Guide to Determine

Quantities of Dangerous Substances

Version 2.1

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Major Hazards Department, Ministry of Manpower

Version History

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Table of Contents

List of Figures

List of Tables

List of Abbreviation

CAS	Chemical Abstract Service
CWC	Chemical Weapons Convention
DS	Dangerous Substance
GHS	Globally Harmonised System
HS	Hazardous Substances
LPG	Liquefied Petroleum Gas
MHD	Major Hazards Department
MHI	Major Hazard Installation
NEA	National Environmental Agency
P&FM	Petroleum & Flammable Materials
SCDF	Singapore Civil Defence Force
SDS	Safety Data Sheet
SPF	Singapore Police Force
WSH	Workplace Safety and Health

1) Introduction

This guide aims to provide guidance to workplaces in determining the quantities of Dangerous Substances (DSs) required under the Workplace Safety and Health (Major Hazard Installations) Regulations.

The quantities shall be reported in the **Major Hazard Installation (MHI) Assessment Form,** which is to be submitted during application or renewal for MHI Certificate Registration or as an attachment to an MHI's Safety Case. The **MHI Assessment Form** can be downloaded from the website: http://www.mom.gov.sg/workplace-safety-and-health/major-hazard-installations.

2) Definition of an MHI

The definition of an MHI is stated under the WSH (MHI) Regulations. For a workplace to be classified as an MHI, it must fulfil **both** the conditions as follows:

(i) the nature of work activities **and**

(ii) the inventory levels of the dangerous substances (present or likely to be present) meeting or exceeding threshold quantities.

Condition (i) – Nature of work activities

The first condition is that the work activities for the premise involve processing, manufacturing or having bulk storage by way of trade or for the purpose of gain of any DS specified in the First Schedule. For processing, it refers to any application of DS in the main work process, e.g. in a chemical plant, its use as a reactant, carrier, diluent, catalyst, additives, heating or cooling medium etc.

Typical workplaces that meet this condition include oil refineries, petrochemical processing plant, chlorine warehouses, oil terminals, large chemical warehouses, pharmaceutical and wafer fabrication plants that use DS.

Condition (ii) – Quantity of DS

To fulfil the second condition on the quantity of DS, at least one of the two below criteria must be met:

(a) quantity of the individual DS present or is likely to be present equals or exceeds the prescribed threshold quantities; or

(b) aggregation of the ratios of DS for one or more hazard classes (i.e. Physical, Health or Other Hazards) equals to or exceeds 1.

This guide focuses on the principles and methodology of identification and quantification of the DSs present or likely to be present at a workplace.

3) Useful Reference Documents

The following documents are essential for identifying and quantifying the reportable DS:

(i) List of all the chemical inventories onsite

(ii) Projected forecast of inventories of DS for the next 5 years, if available

(iii) Safety Data Sheets (SDS) of the chemicals

(iv) Equipment list of process equipment (e.g. process vessels, storage tanks) stating the equipment capacity, process conditions etc.

(v) Plot plan or diagrams indicating the locations of the chemicals

(vi) Other existing licences with regards to use, importing, transport or storage of chemicals applied with the authorities, e.g.

a. Petroleum & Flammable Materials (P&FM) Licence administered by SCDF

b. Hazardous Substance (HS) Permit for storage administered by NEA

c. Arms & Explosives Licence administered by SPF

d. Chemical Weapons Convention (CWC) Licence administered by Singapore Customs

4) Concept of Dangerous Substance (DS)

The concept of DS was adopted from Seveso III Directives used in European countries. In Singapore's context, "dangerous substance" refers to any substance, mixture or preparation specified

(a) in Part 1 of the First Schedule of WSH (MHI) Regulations; or

(b) within a category in Part 2 of the First Schedule of the WSH (MHI) Regulations,

and present or likely to be present as a raw material, product, by-product, intermediate or an intermediate product;

The concept requires MHI to declare DSs that are present or likely to be present onsite. This means that DSs should include:

(i) inventory variations that may occur because of seasonal demands and fluctuations in business activities, or DSs which may be present sometimes but not at other times; and

(ii) those which may be generated (i.e. intermediates, intermediate products or by-products) during the loss of control of an industrial chemical process. Common examples of such DS include dioxin, hydrogen sulphide phosgene etc.

5) Nomenclature

Hazard class

Hazard classes are broad classification of hazards focusing on different types of harms they can cause to people or the environment. There are 3 classes of hazards of interest:

(i) Physical Hazards

Include DSs which have the potential to cause impact to personnel, properties and environment. They are generally classified under explosive, flammable, oxidising, pyrophoric and aerosols.

(ii) Health Hazards

Include DSs which have the potential to cause impact on personnel. They are generally classified under acute toxic and specific target organ toxicity.

(iii) Other Hazards

Include DSs which have the potential to cause impact to personnel, properties and environment under special circumstances. They include substances that emit flammable gases when in contact with water and desensitised explosives.

The aggregation ratios calculations in each of the 3 hazard classes needs to be calculated, and are explained in the later section.

Hazard category

There are various categories of hazards in each of the hazard classes. The various categories of hazards refer to a specific type of hazard classifications under the Globally Harmonised Systems (GHS) classification. For example, under the 'Health' hazard class, there are 3 categories of hazards, namely H1 Acute Toxic, H2 Acute Toxic and H3 Specific Target Organ Toxicity (STOT) - Single Exposure. The categories apply to Part 2 of the First Schedule, to account for chemicals that are not specifically named DSs.

More information on Singapore's GHS Implementation can be found here: https://www.wshc.sg/ghs or the Guidebook on Globally Harmonised System published by the Singapore Chemical Industry Council (SCIC).

6) Hazard Classification of DS

Named DSs

'Named DSs' have been identified due to its potential to cause a major accident and past incidents involving in those chemicals. They are mainly identified by their Chemical Abstract Service (CAS) Numbers, except for liquefied flammable gases (e.g. LPGs) and petroleum and alternative fuels.

The list of **29 named DSs** from Part 1 of the First Schedule of WSH (MHI) Regulations and their respective hazards class are listed in Table 1 below:

No	Named Dangerous Substances	CAS No	Threshold quantities (Tonnes)	Hazards Class		
				Health	Physical	Others
1	2,4-Toulene diisocyanate & 2,6-Toluene diisocyanate	584-84-9 91-08-7	100	Yes	-	-
2	Acetylene	74-86-2	50	-	Yes	-
3	Ammonium nitrate	6484-52-2	5,000	-	Yes	-
4	Anhydrous Ammonia	7664-41-7	50	Yes	Yes	-
5	Arsenic pentoxide, arsenic (V) acid and/or salts	1303-28-2	10	Yes	-	-
6	Arsenic trioxide, arsenious (III) acid and/or salts	1327-53-3	10	Yes	-	-
7	Arsine (arsenic trihydride)	7784-42-1	1	Yes	Yes	-
8	Boron trifluoride	7637-07-2	20	Yes	-	-
9	Carbonyl dichloride (phosgene)	75-44-5	0.75	Yes	-	-
10	Chlorine	7782-50-5	25	Yes	-	-
11	Ethylene oxide	75-21-8	25	Yes	Yes	-
12	Ethyleneimine	151-56-4	20	Yes	Yes	-
13	Formaldehyde (concentration >90%)	50-00-0	50	Yes	-	-
14	Hydrogen	1333-74-0	25	-	Yes	-
15	Hydrogen chloride (anhydrous and refrigerated liquid)	7647-01-0	150	Yes	-	-
16	Hydrogen fluoride (anhydrous)	7664-39-3	15	Yes	-	-
17	Hydrogen sulphide	7783-06-4	20	Yes	Yes	-
18	Liquefied flammable gases, Category 1 or 2 (including LPG)	-	200	-	Yes	-
19	Methanol	67-56-1	5,000	Yes	Yes	-
20	Methyl acrylate	96-33-3	2,000	-	Yes	-
21	Methylisocyanate	624-83-9	0.15	Yes	Yes	-
22	Oxygen	7782-44-7	2,000	-	Yes	-

No	Named Dangerous Substances	CAS No	Threshold quantities (Tonnes)	Hazards Class		
				Health	Physical	Others
23	Petroleum products and alternative fuels (a) gasolines and naphthas, (b) kerosenes (including jet fuels), (c) gas oils (including diesel fuels and gas oil blending streams) (d) heavy fuel oils (e) alternative fuels serving the same purposes and with similar flammability as the products referred to in paragraphs (a) to (d)	-	14,000	-	Yes	-
24	Phosphine (phosphorus trihydride)	7803-51-2	1	Yes	Yes	-
25	Potassium nitrate	7757-79-1	5,000	-	Yes	-
26	Propylamine	107-10-8	2,000	Yes	Yes	-
27	Propylene oxide	75-56-9	25	Yes	Yes	-
28	Sulphur trioxide	7446-11-9	75	Yes	Yes	-
29	Ter-butyl acrylate	1663-39-4	500	-	Yes	-

Table 1: List of named DSs

Categories of DSs

Table 2 below covers the categories of hazards known to have potential to cause major accident and its respective threshold quantities.

Categories	Threshold quantities (Tonnes)
Class 'H' – HEALTH HAZARDS	
H1 ACUTE TOXIC — Acute Toxic, Category 1, any exposure routes	15
H2 ACUTE TOXIC — Acute Toxic, Category 2, any exposure routes — Acute Toxic, Category 3, inhalation exposure route	200
H3 SPECIFIC TARGET ORGAN TOXICITY (STOT) – SINGLE EXPOSURE — STOT SE, Category 1	200
Class 'P' – PHYSICAL HAZARDS	
P1a EXPLOSIVES — Explosives, Unstable explosives or Division 1.1, 1.2, 1.3 or 1.5	50
P1b EXPLOSIVES — Explosives, Division 1.4 or 1.6	200
P2 FLAMMABLE GASES — Flammable gases, Category 1 or 2	25
P3 AEROSOLS — Aerosols, Category 1 or 2	500
P4 OXIDISING GASES — Oxidising Gases, Category 1	200

P5a FLAMMABLE LIQUIDS — Flammable liquids, Category 1 — Flammable liquids, Category 2 or 3 maintained at a temperature above their boiling point — Other liquids with a flash point ≤ 60°C, maintained at a temperature above their boiling point	40
P5b FLAMMABLE LIQUIDS — Flammable liquids, Category 2 or 3 where particular processing conditions, such as high pressure or high temperature, may create major accident hazards — Other liquids with a flash point ≤ 60°C where particular processing conditions, such as high pressure or high temperature, may create major accident hazards	150
P5c FLAMMABLE LIQUIDS — Flammable liquids, Categories 2 or 3 not covered by P5a and P5b	28,000
P5d FLAMMABLE SOLIDS — Flammable solids, Category 1 or 2	200
P6a SELF-REACTIVE SUBSTANCES AND MIXTURES and ORGANIC PEROXIDES — Self-reactive substances and mixtures, Type A or B — Organic peroxides, Type A or B	50
P6b SELF-REACTIVE SUBSTANCES AND MIXTURES and ORGANIC PEROXIDES — Self-reactive substances and mixtures, Type C, D, E or F — Organic peroxides, Type C, D, E or F	200
P7 PYROPHORIC LIQUIDS AND SOLIDS — Pyrophoric Liquids, Category 1 — Pyrophoric Solids, Category 1	200
P8 OXIDISING LIQUIDS AND SOLIDS — Oxidising Liquids, Category 1, 2 or 3 — Oxidising Solids, Category 1, 2 or 3	200
Class 'O' – OTHER HAZARDS	
O1 Substances and mixtures which in contact with water emit flammable gases, Category 1	500
O2 Desensitized explosives when dry are Explosives of Class 1 other than those of compatibility group A, which are wetted with sufficient water, alcohol, or plasticizer to suppress explosive properties	200

Table 2: List of hazards categories for DSs not specifically listed in Table 1

For chemicals that are not specifically listed in Table 1, MHIs shall refer to their SDS to determine if their GHS hazards classification (which is typically under Section 2 - HAZARDS IDENTIFICATION of the SDS) falls under any of the categories of hazards in Table 2. Should there be practical issues in determining the classification, the use of best-available data and other scientifically sound and validated methods is acceptable. In the absence of information, MHI may also refer to other reliable sources (e.g. other suppliers, online databases etc) to get a representative hazards classification of the chemical. One such resource is the chemical inventory database under the European Chemicals Agency (ECHA) which can be found at the website: https://echa.europa.eu/information-on-chemicals/cl-inventory-database.

A quick reference list on the above hazards classification of common HS and P&FM has been developed to assist MHI. This '**Reference List of Dangerous Substances Hazards Classification'** can be downloaded from the website: http://www.mom.gov.sg/workplace-safety-and-health/major-hazard-installations.

Note: The hazard classifications of the substances/chemicals under this list are generic as they were derived from SDS of various sources, based on their CAS numbers and chemical names.

Mixtures Classifications

Mixtures such as reaction mixtures and hazardous waste materials shall be identified and declared under the quantities of DSs. A mixture is essentially made up of two or more substances which do not react. It also includes a single substance in solution with another. By July 2016, all manufacturers/suppliers and users should have implemented GHS classification on mixtures in Singapore. As such, classification of hazards of mixtures should be based on GHS as far as possible.

In the event a mixture does not possess any SDS because it is a self-mixed or blended substance or it exists as an intermediate product, the mixture rules as stipulated in the 'Guidebook on the Globally Harmonised System' apply.

Flowchart on reporting rules

The following flowchart gives an overview of which Table to report for the DS, based on their hazard classifications.

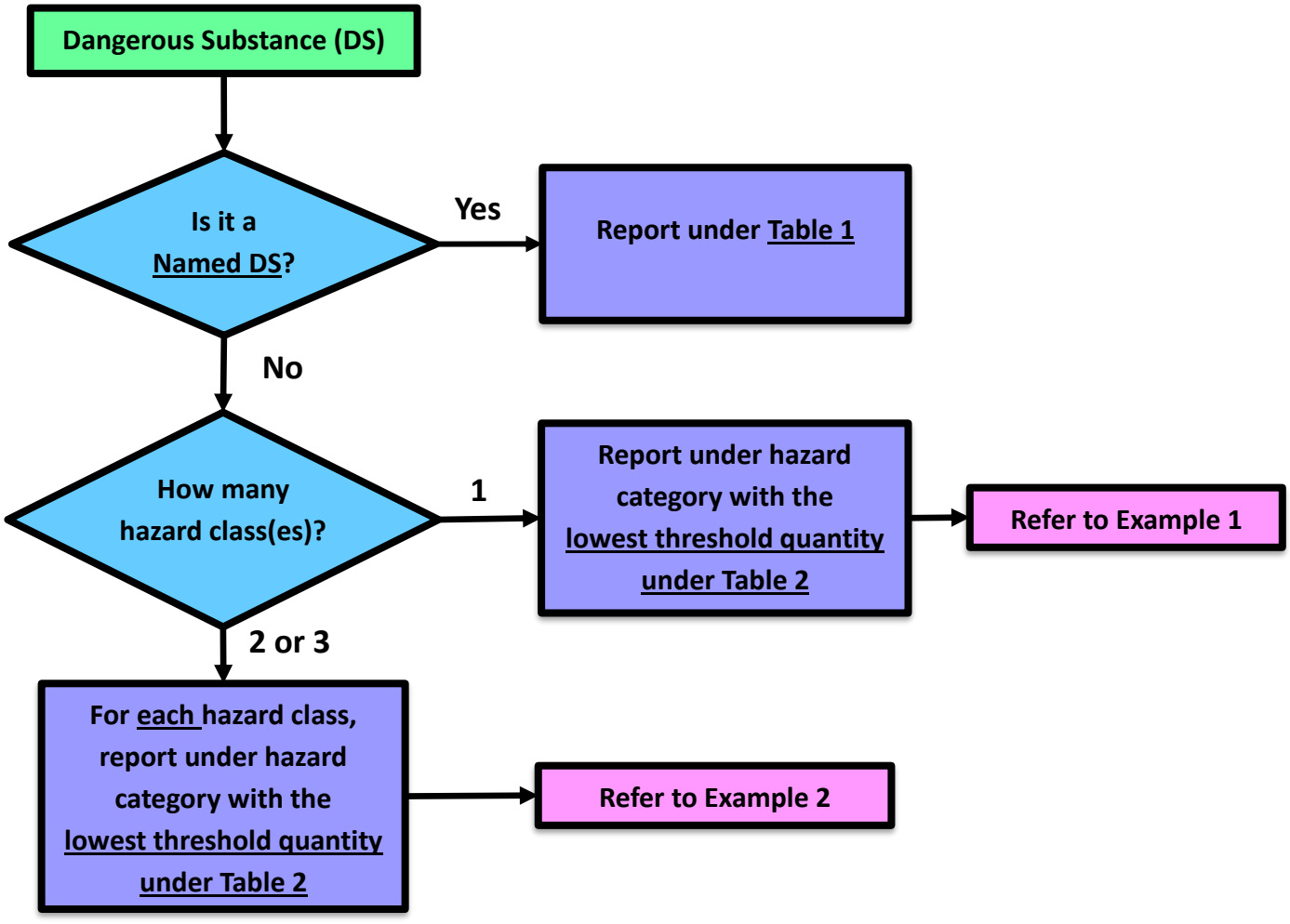

Figure 1: Flowchart on the reporting rules

7) Key Pointers for Reporting DS

Note 1 — Petroleum and alternative fuels

For 'Petroleum products and alternative fuels' under Table 1, they refer to mixtures of hydrocarbons for use as fuels or be subjected to further processing into refined products. Examples of petroleum products include naphtha, gasoline, jet fuel, kerosene, fuel oil, diesel etc. These should be reported in Table 1; the breakdown of quantities of each product should be indicated appropriately. If the hydrocarbon stream comprises mainly pure substance such as methane, ethane, 1,2-butadiene, benzene etc, they should be reported under Table 2 instead. To avoid double-counting of quantities, DSs reported under Table 1 should **NOT** be reported again under Table 2 and vice versa.

Note 2 — Named DSs in aqueous state

For named DSs under Table 1 where the physical state of the substance is not stated, MHIs should declare quantities of the sum of all solid, liquid, gaseous and anhydrous state of the chemical. For substances in aqueous state, it could fall under Table 2 depending on its concentration.

Below are examples of common substances which are commonly classified wrongly:

- **Ammonia (Anhydrous) vs Aqueous ammonia (Ammonium hydroxide)**

The GHS classification for the above substances are different. Ammonium hydroxide need not be declared.

Substance	CAS No	Relevant GHS Classification	Table to report under
Ammonia (Anhydrous)	7664-41-7	Acute Toxicity (Inhalation) Category 3	Table 1
Aqueous ammonia (Ammonium Hydroxide)	1336-21-6	Nil	Nil

- **Hydrochloric acid vs Hydrogen chloride (Anhydrous or refrigerated liquid)**

Although both substances have the same CAS number, hydrochloric acid is different from pure hydrogen chloride stated under Table 1. For hydrochloric acid, MHI should determine its hazard classification, and classify it under Table 2 if relevant.

Substance	CAS No	Relevant GHS Classification	Table to report under
Hydrochloric acid	7647-01-0	Acute Toxicity (Inhalation) Category 2	Table 2
Hydrogen chloride	7647-01-0	Acute Toxicity (Inhalation) Category 3	Table 1

- **Hydrofluoric acid Vs Hydrogen fluoride (Anhydrous)**

Similarly, although both substances have the same CAS number, hydrofluoric acid is different from hydrogen fluoride (anhydrous) which is stated in Table 1. For hydrofluoric acid, MHI should determine its hazard classification, and classify it under Table 2 if relevant.

Substance	CAS No	Relevant GHS Classification	Table to report under
Hydrofluoric acid	7664-39-3	Acute Toxicity (Oral) Category 2, Acute Toxicity (Dermal) Category 1, Acute Toxicity (Inhalation) Category 1	Table 2
Hydrogen fluoride	7664-39-3	Acute Toxicity (Oral) Category 2, Acute Toxicity (Dermal) Category 1, Acute Toxicity (Inhalation) Category 1	Table 1

Note 3 — Class 'H' - Health hazard

Health Hazards

There are 10 hazard classes under the health hazards. These are summarised in Table 3.31.

Table 3.31 Summary of the health hazard classes

* Only for Inhalation route

	Hazard Class	Hazard Category				
1	Acute toxicity	Cat 1	Cat 2	Cat 3	Cat 4	Cat 5
2	Skin corrosion/irritation	Cat 1A	Cat 1B	Cat 1C	Cat 2	Cat 3
3	Serious eye damage/eye irritation	Cat 1	Cat 2A	Cat 2B		
4	Respiratory or skin sensitization	Respiratory Cat 1A	Respiratory Cat 1B	Skin Cat 1A	Skin Cat 1B	
5	Germ cell mutagenicity	Cat 1A	Cat 1B	Cat 2		
6	Carcinogenicity	Cat 1A	Cat 1B	Cat 2		
7	Reproductive toxicity	Cat 1A	Cat 1B	Cat 2	Lactation	
8	Specific target organ toxicity - single exposure	Cat 1	Cat 2	Cat 3		
9	Specific target organ toxicity - repeated exposure	Cat 1	Cat 2			
10	Aspiration hazard	Cat 1	Cat 2			

Figure 2: Summary of the Health hazard classes
(extracted from 'Guidebook on Globally Harmonised System')

Acute toxicity – H1 Acute toxic and H2 Acute toxic

Acute toxicity refers to those adverse effects occurring following oral or dermal administration of a single dose of a substance, or multiple doses given within 24 hours, or an inhalation exposure of 4 hours. It is determined by Acute Toxicity Estimate (ATE). The ATE for the classification of a substance or ingredient in a mixture is derived using the LD_{50} (oral or dermal) or LC_{50} (inhalation) or the appropriate converted ATE that relates to the results of a range test or classification category.

There are **3 main routes of exposure** for acute toxicity:

- Acute toxicity **- Oral**
- Acute toxicity **- Dermal**
- Acute toxicity **- Inhalation**

For the DSs' classification of Class 'H' - Health hazard,

- **Acute toxic - Category 1 (Any exposure routes)** falls under H1 Acute toxic
- **Acute toxic - Category 2 (Any exposure routes) or Category 3 (Inhalation route only)** falls under H2 Acute toxic

Acute toxicity should not be confused with the different hazard classes in the Health hazards. For example, a substance which is classified as Skin corrosion/irritation Category 1 or Skin Sensitisation Category 1. This is different from the Acute toxicity – Dermal, and it should not be classified as the hazard class of H1 Acute toxic.

H3 Specific target organ toxicity (STOT) – Single exposure

Specific target organ toxicity (single exposure) is defined as specific, non-lethal target organ toxicity arising from a single exposure to a substance or mixture. It includes all significant health effects that can impair function, reversible and irreversible, immediate and/or delayed, not specifically addressed by others. This can occur via any route that is relevant for humans, i.e. principally oral, dermal or inhalation. It is recognised that human data will be the primary source of evidence for this hazard class.

For the DSs' classification of Class 'H' - Health hazard,

- Only **Category 1 of Specific target organ toxicity – single exposure** needs to be reported under H3 Specific target organ toxicity (STOT) – Single exposure

Note 4 — Reporting of DSs under the same hazard class

In the event that a DS not named specifically in Table 1 falls under 2 or more categories under the same hazard class (e.g. simultaneously under H1 and H3 category under health hazard), the **lower threshold quantity** is to be used.

Example 1

Hydrogen cyanide (HCN) is a highly toxic chemical with H1 - Acute Toxicity (Oral, Dermal, Inhalation) Category 1, and H3 - STOT SE Category 1.

From Table 2, the thresholds for H1 and H3 are 15 T and 200 T respectively. Therefore, according to the rule to report under the category with lower threshold quantity, HCN should be reported under H1.

Note 5 — Reporting of DSs under different hazard classes

Example 2

Dimethyl disulphide (DMDS) does not fall under named DSs of Table 1, therefore it must be reported in Table 2.

From the SDS, it falls under the following hazard classifications:

- Physical hazard: P5b - Flammable Liquid Category 2, and
- Health hazard: H1 - Acute Toxicity (Inhalation) Category 1.

It needs to be reported separately in each of these two hazard classes.

Note 6 — Reporting of flammable liquid under P5a, P5b or P5c

- For Flammable liquids Category 1, it falls under P5a. For Flammable liquids Category 2 or 3 or liquids with flash point <60°C, it depends on their storage conditions. If the storage condition is above the boiling point of the substances, it should be reported under P5a, otherwise, it would fall under P5c.
- P5b is usually applicable for quantities of flammable liquids Category 2 or 3 or liquids with flash point <60 °C inside **process equipment** where the **processing conditions** may create a major accident hazard.

8) Determination of Quantities

The quantity of DSs that is present or is likely to be present at any given time within the geographical boundary of the MHI shall be reported. This will include DSs that are in the storage vessels and in the major process equipment. Major piping or pipe headers that will contribute significantly to the total volume should be included as well.

In situations such as warehouses where there are frequent inventory fluctuations, or toll manufacturers with varying production campaigns, or plants where there are complex inventories with large numbers of DSs, it is acceptable to notify the maximum limits under the respective hazards categories of DSs which a MHI anticipate might be present.

Storage tanks or vessels

The maximum allowable quantity, or gross capacity defined for storage tanks or vessels, is to be reported for the quantity calculations. However, MHI could declare the maximum operating capacity instead of the maximum capacity of the equipment if there are control measures in place to restrict further inflow of DSs beyond its normal maximum operating capacity, i.e. use of high-high level alarms, hard limit-switches and trip systems etc. It is expected that this quantity should be similar to the respective quantities declared to SCDF for P&FM licence and NEA for HS permit for storage purposes.

In the case of storage tanks that could switch inventories to store DSs of other hazards classes, e.g. flammable materials to toxic materials and vice versa within the considered time frame of 5 years, **all** the DSs should be accounted in the aggregation ratio calculations of their respective hazards classes as it reflects the potential major accident hazards posed by the DSs albeit at different times. In other words, the total quantities of DSs stored as declared in the tables may not reflect the actual quantities of DSs at the installation. MHI should indicate this operation mode under the "Nature of Work" column of the **MHI Assessment Form**.

Process equipment

The quantity calculations should be based on the maximum capacity of the process equipment for both gas-filled systems and liquid-filled systems. For two phase (gas-liquid) systems, the maximum capacity of the vessel filled with the dominant phase can be declared for simplicity. Alternatively, the quantities of both liquid and gas can be added up, i.e. the quantity of liquid should be derived from the maximum operating liquid level and the quantity of gas will be based on the remaining capacity of the vessel. This is applicable for calculations of reactor, tower and catalyst bed hold-up etc.

Similar to the storage tanks or vessels, MHI could declare the maximum operating capacity instead of the maximum capacity of the process equipment if there are justifications on how the system restricts further inflow of DSs beyond its normal maximum operating capacity, i.e. use of hard limit-switches and interlock systems etc.

Pipeline

Pipeline inventory that are under the control of MHI and located within the MHI's premises shall be included in the calculations. Both aboveground and underground pipelines must be considered if they are containing DSs. In view of the large network of pipelines within the MHI, it is acceptable to simplify by only accounting for the major pipelines or headers carrying the DSs.

Small quantities

For small quantities of chemicals that are **not** involved in the main process and its location is such that it cannot initiate a major accident elsewhere on site, it is acceptable to exclude them out of the calculation. One example is the chemicals used in the laboratory for support of quality analysis or quality control of products. A general guideline is that such quantities must be **less than 2%** of the respective threshold quantities stated in Table 1 or Table 2.

However, numerous small quantities, such as small cylinders of toxic gas, each containing less than the 2% threshold but stored adjacent to each other, shall be counted. If it is not practical to manage the quantities of individual DS, it is acceptable to notify the maximum limits under the respective hazards categories of DSs which a MHI anticipate might be present.

Units of Reporting

In any case, all quantities shall be reported in the unit of **metric tonnes** (i.e. 1000 kg). This is such that the reported values are independent of the storage or process conditions, especially for gaseous substances. Conduct the appropriate conversion to mass (tonnes) by multiplying the volume with the density of the substance at that storage or process conditions.

$$Mass = Density \times Volume$$

9) Hazardous Substances vs Dangerous Substances

A list of hazardous substances has been defined in Part 2 of the Fifth Schedule of the Workplace Safety and Health Act (WSHA).

While there are overlaps of DSs defined under WSH (MHI) Regulations with the hazardous substances defined under Fifth Schedule of WSHA, the WSH (MHI) Regulations is only scoped to substances that could cause major accidents and as defined by the GHS. As such, certain substances identified under hazardous substances such as corrosives, irritants, gases under pressure or of lower toxicity etc, are not considered under DS.

In addition, NEA has a set of hazardous substances under the Environment Protection and Management Act (EPMA). Hazardous substances controlled by NEA are generally those that have mass-disaster potential, are highly toxic and pollutive or generate toxic wastes that can only be disposed of with greater difficulty.

Note: MHIs are required to continue abiding by the legal requirements covering DS and hazardous substances defined under the respective legislation.

10) MHI Assessment Form

To facilitate the calculation of the aggregation ratios, the **MHI Assessment Form** was developed. The aggregation ratio is an indication of the intrinsic risks of major accidents posed by the workplace due to the hold-up of the DSs.

There are 3 types of aggregation ratios, namely physical, health and other hazards to be calculated.

The aggregation ratio calculation is in-built in the **MHI Assessment Form**. The outcome of the calculation will be generated automatically.

The users will only need to:

(i) Identify the DSs as appropriate

(ii) Classify them into the correct named DSs (Table 1) or hazards categories (Table 2)

(iii) For named DS, please input the storage and processing quantities in the corresponding cells of Table 1.

(iv) For other DSs, please declare the breakdown of DSs under "Table 2 DS Breakdown" tab. The total quantities (process & storage) under each hazard category will be auto populated in Table 2 of the form.

The form can be downloaded from the website: http://www.mom.gov.sg/workplace-safety-and-health/major-hazard-installations.

Please always review the latest quantities of DSs and use the latest version of the **MHI Assessment Form** during application or renewal for MHI Certificate Registration.

For more information on the calculations involved in the **MHI Assessment Form**, please refer to the Appendix.

11) Further Information

Additional information and guidance are at: http://www.mom.gov.sg/workplace-safety-and-health/major-hazard-installations. For further clarifications, MHD can be contacted at: contact_MHD@mom.gov.sg.

12) Appendix

Aggregation Ratio Calculation

There are 3 types of aggregation ratios (physical, health and other hazards) to be calculated. For each of the 3 aggregation ratios, the quantities of all the DSs present or likely to be present must be summed as partial fractions of their threshold quantities, i.e.

$$Aggregation\ Ratio\ (Physical\ hazards) = \frac{q_{P_1}}{Q_{P_1}} + \frac{q_{P_2}}{Q_{P_2}} + \cdots + \frac{q_{P_n}}{Q_{P_n}} + \cdots$$

$$Aggregation\ Ratio\ (Health\ hazards) = \frac{q_{H_1}}{Q_{H_1}} + \frac{q_{H_2}}{Q_{H_2}} + \cdots + \frac{q_{H_n}}{Q_{H_n}} + \cdots$$

$$Aggregation\ Ratio\ (Other\ hazards) = \frac{q_{o_1}}{Q_{o_1}} + \frac{q_{o_2}}{Q_{o_2}} + \cdots \frac{q_{o_n}}{Q_{o_n}} + \cdots$$

where

q = **total** quantity of the particular DS (in tonnes) present or likely to be present onsite

Q = **threshold** quantities of the particular DS (in tonnes) identified from Table 1 (for named DSs) or Table 2 (for DSs not specifically named in Table 1)

P_1, P_2 ... P_n = DSs that possess Physical hazards

H_1, H_2 ... H_n = DSs that possess Health hazards

O_1, O_2 ... O_n = DSs that possess Other hazards

In other words, only quantities of substances with similar hazards (i.e. physical hazards, health hazards and other hazards) are to be added.

If one or more of aggregation ratios of physical, health or other hazards **equals to or exceeds 1**, the second condition of the 2-fold conditions, i.e. the threshold quantities, is met.

$$Aggregation\ Ratio\ (Physical\ hazards) = \frac{q_{P_1}}{Q_{P_1}} + \frac{q_{P_2}}{Q_{P_2}} + \cdots + \frac{q_{P_n}}{Q_{P_n}} + \cdots \geq \mathbf{1}$$

$$Aggregation\ Ratio\ (Health\ hazards) = \frac{q_{H_1}}{Q_{H_1}} + \frac{q_{H_2}}{Q_{H_2}} + \cdots + \frac{q_{H_n}}{Q_{H_n}} + \cdots \geq \mathbf{1}$$

$$Aggregation\ Ratio\ (Other\ hazards) = \frac{q_{o_1}}{Q_{o_1}} + \frac{q_{o_2}}{Q_{o_2}} + \cdots \frac{q_{o_n}}{Q_{o_n}} + \cdots \geq \mathbf{1}$$

A DS can fall under one or more of the hazard classes shown above. The example below shows how to determine the aggregation ratios for some of the DSs.

Example 3

A site holds Ethylene oxide (EO), which is flammable in nature and falls under the physical hazards category. It would be added to any other explosive, flammable, oxidising, pyrophoric and aerosol substances using the partial fraction formula to calculate the aggregation ratio for physical hazards.

In addition, as EO is toxic in nature, it will be separately calculated in the aggregation ratio for health hazards as shown:

$$Aggregation\ Ratio\ (Physical\ hazards) = \frac{q_{P_{EO}}}{Q_{P_{EO}}} + \frac{q_{P_2}}{Q_{P_2}} + \cdots + \frac{q_{P_n}}{Q_{P_n}} + \cdots$$

$$Aggregation\ Ratio\ (Health\ hazards) = \frac{q_{H_{EO}}}{Q_{H_{EO}}} + \frac{q_{H_2}}{Q_{H_2}} + \cdots + \frac{q_{H_n}}{Q_{H_n}} + \cdots$$

The hazard classes for the named DSs are indicated in Table 1. The threshold quantities (Q) indicated in Table 1 **must** be used for **all** the calculations despite they also fall under the categories in Table 2, possibly sporting a different threshold value.

Example 4

For Ethylene oxide (EO), its threshold is 25 T under Table 1 (named DS) and 200 T under Table 2 (categories of DSs), H2 – Acute toxic Category 3, inhalation exposure route.

Therefore, the correct threshold value to use for any aggregation calculations is from Table 1, i.e. Q_{EO} = 25 T

For a DS which is not specifically named under Table 1 and falls under more than one hazards classes (e.g. both physical and health hazards), the threshold quantity to use in the aggregation ratio calculations will correspond to the thresholds specified for that class. In other words, this DS will have 2 (or more) thresholds to be applied appropriately in the respective aggregation ratio calculations.

13) References

1. *Guidebook on Globally Harmonised System (GHS) (2nd Version),* 2014, Singapore Chemical Industry Council

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3. *The Control of Major Accident Hazards Regulations 2015 (L111),* Oct 2015, Health and Safety Executive, retrieved from website: http://www.hse.gov.uk/pubns/priced/l111.pdf

4. *Chemicals & Labelling (C&L) Inventory*, Sep 2016, European Chemicals Agency (ECHA), retrieved from website http://echa.europa.eu/information-on-chemicals/cl-inventory-database/-/cl-inventory

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