** be left running if a competent operator is not in attendance on site.

## 4.6 PPE requirements

### Listed below are the recommended minimum PPE requirements for Toluene distillation

**Normal distillation conditions:**

- Chemical resistant laboratory coat ***(polyester-cotton blends with no less than 35% cotton are acceptable)*** to be worn over normal overall;
- Safety goggles, should have a panoramic lens with integrated side protection for optimum eye coverage;
- Chemical nitrile gloves (300 mm long) for general handling of cold liquid solvent (i.e., decanting the binder/Toluene mixture and transferring the mixture to the still);
- Shoes made of non-porous material ***(a normal safety shoe or boot is not suitable for protection against solvents);***

**Potential emergency conditions:**

- Heat resistant gloves to be worn over chemical nitrile gloves when an emergency situation requires handling of hot components;
- Half Facepiece Reusable Respirator with a type A1 organic vapour filter cartridge for use in case the likelihood of high solvent vapour concentrations may exist in the distillation room (i.e., spills or other situations where cleaning up is required).

## 4.7 Storage of flammable liquids and general housekeeping in the distillation area

Good housekeeping (maintaining order and a clean workplace) and limiting quantities of hazardous chemical agents are considered to be **KEY CONTROL** measures in a hazardous environment. Besides being BEST PRACTICE, these measures are also prescribed in some regulations and specifically in the Construction regulations and the Regulations for Hazardous Chemical Agents.

The image below shows an example of sub-standard housekeeping and, above all, disregard for the regulatory requirements in a Toluene distillation room.

Note the following about the scenario depicted in the image on the left:

- **i.** The use of plastic containers for storage of the binder/Toluene mixture;
- **ii.** Containers containing binder/Toluene mixture are not labelled;
- **iii.** It seems as if the daily storage threshold limits (for the quantities of binder/Toluene mixture needed for distillation) are not being adhered to;
- **iv.** Use of an electrical extension cord for power supply to the still;
- **v.** No exhaust ventilation evident;
- **vi.** No visible evidence that provision is made for earthing of the still or containers;
- **vii.** Generally, the picture leaves the impression that housekeeping is not given due regard in this facility.

**Figure 5:** A photo of a Toluene distillation room in a field laboratory (*(Pictures supplied by Raubex Group Limited)*

**In order to minimise potential exposure to Toluene vapour the following rules should apply and be enforced in the distillation room:**

- ➢ **ONLY** that quantity of binder/Toluene mixture needed for distillation on **ONE DAY** should be taken into or kept in the room;

- The binder/Toluene mixture to be distilled must be stored in **SUITABLE METAL CONTAINERS** that must be **KEPT TIGHTLY CLOSED** when not in actual use;
- Ensure that a suitable drip tray is in place under the storage containers to contain any spillage;
- Clean up any spillage immediately and recycle or dispose of redundant binder/Toluene mixture as appropriate;
- Ensure that a suitable container with a lid is used for discarding contaminated cleaning materials. Dispose of the contents of such container in the proper manner at the end of the working day.

## 4.8 Hazardous area classification and electrical equipment

**The OHSA Electrical Machinery Regulations, 2011*, Regulation 9. Electrical machinery in hazardous locations*** requires an employer to classify potentially hazardous areas in a workplace. Area classification is a method of analysing and classifying the environment where explosive gas/vapour atmospheres may occur so as to facilitate the proper selection and installation of electrical apparatus to be used safely in the environment. Hazardous areas are classified in terms of Zones on the basis of frequency and duration of the occurrence of a flammable atmosphere, as follows:

- Zone 0 - An area in which an explosive atmosphere is present *continuously* or *for long periods*;
- Zone 1 - An area in which an explosive atmosphere *is likely to occur* in *normal operation occasionally;*
- Zone 2 - An area in which an explosive atmosphere is *not likely to occur* in *normal operation*, but if it does occur, is likely to do so only *infrequently* and will exist for a *short period only*.

Appropriate hazardous area classification is not as straight forward as it may seem and there are a number of aspects and operating conditions which must be considered. It is rarely possible by a simple examination of process equipment and/or the operating environment to decide which parts of the equipment or operating environment can be equated to the three Zoned definitions.

It is not practical, and neither is it intended in this guide, to demonstrate any detailed approach to "Zoning" a Toluene distillation room. Hence, a very basic approach is adopted with practical recommendations on how to avoid the need to install costly electrical apparatus. The principle here being that ***where the likelihood of an explosive vapour atmosphere occurring is reduced; apparatus constructed to a less rigorous standard may be used.***

### Hazardous area classification for a Toluene distillation room

**The most appropriate basic classification for the distillation room is dependent on the type of apparatus used:**

- **i.** For a fully enclosed automatic distillation unit similar to **the type shown in Figure 3,** the appropriate zoning should be Zone 2;
- **ii.** For any type of distillation unit/process utilising glassware and open flame or other uncovered heat source, the appropriate zoning should be Zone 1;

Key aspects of hazardous area classification are identifying potential flammable vapour release sources in the presence of likely ignition sources. With this in mind the following controls are **STRONGLY RECOMMENDED**

- firstly, for reducing the likelihood of an explosive vapour atmosphere; and
- secondly, for eliminating potential ignition sources in a Toluene distillation room:

**Reducing the likelihood of an explosive vapour atmosphere**

Seriously consider applying and enforcing the controls listed in foregoing sections 4.4, 4,5 and 4.7 above.

**Eliminating potential ignition sources**

- **i.** Where possible and reasonably practicable, locate fixed electrical apparatus (wall sockets, light switches and other switchgear) outside the distillation room in non-hazardous or safe areas;
- **ii.** DO NOT allow any electrical apparatus such as extension cords, ***cellular phones***, etc. to be used inside the distillation room;
- **iii.** Ensure provision is made for proper earthing of storage containers to safely discharge static electricity where decanting of liquids is done.

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