PREVENTING CONFLICT
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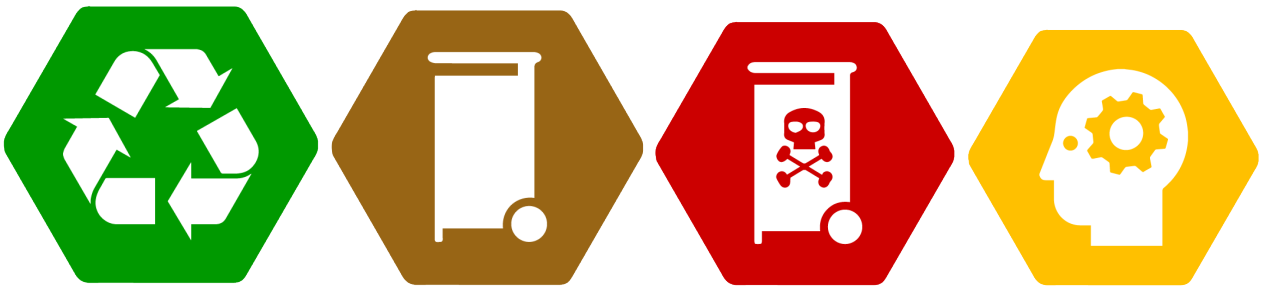
DEPARTMENT OF OPERATIONAL SUPPORT

Manual

Waste Management Handbook for Peacekeeping Operations and Field Based Special Political Missions



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SUSTAINABLE DEVELOPMENT GOALS

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Partners

The Department of Operational Support (DOS) provides operational support to UN Secretariat entities globally, including advisory, operational, and transactional support services and, where needed, exercises delegated authority on behalf of clients. DOS supports the entire UN Secretariat, consisting of almost 100 entities located around the globe.

DOS has a role to play in supporting peacekeeping Missions to achieve the vision and objectives of the DOS Environment Strategy for Peace Operations and to meet their obligations under the UN Environmental policy for Peace Operations and Field Based Special Political Missions and the Environmental Policy for the United Nations Secretariat (ST/SGB/2019/7). Overall leadership is provided by the Under-Secretary-General supported by DOS Pillar Heads and the Field Advisory Committee on Environment (FACE), a group of six Mission Chiefs/Directors of Mission Support (C/DMS) that chair cross-Mission working groups for each of the strategy pillars.

At the working level, an 'Environment Core Team' brings together colleagues within DOS that are dedicated full-time to environmental issues, with ad hoc participants from DOS pillars that are involved in integrating environmental considerations into their broader operational support functions to Missions and the wider UN Secretariat. This group meets at least twice per month, typically with representation from the Procurement and Logistics Divisions of the Office of Supply Chain Management (OSCM) on a monthly basis. Members of this 'core team' plan and facilitate a monthly working group for each pillar of the strategy, bringing together relevant staff from across Missions to exchange information and good practice.

The Environment Section (EnvS) in the Office of the Under-Secretary-General (USG) coordinates implementation of the strategy, determining priorities, identifying opportunities and threats, providing a link between operational activities and strategic deliberations from both UN leadership and Member States, and guiding the overall design of systems, structures, and processes to support environmental performance and risk management.

The **Environmental Technical Support Unit (ETSU),** based within the Global Service Centre (UNGSC) is part of DOS and located in Brindisi, Italy. ETSU leads in the provision of technical advice and assistance to both HQ and Missions – providing 'hands on' technical assistance, developing technical guidance and training materials, and advising on appropriate technology across the three technical pillars of the Environment Strategy (waste, water/wastewater, energy, and wider impact).

The Rapid Environment and Climate Technical project (REACT) is a facility provide to DOS by the United Nations Office for Project Services (UNOPS) to make available dedicated technical expertise to Missions and HQ across all areas of strategy implementation. The REACT facility has operated since 2017 and covers the Phase 1 and Phase 2 aspects of the Environment Strategy for Peace Operations. REACT staff include engineers and technical professionals who are subject matter experts that actively support environmental management and the waste, water/wastewater, energy, and wider impact pillars. This further includes the development of Technical Assistance Strategic Action Plans following a REACT visit to UN Peacekeeping Missions.

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CONTENTS

ACRONYMS & INITIALISMS 10

A. PURPOSE AND SCOPE OF THIS HANDBOOK 13

B. GENERAL REQUIREMENTS FOR SOLID AND HAZARDOUS WASTE MANAGEMENT 15

B.1 The Key Process and Feedback Cycle 15
B.2 Mission Waste Management Plans and Strategies 17
B.3 Environmental Action Planning and Performance (eApp) Reporting for the Waste Management Pillar 19
B.4 Demand Action Planning and Budgeting for Waste Management Solutions . 20
B.5 Non-Hazardous and Hazardous Materials Supply Analyses 21
B.6 Solid and Hazardous Waste Standard Operating Procedure Templates 23
B.7 Solid and Hazardous Waste Services Contracts and Scope Of Requirement Templates 24
B.8 Waste Management Contractor Monitoring and Verification Requirements... 25
B.9 Inspection and Monitoring of UN and Contractor Waste Facilities 29
B.10 Collaborative Engagement with Uniformed Components and Provision of Best Practice Guidance 30

C. SOLID WASTE 33

C.1 Introduction 33
C.2 Overview Table of Solid Waste Management Solutions 34
C.3 Definition of Solid Wastes 38
C.4 Solid Waste Generation Assessments 38
C.5 Waste Minimization Initiatives 41
C.6 Solid Waste Segregation, Collection and Transportation 42
C.7 Centralized Waste Management Yards 44
C.8 Incineration 49
C.9 Plastic Recycling 55
C.10 Aluminium Recycling 59
C.11 Glass Recycling 60
C.12 Paper/Cardboard Reuse and Recycling 62
C.13 Aerobic Composting 64
C.14 Waste to Energy Recovery 66
C.15 Non-Hazardous Construction Wastes 69
C.16 Engineered Landfills 74
C.17 Non-Engineered Landfills and Local Dumpsites 76

D. HAZARDOUS WASTE MANAGEMENT 79
D.1 Introduction 79
D.2 Overview Table of Waste Disposal/Treatment for Hazardous Wastes 80
D.3 Hazardous Materials and Waste at UN Field Missions 85
D.4 Collection, Handling and Storage of Hazardous Materials and Waste 90
D.5 Disposal Options for Hazardous Wastes 100
D.6 Specific Treatment Options for Hazardous Wastes 162
E. SOLID AND HAZARDOUS WASTE MANAGEMENT TRAINING 175
E.1 Introduction 175
E.2 Waste Management Equipment Operator Training 176
E.3 Hazardous Waste Management Training 182
E.4 Soil Bioremediation Training 184

FIGURES

Figure 1: Hierarchical feedback cycle of the five linked mechanisms for Mission solid and hazardous waste management 16
Figure 2: Weighing of wastes for waste sort method and weighing scales 39
Figure 3: Segregation using colour coded and labelled bins 43
Figure 4: Schematic Mission/sector HQ waste management yard 45
Figure 5: WMY showing incineration area and ash mono-fill 47
Figure 6: Solid waste, biomedical and barrel incinerator with air induction 51
Figure 7: Proportions of solid waste feedstock for incineration 52
Figure 8: Emission opacity indicating ideal or problematic incineration efficiency 54
Figure 9: Universal plastic coding system 56
Figure 10: Plastic recycled bricks and beams (Source: Precious Plastics) 57
Figure 11: Range of recycled plastic products 57
Figure 12: PET and PP flossing machines 58
Figure 13: Compacted, baled, and shredded aluminium cans 60
Figure 14: Reusable bottles and crushed glass for aggregate 61
Figure 15: Compactor and baler for cardboard and paper 62
Figure 16: An automated briquette machine and produced briquettes 63
Figure 17: The composting cycle 64
Figure 18: Examples of small to large scale biogas recovery systems 67

Figure 19: Prefabricated building and panel with PUR/PIR insulation 71
Figure 20: Drywall plasterboard waste 72
Figure 21: Plastic pipe and electrical wire waste 73
Figure 22: Schematic for landfill site 75
Figure 23: Uncontrolled dumpsites with high number of vectors, waste pickers and open burning 77
Figure 24: Sample BI dashboard of hazardous waste inventory with retention triggers 88
Figure 25: Sample BI dashboard of hazardous waste inventory with retention triggers and heat map 89
Figure 26: GHS Hazard Communication Standard Pictograms 90
Figure 27: ADR Hazard Communication Standard Pictograms 91
Figure 28: GHS Hazard Communication Standard example product label 92
Figure 29: ADR UN number label example Hypochlorite solution 92
Figure 30: Segregation and separate storage examples (Source: Swiss Safety Centre - see link) 95
Figure 31: Hazardous materials segregation chart 96
Figure 32: Well, organized off floor storage of hazardous materials 98
Figure 33: Inappropriate recycling of lead acid batteries (source: Oeko-Institut) 101
Figure 34: Appropriate and inappropriate storage of lead acid batteries 101
Figure 35: Lithium-ion batteries 102
Figure 36: Nickel-cadmium rechargeable batteries 103
Figure 37: Alkaline batteries 103
Figure 38: Button batteries 104
Figure 39: Typical e-wastes generated across UN Field Missions 106
Figure 40: Fluorescent tubes and bulbs 108
Figure 41: Fluorescent bulb crusher 109
Figure 42: Light ballasts 111
Figure 43: Refrigerants observed at UN Field Missions 114
Figure 44: Well organized and poor storage of POL products 117
Figure 45: Industrial and aerosol paints and thinners 121
Figure 46: Sanitary wastes 125
Figure 47: Pesticides observed across UN Field Missions 127
Figure 48: Different types of cylinders 131

Figure 49: Toner and inkjet printer cartridges 133
Figure 50: Disorganized and organized stacking of tyres 134
Figure 51: Tyre cutter and shredding tyres 136
Figure 52: Waste tyres shredded and processed to granules 136
Figure 53: Pyrolysis of waste tyres for oil extraction and carbonized wastes sold for fuel to a cement kiln 137
Figure 54: Innovative use of waste tyres by UNSOS 138
Figure 55: Biohazard labels for biomedical waste bins 140
Figure 56: Biomedical waste sharp container 140
Figure 57: Destroyed expired ammunition 142
Figure 58: Fired cartridge cases 143
Figure 59: Removed lead shot from a firing range 144
Figure 60: Kevlar jacket, ballistic plate and protective helmets 146
Figure 61: Accumulated stockpiles of hazardous wastes 148
Figure 62: Waste bitumen piles and bitumen fire 151
Figure 63: Examples of poor management of POL products 154
Figure 64: Biomedical waste ash 155
Figure 65: Ash mono-fill example 157
Figure 66: Three main types of asbestos 159
Figure 67: Asbestos containing products 160
Figure 68: Release of asbestos fibres from drilling 160
Figure 69: Mercury switch showing bead of mercury 161
Figure 70: Example chemical treatment area set-up 163
Figure 71: Neutralization treatments of acid and alkaline waste products 165
Figure 72: Alkaline hydrolysis treatment for waste pesticides 167
Figure 73: Diagrams and photos showing inner liner with reinforcing metal and final concrete finish in the drum 169
Figure 74: Diagrams and photos showing outer liner with reinforcing metal and final concrete finish of the culvert encapsulation 170
Figure 75: Contaminated soils from poor vehicle and generator station maintenance controls 172
Figure 76: Solid and biomedical waste and barrel incinerators 177
Figure 77: Typical double shaft shredder 178
Figure 78: Typical compactor and baler 179

Figure 79: Typical woodchipper 180
Figure 80: Bulb crusher 181
Figure 81: Automated composter 182
Figure 82: Example training slide for neutralization treatment 183
Figure 83: Contaminated soils, TPH analysis, bioremediation, and phytoremediation 185

TABLES

Table 1: Example facility inspection checklist for e-waste contractor 28
Table 2: Matrix of waste options and restricted practices for the main solid waste streams 36
Table 3: Composting methods 65
Table 4: Matrix of treatment and end disposal for hazardous wastes 81
Table 5: Hazardous materials/wastes identified as relevant to UN Field Missions by UN Category 85
Table 6: The 16 sections included in an SDS for hazardous materials 94
Table 7: Evaluation table for older (>30 year) lamp ballasts potentially containing PCBs 113
Table 8: Banned refrigerant gases observed at Mission locations 114
Table 9: The three broad types of POL recycling 118
Table 11: Range of pesticides observed in use across Missions 128
Table 12: Common products used for neutralization treatments 164

The following icons are used for each chapter:

General Requirements for Solid and Hazardous Waste Management

Solid Waste Management

Hazardous Waste Management

Solid and Hazardous Waste Training

ACRONYMS & INITIALISMS

ADR	Agreement concerning the International Carriage of Dangerous Goods by Road
BI	Business Intelligence
BOA	Board of Auditors
BPE	Ballistics Protective Equipment
CFC	Chlorofluorocarbon (refrigerant gas)
CFL	Compact Fluorescent Lamps
CMS	Chief of Mission Support
COE	Contingent Owned Equipment
CRT	Cathode Ray Tube
DAP	Demand Action Planning
DMS	Director of Mission Support
DOS	Department For Operational Support
eAPP	Environmental Action Planning and Performance Application
EnvS	Environment Section in The Office of the Under-Secretary-General (USG)
EO	Environmental Officer
EOD	Explosive Ordnance Disposal
ETSU	Environmental Technical Support Unit (based in the Global Service Centre)
EU	European Union
FCC	Fired Cartridge Case
FOB/TOB	Forward Operating Base, Temporary Operating Base
GHG	Greenhouse Gas
GHS	Globally Harmonized System of Classification and Labelling of Chemicals
GSC	Global Service Centre (Brindisi)
GWP	Global Warming Potential
HCFC	Hydrochlorofluorocarbon (refrigerant gas)
HCS	Hazard Communication Standard
HDPE	High Density Polypropylene
HVAC	Heating and Ventilation Air Conditioning

ICT	Information and Communications Technology
ISO	International Organization for Standardization
LDPE	Low Density Polyethylene
NABS	Natural Attenuation and Bio-Stimulation
OIOS	Office of Internal Oversight Services
PCB	Polychlorinated Biphenyls
PCC	Police Contributing Contingent
PDU	Property Disposal Unit (under Integrated Warehouse Pillar)
PET	Polyethylene
PIR	Polyisocyanurate
PKO	Peacekeeping Operation
POL	Petroleum, Oil and Lubricants
PPE	Personal Protective Equipment
PUR	Polyurethane
PVC	Polyvinyl Chloride
PX	Post Exchange (UN base retail store)
REACT	Rapid Environment and Climate Technical Project (a DOS Facility)
SDS	Safety Data Sheet
SOP	Standard Operating Procedure
SOR	Scope of Requirement
SOW	Scope of Work
SPM	Special Political Mission
TCC	Troop Contributing Country
TCLP	Toxicity Characteristic Leaching Procedure
TPH	Total Petroleum Hydrocarbon
USG	Under-Secretary-General
UN	United Nations
UNOE	UN Owned Equipment
UPS	Universal Power Supply
VOC	Volatile Organic Compounds
WMP	Waste Management Plan

WMY	Waste Management Yard
WWTP	Wastewater Treatment Plant

A. PURPOSE AND SCOPE OF THIS HANDBOOK

1. The purpose of this practical handbook is to provide comprehensive guidance, minimum standards, recommendations, and reference information for improved solid and hazardous waste management across UN Peacekeeping Operations (PKOs) and Field Based Special Political Missions (SPMs) in compliance with the Department for Operational Support (DOS) Environmental Policy for UN Peacekeeping Operations and Field Based Special Political Missions (DOS/2022.01) and the Environmental Policy for the UN Secretariat (2019). The handbook further supports and provides valid input towards achieving the objectives of the DOS Environment Strategy for Peace Operations (2017-23) [1].

2. The handbook is intended to serve as a central reference for solid and hazardous waste management. It aims to guide waste management and environmental officers, engineers, service contractors, uniformed environmental focal points, and civilian and uniformed component leadership at PKO and Field Based SPM Missions and across other UN entities.

3. After this introductory section the handbook is divided into four Chapters:

4. Chapter B addresses the general requirements for effective solid and hazardous waste management across Missions and covers:

   - Development of Waste Management Plans (WMPs)
   - Environmental Action Planning and Performance application - eAPP reporting
   - Demand Planning and Budgeting
   - Non-hazardous and hazardous materials supply and metric analyses
   - Templates for Standard Operating Procedures (SOPs)
   - Contractor Scope of Requirements (SOW/SORs) templates
   - Inspection, monitoring,
   - and verification requirements for effective waste management
   - Collaborative engagement with military and police units and provision of ‘best practice’ guidance.

5. Chapters C and D respectively focus on specific waste management topics for solid wastes and hazardous wastes. At the beginning of each Chapter a table summarizes a range of potential waste management solutions viable for different Mission waste scenarios. They include waste reduction, reuse, recycling, recovery, treatment, or disposal options. Areas covered in these Chapters include:

   - Waste definitions
   - Waste generation assessments
   - Waste minimization strategies
   - Waste segregation and storage

[1] Every effort has been made to ensure the accuracy of this Handbook. In the event of inadvertent discrepancies between the Handbook and the resolutions of the General Assembly (including, *inter alia*, its decisions on the recommendations of the Working Group on Contingent-owned Equipment, the decisions of the General Assembly will prevail.

- Identification and development of appropriate waste treatment and disposal solutions
- The use of centralized waste management yards (WMYs) employing a suite of waste management equipment (e.g. incinerators, shredders, compactors, treatment tanks, etc.).

6. Chapter E covers personnel training for a range of waste management topics and operational requirements that can be provided to UN staff or service contractors including:

   - Waste management equipment operations and maintenance
   - Hazardous waste management
   - Soil bioremediation techniques.

7. Greater detail on each specific topic is provided in the sections and sub-sections of each Chapter. This information is supplemented with links to further technical, reference and training documents found in either Microsoft Teams under PeaceOps Environment, in the Solid Waste Pillar Document Library[2], or through external online sites. Access to the Document Library is restricted to personnel across Peacekeeping Operations and Field Based Special Political Missions. If a reader cannot access a link, they are advised to contact ETSU/GSC via environmental@un.org, to request either the specific document of interest or to request, if viable, for access to the Teams Solid Waste Pillar Document Library.

8. This document will be regularly updated with new information or standards as they progress.

9. A note on nomenclature for this document: compliance with the UN Environmental Policy for PKOs and Field Based SPMs is mandatory. The following table indicates prescriptive and less prescriptive language used in this handbook:

Language	**Compliance**
Shall/shall not	Compulsory action
Should/should not	Strongly recommended action
May/may not	Discretionary/optional action

[2] The Solid Waste Pillar Document Library may be accessed here

B. GENERAL REQUIREMENTS FOR SOLID AND HAZARDOUS WASTE MANAGEMENT

B.1 THE KEY PROCESS AND FEEDBACK CYCLE

10. Improved solid and hazardous waste management across UN PKOs will require a system of well-organized infrastructure, high-quality equipment and effective waste management services either provided 'in house' by UN personnel or 'outsourced' through the engagement of external service contractors.

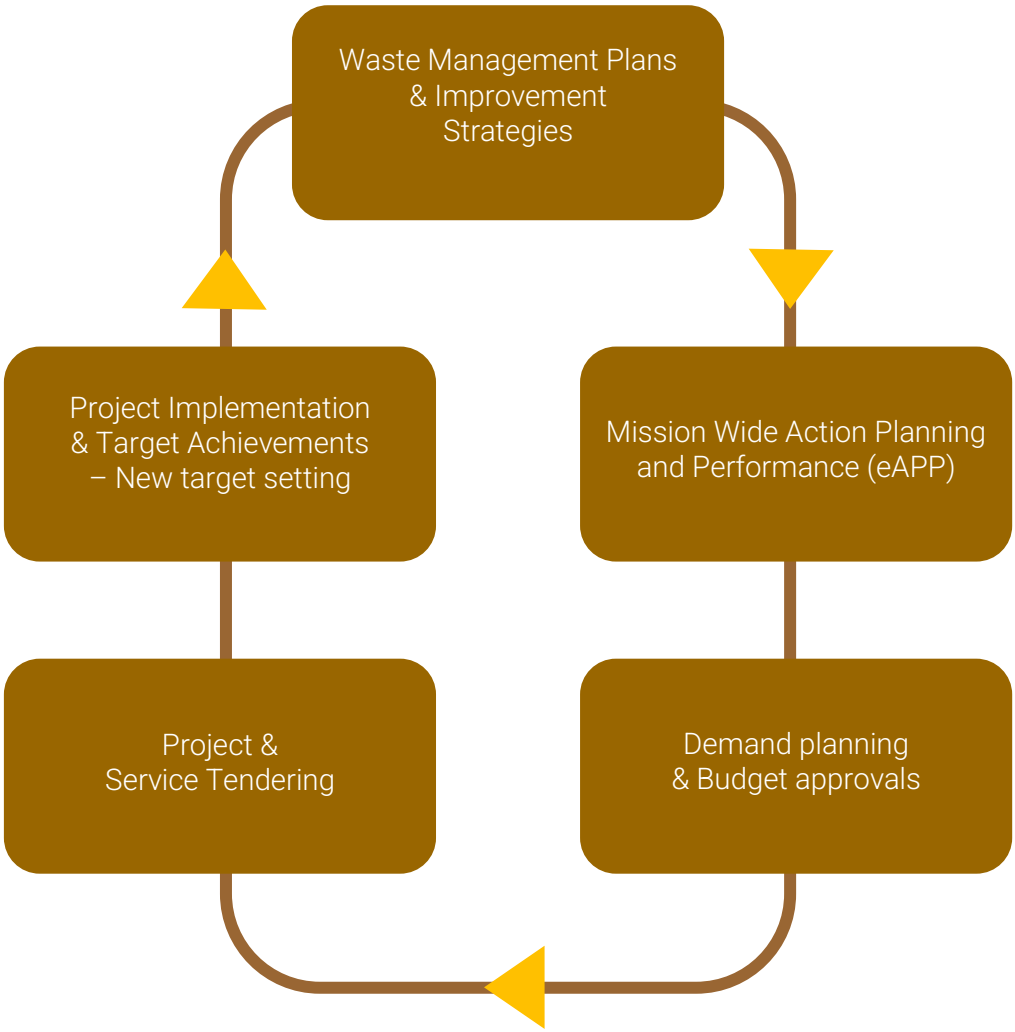
11. To support these efforts, and to provide ongoing evaluation of performance, compliance, and essential feedback for continued improvement, justified and well laid out project plans and procedures are required, along with sound data, clear documentation, and the provision of adequate financial resources assigned for waste management projects through the annual budget cycles.

12. This system flow is embodied in a hierarchical feedback cycle of five key processes (aligning with the Environmental Management System ISO 14001 – Plan, Do, Check, Act) (Figure 1) namely:

- **Waste Management Plans and Improvement Strategies** – represent the overarching Mission document that outlines the Mission strategy, objectives and targets for the achievement of improved solid and hazardous waste management in line with the performance objectives of the Environmental Policies for UN Peace Operations and UN Secretariat, the Waste Management Hierarchy and 4Rs principles (i.e. reduce, reuse, recycle, recover), as well as a comprehensive description of the Mission waste management system and procedures (see section B.2).
- **Mission Environmental Action Planning and Performance (eAPP)** – provides data on ongoing performance, compliance, progress, and risk monitoring for projects/services across the environmental pillars including solid and hazardous waste management and results in a scoring system that reflects continuing pillar improvements (see section B.3).
- **Demand Planning Cycles and Budget Approvals** – a process whereby the budget requirement and justifications (e.g. business case plans) for specific waste management projects and services in support of the WMP strategy are submitted, reviewed and considered for approval by the Mission leadership and UN financial budget committees (see section B.4).
- **Project and Service Tendering** – depending on the above budget approval process, specific waste management project and services are tendered in line with the standard Scope of Work (SOW) Statement of Requirements (SOR) templates and the UN procurement procedures, as validated by the procurement function(see section B.7).
- **Project/service implementation, Target Achievements and New Target Setting** – waste management projects and services are implemented in line with strategy improvement targets that enable potential new targets to be determined. This is supported through performance review as a check cycle of the eAPP procedure.

13. As indicated through the feedback cycle, the combination of each of the above processes represents the primary approach to bring about continued improved solid and hazardous waste management across Missions. Each process is further detailed in the following sections.

Figure 1: Hierarchical feedback cycle of the five linked mechanisms for Mission solid and hazardous waste management



B.2 MISSION WASTE MANAGEMENT PLANS AND STRATEGIES

B.2.1 Summary Description & Guidance

14. In compliance with the SOP for the Development of WMPs for UN Field Missions (2018.30) all Missions must develop a comprehensive and ambitious WMP for improved management of their solid and hazardous wastes.

15. A well-developed WMP should be considered a key strategic tool for planning and reporting all elements of waste management in a single, comprehensive, and concise document.

16. The primary aim of the WMP should be to achieve effective and sustainable 'end to end' management of solid and hazardous waste at the Mission guided by the Waste Management Hierarchy and 4Rs principles. It should:

- Identify a starting point, overall goals and the personnel involved and indicate how the Mission will reach the goals and measure and conduct feedback on a continual cycle to enable further improvements to waste management.
- Help the Mission achieve the objectives of the Environmental strategy under the waste pillar and the performance objectives of the Environmental Policies for UN Peace Operations and the UN Secretariat.
- Support the Mission's performance report on the Results-Based Budget (RBB) and the scorecard of the Mission's Environmental Action Planning and Performance (eAPP).
- Represent a key review and reference document for any environmental staff or in support of waste management audits conducted by Board of Auditors (BOA) or Office of Internal Oversight Services (OIOS) over the lifecycle of the Mission.

B.2.2 Minimum Standards & Recommendations

17. A WMP template and guidance are provided in Annex 1 of the SOP upon which the Mission WMP should be developed.

18. The WMP shall include the following minimum components:

- Summary of the waste management approach, scope, strategy, objectives, and targets of the WMP
- Legislative and policy framework
- Organizational responsibilities for waste management at the Mission
- Classification and estimation of waste materials
- Description of the waste management infrastructure currently utilized or required
- Details of the waste management procedures currently established or required
- Waste reporting, monitoring and inspections
- Provision of training
- Awareness campaigns

- Financial budgeting requirements
- Annexes to be included.

19. When developing the WMP the Mission should further consider the following:

    - That some outlined elements in the WMP template may not be relevant for a specific Mission and can be excluded. Conversely some sections may be copied directly from the guidance template into the Mission WMP.
    - The WMP should ideally be developed during the start-up phase of the Mission, be elaborated over the sustainment phase and include consideration of the final 'liquidation phase when significant amounts of waste materials will require treatment and final disposal.
    - The WMP represents a dynamic document covering both solid and hazardous waste management that requires regular updates (at least annually and for each change of phase i.e. start-up > sustainment > liquidation) to conform with any changes in the waste management approach and to detail performance improvements over time.
    - Preparation of the WMP shall be led by the Waste Management Officer (WMO) or assigned responsible person and developed in collaboration with relevant department managers.
    - The developed WMP shall be subject to independent technical review (e.g. GSC/ETSU) with the final approved version formally signed off by the Chief or Director of Mission Support (CMS/DMS.
    - Strategic actions and targets for improvement projects should be reflected in the eAPP and where resources (e.g. equipment/funds) are required for implementation these elements should be clearly outlined in the Demand Planning cycle. The latter should further include the development of supporting business cases to help gain support through the budget planning and approval cycle.

20. Finalized and signed Mission WMPs will be placed into the PeaceOps Environment section on Microsoft Teams under the Waste Management Pillar, Management Plans. This will enable comparison among Missions and may help identify relevant initiatives to be replicated.

B.2.3 Key References

21. The following documents and links provide more details and reference information:

- The SOP and guidance template for the Development of Waste Management Plans for UN Field Missions is available here.
- UN Environmental Policy for Peacekeeping Operations and Field Based Special Political Missions (DOS/2022.01) is available here.
- Environmental Policy for the UN Secretariat (2019) is available here.
- Environmental Strategy for Peace Operations (2017-2023) is available here
- Manual on Policies and Procedures concerning the Reimbursement and Control of Contingent-Owned Equipment of Troop/Police Contributors Participating in Peacekeeping Missions (A/75/121) is available here

B.3 ENVIRONMENTAL ACTION PLANNING AND PERFORMANCE (EAPP) REPORTING FOR THE SOLID WASTE PILLAR

B.3.1 Summary Description & Guidance

22. The UN Environmental Policy for PKOs and SPMs establishes reporting obligations on environmental performance and actions to improve performance. DOS has provided a methodology and a tool to support Missions in meeting the policy requirements – the Environmental Action Planning and Performance application (eAPP) – formerly the MEAP (Mission-wide Environmental Action Plan).

23. Under the Solid Waste Pillar, the eAPP requires the input of accurate and reliable data for solid waste generation and details of solid and hazardous waste management for selected indicators across Mission sites which are reported biannually for each preceding six-month period. The eAPP also provides a mechanism by which actions within the WMP may be demonstrated, leading to improved environmental performance to support the planning and budgeting process. These might include, for example, an increase in the proportion of improved disposal methods (e.g. composting, recycling and incineration) or waste minimization actions. As part of this process, specific risk indicators for landfills and solid and biomedical incinerators require responses indicating whether significant, moderate, or minimum risks are present at a particular site. Based on each Mission's performance and level of risk, a score is generated for Solid Waste Management. Finally, an overall score is calculated that includes all five pillars: Environmental Management Systems (EMS), Energy Efficiency, Water and Wastewater, and Wider Impact.

24. Ultimately, the Head of Mission (HOM) is accountable for reporting reliable information on environmental performance and the Mission must implement appropriate quality controls over the data gathering and reporting process.

B.3.2 Minimum Standards & Recommendations

25. The following minimum standards and recommendations should be considered:

- The reporting obligations are described in the UN Environmental Policy for PKO operations and SPMs (refer to Annex C of the Policy).
- Guidance for collation of performance data and improvement actions is contained within the eAPP guidance manual.

B.3.3 Key References

26. The following documents and links provide more details and reference information:

- The UN Environmental Policy for Peacekeeping Operations and Field Based Special Political Missions is available here
- The eAPP guidance manual is available here

B.4 DEMAND ACTION PLANNING AND BUDGETING FOR WASTE MANAGEMENT SOLUTIONS

B.4.1 Summary Description & Guidance

27. Demand action planning (DAP) is the primary tool through which a Mission identifies the budgetary and resource requirements for all supply, activities or interventions that will be implemented in the upcoming financial year. The tool is web-based and accessible Mission-wide for assigned users to help prepare annual Mission requirements and budgets.

28. For solid and hazardous waste management, the DAP tool is used to provide information on the physical and financial resources required to support existing supply and service contracts as well as new procurement for activities and interventions outlined in the WMPs to bring about improved waste management.

29. To support any new waste management improvement actions or interventions outlined in the Mission WMP (e.g. development of WMYs, procurement of waste management equipment or supplies, engagement of waste management service contractors) clear justifications should be prepared that adequately indicate the need. This should include information on the precise resources required for the interventions along with the expected outcomes and improvements that will result from implementation. These documents can then be made available for review to support the proposed budgetary requirements by DAP reviewers, the Advisory Committee on Administrative and Budgetary Questions (ACABQ) and ultimately the General Assembly's Fifth Committee for final approval.

B.4.2 Minimum Standards & Recommendations

30. The following minimum standards and recommendations should be considered:

- All planned interventions or actions outlined in the Mission WMP should be included in the annual DAP submissions along with any justifications or supporting documentation to support their inclusion and action.
- ETSU/REACT can assist with the development of justifications for Mission solid and hazardous waste management projects.

B.4.3 Key References

31. The following document and link provide more details and reference information:

- Supply Chain Planning Tool presentation is available here

B.5 NON-HAZARDOUS AND HAZARDOUS MATERIALS SUPPLY ANALYSES

B.5.1 Summary Description & Guidance

32. Effective and timely supply of goods and consumables is a vital requirement for Mission operations. Large amounts of materials are provided to Missions through global system and local procurement contracts that are authorised and tracked through the UN Umoja Supply system. Material supply analyses are required to ensure the provision of these goods reduces supply packaging wastes and avoids oversupply of goods and consumables that either expire or are surplus to requirements resulting in accumulated waste stockpiles. The various material supply analyses that can be conducted include:

- Identify supply materials by quantity and type that generate high amounts of waste.
- Conduct packaging analyses of selected goods to identify areas where packaging may be reduced or amended to use improved environmentally friendly materials that bring about an overall reduction in packaging waste or result in better options for recycling or disposal that can be used for future requisition exercises (e.g. SOW/SORs).
- Examine the rate of usage versus lifespan to better understand the generation of wastes via expiration of unused goods. This problem is especially evident during liquidation when stockpiles of wastes have accumulated.

- Evaluate the disaggregation of aggregated contracts to ensure that only items required by Missions can be procured, and unneeded items that must be procured as part of an aggregated package excluded.
- Examine current hazardous materials supplied to the Mission (e.g. water treatment chemicals, reagents, and pesticides) to ensure they are the most appropriate for use considering a hazard perspective regarding risk and waste management. It is expected that these analyses will result in a list of recommended products and the removal of goods not deemed suitable for supply.
- Consider the issue of security and transportation costs and how this may influence a Mission's decision to procure supplies in bulk that may result in stockpiles or expiry of goods.
- Identify supplied goods that could be contracted to include end of life takeback schemes especially where they are better recycled or reprocessed by the supplier/manufacturer.
- Evaluate the potential for improved data capture and transmission especially for remote operations as a tool to guide supply decisions.
- Assessment of full life cycle costs for critical supplies and equipment as a basis for awarding of contracts.
- Evaluate ways to improve field testing of waste equipment as part of the technical evaluation cycle.

33. These analyses should be conducted in collaboration with the Procurement and Logistics Divisions of the Office of Supply Chain Management (OSCM) and the environmental 'core team' in consultation with all Missions, as required.

B.5.2 Minimum Standards & Recommendations

34. The following minimum standards and recommendations should be considered:

- Material supply analyses are prioritized for the key supply goods that are proven to generate excessive waste or are problematic for waste treatment or disposal.
- A summary report shall be provided by the assigned coordinators for each material supply analysis for consultation before finalization.

B.5.3 Key References

35. The following documents and links provide more details and reference information:

- Mission eAPP data with authorized sign- in credentials is available here
- Analysis reports are available here

B.6 SOLID AND HAZARDOUS WASTE STANDARD OPERATING PROCEDURE TEMPLATES

B.6.1 Summary Description & Guidance

36. All Mission SOPs for solid and hazardous waste management are required to ensure operations are performed consistently and adhere to quality control standards for processes and products/equipment. SOPs should provide clear guidelines and responsibilities, and establish mechanisms, steps, and standards for the safe management of solid and hazardous wastes according to industry 'best practice', UN Environmental Policy for PKOs and SPMs, and international and national environmental laws, treaties, and regulations. The overall aim is to reduce risk and protect the health of the population and environment. In the case of differences in regulations, the most stringent requirements should prevail.

37. To assist Missions in the preparation of their SOPs the following standard templates have been developed:

- SOP 1: Solid & Biomedical (when combined in a service contract) Waste Management
- SOP 2: Managing Centralized WMYs
- SOP 3: Incinerator Operations and Maintenance
- SOP 4: Hazardous Waste Management
- SOP 5: Medical Waste Management (when not combined with SOP 1 or as part of SOP 4).

38. These template SOPs cover the main types of waste management generally encountered and managed across UN Field Missions. Each SOP may be used separately or in a combined form and are designed so that non-relevant aspects can easily be removed without compromising the overall SOP. Depending on the specific circumstances at each Mission, the template SOPs will require editing to ensure the final Mission SOPs are adapted to and represent the precise situation at the Mission, as well as complying with all relevant environmental policy and regulations. The SOP should also in summary be reflected in the SOW/SOR for any contracted waste management services to ensure compliance as covered in the following section.

39. Assistance with or response to queries relating to SOP preparation and implementation is available from the GSC ETSU/REACT waste team.

B.6.2 Minimum Standards & Recommendations

40. The following minimum standards and recommendations should be considered:

- A comparative review of current Mission SOPs and revised SOP templates should be conducted by each Mission to verify conformance and compliance with new standards. Mission SOPs that are not in conformance shall be edited and upgraded accordingly.
- Mission SOPs shall be developed for the main areas of waste management (i.e. solid, biomedical, and hazardous waste) and for specific operational

activities as required (e.g. incinerator and other equipment operations and maintenance).

- All Mission SOPs should be subject to independent technical review (e.g. GSC/ETSU) with the final approved version formally signed off by the DMS/CMS or their assigned representative.

B.6.3 Key References

41. The following documents and links provide more details and reference information:

    - The five template SOPs are available here

B.7 SOLID AND HAZARDOUS WASTE SERVICES CONTRACTS AND SCOPE OF REQUIREMENT TEMPLATES

B.7.1 Summary Description & Guidance

42. A key requirement to achieve improved solid and hazardous waste management across UN field Missions is the engagement of well-established, fully qualified, capable, and cost-effective service contractors able to provide efficient and responsible waste management, equipment, and disposal operations in accordance with industry 'best practice', UN environmental policy for PKOs and SPMs, and international and national environmental laws and regulations. To assist in this task and to help raise the standard of vendors which participate in UN business opportunities SOW/SOR templates have been developed for the following three services:

    - SOW/SOR 1: Solid and Biomedical Waste Management Services
    - SOW/SOR 2: Hazardous Waste Management Services
    - SOW/SOR 3: E-Waste Management Services.

43. The SOW/SORs have been designed following a standard, concise format that clearly describes the main general and technical requirements of the tendered contract service, outlines the technical evaluation and verification process for bidding vendors, and provides additional information and detail for 'best practice' treatment and disposal standards and equipment specifications in attached annexes.

44. The SOW/SOR templates account for a range of needs and circumstances experienced by Missions and are designed so that non-relevant aspects can easily be removed without compromising the overall SOW/SOR.

45. Assistance with or response to queries relating to SOW/SOR preparation and implementation is available from the GSC ETSU/REACT waste team.

B.7.2 Minimum Standards & Recommendations

46. The following minimum standards and recommendations should be considered for the preparation, issuance, and evaluation of waste management SOW/SORs:

- The final content of the SOW/SOR reflects accurately the specific situation and actual needs of the Mission in respect of solid or hazardous waste management.
- Request for proposals (RFPs) for waste management services and equipment supply contracts should be sufficiently advertised to ensure a widespread and optimal response from potential bidders.
- Technical evaluation of bidder proposals is conducted by qualified technical personnel understanding in detail 'best practice' methods for the specific type of waste management requested and with a thorough knowledge of the equipment specifications included in the SOW/SOR.
- Robust and accurate technical scoring should be conducted to ensure only high-quality services and equipment proceed to the commercial evaluation phase.
- Verification of selected bidder facilities, where possible, is conducted to validate that the performance capabilities and required equipment are of an adequate standard to fulfil the contract satisfactorily.
- Verification may be conducted remotely or onsite and those conducting the verification should be qualified to assess the specific technical requirements according to the solicitation requirement and may include the solicitation technical evaluators, environmental officers, engineers or identified technical experts (e.g. ETSU/REACT).

B.7.3 Key References

47. The following documents and links provide more details and reference information:

- The three SOW/SOR templates are available here

B.8 WASTE MANAGEMENT CONTRACTOR MONITORING AND VERIFICATION REQUIREMENTS

B.8.1 Summary Description & Guidance

48. The routine monitoring of contractors (and their associated facilities) engaged to provide waste management services for UN Peacekeeping Missions is an essential element to assure contractor compliance and performance. Monitoring and oversight are required to ensure that any external third-party contractor can be verified, or not, to be conducting the waste management activities for which they have been engaged in an adequate and proper manner aligned with the contract SOW/SOR and industry best management practices.

49. Unfortunately, best management practices associated with solid waste handling are not always implemented well so a level of ongoing oversight is required by the Mission to ensure that proper procedures are continually followed to avoid any harm to human health or the environment, and potential reputational risk to the Mission. Along these lines, improper management of solid and hazardous wastes has, for example, led to open burning, illicit dumping, or the release of toxic hazardous materials such as e-waste, waste petroleum, oils, and lubricants (POL), chemicals and heavy metals, causing air, ground, and water contamination.

50. Moreover, recognized recycling operations have historically been difficult to operate successfully given worldwide fluctuations of commodity prices. This may challenge contractors lacking the economic means or capacity to operate their facilities to the current best management practice standards.

51. Routine monitoring, inspections, and related contract verifications of third-party contractor sites are necessary to:

- Ensure that the Mission's waste materials (e.g. recycled items, e-waste, batteries, POL) are properly managed and all equipment is 'fit for purpose'.
- Identify and address any environmental issues that may negatively impact the contractor's operations (e.g. spills, off-site discharges, visible air emissions).
- Provide a means for the contractor to provide feedback and offer recommendations for improved operations.
- Confirm an adequate spare parts inventory (e.g. incinerator fire rope, thermocouples, etc.).
- Verify that the contractor is keeping adequate records associated with incoming and outgoing waste material volumes and other associated disposal activities, as applicable.
- Confirm conformance to existing contract requirements (e.g. SOW/SOR).
- Ensure operations are being conducted safely and with adequate overall resources (e.g. labour, utilities, etc.).

B.8.2 Minimum Standards and Recommendations

52. Certain minimum standards and actions should be considered for the completion of routine inspections and monitoring of third-party contractors engaged in Mission waste management activities including waste handling, storage, transportation, and ultimate disposal of material(s). They include:

- The responsibility for completion of the required inspections and related monitoring of UN waste management contractor operations typically lies within the Environmental Unit.
- Routine inspections of third-party contractor sites shall at a minimum be completed on a bi-annual basis in line with the eAPP cycles, or where required on a shorter timeframe. This applies particularly to new contractors that are required to demonstrate their ongoing capacity in line with the provided service. If inspections are not possible on the ground due to security constraints, arrangements should be made for a remote inspection using tools such as the Microsoft Dynamics Remote Assist application.

- Not only are visual observations by competent staff required, but it is also imperative that routine inspections of contractor sites are documented in writing. These documents may be requested for verification in BOA or OIOS audits and at minimum should include the following details:

  - Name of inspector(s), location of inspection, inspection date
  - Items being handled by the contractor
  - Issues identified
  - Recommended corrective actions
  - Photographic representation of the contractor's facility
  - Timeline for completion of necessary actions, as applicable
  - Weather conditions.

The following table provides an inspection checklist for an e-waste facility that can be adapted for any service contractor inspection:

Table 1: Example facility inspection checklist for e-waste contractor

Verification area	Resource requirements	Clarification questions
Worker health and safety	• Appropriate worker PPE • Safe working practices and training • First aid kit • Emergency spill kits • Firefighting equipment (e.g. fire extinguishers) • Emergency evacuation and response plan	• Do workers have overalls, safety boots, masks and goggles if required? • Is clear, safe and environmentally friendly working procedures and training of workers evident? • Are appropriate environmental and worker safeguards to prevent accidents in place (e.g. kits, etc.)? • Is appropriate signage in place?
Adequate equipment/ infrastructure/ documentation	• Clean and organized working areas (e.g. work benches) • Appropriate dismantling tools (e.g. screwdrivers, pliers) • Separation containers – correct segregation and labelling, • Wire stripping machine, shredder – other equipment? • A clear chain of custody for e-waste with all adequate documentation	• Is the equipment appropriate and well-maintained? • Are there enough tools/equipment for the work? • Is the e-waste appropriately segregated and identified? • Is the documentation/certification acceptable, well organized, and relevant? • Does this include all downstream material flows?
Demonstrated 'best practice' procedures	• Collection and transportation • Storage and sorting • Dismantling • Separation • Material recovery, including downstream	• Are SOPs in place for all procedures? • Are methods appropriate and do they adequately consider and reduce environmental impacts? • Does evidence of any release of materials to the 'unauthorized informal' e-waste sector exist? • Are separated materials stored correctly? • Are sub-contractors identified?
Correct handling and storage of hazardous materials	• Lithium batteries, lead-acid batteries • CRT screens • Brominated plastics • Lead, mercury, or heavy metal-containing equipment • Refrigerants (e.g. HCFCs, CFCs) • Fluorescent bulbs, lamps, capacitors	• Are the specific hazards of these materials known and adequately addressed? • Any reports of accidents with hazardous materials? • Any accumulated hazardous materials not dealt with? • Any identified bad practice leading to environmental impacts? • Are refrigerant gases stored and disposed of per 'best practice'? • Is a bulb crusher with filters used for bulb disposal?

B.8.3 Key References

53. The following documents and links provide more details and reference information:

- SOW/SOR templates are available here
- Information on contractor inspections is provided in the eAPP guidance manual which is available here

B.9 INSPECTION AND MONITORING OF UN AND CONTRACTOR WASTE FACILITIES

B.9.1 Summary Description & Guidance

54. The routine completion of environmental inspections at UN Peacekeeping Missions is an essential element of current UN environmental management procedures to ensure that civilian, uniformed and service contractor personnel operate in compliance with the UN Environmental Policy for PKOs and SPMs and Mission defined SOPs. For solid and hazardous wastes, management inspections shall be conducted across UN and contractor WMYs, waste segregation and disposal areas, as applicable. This includes Property Disposal Unit (PDU) storage and management facilities (e.g. hazardous materials), external landfill or dumpsites, all transportation unit waste handling operations (e.g. battery, POL, etc.) and the facilities and operations of all civilian, uniformed and service contractors (as above) dealing with solid and hazardous wastes.

55. While the review of operational compliance is considered their main purpose, routine inspections will also help to:

- Identify and address any equipment issues including the development of a troubleshooting plan focused on the re-operation of the equipment in a safe and efficient manner.
- Identify and address any environmental issues that may be negatively impacting the operations (e.g. spills, off-site discharges, visible air emissions).
- Provide a means for operational staff to provide feedback and offer recommendations for improved operations.
- Ensure that proper operation and maintenance activities are being completed.
- Confirm an adequate spare parts inventory.
- Ensure operations are being conducted safely and with adequate overall resources (e.g. labour, utilities, etc.).

B.9.2 Minimum Standards & Recommendations

56. The following minimum standards and actions should be considered for the completion of routine inspections and monitoring activities at UN Peacekeeping facilities:

- The responsibility for completion of the required inspections and related monitoring of UN peacekeeping waste operations typically lies within the Environmental Unit.
- Routine inspections should preferably be completed on a quarterly basis but at minimum on an annual basis, considering if the site is remote or of low headcount.
- Not only are visual observations by competent staff required, but it is also imperative that routine inspections are documented in writing and at a minimum include the following details associated with the inspection and/or monitoring of waste management operational facilities:
  - Name of inspector(s), location of inspection, inspection date
  - Issues identified
  - Recommended corrective actions
  - Timeline and responsible person/s or unit/service for completion of necessary actions, as applicable
  - Weather conditions.

B.9.3 Key References

57. The following documents and links provide more details and reference information:

- An environmental inspection template is available here

B.10 COLLABORATIVE ENGAGEMENT WITH UNIFORMED COMPONENTS AND PROVISION OF BEST PRACTICE GUIDANCE

B.10.1 Summary Description & Guidance

58. UN operating bases, including civilian and uniformed personnel generate varying amounts of solid and hazardous wastes, largely within remote and sometimes isolated areas, that must be managed properly. Overall responsibility for UN facilities is the DMS/CMS. For each uniformed operating base the commanding officer for is responsible for ensuring that proper waste management practices are implemented to successfully meet operational objectives while minimizing risk for the host community and the environment in general.

59. To support uniformed components to implement improved environmental stewardship and specifically to manage solid and hazardous wastes better, Missions should develop and provide 'environmental best practice guidelines' to TCC/PCCs in

collaboration with the Office of the Head of Military Component and the Office of the Heald of Police component.

60. For solid waste management, minimum standards and guidance should cover:

- Opportunities for waste minimization
- Correct solid waste segregation
- Options for solid waste handling, collection, and disposal
- Potential solutions for the recycling of plastics, glass, and aluminium
- Composting of organic wastes.

61. For hazardous materials and wastes, clear guidance should be provided on:

- Hazardous material and waste controls
- Adequate storage, waste inventory, and required documentation (e.g. Safety Data Sheet - SDS)
- Procedures for the repatriation of hazardous materials
- Handover of obsolete, expired, or despoiled hazardous wastes to the Mission PDU.

62. Strong engagement between Mission and uniformed component leadership is necessary to ensure that 'best practices' are both relevant and adhered to and awareness sessions are either provided directly or as part of uniformed component induction sessions. These should be monitored through regular TCC/PCC site inspections to demonstrate compliance.

63. Correct solid waste segregation at TCC/PCC sites is one of the most important actions that can be taken to improve solid waste management. As further outlined in section C.6, segregating waste at its source helps to improve the efficiency of the waste collection and handling process as waste items for recycling (e.g. plastic bottles, cardboard and paper, aluminium cans) or composting (e.g. organics) can easily be separated from other wastes that will either be incinerated or landfilled.

64. Given the remoteness of many TCC/PCC facilities, 'best practice' guidelines may often need to be adapted to reflect the specific situation such as limitations in site size, available equipment and limited local capacity.

65. An 'environmental best practice guideline' template that includes guidance on solid and hazardous waste management is available for use by Missions to develop their own guidelines.

B.10.2 Minimum Standards & Recommendations

66. The following minimum standards and recommendations should be considered:

- All Missions shall prepare 'environmental best practice guidelines' in line with the available template.

- At a minimum, the guidelines must indicate that solid wastes at TCC/PCC facilities and sites are:

  – Correctly segregated and collected by a Mission-assigned solid waste service contractor.
  – Correctly segregated and sent by military and police operating bases to an established Mission WMY for disposal/recycling as part of the Mission Waste Management system.
  – For remote sites (e.g. Forward or Temporary Operating Bases – FOB/TOBs) with capacities under 200 troops and which cannot utilise the above solutions, solid wastes should be segregated and incinerated using Mission provided barrel incinerators with induction air flow.
  – In addition, TCC/PCC facilities are encouraged to develop composting operations to manage organic wastes including food scraps, excess prepared food, etc. Cured compost can be utilized throughout the sites as a fertilizer material especially in areas where soil nutrients are scarce.
  – TCC/PCC facilities are maintaining an on-going inventory and required documentation of hazardous wastes including proper storage of these materials.

B.10.3 Key References

67. The following documents and links provide more details and reference information:

- An ‘environmental best practice guideline’ template is available here
- The United Nations Environmental Management Handbook for the Military Commanders in UN Peace Operations is available here
- Environment Good Practices 2020 is available here

C. SOLID WASTE

C.1 INTRODUCTION

68. Solid waste management is a critical operational requirement for UN field Missions which often work in fragile, conflicted affected environments with generally limited capacity and poor infrastructure. Solid wastes are generated through the supply of goods and consumables, from Mission facilities such as canteens and Post Exchange (PX) outlets and from civilian and uniformed personnel daily operations across Mission sites ranging from Main HQ and sector locations to remote FOB/TOBs). Solid wastes include:

    - Organic food waste/green cut waste
    - Plastics
    - Cardboard/Paper
    - Glass
    - Aluminium
    - Other metals
    - Wood
    - Non-hazardous construction waste
    - Undifferentiated/mixed wastes (e.g. plastic wrappers).

69. Historically, for most Missions, solid waste management has largely involved dumping at UN operated or external un-secured and non-engineered (e.g. unlined) municipal dumpsites where open burning and waste picking is prevalent, and the risk of leachate, air pollution and environmental impacts are significant. Moreover, these dumpsites are often located long distances from the source of waste generation leading to security and financial implications together with increased transport-related fuel and greenhouse gas (GHG) emissions. With landfilling or dumping of wastes also representing the lowest tier on the waste management hierarchy, the need for an improved approach for solid waste management across Missions was evident.

70. Following the launch of the DOS Environment Strategy for Field Missions in 2016 (2016-2023), on the ground technical assessments were conducted across the majority of Missions. These assessments indicated a clear requirement for a comprehensive set of workable and more efficient solid waste management solutions, and actions to be identified and implemented across Missions.

71. The key recommended solutions/actions put forward to bring about improved solid waste management include:

    - Development of Mission WMPs to outline critical steps and actions aligned with the waste management hierarchy and 4R principles (see section B.2).
    - Establishment of WMYs set up and organized around the improved use of solid waste incinerators and other appropriate high-quality waste management equipment (e.g. shredders, balers and compactors, bulb crushers, woodchippers) and sized to deal with the types and volume of solid wastes generated at specific Mission locations. Over the longer term this will enable most solid wastes to be diverted from current disposal in non-engineered landfills and dumpsites and managed in line with the performance

for the environmental policies for UN Peace Operations and Field Based Special Political Missions and the UN Secretariat (see sections B.1 and C.7).

- Development of improved material supply analyses, monitoring and stock inventory to reduce the incidence of oversupply and expiration of products (including ration supply and hazardous materials) that contribute to solid waste generation (see sections B.5 C.5).
- Implementation of accurate waste generation assessments and enhanced efforts for improved waste segregation and awareness (see sections C.4 andC.6).
- Waste reduction/minimization/reuse initiatives such as the use of water fountains and reusable bottles and the reduction of single-use plastic bottles and bags across Mission canteens, PX outlets and supermarkets (see section C.5).
- Increased recycling of plastics, aluminium and glass, expanded composting of organics and food wastes as well as interventions for waste to energy recovery for biogas (e.g. biodigestion) (see sections C.8 to C.14).
- Engaging high-quality local, regional, and international service contractors through improved SOW/SORs for solid waste management services (see sectionB.7).

72. These actions are discussed in further detail below in the sections identified. A summary table of treatment and disposal options for solid wastes is provided in the next section.

C.2 OVERVIEW TABLE OF SOLID WASTE MANAGEMENT SOLUTIONS

73. The following matrix provides an overview of a range of solid waste management solutions aligned with the minimum standards for effective waste treatment and disposal outlined in this document. The reuse, recycling, treatment, and disposal methods are further described in detail in the relevant sections.

74. The table suggests a hierarchy of solutions from Best Option to Last Resort for the most common waste streams generated in field Missions. Solutions can be grouped as Waste Minimization Solutions (Reuse, Recycling, Composting, and Biogas/Energy recovery) and Waste Disposal Solutions (Incineration, Landfilling). Controlled disposal in dumping sites remains the Last Resort for selected waste streams when no contractor/service/technology is readily available for proper treatment and disposal.

75. The table can be used as a guiding framework from which the most appropriate solutions – given the local context and capabilities of the Mission – can be selected and implemented in line with the WMP. All recommended solutions can be ‘outsourced’ to licenced contractors that meet the minimum requirements described in section B.7 when available. Furthermore, Missions are encouraged to build sufficient ‘in house’ technical capacity through implementation of WMYs, as described in section C.7, and implementation of operational and maintenance training for any waste management equipment procured at the Mission (see Chapter E.2). Incineration of combustible materials at the WMY remains one of the key strategies to guarantee safe treatment and disposal of waste, leading to considerable waste volume reductions in locations with limited local infrastructure and services for waste recycling, treatment, and disposal.

76. It is important to recognize that proper segregation (see section C.6) is key to guarantee that the selected solutions are applied effectively for any given waste stream. Waste minimization initiatives (see section C.5) will also aid in minimizing the total mass of waste needing disposal.

77. In further alignment with the UN Environmental Policy for PKOs and SPMs and the Solid Waste Risk Assessment as described in the eAPP, open pit burning and the uncontrolled disposal of untreated waste in the environment, including water bodies, is strictly prohibited.

Table 2: Matrix of waste options and restricted practices for the main solid waste streams

1	Best option
2	Second option
3	Last resort
Don't	Forbidden, high risk
NA	Not applicable: Not feasible or technically difficult

Waste Stream/Waste treatment or disposal	Re-use	Recycling	Composting or bio-digestion	Incineration	Landfill (Engineered/non-engineered)	Open dumping/open burning
Paper/Cardboard	Cardboard boxes (if clean and dry) reused to store materials or shredded and reused as filler material (packaging)	Recycled in a pulp mill or paper manufacturing facility (outsourced). Recycled into briquettes (in house)	Pre-shredded and composted/bio-digested with other biodegradable waste. Avoid bleached paper	With barrel incinerators or twin-chamber incinerators	Shredded and/or compacted before landfilling	X
Plastic	Containers washed and reused/donated, if in proper condition and with a reusable lid	Applicable to some types of plastic (produced by extrusion, moulding, etc.). Outsourced or in house		In small quantities only and depending on type of plastics	Shredded and/or compacted before landfilling	X
Biodegradable (Food, Garden waste, etc.)			Composted/bio-digested with other organic waste	Waste should be pre-dried	Ensuring other recyclables have been segregated	X
Wood	When/if generated from broken furniture/pallets and in good condition	Used as fuelwood source	Pre-shredded and composted/bio-digested only if natural wood. Cannot be applied to processed wood (e.g. plywood)	With barrel incinerators or twin-chamber incinerators	Ensuring other recyclables have been segregated before landfilling	X

Waste Stream/Waste treatment or disposal	Re-use	Recycling	Composting or bio-digestion	Incineration	Landfill (Engineered/non-engineered)	Open dumping/open burning
Glass	Containers washed and reused/donated, if in proper condition and with a reusable lid	Applicable to some types of glass, previous segregation by colour (outsourced). Crushed and used as filler material (in house)			Ensuring other recyclables have been segregated before landfilling	X
Metal (including Aluminium)	Scraps reused to repair/refurbish equipment or furniture. Some metal containers washed and reused, if in proper condition and with a reusable lid	Compacted before sold or donated to local recyclers			Shredded and/or compacted before landfilling	X
Non-hazardous construction waste	Some materials (e.g. bricks, concrete, tiles, ceramic, glass, etc). reused as filling or aggregate materials	Some materials (e.g. metals, wood/lumber, drywall, plastics, etc.) fully reprocessed at a local construction site or recycling facility			All hazardous construction materials such as asbestos removed and handled separately	X

C.3 DEFINITION OF SOLID WASTES

78. For peacekeeping operations solid wastes are defined as:

    Any non-hazardous substance, agent, effluent, object, material or equipment to be discarded, destroyed or disposed of, which has been generated through any UN field Mission operation, activity or process.

79. It is important to note that the definition of solid wastes is not limited to wastes that are physically solid. Many solid wastes are liquid or semi-solid.

80. In this chapter solid wastes are considered as wastes that are non-hazardous. Hazardous solid wastes are dealt with in Chapter C where the specific definition for this type of waste is provided. In addition, sewage sludge from wastewater treatment plants (WWTPs) is not included as a solid waste.

81. Clarification on the above waste definitions for a Mission or for a particular situation may be obtained from GSC/ETSU.

C.4 SOLID WASTE GENERATION ASSESSMENTS

C.4.1 Summary Description & Guidance

82. A key requirement to better understand and effectively plan and implement solid waste management is the gathering of accurate information on the amounts and types of waste that the Mission generates. Data on waste generation is derived through a waste assessment that can be conducted in two ways:

    1. Through the examination of waste transportation or waste payment records from the 'in house' waste management unit or 'outsourced' waste service contractor.
    2. Directly through the implementation of a waste sorting method which provides quantitative data on waste generation, waste types and composition.

83. While the first approach may be simpler to conduct, the data that it provides may be inadequate as it is often based on unrepresentative or inaccurate waste disposal estimations, and generally consists of mixed waste totals rather than specific details of waste composition.

84. In contrast, the waste sorting method is a precise approach that will provide reliable baseline quantitative data across all waste generation aspects including waste type composition and weight data, wastes diverted for recycling and composting, and overall waste disposal totals. This approach may also help identify potential waste reduction options for evaluation, possibly the most important benefit of a waste generation assessment.

85. The waste sorting method does however take time and effort and is often only viable at certain sites. The quantitative data derived from this exercise does nonetheless represent a more reliable baseline for more accurate extrapolations to other sites and can be used as a more dependable performance and comparative monitoring tool for ongoing service contractor reporting. Ultimately more reliable waste assessment

data should enable Missions to improve both the approach and cost-effectiveness of their waste management. For this reason, the waste sort method is recommended.

86. In summary the waste sort method involves:

1. Gathering one or more loads of solid waste from a selected site (e.g. HQ, military/police operating bases) at a sorting area where it is separated by type of waste into separate containers.
2. Each different waste category is then weighed using calibrated quality scales and recorded onto a daily recording sheet to build up a precise picture of the waste composition for each load.
3. To account for the daily variation in waste generation at a specific site, the exercise is repeated over a seven-day period. To determine differences across Mission locations, the method is repeated across multiple Mission sites in the same manner. Sites should be selected to represent the range of situations faced across the Mission (e.g. offices, military/police operating bases, HQ sites).
4. To account for potential seasonal variations (e.g. fruit seasons, wet/dry seasons) if relevant, the waste sort method can be repeated at different times through the year.
5. If the amounts for recycling for each waste type is known, these are recorded.
6. All data gathered through the waste sort exercise is entered onto a specific Mission Waste Assessment Template (MWAT) that automatically calculates and displays extrapolated annual waste generation, and annual waste disposal and recycling volumes by type as visual pie charts.
7. If required, an additional exercise to estimate a waste volume to weight conversion factor of mixed wastes can be conducted before commencing the waste sorting method by filling and weighing 30 (for example) random bin containers of mixed wastes. With the precise volume and weight of the containers averaged across the 30 samples, and the weight of the bins subtracted, the result may be scaled up to represent $1m^3$ indicating a volume to weight conversion factor as kg/m^3 of mixed waste.

Figure 2: Weighing of wastes for waste sort method and weighing scales

87. It should be noted that the entire process will be easier and more efficient to conduct if effective waste segregation is already practised at the Mission using a colour coded bin system, although the additional exercise indicated above may then not be possible.

88. The baseline waste generation data that will result from the waste assessment sorting method and weight to volume estimations will help the Mission to:

- Better develop, cost out and implement waste collection and disposal solutions.
- Monitor ongoing performance of 'in house' waste management or 'outsourced' waste service contractors.
- Improve eAPP waste reporting and the estimation of average per head solid waste generation figures that can be extrapolated for Mission sites for monthly and yearly periods.
- Help identify and evaluate potential waste reduction options that may include alternative purchasing practices (e.g. banning plastic bottles), recycling and composting initiatives, and whether target goals for these practices are being achieved.
- Use the weight to volume mixed waste estimates to enable more accurate visual estimation monitoring of waste vehicle load quantity using specific markers in m^3 increments on the vehicle (e.g. on the corner strut) or percentage full calculations if the vehicles floor area is known.

C.4.2 Minimum Standards & Recommendations

89. The following minimum standards and recommendations should be considered:

- Waste generation assessments should be conducted in line with the waste sort method and weight to volume estimation provided in the standard guidance note.
- All weighing scales should be high-quality, fully functional, and regularly calibrated.
- Site and seasonal variations should be considered, and repeat assessments conducted to account for them.
- It should be noted that weekly solid waste sort data for waste generation, waste disposal and recycling may be considered accurate as it is derived from direct measurements. However, as calculations for monthly and annual figures are extrapolated, they should be only considered as reliable indicators for comparison against monthly or annual contractor reported figures if ongoing measurements are taken.

C.4.3 Key References

90. The following documents and links provide details and reference information:

- A detailed guidance note outlining how to conduct a waste sort evaluation method and weight to volume estimations including required resources is available here

C.5 WASTE MINIMIZATION INITIATIVES

C.5.1 Summary Description & Guidance

91. In line with the Waste Management Hierarchy and the 4Rs principles, waste minimization or reduction is considered key to decreasing overall solid waste disposal at a Mission and the associated costs and environmental impacts. Missions receive vast quantities of goods and consumables, including food rations, through both global and local supply chains and these products generate solid wastes in the form of:

    - packaging materials
    - obsolete, despoiled, or expired goods
    - end of life equipment
    - organic food wastes.

92. While it is inevitable that solid wastes will be generated through the supply of goods and daily Mission operations, opportunities exist for interventions to be implemented at both the UNHQ/DOS level and across Missions to help reduce or minimize quantities generated. These include:

    - Reduction of packaging via improved design and the use of more environmentally friendly alternative packaging materials (see section B.5).
    - Use of takeback schemes that enable the direct removal of waste materials by the vendor or manufacturer of the goods (see section B.5).
    - Replacement of 'single use' plastic bottles, plastic bags, and Styrofoam containers at PX outlets, supermarkets and canteens with reusable water bottles, textile bags, paper bags and washable plastic food containers, along with the use of water fountains across the Mission.
    - Use of larger (e.g. 20-25L) refillable water containers for military/police units rationed water supplies.
    - Donation or direct reuse of scrap metal and wood material from construction/demolition activities.
    - Recycling of plastics, glass and paper/cardboard into different usable products (see sections C.8, 0C.12).
    - Recycling into new base materials (e.g. smelting aluminium cans into new ingots (see section C.10).
    - Diversion of organics, including food scraps, for composting or for biogas recovery (see sections C.13 and C.14).
    - Improved planning for construction projects to result in reduced wastes or use of materials that enable waste recycling or reuse.

93. Initiatives relating to improved packaging and incorporating takeback schemes into selected supply contracts are being implemented at UNHQ/DOS in collaboration with goods suppliers and units providing food rations. All other waste minimization and reuse, including recycling, composting and construction waste minimization initiatives, can be implemented by Missions across PX outlets, canteens, operational facilities and construction sites, and should be further encouraged and supported in all TCC/PCC camps through the provision of 'best practice' guidelines (see section B.10)30. Targets and timeframes for implementing specific activities should be outlined in the Mission WMP and updated on an annual basis. Further information on opportunities and procedures for recycling plastic, glass, paper/cardboard,

aluminium, and construction wastes, and composting or energy recovery from organic wastes, are provided in the following sections.

C.5.2 Minimum Standards & Recommendations

94. The following minimum standards and recommendations should be considered:

- All Missions shall implement waste minimization initiatives that include clear targets and timeframes in their WMPs.
- Reusable products should be preferred over 'single use' plastics together with the use of more easily recyclable materials such as aluminium cans.
- Where possible, collaborative community recycling initiatives should be developed to create employment opportunities and provide community benefits.

C.5.3 Key References

95. The following documents and links provide more details and reference information:

- Information on waste minimization actions and initiatives is available here

C.6 SOLID WASTE SEGREGATION, COLLECTION AND TRANSPORTATION

C.6.1 Summary Description & Guidance

96. Waste segregation is one of the most important actions a Mission can implement and maintain to improve solid waste management. Segregating waste at source helps to improve the efficiency of the waste collection and handling process as waste items for recycling (e.g. plastic bottles, cardboard and paper, aluminium cans) or composting (e.g. organics) can easily be separated from other wastes which will be incinerated or landfilled.

97. If no segregation system is in place, any segregation for recycling or composting has to be conducted from mixed wastes. This can markedly increase labour time and costs and generally results in poorer overall separation and potential recycling efficiencies.

98. While in theory waste segregation and its associated environmental benefits are considered clear, the actual success of a segregation programme is highly dependent on the awareness and 'buy in' of waste generators. This should be addressed through the ongoing implementation of a Mission-wide waste segregation awareness campaign supported with focused awareness materials and its inclusion in Mission Policy, Mission SOPs for waste management, as an activity in the SOW/SOR for Mission waste management service contracts, and in civilian,and uniformed personnel environmental inductions.

Figure 3: Segregation using colour coded and labelled bins at MINUSCA

99. An effective Mission solid waste segregation system should include the following:

- Colour coded waste bin clusters of varying sizes, ideally using corresponding colour coded bags, for offices, external disposal areas and waste collection points with clear labels for each waste type. Segregated waste is collected from all site infrastructures and placed at the central waste collection point for later removal by the waste disposal unit/contractor.
- Vehicle collection of segregated wastes from across Mission sites to the waste management sorting area (e.g. WMY) using separate waste containers or colour coded bags to maintain segregation during transport. If compactor trucks are used, colour coding is important to prevent segregated wastes becoming mixed.
- Waste segregation awareness campaigns supported by posters, signage and electronic adverting, often strengthened with a catchy buzzword slogan or phrase (e.g. ‘Use the right bin’ or ‘Demonstrate to segregate’), and quarterly reinforcement through inclusion in the environmental section of civilian and uniformed component induction presentations.
- Segregated wastes products for community use (e.g. glass jars and lids) or recycling being separated into specific containers.

100. For the collection and transportation of solid wastes, the following basic elements are required:

- A clear and well-publicized scheduling scheme should outline the time and days that segregated waste collections will be conducted.
- All vehicles used for solid waste transportation, whether UN Owned Equipment (UNOE), Contingent Owned Equipment (COE) or contractor provided, should be ‘fit for purpose’, well maintained and include appropriate safety equipment such as fire extinguishers, first aid kits and fuel/oil spill kits.
- Vehicles should use tarpaulin covers or corresponding alternatives to prevent release of waste materials during transportation.

- Safety principles shall be understood, and correct personal protective equipment (PPE) used by all operators and drivers handling or transporting solid wastes.

C.6.2 Minimum Standards & Recommendations

101. The following minimum standards and recommendations should be considered:

- All Missions shall develop and maintain a waste segregation system across UN and military/police sites.
- The colour coding segregation system does not necessarily have to follow a specific standard. Nevertheless, all bins should be clearly labelled and always placed in clusters to provide the choice for correct waste placement. Cluster bins should be relevant for the site (e.g. no biomedical waste in a non-medical environment). A recommended colour coding waste scheme is provided below:

PAPER & CARD PACKAGING ETC.	PLASTIC BOTTLES, PACKAGING ETC.	METAL, GLASS, ALUMINIUM	FOOD AND ORGANIC WASTE	BIOMEDICAL WASTE	NON-REUSABLE NON-RECYCLABLE WASTE

- A segregation system should be included as part of any solid waste service SOW/SOR for a contractor.
- Biomedical waste is included in the above graphic as biomedical waste disposal is included in the solid waste service contract on some Missions.

C.6.3 Key References

102. The following documents and links provide more details and reference information:

- DOS environmental awareness campaign materials are available here. here
- SOP templates for solid waste management (section B.6) are available here
- SOW/SOR templates for solid and biomedical waste service contracts (section B.7) are available here

C.7 CENTRALIZED WASTE MANAGEMENT YARDS

C.7.1 Summary Description & Guidance

103. Centralized WMYs are a recommended key solution to prevent solid wastes dumping at un-secured and non-engineered municipal dumpsites, where open burning and waste picking is prevalent and the risk of leachate, air pollution and environmental impacts are significant. Set up and organized around the improved use of solid waste and biomedical waste incinerators and other appropriate high-

quality waste management equipment, WMYs should be specifically sized to deal with the types and volume of solid wastes generated at different Mission locations.

104. Modularization concept designs and costings have been developed for three tiers of WMYs:

1. **Mission/Sector HQ WMYs** – these will represent the largest WMYs receiving wastes collected from a large number of sites and operating with a wide range of waste management equipment and a high storage capacity. They can be UN or contractor operated and may receive multiple tonnes (>2,000kg) of segregated solid and hazardous wastes, including biomedical waste, per day.

2. **Sub-sector medium WMYs** – these will be smaller in size and receive wastes from a limited number of sites with waste management equipment selected and sized according to the type of received wastes. They can be UN or contractor operated and may receive between 600-2,000kg of segregated solid waste per day. These sites may also receive low volumes of hazardous wastes, including biomedical wastes.

3. **Small and remote WMYs** – these will be for sites that cannot easily send their waste to the above WMYs, such as small single/multiple military/police sites or remote FOBs/TOBs. They will receive wastes from just one or two sites and provide a minimal array of waste management equipment such as small twin chamber or barrel incinerators with air induction. They can be UN operated but are more typically operated by uniformed components especially in areas with security constraints, and would normally generate less than 400kg of solid waste per day.

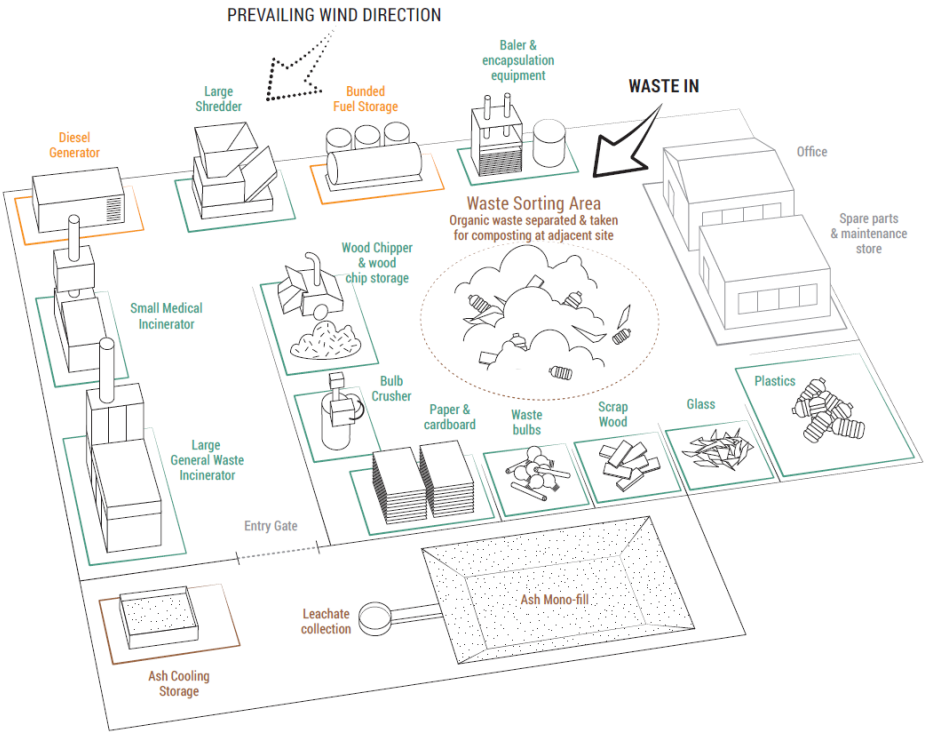


Figure 4: Schematic Mission/sector HQ waste management yard

105. The use of centralized WMYs is considered a logical approach to:

- Reduce long-term costs for the Mission through reduced transportation requirements, improved organization, and lower risk.
- Centralize waste collection and provide a means for better segregation and efficient storage of waste materials.
- Provide a suite of 'fit for purpose' waste management equipment for appropriate handling and improved disposal of non-recoverable solid and selected hazardous wastes.
- Manage compatible materials (e.g. plastics, aluminium, organics) to implement more efficient disposal, recycling or recovery through composting.
- Facilitate ease of waste transfer to disposal or recycling facilities.
- Maintain a secure operating environment with lower environmental risk.
- Improve camp aesthetics through better organization and improved waste management disposal.
- Reduce future burden associated with liquidation of the Mission through continued waste disposal during the sustainment phase.
- Minimize potential for vectors, illicit dumping, and open burning.
- With proper incineration equipment and supporting recycling operations, reduce the volume of wastes required to enter local landfill/dumpsites by up to 90 percent.
- Establish a facility that may be handed over to the government at Mission closure.
- Reduce the overall environmental footprint and GHG emissions of waste management disposal.

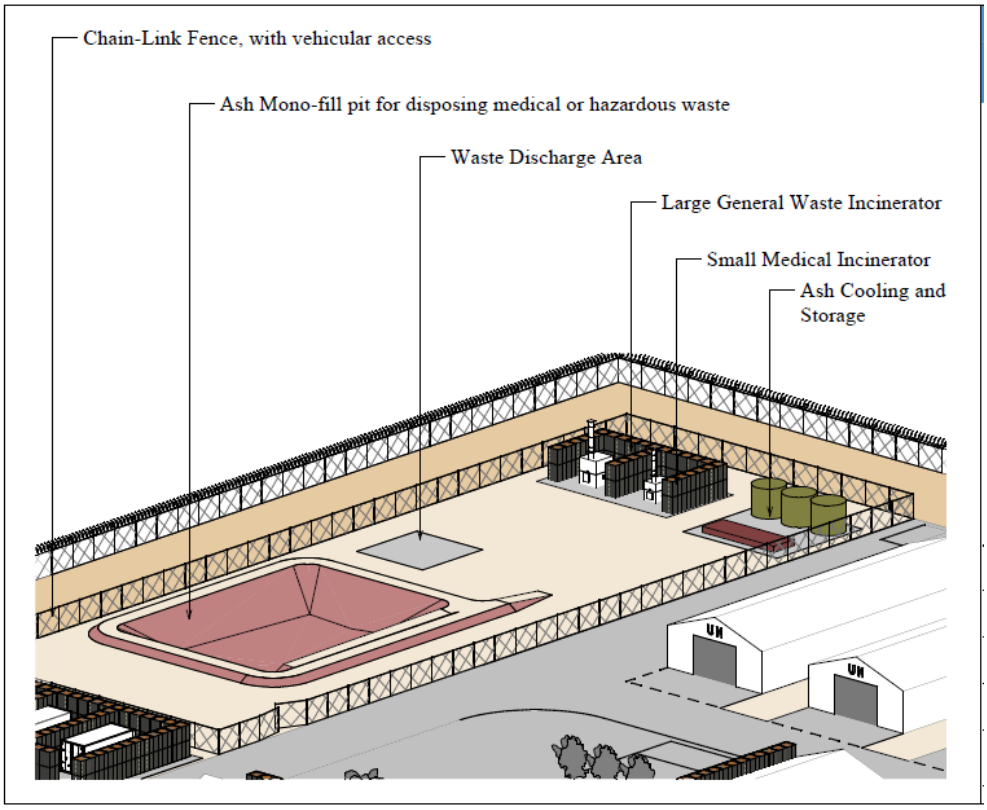


Figure 5: WMY showing incineration area and ash mono-fill

106. To determine the number and size of WMYs suitable for different sites across the Mission, an iterative criteria-based analysis should be conducted using, but not limited to, the following criteria:

- Site and type of location/camp (e.g. single, or multiple UN facilities, military/police sites)
- Head count
- Waste generation calculated at 1.5kg per person per day
- Accessibility and distance between sites
- Site resident times and known drawdown schedule.

107. In summary, criteria analysis in its simplest form can be conducted using three key steps:

Step 1: Obtain a spreadsheet of the UN Civilian and TCC/PCC force laydown divided into the various regions across the Mission on a per site basis. Sites are grouped within each region based on data sorting of the location column. An additional column is provided at the end of the sheet labelled as area group waste solution. This is where the selected waste solution for that site will be assigned at the end of the analysis and these can simply be numbered (e.g. 1, 2, 3, 4, etc.) to represent the different solutions that will be applied.

Step 2: Obtain a GIS KMZ file that can be used in Mapping Software of all the site locations across the Mission. This is then used per the criteria above to see whether sites can be grouped depending on distance and accessibility to

aggregate sites so that the selected waste solution may be scaled to serve those sites.

Step 3: For each site or identified group of sites the total number of troops/police/personnel are calculated, and this number is multiplied by 1.5kg, the estimated per person solid waste generation. This calculation will then provide a total amount of solid waste generated which will indicate which type of waste solution should be applied.

108. More details on how to conduct a criteria-based analysis are provided in a guidance document found at the link below.

109. Once the number and size of WMYs are identified, the types and sizing of equipment and infrastructure to be included at each should be determined. This may include:

- Solid and biomedical waste incinerator(s) of assorted sizes with appropriate fuel supply, including barrel incinerators with air induction
- Shredder
- Woodchipper
- Glass bulb crusher
- Baler or compactor
- Encapsulation equipment
- Waste bins/storage
- Operations office
- Electrical supply (e.g. generator)
- Waste lay down and sorting area
- Waste storage bunkers
- Hazardous ash mono-fill
- Plastic recovery equipment (e.g. extruder, injection moulder, floss machine).

110. Placement and layout of the WMY should further consider the following:

- Prevailing wind direction
- Surrounding storm water drainage flows and patterns
- Proximity and set back distances to existing camp infrastructure and sensitive features (e.g. waterbodies, local communities, runways) should be as far as possible so as not to pose risk and ensure they are not negatively affected. More details are provided in the WMY guidance document
- Ease of access
- Space required to accommodate equipment, laydown and staging areas, ash handling and disposal, and available adjacent area for aerobic or anaerobic composting of organics, as well as potential future lateral expansions
- Country security situation.

111. WMYs will normally be operated as standalone facilities under the Service Delivery Management Pillar (e.g. engineering section) but in some circumstances could be developed in collaboration with the PDU under the Supply Chain Management Pillar.

112. A PDU is meant to be an outlet for the storage of hazardous wastes and difficult to manage materials, but if space is available, it may make sense to combine all waste operations at one central location so that specific waste equipment may be shared.

C.7.2 Minimum Standards & Recommendations

113. The following minimum standards and recommendations should be considered:

- Update the Mission WMP and strategy to include WMY projects.
- Ensure justification, costings and clear rationale and reasoning on the need for the WMY investments are included in demand planning and budgeting cycles (see B.4).
- Procure waste management equipment from the Global Systems contract or via local procurement for additional equipment such as composters, plastic recycling equipment, biodigesters, etc.
- Ensure all WMYs conform to Best Available Technology (BAT) and 'best practice' standards.

C.7.3 Key References

114. The following documents and links provide more details and reference information:

- More details on development of WMYs can be found in the following document; WMYs and equipment guidance for UN field Missions available here
- SOP template for incinerator operations and maintenance (see section B.6) is available here
- A checklist for the selection of WMY sites is available here
- For waste equipment operational training (see section E.2)

C.8 INCINERATION

C.8.1 Summary Description & Guidance

115. Incinerators are key pieces of equipment in WMYs and will reduce solid waste and biomedical waste volumes by up to 90 percent if operated successfully. Good planning and operatorship, technical oversight, and sustained supportive supervision are critical to ensuring effective and safe operations.

116. Separate incinerators should ideally be utilized for managing solid wastes and biomedical wastes. This is because medical waste incinerators often require higher operating temperatures and sometimes underfloor heat retention to deal with wastes that can contain sharps and liquids (e.g. needles and used and expired pharmaceuticals). Importantly the resulting hazardous ash also needs to be treated separately.

117. In general terms, incineration uses combustion to destroy pathogens and render waste materials innocuous while reducing the waste mass and volume by more than 90 percent. Proper incineration can convert certain wastes into gases and incombustible solid residues (e.g. ash) that are relatively harmless. The incinerator should be of high-quality with a minimum of two chambers operating at an optimal temperature range of between 850-1,100°C. The first chamber combusts the solids while the second chamber combusts the gases with a minimum two second retention time to result in lower and cleaner levels of atmospheric emissions.

118. Barrel incinerators with air induction have only one chamber but due to the forced air cycle burn small volumes of mixed solid wastes very effectively. This type of incinerator is used primarily for remote temporary or forward operating bases (TOBs/FOBs) with head counts less than 200. Barrel incinerators may be used for for possible virus infected wastes (e.g. COVID-19) such as PPE and surgical gowns.

Figure 6: Solid waste, biomedical and barrel incinerator with air induction

Incinerator installation

119. It is important that all incinerators be installed properly taking into account electrical connection(s), supplemental fuel storage proximity and connections, and protection from the elements, including roofing or containerization. In the absence of containerization, a concrete floor should be installed beneath the incinerator.

120. Furthermore, is it important that incinerators are placed in areas that can be secured within a locked fence, ideally within the WMY, and in a location that considers emission pathways associated with internal and external receptors such as workers and surrounding communities.

121. A key aspect associated with proper operation and maintenance of an incinerator is access to spare parts, as well as PPE and first aid supplies. Minimum spare parts should include a spare air induction fan, fire rope, high-temperature mastic, a spare burner, and a thermocouple. PPE supplies should include fire resistant gloves and aprons, dust masks and eye shields. It is also important to maintain a working and duplicate stored copy of the incinerator operating manual.

122. The stack height of an incinerator must extend to 4 meters for smaller units (except barrel incinerators) and up to 12 meters for large units so that stack emissions do not reach operators or others in the immediate proximity. Any incinerator selected should be purchased complete with sufficient consumables (e.g. fuel filters, burner nozzles, etc.) and replacement parts (e.g. grates, refractory liners, temperatures sensors, etc.) to ensure operation of the incinerator for its planned life cycle (e.g. 10 years).

Incinerator Feedstocks

123. The use of proper feedstocks is essential to ensure the incineration burn cycle is conducted effectively. This includes the ability for the unit to reach critical operating temperatures while ensuring that air emissions are minimized.

124. Proper feedstocks include a mix of solid waste materials that contain items with high British thermal unit (BTU) values such as paper and cardboard. If organic (food) waste is to be incinerated, it is recommended that this material is at least partially dried under the sun before being incinerated. Supplementary fuels such as diesel fuel are delivered through an injection system to ensure that proper operating temperatures are achieved. Other materials such as (one or two) oil filters are also acceptable, and plastic materials should comprise no more than 15-25 percent of the total feedstock load due to the high caloric value of plastics and potential damage to the refractory lining if higher volumes are incinerated. Inclusion of glass and ceramics should be avoided although medical incinerators are often required to incinerate glass vaccines and reagent vials.

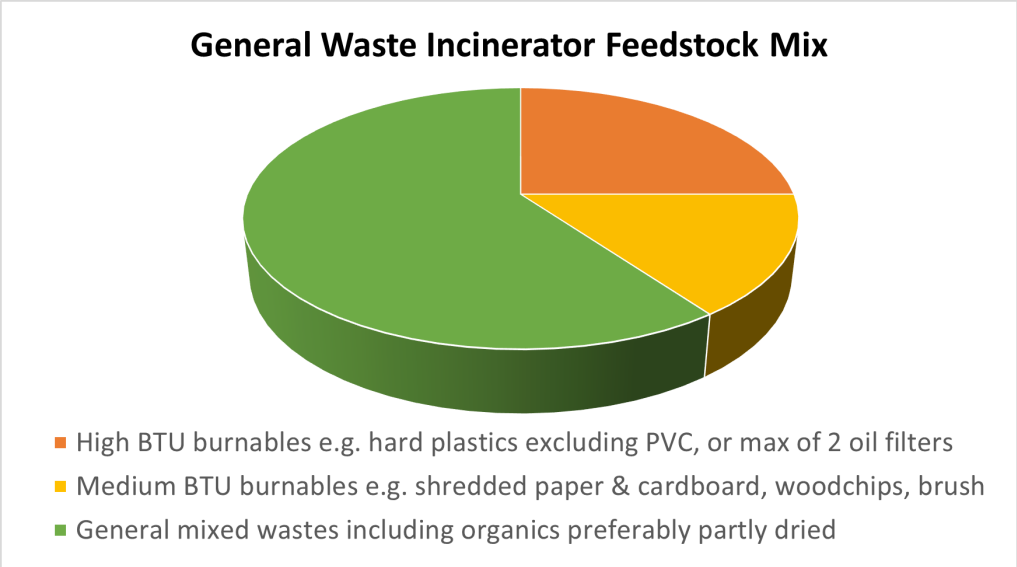


Figure 7: Proportions of solid waste feedstock for incineration

Incinerator Operations

125. To ensure effective incineration of waste materials and safe and optimal performance, it is critical to operate the incinerator correctly, and comprehensive training of operators is required before conducting incineration operations (section E.2.1.1). Furthermore, some incinerators may require initial curing of the refractory materials in the incinerator following a step-by-step system of increasing the temperature over specific periods until the curing process is complete. If this is not completed precisely in line with the instruction manual, extensive cracking of the refractory material may occur. This reduces the ability of the incinerator to retain heat during the burn cycle and reduces the unit's useful life.

126. The key steps below should be followed by operators for each incineration cycle:

1. Wear correct PPE for the task at hand.
2. Ensure diesel fuel is available for operating the incinerator and that the waste to be incinerated is relatively dry.
3. Ensure the incinerator is clean and inspect the unit to identify any faults or issues with the various components.
4. Before placing feedstock in the incinerator, conduct a pre-burn cycle to heat the refractory bricks and bring the incinerator to the lower optimal temperature. This is achieved by running both the primary and secondary burners for a minimum of 30 minutes.
5. After this time the primary burner may be turned off, the incinerator opened, and the correctly prepared well-balanced feedstock placed into the unit taking care to not fill to more than 60 percent of the total first chamber capacity.
6. The door of the incinerator is then closed, and the primary burner restarted to begin the full incineration cycle and achieve optimal incineration temperatures of 850-1100°C. For large WMYs, incineration cycles may extend for up to six hours with multiple batches of waste being fed into the incinerator at 15-40-minute intervals, depending on the type of wastes being incinerated.
7. Any batch feeding of waste material through the cycle should be conducted in line with the manufacturer's instructions, but generally this will entail opening the door, placing batch feedstock quickly into the unit, and shutting the door as soon as possible. It should be noted that opening the door will result in some heat loss and disturbance of gas flow through the second chamber which may result in less optimal emissions. For large units an automated batch feeding system should be considered which uses a ram mechanism. This is more effective in retaining heat inside the incinerator and causes less gas flow disruption. Routine cleaning and maintenance of the ram is essential to ensure effective and efficient operation.
8. After every incinerator cycle, ash and other residues should be removed from the main chamber as well as any obstruction that may block the free passage of air.

Emissions Controls

127. Emissions should be continually monitored to ensure they meet the highest UN standards at least similar to European Union (EU) emission standards. Generally, the smoke should be clear and invisible. Black smoke indicates either poor combustion or that oily materials are being incinerated. In the former case, the airflow fans should be increased to provide more oxygen to the burn cycle. White smoke indicates high moisture content and ideally feedstocks should have no more than 15 percent moisture content and if higher, should be dried before incineration. Removing organics for composting rather than incineration can markedly improve incineration of solid wastes. A 5 percent emission opacity is ideal, indicating an efficient burn cycle of solid wastes.

Figure 8: Emission opacity indicating ideal or problematic incineration efficiency

128. To better guarantee acceptable emissions pollution control, systems can include wet scrubbers, ceramic filters, and lime dosing to reduce potential for dioxin and furan formation. Emissions can be tested using manufacturer recommended kits to determine whether they comply with international standards. UNGSC/ETSU can provide technical support to assess the level of air emissions if required.

Ash Management

129. Solid waste ash is considered non-hazardous and can be disposed of at local landfill/dumpsites. Ash resulting from biomedical or other incinerable hazardous wastes is however considered hazardous and requires disposal either through concrete encapsulation followed by landfilling, or in a small, engineered ash mono-fill pit (see section D.5.19). An ash mono-fill pit can be constructed adjacent to the incineration area with ash placed into the pit once it has cooled in an intermediate ash cooling container. It should be lined with a high-density polyethylene (HDPE) liner that is weld sealed, and in areas with high rainfall it should ideally be roofed and include a leachate catchment system. When the pit is either full or its use discontinued, it should be capped to ensure its integrity is maintained. Both the siting and the closure of any ash mono-fill pit should be conducted in agreement with national government authorities and regulations.

C.8.2 Minimum Standards & Recommendations

130. The following minimum standards and recommendations should be considered:

- Only commercial quality ‘fit for purpose’ twin chamber or barrel incinerators with air induction shall be used for solid waste incineration and may be obtained from the Global Systems contract for Waste Management Equipment.
- Specific biomedical incinerators shall be used for biomedical waste incineration and may be obtained from the Global Systems contract for Medical Equipment.
- An SOP for incinerator operations and maintenance shall be developed by the Mission (see section B.6).
- Incinerator operations should only be conducted by UN staff, TCC/PCC personnel or service contractors trained and certified for these operations (see section E.2.1.1).

- A daily incineration log shall be kept for all UNOE and contingent owned equipment (COE) incinerators indicating total waste loads, minimum and maximum temperatures, and total operation time for waste incineration.
- Daily inspections and maintenance checks shall be conducted by operators of both UNOE and COE equipment, and adequate spare parts shall be procured in line with the manufacturer's instructions.
- Inspections of incineration equipment shall be conducted by the Environmental Unit at least annually to assess operational performance and compliance with Mission incineration standards.
- Emissions testing shall be conducted at least once every two years using approved testing equipment.

C.8.3 Key References

131. The following documents and links provide more details and reference information:

- An SOP template for incinerator operations and maintenance is available here
- An incinerator daily operation and inspection checklist is available here
- An incinerator operator guideline template is available here
- EU emission standards for incineration are available here

C.9 PLASTIC RECYCLING

C.9.1 Summary Description & Guidance

132. Plastics are generated at Missions in the form of single use bottles, packaging and containers, and moulded objects. These items tend to be either HDPE, polyethylene terephthalate (PET/PETE), and to a lesser extent polystyrene. Most waste plastic is a mix of these varying types of plastics and may not be recyclable on that basis. It often includes thin wraps of low-density polyethylene (LDPE) or other composite packaging for snacks.

133. Segregation of all the different types of plastics (by the recognized universal numbering system 1-7 as shown in Figure 9) allows for efficiencies in the recycling of these materials.

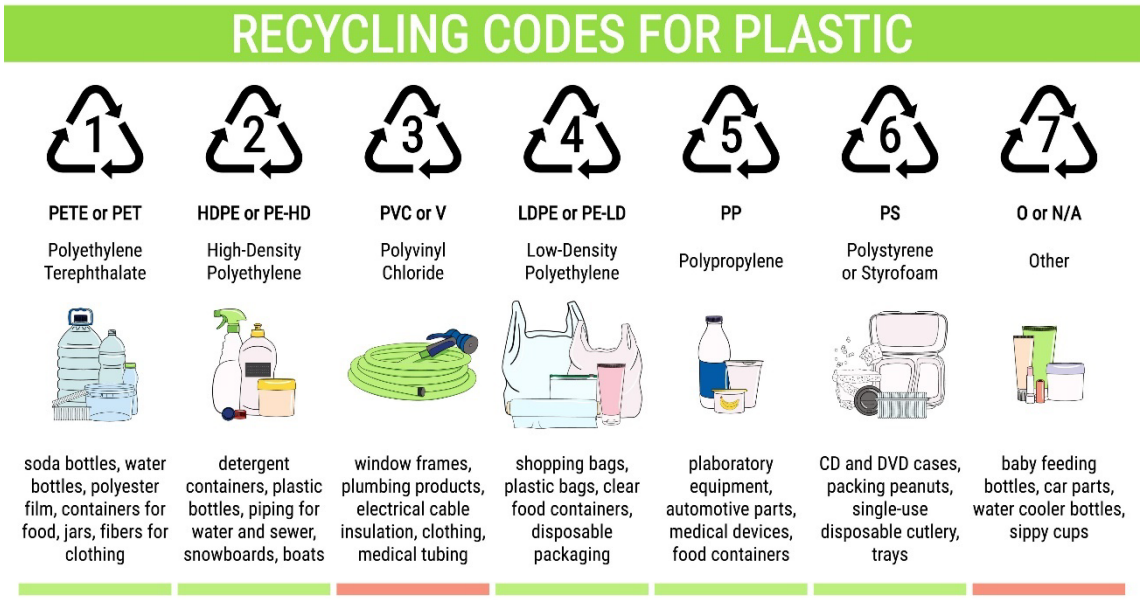


Figure 9: Universal plastic coding system

134. Recycling of plastics is considered a key element of the Environmental Strategy and a means to avoid unnecessary disposal in landfill or open dumpsites or through incineration, especially when such items have the potential to be converted into useable products.

135. Open burning of plastic waste, especially for chlorinated plastics including polyvinyl chloride (PVC) which releases known carcinogens, including dioxin and furan compounds, shall be avoided under any circumstance.

136. Options available for waste plastic recycling include:

- Distribution of the plastics to a contractor or local community group/enterprise or non-governmental organisation (NGO) operating a recycling process or network.
- 'In house' recycling of plastics to produce usable products (e.g. plastic bricks or tiles).
- Provision of UNOE recycling equipment and support to a local community group/enterprise or NGO to conduct plastic recycling.

137. To be considered successful, an endpoint solution for waste plastics is required. Consequently, waste plastic cannot simply be sent onward within the system to be disposed of elsewhere, but a sustainable recovery solution is required.

138. Missions are encouraged to identify possible local recycling centres and/or contractors, or to engage with community groups that can pass on accumulated plastics to recyclers or conduct artisanal recycling themselves. The latter process would need to be demonstrated before any provision. If no direct or community outlets are available locally, waste plastic recycling could be organized 'in house'. In any case, the following proven technologies could be involved:

- Heated reformation (e.g. extrusion)
- Heated and compressed moulding
- PET flossing using spinning machines
- 3D printing using recyclable plastics.

139. Products that may be produced from such technologies include:

- Plastic bricks and beams and roof tiles for construction
- Compressed plastic sheeting that can be cut and formed into various objects
- Small mouldable objects such as key tags, cups, and craft items
- Floss stuffing and insulation materials for bedding, pillows, weaving textiles, or wall and roof insulation.

Figure 10: Plastic recycled bricks and beams (Source: Precious Plastics)

Figure 11: Range of recycled plastic products

Figure 12: PET and PP flossing machines

140. Missions considering 'in house' recycling are encouraged to conduct small pilot studies to demonstrate viability before upscaling and producing a guidance document which provides detailed information regarding each material recovery option (see link below).

C.9.2 Minimum Standards & Recommendations

141. The following minimum standards and recommendations should be considered:

- Valid assessments should be conducted to ensure that the capacity of contractors and community groups is sufficient, that repurposed items and materials are fit for proper reuse, and that there is an endpoint demand for such materials.
- Sorting of plastics should conform to the existing conventional and universal numbering system (e.g. categories 1-7).
- Recyclable plastics are limited to HDPE, PET, LDPE and polypropylene (PP).

- No recycling of PVC or styrofoam is to be conducted when heat is required, but some other re-purposing may be viable. Otherwise, these materials should be shredded and landfilled.
- Measures and safe practices such as passive or active venting (e.g. fume extractors) as well as the use of proper PPE such as correctly rated fume masks must be put in place to ensure operations and fumes associated with the recovery or reprocessing of waste plastics do not cause adverse impacts to human health and/or the environment.
- Pilot projects are conducted before scaling up.
- All plastic recycling initiatives should be clearly outlined in the Mission WMP.

C.9.3 Key References

142. The following documents and links provide more details and reference information:

- Details of recycling technologies are outlined in the guidance document Waste Plastic Recovery Feasibility Study that is available here
- Information on Precious plastics an open-source plastic recycling and education platform is available here

C.10 ALUMINIUM RECYCLING

C.10.1 Summary Description & Guidance

143. Given its ability to be reused/reprocessed repeatedly, aluminium is an ideal recycling commodity when compared with plastic and glass. Aluminium is versatile, lightweight, highly flexible, extremely resistant to corrosion, and can easily be cast, machined, bent, welded, tapered, and alloyed. For these reasons all aluminium generated across a Mission, primarily in the form of aluminium drink cans, should be prepared for recycling rather than being disposed at landfill. It will readily be taken by scrap metal contractors to be smelted into aluminium ingots and may represent an important revenue generator to the Mission.

144. To better prepare for recycling and improve storage and transport efficiencies, WMYs should be set up to reduce volumes of aluminium before transfer to a recycling centre or scrap metal contractor. Aluminium, especially in the form of drink cans, can easily be compacted in a compactor/baling machine or shredded to reduce volumes (Figure13) for placement in containers (e.g. drums).

Figure 13: Compacted, baled, and shredded aluminium cans

C.10.2Minimum Standards & Recommendations

145. The following minimum standards and recommendations should be considered:

- Volume reduction should be conducted before storage and/or off-site transportation.
- The product is an ideal reverse logistics material to main cities/ports where viable markets may be more common.

C.10.3 Key References

146. The following documents and links provide more details and reference information:

- Information on aluminium recycling is available here

C.11 GLASS RECYCLING

C.11.1 Summary Description & Guidance

147. Unlike plastic or aluminium, local glass recycling outlets may be less available in Mission areas.

148. Challenges associated with glass recycling include:

- The amount of energy required to turn glass into a molten material.
- The variability of glass bottle/jar colour (e.g. green, brown, clear) which if not separated, will be rejected for reuse.
- Manufacturers are generally able to produce new bottles/jars more economically using virgin sand.
- Glass is relatively heavy so the costs for transporting whole or even crushed glass are high, especially in Africa, for example.
- Heat-resistant glass, such as Pyrex or borosilicate glass, must not be part of the glass recycling stream, because even a small piece of such material will alter the viscosity of the fluid in the furnace at remelt.

149. Considering the challenges associated with glass recycling, Missions are encouraged to:

- Exchange supply of glass bottle products for more easily recycled products such as aluminium cans, or only supply bottle products that are collected and reused by vendors.
- Work with communities to organize donation of glass jars with lids as these are often sought after for storage containers.
- Investigate community use of glass products for art and craft opportunities.
- Procure a glass crusher to produce glass aggregate for recycling in road or concrete construction, or in the worst case, to transport for landfill disposal.

Figure 14: Reusable bottles and crushed glass for aggregate

C.11.2Minimum Standards & Recommendations

150. The following minimum standards and recommendations should be considered:

- Initiatives for minimal use of glass bottles and jars should be implemented across Missions except where a takeback and reuse scheme are in place with a vendor.
- Glass crushing operations should be conducted with care with operators using appropriate PPE including eyeglasses.

C.11.3 Key References

151. The following documents and links provide more details and reference information:

Information on glass recycling is available here

C.12 PAPER/CARDBOARD REUSE AND RECYCLING

C.12.1 Summary Description & Guidance

152. Paper and cardboard are generated in large quantities across Missions in the form of supply packaging and office and operational documentation. As part of the Mission solid waste segregation programme, paper and cardboard products should be separated and made available for:

- Use as a balance feedstock for solid waste incineration.
- Following shredding, use as a proportional bulk material for aerobic composting.
- Following shredding, use as packing materials.
- Recycling to produce new cardboard materials (only limited usage viable).
- Recycling into briquettes used as an alternative fuel source for local communities or at military/police FOB/TOBs.
- Disposal at approved landfill/dumpsites.

153. While incineration and composting may consume a proportion of generated cardboard/paper, a surplus is likely which could be used for recycling or the production of briquettes rather than disposed at landfill.

154. Cardboard and paper can only be recycled a limited number of times (due to fibre degradation) to produce new cardboard for boxes, packaging materials or egg trays, for example, and such recycling initiatives are currently limited across Missions. More efforts are required to improve these recycling opportunities, along with the production of briquettes for use as an alternative fuel source.

155. To improve these efforts, Missions should actively search for any paper/cardboard recyclers in their area or consider whether recycling or briquetting could be achieved in collaboration with local community groups.

156. As part of the Global Systems contract for waste management equipment, compactors and balers and shredders are available. Before dispatch to a recycling or pulping facility, or removal by a recycling contractor or community group, cardboard (and paper) should be compacted and baled into blocks for ease of stacking and transportation.

Figure 15: Compactor and baler for cardboard and paper

157. Briquetting of cardboard and paper for use as an alternative fuel source is essentially a densification process involving shredded cardboard, paper, and other

additional fibrous material such as sawdust being mixed with water into a paste and converted through applied pressure into convenient and transportable solid fuel blocks. While hand presses are available in the market, the process is considered very labour intensive, and it is therefore recommended that a Mission considering briquetting should procure an automated briquette maker. These small-scale commercial units produce a high-quality briquette following a specific recipe that will burn with a higher heat over a longer period. Processed briquettes can be provided to local community groups or sent as a fuel source for military/police FOB/TOBs. A summary guideline on briquetting is available with the link provided below in references.

Figure 16: An automated briquette machine and produced briquettes

C.12.2Minimum Standards & Recommendations

158. The following minimum standards and recommendations should be considered:

- Active efforts should be made to identify capable paper and cardboard recyclers.
- Compacted and baled cardboard allows more organized storage and efficient transport.
- Due to the uncertainty associated with inks and glues, generated briquettes are NOT intended to serve as a fuel source for direct cooking of food but rather for indirect cooking through the heating of pots and pans. In addition, briquettes should only be burned in well-ventilated areas, and preferably outdoors, to reduce the risk of toxic fumes being inhaled.

C.12.3 Key References

159. The following documents and links provide more details and reference information:

- A short summary on briquette production at Missions is available here

C.13 AEROBIC COMPOSTING

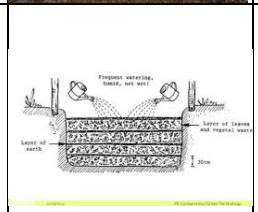
C.13.1 Summary Description & Guidance

160. Organic wastes are generated from canteens, PX outlets, accommodation units and as part of daily camp cleaning and vegetation control. Generally, along with other decomposable materials such as paper and cardboard, they account for approximately 35-45 percent of the solid waste volume. Missions are strongly encouraged to segregate organic wastes and engage in aerobic composting, a simple and cost-effective approach that helps reduce GHG emissions (e.g. methane) through diversion of organics from incineration or disposal at landfill. Composting is a managed process that uses oxygen and heat to accelerate the biological decay of organic material by microorganisms to produce a valuable source of fertilizer in the form of humus or compost. Curing is the final stage in the process. It brings the compost humus to maturity and allows complete degradation of residual pathogens.

Figure 17: The composting cycle

161. Aerobic composting may be implemented at various scales, levels of complexity and cost using the technologies outlined in Table 3. Estimated costs exclude labour and peripheral equipment but may vary markedly depending on the scale of the operations. Planning support can be provided by GSC/ETSU if required.

Table 3: Composting methods

Composting Technique	Example Method	Level of complexity/range of use	Set-up cost excluding labour and peripheral equipment (USD)
Composting bins of varying sizes and designs		**Simple bin system** with manual turnover in a regular cycle, 10-14 weeks followed by curing once removed. Can use homemade, flat pack or plastic bins with lids to prevent vermin	10,000-15,000
Composting pits		**Simple excavated pit system** with layers of organics intermittently covered in soil. Requires frequent watering as open to elements. Can be covered with a tarpaulin or fine grill mesh to prevent vermin. 12 weeks followed by curing	10,000
Basic Windrows		**Managed system** that can be scaled up. Manual turning, mechanised windrow turner or use of plant machinery (e.g. bobcat). Should be covered in tarpaulin to retain moisture and reduce vermin. Actively managed. 12 weeks followed by curing	10,000-80,000 (large scale systems)
Aerated Windrows		**Managed system** roofed and brick-built windrow with active aeration. Minimal turning and cured in-situ. 8-12 weeks followed by curing	30,000-120,000 depending on size
Containerized Auger system		**Mechanised auger system** for effective turning of compost material. Can be bought off the shelf with aeration and watering controls, or be hand-made (e.g. UNAMI). 6-10 weeks followed by curing	40,000-170,000 depending on home-made or off the shelf
Advance enclosed systems		**Automated composters** including aeration and temperature controls. Sized according to organic generation. Shorter timeframe and once initial maturation (approx. 6 weeks) has passed will discharge small amounts of compost daily.	15,000-120,000 depending on size and make

162. The basic requirements for the composting process include:

- The input of a balanced organic or compostable feedstock that may include food scraps, vegetable and fruit waste, shredded paper and cardboard, green garden wastes and bulking agents such as woodchips or sawdust.
- A carbon to nitrogen ratio of approximately 25-30:1. A good C/N ratio can be achieved by ensuring a well-balanced mix of clean organics and bulk materials as outlined above.
- Regular mixing of the pile to ensure sufficient aeration of the decaying material.
- A minimum moisture content of 40 percent.
- System to prevent vermin (e.g. lids, covers).
- A final curing process to bring the compost to full maturation and ensure all phytotoxic compounds are removed.
- Sorting, bagging and provision of the compost product.

C.13.2 Minimum Standards & Recommendations

163. The following minimum standards and recommendations should be considered:

- Fish and meat wastes should generally not be used as feedstock as they can easily unbalance the C/N ratio and increase odours attracting vermin.
- Composting must be actively managed to ensure decaying material has the correct C/N ratio, aeration, moisture, and temperature to optimize the process in the shortest time.
- All contaminants such as plastics and metals must be removed from the feedstock to ensure a high-quality end-product.
- Curing is an important final stage.

C.13.3 Key References

164. The following documents and links provide more details and reference information:

- More details on aerobic composting is provided in the guideline 'Composting in UN field operations' available here

C.14 WASTE TO ENERGY RECOVERY

C.14.1 Summary Description & Guidance

165. As an alternative to aerobic composting, organic wastes can undergo anaerobic digestion to recover biogas that can be used as an alternative fuel source for cooking or electricity generation. In anaerobic digestion (a process that occurs in the absence of oxygen) biogas (which is 60 percent methane) is produced. However, depending on the scale and design of the biodigestion system employed, biogas characteristics can vary greatly in quality and quantity.

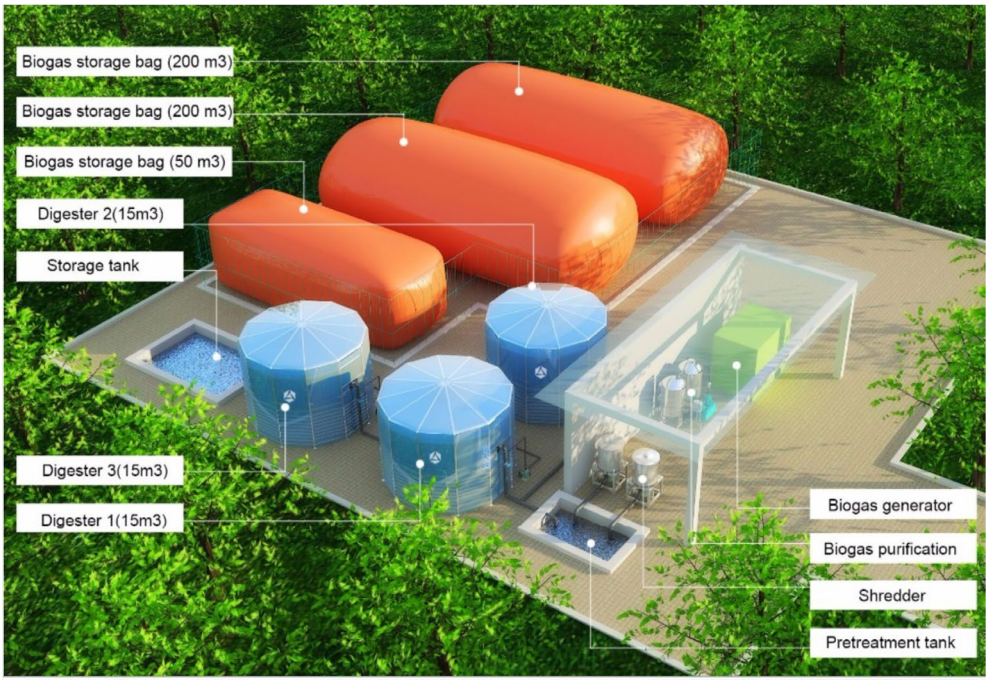


Figure 18: Examples of small to large scale biogas recovery systems

166. Impurities that are present in biogas must first be cleaned to achieve optimum operation and performance in machinery and equipment such as boilers, turbines, engines or cooking stoves. This cleaning is not only done for safety but also to extend the life of the equipment through the removal of water and potential humidity.

167. Use of biodigestion across UN field Missions is currently at an early stage and is envisaged to primarily use organic food wastes in small to medium size systems associated with remote sites or linked directly to canteen kitchens. As these systems are developed and demonstrated, in the future other organic inputs could be used

such as wastewater and sludges from wastewater operations and kitchen grease traps.

168. The primary use for biogas at Missions is expected to be as a cooking fuel, but it could also, either due to a surplus being generated, or if there is a specific need, be used in dedicated biogas generators to produce electricity. In addition, the process also produces a liquid effluent that can be used as a fertilizer.

169. Another benefit of biodigestion systems is the biogas offset for the use of conventional fuels resulting in cost savings and associated reduction in GHG emissions.

170. A guideline on the feasibility of biodigestion for UN field Missions has been developed that provides extensive details on the process and available systems and identifies a range of pilot operations at various scales that could be implemented across Mission locations. The guideline includes a biogas production model (Excel) as an appendix. This can be used to size and cost the best suited system for a particular situation based on the per person organic generation, along with other relevant parameters. This document is provided in the link below.

C.14.2 Minimum Standards & Recommendations

171. The following minimum standards and recommendations should be considered:

- Planned biodigestion projects should be fully elaborated in a project design and implementation plan that includes a specific biogas production model.
- All cooking and electrical generation equipment must be specifically designed for the use of biogas to ensure operational efficiency and safe utilisation.
- Technical advice in the planning of Mission biodigestion projects is available from ETSU/GSC and REACT.

C.14.3 Key References

172. The following documents and links provide more details and reference information:

- More details on the potential for biogas recovery is provided in the guideline 'Biogas Utilization Feasibility Study' is available here
- A biogas model to support the above study is available here

C.15 NON-HAZARDOUS CONSTRUCTION WASTES

C.15.1 Summary Description & Guidance

173. Construction wastes are normally generated directly from the materials used for new construction or renovations to an existing building, or because of demolition activities. Construction wastes can include a wide range of non-hazardous materials but may also include hazardous wastes such as asbestos, mercury switches, asphalt/bitumen, and lead paint debris. Hazardous construction wastes are addressed in various sections of Chapter A and specifically in section D.5.20. This section will only cover the main non-hazardous construction wastes. They include:

- Cement block/brick/concrete debris
- Prefabricated panels
- Metal materials (ferrous and non-ferrous)
- Wood (including pressure treated lumber)
- Drywall panels/offcuts
- Ceramic/vinyl tiles
- Glass (e.g. windows)
- Plastics (e.g. piping, ducting, electrical wiring, roofing materials)
- Porcelain toilets and sinks
- Soils (non-hazardous/contaminated)
- Tree/plant debris.

Cement block/brick concrete debris

174. Where possible, demolition of block/brick walls should be done in a way that enables reuse of the block/brick material for new construction purposes. Where this is not possible, the generated debris should be considered useful as filling material for ground works or, if validated by a civil engineer to be of satisfactory constructional integrity, useful as primary aggregate materials for new build footings or under poured concrete platforms and floors, for example. This material may also be useful for local community construction projects and can be donated and transported to areas where it is needed. This type of material is considered inert and non-flammable and if not reused can be disposed at landfills or dumpsites.

Prefabricated panels

175. Prefabricated metal face panels containing insulating foam are used extensively across UN Missions as wall and roof construction materials for modular designed offices, hospitals, living quarter accommodations and other working areas. Whereas older prefabricated panels manufactured before 2004 may have used Ozone Depleting Substances (ODS) in the blowing agents of the foam insulation, panels produced after this date were primarily fabricated using foam insulation made from polyurethane (PUR) and polyisocyanurate (PIR) which does not contain any ODS and are classified as non-hazardous.

176. If the prefabs have been procured through the current Global Systems contract, they include PIR insulation and will be easier to deal with due to the lack of ODS materials. If prefab panels are known to be manufactured before 2004, or if they have been procured from the local market, checks should be conducted to ascertain whether they may contain ODS agents.

177. For post-2004 panels, all panels should have clear markings on the tape at the panel/panel joint and/or ultraviolet (UV) marking on the face. This gives information about the manufacturer, date, and type of core. If in doubt, the manufacturer can be contacted for more information.

178. As prefabs have a general lifespan of 30 years, by far the best solution for unneeded prefab panels is reuse. While reuse may be conducted within the Mission, consideration should also be given for donation of the panels to local municipal governments or communities as such materials are often in need and have the added advantage of being fire compliant with some level of fire retardant in the insulating materials. Any demolition of prefab buildings should therefore be done carefully to maintain the integrity of the panels for later reuse.

179. For panels that are damaged, or if there is no potential for donation and reuse, available disposal options will depend on the whether the panels contain ODS. For panels that contain ODS, the steel metal outer sheets may be removed and sent for metal recycling. The insulating foam contains dilute ODS and can be incinerated but only in large high-capacity incinerators with adequate specific pollution control systems including wet scrubbing, ceramic filters, and lime injection. Such systems are used in refrigeration recycling facilities and only a few Missions have larger systems with the correct PCS to enable ‘in house’ disposal (e.g. UNSOS). If these solutions are not available, the insulting foam may be shredded and sent to landfill, but only where open burning of waste materials is guaranteed not to take place (e.g. Kolongo landfill – MINUSCA).

180. For panels that do not contain ODS, the insulating foam is not considered hazardous and while efforts should be made to recycle the outer steel panels, the insulating foam may be shredded and sent to landfill.

Figure 19: Prefabricated building and panel with PUR/PIR insulation

Metal materials

181. A wide variety of discarded ferrous and non-ferrous metals may result from construction or demolition activities. Metals are generally recyclable, and these should be segregated according to type and made available to a scrap metal contractor through a purchase agreement (e.g. brass, steel, copper).

Wood/Lumber

182. Wood if in good condition may be reusable for other construction activities in the Mission and should be stored for later use. Wood also represents a widely needed material and could be donated to communities for construction purposes or to tradesmen for production of furniture. Wood that is infested by termites or other insects should not be donated and should be incinerated.

183. With many Missions developing WMYs, wood offcuts or material that cannot be donated may be chipped using woodchippers or shredded using shredders ensuring all nails and other metal objects are removed before chipping/shredding. Both pieces of equipment are to be included in Global Systems contract for waste management equipment. Chipped or shredded wood may be used as bulk material for composting or as burnable material to improve the balance of solid waste incinerator feedstock.

Drywall panels/offcuts

184. Due to the widespread Mission use of modular designed prefabricated buildings using foam filled panels, drywall plasterboard panels are not extensively used except where hard-wall buildings are constructed. For this type of construction, drywall is typically used for internal walls and ceilings, and waste will be in the form of offcuts or as debris when a structure containing drywall is demolished or renovated.

185. In the majority of cases, drywall waste will normally be disposed at a solid waste landfill mixed with other wastes. However, as drywall is generally made up of over 90 percent gypsum, which is comparable to limestone, this material has recently been recycled into new drywall bricks and is also beneficial to soils. Benefits include:

- when used as a soil additive lowers pH level
- can further improve workability of the soil
- can also provide nutritive qualities for composting.

190. For drywall to be used as a soil or compost additive, the paper backing must be removed and the gypsum material ground into a powder form. While this may seem arduous, it can be conducted easily if the material is passed through a shredder or crushed with a compactor while the boards are stood on edge. Small amounts of gypsum material will markedly enhance the composting process by helping to reduce nitrogen losses and thereby increase heat. It also introduces valuable sources of sulphur and calcium and helps to reduce unpleasant odours.

Figure 20: Drywall plasterboard waste

Ceramic/vinyl tiles/flooring

191. Ceramic tiles wastes can if segregated, be crushed into pieces, and used as aggregate material in concrete production. This is especially viable for concrete pads that are reinforced with steel rebar. Whole unused tiles may be stored as replacement material or if not required and in enough quantities could be donated for government or community projects. Alternatively, both whole tiles and offcuts could be used for:

- coasters for glasses and teacups
- tiled plant stands
- tiled trays or tabletops, especially if a glass topped table has been broken
- artisanal purposes.

192. If none of the above can be implemented, ceramic tile waste is relatively inert and can be disposed at landfill.

193. Vinyl tiles or flooring wastes can be recycled but it is unlikely that such an option is available to Missions. These wastes should therefore be disposed at landfill and not incinerated as the top layer coating of these materials often contains aluminium oxides that will produce toxic emissions unless a pollution control system using ceramic filters and lime dousing is in place.

Glass

194. Glass windows should be removed from buildings whole if possible and either reused in new construction projects or if not required, donated to local community groups for reuse. Broken glass wastes can be crushed and used as an aggregate (see section C.11) or alternatively disposed at landfill. Care should be taken with the handling and transportation of glass wastes.

Plastics, electrical fittings, and wires

195. Construction or demolition activities may generate plastic wastes from packaging, the removal of electrical fittings, conduit, piping and wiring, or wiring offcuts. Where possible consideration should be given to potential reuse especially for electrical or water fittings by the Mission or for donation to local government or community groups. In addition, recycling may be viable depending on the type of plastic (e.g. HDPE, PP, PET). Electrical wiring can be stripped to remove the copper core for sale to scrap metal contractors, and small robust stripping machines can be procured for this purpose. Alternatively, it can be provided to an e-waste contractor. Small amounts of plastic may be incinerated in high temperature twin chambered incinerators as part of a balanced feedstock except for PVC pipe as this will produce toxic polluting emissions. Plastics may be disposed at secure landfills but should not be disposed at dumpsites where low temperature open burning occurs.

Figure 21: Plastic pipe and electrical wire waste

Porcelain Toilets and Sinks

196. Waste toilets and sinks may be donated to local community groups for reuse if in good condition, or crushed and used as aggregate material, or sent to landfill.

Soils

197. Excavated virgin soils may be stored onsite for later reuse or for landscaping. Alternatively, this material may be donated for use by external builders or landscapers, or for daily soil cover application at local landfill sites.

Tree/plant debris

198. Green plant debris can be used for composting. Larger plant and woody tree material can be chipped if a woodchipper is available as part of a WMY set-up and used as a soil additive or top layer for landscaping, as bulk material for composting, or as a ground cover material around the base of security perimeter fences to prevent plant growth as an alternative to the use of herbicides.

C.15.2 Minimum Standards & Recommendations

199. The following minimum standards and recommendations should be considered:

- All construction wastes should be reviewed for reuse potential or be disposed to avoid environmental or health impacts and pollution.
- No PVC plastics shall be incinerated but rather shredded and sent to landfill.
- Advice on disposal solutions for construction wastes not covered in this section may be obtained from GSC/ETSU.

C.15.3 Key References

200. The following documents and links provide more details and reference information:

- Information on reuse or disposal of non-hazardous construction wastes is available here

C.16 ENGINEERED LANDFILLS

C.16.1 Summary Description & Guidance

201. An engineered landfill site allows final disposal of solid waste in a secure manner by minimizing the impacts on the environment. By definition, an engineered landfill will at minimum include:

- Protective liner system, normally over an engineered clay base with a minimum thickness of 60cm
- Liquid (e.g. leachate) management and collection system
- Methane gas venting, flaring or biogas recovery system
- Security systems (e.g. perimeter fence, access gate, control house) to prevent waste pickers
- Enhanced maintenance activities such as routine compaction and covering of the waste mass (e.g. with soil) which are typically conducted using heavy construction equipment including but not limited to:

  – excavators/backhoes
  – bulldozers
  – road graders
  – waste compactors
  – dump trucks.

202. In some cases, weigh scales/bridges are common at engineered landfill sites which are used to charge customers appropriate disposal fees, and track arriving volumes (in relation to the overall engineered life of the facility).

203. Landfill maintenance is necessary to ensure that the equipment associated with the infrastructure is operated properly and that the site includes proper landfill gas and stormwater management. Daily spreading of the waste is required using bulldozers and compacters, and proper close out and capping is conducted of the waste cells when full.

204. Vector management is also a key component of a properly run facility to ensure that the presence of rodents, birds and other small wildlife species is minimized. Odours also need to be prevented and any fires or subsurface oxidation events need careful reaction.

205. Liquid management systems associated with engineered landfills typically include a pumping and tank or lagoon storage system. Following collection, the liquids can be treated on site, in some cases via evaporation, or stored for transport or transfer to a wastewater treatment system.

206. Across Missions, few locations have properly engineered municipal solid waste landfills, and in most cases, landfills represent excavated disposal pits, some with limited plant machinery to move waste across the site. These sites are often not secure and heavily sifted by waste pickers. In addition, open burning often occurs, which is prohibited for UN solid wastes under the UN Environmental Policy for PKOs and SPMs.

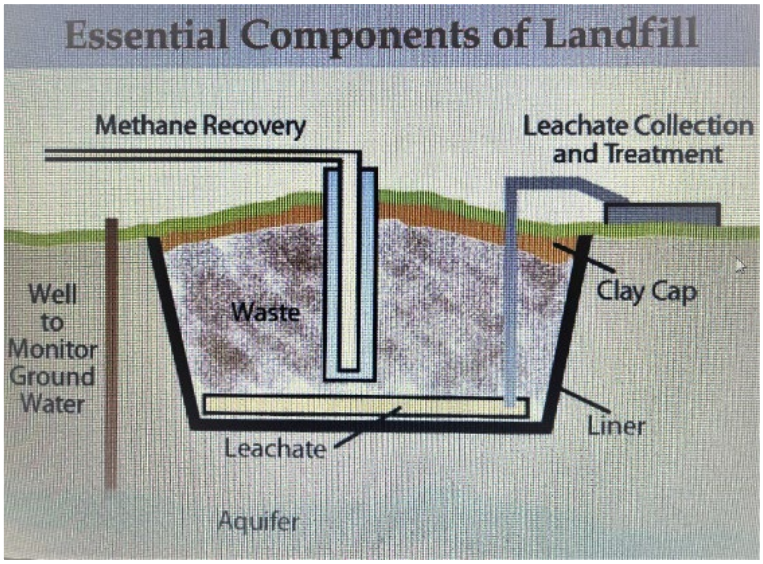


Figure 22: Schematic for landfill site

207. Construction of engineered landfills can be expensive (more than USD 10 million) and while there are a few examples, either constructed (e.g. Nyala landfill – UNAMID) or remediated (e.g. Kolongo Landfill – MINUSCA), that Missions have developed in collaboration with regional authorities, these sites have often failed over the longer term due to a lack of effective and consistent municipal operations at the site, or due to pilferage or vandalism of the equipment (e.g. leachate pumps).

208. For this reason, Missions are generally not encouraged to construct engineered landfills as part of their waste management programme but rather examine alternative solutions for waste disposal such as incineration and increased recycling and composting within WMYs. Ideally the waste management programme should divert all solid wastes from disposal at landfill or dumpsites with the only exceptions being those items that cannot be incinerated, composted, reused, or recycled, along with solid waste ash generated through solid waste incineration.

209. Nonetheless, there may be a situation encountered at the Mission, depending on scale and local capacity, where an engineered landfill may be considered a suitable option to initiate, and in these cases, engineering drawings can be obtained via the GSC/SCS/SSU Database.

C.16.2 Minimum Standards & Recommendations

210. The following minimum standards and recommendations should be considered:

- Where possible Missions should use alternative technologies such as 'fit for purpose' incineration, active composting, and recycling rather than the construction of landfills for solid wastes.
- An Environmental Impact Assessment per the SOP on Environmental Impact Assessment for UN Field Missions and full facility engineering design will be required before the construction of an engineered landfill.
- Landfill construction, equipment and operations should conform with international 'best practice' standards and consideration of the closure of the site at the end of its lifespan by the Mission or Municipal authorities should be included as part of the project plan.

C.16.3 Key References

211. The following documents and links provide more details and reference information:

- Engineering designs for solid waste engineered landfills can be obtained from the GSC/SSU engineering library website available here
- See section C.7 on WMYs

C.17 NON-ENGINEERED LANDFILLS AND LOCAL DUMPSITES

C.17.1 Summary Description & Guidance

212. Missions should be aware of the risk and issues related to the use of non-engineered landfills and local dumpsites for solid waste disposal. Non-engineered landfills and local dump sites can be characterized as follows:

- Non-engineered landfill – an excavated pit
- Dumpsite – typically at ground level
- No engineering or site controls or site security
- Limited or no operating equipment.

213. These types of facilities should be avoided to every extent possible for the disposal of UN Mission solid waste materials and should at minimum only be used for those items that cannot be incinerated, composted, or recycled along with solid waste ash generated through solid waste incineration.

214. Unlike an engineered landfill, non-engineered landfills and local dumpsites are prone to higher levels of risk associated with:

- Varying degrees of waste picking by local communities.
- Presence of vectors (e.g. birds, rodents, flies).
- Open burning at low temperature releasing persistent harmful compounds (e.g. dioxins, furans) into the atmosphere.
- No means for capturing/controlling landfill leachate with potential impact on groundwater and adjacent waterways if the dumpsite is poorly sited.
- Presence of common hazardous wastes such as motor oil, antifreeze, and cleaning fluids.

Figure 23: Uncontrolled dumpsites with high number of vectors, waste pickers and open burning

C.17.2Minimum Standards, Actions and Considerations

215. The following minimum standards and recommendations should be considered:

- Missions should aim to minimize disposal of solid wastes to dumpsites by using alternative waste management solutions (e.g. composting, recycling, incineration).
- At minimum, only non-burnable, non-compostable, non-recyclable, non-reusable wastes, and solid waste ash may be sent to dumpsites if no alternative solution is available. This will require authorization from local authorities.
- Open burning of UN solid wastes is not permitted per the UN Environmental Policy for PKOs and SPMs.
- Due to the risks outlined above, special attention should be considered to conduct regular inspections for haulers transporting the solid wastes to the dumpsites, to check for illicit dumping at the dumpsites, and to evaluate local

waste picking activities regarding the risk of open burning or human health impacts.

C.17.3 Key References

216. The following documents and links provide more details and reference information:

- More details of problems associated with non-engineered landfills and dumpsites is available here

D. HAZARDOUS WASTE MANAGEMENT

D.1 INTRODUCTION

217. The management of hazardous materials and wastes is a key challenge across UN field Missions. Initially supplied as specific items of equipment (e.g. for IT/communications) or as consumables (e.g. chemicals), waste may be generated due to:

- A particular piece of equipment reaching its end of life (e.g. e-wastes, bulbs).
- Residual hazardous waste materials remaining after product use (e.g. water treatment reagents, POL).
- Oversupply of the product.
- Expiration of unused product.
- Despoilment or damage to the product.
- Obsoletion (e.g. change of equipment/approach).

218. Hazardous wastes are generated by UN Mission facilities and operations, and military or police components that manage their own water treatment systems, transport maintenance, or operate UN Mission Level I, II and III clinics and hospitals.

219. Standard control systems for hazardous wastes have been developed for UN facilities. They include the use of SOPs and a general requirement that hazardous wastes are sent to the PDU. However, these systems may be poorly defined (e.g. correct storage and segregation, inventory), followed or enforced, and may not be consistent across Missions. Military and Police components hazardous waste generation has historically been more difficult to control and monitor due to jurisdiction constraints and the fact that their supply may be conducted independently. Collaborative engagement on hazardous wastes is mainly conducted through COE inspection cycles, specific guidelines such as for biomedical waste disposal and the use of X-ray equipment. These are given in the COE manual or the Environmental Management Handbook for Military Commanders and in specific UN Mission environmental guidelines on ‘best practice’.

220. Considering the inherent hazardous nature of these wastes, and the often-limited suitable treatment and disposal solutions available locally, hazardous wastes frequently accumulate during the sustainment phase as large stockpiles often improperly stored. This becomes especially evident and problematic to manage during the liquidation phase of the Mission when labour and resources are further constrained.

221. To better address these issues and bring about an overall improvement of hazardous waste management across Missions, a wide range of actions are required. They include:

- In line with the UN Environmental Policy for PKOs and SPMs, no hazardous or biomedical wastes shall be disposed to land or water without prior treatment appropriate to the waste type.

- Improved supply and inventory of hazardous materials based on identified rates of usage versus expiration cycles and/or improved material composition of products including the use of non-hazardous alternatives. (see section B.5).
- Improved inventory of accumulated hazardous wastes linked to waste retention triggers that activate a treatment or disposal action for a particular hazardous waste once an accumulation threshold has been reached. This should ensure that ongoing treatment or disposal of hazardous waste is conducted through the sustainment phase of the Mission rather than remaining until the Mission is liquidated when resources are further constrained (see section D.3.3).
- Identification of and provision of guidance, training and SOPs for appropriate hazardous waste handling, storage and segregation, along with treatment and disposal methods for specific hazardous wastes that meet 'best practice' criteria and international standards for UN Missions (see sections B.6, D.4-D.6).
- Improved SOW/SORs and engagement, verification and monitoring of capable national and international service contractors for the handling, treatment and disposal of hazardous waste that adhere to the minimum standards outlined above (see sections B.7).

222. These actions are discussed in detail in specific sections of this document, and a summary table of treatment and disposal options for hazardous materials/wastes is provided in the next section.

D.2 OVERVIEW TABLE OF WASTE DISPOSAL/TREATMENT FOR HAZARDOUS WASTES

223. The following summary table lists 21 hazardous waste groups and indicates best case, secondary options, and last resort treatment or disposal options available for each group. It also highlights forbidden high-risk options and those are not applicable, technically unfeasible, or difficult to implement. More information on the precise treatment or disposal options and minimum standards, actions and considerations for each hazardous material/waste group is given in the following sections. Expanded method descriptions for neutralization, alkaline hydrolysis, encapsulation, and soil bioremediation, along with information on training on hazardous waste management, is given in Chapter E section E.3.

Table 4: Matrix of treatment and end disposal for hazardous wastes

1	Best option
2	Second option
3	Last resort
Don't	Forbidden, high risk
NA	Not applicable: Not feasible or technically difficult

Waste Stream/ Waste treatment or disposal	Donation/ Reuse	Takeback	Recycling/ reprocessing	Chemical treatments/ specialized destruction	Incineration	Landfill (engineered)	Encapsulation	Onsite temporary storage	Open dumping/ open burning
HW1/HW11: Alkaline, Lithium, Nickel-metal Hydride, Button batteries			With e-wastes		X		Small quantities		X
HW1: Lead-acid batteries		X	Demonstrated recyclers	Neutralization of de-canted acids	X	X			X
HW2: E-waste – ICT & communication equipment	Only if in good working order	If available	Demonstrated recyclers		X				X
HW2: E-waste – air conditioners and large household appliances	Only if in good working order	If available	Electronic parts as e-waste; metal parts with scrap metal contractor; refrigerants (if HFC/HCFC) specialized destruction		X	Parts that cannot be recycled			X
HW3: Fluorescent and Halogen bulbs				Use Bulb crusher with mercury vapor		Only as a last resort	Encapsulation of glass and phosphorous powder		X

Waste Stream/ Waste treatment or disposal	Donation/ Reuse	Takeback	Recycling/ reprocessing	Chemical treatments/ specialized destruction	Incineration	Landfill (engineered)	Encapsulation	Onsite temporary storage	Open dumping/ open burning
				vacuumed into carbon filters					
HW4: Lamp ballasts			Treated as e-waste	If proven to be manufactured before 1980, specialist disposal of PCBs is required	X	X	Encapsulation in a robust reinforced concrete that passes TCLP tests for leachability		X
HW5: Cooling Refrigerants	HFC/HCFC can be reused in a unit if original refrigerant was the same type			Demonstrated facility for refrigerant destruction		X			X
HW6: Waste petroleum, oils and lubricants (POL)		If available	Demonstrated recyclers/ re-processors		Small amounts can be incinerated using barrel incinerators with designated manufacturer attachment	X			X
HW7: Metal-containing or specialized paints	Only if in a usable condition				X	Mixed with vermiculite or sawdust and dried			X
HW8: Sanitary wastes						Ensure well wrapped			X
HW9: Pesticides	For fogging and spray concentrated pesticides only if not expired for more than			Alkaline hydrolysis	Small quantities only after soaking in absorbents	X			X

Waste Stream/ Waste treatment or disposal	Donation/ Reuse	Takeback	Recycling/ reprocessing	Chemical treatments/ specialized destruction	Incineration	Landfill (engineered)	Encapsulation	Onsite temporary storage	Open dumping/ open burning
	6 months and usable. Aerosol pesticides can be used up to 3 years after expiration								
HW10: Gas cylinders	Only if usable		After gas removal, sent to scrap metal contractor		X	X			X
HW12: Printer ink/toner cartridges	Only if usable	For HP cartridges	Local recycling if possible		Small quantities only				X
HW13: Used tyres	Only if tyres have the legal regulated tread depth remaining and no other flaws		Demonstrated recyclers including pyrolysis (not for re-grooving unless specifically marked on the tyres)		X	After cutting into pieces			X
HW14: Biomedical wastes including expired pharmaceuticals	X			Only for some pharmaceuticals	Biomedical incinerators	Only after encapsulation. Otherwise prohibited	Robust encapsulation		X
HW15: Expired ammunition, used ammunition casings, lead bullet recovery	X		Only after controlled demolition and disfigurement to prevent reuse. All metals (e.g. brass, lead) sent to scrap metal		X	Only for recovered lead			X

Waste Stream/ Waste treatment or disposal	Donation/ Reuse	Takeback	Recycling/ reprocessing	Chemical treatments/ specialized destruction	Incineration	Landfill (engineered)	Encapsulation	Onsite temporary storage	Open dumping/ open burning
			contractor for recycling into new ingots						
HW16: Ballistics Protective Equipment			Kevlar jackets can be recycled into brake pads or new fibres. End disposal certificates required	Helmets may be cut using disc cutters, plates cut or broken into fragments. End disposal certificates required	Jackets can be incinerated above 600°C. End disposal certificates required	X			X
HW17: Expired or obsolete chemicals	Only if in a usable condition. Careful evaluation of the use of expired chemicals	For Hach Lange LCK reagents only, in both used and unused forms		Neutralization/ alkaline hydrolysis, chemical oxidation	For small quantities of specific chemicals	X	Sand soak encapsulation or direct encapsulation followed by disposal at landfill		X
HW18: Bitumen	Only if in a usable condition				X	To reduce fire risk, cut bitumen into small pieces			X
HW19:Contaminated soils				Specialized bioremediation	Small amounts may be incinerated	X	Small amounts possibly		X
HW20: Biomedical waste ash						Only after encapsulation	Mix in slurry blocks or in barrels		X
HW21: Hazardous construction wastes	Only if in a usable condition and not asbestos		Recyclable items	Asbestos products – specialized contractor	For some specific items	X			X

D.3 HAZARDOUS MATERIALS AND WASTE AT UN FIELD MISSIONS

D.3.1 Definition and Types of Hazardous Materials/Wastes

224. The definition of hazardous materials/wastes as written under Mission WMPs is:

Waste material that may cause damage to human health or the environment that requires precautions when storing, handling, transporting, or disposing due to its toxicity, corrosiveness, ignitability or reactivity.

225. Hazardous materials/wastes are classified on the basis of their biological, chemical and physical properties. These properties create materials that are toxic, reactive, ignitable, corrosive, infectious or radioactive.

226. Hazardous wastes may be in solid, liquid, and gaseous forms.

227. Clarification on the above waste definitions for a Mission or for a particular situation may be obtained from GSC/ETSU.

D.3.2 List of Hazardous Materials/Wastes Relevant for UN Field Missions

228. The following hazardous materials/wastes have been identified as relevant across UN Field Missions and conform with UN Category Management for solid and hazardous wastes.

Table 5: Hazardous materials/wastes identified as relevant to UN Field Missions by UN Category

Category	Reference Section	Descriptive List
HW.1	D.5.1	Batteries including Lithium-ion, Nickel-cadmium, Nickel-metal Hydride and Lead-acid (from UPS, generators, laptops, and cars)
HW.2	D.5.2	E-Waste (electronics such as old computers, phones, copiers, televisions, fax machines, handheld and base station radios, ICT networks, other communications peripherals, etc.)
HW.3	D.5.3	Fluorescent tubes and compact bulbs
HW.4	D.5.4	Lamp ballasts
HW.5	D.5.5	Cooling refrigerants (e.g. HCFCs that are now banned and approved HFCs)
HW.6	D.5.4	Spoiled petroleum and waste motor and machine oil and lubricant products (POL), used oil filters, and contaminated rags/ textiles/absorbents
HW.7	D.5.4	Metal containing (e.g. Lead, Chromium) or specialized paints, adhesives and preservatives
HW.8	D.5.4	Sanitary waste
HW.9	D.5.4	Pesticides (e.g. herbicides, insecticides, fungicides, rodenticides)

HW.10	D.5.4	Gas cylinders (e.g. Propane, Butane, Oxy-acetylene,medical Oxygen)
HW.11	D.5.1	Household batteries (Dry Cell)
HW.12	D.5.4	Toner and ink printer cartridges
HW.13	D.5.4	Used vehicle and plant machinery tyres
HW.14	D.5.13	Biomedical waste (including expired pharmaceuticals)
HW.15	D.5.4	Expired ammunitions, used ammunition cartridge casings and lead bullet recovery (The first is normally dealt with by UNMAS, but the last must be dealt with through hazardous waste management)
HW.16	D.5.4	Ballistics Protective Equipment (e.g. Helmets, ballistic plates, Kevlar protective jackets, etc.). These items require end disposal certification
HW.17	D.5.4	Expired or obsolete chemicals • Water and wastewater treatment chemicals (e.g. chlorine products, acids, flocculants, membrane cleaners, reagents and testing kits, bio-enzyme, inoculation products) • Deep cleaning or dilution products (e.g. solvents/thinners, peroxides, industrial disinfectants, alcohols) • Maintenance of machinery and equipment (antifreeze, condenser cleaner) • Fire-fighting agents including powders
HW.18	D.5.4D.5.17	Waste bitumen
HW.19	D.5.18	Contaminated soil (e.g. POL, chemical spill)
HW.20	D.5.4	Biomedical incinerator ash
HW.21	D.5.4	Hazardous construction wastes (e.g. asbestos, asphalt roofing)

D.3.3 Hazardous Waste Inventory and Waste Retention Triggers for Disposal

D.3.3.1 Summary Description & Guidance

229. A hazardous waste inventory is a key tool for recording the levels, types and locations of hazardous waste generation and storage across the Mission. The inventory can be adapted to identify retention thresholds of waste accumulation for specific hazardous wastes that when reached, trigger an alert to indicate that treatment or disposal of the accumulated stockpile is required. Threshold triggers can be organized to reflect the most appropriate weight, volume, or number accumulation of each hazardous waste for a specific type of treatment or disposal solution/s. This results in greater resource and cost efficiencies and ensures that repeated ongoing disposal actions prevent large stockpiles accumulating. In addition, where required, the expiration of supply products can be indicated.

230. An example Waste inventory and Retention Trigger tool is provided in Figures 24 and 25. They indicate the basic spreadsheet layout and the inbuilt triggers for each hazardous material/waste and the system dashboard design. The system should

enable filtering of information for specific wastes or groups of wastes, and by location, including risk heat maps. Alerts to the inventory organizer can be sent via e-mail or SMS message and can be further colour coded in the dashboards using a traffic light system to indicate levels towards the trigger point.

231. This system is currently being considered as a Business Intelligence (BI) tool that may, if developed, be distributed to Missions. In the meantime, Missions should arrange their inventories to include the elements provided in the example dashboards.

D.3.3.2 Minimum Standards & Recommendations

232. The following minimum standards and recommendations should be considered:

- All Missions need to improve their hazardous waste inventory at PDUs, especially to counter large stockpiles requiring management during liquidation of sites or overall Missions.
- Specific personnel or service contractors should be trained in appropriate treatment or disposal methods for hazardous wastes.

D.3.3.3 Key References

233. The following documents and links provide more details and reference information:

- Information on the BI Waste Inventory and Retention Trigger Tool is available here

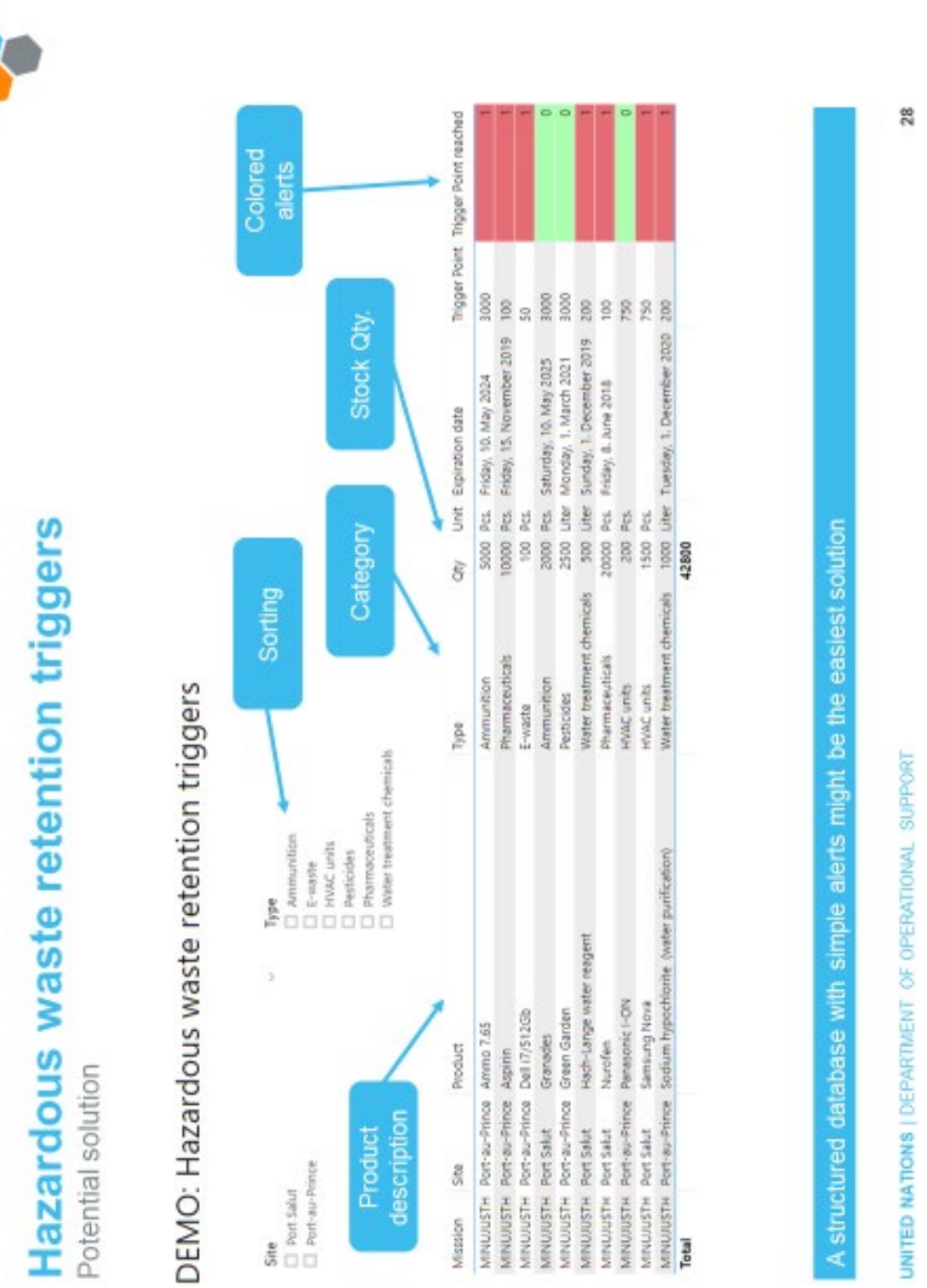


Figure 24: Sample BI dashboard of hazardous waste inventory with retention triggers

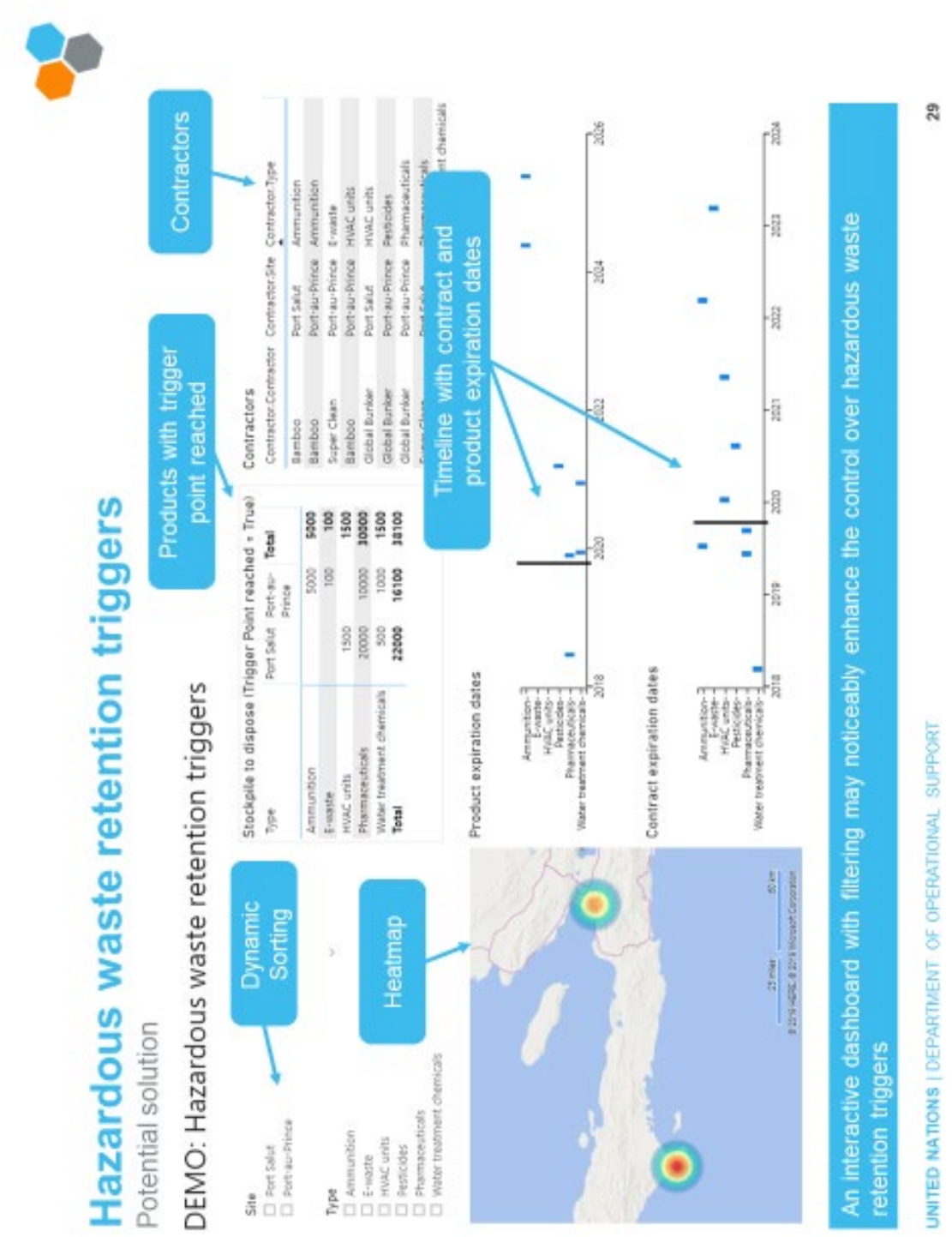


Figure 25: Sample BI dashboard of hazardous waste inventory with retention triggers and heat map

D.4 COLLECTION, HANDLING AND STORAGE OF HAZARDOUS MATERIALS AND WASTE

D.4.1 Hazard Pictograms and Nomenclature

D.4.1.1 Summary Description & Guidance

234. The Globally Harmonized System of Classification and Labelling of Chemicals (GHS) specifies a Hazard Communication Standard (HCS) consisting of nine main hazard classes depicted in pictograms (one repeated) that indicate hazards associated with certain substances (Figure 26).

235. Each pictogram covers a specific type of hazard and is designed to be immediately recognizable to anyone handling hazardous material.

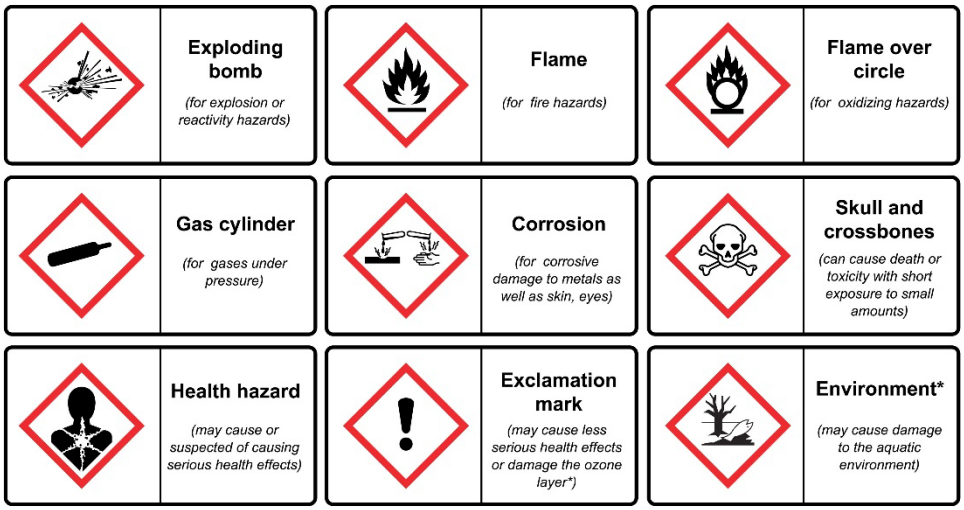


Figure 26: GHS Hazard Communication Standard Pictograms

236. The main hazard classes are further divided into sub-classes under the Agreement concerning the International Carriage of Dangerous Goods by Road (ADR), a European agreement for the international transportation of dangerous goods. This further defines differences between types of gases, liquids, explosive, oxidizing, poisons, toxins, and infectious materials, as well as radioactive and miscellaneous dangerous substances.

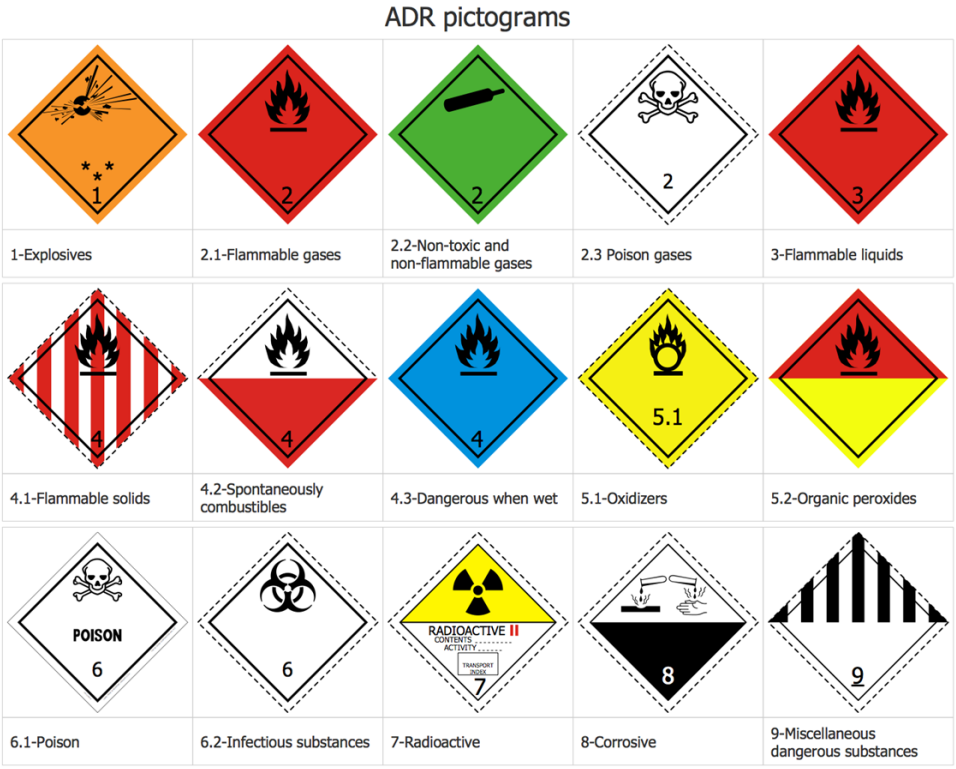


Figure 27: ADR Hazard Communication Standard Pictograms

237. In addition to the hazard pictograms, labels are required to include a signal word ('Danger' or 'Warning'), a brief hazard statement, and a precautionary statement outlining ways to prevent exposure (Figure 28). Furthermore, if the hazardous materials are imported and/or transported (see next section) they will be also labelled in accordance with ADR/SDR transportation protocols and will be assigned either a United Nations number (UN) (example Figure 29), a North America number (NA) or an ID number which is normally restricted to air transport. In the case of UN numbers each are associated with a hazard identifier which encodes the general hazard class and subdivision. These can be found on a categorized list to identify a specific product at least to the category level.

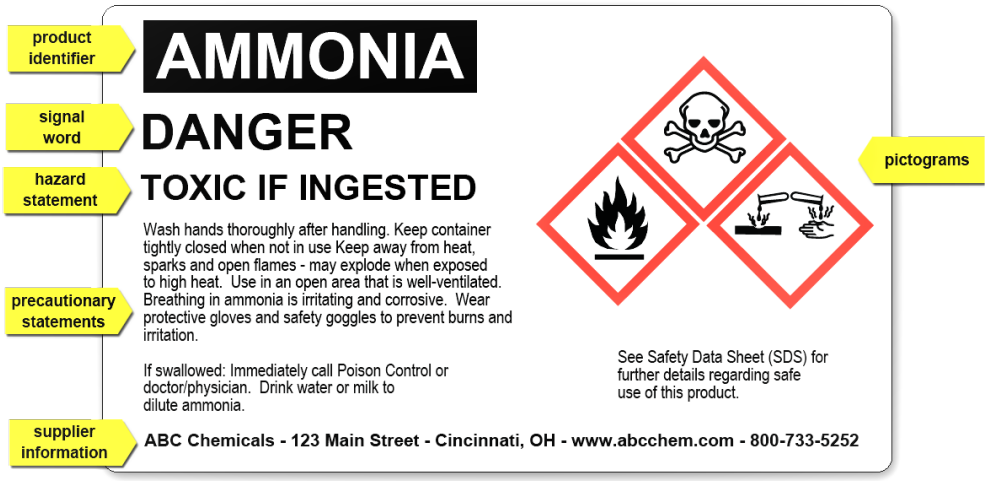


Figure 28: GHS Hazard Communication Standard example product label

Figure 29: ADR UN number label example Hypochlorite solution

D.4.1.2 Minimum Standards & Recommendations

238. The following minimum standards and recommendations should be considered:

- Signage of GHS Hazard Communication Standard Hazard Pictograms shall be displayed at all hazardous waste storage areas (see following sections).
- All hazardous materials/waste containers shall be correctly labelled for that material/wastes.

- Training should be provided to all personnel handling hazardous materials on both GHS and ADR hazard pictograms and correct labelling of hazardous material/wastes (see Main section E.3).
- Containers with poor labelling should be re-labelled to ensure the name of the product, the identifier number, and hazards for the product are clearly indicated.
- Container integrity shall be maintained.

D.4.1.3 Key References

239. The following documents and links provide more details and reference information:

- GHS Hazard Communication Standard is available here
- ADR Standard for transport of dangerous goods is available here
- List of UN numbers is available here

D.4.2 Safety Data Sheets (SDS – Formerly Material Safety Data Sheets – MSDS)

D.4.2.1 Summary Description & Guidance

240. The GHS HCS requires that the chemical manufacturer, distributor, or importer provide Safety Data Sheets (SDSs) for each hazardous chemical to downstream users. The information contained in the SDS is presented in a consistent user friendly 16-section format.

241. The SDS includes information such as the properties of each chemical, the human and environmental health hazards, protective measures, and safety precautions for handling, storing, and transporting it. The information contained in the SDS must be in English (although it may be in other languages as well).

242. SDS Sections 1-8 contain general information about the chemical such as identification, hazards, composition, safe handling practices, and emergency control measures (e.g. firefighting). This information should be helpful to those who need the information fast.

243. Sections 9-11 and 16 contain other technical and scientific information such as physical and chemical properties, stability and reactivity information, toxicological information, exposure control information, and other information including the date of preparation or last revision.

244. The SDS must also contain Sections 12-15 to be consistent with the UN GHS. Section 13 covers disposal considerations but unfortunately often simply indicates that disposal must be in line with national regulations which is unhelpful as it does not provide clear disposal instructions. Nonetheless, for the 21 types of hazardous wastes found across Missions, information on the methods for their treatment and

disposal is generally covered in this handbook (see section D.5). In addition, hazardous waste contractors should provide detailed descriptions of the waste disposal methods for each type of hazardous waste they will be contracted to dispose of.

245. The list of all 16 sections of the SDS is presented in Table 6:

Table 6: The 16 sections included in an SDS for hazardous materials

1. Identification and supplier	9. Physical and Chemical Properties
2. Hazards Identification	10. Stability and Reactivity
3. Composition	11. Toxicological Information
4. First Aid Measures	12. Ecological information
5. Firefighting Measures	13. Disposal considerations
6. Accidental Release Measures	14. Transport Information
7. Handling and Storage	15. Regulatory information
8. Exposure Controls/Personal Protection	16. Other Information

D.4.2.2 Minimum Standards & Recommendations

246. The following minimum standards and recommendations should be considered:

- UN Missions shall ensure that SDSs for all hazardous materials/wastes are available and readily accessible to all UN civilian, uniformed, and service contractor personnel.
- SDSs should be laminated and provided together at a central location within the hazardous material/waste storage area and filed in the appropriate administration/management office.

D.4.2.3 Key References

247. The following documents and links provide more details and reference information:

- Information on SDSs is available here

D.4.3 Storage and Segregation Standards for Hazardous Materials/Waste

D.4.3.1 Summary Description & Guidance

248. In Missions, hazardous supply goods are generally stored at the Integrated Warehouse facilities while hazardous wastes from UN facilities and Military and Police components should be sent with full inventory to Mission PDUs.

249. All hazardous materials and wastes arriving at these sites are required to be stored appropriately to protect them from damage and the weather. They shall, where necessary, be segregated by hazard class to prevent uncontrolled reactions of incompatible materials both generally and in the event of a spill. Accumulations of

stored wastes should ultimately be treated or disposed through 'in house' operations or via hazardous waste service contractors.

250. To assist with the necessary segregation requirements for hazardous materials and wastes, a standard storage and segregation guide by hazardous class is provided in Figure 31 In addition, further storage instructions may be taken from the available SDS for specific hazardous materials or wastes. Missions should ensure that appropriate storage requirements are in place before receiving hazardous goods.

251. In general segregation shall be organized to ensure:

- Segregation of acids from bases (i.e. alkalines)
- Segregation of oxidizers from organic materials/wastes
- Segregate of cyanides and sulphides from acids
- Storage of flammable solvents in suitable containers away from sources of ignition
- Isolation of organic hydrogen peroxides in dedicated stores or cabinets.

252. Generally, a distance of 2.5-5m, is required between non-compatible chemicals, and may be greater above certain threshold quantities. In some cases, separate storage is required in different fire sections.

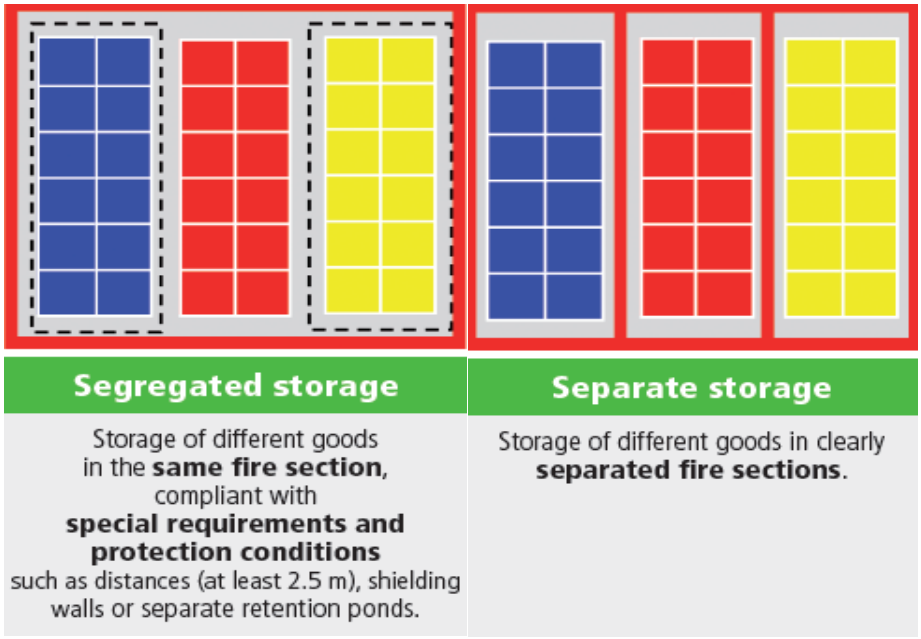


Figure 30: Segregation and separate storage examples (Source: Swiss Safety Centre - see link)

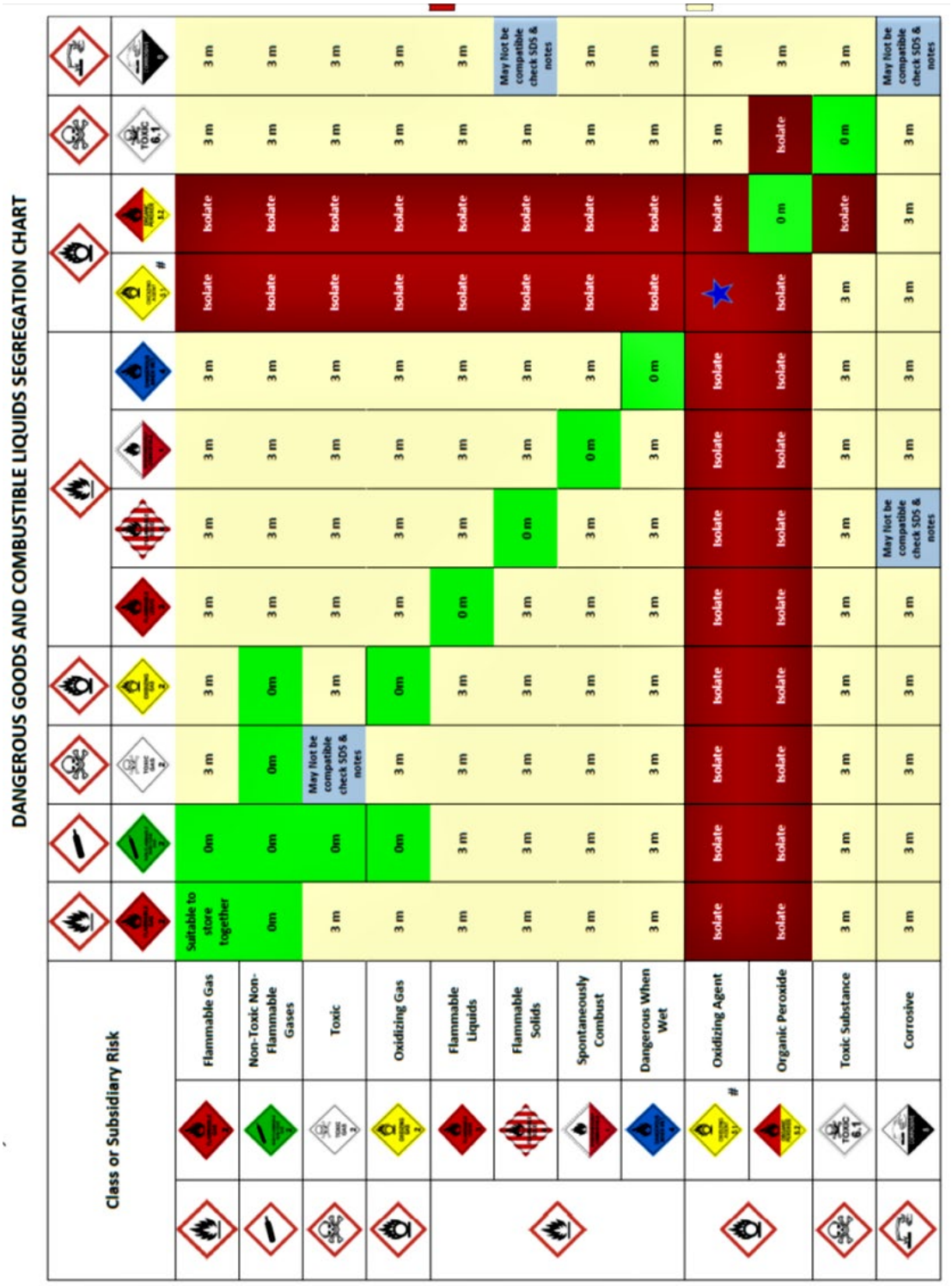


Figure 31: Hazardous materials segregation chart

253. While the set-up of hazardous supply and waste storage areas may vary depending on Mission size, locations, and available resources, they should typically conform to the following arrangements:

- Be in a suitable secure fenced location with outbuildings (e.g. Rubb halls) that have a protective roof, secure walls and doors, adequate lighting, and some form of passive ventilation.
- Include additional shipping containers for specific hazardous wastes (e.g. e-waste).
- Where required, roof height should allow for movement of materials/wastes by forklift.
- Chemical storage areas shall have an impermeable hard standing bunded floor with good accessibility and space for proper segregation and safe handling, as well as optional closable drainage or chemical drip retention containers.
- All hazardous goods shall be stored off the floor on pallets or specific steel shelving in robust and 'fit for purpose' containment and be properly labelled.
- Separate containment areas should be available to conform with flammable risks and incompatible segregation protocols.
- The storage area shall have clear signage that hazardous materials/wastes are stored at that location including hazard pictograms and SDS for specific products/wastes readily available for inspection by relevant personnel.
- Appropriate PPE for the types of hazardous materials/wastes stored shall always be available on site.
- Emergency spill kits including absorbents, first aid kits and eye baths shall be placed at strategic points around the site.
- Firefighting equipment shall be available conforming with the type of hazardous materials and wastes stored at the site.
- An Emergency Response Plan for the site shall be developed in line with the materials/wastes stored at the site.

254. It is the responsibility of all Missions and their uniformed components to focus on continual improvement of all these elements as part of their environmental improvement strategies. This should be clearly defined in the SOP for hazardous materials/wastes and summarized in the Mission WMP.

Figure 32: Well, organized off floor storage of hazardous materials

D.4.3.2 Minimum Standards & Recommendations

255. The following minimum standards and recommendations should be considered:

- Hazardous material/waste storage areas shall be organized in line with correct segregation and 'best practice' standards and be clearly outlined in the Mission hazardous material/waste SOP (see section 6).
- An updated inventory of all hazardous materials or wastes stored at the site shall be available.
- Training shall be provided to supply storage personnel and PDU staff on hazardous waste management that includes proper storage of hazardous materials/ waste (see section E.3).
- Disorderly storage of hazardous materials of different hazard classes is not permissible.
- The storage of flammable empty packaging materials (e.g. wood, cardboard, paper, plastic, etc.) is not permissible in storage areas containing hazardous materials.
- Container defects should be easily detectable and repaired immediately.

D.4.3.3 Key References

256. The following documents and links provide more details and reference information:

- Information on storage and segregation of hazardous materials and waste is available here
- A template for an emergency response plan is available here

D.4.4 Transportation of Hazardous Materials and Waste

D.4.4.1 Summary Description & Guidance

257. Transportation of hazardous materials/wastes is generally conducted by trucks over public highways. In view of its toxic, flammable, explosive or corrosive characteristics, transportation of hazardous materials/wastes shall be planned to not cause danger to human health or the environment. For this to be assured the following requirements are required:

- All hazardous materials/wastes shall be stored in appropriate leak-proof containment with structural integrity, and packed, fastened and spaced correctly considering compatibility between hazardous materials/waste and to avoid movement or leakage during the journey considering all potential road conditions.
- All hazardous materials/wastes shall be correctly labelled (see section D.4.1) with information available on remedial measures in the event of an accidental spill.
- The vehicle shall be of a condition and type appropriate for the transportation of hazardous materials/wastes.
- The driver of the vehicle shall have the relevant technical competence and skills for the transportation of hazardous materials/wastes.
- A complete manifest system shall be used to monitor the journey of hazardous materials/wastes from its point of origin to the point of final delivery/disposal. This allows the type and quantity of hazardous materials/waste transported to be determined, as well as the recommended emergency procedures in the event of an accidental spill.
- In the event of a leak or accidental spill of hazardous waste during its transport, the transporter shall take immediate and appropriate actions, including notifying local authorities of the discharge.

D.4.4.2 Minimum Standards & Recommendations

258. The following minimum standards and recommendations should be considered:

- The generator of the hazardous materials/wastes shall ensure that the materials/wastes are packaged in a manner suitable for safe handling, storage, and transport.

- Labelling on the packaging is readily visible and material(s) used for packaging shall withstand physical and climatic conditions.
- The SDSs are provided to the transporter, or adequate information regarding the characteristics of the hazardous materials/wastes is provided on the label.
- Where transboundary transport is required, documents pertaining to the Basel Convention of the transboundary transport of hazardous wastes (e.g. Prior Informed Consent - PIC - form) are completed accordingly and available with the manifest.

D.4.4.3 Key References

259. The following documents and links provide more details and reference information:

- Information on the transportation of hazardous materials/wastes is available here
- Presentation by UNECE on the transportation of hazardous or dangerous goods is available here
- Details of hazardous waste transboundary movements under the Basel Convention is available here

D.5 DISPOSAL OPTIONS FOR HAZARDOUS WASTES

D.5.1 HW1/HW11: Batteries: Lead Acid, Lithium-ion, Nicad/metal and Alkaline

D.5.1.1 Summary Description & Guidance

260. Batteries come in a variety of forms and sizes with the majority being considered hazardous either due to their acid or metal content. Each category of battery is discussed below with the recommended disposal methods indicated.

Lead Acid batteries

261. At Missions lead acid batteries are primarily used for vehicles and plant machinery but may also be used for solar energy storage. They are hazardous as they contain an electrolyte of sulphuric acid, and lead, a toxic soluble metal. Sulphuric acid is highly corrosive while lead has been linked to health effects in humans, particularly children.

262. All used lead acid batteries should be taken to the PDU for storage until a qualified service contractor removes them for recycling. It is imperative that the Mission only release lead acid batteries to proven contractors who can demonstrate through verification inspections that recycling is conducted without environmental and human health impacts. The main aim of recycling is to remove the lead from the battery for re-smelting into new lead ingots. If done poorly this process can result in excessive lead pollution through emissions and output of lead particles into the surrounding environment.

Figure 33: Inappropriate recycling of lead acid batteries (source: Oeko-Institut)

263. The following preparation steps are required for lead acid batteries to be transported for recycling:

1. Collected batteries shall be emptied of the sulphuric acid into clearly labelled and closable (e.g. hazardous acid product) plastic containers for later neutralization.
2. Emptied batteries should be stacked carefully onto pallets up to a height of four batteries, strapped across in both directions, and covered with plastic wrap.
3. Pallets should be placed into suitable transport to a height of two pallets only.

264. Collected sulphuric acid can be neutralized through dilution into water at a rate of 10:1 followed by the addition of an alkaline product to change the pH of the diluted product to a neutral pH 7-8. As this process will convert the acid product to simple salts, water, and CO_2 the neutralized solution may be dispersed after treatment over a hard surface area for evaporation (see section D.6.2 for further details).

Figure 34: Appropriate and inappropriate storage of lead acid batteries

Lithium-Ion Batteries

265. Lithium-Ion (Li-ion) batteries are a type of rechargeable battery used for many applications, most commonly in the electronics industry. They provide portable electricity for gadgets such as mobile phones, laptops and tablets, and supply energy

to medical equipment, electric vehicles, power tools, solar energy storage, and UPS back up power devices.

266. Li-ion batteries are considered relatively less toxic than other types of rechargeable batteries, but they can still contain metals such as iron, nickel, and cobalt. They may also represent a fire hazard with even used batteries having enough energy to start fires if handled incorrectly. To help prevent the risk of fire, terminals on the batteries should be covered with non-conductive tape (e.g. electrical tape) and the batteries should be stacked in an organized manner to prevent terminal to terminal contact. Damage to the batteries should be avoided and safety use as indicated by the product markings followed.

267. Li-ion batteries should be considered as e-waste and a service contract should be sought to conduct 'formal' e-waste processing and recycling. A global e-waste systems contract is being organized for all Missions (see next section). Informal e-waste processing is not permitted as this can cause excessive pollution and impacts to human health. Recycling of Li-ion batteries is possible but currently this is conducted by only a few facilities globally and none of these are located in Africa so export may be required.

268. Small quantities of Li-ion batteries may in the absence of an e-waste contract be encapsulated (see section D.6.4) and sent to landfill. Before encapsulation each battery should be placed into a separate plastic bag.

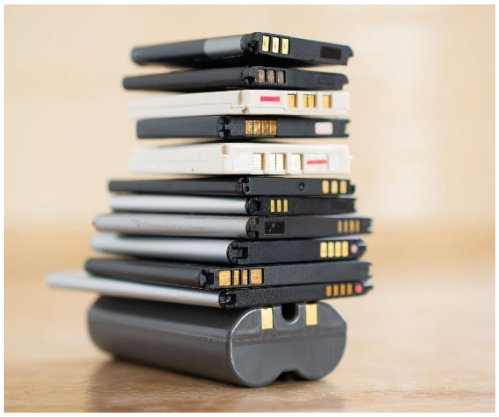


Figure 35: Lithium-ion batteries

Nickel-cadmium/Metal hydride batteries

269. Nickel-cadmium/Metal hydride batteries are rechargeable batteries that are used in high drain devices such as digital cameras, high power torches and other electronics that require above average power supply. These batteries are different from alkaline batteries (see below) as they contain nickel, cadmium, lead and sometimes mercury, which can cause environmental pollution through leakage if dumped in landfill.

270. These batteries are considered hazardous and therefore must be properly disposed of through a specific recycling facility or at a specific hazardous waste landfill. It is recommended that they be considered an e-waste and disposed through a 'formal' e-waste contractor. Alternatively, small quantities can be encapsulated

using a super strength concrete mix (see section D.6.4) and sent to landfill, but landfill is not permitted in their loose form.

Figure 36: Nickel-cadmium rechargeable batteries

Household batteries – Alkaline

271. Alkaline batteries used to be considered hazardous as they contained mercury, but this toxic metal is no longer used in their production. Modern alkaline batteries contain manganese, steel, and zinc, all of which are derived from naturally occurring metals or alloys that pose no risk to the environment. These types of batteries do not exhibit any of the following criteria to be classified as hazardous: ignitability, corrosivity, reactivity and toxicity. As such, they are not listed as hazardous waste and can be safely disposed as solid waste at landfill.

272. Research studies have shown that alkaline batteries in landfills do not pose a significant risk to the environment. While recycling of alkaline batteries does exist, the difficulty of recovering materials from them is cost-prohibitive and few recycling companies accept them.

Figure 37: Alkaline batteries

Household batteries – button type

273. Button batteries generally include lithium but can also include silver and mercury. Consequently, they are classified as hazardous and should be sent for recycling. Where no recycling is available, it is recommended that button batteries are encapsulated (see section D.6.4) and sent to landfill.

Figure 38: Button batteries

D.5.1.2 Minimum Standards & Recommendations

274. The following minimum standards and recommendations should be considered:

- Procedures for battery recycling and disposal shall be clearly outlined in the Mission Hazardous Waste SOP.
- Appropriate PPE should be available for personnel handling batteries, especially for lead acid batteries and decanting the acid electrolyte.
- Correct storage of Li-ion and Metal hydride batteries shall be conducted to prevent fire and pollution risk, and these batteries should be considered as e-waste to be recycled by a 'formal' e-waste contractor.
- Encapsulation should be conducted in line with the method described in section D.6.4.

D.5.1.3 Key References

275. The following documents and links provide more details and reference information:

- Recycling used lead acid batteries: health considerations is available here. here
- Lead recycling in Africa is available here
- Guidelines for Environmentally Sound Management of Used Lead Batteries in the Mediterranean is available here
- Information on Lithium battery recycling is available here

D.5.2 HW2: E-waste

D.5.2.1 Summary Description & Guidance

276. E-waste is generated across Missions from UN facilities and operations.It includes ICT equipment (e.g. personal computers, telephones, mobile phones, laptops, printers, scanners, short and long wave radios, photocopiers, etc.) and both large and small electrical appliances (e.g. air conditioners, refrigerators, coffee

machines, etc.) as well as medical equipment (e.g. electrocardiogram - ECG or EKG units, imaging and monitoring equipment, etc.) which can also include electronic radiation emitting devices.

277. E-waste is considered a hazardous waste due to the presence of toxic metals such as mercury and lead and other hazardous substances. E-waste may also contain precious metals such as gold, copper and nickel and other rare materials of strategic value such as indium and palladium that can be recovered, as well as common plastics and glass.

278. The most environmentally safe and beneficial form of disposal is through 'formal' recycling which when conducted properly can bring about significant financial dividends, create employment, and markedly reduce the volume of final waste. In contrast 'informal unregulated' recycling using basic artisanal dismantling and recycling techniques, including open burning and open acid baths, can cause extensive environmental pollution and human health impacts from the release of toxic emissions and materials such as cadmium, mercury, lead, beryllium, halogen, and plastics treated with brominated fire retardants.

Figure 39: Typical e-wastes generated across UN Field Missions

279. In summary, 'formal' recycling, which may combine both manual and mechanical methods, will probably include the following stages:

1. **Pre-sorting** – manual procedure to categorize e-waste by type and help identify whether any equipment is operational and may be cleaned/refurbished and made available for reuse. If determined to be neither operational nor repairable, the e-waste should be dismantled.

2. **Dismantling** – breakdown by hand of electronic goods as the first stage of material recovery with the working and non-working components extracted and separated based on their type and nature (e.g. hazardous, inert, non-hazardous).

3. **Separation** – sorting of dismantled materials into separate batches and consolidating them for specialized material recovery either at the facility or other facilities specialized for the task (e.g. batteries, mercury containing equipment, mother board, wires). This can be done manually but is often improved through use of mechanical equipment such as shredders, magnets, cyclones, and eddy current separators.

4. **Recovery** – involves advancement of separated batches of materials into one or more specialized processes. For example, this may include copper recovery with remaining plastics being shredded or granulated, or other materials such as glass, steel or aluminium being recovered, and any residues being further refined. It may also involve high-temperature methods such as smelting and other pyro-metallurgical processes as well as the use of strong chemicals (such as acids and cyanides) for hydro-metallurgical extraction.

280. With the need to ensure that any handling or recycling of Mission e-waste is not conducted through the 'informal' sector, Missions may be challenged to confidently source and verify contractors with the appropriate capacity and equipment to guarantee that correct and environmentally safe procedures are followed, even for the initial dismantling and separation stages. Moreover, it is often difficult to ensure all end-to-end material flows are documented with a clear chain of custody and proven not to enter the 'informal' sector.

281. An alternative option is to export e-waste across borders to a location where environmentally sound recycling can be conducted but this is often expensive and difficult to organize and will also require administrative legal compliance with international agreements such as the Basel/Bamako Conventions (discussed below). Under these circumstances, and in the absence of proven locally available treatment and final disposal or reuse, many Missions have resorted to accumulating and storing their e-waste predominantly in shipping containers.

282. To address this situation and better ensure 'formal' recycling of Mission e-wastes, three initiatives have been implemented:

1. A Technical Discussion Paper: Potential Options for Improved E-Waste Management at UN Field Missions has been launched, and an e-waste Management Feasibility Report was developed that evaluated two potential e-waste recycling facilities in Kenya and Rwanda.
2. Based on the findings from the above reports, a revised SOW/SOR template for local or regional 'formal' recycling E-waste service contractors was developed (see section B.7). The SOW/SOR provides a higher standard of general and technical requirements and a more robust technical evaluation and verification process for bidding vendors as well as describing in detail the 'best practice' treatment and disposal standards and equipment specifications required for 'formal' recycling of E-wastes.
3. A Request for Proposal (RFP) for a global systems contract based on the above SOW/SOR template has been launched after a positive response from international vendors interested in providing a 'formal' recycling service to UN field Missions. It is hoped that a service contractor will be engaged by mid-2022 so that all Missions may utilize this contract for handling, recycling, and disposal of their e-wastes.

283. Ultimately, 'formal' e-waste recycling should be guided by Environmentally Sound Management (ESM) approaches to protect workers and ensure a minimal environmental footprint. Facilities should have the appropriate equipment and technologies for their specific recycling area to optimize value and material recovery. All workers should be adequately trained for their specific operations to be able to perform them effectively and safely.

D.5.2.2 Minimum Standards & Recommendations

284. The following minimum standards and recommendations should be considered:

- E-wastes shall only be disposed through service contractors proven able to attain the standard levels of 'formal' recycling of e-wastes as set out in the template SOW/SOR.

- All Missions are strongly encouraged to use the Global Systems Service contract for the disposal of e-waste once this contract is awarded.

D.5.2.3 Key References

285. The following documents and links provide more details and reference information:

- REACT report on potential options for improved e-waste management across UN field missions is available here
- REACT e-waste management assessment report is available here
- Environmentally sound management of e-waste is available here
- The e-waste SOW/SOR service contract B.7template is discussed further in section B.7

D.5.3 HW3: Fluorescent and Mercury Halide Tubes and Bulbs

D.5.3.1 Summary Description & Guidance

286. Fluorescent tube lamps and compact fluorescent lamps (CFLs) are widely used throughout UN Missions as they provide an energy efficient source of lightning. Mercury halide lamps are used for intensive security lighting.

287. Lamps are normally replaced one at a time as they burn out but in some circumstances group re-lamping may be undertaken and is usually conducted at around 90 percent of the lamp's rated life. Group re-lamping operations generate large quantities of lamps to be stored or disposed of at a single time.

288. Fluorescent and mercury halide lamps in both tube and compact form are considered hazardous as they contain elemental mercury in vapor form which is extremely toxic and can bio-accumulate through the food chain. Mercury is also the only heavy metal that is liquid at room temperature and because of this and other useful properties is widely used in the manufacturing of other equipment such as medical manometers and thermometers. Studies have shown that it is more harmful to inhale the vapor from a bead of mercury than to ingest the same bead.

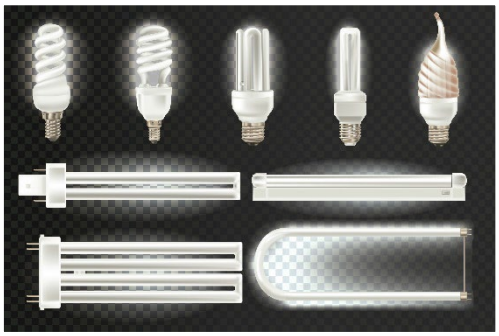


Figure 40: Fluorescent tubes and bulbs

289. The amount of mercury in fluorescent and mercury halide lamps varies across different manufacturers and lamp types and sizes. A typical modern four-foot (120cm) tube lamp or compact fluorescent lamp will contain between 3-7mg of mercury, but this can increase to 115mg in lower quality or older tube lamp products.

290. Mercury emissions from broken lamps can reach dangerous levels for people in poorly ventilated areas. Therefore, care must be taken during usage, transportation, and storage, and for later disposal or recycling.

291. To prevent the release of mercury into the environment, lamps shall be safeguarded from breakage. Spent tubes and bulbs should be collected and stored, ideally in their original packaging, until disposal is required.

292. The recommended safest way to dispose of fluorescent and mercury halide tubes and bulbs is to use a dedicated mechanical bulb crusher with a specialized vacuum system and filters to trap the mercury vapor (Figure 41). Bulb crushers are available for Mission procurement from the Global Systems contract for waste management equipment and are considered a key item for waste management.

293. The fluorescent or mercury halide bulbs are fed into tubes or through a hopper where they are imploded using spinning chains with the mercury vapor vacuumed into carbon filters and the remaining crushed glass and phosphor powder collected into a 200L drum below the unit. This material should then be transferred and encapsulated using the standard procedure outlined in section D.6.4 in specially engineered 200L drums with a cement/gravel/sand mixture to prevent leaching, followed by disposal in landfill.

294. Crushed lamp capacity per drum is between 300-1,500 tube lamps depending on their length (e.g. four-foot or eight-foot) and type (e.g. T5, T8, T12, etc.) and can alternatively take up to 3,000 CFLs up to 6 inches (15cm) wide.

Figure 41: Fluorescent bulb crusher

295. There may be situations when a mechanical bulb crusher may not be available. In this case, a significantly less satisfactory alternative involves fluorescent lamps being manually crushed using shovels or a weighted tamping tool in an open

concrete floored area with continual wetting provided by a spray headed water hose to reduce dust emissions and mercury vapor release before the resultant material is collected and encapsulated as above. However, considering the relatively low cost of a mechanical bulb crusher (i.e.. approximately USD 8,000), their portability (only a few units will be required), and the ability to safely stockpile tubes and bulbs, this should only occur only in exceptional circumstances. Appropriate PPE must be used by personnel conducting mechanical or manual operations.

D.5.3.2 Minimum Standards & Recommendations

296. The following minimum standards and recommendations should be considered:

- Fluorescent lamps shall be safeguarded from breakage during collection, handling, transportation, and storage.
- All personnel should be adequately trained in the use of a bulb crusher and provided with appropriate PPE.
- Mercury containing carbon filters should be adequately encapsulated when full to prevent leaching before disposal at landfill (see section D.6.4).
- Manual crushing should only be used as a last resort in the absence of a bulb crusher or ability to stockpile.

D.5.3.3 Key References

297. The following documents and links provide more details and reference information:

- A Global Advice note on fluorescent tube and bulb disposal is available here
- Information on bulb crusher equipment is available here

D.5.4 HW4: Lamp Ballasts

D.5.4.1 Summary Description & Guidance

298. Lamp ballasts are a key feature of many standard fluorescent and light-emitting diode (LED) light systems. They are a type of electrical resistor that controls and regulates supplied current during operating phases for certain bulb types. They come in a range of sizes and types and over time will eventually fail and need to be replaced.

Figure 42: Light ballasts

299. Lamp ballasts manufactured before 1980 may contain polychlorinated biphenyls (PCBs) which are hazardous to both the environment and human health. After 1978 PCBs were banned in the use of lamp ballasts and those manufactured thereafter were marked with 'No PCB, non-PCB or PCB free' to indicate they do not contain any PCBs. If a ballast is suspected to be more than 30 years old and does not have this marking, the date of the product or the catalogue code should be checked against table 7 below to determine if the ballast contains PCBs. It is however unlikely to encounter such lamp ballasts unless an older building is occupied by the Mission. If an older lamp ballast is suspected to contain PCBs either by identification in the table below, or because it cannot be determined appropriately, the ballasts should be stored in a lidded metal container (e.g. 200L drum or bucket) and a communication sent to GSC/ETSU to provide advice on correct handling, storage, packaging, transportation and disposal. PCBs containing ballasts will generally not be harmful to personnel unless they are shown to be leaking.

300. All modern ballasts generally used across Missions will be considered non-hazardous, but they may contain some recyclable materials such as metals. For this reason, they should be considered an e-waste and dealt with by an e-waste service contractor either arranged by the Mission or as part of the global systems e-waste contract.

D.5.4.2 Minimum Standards & Recommendations

301. The following minimum standards and recommendations should be considered:

- Lamp ballasts suspected to be greater than 10 years old shall be evaluated in line with the method described above to ensure they are PCB free.
- E-waste service contractors should demonstrate 'formal' e-waste processing in line with the methods described in the SOW/SOR e-waste service contract template (see section B.7) and through inspection of the service contractor premises using the standard checklist for e-waste contractor inspection.

D.5.4.3 Key References

302. The following documents and links provide more details and reference information:

- Information on lamp ballasts and their correct disposal is available here

Table 7: Evaluation table for older (>30 year) lamp ballasts potentially containing PCBs

MANUFACTURER	DATE CODE	LOCATION	NOTES
ADVANCE	1-90 month-year January 1990	Stamped on the cover	Pre 1979 could contain PCB 1978 was a transition year
ALLANSON Division of Jannock	DM month-year 1969=A, no Q April-1981	Stamped on ballast nameplate	Switched to non-PCB in 1980 Code AM and high do not contain PCB May 1987 switched to numeric (i.e. 0587) and added "NO PCB"
GENERAL ELECTRIC Canadian	17A287E	Up left side of label	Ends in E (for environment) or E1, ER, EW, means no PCB A or N is PCB
	2811 year backwards-month November-1982	Stamped on back	8701 onwards are non-PCB
HOLOPHANE Canada	Alpha numeric	Capacitor	Only HID ballasts After 1980 non-PCB
MAGNATEK Polygon	218 XX XX (pre '68) J XX XX (after '67) W XX XX (after '77) Xs are year & month	Ballast label	After July 1980 non-PCB 1978 to 1980 must have green sticker or "NO PCB" on label
MAGNATEK Universal Manufacturing	C79 month-year March-1979	Ballast cover opposite company label	Switched to non-PCB in 1978 Marked "NO PCB"
PHILIPS Lighting	575 month-year January-1968	Stamped on side or back	Stopped using PCBs in late 1978 Marked "NO PCB"
SOLA Canada	A68 month-year January-1968	Ballast label	1980 or later (A80) are non-PCB
SOLA Electric (USA)	61F311EG year-month-lot-plant June-1961	Nameplate on housing	1980 or later are non-PCB
WESTINGHOUSE Canada	A-78 month-year January-1978 or 01-99 month-year January-1999	Stamped on enclosure	1978 onward have "NO PCB" marked on the label Canadian General Electric date code system since early 1970s

D.5.5 HW5: Cooling Refrigerants

D.5.5.1 Summary Description & Guidance

303. Refrigerant freon gases are used in all refrigeration equipment such as heating and ventilation air conditioning (HVAC) units, commercial and domestic fridges, chillers, freezers, ice makers and dehumidifiers. Many of these refrigerants, especially older gases such as CFCs and HCFCs can, if not disposed of properly

and released to the atmosphere, result in major environmental impacts through their ability to cause ozone depletion and their potent contribution towards global warming. Venting of these gases is therefore considered illegal under the Montreal Protocol on Substances that Deplete the Ozone Layer, a global agreement that all 197 countries signed.

304. A list of the types of refrigerant gases observed across Missions is provided in Table 8 which indicates the Ozone Depleting Potential (ODP) and Global Warming Potential (GWP) for each gas, and whether they are currently in use or banned.

305. Of the banned gases, HCFC 22 is by far the most common refrigerant due to its use in wall and split type HVAC units. While banned for manufacture and trade, this gas can however continue to be used, but only in units that were originally supplied with this gas type. The bottom four refrigerants are used across a range of equipment and while having a zero ODP they are still considered to impact the environment due to their high GWP. The new Global Systems contract that will provide HVAC units to Missions will address this problem by use of an advanced refrigerant with a GWP of less than 700.

Figure 43: Refrigerants observed at UN Field Missions

Table 8: Banned refrigerant gases observed at Mission locations

Gas Type/Number	Ozone Depleting Potential (ODP)	Global Warming Potential (GWP)	Impact rating	Status
CFC 11	High	4750	High	Banned
CFC 12	High	10900	High	Banned
CFC 502	High	4657	High	Banned
HCFC 22	Medium	1810	Medium	Banned
HCFC 402A	Medium	2788	Medium	Banned
HFC 134A	Zero	1430	Medium	In use
HFC 404A	Zero	3922	High	In use
HFC 407C	Zero	1774	Medium	In use
HFC 410A	Zero	2088	Medium	In use

306. When refrigeration equipment or HVAC units are no longer required, or if a Mission site is to be liquidated, these units may have to be decommissioned with the following options available depending on their condition:

- When a site is to be handed over to a national or local government or another entity and includes all infrastructure, and the refrigeration and HVAC equipment still in good working condition, with refrigerant charge intact, it may be donated as part of the overall handover agreement.
- If the refrigerant or HVAC equipment is not wanted or not in a good working condition, it may be sent back to the manufacturer if a takeback scheme is in place, or if not, can be decommissioned for spare parts or for recycling (e.g. scrap metal) with remaining parts sent to landfill ensuring that all refrigerant gases are first extracted correctly as indicated below. Alternatively, a dedicated ODS collection service operated by the government may be used.
- Where a take-back scheme exists, an assessment should be conducted on whether it is economically and environmentally advantageous to use this service, or to keep the unit for spare parts, factoring in disposal costs.
- Recovery of refrigerant gases shall only be carried out by certified operators using proper certified equipment, so that the extracted gases can be safely recycled, reclaimed, or destroyed by an appropriate and licensed facility in line with national and international regulations.
- Venting of refrigerant gases into the atmosphere shall not occur in any cases and Mission contracted refrigerant and HVAC operators shall use all precautions to avoid this.
- For information on the detailed steps for correct recycling of both refrigerators and HVAC units to be used in the SOW/SORs for service contractors or for 'in house' recycling, the Guideline on the Manual Dismantling of Refrigerators and Air conditioners is available at the link below.

D.5.5.2 Minimum Standards & Recommendations

307. The following minimum standards and recommendations should be considered:

- A detailed SOP for refrigerant equipment procurement, operation, maintenance, and end of lifetime disposal should be developed by the Mission based on the UNFICYP SOP example provided in the reference section below.
- Regular maintenance and leak check inspections should be conducted to prevent accidental leakage of refrigerant gases from refrigerant equipment. If a leak is detected, the equipment should be repaired without delay,
- Records, which may be requested by BOA or OIOS audits, shall be kept of all refrigerant equipment supplied, maintained, and decommissioned across the Mission. They should include:
  - Quantity and type of the refrigerant equipment and refrigerant gases installed
  - Quantities of refrigerant gases replaced during maintenance or due to leakage

– If the equipment was decommissioned, the measures taken to recover and dispose of the refrigerant gases.

D.5.5.3 Key References

308. The following documents and links provide more details and reference information:

- An example SOP on HVAC operations, maintenance and decommissioning from UNFICYP is available here
- More details on the recovery of refrigerant gas are available here
- Information on how to dispose of refrigeration and HVAC equipment is available here

D.5.6 HW6: Waste Petroleum, Oil and Lubricants (POL)

D.5.6.1 Summary Description & Guidance

309. Used POL are a hazardous pollutant waste material that requires responsible management to avoid negative environmental impacts. Used POL mainly consist of three products: contaminated diesel fuel, used engine oil and other lubricant oils. Used POL primarily removed during servicing cycles is generally deemed unsuitable for further use due to the presence of contaminants and impurities or the loss of its original properties. Contaminants can include water, dirt, insects, metal particles, oxidation products, corrosion inhibitors, lead and PCBs.

310. Used POL is generated from the following Mission operations:

- Vehicle and plant equipment servicing
- Generator servicing and fueling
- Fueling stations and storage.

Figure 44: Well organized and poor storage of POL products

311. In order to avoid pollution, it is important to:

- Ensure all fuel transfer, vehicle servicing areas and generator stations have concrete hard floors with appropriate bunding for adequate containment and drainage to a specific sealed collection sump or tank.
- Ensure clear SOPs for drainage (e.g. oil change and oil filters), placement, storage and collection for used POL products are in place and complied with.
- Ensure spill response kits are available at all service areas and UN commercial vehicles.

312. Under the current Turnkey service contracts fuel providers to Missions are responsible for takeback of all used POL products which they are required to recycle or dispose of in line with 'best practice' environmental standards. For some Missions, specific contracts are in place for managing used POL products.

313. Generally used POL products may be considered a resource of value and would therefore not be expected to be simply disposed of. Moreover, if they are poorly managed or disposed of (e.g. directly into the ground or into a water body, including sewers) this could have major environmental impacts and harm human health.

314. Used POL products can be recycled or reused in a variety of ways through an authorized processor approved by national environmental authorities and in line with best practice methods including

- Throughhe recovery of heating value, once the used POL has been filtered and processed to remove contaminants to approved standards. The filtered POL can be used as a fuel source in appropriate heating equipment that includes proper emissions control systems to prevent air pollution. (e.g. heating water, boiler fuel).
- Through some form of filtering, cleaning and reclamation to approved standards to restore the original properties and allow reuse (e.g. engine oil).
- Through a more sophisticated re-refining process to produce a variety of higher quality base oil grades that can be used to produce new oils, and which may further provide benefits through reduced consumption of virgin oils.

315. Table 9 below provides a summary of these processes and outlines the advantages and disadvantages for each. For used POL products produced by UN Missions, the option of direct incineration unless undergoing effective contaminant removal through filtering is generally considered unsuitable whereas reprocessing/reclamation is probably the most viable and acceptable option. While re-refining would also be acceptable, it is a more sophisticated process that requires higher capital investment and would normally only be viable at facilities with a high volume of waste used oils.

Table 9: The three broad types of POL recycling

Method	Advantages	Disadvantages
Direct Incineration At minimum contaminant removal through filtering must be conducted	• Economically feasible • Cement factories and other industries are willing to procure waste oil	• Air pollutant emissions could be a problem if contaminant removal is insufficient or if burned in poor quality burners/incinerators

	• Minimal processing required such as settlement of sludges and filtration in line with best practice to remove contaminants • **Generally considered below UN standards for used POL disposal**	• Can be opposed by regulatory and environmental authorities •
Reprocessing/reclamation Goes through a cleaning process to remove contaminants and particles such as metals so that it can be reused	• Can clean the oil to allow reuse for its original or an alternative use • The quality control of the reprocessed fuel is monitored by the processor • Simple techniques can be used and include heating, filtering to remove contaminants, dehydrating, and centrifuging • **Suitable standard for UN waste oils**	• Some capital investment is required for reprocessing equipment • Proper disposal of end wastes (e.g. sludges, used filters, metal fragments) is required • End wastes can often be used for asphalt production
Re-refining Goes through a more sophisticated cleaning process to remove contaminants and particles and thereby upgrade the used oil to a clean lubricant base to make new oils	• Environmentally sound long-term solution as it reduces the need for new oil production • Provides a ready supply of high-quality lubricant that can be sold • Can further provide stripped light fuels and diesel • Standard to be encouraged for UN waste oils but probably only viable in a large-scale system	• Requires a well-developed collection system ideally with good segregation • Market required to sell the refined lubricant oil • Requires more capital investment • More complex procedures required including pre-distillation, treatment with acids, solvent extraction, activated clay and hydrotreating • Proper disposal of end wastes is required

D.5.6.2 Minimum Standards & Recommendations

316. The following minimum standards and recommendations should be considered:

- An SOP for used POL drainage shall be clearly defined to ensure servicing is conducted in specific hard floored bunded areas, and that used POL products are adequately collected and stored until collection by the service contractor.
- Takeback by the fuel supplier is considered the primary option of disposal.
- If no takeback is available, methods for reuse or refining (as defined above) or alternative uses by a service contractor should be properly assessed and

their capacity demonstrated to ensure avoidance of environmental pollution and human health impacts.

- All methods for used POL must be approved by national authorities.
- Technical advice on used POL products disposal is available from GSC/ETSU and REACT.

D.5.6.3 Key References

317. The following documents and links provide more details and reference information:

- A guidance note provided to MONUSCO on POL management and disposal is available here
- For more detailed guidance on the Basel Convention Technical Guidelines used on oil re-refining or other re-uses of previously used oil is available here
- Fuel management guideline and the SOW for fuel and fuel model contract is available here

D.5.7 HW7: Metal Containing or Specialized Paints, Adhesives and Preservatives

D.5.7.1 Summary Description & Guidance

318. Most paints fall into one of two categories: water-based or oil-based. Water-based formulas are sometimes referred to as latex, vinyl, or acrylic. Oil-based formulas are sometimes referred to as alkyd, polyurethane, or varnish. Paints may be regulated as a hazardous waste when disposed, depending on the formulation.

319. Oil-based paints (including stains) are regulated due to their flammability and the presence of volatile organic compounds (VOCs) such as xylene and toluene. However, paints (both water-based and oil-based) and stains that contain certain metallic pigments or fortifiers are regulated as a hazardous waste when disposed. Regulated metals include cadmium, chromium, lead, silver, barium, mercury, arsenic, and selenium.

320. Aerosol cans containing paint and other materials are also regulated as a hazardous waste when disposed. This can be due to the oil-based paints in the can, certain chemical mixtures, or the propellants.

321. Information concerning the presence of regulated materials and the type of formulation can be obtained from the label, material SDS, or manufacturer.

322. Paints may be considered waste if spoiled, unused or obsolete due to a site closure. Depending on the condition of the paint, the following options are available for each paint type.

Figure 45: Industrial and aerosol paints and thinners

Water-based Paints

323. Water-based paints that are designated as waste and do not contain regulated metals can be dealt with using the following options:

- If in a decent usable condition, paints may be donated to other UN Missions or agencies, the local authority, or to local community groups for reuse.
- Where donation is not viable or the condition of the paint is poor, containers may be opened, and the paint allowed to dry out. For large quantities this may take several days and during this period the paint should be protected from rain. If only a small quantity, this process may be speeded up by painting cardboard with the paint to air dry or alternatively it can be mixed with a material such as cat litter, vermiculite, sawdust, or shredded cardboard/paper to soak up the paint and speed up the overall drying process. Once dry, the paint may be disposed of as normal waste at a Mission landfill or dumpsite.

324. Water-based paints that are designated as waste but are shown to contain regulated metals, can be dealt with using the following options:

- Depending on the type of paint, an assessment of the risks associated with the metal content in the paint should be conducted using the SDS and documented.

- Depending on the result of the above assessment, donation may be considered if shown to be minimal risk as outlined above. Alternatively, when some level of risk is identified, the paint may only be donated to a commercial entity that has a clear and direct demonstrated use for the product.
- Where donation is not viable or the condition of the paint is poor, a drying process in line with the procedure above may be conducted but ensuring appropriate PPE is used by the operator rated at the hazard and/or risk level associated with the specific type of paint as indicated in the SDS and the assessment report for the product.

Oil-Based Paints

325. Where possible, oil-based paint should be substituted with water-based paints. If oil-based paint must be used, all wastes must be managed appropriately. The following options are available:

- If the paint is a standard oil-based paint product and is in a usable condition, donation may be conducted as above.
- If the paint is considered specialized, or specifically hazardous (e.g. presence of metals), donation may only be considered to a commercial entity that has a clear and direct demonstrated use for the product. The SDS for the product should be reviewed and an assessment conducted to show there is no heightened risk for the reuse of the product by the identified commercial entity.
- Where donation is not viable, it is generally recommended that oil-based paints, since they contain VOCs that react when released to form low-level ozone or smog, and because they are flammable, should not be dried for disposal. In this case:
  - Depending on the quantity and the specific circumstances at a Mission, this may be considered the only option and if it is to be conducted, the risks must be fully assessed before implementation.
  - Drying of the paint should only be conducted in small batches and ideally with the paint being mixed with an absorbing medium such as cat litter or vermiculite to speed up the drying process.
  - As there will be fume and possible ignition risk drying oil paints, this procedure should only be conducted in an open area well away from any facilities, offices, or communities (approximately 100m) and with operators wearing appropriate PPE, including a fume rated mask.
  - Fire extinguishing equipment rated for the product and adequate to cope in the event of fire should be available at the site.

Never discharge any oil-based paint or residuals down the drain.

Paint Thinners

326. The following options are available for used paint thinners:

- Collected in metal cans or glass bottles with a tight-fitting lid and labelled ‘hazardous waste’.
- Thinners can be recycled by placing them in a covered container and allowing the paint solids to settle for several weeks. After the solids have settled, the

clear supernatant liquid can be poured off and reused. The remaining solids can be disposed at landfill.

- Alternatively, sand soaks or vermiculite may be used to absorb the thinners which can then be spread over a hard surface to aid drying.

Never discharge any paint thinners or residuals down the drain.

Aerosol Cans

327. The following options are available for full or partially full aerosol paint cans:

- Donation of the product for reuse as above.
- Emptying of the product following by provision of the can to a scrap metal contractor for recycling.
- Cans that have been emptied and contain no residual materials or pressure are not regulated as hazardous wastes and can be disposed at landfill if no scrap metal contractor is engaged.

Never puncture an aerosol can as this may cause an explosion.

Industrial Adhesives

328. Certain industrial adhesives and solvents are considered hazardous. They include solvent contact adhesives, chemically curing adhesives including single and double component epoxies and polyurethanes, and silicone mastics. Wood glues and hot melts tend to be considered non-hazardous.

329. The main hazards associated with industrial adhesives include flammability and irritation potential both on the skin and due to vapour release, which can cause eye and lung irritation.

330. The following options are available for industrial adhesives:

- If the adhesive is in a usable condition, it may be donated as above.
- If the adhesive is considered specialized, or specifically hazardous, donation may only be considered to a commercial entity that has a clear and direct demonstrated use for the product. The SDS for the product should be reviewed and an assessment conducted to show there is no heightened risk for the reuse of the product by the identified commercial entity.
- Where donation is not viable, it is generally recommended that adhesives should be dried for disposal. In this case:
  - Drying of the adhesives should only be conducted in small batches. Depending on the size of the container and adhesive type this can be achieved by opening the container, slitting the tube, or otherwise spreading the adhesive onto layers of cardboard to speed up the drying process. Two-part adhesives should be mixed before allowing them to dry.
  - With some solvent adhesives there may be fume and possible ignition risk and in this case the drying of the adhesives should only be conducted in an open area well away from any facilities, offices, or communities (approximately 100m) and with operators wearing appropriate PPE, including a fume rated mask.

– Fire extinguishing equipment rated for the product and adequate to cope in the event of fire should be available at the site.
– Once the adhesive product is dry it will be generally considered non-hazardous and inert and can be sent to landfill or if the SDS indicates, incinerated using a 'fit for purpose' twin chamber incinerator.

Never discharge any adhesives or residuals down the drain.

D.5.7.2 Minimum Standards & Recommendations

331. The following minimum standards and recommendations should be considered:

- Ensure that all planned donation of paint products, especially metal containing, or specialized paint and adhesives, is fully vetted including SDS review, and considered minimal risk with a handover and liability transfer certificate provided by the receiver of the goods.
- Disposal of oil or specialized paints, including aerosols cans and hazardous adhesives procedures, shall be reported in the form of an advice note which clearly indicates the risks and risk mitigation measures for the disposal procedure (e.g. small batch mixing with vermiculite, open air environment, PPE, etc.).
- Technical advice on paint/thinner/adhesive disposal is available from GSC/ETSU and REACT. Photos should be provided of the product and its label and SDS if available.

D.5.7.3 Key References

332. The following documents and links provide more details and reference information:

- Information on paint disposal is available here
- Information on disposal of household hazardous wastes including paints is available here

D.5.8 HW8: Sanitary Waste

D.5.8.1 Summary Description & Guidance

333. Sanitary waste is not categorized as hazardous waste, providing it is non-infectious, but defined as 'offensive/hygiene waste' because it can be offensive in appearance and smell. It may include:

- Human and animal waste (faeces)
- Catheter and stoma bags
- Incontinence pads
- Sanitary waste (e.g. sanitary towels,tampons)
- Condoms
- Vomit and soiled human bedding from a non-infectious source

- Plasters or small dressings used in minor first aid or self-care.

Figure 46: Sanitary wastes

334. Sanitary waste is the product of a population that is not known to be infectious, and while considered 'offensive/hygiene waste' it does not require specialist treatment or disposal methods. There is nonetheless a small residual health risk from handling sanitary waste, which should be assessed, and appropriate precautions put in place. This is why is it included in the hazardous waste section. However, if the waste is suitably wrapped and bagged and properly handled in line with the standard solid waste regulations and is free from residual liquids, the risk to human health is considered low.

335. All Missions should provide a suitable method for the collection and disposal of sanitary waste, where required, which should be a mandatory inclusion in both male and female ablution blocks and toilets. Aside from human and animal waste (faeces), no sanitary waste should be flushed down toilets to prevent blockages or problems with the drainage system, WWTP or septic tanks and sewers.

336. All ablution areas should be provided with specific safe hygiene bins that include colour coded bin bags for the collection of sanitary waste. Due to the nature of the waste the bins should be emptied daily with the collected bagged wastes ideally sent for incineration at the WMY or using supplied barrel incinerators with air induction. If incinerators are not available, sanitary wastes can be sent to landfill, but this should be considered a last resort.

D.5.8.2 Minimum Standards & Recommendations

337. The following minimum standards and recommendations should be considered:

- A procedure for sanitary wastes shall be included in the SOP for hazardous wastes.
- A poster/signage should be placed above each sanitary waste bin, indicating the types of sanitary wastes, making clear which should not be flushed down toilets, and showing how they should be wrapped in paper before placement in the sanitary bin.
- Awareness campaigns should include a specific section on sanitary wastes and how they should be correctly disposed.

D.5.8.3 Key References

338. The following documents and links provide more details and reference information:

- An example SOP procedure for sanitary wastes is provided in the Hazardous Waste SOP template (see section B.6).
- Information on sanitary wastes is available here

D.5.9 HW9: Pesticides

D.5.9.1 Summary Description & Guidance

339. Pesticides are classified as any substance used to kill, repel, or control forms of plant or animal life that are considered pests. Across Missions the following pesticides are used:

- Herbicides are used to destroy weeds and for perimeter vegetation control.
- Insecticides are used for fogging and direct spraying for malarial mosquito control and to kill other insects such as cockroaches.
- Fungicides are used to prevent moulds and mildew.
- Rodenticides are used to control mice, rats and other vermin.
- Other compounds are used to deter snakes.

Figure 47: Pesticides observed across UN Field Missions

340. By their very nature, pesticides are potentially toxic to other organisms including humans and need to be used safely and disposed of properly to reduce human health and environmental risk. Pesticides can be in solid, liquid or aerosol form.

341. Pesticides may be supplied directly by the Mission through local procurement, provided as part of a service contract through Facilities Management, or be supplied and used by uniformed components. Due to their hazardous nature, it is vitally important that oversupply of pesticides is prevented to avoid unused products becoming expired. This represents both a wasted resource and the disposal measures required are complicated, time consuming, often costly and may include additional environmental risk. SDS should be provided for all pesticides supplied to the Mission or brought to the Mission via uniformed components.

342. Table 11 provides a list of pesticides observed in use across Missions and all are currently considered suitable as recommended by WHO for the listed use except for Dichlorvos and Chlorpyrifos. The use of both these pesticides should be discontinued, as they have high toxicity and low persistence which means that treatments need to be overly applied for a comparative level of effectiveness. In addition, Glyphosate has been indicated by WHO as a possible carcinogen and while few international bans are in place, this may change soon so missions may want to consider when current stocks of glyphosate are used to switch to the use of Glufosinate-ammonium or alternatively a Nanamoic Acid herbicide. These organic herbicides breakdown quickly in the soil pose little environmental risk are not considered carcinogenic and do not impact pollinators (e.g. bees). Links to the WHO classification of pesticides and a list of internationally banned pesticides are provided in the reference section.

343. Pesticide applications should not be conducted before dusk to ensure best effectiveness and avoid solar degradation of the residual pesticide until the following day. This is especially important to reduce potential impacts to pollinators that are active in the daytime.

Table 10: Range of pesticides observed in use across Missions

Pesticide Name	Pesticide Type	Pesticide Use	Comments on suitability
Insecticides			
Deltamethrin	Pyrethroids synthetic similar to natural pyrethrins	Malarial control – fogging, spray, and nets	WHO Recommended, Half Life (HL) = 5.9-17 days Moderately Hazardous
Cypermethrin	Pyrethroids synthetic similar to natural pyrethrins	Malarial control – fogging, spray, and nets	WHO Recommended, HL = 8-16 days Moderately Hazardous
Lambda-cyhalothrin	Pyrethroids synthetic similar to natural pyrethrins	Malarial and insect control (mosquitos and cockroaches) – fogging, spray, and nets	WHO Recommended, HL = 30 days Moderately Hazardous
Permethrin	Pyrethroids synthetic similar to natural pyrethrins	(Mosquitos and cockroaches) – spray and nets	WHO Recommended, HL = 40 days Moderately Hazardous
Malathion	Organophosphate	Malarial control – fogging, spray, and nets	WHO Recommended, HL = 7 days Slightly hazardous Less toxic than other organophosphates
Dichlorvos	Organophosphate	Insect control (e.g. cockroaches	Banned in the EU since 1998, HL = 2 days Highly Hazardous **Not recommended for use** due to high toxicity against short persistence so has to be overly used to be effective
Chlorpyrifos	Organophosphate	Insect control (e.g. cockroaches	HL = 7 days Moderately Hazardous **Not recommended for use** due to high toxicity against short persistence so has to be overly used to be effective
Herbicides			
Glyphosate	Acid and salt forms	Non-selective plant control – spray	Highly effective herbicide with low environmental impact but controversial as indicated by WHO to be a probable carcinogen. Pure form far less toxic than mixed products such as **ROUNDUP**.
Glufosinate-ammonium or Nanamoic Acid	Acid and salt forms	Non-selective plant control – spray	Alternative to Glyphosate. Provides broad spectrum weed control, rapidly breaks down in the soil, poses little environmental and health risk and does not impact pollinators (e.g. bees)

Rodenticides			
Bromadiolone	NEOGEN, Anticoagulant as a rodent poison	Normally used as bait pellets but can also be in powder from	Extremely Hazardous but needs to be to act as an effective rodenticide Secondary poisoning risk to birds and mammals Use should be restricted to when a direct rodent problem is evident. Extreme care should be taken when handling this product
Reptile repel products			
	Lime mixed with chilli	Poured around the perimeter of fences and buildings	Reported as an effective snake repellent

344. For obsolete or expired pesticides in either solid or liquid form, two options can be used for disposal:

1. High temperature incineration can be conducted for small quantities only. Pesticides are poured onto textile absorbents (e.g. oil spill kits) or sawdust material to absorb the liquid and then incinerated using 'fit for purpose' twin chamber units at the highest possible temperature (minimum 850°C) and ideally with advanced pollution controls such as wet scrubbers, lime dousing and ceramic filters.
2. Alkaline hydrolysis can be conducted for small and larger quantities using specific treatment tanks. Pesticides are mixed with an alkaline product to bring the pH above 12 to denature the active ingredients. The mix is left for a number of days depending on the pesticide type and then neutralized using an acid product to bring the pH to 7-8. The liquid may then be dispersed over a hard surface area (e.g. carpark or road) for evaporation (see section D.6.3 on alkaline hydrolysis). This treatment should only be conducted by a trained expert in this type of chemical treatment.
3. Never pour leftover pesticides down the sink, into the toilet, or down a sewer or street drain.

345. For aerosol pesticides the best solution is to continue to use them until they are empty. One problem observed across Missions are large volumes of these type of sprays being discontinued for use after expiration. However, it is unlikely that these sprays, often new and unused, would not work, and may only require a small increase (e.g. 5 percent) in the amount of the product used for the same level of effectiveness. This has been demonstrated with aerosols expired more than 10 years which quickly and effectively killed cockroaches.

346. All packaging of both solid and liquid pesticides is likely to retain a small residual amount of pesticide even when empty. Therefore, any reuse must be prevented by conducting the following:

- All glass, metal and plastic containers shall be rinsed out three times with water and the wastewater collected for treatment with an alkaline product in line with the alkaline hydrolysis method.

- All rinsed plastic or metal containers shall be punctured, cut into pieces, or shredded to prevent their reuse and then either incinerated in high temperature incinerators or sent to landfill.
- Glass containers should be carefully broken to prevent reuse and the glass shards collected and disposed through burial or encapsulation.
- Aerosol cans must be fully emptied so that no propellant/pesticide remains and can then be safely punctured, rinsed three times and the empty cans sent to landfill or provided to a scrap metal contractor for recycling.
- All plastic bags containing pesticides in powder form should be collected and placed into bin bags and sent for incineration. These bags should not be sent to landfill/dumpsites due to the risk of poisoning and environmental pollution.

D.5.9.2 Minimum Standards & Recommendations

347. The following minimum standards and recommendations should be considered:

- Disposal of pesticides is a specialized activity and shall only be conducted by personnel specifically trained for such disposal treatments.
- Before any disposal treatment, an advice note should be prepared clearly indicating the method, the risk of the procedure, and the risk mitigation measures required.
- Technical advice on pesticide disposal is available from GSC/ETSU and REACT.
- All pesticide containers shall be made unusable and disposed of appropriately to prevent cross contamination.

D.5.9.3 Key References

348. The following documents and links provide more details and reference information:

- Advice note on alkaline hydrolysis for pesticide products is available here
- Guidelines for the management of small quantities of unwanted and obsolete pesticides (FAO) is available here
- The WHO classification for pesticides and the PAN list of prohibited pesticides by country are available here

D.5.10 HW10: Gas Cylinders

D.5.10.1 Summary Description & Guidance

349. Across Missions a range of gas cylinders may be utilized. They include:

- Propane/butane or natural gas cylinders for cooking purposes
- Medical oxygen cylinders
- Nitrogen cylinders
- Oxygen/Acetylene cylinders for welding, metal heating or cutting
- Freon gas cylinders for refrigeration

- Fire extinguishers.

Figure 48: Different types of cylinders

350. Gas cylinders may be considered a waste item due to:

- Obsoletion related to site or operational closure
- End of life of equipment that the cylinder supports (e.g. medical, HVAC)
- End of life of the cylinder itself, normally defined through a testing process whereby the integrity of the tank fails and is then condemned for further use
- Direct damage to the cylinder making it unusable.

351. Gas cylinders themselves are not considered hazardous but the gases that they contain can be due to potential flammability (e.g. cooking gas), explosion (e.g. oxygen) or environmental impact (e.g. refrigerants - see section D.5.5). While a cylinder may be indicated as empty, usually some residual gas will remain inside, and is a common practice to prevent internal corrosion of refillable cylinders. End of life cylinders therefore need to be decommissioned by having any residual gases removed by a qualified service technician/contractor. Thereafter the completely empty cylinders should have their valves removed to indicate they are no longer in use.

352. All un-valved cylinders made either of steel (round bottom in a rubber boot) or aluminium (flat bottom) will have scrap value and can be sold to a scrap metal vendor.

D.5.10.2 Minimum Standards & Recommendations

353. The following minimum standards and recommendations should be considered:

- All cylinders should be considered hazardous until all gas contents are safely removed by a qualified technician and the cylinder is de-valved.
- All safety precautions shall be taken when removing gases from cylinders.
- Technical advice on cylinder de-gassing and recycling is available from GSC/ETSU and REACT.

D.5.10.3 Key References

354. The following documents and links provide more details and reference information:

- Information on safe handling and de-commissioning of end-of-life cylinders is available here

D.5.11 HW12: Toner & Ink Printer Cartridges

D.5.11.1 Summary Description & Guidance

355. In most cases lithographic inks and toners are not considered hazardous but exceptions exist. For example, if an ink/toner pigment contains heavy metals such as lead, cadmium, or chromium, or is mixed with solvents containing hazardous materials, it will be deemed hazardous and will generally be identified with hazard symbols or pictograms located on the outside of the printer cartridge. Most Missions are supplied with toner cartridges that are confirmed to be non-hazardous via the UN supply system from Danoffice but a small risk exists of hazardous toners being received if procured locally.

356. Although most toners are non-hazardous some care is needed when they are handled as the fine toner powder can represent a respiratory or eye exposure hazard if spilt or thrown into the air. However, with careful handling, the risk is considered minimal and further resolved using basic PPE, including mask, goggles, and gloves, when handling toner cartridges.

Figure 49: Toner and inkjet printer cartridges

357. As most toner cartridges are refillable when empty, they should be recycled and for HP toner cartridges supplied to Missions by Danoffice, a takeback scheme is in place for their return to the manufacturer. Packing boxes and packing instructions are requested from the vendor for this scheme, and when a particular quantity threshold is met (e.g. a full 40ft container with 21 pallets equivalent to 3,500 empty cartridges), the cartridges are returned to the manufacturer.

358. A takeback scheme should be arranged with the supplier as part of the contract for cartridges that are supplied locally, or an ink refill vendor should be sought to help ensure recycling. If no takeback scheme is in place or a refilling vendor is not identified, the following options are available:

- Printer cartridges may be incinerated but only in twin chamber incinerators (not barrel incinerators) with a maximum of three cartridges placed in the incinerator at one time.
- Cartridges may be emptied into sand, mixed thoroughly and the emptied cartridges then shredded. The mixed sand and shredded materials can be sent to landfill.

D.5.11.2 Minimum Standards & Recommendations

359. The following minimum standards and recommendations should be considered:

- Missions should be supplied through the Danoffice contract to make use of the takeback scheme for recycling spent cartridges.
- Incineration is the preferred disposal method when a takeback scheme is not available.

D.5.11.3 Key References

360. The following documents and links provide more details and reference information:

- The Danoffice forms for takeback and a PowerPoint presentation on the correct procedure are available here
- Information on the hazards of printer inks and toners is available here

D.5.12 HW13: Used Vehicle & Plant Machinery Tyres

D.5.12.1 Summary Description & Guidance

361. Used tyres are generated from UNOE and COE vehicles and plant machinery. Used tyres are not classified as hazardous wastes, but due to their structure and the materials they are made of their storage and disposal should be responsibly managed to prevent:

- Stockpiled tyres collecting water becoming a breeding ground for mosquitos that spread diseases such a malaria and dengue fever.
- Whole tyres being dumped at landfills as they occupy considerable space and can resurface.
- Used tyres being used for illicit regrooving rather than 'formal' re-treading.
- Low grade pyrolysis reprocessing of tyres that pollutes the environment and risks worker health.

362. Across Missions used tyres are either disposed by the Mission or taken by contracted vendors for recycling (re-treading, regrooving) or reprocessing. Typically, good condition tyres will either be directly reused or re-treaded or used for patching.

Figure 50: Disorganized and organized stacking of tyres

Used tyre re-treading

363. Re-treading allows old tyres with a proven good structural quality to be recycled. It involves three main steps:

1. Expert inspection to determine if the original tyre casing is of a condition to be re-treaded.
2. If approved, the old tread is removed, the base casing cleaned, and a completely new tread and sidewall rubber added.
3. The new tread is vulcanized to the original tyre casing using a specialized curing process and is then ready for use.

364. If re-treading is done in the correct manner, the re-treads are safe to use and provide a second life to the tyre. Benefits include:

- Second use and even a third use of a tyre is environmentally friendly.
- Potentially saves landfill space.
- Reduces CO_2 emissions and oil consumption required to make new tyres.
- Re-treaded tyres are cheaper than the new tyres with little compromise to tyre integrity or longevity.

Used tyre regrooving

365. Regrooving tyres to extend the tyre life is generally only conducted on commercial truck tyres indicated as re-groovable on the side wall of the tyre. Regrooving is a specialist process in which the grooves in a tyre are re-cut using a handheld tool to a deeper level to restore up to 4mm of groove depth. Generally, it is best done when the tyre groove is worn down to 3-4mm, resulting in a 7-8mm tread depth being reinstated. Regrooving a tyre may only be conducted once.

366. This practice is not considered suitable for passenger car tyres as the tread depth in the grooves is generally not adequate and can seriously compromise the safety and structural integrity of the tyre. For this reason, passenger car tyres are not marked as re-groovable on the side walls.

367. Despite these constraints there is evidence that regrooving of car tyres is conducted at some Mission locations and Missions should pay attention and ensure that their tyre contractors are not conducting this practice illicitly on tyres they take.

Management of end of life tyres

368. For end-of-life tyres that cannot be directly recycled, the following reprocessing or disposal options are available:

- Shredding or cutting using mechanical shredders or specialized tyre slicers either for direct disposal in landfill or for size reduction for later granulation.

Figure 51: Tyre cutter and shredding tyres

- Granulation of the tyres into small rubber granules through granulation machines, grinding, or other more specialized temperature treatments. The granulate can then be sieved into different particle sizes and used for:
  - Road surfaces (modification of bitumen with rubber)
  - Flooring and surface for indoor and outdoor sports or children's play areas
  - Compounding material for various applications in rubber industries.
  - Roofing materials
  - Fuel for cement kilns.

Figure 52: Waste tyres shredded and processed to granules

- Pyrolysis is a process that uses heat, in the total or partial absence of oxygen, to induce a chemical conversion or breakdown of the organic compounds to produce a pyro-oil, carbon black and scrap steel. The pyro-oil may be used as a direct fuel in boilers, can be mixed in equal proportions with diesel and used as a fuel for industrial engines, or sent for reprocessing into higher grade fuels. Carbon black in its un-refined form can be used as a fuel source for cement kilns, or can be sent for reprocessing into pyro-carbon and used as an active carbon or as a thermal interface material (e.g. heat sinks).

Figure 53: Pyrolysis of waste tyres for oil extraction and carbonized wastes sold for fuel to a cement kiln

- Innovative reuse for chairs, tables, flowerpots, or other products. The following photographs are examples from UNSOS.

Figure 54: Innovative use of waste tyres by UNSOS

D.5.12.2 Minimum Standards & Recommendations

369. The following minimum standards and recommendations should be considered:

- Missions shall ensure that used tyre vendors do not conduct regrooving on passenger car tyres or truck tyres that are not stamped with 're-groovable' on the tyre side wall.
- If a vendor conducts pyrolysis, the facility should be inspected to confirm that unacceptable environmental pollution does not result.
- All waste tyre material sent to landfill must be cut or shredded before disposal.
- If reused innovatively, later disposal or donation should be considered upon Mission liquidation.

D.5.12.3 Key References

370. The following documents and links provide more details and reference information:

- Information on used tyre recycling, reprocessing or disposal is available here

D.5.13 HW14: Biomedical Wastes Including Expired Pharmaceuticals

D.5.13.1 Summary Description & Guidance

371. Biomedical wastes are generated from the daily medical functions of UN Mission Level I clinics and dental facilities and Level II and III hospitals operated by UN personnel or assigned military component. The COVID-19 pandemic has led to increased amounts of infectious wastes and PPE (e.g. masks, gloves) being generated across all Missions, and in the early stages concerns emerged that Missions could be overburdened with the marked increase. In response a specific practical guideline was provided for the handling, storage, and disposal of COVID-19 infected wastes, including PPE. This guidance clearly indicates that COVID-19 wastes should be treated no differently from biomedical wastes. In the following, both types of wastes are referred to as biomedical wastes.

372. Biomedical wastes, primarily due to their infectiousness or specialized medical use, are considered hazardous and must be handled and disposed in agreement with the specific protocols and standards promulgated by the Medical Unit.

373. Biomedical wastes may include:

- **Biohazard waste including COVID-19 wastes** – infectious materials and waste, human tissue, blood products, contaminated PPE, IV tubing, cultures and stacks
- **Sharps** – needles, ampules, broken glass, blades, razors, staples and other sharps
- **Soiled materials** – non-reusable bedlinen or clothing
- **Trace chemicals** – empty vials, ampules, gloves, gowns, wipes and packaging
- **Unused or expired pharmaceuticals** – general and controlled liquid drugs and tablets, ointments and reagents.

374. All biomedical wastes must be appropriately segregated into:

- Biohazard waste and soiled materials – generally red or yellow bins with corresponding-coloured bags are used for the collection of biohazard wastes with each bin clearly labelled with the biohazard sign.

Figure 55: Biohazard labels for biomedical waste bins

- Sharps – must be stored in specific medical standard containers for sharps which should preferably be cardboard but can also be plastic.

Figure 56: Biomedical waste sharp container

- Pharmaceutical waste and trace chemicals – a full inventory of expired pharmaceuticals should be prepared, and controlled pharmaceuticals kept in a locked cupboard until disposal.

375. In compliance with the Mission SOP, biomedical waste disposal may be conducted directly by the UNOE or COE medical facility, by an assigned waste management service contractor, or in some cases by a local medical establishment with appropriate biomedical waste disposal facilities. For controlled expired pharmaceuticals (e.g. opioids, anaesthetics, ethers, chloroform) destruction must be verified and signed off by the Mission Medical Officer or their assigned representative.

376. The standard disposal methods for biomedical wastes are:

- Incineration using 'fit for purpose' twin chamber pyrolytic biomedical incinerators. These can be UNOE incinerators taken from the Global Systems contract or provided as COE by the military component operating the medical facility. However, they must be demonstrated to conform with minimum

standards for such equipment and operate effectively for biomedical waste ash disposal (see section D.5.19).
- Autoclaving or sterilization. This is normally conducted by assigned local medical facilities.
- Repatriation of expired pharmaceuticals to the country of the military component medical facility. This requires verification.
- Encapsulation of specific expired pharmaceuticals in a sand or gravel concrete mix before disposal at landfill.

D.5.13.2 Minimum Standards & Recommendations

377. The following minimum standards and recommendations should be considered:

- Biomedical waste handling, collection, treatment, and disposal must be clearly described in an SOP signed off by the Chief Medical Officer.
- Biomedical waste management by a service contractor shall conform to the procedures and standards outlined in the above SOP and the SOW/SOR template for biomedical waste disposal detailed in section B.7.
- All expired controlled pharmaceutical (e.g. opioids, anaesthetics, ethers, chloroform) destruction must be verified, signed off and archived.

D.5.13.3 Key References

378. The following documents and links provide more details and reference information:

- The SOP template for biomedical waste handling, collection and disposal is detailed in section B.6 and is available here
- Guideline for COVID 19 waste management is available here

D.5.14 HW15: Expired Ammunitions & Fired Cartridge Casing and Lead Bullet Recovery

D.5.14.1 Summary Description & Guidance

Disposal of Unserviceable Ammunition

379. Ammunition is used across Missions by UN and UNMAS as well as by UNDSS personnel. It has a finite shelf life and when expired and the shelf life cannot be extended through surveillance and in-service evidence, the ammunition is considered unserviceable. When it is unsafe for transportation to the home country of the contingent so it can be demilitarized, it must be disposed in the Mission area. The approval process necessary before the disposal are provided in theSOP on Expenditure of Ammunition and Explosives on Operations (2004) and in the 2020 Manual on Ammunition Management.

380. In summary the following steps are required:

1. The contingent commander will obtain the authorization for disposal from the national authorities and start the process to get approval from the Senior Ammunition Technical Officer (SATO) and the Head of the Military Component/Force Commander through the Operational Ammunition and Explosives Expenditure Certificate (OAEC) in case the contingent was to be reimbursed for the disposed ammunition.
2. Force Explosive Ordnance Disposal (EOD) units are responsible for the disposal of unserviceable ammunition in line with their national standard technical execution methods.
3. If no EOD units are present, UNMAS may be requested to dispose of unserviceable ammunition.
4. Explosives used for the demolition are reimbursable.
5. A certificate of destruction shall be provided by the EOD unit or UNMAS to the military/police components.
6. All destroyed ammunition casings will be sent to the PDU along with a certificate indicating that they are free from explosives (FFE)and safe for disposal as metal waste.
7. The metal waste can be sold to a scrap metal vendor for recycling into new ingots or returned bact to the country.

Figure 57: Destroyed unserviceable ammunition

Disposal of Fired Cartridge Cases

381. The UN is responsible for providing firing ranges for practice shooting and weapon calibration tests. After a miltary/police component or UNDSS firing event all fired cartridge cases (FCCs) are to be collected and provided to the PDU along with a certificate indicating that the FCCs are free from explosives and safe for disposal as metal waste. Before this can happen however, as the FCCs remain in a good condition, it may be necessary to conduct some form of treatment to misshape the casings to ensure they cannot be refilled and reused.

Figure 58: Fired cartridge cases

382. Methods to achieve this may include:

- Shredding the casings using industrial shredders.
- Crushing the casings using a compactor or heavy plant machinery such as a bulldozer running over the casings.
- 'In house' re-smelting of the casings into ingots.

383. Following disfigurement, the FCCs or smelted ingots can be sold to a scrap metal vendor.

Removal of Lead Shots Following Firing Range Closure

384. Firing ranges will accumulate large amounts of used lead shot in the shooting area. In the event of the closure of the site, the lead shot, which represents a toxic soluble metal, will have to be removed to reduce risk for future land use of the site.

385. Remediation of the firing range should be conducted by the field Mission (Engineering Section) and will require:

1. Initial survey of the site to determine the extent of the range impact zone.
2. Excavation of materials and soil from the range impact zone.
3. Extraction of spent lead bullets from the soil, usually through a sieving process, to remove all lead shot and fragments.
4. Remediation of soil until analyses indicate a maximum safe threshold of 1,200mg/kg lead content has been reached.
5. Remediated soil may be replaced at the site or disposed of at landfill.
6. Removed lead shot should be sold to a scrap metal vendor for recycling into new lead ingots.

Figure 59: Removed lead shot from a firing range

D.5.14.2 Minimum Standards & Recommendations

386. The following minimum standards and recommendations should be considered:

- Unserviceable ammunition shall only be destroyed by Force EOD units, national qualified ammunition eperts fo the P/TCC or UNMAS.
- Disposal sites and the related SOPs for the disposal of unserviceable ammunition should be established in close coordination with host governments.
- Open burning and detonation (OBOD) as main disposal process should be avoided whenever possible, and it is not required from a safety perspective. More environmentally friendly demilitarisation methods (mobile demilitarisation units with incinerators and emission filtering systems) should be introduced, especially for the disposal of larger amounts of ammunition.FCCs should be misshapen to prevent potential refilling and reuse.
- Lead content in remediated firing ranges shall not exceed 1,200mg/kg.
- 'In house' smelting should be conducted using 'fit for purpose' smelting equipment and operators using appropriate PPE.

D.5.14.3 Key References

387. The following documents and links provide more details and reference information:

- Information on unserviceable ammunition disposal, FCC disposal and closure of firing ranges is provided in the 2020 Manual on Ammunition Management available here
- A guideline on 'in house' smelting of FCCs 'Used ammunition casing recovery' is available here
- Technical advice on firing range clean-up surveys and remediation is available from GSC/ETSU and REACT and a firing range excavation plan for UNAMID is available here

D.5.15 HW16: Ballistics Protective Equipment

D.5.15.1 Summary Description & Guidance

388. Ballistic protective equipment (BPE) is used by Mission personnel and military and police components to safeguard against personal attack, incoming projectiles, and blade use. BPE may include protective helmets, bullet and stab resistant jackets, ballistic protective plates, and arm and leg protectors. BPE helmets, jackets and body protection is generally made from specialized materials such as Kevlar or Aramid fibres, while the plates can be metal, ceramic, reinforced plastics or layered specialized resin composites with Kevlar.

Figure 60: Kevlar jacket, ballistic plate and protective helmets

389. When BPE is no longer required either through expiry, end of life or due to liquidation of a site or Mission it will be considered waste and should be sent to the PDU to arrange for its disposal either 'in house' or via a qualified service contractor. It is vitally important that such items are not passed on for illicit use and any destruction or recycling of these materials needs to be adequately verified with end disposal certificates required for final sign off.

390. With BPE generally being constructed from specialized highly indestructible materials (e.g. Kevlar/Aramid and composites), specific treatment or destruction methods will be required to ensure these materials cannot be reused in their original form. Options for the treatment or disposal of BPE include:

- Jackets and helmets may be reprocessed to extract the Aramid and Kevlar fibres for recycling into new products such a brake pads or textiles.
- Jackets may be cut along the seam joins into pieces using heavy duty shears and the separated pieces incinerated in twin chamber incinerators at a temperature above 850°C.
- Helmets may be cut into pieces using rotary disc cutters and then sent to landfill.
- Ballistic plates can be cut into pieces using a diamond tipped tile saw or broken into fragments using an air powered jack hammer. Fragments can be sent to landfill or alternatively mixed with aggregate for concrete flooring.

D.5.15.2 Minimum Standards & Recommendations

391. The following minimum standards and recommendations should be considered:

- All BPE shall be prevented from illicit reuse through complete destruction or transformation of the original form to render it unusable.
- End disposal certificates outlining type and precise quantities shall be provided by the service contractor and archived for reference.

D.5.15.3 Key References

392. The following documents and links provide more details and reference information:

- An advice note for the handling and disposal of BPE is available here

D.5.16HW17: Expired or Obsolete Chemicals

D.5.16.1 Summary Description & Guidance

393. Hazardous waste chemicals can be a particular problem for Missions as their safe and correct disposal often requires specialized expertise and treatments. A wide range of hazardous chemicals are used in UN and military/police operations and while generally supplied as consumables to be used, they can become wastes through:

- Expiration of the product
- Obsoletion due to a change in equipment for specific operations
- Despoilment
- Residual hazardous waste material after product use (e.g. water/wastewater reagents)
- Site closure or Mission liquidation.

394. Hazardous chemicals used across Missions include:

- Water/wastewater treatment (e.g. chlorine products, acids, alkalines, flocculants, membrane cleaners, lab reagents and testing kits, and bio-enzyme and inoculation products
- Deep cleaning or dilution products (e.g. solvents/thinners, peroxides, industrial disinfectants, alcohols)
- Machinery and equipment maintenance (e.g. antifreeze, condenser cleaner)
- Firefighting (e.g. extinguisher chemicals).

Figure 61: Accumulated stockpiles of hazardous wastes

395. While improved procurement through the UN UMOJA system can reduce oversupply, some Missions obtain hazardous chemicals independently through local procurement or via service contractors. For military and police components, chemicals are often self-supplied and are therefore more difficult to control and monitor. In this regard, the provision of 'best practice' guidelines (see section B.10) for both service contractors and military/police components is important, and should at minimum help ensure that any hazardous chemical brought into the Mission will be correctly labelled and contained, and include the SDS for that product.

396. Due to these variations in supply the type and quantities of hazardous chemicals used across Missions can vary markedly. A recent survey identified the supply of more than 26 water/wastewater chemicals and 29 water/wastewater testing reagents from both the UN system and via alternative suppliers.

397. All these chemicals are considered hazardous and specific guidance is required on their correct and safe handling, storage and final treatment or disposal. All identified waste chemicals shall be sent to the PDU with an accompanying inventory of items and quantities along with an SDS for each product per the required SOP for hazardous wastes. In addition, each waste chemical must be clearly labelled, even for used residual waste chemicals, and stored according to their hazards and compatibility with all waste chemicals placed off the floor on pallets or in drip proof containers (see section D.4.3 for details).

398. To determine and implement the correct treatment or disposal of hazardous waste chemicals, the following steps are generally required:

1. For correct technical guidance (at least for the first time) an inventory of hazardous waste chemicals with photographs of the container, label and SDS should be provided by the Mission to GSC/ETSU for evaluation.

2. Based on the findings of the above evaluation, specific advice notes or standard guidance will be provided that outlines the method/s of treatment/disposal, the resources of equipment and personnel required, the potential risks and hazards of the treatment process, and any risk mitigation measures required.
3. Depending on the recommended treatments, some may be conducted 'in house' by specifically trained Mission personnel, or others may require more advanced specialized expertise either from GSC/ETSU or a demonstrated qualified service contractor to train, conduct and/or supervise treatment and disposal operations.
4. A report on the treatment and disposal operations shall be prepared based on the reporting template provided and archived for reference.

399. The types of treatment or disposal options for waste chemicals may include:

- Potential donation for use if before expiration and in good condition.
- Takeback (for LCK water/wastewater reagents).
- Dilution and disposal through the wastewater system (very small quantities only – e.g. reagent residual wastes).
- Neutralization of the products using dilution and addition of acid or alkaline products (see section D.6.2).
- Chemical oxidation.
- High temperature incineration (see sections C.7 and E.2.1.1).
- Sand soaks followed by encapsulation (see section D.6.4).
- Encapsulation in concrete (see section D.6.4).

400. Even emptied packaging of both solid and liquid chemicals is likely to retain a small residual amount of the chemical. Any reuse must therefore be prevented by conducting the following:

- All glass, metal and plastic containers should be rinsed out with water three times and the wastewater collected for treatment with an alkaline or acid product depending on the original form.
- All rinsed plastic or metal containers shall be punctured, cut into pieces, or shredded to prevent their reuse and either incinerated in high temperature incinerators or sent to landfill.
- Glass containers should be carefully broken to prevent reuse and the glass shards collected and disposed through burial or encapsulation.
- All plastic bags containing pesticides in powder form should be collected and placed into bin bags and sent for incineration. These bags should not be sent to landfill/dumpsites due to the risk of residual hazards and environmental pollution.

D.5.16.2 Minimum Standards & Recommendations

401. The following minimum standards and recommendations should be considered:

- Chemical and waste treatment or disposal shall not be conducted without prior evaluation by GSC/ETSU regarding the appropriate methods and resources.

- Chemical waste treatment or disposal practices shall only be conducted by qualified operators with adequate equipment and PPE according to the risks the products and those associated with the treatment or disposal process as outlined in the guidance or advice note provided.

D.5.16.3 Key References

402. The following documents and links provide more details and reference information:

- A series of advice notes for reference are available here These notes do not however negate the need for the evaluation outlined above by GSC/ETSU before any treatment or disposal being conducted for waste chemicals.

D.5.17 HW18: Waste Bitumen

D.5.17.1 Summary Description & Guidance

403. Bitumen, also referred to as tar and asphalt, is a standard ingredient mixed with gravel for road building or used in pure form for waterproofing and sealing roofs. Consisting of a mixture of long chain hydrocarbons, it must be heated to over 200°C to be poured and is often mixed with a solvent to act as a softener to make the product more workable. It is characterized by:

- A high viscosity and boiling point
- Extremely low water solubility.

404. Stored unused bitumen may degrade over time and become unusable. Despoiling is liable to occur more quickly if the product is exposed to air, water, sunlight and heat which will cause the bitumen to harden and oxidize. Generally, stockpiles of bitumen will harden to a crust on the outside with softer less degraded bitumen remaining in the centre.

Figure 62: Waste bitumen piles and bitumen fire

405. Bitumen is classified as hazardous waste and contains several compounds that are proven carcinogens (e.g. compound that cause or contribute to an increased risk of cancer). The most important of these are polyaromatic hydrocarbons (e.g. benzopyrenes and cresols), which normally make up a very small percentage by mass of the bitumen.

406. Two further hazards of concern for waste bitumen are toxicity and fire, which are partly linked as fire generates toxic smoke and mobilizes potentially toxic compounds. In this regard the presence of dry brush covering any bitumen stockpile is of particular concern.

407. While bitumen has a relatively high toxicity if ingested or directly contacted in its heated form, its availability in the natural environment is limited due to its very low solubility, its tendency to attract dirt on exposed surfaces, and it's very high sorption ratio (i.e. readily bound by soil and waste carbon). Once the volatile fraction has been removed, however, bitumen is relatively slow to degrade, and solid bitumen remains relatively stable for hundreds of years.

408. Consequently, the main disposal practice available to Missions for despoiled bitumen products will be removal of the product for placement in a municipal

approved landfill, ideally in a specifically arranged excavated area with appropriate liner.

409. It is considered highly unlikely that significant quantities of properly disposed bitumen waste will start and continue to burn for a significant period. Commercial quality non-degraded liquid bitumen blend has a reported auto-ignition temperature of approximately 400°Celsius, compared to 350°C for polyethylene, 310°C for rubber and 230°C for paper. Degraded bitumen is anticipated to have a much higher ignition temperature, due to the prior loss of more flammable volatile compounds.

410. In summary, degraded and solidified bitumen is not anticipated to start to burn easily or to continue to burn without an accelerant and sustained very hot and well-oxygenated conditions. These conditions are not anticipated to be uniformly present at the landfill where any fires are mainly plastic based and smoulder at or near the surface due to poor ventilation. These fires however are long lasting and so can generate significant heat which could be conducted down into the landfill. It is also possible that anaerobic decay in the landfill generates methane, which migrates to the surface and ignites where sufficient oxygen and open flames are present, thereby adding to the intensity and longevity of the fire. Consequently, some parts of the landfill may experience transient and local high temperature fires with the potential to ignite and sustain bitumen burning.

411. The most appropriate risk management measure is to reduce the volume of bitumen likely to be ignited by existing fires and reduce its capacity to continue to burn and to spread. This can be achieved by the 'break up', dilution and absorption of the bitumen with an inert dense and fire-retardant material, such as coarse to medium grained subsoil (e.g. fine gravel, sand, silt). Clay can be used but has a limited absorption capacity for bitumen flow due to the viscosity of the latter.

412. It is assumed that the toxicity and fire risks to Mission personnel and contractors during bitumen removal operations can be mitigated through appropriate health and safety planning. The toxicity and fire risks for the disposed waste are nonetheless longer term and cannot realistically be controlled by any authority, apart from the above outlined measures.

D.5.17.2 Minimum Standards & Recommendations

413. The following minimum standards and recommendations should be considered:

- Waste bitumen should be broken up into pieces and mixed with a fire-retardant material (e.g. soil) before disposal at landfill to reduce the risk of fire.
- Appropriate PPE should be used when handling bitumen waste.

D.5.17.3 Key References

414. The following documents and links provide more details and reference information:

- Information on bitumen wastes provided in an Advice note written for UNMIL when under liquidation is available here

D.5.18 HW19: Contaminated Soils

D.5.18.1 Summary Description & Guidance

415. Contaminated soils may occur due to chemical spillage or poor fuel transfer management. Maintenance works for vehicles, electrical generator stations and fuel holding areas may also be responsible. Prevention and risk reduction measures include compliance with SOPs, concrete flooring with appropriate bunding, provision of spill containment kits, and correct storage and transportation of fuel, POL wastes and hazardous chemicals.

Figure 63: Examples of poor management of POL products

416. The following considerations and actions are required for the treatment and clean-up of contaminated soils:

1. Identify the source of the spillage and take measures to prevent further leakage of the contaminating products.
2. If a chemical spillage, the SDS for the product should be reviewed and actions taken in line with the guidance.
3. If wet product is present, use appropriate sorbent material such as pads, vermiculite, or sand to absorb all excess liquid.
4. Mark out the extent of the contaminated soil area and excavate the soil onto a sealed base such as concrete flooring or waterproof tarpaulin. The depth of penetration of the spillage will have to be determined and may require the testing of soil samples. Visual seepage lines may be visible and odour indicators may help to identify the extent of the spillage. As a precautionary measure, a further 20cm of soil may be removed below the identified penetration depth to ensure most of the contaminated soil is removed.
5. Excavated contaminated soils will require treatment or disposal depending on the spillage product. For POL contaminated soils, bioremediation shall be conducted to a maximum level of 5,000 ppm or lower of contamination (see section D.6.5). For chemical spillage, contaminated soils may require specialized treatments, soil washing, heat treatment or bioremediation. The SDS should be referred to and further advice sought from GSC/ETSU after providing information on the chemical product of concern.

D.5.18.2 Minimum Standards & Recommendations

417. The following minimum standards and recommendations should be considered:

- Adequate prevention measures are key for the avoidance of contaminated soils.

- Appropriate PPE should be used when handling contaminated soils and any clean up absorbents.
- Technical advice on prevention and treatment of soil contamination is available from GSC/ETSU and REACT.

D.5.18.3 Key References

418. The following documents and links provide more details and reference information:

- POL soil bioremediation is further detailed in section D.6.5 and under training in section E.4.

D.5.19 HW20: Biomedical Waste Ash

D.5.19.1 Summary Description & Guidance

419. Biomedical waste ash generated by the incineration of biomedical wastes and expired pharmaceuticals is considered hazardous as residual toxic properties and heavy metals may remain in the ash debris. Consequently, biomedical waste ash shall be disposed of in an appropriate and safe way to prevent soil or waterway contamination and minimize human health impacts.

Figure 64: Biomedical waste ash

420. Disposal of biomedical waste ash can be achieved using the following three options:

1. **Engineered hazardous waste landfill**

421. An engineered hazardous waste landfill has specific design requirements to receive a wide range of hazardous wastes that include:

- Double liner
- Double leachate collection and removal systems
- Leak detection system
- Run on, runoff and wind dispersal controls
- Construction quality assurance programme
- Continued maintenance and monitoring beyond the lifespan of the landfill.

422. As the required controls are both highly technical and costly to operate it is unlikely that such developed infrastructure will be available at most peacekeeping Mission locations.

2. Specially designed biomedical waste ash monofil

423. A biomedical waste ash monofil is an alternative option that can be constructed as part of WMY infrastructure, or where appropriate at the site of a Level II or III hospital where onsite incineration of biomedical waste is conducted. The ash monofil will be lined and sealed with an approved and appropriately sized HDPE liner (e.g. 1.8-4mm thickness) and have a basic leachate collection system incorporated as part of the design. As the ash monofil will only receive small amounts of biomedical waste ash, it will be relatively small, and it is recommended that it is covered by a roof to prevent rainfall incursion.

424. The monofil should be sized according to a maximum 10-year biomedical waste ash generation estimate with a 20 percent contingency added to ensure spare capacity. As the monofil will be sealed and capped with a concrete cover (and overlain with soil if required) either when full, or when the Mission site is liquidated, specific approval will be required by the landowner of the site or the municipal authorities recognizing that the monofil will be a permanent fixture. In certain situations, a smaller excavated pit lined with concrete rendered blocks and with a sealed concrete floor can be constructed. Once full, a wet slurry of mixed sand, gravel and cement can be poured into the pit to bind the ash in a solidified mass to prevent leaching, followed by a cap of concrete.

425. A link to guidance and specific design criteria for these two types of ash monofil is provided in the reference section below.

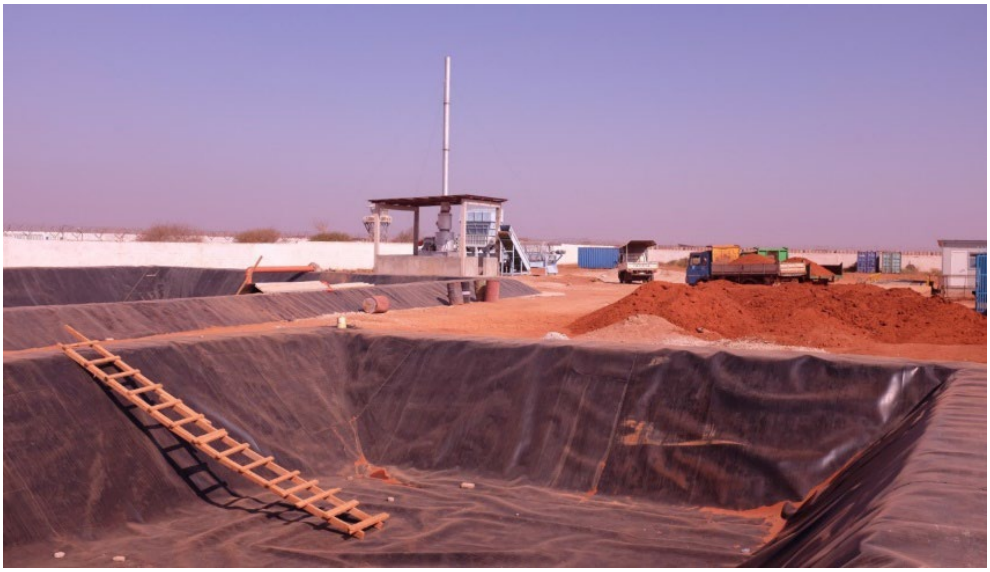


Figure 65: Ash mono-fill example

3. Encapsulation and solidification of the biomedical waste ash

426. A third option for the safe disposal of biomedical waste ash is through encapsulation in a sand, gravel, and cement mix for later disposal at municipal solid waste landfill. Through solidification, the encapsulation process creates a barrier between the waste components and the environment by either reducing the permeability of the waste, reducing the effective surface area for diffusion, or both. The encapsulated materials can then be placed at a solid waste landfill, ideally in a specially excavated lined site. A recommended encapsulation procedure for biomedical waste ash is given in section D.6.4.

D.5.19.2 Minimum Standards & Recommendations

427. The following minimum standards and recommendations should be considered:

- Biomedical waste ash shall only be disposed at engineered hazardous waste landfills, ash monofils, or if properly encapsulated, sent to solid waste landfills.
- Ash monofils must be constructed to the standard design template.
- Encapsulation should be conducted using the standard method outlined in section D.6.4.

D.5.19.3 Key References

428. The following documents and links provide more details and reference information:

- Information on disposal of biomedical waste ash and designs of waste ash monofils is available here
- Encapsulation is covered in section D.6.4

D.5.20 HW21: Hazardous Construction Wastes

D.5.20.1 Summary Description & Guidance

429. Hazardous construction wastes can either be generated directly from construction materials or result from renovations to an existing building that will demolish or disturb historical construction elements containing hazardous materials. Hazardous construction wastes may include:

- Asbestos
- Mercury switches
- Paints containing metals and preservatives (see section D.5.7)
- Adhesives (see section D.5.7)
- Solvents (see section D.5.7)
- Lamps and lamp ballasts (see sections D.6.3 and D.6.4).

430. Asbestos and mercury switches are discussed below. Details of the other hazardous constructions wastes are provided in the indicated sections.

Asbestos

431. Asbestos is a naturally occurring material that was historically used for a wide range of construction materials including corrugated roofing sheets, boiler and pipe insulation, ceiling and floor tiles, wall and ceiling insulation, and gaskets. The following characteristics were valued:

- Fibres are virtually indestructible
- Resistant to both chemicals and heat
- Stable in the environment
- Does not evaporate in air or dissolve in water
- Significant insulation properties.

432. Three main types of asbestos are used commercially: Chrysotile, Amosite and Crocidolite. All break into minute fibres up to 700 times finer than a human hair, and once released may stay suspended in the air for hours or even days.

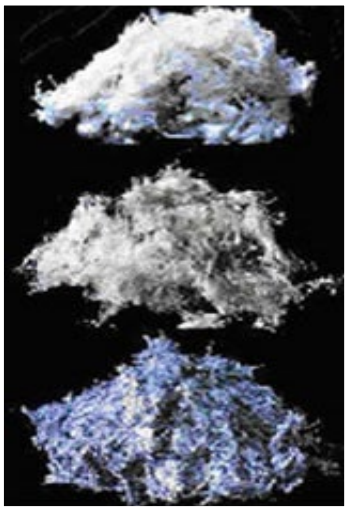


Figure 66: Three main types of asbestos

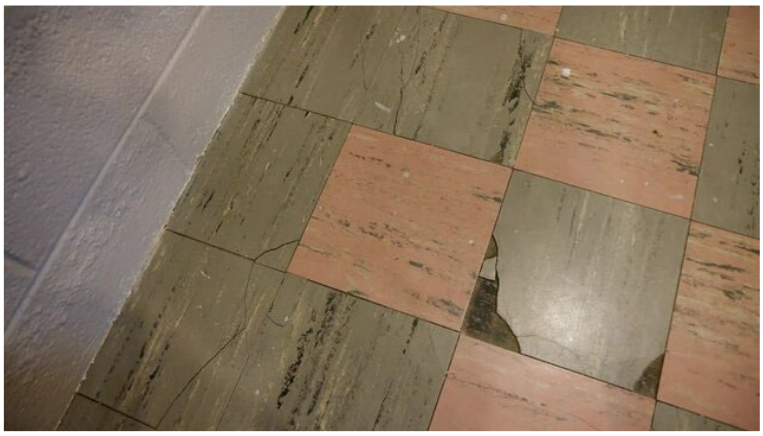


Figure 67: Asbestos containing products

433. These fine fibres can have chronic impacts on human health causing lung diseases such as Asbestosis, lung cancer and Mesothelioma.

434. If left undisturbed, asbestos is not generally considered harmful unless it is releasing dust or fibres that can be inhaled or ingested. It is most dangerous when it is friable or easily crumbled by hand, releasing fibres in the air.

435. Damage, deterioration and the release of fibres can be caused by water damage, drilling, grinding, cutting, sawing or breakage (e.g. striking).

Figure 68: Release of asbestos fibres from drilling

436. Internationally, it is recommended not to remove asbestos unnecessarily, as removing it can be more dangerous than simply managing it. For this reason, if any asbestos material is suspected or identified on a construction site at a Mission, work should immediately cease until a comprehensive assessment of the material and the possible risk to human health is determined.

437. Safe removal of asbestos is a specialized activity generally governed by national and international regulations, specific procedures, and the use of daily renewable asbestos proof PPE. Options available for dealing with asbestos include:

- Encapsulation to seal off the material in a surround material such as concrete.
- Enclosure by removing access to the site of the asbestos materials leaving them undisturbed.
- Removal and containment using specialized techniques with adequate controls (e.g. sealed vacuum containment systems, double bagging, appropriate PPE) to prevent airborne release of the fibres and worker exposure.

Mercury Switches

438. A mercury switch is an electrical switch that uses a small amount of mercury to close the circuit. Due to the presence of mercury, which is a poisonous heavy metal, these switches are considered hazardous for disposal. If spilled, mercury slowly evaporates and gives off invisible and odourless hazardous vapours. Consequently, their use has been eliminated in most modern applications, but their use may be evident in older equipment or in less regulated locations and correct handling and disposal is required.

Figure 69: Mercury switch showing bead of mercury

439. The following options are available to dispose of mercury switches and any other mercury containing equipment such as thermometers or other medical equipment:

- The switches should be kept intact and placed without breakage in double sealed bags or containers, and clearly labelled as containing hazardous mercury waste.
- If broken and the small amount of mercury is released, the work area should be isolated.
- Using correct PPE such as a mask with vapor filters and gloves, the beads of mercury can be collected using a piece of card, and the mercury picked up using the sticky side of duct tape.
- The mercury contaminated clean-up materials (cardboard, gloves, tape, etc.) should be placed into double sealed bags or containers and clearly labelled.

- The mercury switches and any collected mercury material can then be stored as hazardous waste until either a licenced and engineered hazardous waste facility is identified to take and dispose of them, or a hazardous waste service contractor demonstrates they can supply appropriate and safe disposal.
- If no suitable local solution is available, encapsulation of the mercury containing material can be conducted using a small-scale standard encapsulation method (see section D.6.4). This method should ensure the mercury materials are completely encased in a strong and robust concrete mix to form a solid non-leachable block that can be handled with no risk and disposed in standard landfill.

D.5.20.2 Minimum Standards & Recommendations

440. The following minimum standards and recommendations should be considered:

- If asbestos materials are suspected or identified at a construction site, the materials shall not be disturbed, the site is to be placed out of bounds, and a technical request for assistance provided to GSC/ETSU to determine next steps. This is likely to requiring sampling of the material and testing which requires a specific procedure to ensure safety of the sampler.
- All mercury disposal methods shall be verified as meeting international 'best practice' standards to minimize risk of mercury bead or vapor exposure.

D.5.20.3 Key References

441. The following documents and links provide more details and reference information:

- Information on Asbestos management is available here
- Information on Mercury and Mercury switch management is available here

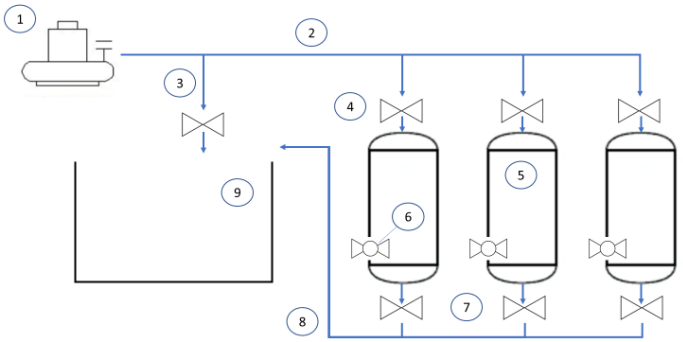
D.6 SPECIFIC TREATMENT OPTIONS FOR HAZARDOUS WASTES

D.6.1 Hazardous Waste Treatment Area

D.6.1.1 Summary Description & Guidance

442. For Missions to effectively conduct treatment procedures for hazardous waste chemicals, a hazardous waste treatment area (HWTA) should be organized. Both neutralization and alkaline hydrolysis will require dilution of hazardous products so a water supply and treatment tanks to hold the diluted solutions for treatment are needed. In addition, once the treatment is complete, the contained solutions in the treatment tanks will require draining either directly into a honeysucker truck for dispersion over hard surfaces such as roads, carparks etc., or for temporary storage in a containment tank (Figure 70). It should be noted that only the same treatment type solutions should be mixed or stored together in the containment or there may be a risk of a reaction between them. In addition, the treatment areas should be set

up on a concrete hard surface area, preferably with bunding for containment in the event of a spill.



1. Water supply
2. Water pipeline (2'')
3. Water pipeline (2'') connecting water supply to containment tank
4. Inlet valve(s)
5. Water tank(s)
6. Sampling valve(s)
7. Discharge valve(s)
8. Chemical discharge pipeline (3'')
9. Large containment tank for temporary storage of treated chemicals storage (optional)

Figure 70: Example chemical treatment area set-up

443. As some chemical waste products such as acids and alkaline bases can react with metals, treatment tanks and piping should be plastics such as HDPE, PVC or fibreglass.

444. Treatment areas should include:

- Emergency spill kits including absorbents
- First aid, washing facilities and emergency eye baths
- Firefighting equipment.

D.6.1.2 Minimum Standards & Recommendations

445. The following minimum standards and recommendations should be considered:

- Robust leakproof tanks, piping and equipment must be used for chemical treatments.
- Emergency spill and first aid kits should be available at the site.
- The treatment area should be verified for suitability by GSC/ETSU before commencing chemical treatments
- Only trained personnel are permitted to conduct chemical treatments.

D.6.1.3 Key References

446. The following documents and links provide more details and reference information:

- Information on the layout of chemical treatment areas is available here

D.6.2 Neutralization

D.6.2.1 Summary Description & Guidance

447. Neutralization is a chemical treatment used to produce a quantitative chemical reaction between acids and alkaline products to convert them to simple salts, water and CO_2. The main aim of the treatment is to cancel out extreme low (acid) or high (alkaline) pH values to produce a more neutral pH 7-8.

448. In summary neutralization will involve the following:

1. Dilution of the acid or alkaline product to be neutralized at a minimum ratio of 10:1 is conducted to reduce its hazardous concentration. It is very important that the acid or alkaline product is added slowly to the water and not the other way around to avoid a violent reaction with the acid/alkaline product boiling or splashing out.
2. Once the correct amount of acid or alkaline product is added, according to the size of the treatment tank and the dilution factor, neutralization is conducted. Depending on the product to be neutralized (acid or alkaline) this requires the incremental addition of a high or low pH alkaline or acid product to adjust the pH of the solution upwards or downwards until it reaches a neutral pH 7-8.
3. Due to the chemical reaction between the products, the treatment procedure may generate fumes and excessive heat through exothermic reaction and will require continuous monitoring and the use of correct PPE.
4. A calibrated pH meter is required to read pH along with a thermometer to measure temperature of the treatment solution. Calibration will be required each day to ensure readings are accurate, and buffer solutions to do this will be required.
5. Once the pH level reaches 7-8, the hazardous potential of the solution is markedly reduced, and it can then be dispersed over hard surface areas such as roads or carparks for evaporation.

449. Before upscaling neutralization treatment, a product dilution and neutralization test is recommended which follows the steps given above but at a smaller scale. This allows the correct ratio of the neutralizing product (acid or alkaline) required to be determined. Once the precise ratio is known, the amounts of neutralizing product required for the upscaled treatment volume can be calculated and costed if it needs to be purchased. In addition, chemical oxygen demand/biochemical oxygen demand (COD/BOD) tests need to be conducted on the treated solutions to ensure no harm will result from their later disposal through dispersal and evaporation.

Table 11: Common products used for neutralization treatments

Acids	Alkalines/bases
Citric Acid	Sodium Hydroxide
Sulfuric Acid	Calcium Hydroxide (lime)
Hydrochloric Acid	Sodium Carbonate (soda ash)
Nitric Acid	Calcium carbonate (chalk)
Phosphoric Acid	Sodium Hydroxide

450. As mentioned above, risks exist both due to the hazardous nature (e.g. corrosiveness, reaction to metals) of the products used and from potential exothermic reaction and fume generation. Consequently, the neutralization process requires careful planning and expert supervision and should not be conducted by persons who are not specifically trained. In general, risks may be controlled using appropriate equipment and correctly rated PPE. PPE should include masks with acid/alkaline fume filters, safety glasses, long rubber gloves and acid resistant overalls. In addition, appropriate emergency equipment such as spill containment kits, first aid and firefighting equipment should be available at the treatment site.

Figure 71: Neutralization treatments of acid and alkaline waste products

D.6.2.2 Minimum Standards & Recommendations

451. The following minimum standards and recommendations should be considered:

- For correct technical guidance on neutralization treatments, an inventory of the waste chemicals to be treated, with photographs of the container, label and the SDS, shall be provided by the Mission to GSC/ETSU for assessment.
- Based on this information, a specific advice note will be provided, that outlines the method/s of treatment/disposal, the equipment and personnel resources required, the potential risks and hazards of the treatment process, and any risk mitigation measures that need to be implemented.

- Recommended treatments may be conducted 'in house' by specifically trained Mission personnel or may require more advanced specialized expertise either from GSC/ETSU or a demonstrated qualified service contractor to train, conduct or supervise operations.
- A report on the treatment and disposal operations shall be prepared based on the reporting template provided and archived for reference.

D.6.2.3 Key References

452. The following documents and links provide more details and reference information:

- Advice notes on neutralization and chemical treatments are available here

D.6.3 Alkaline Hydrolysis

D.6.3.1 Summary Description & Guidance

453. Alkaline hydrolysis can be used to denature or degrade the active ingredients in specific pesticides to a safe level for disposal. It achieved by:

1. An alkaline product is added to a 10:1 diluted concentration of the pesticide to increase the pH to 12 or more.
2. Depending on the type of pesticide, the solution is left for a specified period for the degradation process to complete.
3. After the specified period, the treated solution is neutralized back to pH 7-8 using an acid product.
4. The resulting low residual toxicity solution is dispersed for evaporation over a hard surface area such as a road or carpark and will degrade further under sunlight.
5. Care should be taken to ensure that none of the solution can directly enter a watercourse or sewage system as even after treatment pesticides may have some residual toxicity for aquatic life.
6. Alternatively, the solution is mixed with soil and spread over an open field where it will continue to further degrade.

454. While pesticides are considered toxic to humans, any risk during disposal treatments can be mitigated with the use of appropriate PPE and care during the treatment procedure. The biggest danger is direct contact with the concentrated form of the pesticide so pouring of pesticides for dilution should be done slowly to avoid any splashing or spillage. All empty pesticide containers will have to be rinsed three times and punctured or shredded to ensure they cannot be reused (see section D.5.9 on pesticides).

Figure 72: Alkaline hydrolysis treatment for waste pesticides

D.6.3.2 Minimum Standards & Recommendations

455. The following minimum standards and recommendations should be considered:

- For correct technical guidance on alkaline hydrolysis treatments, an inventory of the waste pesticides to be treated with photographs of the container, label and the SDS shall be provided by the Mission to GSC/ETSU for evaluation.
- Based on this information, a specific advice note will be provided, that outlines the method/s of treatment/disposal, the equipment and personnel resources required, the potential risks and hazards of the treatment process, and any risk mitigation measures that need to be implemented.

- Recommended treatments may be conducted 'in house' by specifically trained Mission personnel or may require more advanced specialized expertise either from GSC/ETSU or a demonstrated qualified service contractor to train, conduct or supervise operations.
- A report on the treatment and disposal operations shall be prepared based on the reporting template provided and archived for reference.

D.6.3.3 Key References

456. The following documents and links provide more details and reference information:

- Information on Alkaline hydrolysis and an advice note for the safe disposal of pesticides is available here

D.6.4 Encapsulation

D.6.4.1 Summary Description & Guidance

457. Encapsulation is a method to contain hazardous waste products or ash through its solidification in a concrete mix of sand, gravel, and cement. It is achieved using a suitable container/mould with an internal liner between which reinforcing metal is placed and a 50mm minimum thick wall of concrete mix is poured. Following the insertion of a concrete plug at the bottom of the internal liner, the waste materials are packed to the top of the liner and a concrete cap is placed on top to completely seal the unit. For liquid wastes, sand, sawdust, or even shredded paper may be placed into the internal liner to absorb the liquids.

458. Figure 73 indicates the use of a steel drum, 3mm plywood internal liner, and reinforcing metal in the concrete wall. For smaller encapsulations other moulds could be employed using the same design principles. In contrast, Figure 74 shows prefabricated reinforced concrete culverts used for the same purpose after capping with concrete.

459. It is important to conduct encapsulation correctly to:

- Ensure a complete and robust outer casing of concrete so that none of the encapsulated hazardous waste can escape.
- Prevent leaching into or out of the concrete casing
- Prevent waste picking of the solidified encapsulations.
- Enable the encapsulations to be disposed at landfill with minimal risk.

460. The type of wastes that can be encapsulated include:

- Expired pharmaceuticals
- Biomedical waste ash
- Small quantities of hazardous liquid chemicals using sand soaks

- Expired water treatment chemicals in solid form (e.g. chlorine tablets)
- Used or expired water treatment reagents.

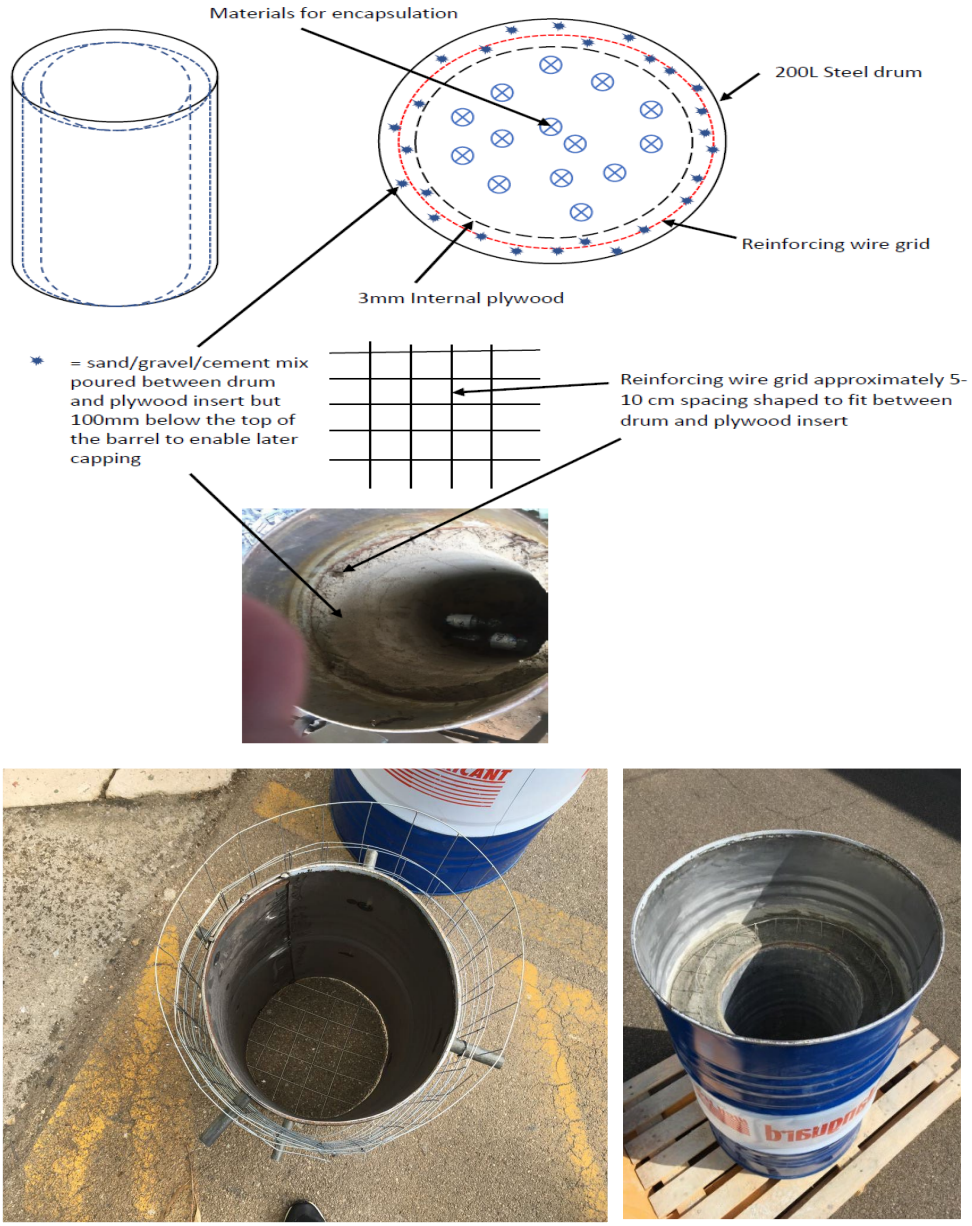


Figure 73: Diagrams and photos showing inner liner with reinforcing metal and final concrete finish in the drum

Figure 74: Diagrams and photos showing outer liner with reinforcing metal and final concrete finish of the culvert encapsulation

D.6.4.2 Minimum Standards & Recommendations

461. The following minimum standards and recommendations should be considered:

- All encapsulations shall be conducted using the standard methods shown here which can be upscaled or downscaled as required.
- A robust concrete mix is required to ensure strength and resistance to leaching.
- Both cap ends require the use of reinforcing metal.

D.6.4.3 Key References

462. The following documents and links provide more details and reference information:

- Information on the various procedures for waste encapsulation is available here

D.6.5 Bioremediation of POL Contaminated Soils

D.6.5.1 Summary Description & Guidance

463. POL products are used by UN Field Missions for the operation of mechanical equipment such as vehicles and plant machinery, and to produce electricity using diesel fuelled generator sets. Despite SOPs and measures such as containment infrastructure being developed and promulgated for the safe handling, transfer and storage of POL products, accidental and/or deliberate spillage incidents will occur during a Mission's lifecycle, including some related to equipment failure.

464. Soil contamination may result from:

- Poor diesel transfer
- Inadequate containment or control of used oil and oil filters from vehicle maintenance
- Insufficient bunding or use of hard surface areas at power generation sites.

465. While varying in size, such incidents may accumulate to result in extensive soil contamination within the Mission. If not dealt with effectively, they could result in significant health or environmental impacts, including the potential to be an odour nuisance, or an air and/or groundwater pollutant, and ultimately hinder site handover during closure and give rise to legal and financial liabilities.

466. As it may be anticipated that extensive soil remediation will be required during the final liquidation phases of a Mission (likely under a time deadline), it is strongly recommended that soil remediation be actively conducted during the sustainment phase when soil contamination is identified, and when the time pressure is less. Needless to say, day-to-day prevention of oil/diesel spills through improved engineering and operational controls and management should remain the primary objective of the Mission.

Figure 75: Contaminated soils from poor vehicle and generator station maintenance controls

467. Remediation of contaminated soils can be achieved using a wide range of techniques that include:

- Oil washing using solvents or other chemicals
- Thermal treatments such as incineration and thermal desorption
- Bioremediation often enhanced with active aeration, which relies on natural microorganism degradation processes
- Phytoremediation using plants to uptake, absorb and degrade pollutants.

468. It is recommended that bioremediation of contaminated soils is conducted using Natural Attenuation and Bio-Stimulation (NABS) followed by phytoremediation for the treatment of POL contaminated soils.

469. In summary, the NABS method intends to reduce the total petroleum hydrocarbon (TPH) content of the contaminated soils through physical and biological interventions to the condition before operations, or at minimum to levels under 5,000 ppm. The soils can then be used to re-vegetate and re-grass distressed or unvegetated areas

using native species to further reduce residual levels of TPH and confirm physical and visual remediation through successful plant growth.

470. Five key elements are required to achieve effective NABS of POL contaminated soil:

1. **Contaminated soils should be identified** based on whether they are contaminated by diesel, oil or a mixture, and the level of contamination should also be assessed.
2. **Use of a surfactant** is a critical pre-treatment process which increases the aqueous solubility of the hydrophobic POL pollutant and reduces the surface /interfacial tension or grip between the soil particles and the POL pollutant. This enables their separation and ensures their bioavailability for remediation. Surfactants can be natural products (e.g. black soap) or specialized synthetic products.
3. **The addition of a fertilizing medium** consisting of macro/micro-nutrients such as nitrogen (N), phosphorous (P), potassium (K), calcium (Ca) and magnesium (Mg) to bio-stimulate microorganisms to degrade and/or detoxify the organic POL contamination. Fertilizer medium may include:
   - Animal wastes (e.g. chicken guano – high in nutrients)
   - Dewatered activated sewage sludge – readily available from WWTPs used at Missions
   - Commercial agricultural fertilizers – nitrogen, phosphate and potassium (NPK) mixes
   - Specific commercial products for acceleration of bioremediation (e.g. RemActiv).
4. **Addition of water followed by homogeneous mixing** of the products to combine and aerate the mixture to ensure ongoing aerobic degradation. This can be achieved using large concrete mixers, hand or tractor driven tillers, mechanical windrow turners or front loaders. Alternatively, it can be done manually, although this is only suitable for small quantities.
5. **Chemical or field-based analysis** to measure the TPH of the contaminated soil. This is required before treatment, both during and after bio/phytoremediation treatment, and for final sign off indicating that acceptable TPH levels of the soils have been achieved. In the absence of available testing, a change detection analysis such as the normalized difference vegetation index (NDVI) can be conducted using comparative analysis of satellite imaging collected before and after treatment to identify vegetation changes. Vegetation growth following phytoremediation could indicate the health of the soil.

D.6.5.2 Minimum Standards & Recommendations

471. The following minimum standards and recommendations should be considered:

- POL soil remediation shall be conducted in line with the standard guideline indicated in the references below.
- Sample analysis can be conducted by GSC/ETSU using a RemScan unit.
- Bioremediation shall result in a total TPH contamination acceptable level of 5,000 ppm or less.

D.6.5.3 Key References

472. The following documents and links provide more details and reference information:

- The guidance document titled Remediation of POL contaminated soils at UN Field Missions is available here
- Section D.5.18 provides summary information on contaminated soils.

E. SOLID AND HAZARDOUS WASTE MANAGEMENT TRAINING

E.1 INTRODUCTION

473. The DOS Environmental Strategy (2017-2023) identified overall capacity building and the provision of effective environmental and equipment operational training as a significant area requiring improvement. Intended for Mission civilian, uniformed and service contractor personnel at both the technical and management level, this is considered a keynote action to be implemented across all pillars. Effective training will ensure that knowledge, skills, and attitudes can be strengthened, operational efficiencies improved, and current environmental challenges addressed more effectively at the Mission field level.

474. To bring about improvements to solid and hazardous waste management, most Missions have defined a range of planned interventions in their WMPs that include but are not limited to:

- Development of WMYs and procurement of a suite of waste management equipment to address recycling, composting and disposal of solid wastes better.
- Improvements to hazardous waste supply, handling, storage, inventory and the treatment and disposal of hazardous wastes especially in relation to liquidating sites and Missions.
- Implementation of proactive efforts to prevent soil POL contamination and where evident, conduct effective bioremediation and phytoremediation techniques to restore these areas to an acceptable condition.

475. Considering these interventions, and the need to support Missions to achieve their objectives better, three main training opportunities are currently identified for implementation:

1. Waste management equipment operational and maintenance training, including:
   - Solid and biomedical incinerators and barrel incinerators with air induction
   - Shredders
   - Compacters and balers
   - Woodchippers
   - Bulb crushers
   - Automated composting machines
   - Biodigesters for energy recovery.
2. Hazardous waste management training.
3. POL contaminated soil bioremediation training.

476. Training will be provided initially through the GSC/ETSU/REACT Waste Team, arranged on request, to build a Mission wide team of trainers able to conduct ongoing training of Mission civilian, uniformed and contractor personnel. For each type of training, theoretical classroom presentation materials have been developed that can be provided to Mission participants either directly onsite or remotely through MS Teams or webinars. In addition, practical ‘hands on’ training demonstrations can be provided onsite at the Mission, via biennial Environmental workshops held in Brindisi,

or at a specific selected location for multi-Mission participants. Certificates of attendance can be provided and are generally indicated as Level I theory training and Level II practical training. For the operation and maintenance of equipment and for hazardous waste treatments, Level II training is a mandatory prerequisite before advancing with these operations.

477. To ensure ongoing evaluation and improvement of each training programme, a feedback session is held to ascertain the positive and negative aspects of the training, and to determine recommendations for improving the content, conveyance, and implementation of the training.

478. Furthermore, to further facilitate the necessary behavioural change required to fulfil Missions' environmental goals, this capacity building should be complemented and reinforced with ongoing environmental awareness campaigns, focused awareness materials and provision of 'best practice' guidelines (see section B.10) for both UN personnel and TCC/PCCs.

E.2 WASTE MANAGEMENT EQUIPMENT OPERATOR TRAINING

E.2.1 Summary Description & Guidance

E.2.1.1 Solid and hazardous waste incinerators

479. Training is provided for twin chamber solid, biomedical, and barrel incinerators with air induction. For each make and model of incinerator used at a Mission a specific training presentation is adapted but generally covers the following subjects:

- Why should we incinerate?
- Incineration technology – different types and sizes of incinerator and component parts
- Incineration principles
- Effective waste feedstock mix
- General incineration process and achieving optimum batch size
- Incinerator monitoring and reporting
- Emissions control
- Cool down, de-ashing, and daily spot checks
- Maintaining operator safety.

480. Twin chamber solid, biomedical, and barrel incinerators with air induction are considered key pieces of equipment for effective management of solid and biomedical wastes across Missions. Incineration of solid and biomedical wastes may result in benefits such as:

- 90 percent reduction in volume of wastes
- Diversion of solid wastes from local landfill and dumpsites
- Improved GHG emissions resulting from reduced transportation of wastes to dumpsites
- Safe disposal of hazardous infectious wastes and expired pharmaceuticals.

481. It is important that only high quality 'fit for purpose' incinerators are used to ensure effective incineration of wastes and acceptable emissions. These can be

obtained from the UN Global Systems contract for waste management equipment, as can each of the pieces of waste management equipment described below. Incinerators and the incineration process are more fully explained in section C.8.

Figure 76: Solid and biomedical waste and barrel incinerators

E.2.1.2 Shredders

482. Training is provided on the basic operation of double shaft shredders and waste types that can be shredded. For each make and model of shredder, a specific training presentation is adapted but generally covers the following subjects:

- Why shred waste materials?
- Shredder technology – different types, sizes, and component parts of a shredder
- Shredder operational principles
- Waste types that can be shredded

- Shredder maintenance
- Maintaining operator safety.

483. Industrial shredders can serve several different purposes, can be obtained in various sizes, and are known for being efficient, durable and reliable. Shredders are useful for reducing the sizes of various waste materials that include:

- Textiles
- Metals, including steel drums
- Plastics
- Paper and cardboard
- Pallets
- Rubber tyres (depending on size of shredder).

484. Most industrial shredders are versatile units that rely on two parallel counter-rotating cutters that interconnect at low speed and under very high torque. As the cam shaped cutters intermesh at close clearance, they cut, shear, tear, slice and rip apart a variety of materials into smaller pieces, typically into a strip or chip-like output shape.

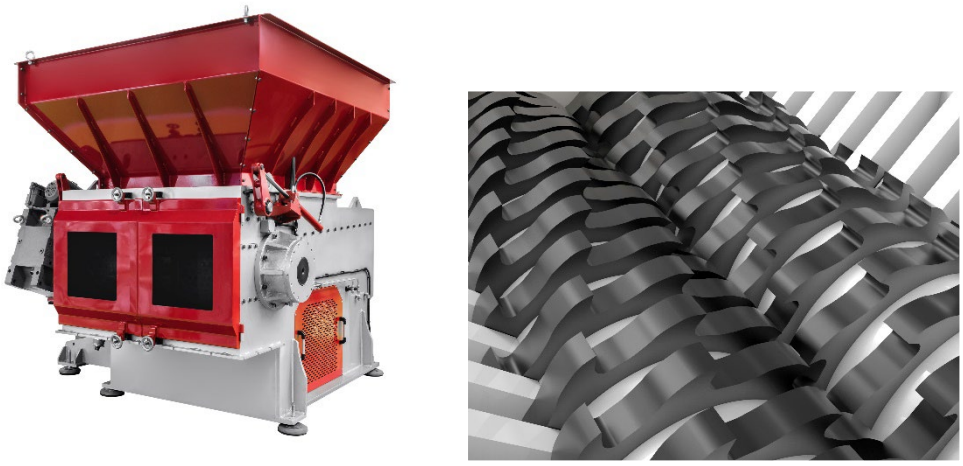


Figure 77: Typical double shaft shredder

E.2.1.3 Compactor/balers

485. Training is provided for compactor/balers on their basic operation and waste types that can be compacted and baled. For each make and model of compacter/baler a specific training presentation is adapted but generally covers the following subjects:

- Why compact and bale waste materials?
- Compactor/baler technology – different types, sizes, and component parts of a compactor/baler
- Compactor/baler operational principles
- Waste types that can be compacted and baled
- Compactor/baler maintenance

- Maintaining operator safety.

486. Waste compactors and balers are a type of heavy-duty machinery used for the compression of waste materials into small bales or bundles. Waste balers can process a variety of waste materials, including cardboard, plastic, and aluminium cans. Waste balers are used not only for the compression and easy disposal of waste, but also to help create a secured bundle in which to transport waste to a repurposing or recycling facility or to landfill.

487. The basic design of a waste baler consists of three main parts: the container, the compactor, and the power unit. Waste balers are advantageous for several reasons and often make it possible to collect even the smallest pieces or shards for baling. Additionally, they are an economical choice for waste collection and transport, whether it is for disposal, recycling or selling to another company for repurposing.

Figure 78: Typical compactor and baler

E.2.1.4 Woodchippers

488. Training is provided for woodchippers on their basic operation and materials that can be chipped. For each make and model of woodchipper, a specific training presentation is adapted but generally covers the following subjects:

- Why use a woodchipper?
- Woodchipper technology – different types, sizes, and component parts of a woodchipper
- Woodchipper operational principles
- Wood and green timber materials that can be chipped
- Use of woodchips
- Woodchipper maintenance
- Maintaining operator safety.

489. Like industrial shredders, woodchippers are versatile units that reduce wood sizes to provide products in the form of wood chips that can be used for incinerator fuel as part of feedstock, as bulk material for composting, and for landscaping purposes. These units are used to chip cut vegetative material and wooden construction debris. Shredded pallets, once de-nailed, may also be chipped with this equipment.

Figure 79: Typical woodchipper

E.2.1.5 Glass bulb crushers

490. Training is provided for glass bulb crushers on their basic operation and bulb and tube types that can be crushed. For each make and model of bulb crusher, a specific training presentation is adapted but generally covers the following subjects:

- Why use a bulb crusher?
- Bulb crusher technology – different types, sizes, and component parts of a bulb crusher
- Bulb crusher operational principles and the vacuum system
- Bulb and tube types that can be crushed
- Bulb crusher maintenance and filter replacement
- Maintaining operator safety.

491. Like shredders or chippers, bulb crushers also reduce volume(s). Conventional bulb crushers are designed with a vacuum system and carbon filters to capture harmful mercury safely, and high efficiency particulate air (HEPA) filters to capture fine dust particles. These units, as described below, are relatively inexpensive and are strongly recommended for all UN field Missions to manage fluorescent bulbs.

492. A fluorescent lamp consists of a glass shell, a high vacuum, a small amount of mercury vapor and phosphor powder, and metal end caps. Mercury vapor within fluorescent bulbs is odourless and colourless and caution should be taken when handling and storing these items.

493. Mercury is a persistent, bio-accumulative toxin that has increased at least three-fold in the atmosphere and ocean over the past century, posing a risk to human health, wildlife, and the environment. Mercury is highly toxic to the human nervous system and particularly poisonous to the kidneys. Once absorbed by the body, mercury is distributed by the blood to all tissues of the human body, and as it easily crosses the placental barrier, prenatal exposure can lead to various health problems including a severe form of cerebral palsy.

Figure 80: Bulb crusher

E.2.1.6 Automated composters

494. Training is provided for a range of automated composters on their basic operation and the types of organic materials they can receive and process. For each make and model of automated composter, a specific training presentation is adapted but generally covers the following subjects:

- Why use an automated composter?
- Automated composter technology – different types, sizes, and component parts of an automated composter
- Automated composter operational principles and the moisture, aeration, temperature and leachate management systems
- Organic materials that can be composted and the final end product
- Automated composter maintenance and spare part replacement
- Maintaining operator safety.

495. Automated composters make the process of composting easier by automating, through pre-set controls, the turning of the decomposing material, the optimum moisture, aeration and temperature, and leachate management to refine and expedite the breakdown of organics into compost. Units are sized according to organic generation and once initial maturation has been achieved (approximately 6 weeks) the technology will provide small daily amounts of finished compost that requires only a short period of curing before final processing for use.

Figure 81: Automated composter

E.2.2 Minimum Standards & Recommendations

496. The following minimum standards and recommendations should be considered:

- Initial Training for waste equipment should be conducted in collaboration with GSC/ETSU/REACT until Mission trainers are in place for continued training.
- All operators of waste management equipment shall be fully trained and certified before operating a piece of machinery.
- Maintenance operations shall be logged for compliance with manufacturer maintenance schedules and conducted by a qualified technician.
- SOPs shall be developed for all operations and maintenance for each type of waste management equipment (see section B.6).

E.2.3 Key References

497. The following documents and links provide more details and reference information:

- Training materials and additional information are available here

E.3 HAZARDOUS WASTE MANAGEMENT TRAINING

E.3.1 Summary Description & Guidance

498. This training intends to provide participants with an understanding of correct and safe hazardous waste management. It will provide information about the various types of hazardous wastes likely to be encountered across a Mission, how to correctly handle and store them according to their hazards, and what documentation

and safety equipment is required. Details of the various waste treatment and disposal options available for the different types of hazardous wastes will also be covered.

499. The training is comprised of two parts: a classroom presentation on hazardous waste management that can be conducted either onsite or remotely via MS Teams; and a practical 'hands on' demonstrations if required on hazardous waste disposal treatments such as neutralization or encapsulation.

E.3.1.1 Presentation on hazardous waste management

500. The presentation on hazardous waste management covers the following subjects:

- Introduction
- Types of hazardous waste
- Physical, health and environmental hazards
- Appropriate storage and segregation of HAZMAT/wastes
- Examples of poor handling, storage, and segregation of HAZMAT/wastes
- Improved supply change management – expired goods
- Incineration of specific hazardous wastes
- Chemical disposal treatments:
  - Dilution and neutralization
  - Alkaline hydrolysis
  - Required resources.
- Alternative disposal treatments:
  - Encapsulation.
- Documenting the process.

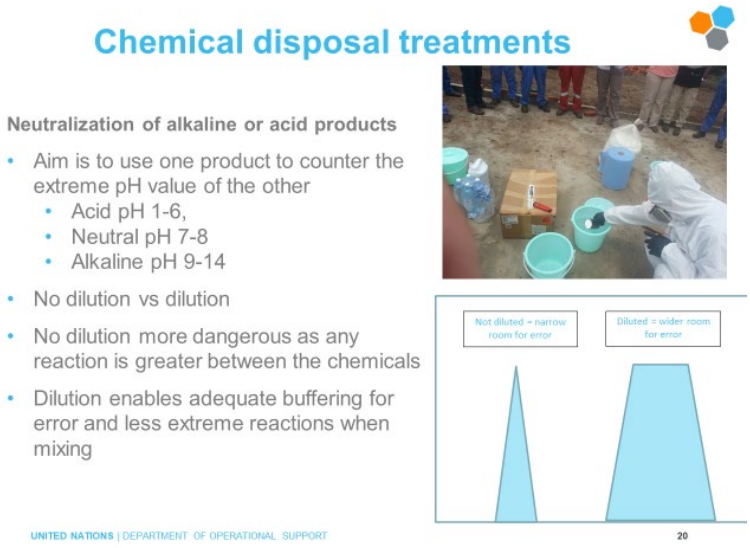


Figure 82: Example training slide for neutralization treatment

E.3.1.2 Practical demonstration on hazardous waste treatments and disposal options

501. A practical exercise is conducted with participants to demonstrate neutralization of acids and bases, the denaturing of pesticides through alkaline hydrolysis, and how to conduct effective encapsulation of waste ash or expired pharmaceuticals.

502. The practical demonstration includes:

- Product dilution and treatment calculations at smaller scale to determine correct ratios of neutralizing or hydrolysis products (acid or alkaline) required for successful treatment
- Scaling up to larger scale treatments
- Alkaline hydrolysis decomposition timing
- Equipment and human resources required for hazardous waste treatments and the recommended set-up of hazardous waste treatment area (see section D.6.1)
- Minimum safety requirements and correct use of PPE
- Analyses of treated solutions and final disposal options
- Standard encapsulation procedures and final disposal arrangements
- Documenting the process.

E.3.2 Minimum Standards & Recommendations

503. The following minimum standards and recommendations should be considered:

- Only personnel that have participated in the standard hazardous waste management training may be responsible for hazardous waste storage and management and conduct treatment operations.
- Correct 'fit for purpose' PPE shall be always used when handling or treating hazardous wastes.

E.3.3 Key References

504. The following documents and links provide more details and reference information:

- The hazardous waste management training presentation is available here

E.4 SOIL BIOREMEDIATION TRAINING

E.4.1 Summary Description & Guidance

505. This training intends to provide participants with an understanding of piloting and scaling suitable bioremediation approaches for POL contaminated soils. The training will inform and demonstrate the use of various surfactants and nutrient rich feedstocks, soil characterization and analyses for verification, various methods of

aeration of the treated material, and planting methods for phytoremediation to achieve continued soil enhancement.

506. The training is comprised of two parts: a classroom presentation on bioremediation of POL contaminated soils that can be conducted either onsite or remotely via MS Teams; and a practical 'hands on' demonstration that goes through the required steps to bioremediate a volume of POL contaminated soil using a cement mixer and by hand using shovels.

Figure 83: Contaminated soils, TPH analysis, bioremediation, and phytoremediation

E.4.1.1 Presentation on soil bioremediation

507. The presentation on bioremediation of POL contaminated soils covers the following subjects:

- POL contaminated soils – the issue
- Prevention of spillage is key
- Bioremediation using NABS
- Five key elements for NABS:
    1. POL contaminated soils
    2. Use of a surfactant
    3. Addition of a fertilizing medium

4. Addition of water and mixing
5. Chemical analysis.

- Gathering POL contaminated soils
- Required steps for soil analysis and verification – advantages and disadvantages (including equipment and samples)
- Pilot studies to determine best bioremediation approach and treatment application (including different surfactants and feedstocks)
- Large scale remediation treatments
- Post treatment phytoremediation
- PPE use and safety requirements
- Documenting the process
- What will be demonstrated?

E.4.1.2 Practical soil bioremediation demonstration

508. A practical exercise is conducted with participants to demonstrate the addition of surfactant and feedstock in the right quantities to a pile of contaminated soil, followed by appropriate mixing and aeration, and final analysis. This exercise will include the following:

1. Soil contamination: A 1m^3 pile of soil will be contaminated with used engine oil or diesel and mixed.
2. Soil characterization: Technical analysis equipment will be used to obtain readings of polycyclic aromatic hydrocarbons (PAH), TPH and other physical and chemical characteristics of the contaminated soil both before and after treatment to understand changes in the sample.
3. Surfactant materials: Selected surfactants in the right quantity, based on specific calculations conducted by the participants, will be added to the contaminated piles in line with the bioremediation procedure.
4. Types of feedstocks: Selected feedstock proportions, based on specific calculations conducted by the participants, will be added to the contaminated piles in line with the bioremediation procedure.
5. Water and mixing: The addition of water in the correct proportion, based on specific calculations conducted by the participants, will be added in line with the bioremediation procedure, and the participants will then mix the materials. One group will use a cement mixer and the others will do it by hand using shovels.
6. Scaling up remediation: The two participant groups will be handed a form to conduct calculations for a scaling up exercise to identify what combination of quantities of the various treatment elements should be used for 50m^3, 75m^3 and 200m^3 of similarly contaminated soil.

E.4.2 Minimum Standards & Recommendations

509. The following minimum standards and recommendations should be considered:

- Bioremediation of POL contaminated soils shall be conducted using the treatment, analytical methods and standard outlined in section D.6.5 and further detailed in the bioremediation guidance document indicated below.

- Bioremediation shall result in a total TPH contamination acceptable level of 5,000 ppm or less.
- Bioremediation of POL contaminated soils shall only be conducted by personnel who have completed this training.

E.4.3 Key References

510. The following documents and links provide more details and reference information:

- Information on the standard approach for contaminated soil clean-up is detailed in the UN Environment Technical Advice Note: Remediation of POL contaminated soils at UN Field Missions available here.
- A training presentation for bioremediation of POL contaminated soils is available here