

PETRONAS TECHNICAL STANDARDS

HEALTH, SAFETY AND ENVIRONMENT

GUIDELINE

ENVIRONMENTALLY HAZARDOUS SUBSTANCE

PTS 60.3310

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PTS 60.3310 – Environmentally Hazardous Substance Guide has been developed to incorporate PETRONAS Lessons Learnt, Best Practice and new information issued by relevant industry code and standards.

The custodian of this PTS is: Manager - HSE MS, Standards & Regulations, GHSED.

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PREFACE

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1.0 INTRODUCTION

Release of toxic and hazardous chemicals, both naturally occurring and anthropogenic, can adversely affect ecosystems and human health through acute (immediate) or chronic (long-term) impacts resulting from emissions or releases. Chemicals recommended by international conventions to avoid from use include, but are not limited to: ozone-depleting substances, persistent organic pollutants (POPs), hazardous chemicals and pesticides that are defined as carcinogenic or mutagenic, or affect reproduction, or endocrine disrupting, or persistent bioaccumulative and toxic chemicals.

The Mandatory HSE Control Framework on Environmentally Hazardous Substances (MCF EHS) requires PETRONAS Operating Units (OPUs) to protect human health and the environment by phasing out the use of 20 ozone-depleting substances listed under the Appendix 1 of the MCF EHS. OPUs are required to develop, and endeavor to put into practice implementation plan setting out how they will implement their obligations under the MCF EHS. This requires the establishment of guidance document to facilitate OPUs implementation.

In addition to the chemicals listed in the MCF EHS, this guidance document introduces a group of chemical where its usage is preferably avoided, or shall strictly follow recommendations in this guideline in addition to applicable local legislation.

1.1 Objective

The objectives of this document are as follow:

- To describe the management standards on elimination of use for EHS listed in the MCF (Banned Chemicals).
- To describe the management standard on the use of chemicals listed as Controlled Chemicals in this guidance document.
- To assist operating facility/site managers to identify the use of EHS in operations and to implement and review hazardous substances control measures.

1.2 Scope

- This guideline is applicable to all PETRONAS-operated facilities where EHS may be present or in use.
- This guideline applies to all products, by-products, intermediates, packaging and indirect materials that may have or use EHS or EHS derivatives.

This guideline does not apply to;

- Pharmaceuticals, including narcotics, drugs and psychotropic substances
- Radioactive materials
- Chemicals imported for the purposes of research or analysis in quantities not likely to affect the environment or human health
- Food additives

This prohibition or restriction on use does not apply to Banned and Controlled Chemicals use in laboratory that include;

- equipment calibration
- use as extraction solvents
- diluents or carriers for chemical analysis
- biochemical research

- inert solvents for chemical reactions
- as a carrier or laboratory chemical
- other laboratory purposes.

1.3 Reference

The following referenced documents shall be read in conjunction for the application of this document. The latest edition of the referenced document (including any amendments) applies.

PETRONAS Technical Standard 60.1502 Guideline on Chemical Management Program
 PETRONAS Technical Standard 60.3005 Waste Management Guideline

The following external guidelines and web portals are referred to in preparing this guideline.

Advice on Alternatives and Guidelines for Users of Fire Fighting and Explosion Protection Systems, Department of Trade and Industry, United Kingdom.

Advice on Alternatives and Guidelines for Users for Refrigeration and Air Conditioning, Department of Trade and Industry, United Kingdom.

Advice on alternatives and guidelines for users of CFC, HCFC and 1,1,1-Trichloroethane, Department of Trade and Industry, United Kingdom.

Vienna Convention on the Protection of Ozone Layer
<http://untreaty.un.org/cod/avl/ha/vcpol/vcpol.html>

Stockholm Convention on Persistent Organic Pollutants
www.pops.int/

United States Environment Protection Agency – Ozone Layer Protection
www.epa.gov/ozone/

1.4 Terms and definition

For the purposes of this document, the following terms and definitions shall apply.

Environmentally Hazardous Substance (EHS)	Chemicals hazardous to ecological environment, i.e. air, water bodies, land, flora, fauna and human.
Banned Chemicals	Chemicals listed in the HSE Mandatory Control Framework for Environmentally Hazardous Substances (Table 1 of this document), that for environmental reasons are prohibited from all uses in PETRONAS-operated facilities.
Controlled Chemicals	Chemicals listed in Table 2 of this guidance document that for environmental reasons their usage is preferably avoided, or restricted in addition to compliance to applicable local legislation.
Chlorofluorocarbon	Greenhouse gases covered under the 1987 Montreal Protocol and used for refrigeration, air conditioning, packaging, insulation, solvents, or aerosol propellants. Since they are not destroyed in the lower atmosphere, CFCs drift into the upper atmosphere where, given suitable conditions, they break down ozone. These gases are being replaced by other compounds, including hydrochlorofluorocarbons and

	hydrofluorocarbons, which are greenhouse gases covered under the Kyoto Protocol.
Ozone Depleting Substance (ODS)	A family of man-made compounds that includes, but are not limited to, chlorofluorocarbons (CFCs), bromofluorocarbons (halons), methyl chloroform, carbon tetrachloride, methyl bromide, and hydrochlorofluorocarbons (HCFCs). These compounds have been shown to deplete stratospheric ozone, and therefore are typically referred to as ODSs.
Ozone Depleting Potential (ODP)	ODP is a ratio of the impact of a chemical on ozone compared to the impact of a similar mass of CFC-11. Thus, the ODP of CFC-11 is defined to be 1.0.
Persistent Organic Pollutants (POPs)	POPs are chemical substances that have toxic properties, resist degradation in the environment, bioaccumulate through the food chain, and are transported through air, water and migratory species, within and across international boundaries.
Indirect materials	Indirect material refers to packaging materials (carton, plastic bag, cushioning material, tape, label, ink, adhesive, etc.) and chemicals (mold lubricant, solvent, cleaning agent, pesticides etc.)
Use of EHS	The use of EHS is defined as “the utilisation of controlled substances in the production or maintenance, in particular refilling, of products or equipment or in other processes except for feedstock and processing agent uses”. An existing system can be kept until it requires refilling or topping up.

2.0 ENVIRONMENTALLY HAZARDOUS SUBSTANCES

Two groups of Environmentally Hazardous Substances (EHS) exist where different sets of requirements apply;

- Banned Chemicals – prohibited from all uses in PETRONAS-operated facilities effective 1st January 2015.
- Controlled Chemicals – usage of these chemicals should be avoided, or shall strictly follow requirements in this guideline in addition to applicable local legislation.

OPU should seek to avoid the use of other ozone depleting substances and persistent organic pollutants not prescribed in the lists, and other toxic and hazardous chemicals that are defined as carcinogenic or mutagenic, or affect reproduction, or endocrine disrupting, or persistent bioaccumulative and toxic chemicals.

2.1 List of Banned Chemicals

The Banned Chemicals refer to 20 ozone-depleting substances (ODS) listed under the Mandatory HSE Control Framework on Environmentally Hazardous Substances (MCF EHS) as shown in **Table 1**. Their use is prohibited at all PETRONAS-operated facilities:

Table 1: List of Banned Chemicals

Chemicals used in operations			
Type of EHS	Reference	Category of Use	Chemicals
Ozone-depleting substances (ODS)	Montreal Protocol	Refrigerant	Trichlorofluoromethane (CFC-11) Dichlorofluoromethane (CFC-12) Trichlorotrifluoroethane (CFC-113) Dichlorotetrafluoroethane (CFC-114) Chloropentafluoroethane (CFC-115)
		Fire retardant	Bromochlorodifluoromethane (Halon-1211) Bromotrifluoromethane (Halon-1301) Dibromotetrafluoroethane (Halon-2402)
		Industrial chemical	Carbon tetrachloride 1,1,1-trichloroethane (methyl chloroform)
		Propellants and Blowing Agents	Chlorotrifluoromethane (CFC-13) Pentachlorofluoroethane (CFC-111) Tetrachlorodifluoroethane (CFC-112) Heptachlorofluoropropane (CFC-211) Hexachlorodifluoropropane (CFC-212) Pentachlorotrifluoropropane (CFC-213) Tetrachlorotetrafluoropropane (CFC-214) Trichloropentafluoropropane (CFC-215) Dichlorohexafluoropropane (CFC-216) Chloroheptafluoropropane (CFC-217)

Refer to **Appendix 1** for background information on the effect of ODS to ozone layer, human health and the environment, and **Appendix 2** for a list of trade name and manufacturing company for the Banned Chemicals. The products that contain Banned Chemicals can exist as a single component or more than one component (blend).

2.2 List of Controlled Chemicals

Controlled Chemicals are chemicals that pose a high hazard to environment and for that reason their usage should be avoided, or its use in operations and activities is restricted. Applicable local legislation on the use of Controlled Chemical shall be complied with, in addition to the requirements stated in this guideline.

Controlled Chemicals comprise of 25 types of persistent organic pollutants (POPs) and lead-based paint. The POPs are significant because low-dose exposure may pose a threat to human health and the

environment. Humans can be exposed to Controlled Chemicals through diet, occupational accidents and the environment (including indoor). Exposure to Controlled Chemicals, either acute or chronic, can be associated with a wide range of adverse health effects, including illness and death. The Controlled Chemicals comprise:

- 10 types of industrial chemicals
- 2 types of unintentionally produced chemicals (dioxins and furans), that result from some industrial processes and from combustion
- 13 types of halogenated pesticides

Table 2: List of Controlled Chemicals

Chemicals used in operations			
Type of EHS	Reference	Category of Use	Chemicals
Persistent Organic Pollutants (POPs)	Stockholm Convention	Pesticides	Aldrin Chlordane Endrin Heptachlor Mirex Toxaphene DDT (1,1,1-trichloro-2,2-bis (4-chlorophenyl) ethane) Chlordecone Alpha hexachlorocyclohexane* Beta hexachlorocyclohexane* Lindane Pentachlorobenzene Endosulfan
		Industrial chemicals	Polychlorinated biphenyls (PCBs)* Hexachlorobenzene (HCB)* Hexabromobiphenyl, Hexabromodiphenyl ether
		Industrial chemicals	Heptabromodiphenyl ether Pentachlorobenzene* Perfluorooctane sulfonic acid and its salt Perfluorooctane sulfonyl fluoride Tetrabromodiphenyl ether Pentabromodiphenyl ether
		Chemical byproducts	Dioxins (polychlorinated dibenzo- <i>p</i> -dioxins) Furans (polychlorinated dibenzofurans)

Note:

*can also be unintentionally formed chemical by-products.

Controlled Chemicals are organic compounds that are highly resistant to degradation by biological, photolytic or chemical means. Controlled Chemicals are often halogenated and most often chlorinated.

They originate almost entirely from anthropogenic sources associated largely with the manufacture, use and disposition of certain organic chemicals. In contrast, HCB, dioxins and furans are formed unintentionally in a wide range of manufacturing and combustion processes.

Table 3 shows the typical application of Controlled Chemicals and their trade names while **Appendix 4** provides background information on toxicological properties and impact of POPs to human and the environment.

Table 3: Trade Name and Application of Controlled Chemicals

POP	Trade Name	Global Historical Use
Aldrin	Aldrec, Aldrex, Aldrex 30, Aldrite, Aldrosol, Altox, Compound 118, Drinox, Octalene, Seedrin.	Pesticides used on crops such as corn, potatoes and cotton. Insecticides for soil insects and termite control.
Dieldrin	Alvit, Dieldrite, Dieldrix, Illoxol, Panoram D-31, Quintox	Insecticides used on crops such as corn and cotton; also used for termite control.
Chlordane	Aspon, Belt, Chlориandin, Chlorkil, Chlordane, Corodan, Cortilan-neu, Dowchlor, HCS 3260, Kypchlor, M140, Niran, Octachlor, Octaterr, Ortho-Klor, Synklor, Tat chlor 4, Topichlor, Toxichlor, Veliscol-1068	Insecticide used on crops, including vegetables, small grains, potatoes, sugarcane, sugar beets, fruits, nuts, citrus, and cotton. Used on home lawn and garden pests. Also used extensively to control termites.
DDT	Agritan, Anofex, Arkotine, Azotox, Bosan Supra, Bovidermol, Chlorophenothan, Chloropenothane, Clorophenotoxum, Citox, Clofenotane, Dedelo, Deoval, Detox, Detoxan, Dibovan, Dicophane, Didigam, Didimac, Dodat, Dykol, Estonate, Genitox, Gesafid, Gesapon, Gesarex, Gesarol, Guesapon, Gyron, Havero-extra, Ivtan, Ixodex, Kopsol, Mutoxin, Neocid, Parachlorocidum, Pentachlorin, Pentech, PPzeidan, Rudseam, Santobane, Zeidane, Zerdane.	Insecticide used on agricultural crops, primarily cotton. Vector control for insects that carry diseases such as malaria and typhus.
Endrin	Compound 269, Endrex, Hexadrin,	Insecticide used on crops such as cotton and

POP	Trade Name	Global Historical Use
	Isodrin Epoxide, Mendrin, Nendrin.	grains. Use to control rodents.
Mirex	Dechlorane, Ferriamicide, GC 1283	Insecticide used to combat fire ants, termites, and mealybugs. Used as a fire retardant in plastics, rubber, and electrical products
Heptaclor	Aahepta, Agrocere, Baskalor, Drinox, Drinox H-34, Heptachlorane, Heptagran, Heptagranox, Heptamak, Heptamul, Heptasol, Heptox, Soleptax, Rhodiachlor, Veliscol 104, Veliscol heptachlor.	Insecticide used primarily against soil insects and termites. Pesticides and to control malaria vector.
Hexachlorobenzene	Amaticin, Anticarie, Bunt-cure, Bunt-no-more, Co-op hexa, Granox, Sanocide, Smut-go, Sniecotox	Fungicide used for seed treatment. Industrial chemical used to make fireworks, ammunition, synthetic rubber, and other substances. Also unintentionally produced during combustion and the manufacture of carbon tetrachloride, perchlorethylene, trichloroethylene and pentachlorobenzene. May exist as impurity in certain pesticides.
Taxophane	Alltex, Alltox, Attac 4-2, Attac 4-4, Attac 6, Attac 6-3, Attac 8, Camphechlor, Camphochlor, Camphoclor, Chemphene M5055, chlorinated camphene, Chloro-camphene, Clor chem T-590, Compound 3956, Huilex, Kamfochlor, Melipax, Motox, ctachlorocamphene, Penphene, Phenacide, Phenatox, Phenphane, Polychlorocamphene, Strobane-T, Strobane T-90, Texadust, Toxakil, Toxon 63, Toxyphen, Vertac 90%.	Insecticide used to control pests on crops and livestock, and to kill unwanted fish in lakes. control ticks and mites in livestock
Chlordecone	Kepone® and GC-1189	Insecticide to control the banana root borer, application on non-fruit-bearing citrus trees to control rust mites, control of wireworms in tobacco fields, control of apple scab and powdery mildew, control of the grass mole cricket, and control of slugs, snails, and fire ants

POP	Trade Name	Global Historical Use
Alpha hexachlorocyclohexane	No trade name	Unintentional by-product of lindane. For each ton of lindane produced, around 6-10 tons of the other isomers including alpha- and beta-HCH are created.
Beta hexachlorocyclohexane*	No trade name	Unintentional by-product of lindane. For each ton of lindane produced, around 6-10 tons of the other isomers including alpha- and beta-HCH are created.
Lindane	Agrocide, Aparasin, Arbitex, BBH, Ben-hex, Bentox, Celanex, Chloresene, Dvoran, Dol, Entomoxan, Exagamma, Forlin, Gallogama, Gamaphex, Gammalin, Gammex, Gammexane, Hexa, Hexachloran, Hexaverm, Hexicide, Isotos, Kwell, Lendine, Lentox, Linafor, Lindafor, Lindagam, Lindatox, Lintox, Lorexane, Nexit, Noco-chloran, Novigam, Omnitox, Quellada, Silvanol, Tri-6, Vitron	Insecticide for seed and soil treatment, foliar applications, tree and wood treatment and against ectoparasites in both veterinary and human applications.
Pentachlorobenzene	No trade name	Produced unintentionally during combustion, thermal and industrial processes. It also present as impurities in products such as solvents or pesticides.
Endosulfan	Thiodan® , Thionex, Endosan, Farmoz, Nufarm, Endosulfan	Insecticide to control crop pests, tsetse flies and ectoparasites of cattle and as a wood preservative. As a broad-spectrum insecticide, endosulfan is currently used to control a wide range of pests on a variety of crops including coffee, cotton, rice, sorghum and soy.
Hexabromobiphenyl, Hexabromodiphenyl ether, Heptabromodiphenyl ether, Tetrabromodiphenyl ether	FireMaster BP-6 and FireMaster FF-1	Fire retardant in commercial products; acrylonitrile-butadienestyrene (ABS) thermoplastics for constructing machine housings such as motor housing and radio and TV parts, as a fire retardant in coatings and lacquers, and in polyurethane foam for auto upholstery.
Pentachlorobenzene*	No trade name	Produced unintentionally during combustion, thermal and industrial processes. It also present as impurities in products such as solvents or pesticides.

POP	Trade Name	Global Historical Use
Perfluorooctane sulfonic acid and its salt (PFOs)	Fluorotenside-248 and SurTec 960	Textiles and leather products, metal plating, food packaging, fire fighting foams, floor polishes, denture cleansers, shampoos, coatings and coating additives, in the photographic and photolithographic industry, and in hydraulic fluids in the aviation industry.
Perfluorooctane sulfonyl fluoride	DF-8, FX-8, FC-8	In electric and electronic parts, fire fighting foam, photo imaging, hydraulic fluids and textiles.
Pentabromodiphenyl ether	Bromkal 70, Bromkal 70 DE, Bromkal 70 5DE, Bromkal G1, Great Lakes DE 71, Great Lakes DE-60 F (85% PeBDE), FR 1205/1215, Pentabromprop, Saytex 115, Tardex 50	Flame retardant, incorporated in polyurethane foam, used in domestic and public furniture.
PCBs	Aroclor, Pyranol, Pyroclor, Phenochlor, Pyralene, Clophen, Elaol, Kanechlor, Santotherm, Fenchlor, Apirolio, Sovol.	Used for a variety of industrial processes and purposes, including in electrical transformers and capacitors, as heat exchange fluids, as paint additives, in carbonless copy paper, and in plastics. Also unintentionally produced during combustion.
Dioxins and Furans	No trade name	Unintentionally produced during most forms of combustion, including burning of municipal and medical wastes, municipal waste, hazardous waste and industrial processes. Also can be found as trace contaminants in certain herbicides, wood preservatives, and in PCB mixtures.

3.0 ACCOUNTABILITY, ROLES & RESPONSIBILITY IN EHS MANAGEMENT

3.1 Accountability, Roles & Responsibilities

Phasing out Banned Chemicals and managing the use of Controlled Chemicals require commitment and support at all levels in order to make it effective. **Table 4** describes the accountability, the roles and responsibility for drivers and implementers of the program.

Table 4: Accountability, Roles & Responsibility on EHS Management

Position	Accountability, Roles & Responsibilities
Group HSE	- Update EHS list of Banned or Controlled Chemicals. - Disseminate the introduction of new Banned or Controlled Chemicals to Business Units.
Business Head	- Accountable to phase out the use of Banned Chemicals in all business activities. - Accountable to prohibit the use of Banned Chemicals for all projects initiated by his/her business division after January 2012. - Accountable to ensure the management standards on the use of Controlled Chemicals is complied with.
Facility Head/Project Head	- Develop and implement a program to systematically identify and phase-out the use of Banned Chemicals in operations and on-site contractual services for existing facilities. - Should the use of Controlled Chemicals is unavoidable, the Facility Head/Project Head shall ensure that control measures on its use is implemented as required in this guideline.
HSE Manager	- Conduct a review on the use of Banned and Controlled Chemicals in operation. - Ensure Banned Chemicals is not use in operation. - Assist site managers and supervisors to identify alternatives for Controlled Chemicals. - Assist or provide adequate training on the handling, storage, use and distribution of Controlled Chemicals including the health risks associated with the use for employee and contractors handling Controlled Chemicals. - Develop ERP to address incidents involving Controlled Chemicals both on-and off-site. - Conduct Tier 1 audit to ensure Banned Chemicals are not use in operations and to verify the use of Controlled Chemicals is in compliance with this PTS. Tier 1 audit checklist is made available in Appendix 4.
Procurement or Tender Manager	- Incorporate the requirement of Banned Chemicals in contract agreement or ITB. - Ensure any purchase of Controlled Chemicals follow the requirements of this guideline.
Area Manager/Project Manager	- Comply with the prohibition of use of Banned Chemicals - Responsible to develop procedure on the safe use of Controlled Chemicals and ensure its implementation. - Ensure control measures are implemented to eliminate or reduce the likelihood of harmful exposure, e.g. allocating resources for storage facilities, signage, removal of hazardous substances, provision of PPE. - Maintain inventory on the amounts and types of Controlled Chemicals used and released. - Ensure that maintenance engineers working on halon systems are fully trained and competent. - Conduct routine inspection on the use of Controlled Chemicals.
Environment TP	Responsible to provide advice on the handling, disposal and replacement alternatives for Banned and Controlled Chemicals.
Employee and	- Do not use Banned Chemicals in PETRONAS site. - Use Controlled Chemicals in accordance with site procedure and/or this

Position	Accountability, Roles & Responsibilities
contractors	document.

4.0 MANAGEMENT REQUIREMENT FOR BANNED CHEMICALS

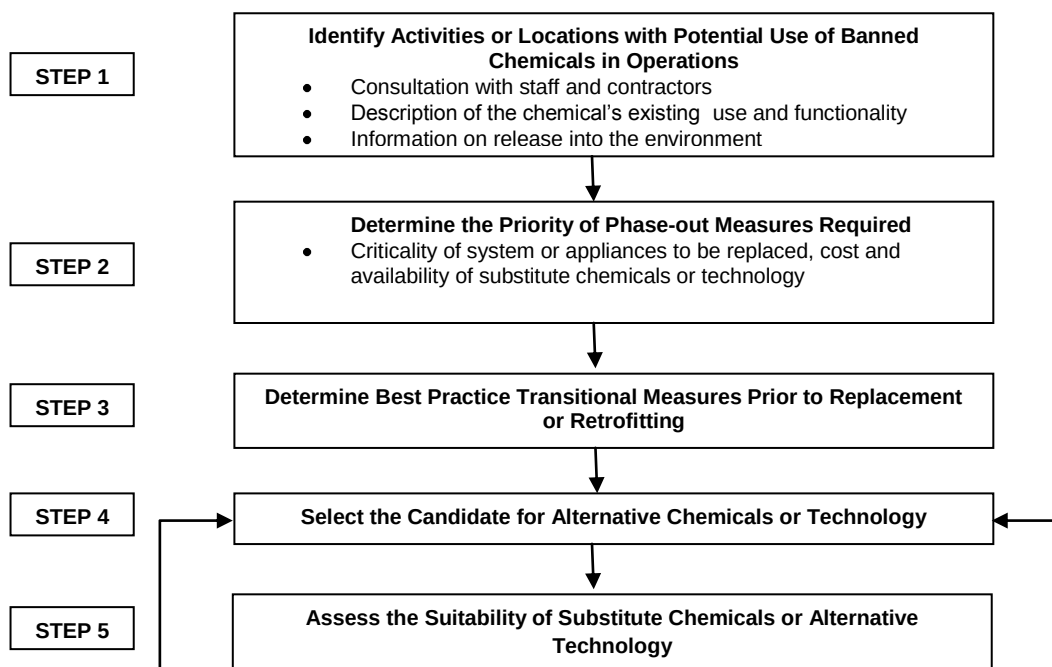
In meeting the requirements of MCF EHS, OPU's are required to;

- Systematically identify the use of Banned Chemicals in operations including those of contractors working on behalf of the OPU.
- Develop clear action plan to phase-out the use of Banned Chemicals within two years from the date of MCF endorsement.
- Implement the Banned Chemicals phase-out program.
- Prohibit the use of Banned Chemicals for all projects initiated in and after January 2012.

4.1 Identifying the Use of Banned Chemicals in Operations and Assessment of Alternatives

Diagram 1 outlines the steps to be taken in developing a Phase-out Program for Banned Chemicals.

Diagram 1: The steps in the development of phase-out program for Banned Chemicals.



The step-by-step approach to develop phase-out plan for Banned Chemicals is described below.

Step 1: Identify Activities or Locations with Potential Use of Banned Chemicals in Operations

Purpose

- Identify site activities and services that may use Banned Chemicals including by contractors working on behalf of the OPU.
- Establish an inventory of equipment or systems where refilling or retrofitting or replacement will be required.
- Establish an inventory of Banned Chemicals to be recovered and disposed off at designated facilities.

General Requirements

- Specifications for refrigerant in refrigeration system, air conditioning system, and fire retardant use in fixed and portable fire suppression and explosion protection system.
- Records of the maintenance and servicing of the above system and appliances.
- The latest copy of site Chemical Register.

Methodology

- Identify all typical activities, products and services that may use Banned Chemicals. They can be;

Table 5: Typical activity, product and services that may use Banned Chemicals

System or appliance or activity	Document	Item to check against EHS list
Refrigeration system • refrigerators • cold stores and warehouses • freezers • product transport refrigeration.	System specifications or label on appliances	Type of refrigerant use
Air conditioning • water chillers • central or split air conditioning systems • vehicle air conditioning.	System specifications or label on appliances	Type of refrigerant use
Fixed fire suppression and explosion protection	System specifications or label on appliances	Type of fire retardant use
Potable fire extinguishers	Label	Type of fire retardant use
Spray chemicals (aerosols)	Label	Type of propellant use
Sterilants	Label	Type of propellant use
Adhesive • laminate adhesives, • flexible foam adhesives, • hardwood floor adhesives, • metal-to-rubber adhesives, and • tire patch adhesives.	Label or product specifications	Type of carrier solvent use
Coatings and inks • flexographic and rotogravure printing inks	Label or product specifications	Type of carrier solvent use

System or appliance or activity	Document	Item to check against EHS list
- wood stains - metal coatings		
Cleaning chemical - electronics defluxing - precision cleaning - metal cleaning	Chemical Register/SDS	Type of solvent use (Trichlorotrifluoroethane (CFC 113), carbon tetrachloride, 1,1,1-trichloroethane (methyl chloroform))
Solvent use in process	Chemical Register/SDS	Type of solvent use (Trichlorotrifluoroethane (CFC 113), carbon tetrachloride, 1,1,1-trichloroethane (methyl chloroform))

- If chemical information in system specification or label is unavailable or uncertain, obtain with the suppliers.
- Check the maintenance and service records for the system or appliances that are re-filled with refrigerants or fire suppressant to determine the type of chemicals used.
- The name used in the specification, label or maintenance record may be the trade name. Often the prefix "R" is use to indicate a refrigerant.
- Refer to **Appendix 2** for a list of trade names, manufacturing companies for the Banned Chemicals. The products can contain one substance (single component) or more than one substance (blend).

Step 2: Determine the Priority of Phase-out Measures Required

Purpose

- Establish the priority to implement phase-out measures based on environmental risk, operational and commercial considerations.

General Requirements

- Inventory of system or appliances containing Banned Chemicals as refrigerant or fire suppression agent, or as cleaning or solvent agent.
- Specifications for refrigerant system, air conditioning system, fire suppression system.
- Maintenance record of refrigerant system, air conditioning system, fire suppression system.

Methodology

- Determining priority for retrofitting and replacement or chemical substitution measures based on the following factors;
 - availability of alternative chemicals to replace Banned Chemicals.
 - criticality of a refrigeration or fire suppression system to the production activity (this will determine the timing for retrofitting, e.g. during turnaround vs normal operations).
 - availability of approved or designated site or facility where Banned Chemicals can be disposed off in an environmentally responsible manner. Refer to **Appendix 2** for a list of approved disposal or repository facilities for Banned Chemicals.
- More complex refrigeration system or appliances usually require on-site systems assembly and refrigerant filling. These systems are susceptible to refrigerant leakage and often require regular maintenance.

- Typical leakage rates:

Hermetic compressor	: 1 - 2%
Split units	: 6 - 8%
Automotive air conditioning	: 10 - 20%

- Priority for replacement or retrofitting can also be given to refrigeration system that has a refrigerant charge of more than 50 pounds and exceeded the following trigger leak rates for a 12-month period;

Appliance Type	Trigger Leak Rate
Commercial refrigeration	35%
Industrial process refrigeration	35%
Comfort cooling	15%
All other appliances	15%

Step 3: Determine Best Practice Transitional Measures Prior to Replacement or Retrofitting

Any system or appliances found to be using any of the Banned Chemicals after the cut-off date can remain operational until 1st January 2015 provided it requires no top-up and no leakage of Banned Chemicals from the system or appliances. In case an appliance breaks down and starts to lose its charge of refrigerant or fire retardant the Banned Chemicals shall be recovered from the appliances and disposed off at approved facilities.

By 1st January 2015, all Banned Chemicals in the system and equipment must be recovered and disposed of at approved facilities.

Refer to **Appendix 5** for a list of approved disposal or repository facilities for Banned Chemicals, or check with local environmental agency for such facility.

3a: Best Practices Transitional Measures for Refrigeration Appliances

- Small self-contained units, e.g. refrigerators and freezers that are mass-produced in a factory using hermetically sealed compressors are usually leak free for the whole of their working life (up to 15-20 years without requiring maintenance). If these appliances are found to be using Banned Chemicals, they can still be run until they reach the end of their useful life.
- In case the appliances break down and start to lose their charge of refrigerant the Banned Chemicals shall be recovered from the appliances and disposed of at approved facilities. The refrigerant is then replaced with acceptable substitute.
- Any fixed equipment with a refrigeration fluid charge greater than 3 kg must be checked at least annually for leakage.
- All precautionary measures practicable must be taken in order to prevent and minimise leakage of the Banned Chemicals.

3b: Best Practice Transitional Measures for Halon Fire Suppression and Explosion

- Stop the release of halons during fire training.
- For the purpose of service and maintenance activity, do not test the release of halon. If need to, use enclosure pressurization integrity testing instead and put systems on manual operation where personnel are present.
- Make all involved personnel aware of the importance of avoiding non-fire related halon discharges.
- Investigate all inadvertent halon releases thoroughly to determine their root causes and implement measures to remove those causes.
- For fixed halon fire suppression system, review the detection arrangements to avoid false alarms.

3c: Best Practice Transitional Measures for Solvent Containing Banned Chemicals

- Banned Chemicals that is used as solvent or exist as component in a solvent must be removed and disposed of to the repository facility by the cut-off date.
- Specific legislation and site procedures shall apply to the transportation, storage and use of flammable materials, particularly those with lower flashpoints.

Step 4: Select the Candidate for Alternative Chemicals or Technology

4a: Alternative Refrigerants

The alternative chemicals or technology on refrigeration depends on the purpose; e.g office cooling, process requirement, instrument air generation, etc.

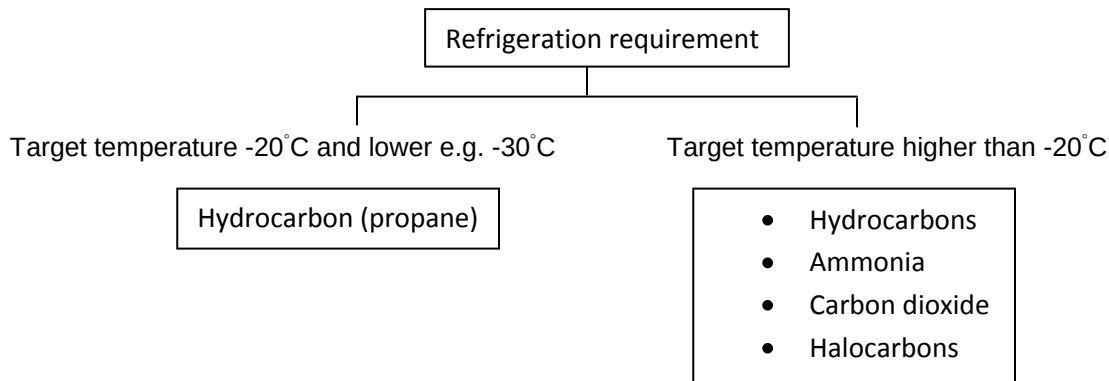


Table 6: Comparison on alternative refrigerants

Refrigerants	Advantage	Disadvantage
Ammonia	• Zero ODP and GWP • Excellent thermodynamic characteristics: small molecular mass, large latent heat, large vapour density and excellent heat transfer characteristics • High critical temperature (132C) : highly efficient cycles at high condensing temperatures • Its smell causes leaks to be detected and fixed before reaching dangerous concentration • Relatively Low price	• Toxic • Penetrating smell • Flammable (16 – 28% conc.) • Not compatible with copper • Temperature on discharge side of compressor is higher compared to other refrigerants

Refrigerants	Advantage	Disadvantage
Hydrocarbons e.g.; R170 Ethane R290 Propane R600 Butane R600a Isobutane Blends of the above gases	• Zero ODP and negligible GWP • Good substitutes for CFC's, HCFC's, and HFC's. • Compatible with copper • Miscible with mineral oil • Compatible with most lubricants • A third of original charge only is required when replacing halocarbons refrigerant in existing equipment • Energy saving : up to 20% due to lower molecular mass and vapour pressure • Viable alternatives in small systems (<0.25 kW, 1 to 10 kW) and in larger systems (>10 kW) away or protected from public access.	• Flammable, great care must be taken to address safety issues. Approximate auto ignition temperature for some hydrocarbon refrigerants are; R22 (630 °C), R134a (740 °C), R290 (465 °C) R600a (470 °C)
Carbon dioxide	• Non Flammable • Non toxic • Inexpensive and widely available • Its high operating pressure provides potential for system size and weight reducing potential.	• Operating pressure (high side) : 80 bars • Low efficiency
Halocarbons e.g.: HCFCs : R123, R401a, R401b, 403a, R403b, R408a, R409a, 409b, R411B HFCs : R134a, R404a, R407a, R407b, R407c, R410a, R413a, R507,	• Zero Ozone Depletion Potential. • All pure HFCs and most HFC blends require use of synthetic lubricating oils in place of the more conventional mineral oils used for CFCs and HCFCs. This makes retrofit more expensive, but it is still a practical proposition in many situations. • Zero flammability and zero toxicity displayed by most HFCs make them a popular alternative in both existing and new systems.	• HFCs have a high Global Warming Potential (although lower than those of CFCs) and if they need to be used they must be used with care - every effort must be made to prevent/minimise leakage.

4b: Select from Alternative Technology for Halon Fire Suppression and Explosion System

Halons have been used to protect a wide range of risks and the choice of alternative has to be based on consideration of the hazard to be protected. The following sections suggest a number of alternative technologies and give an indication of their applicability and limitations.

Some traditional alternatives to halon are shown below;

(i) Detection and manual intervention

- With the introduction of high sensitivity smoke detection and aspirating systems, it is possible to base a fire protection strategy on suitable detection coupled with arrangements for the fire to be tackled manually with fire extinguishers and hose reels or by the Fire Brigade.
- It must be emphasized that detection systems themselves do nothing to suppress the fire (although they may isolate and shut down electrical power sources).

- Adopting a detection and manual intervention approach represents a major change to your fire protection strategy if you have previously been using a fire suppression system.

(ii) Water Sprinkler Systems, including those with pre-action and/or quick response features

- These achieve their extinguishing action by projecting water droplets into the flames which extract heat from the fire by being partly vaporised to steam. The steam produced locally expels the air thus reducing the combustion process even further. The non-vaporised water cools equipment surfaces.
- This system should not be used for certain hazards including live electrical equipment, fires of flammable liquids, areas of hot working such as salt-baths or anything that would react violently with water.
- For shielded fires, such as those in computer cabinets or in switchgear housing, water cannot penetrate in the same way as halon gas and sprinklers should not be used as the primary system in such fire risks, unless systems are designed with nozzles inside the cabinets.

(iii) Water Mist

- Water Mist has a number of advantages over conventional water spray and sprinkler systems.
- They extinguish by projecting minute water droplets (less than 400 microns in size) into the flames. These vaporise almost completely, cooling the flames and forming steam which displaces oxygen. The result is rapid and efficient extinguishment using very small quantities of water compared to sprinkler or water spray systems.
- The small quantity used means water damage is negligible, even if the system is actuated accidentally. In many enclosed spaces and some local applications this type of system has proved itself a good alternative to halon, even in areas where water supply is a problem.
- However, this system should not be used for certain hazards including live electrical equipment, fires of flammable liquids, areas of hot working such as salt-baths or anything that would react violently with water.
- For shielded fires, such as those in computer cabinets or in switchgear housing, water cannot penetrate in the same way as halon gas and sprinklers should not be used as the primary system in such fire risks, unless systems are designed with nozzles inside the cabinets.
- Current applications within PETRONAS include turbine enclosures and flare stack snuffing systems.

(iv) Carbon Dioxide - local application and total flood

- Carbon dioxide flooding systems have been in use for many years. However, carbon dioxide is toxic and an asphyxiant at the concentrations necessary to extinguish fire.
- Because of this, carbon dioxide total flooding systems should not be on automatic control when the spaces they protect are occupied.
- Carbon dioxide is a clean agent and safe to use on live electrical equipment, telecommunications facilities, computer rooms, control rooms, transformer and switchgear rooms, record storage, cultural heritage, flammable liquid hazards and shipboard machinery spaces.
- Carbon dioxide is stored at high pressure and high concentrations are required to effect extinguishment. As a result such systems involve bulky and heavy hardware and are not suitable for applications where space and weight are important considerations.
- If carbon dioxide total flooding systems are used they should be locked off when people are in the protected area.
- As carbon dioxide is odourless and, in addition to locking devices, the use of odourisers on a system may assist in detecting if the system is in good operating condition or malfunctioned.

(v) Foam - low expansion, high expansion and foam spray systems

- The use of low and medium expansion foams is most suited to liquid pool fires, where it acts by forming a barrier between the fire and the supply of oxygen and also by cooling.

- Foams are not generally effective against running or spray fires. Some liquid fuels, such as alcohols, can destroy some foam blankets by chemical reaction and care must be taken to ensure that an appropriate foam compound is chosen.
- Since foams are aqueous solutions, they should not be used to protect against anything that would react violently with water.
- High expansion foam systems can be used as flooding agents in enclosed areas where the foam works primarily by smothering the fire and less by cooling. This makes it suitable for warehousing and document stores or libraries, flammable liquid stores, engine compartments, computer floor voids, cable tunnels and shipboard machinery spaces.
- Care should be taken in occupied spaces where there is a risk of suffocation and very poor visibility.

(vi) Dry Powder

- Dry powder systems are effective against fires of flammable liquids, including spray fires.
- Powders are capable of effecting very rapid extinguishment but provide little cooling effect and are ineffective once the powder has settled.
- Different types of powders are available to address different types of fire and it is essential to ensure that the powder selected is suitable for use on the risk to be protected.
- All types of powder are unpleasant to breathe, obscure visibility, and would not be recommended for use in occupied spaces.
- Powders settle out after use and present the problem of post-fire clean up. This must be a consideration in their use

(v) Inert Gases

- Inert gas agents are electrically non-conductive clean fire suppressants that are used in design concentrations of 35-50% by volume to reduce ambient oxygen concentration to between 14 and 10%. Oxygen concentrations below 14% will not support the combustion of most fuels (and human exposure must be limited).
- Several gases and mixtures are available commercially, some are shown below.

Trade Name	Designation	Gas Blend
NN100	IG-100	Nitrogen
Argotec	IG-01	Argon
Argonite I	IG-55	Nitrogen/Argon mixture
Inergen	IG-541	Nitrogen/Argon/Carbon dioxide mixture

- Argon and argon-nitrogen mixtures (IG-55) are usually treated in the same way as carbon dioxide although they do not exhibit its physiological effects and as a result, do not interfere with the human control mechanisms for the respiration process.
- The argon-nitrogen inert gas mixture (IG-541) includes a small percentage of carbon dioxide to stimulate respiration in reduced oxygen atmospheres and is suitable for automatic release into areas occupied by personnel.
- The main benefit of inert gases and their mixtures is that they are essentially environmentally benign and do not contribute to ozone depletion or global warming.

(vi) Halocarbon Gases

- A number of fire extinguishing halocarbon gases with ODP have been developed. These include both HFCs (hydrofluorocarbons) and PFCs (perfluorocarbons). Some compounds are shown below;

Trade Name	Designation	Chemical Formula	Formula Name
FE13	HFC 23	CHF3	Trifluoromethane
FE-125	HFC 125	CF3CHF2	Pentafluoroethane
FM-200	HFC 227ea	CF3CHFCF3	Heptafluoropropane
FE-36	HFC 236fa	CF3CH2CF3	Hexafluoropropane
CEA-308	PFC-2-1-8	C3F8	Perfluoropropane
CEA-410	PFC-3-1-10	C4F10	Perfluorobutane

- HFCs are electrically non-conductive, vaporise readily and leave no residue and space and weight efficient.
- However, compare the ODP and global warming potential numbers when making selection.

(vii) Fine Solid Particulates

- Solid aerosol acts directly on the flame and cooling it.
- Solid particulates have very high effectiveness to weight ratios. They also have the advantage of reduced wall and surface losses relative to water mist and the particle size is easier to control.
- However, they may damage sensitive equipment, are not suitable for explosion suppression due to the high temperature at which they are generated and there are severe physiological problems associated with inhalation of particulate material in the size range required.
- These problems limit the utility of this technology to unmanned areas.

Table 7 below shows a comparison between alternative technologies for halon fire suppression against common fire hazard areas while **Appendix 6** presents a summarized requirement for specific fire hazard area in PETRONAS.

Table 7. Summary on Suitable Alternative Technology to Fire Hazard Areas

Alternative Technology	Telecom/ Computer/ Control Rooms	Record Storage	Cultural Heritage	Flammable Liquid	Shipboard Machinery Spaces	Transformers Switchgear room
Automatic Sprinklers	√	√	√	√ (only with foam)	√ (only with foam)	X
Detection and pre-action sprinkler	√	√	√	X	X	X
Detection and water sprays (mist)	X	√ (in rack)	√ (local)	√	√	√
Detection and total flood CO ₂	√	√	√	√	√	√

Alternative Technology	Telecom/ Computer/ Control Rooms	Record Storage	Cultural Heritage	Flammable Liquid	Shipboard Machinery Spaces	Transformers Switchgear room
Foam	√ (under floor)	√	X	√	√	√
High sensitivity smoke detection aspirating systems	√	√	√	X	X	X
Detection and dry powder	X	X	X	√	√	X
Detection and manual intervention	√	√	√	X	X	X
Detection and inert gas	√	√	√	√	√	√
Detection and fire particulate aerosol	X	X	X	√	√	X
Detection and halocarbon gas	√	√	√	√	√	√

4c: Select Alternative Solvent

The best course of action is to eliminate some cleaning operations or to reduce the burden of cleaning by minimising contamination.

Table 8: Alternative Solvent for Cleaning Purpose

Category	Description	Solvent Name
Chlorinated solvents	Non-flammable, chlorinated solvents not regulated as ozone depleters. Suitable for cleaning metal and precision engineered parts.	- Trichloroethylene (trichloroethene) - Perchloroethylene (tetrachloroethene) - Methylene chloride (dichloromethane)
HFC, HFE and PFC solvents	Do not contain chlorine and do not deplete the ozone layer.	- HFC (Hydrofluorocarbon) - HFE (Hydrofluorocarbon ether) - PFC (Perfluorocarbon)
Volatile	Common solvents that work well on non-	Methyl alcohol (methanol)

Category	Description	Solvent Name
flammable solvents	ionic contaminants such as oils and greases. They have low flashpoints and should not be used for wipe cleaning.	- Isopropyl alcohol (isopropanol) - Acetone - Methyl ethyl ketone (MEK) - Ethyl acetate - Butyl acetate
Low volatility solvent	Do not evaporate readily at room temperature, have lower flammability and have excellent solvency for oils and greases. Many have low toxicity and are suitable for wipe and immersion cleaning.	- Terpenes (from vegetation) - Petroleum distillation by-products - Synthetic chemicals

4d: Select Alternative Cleaning Process

(i) Water and Detergent

- Oils, grease, rosin fluxes and other non-ionic contaminants can be cleaned using hot water but only if the contaminants are first solubilised or emulsified. This is usually done by saponifying the contaminant - converting it chemically into a soluble soap.
- Detergents emulsify oils and greases and can be highly ionic which can cause serious problems unless copious rinsing follows the wash.

(ii) Water and Water-soluble Flux

- When cleaning electronic assemblies and the only contaminant of concern is the flux, it is possible to formulate and use a flux that is removable by water alone. The absence of soap leads to the possibility of recycling of the water.
- Water soluble products are usually formulated with stronger acidic activity than rosin fluxes; the residues are more corrosive and more conducting and must always be washed off completely. On the other hand, the stronger activity can allow improved yields, less rework and a more reliable product and water washing is the second preferred option after no-clean technology to deal with flux.

(iii) Other processes

There is an expanding range of other processes for cleaning surfaces;

- blasting the surface with air or microscopic particles of dry ice
- using the excellent solvency of supercritical fluids
- plasma cleaning
- steam cleaning
- decomposing and volatilising the contamination using ultra-violet light or a vacuum-thermal process.

Table 9 on summarises the applicability of various alternatives to ozone depleting solvents.

Alternative Solvent or Technology	Metal and Precision Cleaning	Electronics De-fluxing	Dry-Cleaning	Adhesive Formulation
Avoid Cleaning	√	√	X	X

Alternative Solvent or Technology	Metal and Precision Cleaning	Electronics De-fluxing	Dry-Cleaning	Adhesive Formulation
No cleaning option				
Volatile Solvents				
Chlorinated solvents	√	X	√	√
HFC, HFE and PFC solvents	√	√	X	√
Alcohols, ketones and esters	√	√	X	√
Low Volatility Solvents				
Hydrocarbon solvent, forced evaporation	√	√	√	√
Hydrocarbon solvent, volatile solvent dry	√	√	NA	NA
• Hydrocarbon solvent, water rinse, dry	√	√	NA	NA
• Hydrocarbon/water emulsion, water rinse, dry	√	√	NA	NA
Water				
• Water plus Detergent	√	√	X	√
• Change process	X	√	NA	√
Other processes				
• Dry-ice blasting	√	X	X	X
• Supercritical carbon dioxide	√	√	X	X
• Plasma	√	X	X	X
• Thernak vacuum	√	X	X	X
• UV/ozone	√	X	X	X
• Steam cleaning	√	X	X	X

4e: Alternatives to Carrier Solvents for Adhesive, Coatings and Inks

- Adhesive, coatings and inks containing Banned Chemicals as carrier solvent shall be disposed off as hazardous waste.
- Acceptable carrier solvents that are substitutes for CFC-113 includes; Non-ozone-depleting chlorinated solvents (methylene chloride, trichloroethylene, perchloroethylene)