Australian Government
Department of the Environment, Water, Heritage and the Arts
Supervising Scientist

*internal report* 548

# A review of chemical storage and handling protocols in the Environmental Radioactivity laboratories of *eriss*

P Medley

September 2009

(Release status - unrestricted)

# A review of chemical storage and handling protocols in the Environmental Radioactivity laboratories of *eriss*

**P Medley**

Supervising Scientist Division
GPO Box 461, Darwin NT 0801

September 2009

Registry File SG2009/0130

(Release status – unrestricted)

**Australian Government**

**Department of the Environment, Water, Heritage and the Arts**
**Supervising Scientist**

*How to cite this report:*

Medley P 2009. A review of chemical storage and handling protocols in the Environmental Radioactivity laboratories of ***eriss***. Internal Report 548, September, Supervising Scientist, Darwin. Unpublished Paper

*Location of final PDF file in SSD Explorer*

\Publications Work\Publications and other productions\Internal Reports (IRs)\Nos 500 to 599\IR548_review chemical storage and handling protocols in EnRad lab (Medley)\IR548_review chemical storage and handling protocols (Medley).pdf

*Location of all key data files for this report in SSD Explorer:*

Corporate Management\Property Management (including Environmental Management System)\Environmental Management Systems (EMS)\SSD Environmental Management System development 2005 onwards including sustainability reporting\Data Collection\EMS- Chemical waste for drains etimates.xls
ENRAD Administration\Darwin_Laboratory\Audits & Reviews\Peroxide Testing.xls
ENRAD Administration\Darwin_Laboratory\Audits & Reviews\Phosgene Testing In Chloroform.xls
ENRAD Administration\Darwin_Laboratory\Laboratory Management\EnRad Chemical Inventory\CAMEO-NOAA reactivity templates
ENRAD Administration\Darwin_Laboratory\Laboratory Management\EnRad Chemical Inventory\EnRad Chemical Incompatibility.xls
ENRAD Administration\Darwin_Laboratory\Laboratory Management\EnRad Chemical Inventory\EnRad Chemical Inventory.xls
ENRAD Administration\Darwin_Laboratory\Laboratory Management\EnRad Chemical Inventory\EnRad Chemical Inventory.xls' in worksheet 'EnRad - Radiochemistry - Jul 09'
ENRAD Administration\Darwin_Laboratory\Laboratory Management\EnRad Chemical Inventory\Inventory - Chemicals to be disposed Jan 2009.xls
ENRAD Administration\Darwin_Laboratory\Laboratory Management\EnRad Chemical Inventory\Legacy Standards & Chemicals list.xls
OH & S\Safety Manuals\Radiation_Safety\Radiation_Source_Control_Plan\Versions\RadSourceControlPlan_v10.doc

*Author of this report:*

Peter Medley – Environmental Research Institute of the Supervising Scientist, GPO Box 461, Darwin NT 0801, Australia

The Supervising Scientist is part of the Australian Government Department of the Environment, Water, Heritage and the Arts.

Supervising Scientist
Department of the Environment, Water, Heritage and the Arts
GPO Box 461, Darwin NT 0801 Australia

e-mail: publications_ssd@environment.gov.au

Internet: www.environment.gov.au/ssd   (www.environment.gov.au/ssd/publications)

Printed and bound in Darwin NT by Supervising Scientist Division

# Contents

# Executive summary

A review of chemical storage and handling protocols in the Environmental Radioactivity section (EnRad) of ***eriss*** was undertaken after two incidents involving EnRad staff. Investigations from these incidents also made recommendations regarding the updating of procedures within the section. A review of the management of all chemicals held by EnRad, including an assessment of potential improvements in chemical safety and laboratory management, was conducted. The major themes of the chemical management review were a review of all MSDS (material safety data sheet) information and protocols for the purchasing, storage, handling and disposal of chemicals and chemical waste. Particular emphasis was placed on addressing any current issues of significance identified and on providing recommendations for implementing a Chemical Management Framework for all chemicals handled by EnRad staff. Implementation of these recommendations will ensure all procedures in place in the EnRad radiochemical laboratory have undergone a rigorous safety assessment. Following this report recommendations will guide and complement the development of a comprehensive procedures manual for the EnRad laboratories.

# 1 Introduction

This report was inititated after a serious incident (referred to as the L19 incident) resulted in injury (requiring hospitalisation) to a staff member who was working in the radiochemistry laboratory. The incident involved the handling of time-sensitive organic waste, the disposal procedures for which were not accounted for adequately within the OH&S framework within ***eriss*** at the time.

As a result of this incident, a review of the management of all chemicals held by the Environmental Radioactivity section (EnRad), including an assessment of potential improvements in chemical safety and laboratory management, was conducted. Particular emphasis was placed on addressing any current issues of significance identified and on providing recommendations for implementing a Chemical Management Framework for all chemicals handled by EnRad staff.

Internal and Comcare investigations identified that a number of MSDS for chemicals in the EnRad laboratory were out of date. Further, up to date information on several chemicals indicated there were at least two time-sensitive chemicals (Chloroform and Isopropanol) that had not previously been identified (Bailey et al 2004). There were also a number of issues identified with procedures for the storage and disposal of organic wastes.

The major themes of the chemical management review are:

- A review of all MSDS information held by EnRad
- Storage and handling of chemicals held – especially with respect to time-sensitive chemicals and waste
- Disposal of chemicals (including acidified samples)
- Purchasing chemicals

These four major themes were identified from two primary sources. Firstly, recommendations from the investigation report for the L19 incident described above. Secondly, recommendations arising from another incident involving the spillage of an acidified sample on a staff member due to the structural failure of an aged and degraded plastic container. In addition this report also contains some further improvements that are currently being implemented following recommendations from EnRad staff.

Investigations from the L19 incident also made recommendations regarding the updating of procedures with the aim to guide and complement the development of a comprehensive procedures manual for the EnRad laboratories. Implementation of these recommendations will ensure all procedures in place in the EnRad radiochemical laboratory have undergone a rigorous safety assessment. The updated procedures manual will be published in a separate report. The EnRad radiochemistry laboratory manager bears responsibility for the implementation and completion of recommendations highlighted in this report.

# 2 MSDS review

Currently MSDS information for chemicals held by EnRad is located in several places:

- A red binding folder named ‘MSDS for commonly used and hazardous chemicals’ located in the top left cupboard upon entering room L.19. Contains MSDS for commonly used and hazardous chemicals in the Radiochemistry laboratories (L.19 – L.25)
- A complete set of MSDS in the bottom cupboard on the left of the weighing bench in L.19
- A complete set of MSDS held in the central foyer area of the ***eriss*** wing
- A complete set of MSDS held by the gate entrance to the back car park of SSD.

A review conducted immediately following the L19 incident showed that the majority of MSDS for all chemicals were significantly out of date, with some dating back to 1985. In addition, several of the MSDS were incorrect as they did not correspond exactly to the form of the chemical that ***eriss*** held.

Follwing the L19 Incident, the Director of ***eriss*** requested that all laboratory area managers conduct an immediate review of MSDS holdings to ensure they were up to date. A key recommendation in the L19 Incident Investigation Report was that MSDS holdings should be reviewed every two years and updated.

The updating of all EnRad MSDS was undertaken in three phases.

1) All out of date MSDS were replaced by MSDS accessed from the ChemWatch database tool provided by the Department.
2) All chemicals currently held in the Radiochemistry laboratory were listed and checked to ensure an appropriate MSDS was held. The Enrad chemical inventory is located on SSD-Explorer (SSDX) at:

   *ENRAD Administration\Darwin_Laboratory\Laboratory Management\EnRad Chemical Inventory\EnRad Chemical Inventory.xls*
3) All chemical suppliers were instructed to provide the latest available MSDS for each chemical ordered to ensure that variations between manufacturers’ products could be taken into account.

Phase 3 is ongoing and will continue until updated MSDS have been received for all chemicals held.

The manager of the radiochemistry laboratory evaluated all new MSDS to ensure EnRad complied with all necessary requirements. Additional information relating to specific chemicals that was considered of benefit to staff and that can provide assistance when implementing new procedures or modifying existing ones is given in Appendix 1 of this report. Appendix 2 includes a list of the current chemicals held by EnRad, with details regarding some of the more relevant hazards posed to staff. This material can also be found on SSDX at:

> *\ENRAD Administration\Darwin_Laboratory\Laboratory Management\EnRad Chemical Inventory\EnRad Chemical Inventory.xls’* in worksheet ‘*EnRad - Radiochemistry - Jul 09*’.

In addition to the chemicals currently in use, there were a number of chemicals stored in the radiochemistry laboratory that are no longer required. These are made up of several groups which are detailed below:

- Old standards or Standard Reference Materials (SRMs)
- Legacy chemicals, including:
  - Old chemicals that have been stored in the EnRad laboratory areas in their original containers
  - Chemical solutions prepared for use in Radium separation based on an SSR180 (Martin & Hancock 2004) method that is no longer functional

### Old standards or Standard Reference Materials (SRMs)

A list of these was provided to Charles Darwin University (CDU) for scrutiny, and several of these reference materials were subsequently donated to CDU.

### Legacy chemicals

*Old chemicals stored in original containers*

There were a number of chemicals currently held for which there is no current need. These were either disposed of or formally donated to CDU or to another group within ***eriss***. A list of these materials and disposal details is in Appendix 3.

*Chemicals solutions used for Radium separation*

There were a number of chemical solutions used for separation of radium isotopes according to an in-house procedure detailed in SSR180 (Martin & Hancock 2004). Due to a change in the properties of a cation exchange resin (Dowex 50x12) used in the procedure, it was no longer suitable for radium separation. At the time a new and faster technique for radium analysis ($^{226}$Ra only) was being implemented and this has since been adapted to allow for determination of the other radium isotope of main interest to ***eriss*** (Medley 2009). As such, the method described in SSR180 has not been used since 2001.

## 2.1 Recommendations from review of chemical holdings

**It is recommended** that all chemicals in the radiochemistry laboratories that are no longer required are disposed of as soon as possible by an approved contractor. There are also a number of chemicals that are used infrequently or in small quantities. These were detailed, and several that have been held for extensive periods of time were recommended for disposal (Appendix 3). These chemicals should also be managed within the time-management framework for chemicals that is currently being developed.

**It is recommended** that a list be prepared detailing important information regarding all chemicals held by EnRad. This list needs to be accessible (read-only) to all staff. The Radiochemistry Laboratory Manager should be responsible for managing this list and associated data.

Details that are mandatory on this list are detailed below:

- Chemical name
- Hazard Alert Code
- Dangerous Goods (DG) Class
- CAS No. – A unique chemical identification number for each chemical
- UN No. – A unique United Nations identification number for each chemical/group

- Location to be stored – Include room and safety cabinet/cupboard (ie – corrosives, poisons etc). (This will ensure any storage requirements and incompatibilities are assessed before purchasing new chemicals.)
- Origin of MSDS – Ideally a Chemwatch and Manufacturer's MSDS should be held
- Expiry date of MSDS
- Storage time limits – this is critical for developing a time-management framework for time-sensitive chemicals

# 3 General chemical storage and handling considerations

The review of the status of the chemical storage and management system for EnRad was contingent on completion of the MSDS review, including the provision of up-to-date MSDS and chemical inventory information. This part of the review process focussed on storage and handling procedures for currently held chemicals. A review of chemical storage considerations including an assessment of any potential reactivity concerns and storage incompatibilities was undertaken. Of particular importance was the assessment of potentially time-sensitive chemicals (see Appendix 4 for testing details) with the intent of creating a register of time sensitive chemicals to manage the additional risks associated with the longer term storage of these chemicals.

Cases where the inappropriate storage of a chemical or mixture of chemical have been identified are detailed individually in this review. This includes the storage and handling of organic waste as distinct from issues associated with pure unused chemicals. Particular reference is made to the potential consequences of inappropriate management of time-sensitive chemicals or unstable chemical mixtures, especially those chemicals involved with the L19 incident.

To assess the suitability of the current storage arrangements regarding the proximity of chemicals to each other, reactivity checks were undertaken using the ChemWatch database and a reactivity database jointly run by Cameo Chemicals and the National Oceanic and Atmospheric Administration (NOAA) branch of the US Department of Commerce (http://cameochemicals.noaa.gov/, accessed 29 January 2009). The results from these reactivity checks are shown in Appendix 5. Electronic spreadsheets have been set up to maintain ongoing details for chemical reactivity and to enable easy updates of information when new chemicals are acquired. These spreadsheets are located on SSDX:

> *\ENRAD Administration\Darwin_Laboratory\Laboratory Management\EnRad Chemical Inventory\CAMEO-NOAA reactivity templates*

Recommendations for improvement in chemical storage procedures arising from the reactivity evaluation process described above are given at the end of this section.

## 3.1 Time-sensitive chemicals

### 3.1.1 Storage and handling of organic waste from U and Th separation

Organic waste is generated during the process of separation of U and Th isotopes from sample matrices, (Martin & Hancock 2004). This waste consists of 20 mL Xylenes and 5 mL Tri-butyl Phosphate (TBP) per sample. Additionally nitric and hydrochloric acids and water, and traces of metals are likely components of this waste.

The problem with the use of low volatile xylene as the extractant is that it resulted in the build up of vapour (with attendent OH&S risks) in the detergent baths used to clean the funnels between uses. In 2002 a solution was found to this issue. Rinsing the funnels with isopropanol prior to their removal from the fume cupboard was found to effectively strip the xylene from the glass prior to the washing process.

Isopropanol (~10–25 mL  per sample) has subsequently been used for rinsing the separating funnels prior to normal washing of the equipment. Typically the isopropanol wash residues have been combined with the extraction wastes described above.

The mixed organic waste was stored in 2.5 L amber glass Winchesters, which had been accumulating in a fume hood in laboratory L.19 in the Enrad Radiochemistry laboratory since the facility was moved to Darwin from Jabiru in August 2002. Some of the waste may have been carried through to Darwin from the Jabiru site, and was thus many years old. A total of 11 x 2.5 L bottles containing 27.5 L in L.19 and L.21, and 1 x 1 L bottle in L.25 containing 150 mL of this type of organic waste was being stored at the time of the L19 incident. At this time there was no documented procedure for the disposal of this type of waste and no formal risk assessment had been made regarding the storage of this waste at the Darwin site.

The fume cupboard in laboratory L19 was primarily used for storing organic reagents in regular usage, and was also occasionally used for sample concentration through precipitation of iron oxyhydroxides as described by Martin and Hancock (2004).

As part of the investigation process following the explosion that occurred in the L19 incident, detailed investigations were conducted into the hazard posed by this waste.

Two possible modes of production of explosive materials by components of this waste were identified:

- Organic peroxides are produced in isopropanol if stored for long periods or if not stored correctly (eg when contaminated; Bailey et al 2004b).
- Nitric acid can catalyse the hydrolysis of TBP, which can lead to the production of potentially explosive butyl nitrate, or other nitrated organics at higher temperature (Robinson et al 2003).

Details of each of these modes are provided below

#### 3.1.1.1 Peroxidation of Isopropanol

Isopropanol is a time-sensitive chemical, that may form explosive peroxides following prolonged contact with air or sunlight, or if stored for lengthy periods of time (Chemwatch 2008a). The MSDS on file in the laboratory at the time of the L19 incident in mid-2008 was dated 1985 and made no mention of the risk of peroxide formation.

As part of the incident investigation to determine the possible cause of the explosion it was recommended that the winchesters containing the waste should be tested for peroxides. Test strips were purchased (QUANTOFIX® Peroxide 25 and Peroxide 100) for this purpose. However such strips were not suited to testing the organic waste because:

- Test strips are difficult to use with water-immiscible, low volatility chemicals – such as Xylenes and TBP –  as the strips need to be dried to give a result
- There is the potential of explosive material crystallising around the rim of the lid due to long term storage and shaking prior to the attempt to digest the waste. This applies to any test method requiring a sub-sample.
- Potential of alternative unstable or explosive material in the waste other than peroxides
- Potential for precipitation of peroxides out of solution, or formation of polyperoxides which may lead to readings much lower than what is actually there (Bailey et al 2004a, 2004b). This may lead to the incorrect disposal method being used.

**It is recommended** that separate waste bottles are used for the Xylenes/TBP waste and the isopropanol washings. The Xylenes/TBP waste shall be disposed of annually, and the isopropanol washings shall be disposed of more regularly: within 12 months of opening the oldest isopropanol source used for washing.

All squirt bottles and open Winchesters of Isopropanol were tested with the Quantofix® peroxide 25 tests strips. The results of this are detailed in Appendix 4. Of note is the low but significant concentration of peroxides (~2 ppm) found in one of the squirt bottles.

**It is recommended** that squirt bottles of Isopropanol are dated when filled. Excess Isopropanol should disposed into an appropriately labelled storage winchester after 2 months and the squirt bottles cleaned with Decon 90 prior to re-use.

#### 3.1.1.2 Hydrolysis of TBP by Nitric acid

The hydrolysis of TBP by nitric acid is well documented in industrial use of TBP for solvent extraction of uranium and other actinides. This is usually related to the production of Red Oil.

Red oil is as a substance of varying composition containing potentially explosive nitrated organics (Robinson et al 2003). Red oil forms when organic solutions come into contact with concentrated nitric acid at temperatures above 120°C. Although Red oil is relatively stable below 130°C, it can decompose explosively when heated above above 130°C (Robinson et al 2003).

Specific mention was made in the internal investigation report for the L19 incident of the possibility of concentrated nitric acid having being inadvertently added to the digest beaker that exploded. Additionally, photographic evidence indicated the likelihood that the temperature at which the digest was being performed was significantly in excess of 130°C. Although the possibility of Red Oil formation is considered an unlikely cause of the explosion, the mechanism through which TBP is hydrolysed by nitric acid may have led to the formation of explosive material. Given the length of time the waste was stored, these hydrolytic reactions may have been taking place for some time. The formation of butyl nitrate may have increased quantities of explosive material in the waste. Build-up of Butanol and Phosphoric acid in the organic waste may increase the risk of hazardous decomposition products being formed under long term storage.

Considering the unknown characteristics of the mixed waste an experienced external contractor was engaged to provide a quote to remove the waste from site without additional handling by ***eriss*** staff. This task was ultimately undertaken by Dangerous Goods Management (DGM), who have removed the waste from the ***eriss*** site (to a facility in Darwin). DGM will provide ***eriss*** with a certificate of destruction when the material is finally destroyed. Destruction may take up to 18 months due to a low overall volume of this type of waste handled by DGM, and the need to accumulate a sufficiently large volume for economic destruction.

### 3.1.2 Phosgene formation from Chloroform

Chloroform is used in the EnRad laboratories for $^{210}$Po and $^{210}$Pb separation.

Although it is not normally mentioned in current MSDS', chloroform has the potential to form the toxic gas Phosgene which is both stable and soluble in chlororform (Bailey et al 2004b). Additionally, pure chloroform will readily decompose to form free radical degradation products which can lead to the formation of hydrochloric acid (Honeywell

International 2008). Therefore prolonged storage of chloroform can lead to a reduction in pH and/or a build-up of phosgene gas in the headspace of the container and the reagent.

Chloroform is generally supplied in 3 forms (Turk 1998):

- Unstabilised (ie pure)
- Stabilised with Amylene
- Stabilised with Ethanol

Bailey et al (2004b) indicate that unstablised chloroform will undergo auto-oxidation to produce phosgene at room temperature in the presence of sunlight, humidity or a metal catalyst. Bailey et al (2004b) also suggest that metals only need to be in trace amounts to catalyse this reaction. This raises the possibility of phosgene formation in unopened bottles of chloroform due to the presence of trace metals and after long-term storage.

Chloroform stabilised with amylene has been shown to be unstable on prolonged storage, even in cool conditions and the absence of air and light (Turk 1998). Ethanol stabilised chloroform is considered to be reasonably well protected from phosgene formation (Honeywell International 2008; ARS 2008), possibly due to ethanol both inhibiting the formation of phosgene and reacting with phosgene to form diethyl carbonate, which is relatively harmless.

Chloroform vapours are dangerous to human health (Chemwatch 2008a) and precautions have been taken to minimise risks posed by these to staff of EnRad. This includes instruction not to open or handle chloroform outside of a fume hood. These precautionary measures are considered sufficient to prevent any significant additional risk being posed to laboratory staff handling chloroform.

Chloroform used at ***eriss*** is stablised with 0.6 – 1.0% ethanol and is therefore considered to pose a low risk of having significant levels of phosgene formed. Due to an administrative error in 2004 however, approximately 30 L of ethanol stabilised chloroform was purchased at one time. This excess chloroform has been stored in the flammables store L.36 since delivered. The recommended storage temperature (MSDS, Chemwatch 2008a) is less than 30°C. However, measurement of ambient temperature in the flammables store over a period of two days in October 2008 indicated temperatures in excess of this. This temperature may have reached several degrees higher during hotter days of the year. Although the flammables store should have been ventilated, investigations revealed that the ventilation unit was not functioning and was not being regularly serviced after a change in service contractor for the unit. It was repaired in early 2009 and has now been placed on the service schedule overseen by the facilities manager. At the ***eriss*** site there is an additional flammables store (L.35) that is airconditioned, and this should be considered utilisation in future for storage of EnRad flammable stocks.

Based on this information it was considered prudent to test for phosgene formation in older bottles of chloroform. A preliminary pH test was conducted on the only opened bottle of chloroform from L.19 to use as an indicator of potential degradation of the chemical. Even though results from this test indicated no degradation of the chloroform (pH of 7; see Appendix 4 for further details) it was considered prudent to conduct specific testing for phosgene. Phosgene testing was conducted on the opened bottle of chloroform, and one bottle that had not yet been opened. A suitable test method is given by the US Department of Agriculture (ARS 2008) involving the preparation of test strips with 4-(dimethylamino)benzaldehyde and diphenylamine. The test results were negative (see results in Appendix 4).

Despite not finding phosgene in measurable concentrations in this instance, it is recommended that chloroform be integrated into the time-sensitive chemicals management framework as detailed below.

Chloroform has an additional risk in that it may react violently with acetone in the presence of an alkali (Chemwatch 2008a). For this reason the ChemWatch MSDS recommends segregation of these two chemicals. This has also been considered in recommendations for improvements in the storage of both of these organic chemicals.

**It is recommended** that once current stocks of **chloroform** have been depleted, sufficient stock should be purchased at any one time to last only an estimated 6 months. Chloroform stock is to be dated upon arrival and when opening each container. In no case should storage of chloroform be for no longer than 18 months after receipt or 12 months after opening, whichever is earliest. Chloroform should be stored in a flammables cabinet inside the laboratory to ensure storage below 30°C.

**It is recommended** that the L.35 flammables store Manager should be consulted and a risk assessment be undertaken for the transfer of the two EnRad flammables cabinets from the L.36 store to the L.35 store.

**It is recommended** that **acetone** be stored separately to other flammable liquids. Co-ordination between users of acetone should be sought to find a common storage cabinet. If this is not possible, flammable cabinets should be sought to store acetone separately to other flammable liquids held at ***eriss***.

### 3.1.3 Other time-sensitive chemicals

There is one additional time-sensitive chemical (Ultima Gold AB) used by EnRad that has not yet been incorporated into the time sensitive chemicals-management framework. This chemical is used for preparation of samples for liquid scintillation counting, and comprises an organic solvent mixture containing a dissolved scintillant. The manufacturers information indicates that the reagent will degrade through time and hence its perfomance as a reagent will deteriorate. However, this degradation is indicated not to result in the production of unstable byproducts (Chemwatch 2008b).

Current suppliers of this chemical provide expiry date details for each reagent bottle supplied, and these details should be used to incorporate this chemical into an effective time sensitive chemical management framework.

## 3.2 Disposal of old acidified water samples

Many acidified water samples are held in the EnRad Radiochemcistry laboratory, some of them of considerable age. According to an agreement reached with PowerWater, disposal of chemicals to the sink is acceptable, provided concentrations and volumes do not exceed a specified limit. The agreement with PowerWater should be consulted when any chemicals are to be disposed of and is located on SSDX at the location given below.

> *\Corporate Management\Property Management (including Environmental Management System)\Environmental Management Systems (EMS)\SSD Environmental Management System development 2005 onwards including sustainability reporting\Data Collection\EMS- Chemical waste for drains etimates.xls*

The following volume limits for disposal of acidified water are recommended based on this agreement:

- 20 L of 2% Nitric acid disposed to sink in any 24 hour period
- 30 L of 0.5% Hydrochloric acid to sink in any 24 hour period

This represents a limit for total disposal of acidified water from the ***eriss*** site. To ensure this daily limit is not exceeded consultation with other laboratory managers must be sought before disposing of acidified water (including wash baths) in volumes larger than 5L.

When disposing of samples, other constituents of the sample must also be taken into consideration. Examples of additional constituents of relevance include metal and radionuclide concentrations. It is the responsibility of those directing sample disposal to ensure that waste is disposed of appropriately. The ***eriss*** radiation source control plan and agreement with PowerWater (indicated above) on SSDX can be used to identify acceptable limits of radionuclides for disposal to the sewer:

> *\OH & S\Safety Manuals\Radiation_Safety\Radiation_Source_Control_Plan\Versions\RadSourceControlPlan_v10.doc*

For limits on the disposal of metals in solution and other potential constituents of samples the PowerWater Trade Waste code (Power And Water Corporation 2004) should be consulted. If there is any uncertainty regarding limits for disposal or pre-treatment requirements the PowerWater Trade Waste Manager should be consulted for advice and clarification.

The EnRad Radiochemist is currently in the process of identifying and scheduling disposal of all water samples for which all required analyses have been performed. However, there are currently no default holding periods specified for non-commercial samples beyond which disposal is automatically scheduled. This can impede the scheduling of such disposal. As a starting point a sample should not be disposed of until all required analyses are completed, or the period in storage exceeds the maximum recommended holding time for reliable analysis. It is recommended that the default period should be one year in the absence of advice to the contrary on a given sample bottle. It must also be noted in this report that there is no clear or consistent procedure across ***eriss*** for ensuring samples are disposed of within appropriate timeframes. A broader ***eriss*** review of these procedures should be undertaken to ensure therse procedures are improved.

Prior to beginning sample disposal, the marble chip containing neutralisation sump outside the EnRad laboratory was tested and showed A pH of around 6–8 for water flowing out of the sump. This indicates that the sump has neustralised previous flushes of acid and that there is still at least some residual neutralising capacity present.

Also of importance in this process is the fact that the agreement with PowerWater has not been updated since the ***eriss*** laboratories were occupied in 2002. As such it is possible that there have been changes to the type and quantity of material that is being disposed of to the sewer by activities on the ***eriss*** site. It is also possible that the PAWA acceptance conditons for waste to sewer have changed. Additionally, it is not clear in the agreement whether laboratories other than those in EnRad can dispose of significant quantities of acid to their drains – ie without passing through a neutralisation sump.

**It is recommended** that pH testing of the sump outflow water continues on a regular basis (no more than 24 hours before and after any disposal events) until daily sample disposals to the maximum allowable limit are no longer required. Additional testing should be mandated on a 6 monthly basis to ensure the marble chip s are not depleted.

**It is recommended** that a holding period is specified for every sample that is received in future within the EnRad Laboratory. It is recommended that a default holding time of 6 months after final results have been reported be implemented immediately for all new samples, and currently held samples.

**It is recommended** that an audit of current practices for disposing of laboratory waste to the sewers is conducted for the ***eriss*** site. This should include all chemical types and quantities that are intended to be disposed of to the sewer. The information gathered in this audit should be used to update the 'Chemical waste for drains estimates' spreadsheet and assessed by a competent person to determine if changes need to be made to ***eriss***'s agreement with PowerWater. Note that this may change the testing recommendation for the sump indicated above.

**It is recommended** that an audit of current practices for disposing of laboratory waste to the sewers is conducted for the ***eriss*** site. This should include all chemical types and quantities A review should be conducted to ensure that the disposal of chemicals to sewer by ***eriss*** is consistent with current best practice environmental management requirements.

## 3.3 Reactivity checks

An assessment of the potential for cross reactivity between chemicals (divided into solids liquids, flammables etc) is provided in the tables contained in Appendix 5. These tables identify the number of storage groups of compatible chemicals that are required. A storage group is defined as a group of chemicals of similar type (ie – solid, liquid, flammable etc) that can be stored together without risk of hazardous cross reaction. As a result of this assessment some modifications to current practice of chemical storage need to be implemented, as detailed below.

**It is recommended** that a small flammables cabinet is purchased specifically for the purpose of storing Acetic Acid, Acetone and Nitromethane.

**It is recommended** that a small corrosives cabinet is purchased for the storage of solid sodium hydroxide pellets.

## 3.4 Other recommendations

**It is recommended** that MSDS data sheets are obtained for all radioactive sources for which there is no current MSDS data sheet.

**It is recommended** that the solutions containing tritium stored in the Source Store fridge be transferred to glass containers with Teflon lined lids to ensure an adequate seal. This will prevent evaporation of tritiated water to ambient air through plastic container walls.

# References

ARS 2008. Chloroform Phosgene SOP. 2008. Agricultural Research Service Department of Agriculture, Agricultural Research Service, United States Department of Agriculture. University Park, Pennsylvania. Accessed on 29 September 2008, <http://www.ars.usda.gov/Main/docs.htm?docid=3594&page=6>.

Bailey J, Blair D, Boada-Clista L, Marsick D, Quigley D, Simmons F & Whyte H 2004a. Management of time sensitive chemicals (I): Misconceptions leading to incidents. *Chemical Health & Safety* 11 (5), 14–17.

Bailey J, Blair D, Boada-Clista L, Marsick D, Quigley D, Simmons F & Whyte H 2004b. Management of time sensitive chemicals (II): Their identification, chemistry and management. *Chemical Health & Safety* 11 (5), 14–17.

Chemwatch 2008a. Material Safety Data Sheet: Chloroform. Chemwatch No. 1888. October 2008.

Chemwatch 2008b, Material Safety Data Sheet: Ultima Gold AB. Chemwatch No. 4955-35. October 2008.

Honeywell International 2008. Solvent stabilisation. 2008. Honeywell International, Morristown.. Accessed on 29 September 2008, http://www51.honeywell.com/sm/rlss/bandj/products-applications/solvents/solvents_stabilization.html?c=21.

Martin P & Hancock GJ 2004. *Routine analysis of naturally occurring radionuclides in environmental samples by alpha-particle spectrometry*. Supervising Scientist Report 180, Supervising Scientist, Darwin NT.

Power and Water Corporation 2004. Power And Water Corporation, Darwin Northern Territory. Accessed on 10 August 2009 at <http://www.powerwater.com.au/__data/assets/pdf_file/0016/7072/trade_waste_code_oct_2004.pdf>

Robinson R, Gutowski D & Yeniscavich W 2003. *Control of red oil explosions in defense nuclear facilities*. Technical Report DNFSB/TECH-33, Defense Nuclear Facilities Safety Board, Washington D.C. Washington.

Turk E 1998. Phosgene from chloroform. *Chemical & engineering news* 76 (9), 6.

# Appendices

## Appendix 1  Specific information for selected chemicals

Additional information about some specific chemicals is detailed here, and some recommendations for modification of current procedures relating to the storage and handling of these chemicals are given. Data has been taken from MSDS sheets, the Cameo and NOAA chemical reactivity database and Chemwatch. All information was up to date as of February 2009.

### Acetic acid (glacial)

MSDS information indicates a possible incompatibility with xylene, in particular p-xylene, and acetone.

### Acetone

Indications are acetone and chloroform may react violently in the presence of alkalis or in contact with an alkaline surface.

### Ammonia

Mixtures of ammonia and air lying within the explosive limits can occur above aqueous solutions of varying strengths. Several incidents involving sudden ‘boiling’ (occasionally violent) of a concentrated solution (d, 0.880, 35 wt %.) have occurred when screw-capped winchesters are opened. These are attributable to supersaturation of the solution with gas caused by increases in temperature subsequent to preparation and bottling. The effect is particularly marked with winchesters filled in winter and opened in summer.

### Ammonium persulfate

Avoid any contamination of this material as it is very reactive and any contamination is potentially hazardous. Stable when dry. In the presence of moisture, it decomposes slowly evolving oxygen and some ozone – keep in a dessicator.

### DDTC

Refigerated storage is recommended, though not currently in practice. It was noted on the previous MSDS that refrigeration is recommended, however, an unsigned handwritten note indicates that this was considered unnecessary as the compound is stable under conditions of normal temperature and pressure.

### Decon 90

Phosphates are susceptible to formation of highly toxic and flammable phosphine gas in the presence of strong reducing agents such as hydrides. Partial oxidation of phosphates by oxidising agents may result in the release of toxic phosphorus oxides.

**It is recommended** that refrigerated storage be undertaken in future due to potentially significant temperature variations during blackouts which are quite common during the wet season.

## Hydrochloric acid

Forms toxic gases with dithiocarbamates and nitriles. The MSDS glove index for Hydrochloric acid indicates nitrile gloves are suitable, however.

## Hydrogen peroxide

Contact with combustibles such as wood, paper, oil or finely divided metal may produce spontaneous combustion or violent decomposition. May emit irritating, poisonous or corrosive fumes. Avoid any contamination of this material as it is very reactive and any contamination is potentially hazardous

## Ferric chloride

Avoid or control reaction with peroxides. All transition metal peroxides should be considered as potentially explosive. For example transition metal complexes of alkyl hydroperoxides may decompose explosively. Hydrolyses to HCl, and decomposes to HCl – should dilute only in a fume cupboard

## Gallay Clean N Powder

Phosphates are susceptible to formation of highly toxic and flammable phosphine gas in the presence of strong reducing agents such as hydrides. Partial oxidation of phosphates by oxidizing agents may result in the release of toxic phosphorus oxides.

## Mercurisorb (silver nitrate)

Silver or silver salts readily form explosive silver fulminate in the presence of both nitric acid and ethanol. The resulting fulminate is much more sensitive and a more powerful detonator than mercuric fulminate. Silver and its compounds and salts may also form explosive compounds in the presence of acetylene and nitromethane. Avoid any contamination of this material as it is very reactive and any contamination is potentially hazardous. Avoid or control reaction with peroxides. All transition metal peroxides should be considered as potentially explosive.

## Millipore chlorine tablets

Material contains oxidising agent/organic peroxide. Oxygen provided makes fire fierce and self sustaining. Smothering action may not be effective for established fire. Intense heat may cause spontaneous decomposition (detonation). Due to possibility of reignition, extinguished residues must be thoroughly cooled before approaching. Avoid any contamination of this material as it is very reactive and any contamination is potentially hazardous. Cecomposes to chlorine gas. This material is used regularly in the maintenance of the pure water system. This material is not currently stored in a fume cupboard or safety cabinet as this is not a specific requirement and there are no other chemicals of this type requiring storage.

**It is recommended** that an additional outer container is provided to minimise any chances of spillage or contamination of the Millipore Chlorine tablets.

## Nitromethane

Forms shock-sensitive mixture with amines, compounds formed with alkalis are explosive when dry. Do not trap between closed valves or use positive-displacement pumps to discharge nitromethane. Mixtures containing nitromethane and both amines and heavy metal oxides may explode spontaneously. This is used solely for the preparation of quench standards for the Liquid Scintillation Counter (LSC).

**It is recommended** that standards prepared with Nitromethane are not held for long-term storage, also due to the low usage it is recommended that this chemical is integrated into a time-management framework.

## Perchloric acid

Heating may cause expansion or decomposition leading to violent rupture of containers. Heat affected containers remain hazardous. Avoid any contamination of this material as it is very reactive and any contamination is potentially hazardous. Forms incompatible sometimes explosive mixtures with powdered carbon, aqua regia and nitric acid. With concentrated sulfuric acid a violent explosion can occur unless effective cooling is used. NOTE: May develop pressure in containers; open carefully. Vent periodically. Many of the reported explosions involving perchlorate may result its ability to form unstable perchlorate esters or salts of the anhydrous acid – DO NOT allow to dry out. This chemical is used very little in the Radiochemistry laboratory and holding times should be carefully monitored and reduced if possible. It is currently stored in a fume cupboard with both concentrated Nitric and Sulfuric acids. Compatibility testing indicates storage of these chemicals together is suitable.

## Phosphoric acid

Forms explosive mixtures with nitromethane.

**It is recommended** to prevent Phosphoric acid and nitromethane from being stored in the same area (ie a fume cupboard or cabinet) a label is placed on new containers of both chemicals to indicate that they should never be stored in the same area or handled at the same time.

## Potassium permanganate

Avoid any contamination of this material as it is very reactive and any contamination is potentially hazardous. This chemical is used in small quantities for gross alpha/beta analysis by LSC. Permanganates may reacts violently when exposed to sulfuric acid or hydrogen peroxide. May form explosive compounds with ammonium compounds, cellulosics (such as cotton, paper or the filter papers commonly used by EnRad).

**It is recommended** that, due to low usage, this Potassium permanganate is integrated into a time-management framework.

# Appendix 2 EnRad chemical inventory

**Table A2.1** EnRad Chemical Inventory as of February 2009

| Lab | Chemical | Quantity avg | Chemical group | MSDS updated | Notes |
|---|---|---|---|---|---|
| **19** | | | | | |
| | Aluminium Oxide | 3 x 25 g | Current | Yes | |
| | Ammonia (28% Conc) | 1 L | Current | Yes | |
| | Ascorbic Acid | 1 x 1 kg,<br>1 x 500 g | Current | Yes | Dispose of most of this and prepare a more suitable container. Current containers have aged condsiderably. The product appears stable and continues to perform adequately in procedures. |
| | Barium Chloride, dihydrate | 4 x 500 g, 1 x 20 g | Current | Yes | Have approx 2 kg of this. Far over requirements. 1 kg is very aged and should be disposed of. |
| | Calcium Phosphate | 1 x 1 kg | Current | | Used for preparation of attenuation standards for gamma spectrometry. Not currently used, but is quite stable and may be used in future. |
| | Chloroform | 4 x 2.5 L | Current | Yes | Test for Phosgene formation - dispose of excess and integrate into time-management framework. |
| | Decon 90 | 5 L | Current | Yes | |
| | Diethylenetriamine pentaacetic acid (DTPA) | 3 x 1 kg | Current | Yes | |
| | 4-(Dimethylamino)benzaldehyde | | | Yes | For making a phosgene testing reagent. |
| | Diphenylamine | | | Yes | For making a phosgene testing reagent. |
| | BioRad 1x8-50 Ion Exchange Resin | 2 x 500 g | Current | Yes | The MSDS is for the Dowex resin. |
| | Ethanol | 6 x 2.5 L | Current | Yes | |
| | Ferric Chloride, Anhydrous | 1 x 500 g | Current | Yes | Stored in dessicator. |
| | High Vacuum Grease, Technical | 1 x 100 g | Current | Yes | |
| | Isopropanol | 1 x 2.5 L | Current | Yes | Test for Peroxide formation - dispose of excess and integrate into time-management framework. |
| | Lead Nitrate | 1 x 500g,<br>1 x 250g | Current | Yes | Current stocks may be old or excessive, this should be assessed. |
| | Manganese Chloride, Tetrahydrate | 1 x 500 g | Current | Yes | Used occasionally for Manganese Dioxide precipitation. |
| | Mercurisorb (Silver Nitrate) | 1 x 100 g | Current | Yes | Part of the Mercury Spill Kit. |
| | Millipore Cleaning tablets | 1 x 100 g | Current | Yes | Used for autoclean function on Millipore pure water system. |
| | Nitric Acid | 3 x 2.5 L | Current | Yes | |

| Lab | Chemical | Quantity avg | Chemical group | MSDS updated | Notes |
|---|---|---|---|---|---|
| | Perchloric Acid (Concentrated) | 1 x 2.5 L | Current | Yes | Volumes held are far in excess of those needed for EnRad. Recommended that smaller containers are sourced and that this chemical is placed within the time-management framework. |
| | Phosphoric acid (85%) | 1 x 1 L | Current | Yes | Used for New LSC method. |
| | Sodium Hydroxide | 1 x 500g,<br>1 x 1 kg | Current | Yes | |
| | Sodium Hydrogen Sulphate | 1 x 500 g | Current | Yes | |
| | Sodium Sulphate (Anhydrous) | 3 x 12 kg | Current | Yes | |
| | Sulfuric Acid | 1 x 2.5 L | Current | Yes | |
| | Thymol Blue | < 5 g | Current | Yes | Very aged, but stable chemical in very low quantities - not recommended for disposal. |
| | Tributyl Phosphate | 500 mL | Current | Yes | |
| | Xylenes | | Current | Yes | |
| **21** | | | | | |
| | Acetic Acid (Glacial) | 3 x 500 mL | Current | Yes | |
| | Ammonium Persulfate | 2 x 500 g | Honours | Yes | This chemical was purchased for digestion of EDTA as part of an Honours Project conducted by P.Medley. It has no current intended use. Most of the product is remaining. |
| | Diethylammonium Diethyldithiocarbamate (DDTC) | 3 x 25 g | Current | Yes | |
| | Gallay Clean N powder | 1 x 5 kg | Current | Yes | |
| | Nitric Acid (70%) | 2.5L | Current | Yes | |
| | Nitromethane | 1 x 500 mL | Current | Yes | Used for preparation of quench standards for LSC. |
| | **Perchloric Acid (Concentrated)** | 100ml | Current | Yes | |
| | Potassium Permanganate | 1 x 500 g | Current | | Used for New LSC method. |
| | Sulphuric Acid (98%) | 1 x 2.5 L | Current | Yes | |
| **22+23** | | | | | |
| | Acetone | 1 x 2.5 L | | Yes | Check to find alternative storage. |
| | Ammonia (28% Conc) | 1 x 2.5 L | Current | Yes | |
| | Ethanol (96%) | 1 x 2.5 L | Current | Yes | |
| | Hydrochloric Acid (32%) | 1 x 1 L | Current | Yes | |
| | Hydrochloric Acid (32%) | 8 x 2.5 L | Current | Yes | |
| | Hydrogen Peroxide (30%) | 3 x 2.5 L | Current | Yes | |
| | Isopropanol | 1 x 2.5 L | Current | Yes | Test for Peroxide formation - dispose of excess and integrate into time-management framework |

| Lab | Chemical | Quantity avg | Chemical group | MSDS updated | Notes |
|---|---|---|---|---|---|
| **25** | | | | | |
| | Assorted radioactive sources (Class 7) | | Current | Yes | Some of these sources may need MSDS data - eg thorium and uranium salts. Recommended that this is undertaken by Radiochemist of EnRad. |
| | Assorted radioactive sources (Class 8) | | Current | Yes | Some of these sources may need MSDS data - eg thorium and uranium salts. Recommended that this is undertaken by Radiochemist of EnRad. |
| | Assorted radioactive sources (Class 7) | | Current | Yes | Some of these sources may need MSDS data - eg thorium and uranium salts. Recommended that this is undertaken by Radiochemist of EnRad. Tritium containers are plastic - this is not appropriate as the plastic is semi-permeable to water. New glass containers. |
| | Ethanol (96%) | 4x 2.5L | Current | Yes | |
| **27** | | | | | |
| | Iron, Powder (>99%) | 2 x 500 g | Current | Yes | Used for preparation of attenuation standards for gamma spectrometry. Not currently used, but is quite stable and may be used in future. |
| | Silica Gel, Orange | 1 x 2.5 kg | Current | Yes | |
| **30** | | | | | |
| | High Vacuum Grease, Technical | 2 x 100 g | Current | Yes | |
| **Fire Store** | | | | | |
| | Chloroform | 10 x 2.5L | Current | Yes | Test for Phosgene formation - dispose of excess and integrate into time-management framework. |
| | Isopropanol | 1 x 2.5 L | Current | Yes | Test for Peroxide formation - dispose of excess and integrate into time-management framework. |
| | Ethanol | | Current | Yes | |
| | Tributyl Phosphate | 1 x 500 mL | Current | Yes | |
| | Xylenes | | Current | Yes | |
| | **Chemical Solutions/Dispensers** | **Quantity Avg** | **Chemical Group** | | Container |
| **19** | | | | | |
| | Ammonia Solution (4%) | 500 mL | Current - Solution | | 500 mL plastic bottle |
| | Amonia solution (28%) | 125 mL | Current - Solution | | Glass Dropper bottle |
| | Hydrochloric Acid (5M) | 2.5 L | Current - Solution | | 2.5L Winchester - Optifix dispenser |
| | Nitric Acid (8M) | 2.5 L | Current - Solution | | 2.5L Winchester - Optifix dispenser |
| | Hydrochloric Acid (9M) | 2.5 L | Current - Solution | | 2.5L Winchester - Optifix dispenser |
| | Nitric Acid (2%) | 500 mL | Current - Solution | | |

| Lab | Chemical | Quantity avg | Chemical group | MSDS updated | Notes |
|---|---|---|---|---|---|
| | Sulphuric Acid (1%) | 500 mL | Current - Solution | | |
| | Ammonium Hydroxide Wash Solution | 500 mL | Current - Solution | | |
| **21** | | | | | |
| | Sodium Sulphate (20%) | 4 x 2 L | Current - Solution | | |
| | Lead Nitrate (3.2%) | 2 L | Current - Solution | | 2 L Stock solution - Nalgene lid with stopper |
| | Lead Nitrate (3.2%) | 250 mL | Current - Solution | | 500 mL plastic bottle |
| | DTPA (0.2M) | 2 L | Current - Solution | | |
| | Hydrochloric Acid (2.5%) | 1 L, 2 L | Current - Solution | | |
| | Hydrochloric Acid (0.1M) | 2 x 500 mL | Current - Solution | | |
| | Ethanol (60%) | 500 mL | Current - Solution | | |
| | Ethanol (80%) | 500 mL | Current - Solution | | |
| | Nitric Acid (2%) | 500 mL | Current - Solution | | |
| | Sodium Sulphate (0.3M) | 100 mL | Current - Solution | | |
| | Thymol Blue (0.2%) | 125 mL | Current - Solution | | |
| | DTPA (0.2M) | 500 mL | Current - Solution | | |
| | Sodium Hydrogen Sulphate (70%) | 125ml | Current - Solution | | |
| | Barium Carrier Solution | 250 mL | Current - Solution | | |
| | 4.7M NaOH | 400 mL | Current - Solution | | |
| **30** | | | | | |
| | Isopropanol | 500 mL | Current | | Test for Peroxide formation - dispose of excess and integrate into time-management framework |
| | Hydrochloric Acid (0.1M) | 500 mL | Current - Solution | | |
| | Ethanol (60%) | 500 mL | Current - Solution | | |
| | Ethanol (80%) | 500 mL | Current - Solution | | |
| | Nitric Acid (2%) | 500 mL | Current - Solution | | |
| | Sodium Sulphate (0.3M) | 100 mL | Current - Solution | | |
| | Thymol Blue (0.2%) | 125 mL | Current - Solution | | |
| | DTPA (0.2M) | 500 mL | Current - Solution | | |
| | Sodium Hydrogen Sulphate (70%) | 125 mL | Current - Solution | | |
| | Barium Carrier Solution | 250 mL | Current - Solution | | |
| | 10 M NaOH | 400 mL | Current - Solution | | |
| | Isopropanol | 500 mL | | | |

# Appendix 3  Disposal of chemicals from the EnRad laboratories

**Table A3.1**  Chemical disposal of old chemicals, standards and reference materials from the EnRad laboratories

| Chemical | Quantity | From | Product No: | Disposal |
|---|---|---|---|---|
| Lithium Chloride | 4 x 25 g | BDH Chemicals Ltd England | 14042 | Disposed of by Waste Solutions January 2009. |
| Ta PS:45-350um | 3 x 20 g | Good Fellow Metals, Science park, England | Cat No: TA006010 | Disposed to landfill through Veolia November 2008. |
| Buffer tablets (ph 9.2) | 25 tablets | BDH Chemicals Australia | 33156 | Neutralised with 8 M Nitric acid. Disposed of to sewer. 21/10/2008 |
| Vanadium PS: 45-75um | 10 g | Good Fellow Metals, Science park, England | Cat No: V006011 | Disposed to landfill through Veolia November 2008. |
| Lead PS: 75-150um | 20 g | Good Fellow Metals, Science park, England | Cat No: PB006030 | Disposed to landfill through Veolia November 2008. |
| Iron PS: -500 | 20 g | Good Fellow Metals, Science park, England | Cat No: FE006030 | Disposed to landfill through Veolia November 2008. |
| Copper PS: -800 | 20 g | Good Fellow Metals, Science park, England | Cat No: CU006030 | Disposed of by Waste Solutions January 2009. |
| Molybdenum PS: 2 avg | 100 g | Good Fellow Metals, Science park, England | Cat No: MO006020 | Disposed of by Waste Solutions January 2009. |
| Manganese PS: flakes | 100 g | Good Fellow Metals, Science park, England | Cat No: MN006100 | Disposed to landfill through Veolia November 2008. |
| Arsenic PS: lumps | 2 x 5 g | Good Fellow Metals, Science park, England | Cat No: AS006100 | Arrange for disposal by an authorised contractor. |
| Cromium PS: -38 | 20 g | Good Fellow Metals, Science park, England | Cat No: CR006021/2 | Disposed to landfill through Veolia November 2008. |
| Pepsin | 10 g | Sigma Chemical Co, USA | P-7000 | Digested with conc. nitiric acid. Disposed of to sewer. 21/10/2008 |
| Platihypnidium Riparioides | 20 g | Community Bureau of Reference | No: 289 | Given to CDU. Taken by David Parry on 08/02/2008. |
| Sn PS: -150 | 100 g | Good Fellow Metals, Science park, England | SN006010/2 | Disposed of by Waste Solutions January 2009. |
| Ni PS: -63 | 20 g | Good Fellow Metals, Science park, England | NI006030/4 | Disposed to landfill through Veolia November 2008. |
| Zn PS: 75-150 | 20 g | Good Fellow Metals, Science park, England | ZN006030/3 | Disposed to landfill through Veolia November 2008. |
| Co PS: -250 | 10 g | Good Fellow Metals, Science park, England | CO006030/3 | Disposed to landfill through Veolia November 2008. |
| Cd PS: -53 | 20 g | Good Fellow Metals, Science park, England | CD006010/2 | Disposed to landfill through Veolia November 2008. |
| Ti PS: -250 | 100 g | Good Fellow Metals, Science park, England | None given. | Disposed to landfill through Veolia November 2008. |
| Selenium PS: pellets | 10 g | Good Fellow Metals, Science park, England | Cat No: SE006100 | Disposed to landfill through Veolia November 2008. |
| Iron(II)sulfide | 40 g | Aldrich Chemical Co. USA | 01607BQ | Disposed to landfill through Veolia November 2008. |
| Indium Oxide | 1 g | Johnson, Matthey and Co. Ltd London | Cat No: IM385 | Disposed to landfill through Veolia November 2008. |

**Disposal to landfill:**

All of the metals that were held were in unopened sealed glass ampoules with an outer plastic container.
The actual mass of metal in these packages is considered low enough for general disposal to landfill after suitable additional packaging.

The outer plastic containers were double bagged separately. All bags were then placed into a plastic container, then sealed. This was then placed in a heavy duty cardboard box, sealed and disposed of to general waste.

**Table A3.2** List of those chemicals colleced and disposed of by Waste solutions in January 2009 (some chemicals were not from the EnRad laboratories)

| Waste solutions/chemicals to be removed from Supervising Scientist Division, cnr Pederson road & Fenton court, Marrara (near airport) | | | | | | |
|---|---|---|---|---|---|---|
| **# Containers** | **Dangerous Goods Classification** | **Hazardous Substance** | **Name (Written On Container)** | **Volume/ Weight** | **Notes** | **Location at SSD** |
| 1 | **4.2** | No | Charcoal | 100 g | Not original container | L.19 |
| | | | | | | L.19 |
| 1 | **5.1** | Yes | Stock MnO2 (80%) | 13 g | Not original container, no label just writing in texter on outside of container. | L.19 |
| 1 | **5.1** | Yes | Sr(NO3)2 | 50 g | Strontium Nitrate - Not original container, handwritten label is slightly damaged. | L.19 |
| 1 | **6.1** | Yes | Methyl Orange, screened (powder) | < 25 g | | L.19 |
| 1 | **6.1** | Yes | BaCl2 | 50 g | Barium Chloride - Not original container. | L.19 |
| 1 | **8** | Yes | Borate Buffer solution | 125 mL | | L.16 |
| 1 | **9** | Yes | Metol | 500 g | 4-Methylaminophenol sulphate | L.19 |
| 1 | **9** | Yes | Methyl Violet 6B (powder) | < 25 g | | L.19 |
| 1 | **9** | No | Bromophenol blue solution | < 100 mL | | L.19 |
| 1 | | Yes | Copper - 99.99+% purity - unopened (powder) | 20 g | | L.19 |
| 1 | | Yes | Sn - 99.75+% purity - unopened | 100 g | | L.19 |
| 1 | | Yes | Molybdenum 99.9+% purity - unopened (powder) | 100 g | | L.19 |
| 4 | | Yes | Lithium chloride | 25 g | | L.19 |
| 1 | | Yes | Sodium alizarinsulphonate - alizarin Red S (powder) | < 100 g | | L.19 |
| 1 | | Yes | Neutral Red indicator (powder) | < 25 g | | L.19 |
| 3 | | Yes | Fuchsin basic – unopened (powder) | 25 g | | L.19 |
| 1 | | Yes | Fuchsin basic (powder) | < 25 g | | L.19 |

**Waste solutions/chemicals to be removed from Supervising Scientist Division, cnr Pederson road & Fenton court, Marrara (near airport)**

| # Containers | Dangerous Goods Classification | Hazardous Substance | Name (Written On Container) | Volume/ Weight | Notes | Location at SSD |
|---|---|---|---|---|---|---|
| 1 | | Yes | Lyssamine green B | < 10 g | Label is slightly damaged. Spelling on container is: "Lyssamine" while msds sheet details spelling as "Lissamine" | L.19 |
| 1 | | Yes | Phenolphthalein Solution | < 100 mL | | L.19 |
| 1 | | Yes | Spinkote (tube) | 30 g | | L.19 |
| 1 | | Yes | Phenolphthalein (powder) | < 25 g | | L.19 |
| 1 | | Yes | tetrasodium pyrophosphate | 20 g | | L.19 |
| 1 | | Yes | Calcium chloride hydrated | 10 g | | L.19 |
| 1 | | Yes | Formazin waste (<20NTU) | 20 L | Jerry can | L.16 |
| 1 | | No | Magna floc (granular) | < 70 g | Not original container, no label just writing in texta on outside of container. | L.19 |
| 1 | | No | Crystal violet (granular) | < 25 g | | L.19 |
| 2 | | No | Potassium Sulfate - 99+% purity (powder) | 500 g | | L.19 |
| 1 | | No | L-Ascorbic acid | < 500 g | | L.19 |
| 1 | | No | Eriochrome black T (powder) | < 25 g | | L.19 |
| 1 | | No | Methylthymol blue | 1 g | | L.19 |
| 1 | | No | Thymol blue | < 5 g | | L.19 |
| 2 | | No | Bromocresol green (powder) | < 5 g | | L.19 |
| 1 | | No | 2,7 - Dichlorofluroescein (powder) | < 10 g | | L.19 |
| 1 | | No | 0.1% Bromothymol blue (solution) | 50 mL | Dropper bottle, handwritten label. | L.19 |
| 1 | | No | Methyl Red (Powder) | 10 g | | L.19 |
| 1 | | No | Porphyrin | 3 g | Not original container, handwritten label. | L.19 |
| 1 | | No | Bromothymol blue (powder) | < 5 g | | L.19 |
| 1 | | No | Magnesium sulfate | 10 kg | | L.16 |

# Appendix 4 Testing of currently held time-sensitive chemicals

**Table A4.1** Details of pH testing of chloroform

| **pH testing of Chloroform** | **Date: 29/10/08** | **Analysts: PSM / JS** |
|---|---|---|

| **Location** | **Storage** | **pH** |
|---|---|---|
| Chem Lab (L.19) | 2.5L Opened Winchester | 7 |

**Method:**
10-20ml of chloroform was poured into a petri-dish and tested with a pH strip (1-14 range).

**Results:**
Strip indicated a pH of 7 (neutral) which would indicate that there hasn't been any formation of Hydrochloric Acid within the chloroform, therefore no phosgene would be expected.

**Table A4.2** Details of phosgene testing of chloroform

| **Phosgene Testing in Chloroform** | **Date: 29/10/08** | **Analysts: PSM / JS** |
|---|---|---|

**Test Bottle: 1**

| **Location** | **Storage** |
|---|---|
| Chem Lab (L.19) | 2.5L Opened Winchester |

**Method:**
Prepared a 25ml alcoholic solution containing a 10% mixture of Dimethylaminobenzaldehyde & Diphenylamine. This solution was dripped onto white strips of paper and allowed to dry completely. From this 2 strips were fixed onto the neck of the Chloroform Bottle along with a Plastic Bag containg the strips and Bottle Cap which was then removed to ensure all gas was trapped within the bag and exposed to the strips. Strips were left for 1minute before checking results.

**Results:**
The strip did not change colour, indicating no phosgene present within this Chloroform bottle.

**Test Bottle: 2**

| **Location** | **Storage** |
|---|---|
| Chem Lab (L.19) | 2.5L Unopened Winchester |

**Method:**
Prepared a 25 ml alcoholic solution containing a 10% mixture of Dimethylaminobenzaldehyde & Diphenylamine. This solution was dripped onto white strips of paper and allowed to dry completely. From this a Test Strip was fixed to the inside of the Chloroform Bottle lid and was placed onto the Chloroform Bottle for 1minute.

**Results:**
The strip did not change colour, indicating no phosgene present within this Chloroform bottle.

**Table A4.3** Peroxide testing of Isopropanol in EnRad laboratories and work areas

| **Peroxide Testing of Isopropanol** | | | | |
|---|---|---|---|---|
| **Location** | **Storage** | **Peroxides Present (mg/L)** | **Hydro-Peroxides Present (mg/L)** | **Comments** |
| Chem Lab (L.19) | 500 mL Squirt Bottle | 0 | 0 | Slight blue colour around edge of strip. |
| Chem Lab (L.21) | 500 mL Squirt Bottle | 0 | 0 | |
| Chem Lab (L.19) | 2.5 L (Unopened Winchester) | 0 | 0 | Possibly a little bit of blue around strip edges |
| Detecter Room (L.29) | 500 mL Squirt Bottle | 2 | 2 | Maybe a slight increase in Hydro-peroxide Test. |
| Source Lab (L.25) | 500 mL Squirt Bottle | 0.5 | 0 | |
| Source Lab (L.25) | 2.5 L Opened Winchester | 0 | 0 | Possibly a little bit of blue around strip edges |
| **Method:**<br>10–20 ml of each solution was poured into a labelled petri-dish and tested with Quantofix Peroxide 25 Test Strips (Sigma Aldrich) according to pack instructions. | | | | |

# Appendix 5  Chemical incompatibility assessment for EnRad holdings

Chemical compatibility assessment for the EnRad laboratories as of February 2009.

**Table A5.1** Incompatibility classes as taken from the Cameo and NOAA website (http://cameochemicals.noaa.gov/)

| ***Incompatibilities*** | |
|---|---|
| *Incompatible 1* | Exothermic reaction. May generate heat and/or cause pressuriasation |
| *Incompatible 2* | Reaction may be intense or violent |
| *Incompatible 3* | May form explosive peroxides |
| *Incompatible 4* | Increased sensitivity to detonation |
| *Incompatible 5* | Generates water soluble toxic products |
| *Incompatible 6* | May be hazardous but unknown |
| *Incompatible 7* | Reaction proceeds with explosive violence and/or forms explosive products |
| *Incompatible 8* | Explosive when mixed with combustible material |
| *Incompatible 9* | Combination liberates gaseous products, including both flammable and toxic gases. May cause presssurisation |
| *Incompatible 10* | Combination liberates combustion-enhancing gas (eg oxygen). May cause pressurisation |
| *Incompatible 11* | Forms very unstable explosive metallic compounds |
| *Incompatible 12* | Heat generated from chemical reaction may initiate explosion |
| *Incompatible 13* | Spontaneous ignition of reactants or products due to reaction heat |
| *Incompatible 14* | Combination liberates gaseous products, at least one of which is toxic. May cause pressurisation |

**Table A5.2** Cross reactivity assessment for solid poisons held by EnRad

***Reactivity Data information for Solid Poisons held by EnRad.***

| ***Chemical Name*** | **Barium Chloride** | **Diphenylamine** | **Lead Nitrate** | **Mercurisorb (Silver Nitrate)** |
|---|---|---|---|---|
| **Barium Chloride** | N/A | *Incompatible 5* | *Incompatible 1* | *Incompatible 1* |
| **Diphenylamine** | *Incompatible 5* | N/A | *Incompatible 1, 7, 11-14* | *Incompatible 1, 7, 11-14* |
| **Lead Nitrate** | *Incompatible 1* | *Incompatible 1, 7, 11-14* | N/A | *Incompatible 6* |
| **Mercurisorb (Silver Nitrate)** | *Incompatible 1* | *Incompatible 1, 7, 11-14* | *Incompatible 6* | N/A |

| ***Suitable Storage Groups identified*** | ***Updated 13/11/2008. PSM*** |
|---|---|
| **Group 1: PSC19.01** | ***Class*** |
| Barium Chloride | 6.1 |
| Diphenylamine | 6.1 |
| Lead Nitrate* | 5.1 (6.1) |
| Mercurisorb (Silver Nitrate)* | 5.1 (6.1) |

*Lead Nitrate and Mercurisorb (Silver Nitrate) are incompatible with the other Class 6 chemicals. Due to limited quantities and limited storage capacity these are to be stored in the same Poisons Cabinet on different shelves. PSM

**Table A5.3** Cross reactivity assessment for solids held by EnRad and stored in dessicators

| ***Chemical Name*** | **Ammonium Persulfate*** | **DDTC** | **Ferric Chloride** | **Potassium Permanganate** | **Sodium Hydrogen Sulfate** | **Sodium Hydroxide** |
|---|---|---|---|---|---|---|
| **Ammonium Persulfate*** | N/A | *Incompatible 1, 2, 13, 14, 15* | *Incompatible 1, 9* | None | *Incompatible 1, 9* | *Incompatible 1, 7, 10, 13, 14* |
| **DDTC** | *Incompatible 1, 2, 13, 14, 15* | N/A | None | *Incompatible 1, 2,13, 14, 15* | None | *Incompatible 1, 14* |
| **Ferric Chloride** | *Incompatible 1, 9* | None | N/A | *Incompatible 1, 9* | None | *Incompatible 1, 3* |
| **Potassium Permanganate** | None | *Incompatible 1, 2,13, 14, 15* | *Incompatible 1, 9* | N/A | *Incompatible 1, 9* | *Incompatible 1, 7, 10, 13, 14* |
| **Sodium Hydrogen Sulfate** | *Incompatible 1, 9* | None | None | *Incompatible 1, 9* | N/A | *Incompatible 3* |
| **Sodium Hydroxide** | *Incompatible 1, 7, 10, 13, 14* | *Incompatible 1, 14* | *Incompatible 1, 3* | *Incompatible 1, 7, 10, 13, 14* | *Incompatible 3* | N/A |

*It is not required that Potassium Permanganate be stored in a dessicator. As a Class 5.1 chemical it has been assessed as best stored with Ammonium Persulfate, and is thus included in this group. PSM

| ***Suitable Storage Groups identified*** | ***Updated 20/11/2008. PSM*** |
|---|---|
| **Group 1** | ***Class*** |
| DDTC | None |
| Ferric Chloride | 8 |
| Sodium Hydrogen Sulfate | 8 |
| **Group 2** | |
| Sodium Hydroxide* | 8 |
| Ammonium Persulfate | 5.1 |
| Potassium Permanganate | 5.1 |

*Sodium Hydroxide is incompatible with the Class 5.1 chemicals. Due to limited quantities and limited storage capacity these are to be stored in the same Dessicator on different shelves, until a new solid corrosives cabinet is acquired. Ensure Sodium Hydroxide has a tray sufficient to capture any spillage. PSM

**Table A5.4** Reactivity data held for flammable liquids held by EnRad

***Reactivity Data information for Flammable liquids held by EnRad.***

| ***Chemical Name*** | **Acetic Acid, Glacial** | **Acetone** | **Chloroform** | **Ethanol** | **Isopropanol** | **LSC Cocktails** | **Nitromethane** | **Toluene** | **Tri-butyl phosphate** | **Xylenes** |
|---|---|---|---|---|---|---|---|---|---|---|
| **Acetic Acid, Glacial** | N/A | None | None | *Incompatible 1, 2* | *Incompatible 1, 2* | Unknown | None | None | None | None |
| **Acetone** | None | N/A | *Incompatible 2** | *Incompatible 3* | *Incompatible 3* | Unknown | *Incompatible 4* | None | None | None |
| **Chloroform** | None | *Incompatible 2** | N/A | None | None | Unknown | *Incompatible 4* | None | None | None |
| **Ethanol** | *Incompatible 1, 2* | *Incompatible 3* | None | N/A | None | Unknown | *Incompatible 1, 2* | None | None | None |
| **Isopropanol** | *Incompatible 1, 2* | *Incompatible 3* | None | None | N/A | Unknown | *Incompatible 1, 2* | None | None | None |
| **LSC Cocktails** | Unknown | Unknown | Unknown | Unknown | Unknown | N/A | Unknown | Unknown | Unknown | Unknown |
| **Nitromethane** | None | *Incompatible 4* | *Incompatible 4* | *Incompatible 1, 2* | *Incompatible 1, 2* | Unknown | N/A | *Incompatible 1* | None | *Incompatible 1* |
| **Toluene** | None | None | None | None | None | Unknown | *Incompatible 1* | N/A | None | None |
| **Tri-butyl phosphate** | None | None | None | None | None | Unknown | None | None | N/A | None |
| **Xylenes** | None | None | None | None | None | Unknown | *Incompatible 1* | None | None | N/A |

*This incompatibility taken from the ChemWatch MSDS. Not indicated on NOAA website.

| ***Suitable Storage Groups identified*** | ***Updated 22/10/2008. PSM*** | |
|---|---|---|
| **Group 1** | ***Class*** | ***Notes*** |
| Acetic Acid, Glacial | 8 (3) | A new Flammables cabinet of limited size is required for chemicals in this group |
| Acetone | 3 | |
| Nitromethane | 3 | |
| **Group 2** | | |
| Chloroform | 6.1 | |
| Ethanol | 3 | |
| Isopropanol | 3 | |
| Toluene | Unknown | This solution contains Naphrax in Toluene. |
| Tri-butyl phosphate | None | Combustible liquid |
| Xylenes | 3 | |
| ***Chemicals with no current reactivity data*** | | |
| **LSC Cocktails** | | |

**Table A5.5** Cross reactivity assessment for chemicals held in general storage by EnRad

***Reactivity data information for chemicals in general storage held by EnRad***

| *Chemical Name* | Aluminium Oxide | Ascorbic Acid | Calcium Phosphate | 4-(Dimethylamino)benzaldehyde | DTPA | EDTA | High Vacuum Grease |
|---|---|---|---|---|---|---|---|
| **Aluminium Oxide** | N/A | None | None | unknown | None | *Incompatible 5* | None |
| **Ascorbic Acid** | None | None | None | unknown | None | None | None |
| **Calcium Phosphate** | None | None | N/A | unknown | None | *Incompatible 5* | None |
| **4-(Dimethylamino)benzaldehyde** | unknown | unknown | unknown | N/A | None | None | None |
| **DTPA** | None | None | None | unknown | N/A | None | None |
| **EDTA** | *Incompatible 5* | None | *Incompatible 5* | unknown | None | N/A | None |
| **High Vacuum Grease** | None | None | None | unknown | None | None | N/A |
| **Ion Exchange Resin (1x8)** | None | None | None | unknown | None | None | None |
| **Manganese Chloride** | None | None | None | unknown | None | None | None |
| **Methyl Red** | None | None | None | unknown | None | None | None |
| **Millipore Chlorine Tablets** | None | None | None | unknown | None | None | None |
| **Potassium Sulfate** | None | None | None | unknown | None | None | None |
| **Sodium Sulfate** | *Incompatible 6* | None | *Incompatible 6* | unknown | None | None | |
| **Thymol Blue** | None | None | None | unknown | None | None | None |

| *Chemical Name* | Ion Exchange Resin (1x8) | Manganese Chloride | Methyl Red | Millipore Chlorine Tablets | Potassium Sulfate | Sodium Sulfate | Thymol Blue |
|---|---|---|---|---|---|---|---|
| **Aluminium Oxide** | None | None | None | None | None | *Incompatible 6* | None |
| **Ascorbic Acid** | None | None | None | None | None | None | None |
| **Calcium Phosphate** | None | None | None | None | None | *Incompatible 6* | None |
| **4-(Dimethylamino)benzaldehyde** | unknown | unknown | unknown | unknown | unknown | unknown | unknown |

| *Chemical Name* | Ion Exchange Resin (1x8) | Manganese Chloride | Methyl Red | Millipore Chlorine Tablets | Potassium Sulfate | Sodium Sulfate | Thymol Blue |
|---|---|---|---|---|---|---|---|
| **DTPA** | None | None | None | None | None | None | None |
| **EDTA** | None | None | None | None | None | None | None |
| **High Vacuum Grease** | None | None | None | None | None | None | None |
| **Ion Exchange Resin (1x8)** | N/A | None | None | None | None | None | None |
| **Manganese Chloride** | None | N/A | None | None | None | None | None |
| **Methyl Red** | None | None | N/A | None | None | None | None |
| **Millipore Chlorine Tablets** | None | None | None | N/A | None | None | None |
| **Potassium Sulfate** | None | None | None | None | N/A | None | None |
| **Sodium Sulfate** | None | None | None | None | None | N/A | None |
| **Thymol Blue** | None | None | None | None | None | None | N/A |

***Suitable Storage Groups identified*** ***Updated 21/10/2008. PSM***

| **Group 1: GCS19.02** | ***Class*** |
|---|---|
| Aluminium Oxide | None |
| Ammonium Acetate | None |
| Calcium Phosphate | None |
| DTPA | None |
| High Vacuum Grease | None |
| Ion Exchange Resin (1x8) | None |
| Manganese Chloride | None |
| Methyl Red | None |
| Millipore Chlorine Tablets | None |
| Potassium Sulfate | None |
| Thymol Blue | None |
| **Group 2** | |
| EDTA | None |
| Sodium Sulfate | None |

***No current reactivity data***

**4-(Dimethylamino)benzaldehyde**

**Table A5.5** Reactivity data for corrosives liquids held by EnRad

***Reactivity Data information for Corrosive liquids held by EnRad***

| ***Chemical Name*** | **Hydrochloric acid** | **Nitric Acid** | **Perchloric Acid** | **Phosphoric Acid** | **Sulfuric Acid** |
|---|---|---|---|---|---|
| **Hydrochloric acid** | N/A | *Incompatible 1, 9, 12, 15* | *Incompatible 1, 9, 12, 15* | None | *Incompatible 1, 9, 12, 15* |
| **Nitric Acid** | *Incompatible 1, 9, 12, 15* | N/A | None | *Incompatible 1, 9, 12, 15* | None |
| **Perchloric Acid** | *Incompatible 1, 9, 12, 15* | None | N/A | *Incompatible 1, 9, 12, 15* | None |
| **Phosphoric Acid** | None | *Incompatible 1, 9, 12, 15* | *Incompatible 1, 9, 12, 15* | N/A | *Incompatible 1, 9, 12, 15* |
| **Sulfuric Acid** | *Incompatible 1, 9, 12, 15* | None | None | *Incompatible 1, 9, 12, 15* | N/A |

| ***Suitable Storage Groups identified*** | ***Updated 22/10/2008. PSM*** |
|---|---|
| **Group 1** | ***Class*** |
| Hydrochloric acid | 8 |
| Phosphoric Acid | 5.1 (8) |
| **Group 2** | |
| Nitric Acid | 8 |
| Perchloric Acid | 8 |
| Sulfuric Acid | 8 |