

SELLER'S GUIDE TO WAREHOUSING OF DANGEROUS CHEMICALS

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<p>Abstract</p> <p>The warehousing of dangerous chemicals in Finland is still in its infancy stage. Nevertheless, it is constantly growing. The chemical experts are rare and overworked. Schenker Cargo Oy needed a guide for their warehousing space sellers, which would introduce the most common aspects of warehousing of dangerous chemicals. This would lessen the load of chemical experts inside the company.</p> <p>Utilizing interviews with Schenker Cargo Oy's employees and official internet sites, this research delivers introduction into the key features and explains how they effect to warehousing price. The newly opened logistics center at Ilvesvuori, Nurmijärvi was used as a prime example for the theory part contents. Using the pragmatic approach, the certification, standards and the laws and regulations were found out to be the most common aspects of warehousing.</p> <p>The result of this thesis was the theory part which will be translated into Finnish and given to Schenker Cargo Oy's sellers for everyday use. With this guide, they will be able to answer to most common questions asked by customers, to recognize hazardous chemicals and know the background regulations. Given that the theory content is applicable to other warehouses, this guide can be used outside of Ilvesvuori logistics center.</p>		
<p>Keywords</p> <p>Warehousing, chemicals, CLP, ATEX, REACH, Schenker, classification, guide, explosives, ISO, OHSAS, TAPA, AEO</p>		
<p>Miscellaneous</p> <p>The Finnish translation of this guide, going to Schenker Cargo Oy's use, is confidential and is not included in this research.</p>		

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DEFINITIONS

TERM	DEFINITION
CLP	Classification, Labelling and Packaging
GHS	Globally Harmonized System
ANFO	Ammonium Nitrate-Fuel Explosive
STOT	Specific Target Organ Toxicity
REACH	Registration, Evaluation, Authorization and restriction of Chemical substances
ECHA	European Chemicals Agency
SVHC	Substances of Very High Concern
CMR	Carcinogenic, Mutagenic or toxic to Reproduction
vPvB	very Persistent and very Bio accumulative
PBT	Persistent, Bio accumulative, Toxic
CAS	Chemical Abstract Service
ISO	International Organization for Standardization
QMS	Quality Management System
EMS	Environmental Management System
OHSAS	Occupational Health and Safety Assessment
TAPA EMEA	Transported Asset Protection Association - Europe, Middle East and Africa
FSR	Freight Security Requirements
TSR	Trucking Security Requirements
TACSS	TAPA Air Cargo Security Standards
AEO	Authorized Economic Operator
AEOC	Authorized Economic Operator Customs simplifications
AEOS	Authorized Economic Operator Safety and Security
AEOF	Authorized Economic Operator Full

1 INTRODUCTION

Depending on the angle, warehousing activities can be very different. A warehouse worker, doing picking all day, has very different perspective compared to a seller, who sells the warehouse space from his office. One could say that these are the opposite sides of the coin. Nonetheless, they are equally important.

In 2012, Schenker Cargo Oy, a side branch of Schenker East Ab, opened a new logistics center to Nurmijärvi's Ilvesvuori in Finland. Schenker Cargo Oy's most known service in Finland is Kiitolinja delivery. In 2012 the, DB Group, had sales revenue of 37,812 million € and employed 235 000 persons worldwide. This new logistics center in Ilvesvuori is specialized into warehousing of dangerous chemicals. As the chemical business is still in its infancy state in Finland, there are only few specialized people who focus into dangerous chemicals and have wide knowledge about them. As the seller's don't need to know much about the chemicals they sell, they usually turn to these experts and specialists for help. Schenker Cargo Oy made a request for a thesis topic which would give *general* information guide for sellers about dangerous chemicals. As the guide for dangerous *transports* already exists and the chemical business is growing, the need to update seller's knowledge is growing too. The guide wouldn't need to be a complete one, as the seller's point of view is fairly limited. Rather than being able to cite every possible law, directive and regulation in dangerous chemicals warehousing, they should be able to have comprehensive bird perspective. This would lessen the load of already hard working specialists as the seller could describe the situation better for them.

The thesis will bring forth basic knowledge about dangerous chemicals categorization, labeling, laws and certificates. The scarcity of related book sources can be seen in the reference page as most of the sources are from the official internet pages of European Union, Finnish government and International Organization of Standardization. These sources offer up to date information and are easier to find when compared to similar related books. Most of the book sources cannot keep up with rapidly supplemented laws and directives, and therefore are outdated. Some of them are still usable though. Also, some interviews with Schenker

Cargo Oy's tender and sales manager were carried out. These interviews were utilized to focus theory part more for their needs. The interviews were carried out by phone and visiting the Ilvesvuori logistics center. The Ilvesvuori logistics center is used as an example warehouse for this thesis. The theory part contents are shaped towards certificates and laws concerning this warehouse in particular. Combining Schenker Cargo Oy's wishes and interview results, the following questions were formed to be answered:

- What things sellers need to know about warehousing of dangerous chemicals?
- What background issues affect to price of warehousing?

This thesis work will be used as a prime guide for Schenker Cargo Oy's sellers. Most importantly, with this guide a seller should be able to identify dangerous chemicals by their labeling and tell to the customer can they be warehoused or not. Other included information shows what regulations, laws and certificates demand from this kind of business. With this background information, the seller can describe how the pricing of warehousing changes because of additional requirements posed by hazardous chemicals. From the self-development point of view, this thesis work will give information that wasn't included in the original logistics engineering curriculum. As the dangerous chemicals are still young but constantly growing business trade in Finland, the expertise in this field could be very beneficial especially considering a future job.

2 CLP CLASSIFICATION

Classification, Labeling and Packaging of substances and mixtures (CLP) is a regulation issued by European parliament and council. CLP or EU regulation 1272/2008, came into effect in 20th of January 2009 and replaced any older regulations concerning chemical markings and packaging. It's a part of Globally Harmonized System (GHS) of labeling and classification of chemicals, which aims to standardize above mentioned issues worldwide. According to CLP, the dangerous goods are classified by their hazardousness to *physical surroundings*, to *human health*, to *water environment* and to *ozone layer*. Understanding this categorization

brings forth the basic knowledge about dangerous chemicals and their primary properties. All categories come with danger warning phrases:

- H phrase describes *danger*
- P phrase describes *safety*.

The P phrases are used to describe preventive measures, rescue measures, warehousing measures and waste handling measures. There are hundreds of danger and safety phrases in existence and they can be either category or substance specific. From the seller's point of view, the new GHS markings and labels are a must to know, since they are gradually replacing the *old* labels, designated by:

- EU directive 67/548/ETY
- EU directive 1999/45/EY.

The old markings, categorization and labels are *still in use*, alongside the new CLP regulation until 2017. Because of this, the seller must know both. The labels and categorization differ a little. CLP has more chemical classes and label colors are different. Most of the categorization and labels in use today are still the old ones, marked with orange background and black drawings.

All *old* markings and subcategories can be found from Appendix 1: Ceding labels and categorization. In the upcoming categorization chapters, the H and P phrases are used for substance *categories* only. The specific H phrases are used in combination with written category introduction under the substance chapters.

2.1 Physical hazards

Explosives are determined as sole explosive substances, explosive mixtures or explosive devices. They exclude devices which won't have any external reaction from internal explosion in form of fire, smoke, heat or noise. Explosives consist of 6 different *stable* danger classes ranging from 1.1 to the 1.6 category. Everything else outside of stable explosives category is labeled *unstable* explosives and they have unnumbered category. All explosives except categories 1.5 and 1.6 are required to be marked with GHS01 label, found from FIGURE 1. The P phrases used for this category

generally mention that explosives should be sheltered from heat, sparks and fire. Smoking near them is not advised and holding silos, if any, must be grounded. In case of fire, the area should be evacuated and substances should not be tried to extinguished once fire has reached them. Most common consumer grade mixture explosives are fireworks. Industrial grade explosives are for example ammonium nitrate and fuel oil (ANFO), which is common explosive in mining. In civil side, it's common agricultural fertilizer. Since explosive substances require special warehouse arrangements, permits and possess a high risk of disaster, their warehousing is expensive and not practiced in wide scale. For example, the Schenker's warehousing center in Ilvesvuori can't house explosives, regardless of their category.

- 1.1 Explosive, partial mass explosion *danger*, H201
- 1.2 Explosive, severe shrapnel *danger*, H202
- 1.3 Explosive, fire/explosion/shrapnel *danger*, H203
- 1.4 Fire or shrapnel *warning*, H204
- 1.5 Total mass explosion *danger* if in contact with fire, H205
- 1.6 Stable explosives falling out of first five categories
- Unstable explosives, H200

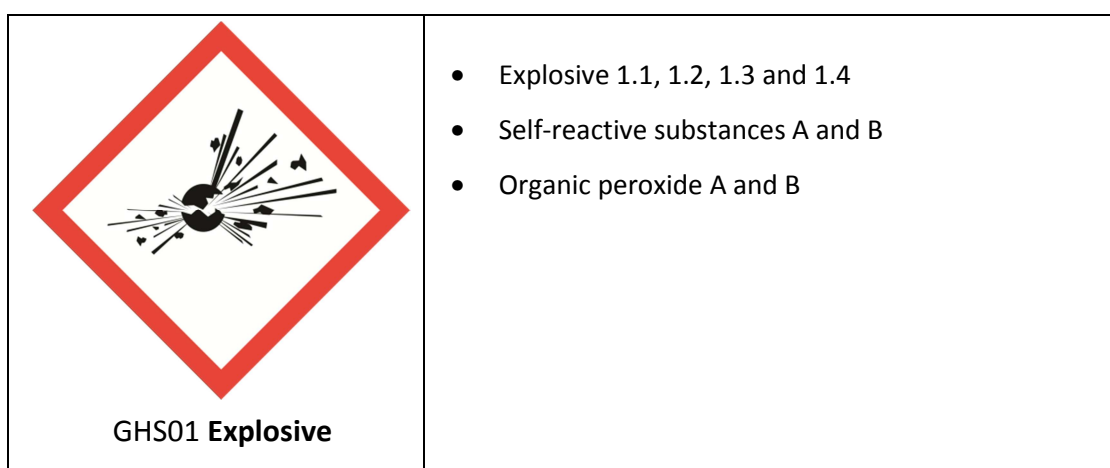


FIGURE 1. GHS01 warning label and involved categories

Combustible gases are either sole gases or gas mixtures which ignite easily when coming in contact with air under temperature of +20 °C and in standard air pressure of 101,3 kPa. These gases have 2 categories. First one is marked with GHS02 label, but category 2 flammable gases don't have warning label. The markings can be found

from FIGURE 2. P phrases describe that these substances should be sheltered from heat, sparks and fire. If a bottle leak catches fire, it should not be tried to extinguished if the leak cannot be sealed. No ignition starters should be placed near them. Gases like methane, propane and hydrogen fall under this category. Gases which aren't compressed under low temperatures belong to this category as well.

- 1 Extremely flammable gases, H220
- 2 Flammable gases, H221


 <p>GHS02 Flammable</p>	<ul style="list-style-type: none"> • Combustible gases 1 • Combustible aerosols 1 and 2 • Combustible liquids 1-3 • Combustible solids 1 and 2 • Self-reactive substances B, C, D, E and F • Pyrophoric liquids and solids • Self-heating substances 1 and 2 • Substances producing <i>igniting</i> gases with water contact 1-3 • Organic peroxide B, C, D, E, F
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FIGURE 2. GHS02 warning label and involved categories

Combustible aerosols are disposable liquids which are either under pressure as gas, liquefied or compressed to a bottle. Aside of liquids, these aerosol bottles might include paste or powder. Combustible aerosols have 2 categories. The main differences between these categories are burning temperature and compounds, ignition distance, flame height and duration. Both categories are marked with GHS02 label. P phrases describe that these substances should be sheltered from heat, sparks and fire. Smoking near them is not advised and they should not be sprayed to fire. Most common consumer aerosols are hairsprays and deodorants. Also, some propellant gases inside bug spray aerosols are categorized as flammable, as the rest of contents might be toxic or harmful. Products falling into this category are very common.

- 1 Extremely flammable aerosol, H222
- 2 Flammable aerosol, H223

Oxidizing gases are gases or gas mixtures which assist burning of other materials. These gases have only one category and they are marked with GHS03 label, found from FIGURE 3, and H270 phrase. The P phrases describe that these substances should be avoided from clothing contact and flammable materials. In case of fire, possible leaks should be closed. They should be warehoused in well ventilated areas. Most common oxidizing gases are oxygen and nitrogen oxide.

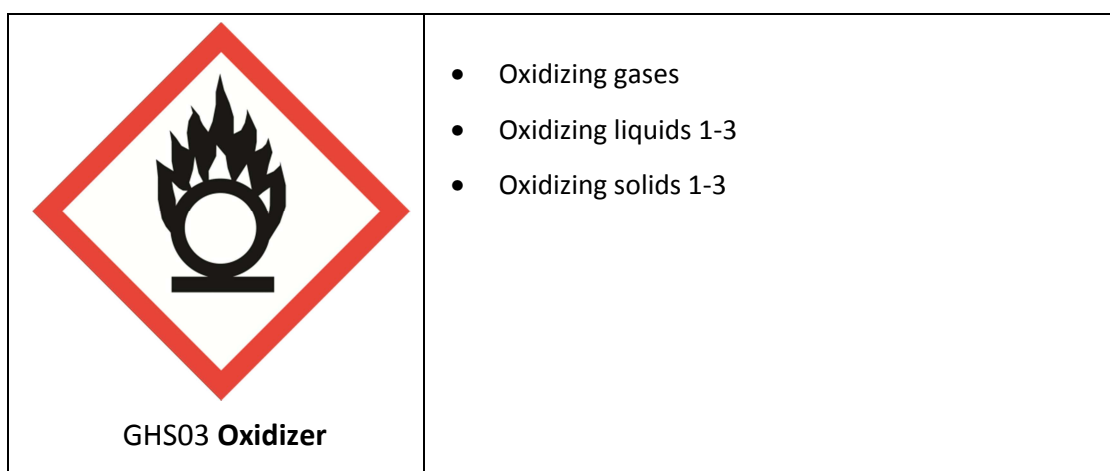


FIGURE 3. GHS03 warning label and involved categories

Gases under pressure or compressed gases, are gases which are stored in at least or over 200 kPa pressure. When compressed, their form is liquefied or liquefied and frozen. They are categorized by their packing style into four categories which all share the same GHS04 label found from FIGURE 4. According to P phrases, these substances should be warehoused away from sunlight and to well ventilated place. Most welding gases like acetylene fall under this category. Liquid nitrogen is also compressed gas and commonly used for cryogenic purposes in hospitals or chemical industries. They are fairly common in warehouses.

- Compressed gas, might explode when heated, H280
- Liquefied gas, might explode when heated, H280
- Cooled liquefied gas, might cause frost injury, H281
- Dissolved gas, might explode when heated, H280


 <p>GHS04 Gases under pressure</p>	<ul style="list-style-type: none"> • Compressed gas • Liquefied gas • Cooled liquefied gas • Dissolved gas
--	--

FIGURE 4. GHS04 warning label and involved categories

Combustible liquids are determined as liquids which have flashpoint maximum of +60 Celsius degrees. Their categorization is dependent from different flashpoint and boiling point temperatures. In total, there are 3 categories and all are marked with GHS02 symbol found from FIGURE 2. P phrases describe that these substances should be stored as tightly sealed, possible silos should be grounded and sparkles tools should be used. Static electricity discharges should be avoided and proper employee safety equipment should be used during handling. These substances should be stored into well ventilated and cool area. Most common products of combustible liquids are oils and motor oils. Since there are wide varieties of motor oils, they have their own definition branch below the combustible liquids as their properties differ greatly.

- 1 Extremely flammable liquid and vapor, H224
- 2 Easily flammable liquid and vapor, H225
- 3 Flammable liquid and vapor, H226

Combustible solids are substances that ignite easily or could start fire with abrasion. Their form is grain, paste or powder or mixtures, which ignite fast when come in contact with fire. Combustible solids are divided into 2 categories depending from their burning time, burning speed and how well they stop for wet areas or can they pass them through. Both categories are marked with GHS02 label found from FIGURE 2. P phrases say that these substances should be sheltered from sparks, heat and

fire. Possible containers should be grounded and ATEX certified equipment should be used in their vicinity. For example, magnesium is under this category.

- 1 Combustible solid, *danger*, H228
- 2 Combustible solid, *warning*, H228

Self-reactive substances and mixtures are unstable substances which produce powerful exothermic reaction. In some cases even external air is not needed for this reaction to happen. Although the reaction is powerful, these substances aren't categorized as explosives solely. P phrases tell that these substances should be sheltered from heat, sparks and fire. Smoking near them is not allowed. Safety equipment should be used when handling them and they should be stored to a well-ventilated and cool place. Also, they must be warehoused apart from other substances. Self-reactive substances come in 7 different categories and use two different GHS labels found from FIGURE 1 and FIGURE 2.

- Type A, might explode when heated, H240, GHS01
- Type B, might explode or start fire when heated, H241, GHS01 and GHS02
- Type C and D, starts fire when heated, H242, GHS02
- Type E and F, starts fire when heated, H242, GHS02
- Type G

Pyrophoric liquids ignite in less than 5 minutes when they come into contact with air even in small amounts. They are classified into one category only and labeled under GHS02 label, found from FIGURE 2, and H250 phrase. P phrases describe that these substances should be sheltered away from heat, sparks and fire. Air contact should be prevented and smoking near them is not allowed. Proper safety gear should be utilized when handling them.

Pyrophoric solids are the same as pyrophoric liquids in terms of ignition properties but their form is the opposite. They are classified into one category and are marked with GHS02 label, found from FIGURE 2, and H250 phrase. P phrases describe that these substances should be sheltered away from heat, sparks and fire. Air contact

should be prevented and smoking near them is not allowed. Proper safety gear should be utilized when handling them.

Self-heating substances and mixtures are close to pyrophoric substances but they cannot ignite without substantial amounts of mass. They ignite when come into contact with air, but the process is much slower compared to pyrophoric substances. They are classified into two categories. The main differences come from the substance amounts and ignition or heating speed. P phrases indicate that these substances should be warehoused in cool place and sheltered from sunlight. Proper safety gear must be worn during handling. Packaging surfaces should have a proper safety slit between in stacking. Finally they should be stored away from other materials. Both substances are marked with GHS02 label found from FIGURE 2.

- 1 Self-heating substance, might start fire, H251
- 2 Self-heating substance, might start fire in big amounts, H252

Substances and mixtures which create hazardous gases when come in contact with water are either liquids or solids. When in contact with water, they produce gases or ignite. They are classified into three categories. Category differences come from reaction speed and amount of produced gas per substance amount. All substance categories are under GHS02 label. P phrases describe that these substances should be sheltered away from water and moisture. Handling should be practiced in inert gas and substances should be warehoused to dry place and packages should be sealed.

- 1 Produces *self-igniting* gases with water contact, H260
- 2 Produces *igniting* gases with water contact, H261
- 3 *Might Produce igniting* gases with water contact, H261

Oxidizing liquids ignite or assist burning of other materials. In their most common product form, are acids. Category differences are self-ignition properties and average pressure rise time. P phrases tell that these substances should be sheltered from

heat, sparks and fire. Smoking near them is not allowed. They should be stored away from other flammable materials and garments. Proper safety gear should be utilized during handling. If big amounts of this substance catch fire, evacuate the area and try to extinguish the fire far away because of explosion danger. All categories are under GHS03 label found from FIGURE 3.

- 1 Fire or explosion danger, strong oxidizer, H271
- 2 *Might* assist fire, oxidizer, H272
- 3 *Might* assist fire, oxidizer, H272

Oxidizing solids are the same as oxidizing liquids but their form is the opposite. They are divided into 3 categories. Categories are dependent from the properties of average burning time and mixture mass ratios. P phrases tell that these substances should be sheltered from heat, sparks and fire. Smoking near them is not allowed. They should be stored away from other flammable materials and garments. Proper safety gear should be utilized during handling. If big amounts of this substance catch fire, evacuate the area and try to extinguish the fire far away because of explosion danger. All categories are under GHS03 label found from FIGURE 3.

- 1 Fire or explosion danger, strong oxidizer, H271
- 2 *Might* assist fire, oxidizer, H272
- 3 *Might* assist fire, oxidizer, H272

Organic peroxides are organic substances, liquid or solid, and a derivative of hydrogen peroxide. They are usually unstable and may have self-accelerating dissolving reactions. The reaction is close to explosion. These substances are also sensitive to hits and abrasion. Categories go from A to G like the explosives. Differences come from detonation properties like power or partial detonation. P phrases indicate that these substances should be sheltered from heat, sparks and fire. Smoking near them is prohibited. They should be kept away from flammable materials and sunlight. Proper safety gear should be used and these substances should be kept in their original packaging. These substances use two different GHS

labels, depending from their properties. These labels can be found from FIGURE 1 and FIGURE 2.

- Type A, explosive *danger* when heated, H240, GHS01
- Type B, explosive or fire *danger* when heated, H241, GHS01 and GHS02
- Type C and D, fire *danger* when heated, H242, GHS02
- Type E and F, fire *warning* when heated, H242, GHS02
- Type G, other organic peroxides outside of A to F classes

Metal corroding substances and mixtures are close to acids but instead of corroding, they damage or even destroy metals. They have only one category. Properties are corrosion speed for different materials. P phrases tell that these substances should be stored in their original packaging, absorb leaks to prevent accidents and possible silos should be corrosion resistant. Corrosive substances are under GHS05 label, found from FIGURE 5, and H290 phrase.

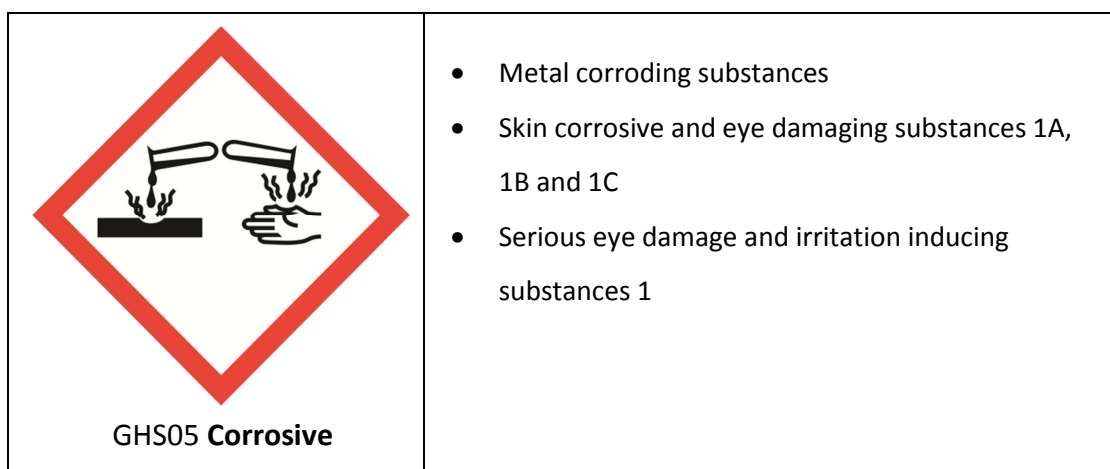


FIGURE 5. GHS05 warning label and involved categories

2.2 Substances hazardous to human health

Substances that are immediately toxic are lethal to humans when they are swallowed through mouth, have *skin contact* or *breathed* through airways. They are divided into four categories whose main differences come from the lethal dosage amount which is enough to kill 50% of the test animals in laboratory testing. All four categories are

the same for swallowing, skin contact or breathed through airways. Used GHS warning labels for each category are marked after descriptions below. The warning label can be found from FIGURE 6.

- 1 Lethal when swallowed/touched/breathed, H300, GHS06
- 2 Lethal when swallowed/touched/breathed, H300, GHS06
- 3 Toxic when swallowed/touched/breathed, H301, GHS06
- 4 Harmful when swallowed/touched/breathed, H302, GHS07

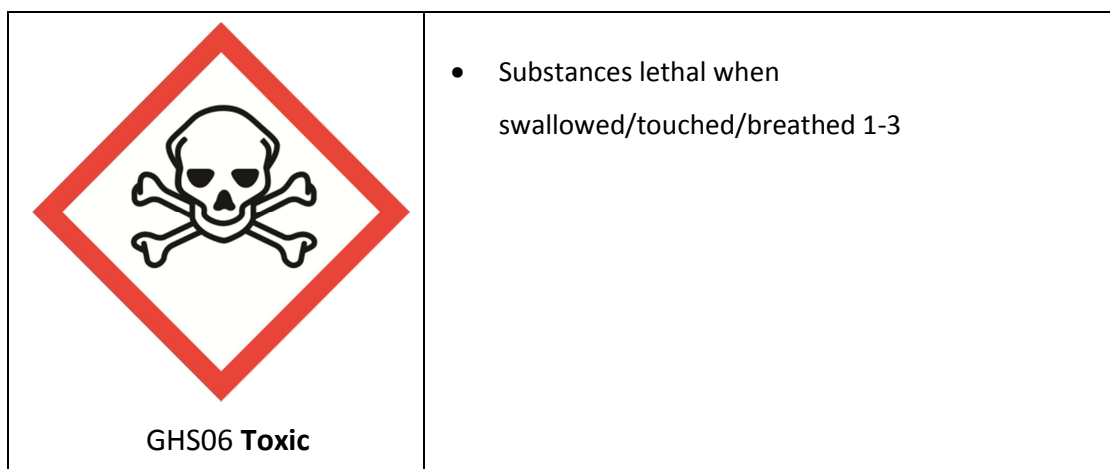


FIGURE 6. GHS06 warning label and involved categories

Skin corrosive and *irritating* substances are divided into three categories. Corrosive category has three subcategories depending how long it takes for the corrosion effects to take visible effect. The irritating subcategory has only one classification. Corrosive materials destroy skin and make permanent damage. Irritating materials damage skin but injuries aren't permanent and they heal. GHS labels are marked after each category description below. The warning label is presented in FIGURE 7.

- 1A Skin corrosive and eye damaging, H314, GHS05
- 1B Skin corrosive and eye damaging, H314, GHS05
- 1C Skin corrosive and eye damaging, H314, GHS05
- 2 Skin irritant, H315, GHS07


 <p>GHS07 Irritant</p>	<ul style="list-style-type: none"> • Substances lethal when swallowed/ touched/ breathed 4 • Skin corrosive and eye damaging substances 2 • Serious eye damage and irritation inducing substances 2 • Airway and skin sensitizing substances 2 • Single exposure STOT substances 3
--	---

FIGURE 7. GHS07 warning label and involved categories

Serious eye damage and irritation inducing substances have two categories. Eye damage is permanent but irritation damage can be healed. Used GHS labels are after the category description below and can be found from FIGURE 5 and FIGURE 7.

- 1 Permanent eye damage, H318, GHS05
- 2 Strong eye irritation, H319, GHS07

Airway and skin sensitizing substances induce oversensitivity. When coming into contact with skin, the reaction equals to allergic one. There are two categories depending from the affected area. GHS label is marked after the category description below and can be found from FIGURE 7 and FIGURE 8.

- 1 Respiratory symptoms, H334, GHS08
- 2 Skin sensitizing, H317, GHS07

Sex cell genotype damaging substances induce substantial mutations to genotypes. Substances are divided into 3 categories, depending from their known mutation properties. GHS labels are marked after the category description below and warning label is displayed in FIGURE 8.

- 1A *Known* to cause sex cell mutations, H340, GHS08
- 1B *May* cause sex cell mutations, H340, GHS08
- 2 *Believed* to cause sex cell mutations, H340, GHS08


 <p>GHS08 Long-lasting/permanent damage to human body</p>	<ul style="list-style-type: none"> • Airway and skin sensitizing substances 1 • Sex cell genotype damaging substances 1A, 1B and 2 • Carcinogenic substances 1A, 1B and 2 • Substances dangerous to reproduction 1A, 1B and 2 • Single exposure STOT substances 1 and 2 • Continuous exposure STOT substances 1 and 2 • Aspiration hazard substances 1
---	---

FIGURE 8. GHS08 warning label and involved categories

Carcinogenic substances cause cancer. They are divided into three categories depending from their known cancer inducing properties. All subcategories are marked with GHS08 label found from FIGURE 8.

- 1A *Known* to cause cancer, H350, H350i
- 1B *Assumed* to cause cancer, H350, H350i
- 2 *Believed* to cause cancer, H351

Substances dangerous to reproduction induce damage to fertility, reproductive functions and may cause developmental disorder. They are divided into three categories depending from their known properties to cause reproduction damage. GHS labels are marked after the category description below. This warning label can be found from FIGURE 8.

- 1A *Known* to decrease fertility and damage fetus, H360, GHS08
- 1B *Assumed* to decrease fertility and damage fetus, H360, GHS08
- 2 *Believed* to decrease fertility and damage fetus, H361, GHS08

Specific Target Organ Toxicity (STOT) substances are divided between *single* and *continuous* exposure instances. Any toxic substances harmful to human body, which cannot be categorized into above mentioned categories belong to this one. These

substances are especially affecting to one organ, instead of many at the same time. GHS labels are marked after the category description below. The used labels can be found from FIGURE 7 and FIGURE 8.

- 1 Single exposure, damages organs, H370, GHS08
- 2 Single exposure, may damage organs, H371, GHS08
- 3 Single exposure, narcotic symptoms, H335, GHS07

- 1 Continuous exposure, organ damages, H373, GHS08
- 2 Continuous exposure, possible organ damages, H374, GHS08

Aspiration hazard substances, when swallowed, damage lungs or respiratory system in general. They might cause pneumonia or even be lethal. There is only one category, which might be lethal when swallowed and end up in respiratory system. The category is marked with GHS08 label, found from FIGURE 8, and H304 phrase.

2.3 Substances hazardous to water systems

Like the name tells, these substances are especially dangerous to water systems. These substances represent the third category in CLP regulation and are divided into 4 main categories depending from their chronic toxicity to animals living in water systems, their dissolving properties and their discovered bio accumulation. All categories are marked with GHS09 label found from FIGURE 9. These substances won't possess any P or H phrases.

- Immediate category 1
- Chronic category 1
- Chronic category 2
- Chronic category 3
- Chronic 4 (safety net)


 <p>GHS09 Danger to environment</p>	<ul style="list-style-type: none"> • Substances <i>immediately</i> hazardous to water systems 1 • Substances <i>chronically</i> hazardous to water systems 1-4
---	--

FIGURE 9. GHS09 warning label and involved categories

2.4 Substances hazardous to ozone layer

These substances damage the ozone layer's structure and might hinder its function. Mixtures containing more than 0,1% or more of ozone harmful substances mentioned in EU regulation 2037/2000 are also included in this category. This category doesn't have a GHS warning label like the rest have. According to P phrases, these substances should be prevented from leaking into environment.

3 REACH

European Commission published Registration, Evaluation, Authorization and restriction of Chemical substances (REACH) regulation 1907/2006 in order to improve human health and environmental safety. REACH came into effect in 1st of June 2007 and its main purpose is to provide safety information database, warning announcements and ban dangerous products from market. The REACH database is managed by European Chemicals Agency (ECHA) from Helsinki. They also provide regulation compliance advices to consumers and professionals alike.

3.1 REACH process

Registration section of the REACH regulation obligates every company to collect information about their imported or manufactured chemicals which amount is over

one ton per year. Also, an assessment form for possible chemical hazards, risks and risk control has to be relayed to ECHA. Chemical manufacturer and importer won't need to send two registrations, because one joint registration is enough for one substance. According to pricing established by TUKES in 2012, making 1 to 200 registrations per year costs 36€ per registration. If there are more than 200 registrations, the unit price drops down to 18€. Depending from the company's position in the supply chain, even Schenker Cargo Oy must file down these reports if they happen to be the importer to Finland. The registration form is very close to Appendix 3: Safety data sheet example.

Evaluation process means that REACH complying member countries and ECHA will check the registration form information quality. This ensures that the registered substances really are a risk to human health. Evaluation is done in three levels: testing proposals, dossier compliance check and substance check.

Authorization process ensures that very high concern substances are controlled properly. Also, these substances are aimed to be replaced gradually by less dangerous equivalents or substituting chemicals in order to ensure stable markets. Substances of Very High Concern (SVHC) are those which can be categorized by:

- EU Commission regulation 1272/2008 CMR substances, as : 1A or 1B category toxic for reproduction, carcinogenic or mutagenic
- REACH Annex XIII, as: persistent/very persistent, toxic/very toxic or bio accumulative/very bio accumulative
- Case inspected substances equivalent to CMR or vPvB

When the regulatory process is ready and approved, the substance can only be used for specific, requested use. If substance cannot pass the authorization process, their use is forbidden completely.

Restriction protocol ensures that too dangerous chemicals cannot enter the market. With this protocol, manufacturers of dangerous substances can be banned or limited from the markets if needed. The limit or ban can also be applied to substances which aren't registered to REACH or are just imported. The restriction process follows all

aforementioned registration, evaluation and authorization processes. ECHA or a member state of REACH can instill a restriction with a request coming from European Commission. The restriction decision making is done with experts from various member countries and EU Commission together.

3.2 Safety data sheet

The safety data sheet is the source of information when new chemical arrives to the warehouse. It contains all necessary information including substance identification numbers, handling instructions and warnings, labels, and so on. All necessary information is handled there. The one who compiles the safety data sheet is either the substance *manufacturer, distributor, importer* or other user. Either one of these market players has to make the safety data sheet, if they are responsible for chemical's *market introduction* or its *relinquish over to end user*. According to TUKES, the substance or mixture requires safety data sheet if it's classified as:

- Dangerous, persistent, bio accumulative and toxic (PBT)
- Very persistent and strongly bio accumulative (vPvB)
- Other named and subject to license substances which are major cause of concern

The receiver of the substance can also *request* a safety data sheet if the mixture or substance is *unclassified*. The substance doesn't need to be classified as dangerous, but if it contains the following, the safety data sheet is necessary:

- Substance or mixture, containing 1% of its mass or 0,2 volume percentage of another substance hazardous to human health or environment
- At least 0,1 mass percentage of substance is PBT, vPvB, or other registered substances under the license
- Other substances which have work time exposure limits stated

The safety data sheet consists in total of 16 chapters, all offering necessary information about the stated substance. An example of safety data sheet template can be found from Appendix 3: Safety data sheet example. The first chapter presents *substance identification* and *company* contact information. It includes product name,

other chemical name and supplier contact information. Second chapter *identifies* product by its code numbers. These might be CAS or EU index number. Third chapter presents *ingredients composition* and necessary information concerning *hazards* and possible *symptoms*. They are notified the same way as the danger phrases in CLP. Fourth chapter is about the *first aid measures* for this specific substance. Symptoms are briefly described and expert assistance described if any is necessary. Fifth chapter describes the *firefighting* requirements. This contains suitable extinguishing equipment and extinguishing methods. Sixth chapter is about *accidental spill measures*. Basically this chapter gives advices how to act in case of emergency which includes this specific substance. Clean-up methods are also included to this chapter. Seventh chapter states *handling and storage*. This chapter focuses into environment, human health and safety. Eighth chapter is *exposure control and personal protection*. Like the name implies, the protective gear exposure limit values and controls are described here.

Ninth chapter is about *physical and chemical properties*. Here are described things such as chemical appearance, physical state, pH values, odor and boiling point. Tenth chapter introduces *stability and reactivity*. In short, it states how the specific substance behaves during changing external conditions. It also states the environmental conditions which should be avoided. Eleventh chapter is about *toxicological information* where health effects are described. Twelfth chapter states *ecological information*. This means declaring the danger to environment and effects to air, water and soil. Bio accumulation and persistence also belong to this chapter. Thirteenth chapter is about *disposal considerations*. The safe handling of disposal waste, packaging preparation and disposal methods are described here. Fourteenth chapter introduces *transportation information*. This chapter states all precautions necessary for different transportation modalities. Fifteenth chapter is about the *regulatory information*. In this part the possible chemical safety assessment is mentioned if it's carried out. Also, other information like applied international laws are stated. The last chapter, sixteenth, is reserved for *other information*. For example, possible R phrases are referred here in their full form.

4 AUTHORITIES & LAW

All regulations in warehousing of dangerous materials are decreed by some higher authority. In this case, the main regulating authorities are EU, Finnish government and TUKES. In most cases the EU has the main role and the Finnish Government just forwards on the issued rules down to TUKES which handles the information distribution to common media. Knowing the basis of the newest regulations, what additional costs they may bring and their effects in general is essential in warehousing from seller's point of view.

4.1 Law 3.6.2005/390

The Finnish government works closely with the EU. Most chemical warehousing regulations are handled by government's safety and chemical agency, TUKES. Latest law for warehousing and handling of dangerous chemicals is 3.6.2005/390, which runs alongside the EU conventions like REACH and CLP. Articles 22 to 40 cover the warehousing and handling of dangerous chemicals. The followings are outtakes from "Laki vaarallisten kemikaalien ja räjähteiden käsittelyn turvallisuudesta", 3.6.2005/390.

22 §: Industrialized treatment and warehousing are divided into *large scale* and *minor*, depending from substance amounts and hazard level.

23 §: *Large scale* treatment and warehousing are only allowed with *permission* from TUKES. A report from activity and safety planning should be filed to TUKES.

24 §: *Minor* treatment and warehousing is allowed under sent *notice* to TUKES. A report from activity and safety planning should be filed to TUKES.

27 §: TUKES carries out regular and consistent inspections to company premises in which *large scale* treatment and warehousing of dangerous chemicals is performed.

28 §: Companies performing *large scale* treatment and warehousing of dangerous chemicals are required to have internal safety plan.

29 §: Companies performing *large scale* treatment and warehousing need to appoint safety person in charge.

30 §: catastrophe prevention plan required from *large scale* treatment and warehousing businesses

31 §: Safety report and a catalogue of involved substances should be put into display

32 §: Persons or objects which might be affected by a catastrophe must be informed about the dangerous substances and safety protocols.

After that, the law continues with application procedures and declarations coming down to the safety authorities and piping inspections. Chapters 2 to 13 are the main warehousing concerned chapters. They focus into safety requirements, handling and warehousing of dangerous chemicals, explosives, dangerous chemical products like fireworks and accident announcements. From 14 to 18, the chapters are mainly concerned with authorities, application procedures and inception times. The Law 3.6.2005/390 lays the Finnish regulation foundation from which the decree 856/2012, decree 855/2012 and ATEX will continue with more details.

4.2 Decree 856/2012

Finnish government issued the decree 856/2012 “vaarallisten kemikaalien teollisen käsittelyn ja varastoinnin turvallisuusvaatimuksista” in 20th of December 2012 in Helsinki. It’s based upon the aforementioned “Laki vaarallisten kemikaalien ja räjähteiden käsittelyn turvallisuudesta” 3.6.2005/390 and its purpose is to specify or reinforce utilization of the issued law. In this case, it specifies the handling safety regulations of dangerous chemicals and explosives. Followings are outtakes of the decree 856/2012 bringing up the main points from the warehousing point of view.

22 §: Warehousing of following substances should be practiced with extra care and they *shouldn't* be stored with other chemicals because of their hazardous properties.

- Flammable liquids and gases
- Organic peroxides
- Explosive chemicals
- Oxygen and other strong oxidizers
- Chemicals which combust with air contact, are self-reactive, degrade easily, are toxic or otherwise present a special hazard

Compound specific compatibility chart can be found from Appendix 5: Chemical compatibility table. Category based segregation table can be found from Appendix 6: Directional chemical segregation table.

23 §: Tanks are allowed to contain no more than 30 000 cubic meters of dangerous chemicals. Tank groups should hold no more than two rows.

24 §: Flammable liquids should be stored away from other storages or dangerous chemicals so that in case of fire it doesn't spread, cause dangerous pressure rising or heating up. Safe separation distances are dependent from the heat radiation values of the substances.

25 §: Flammable liquids should be stored away from other chemicals so that possible fire cannot spread. Position inside the warehouse should be evaluated with the substance properties and behavior when it comes to contact with fire.

26 §: Explosive storage distances should be evaluated by their pressure effect properties.

27 §: Oxidizing storage placement should be chosen so that placement of flammable substances nearby, workers and space safety requirements should be taken into account.

28 §: Substances hazardous to human health should be stored so that placement in where workers reside should be taken into account.

29 §: Environmentally dangerous chemicals should be stored so that every escape or leak route to environment in case of accident should be taken into account.

In its entirety, the decree 856/2012 describes about the location placement of warehouse, dangerous chemicals placement inside the warehousing area, structure safety requirements, accident anticipation plan, ammonium nitrate specific warehousing instructions and other regulation inception times. ATEX directive specifies this decree even further down on explosive material handling and structures.

4.3 Decree 855/2012

Finnish government issued decree 855/2012 “vaarallisten kemikaalien käsittelyn ja varastoinnin valvonnasta” in 20th of December 2012. This decree is also based upon the aforementioned law 390/2005 and offers precise information about handling of dangerous chemicals and warehousing supervision. Moreover, it determines the storage quantities for each individual dangerous substances and permission procedures according to storage quantities.

In this decree, the dangerous chemicals are divided by the *old categorization* found from Appendix 1: Ceding labels and categorization. Depending from the substance amounts, the treatment and warehousing is either *large scale* or *minor*.

This is determined by a ratio between existing dangerous chemicals and permitted amounts: $s = q_1/Q_1 + q_2/Q_2 \dots q_n/Q_n$

Where:

- s = ratio
- q = existing/warehoused dangerous chemicals [tons]
- Q = permitted amount [tons]

If ratio $[s]$ is *bigger* or equivalent to 1, the treatment and warehousing is considered large scale. If ratio is *below* 1, treatment and warehousing is minor.

The substance ratios are calculated in three steps. First one determines substance specific amounts in warehouse. Second step adds all substances under categories found from Appendix 1: Ceding labels and categorization. Then the third step calculates the ratio (s) between existing amounts (q) and permitted amounts (Q). The

substance limits are dependent from permissions. Amounts may vary depending from warehouse location and substance hazardousness. Whenever a ratio is exceeded, the needed actions are stated in the left corner of charts in TABLE 1.

FIGURE 10. Step 1: substance specific amounts and permission limits example

	Hydrogen	Motor and industry oil	Petroleums	Gas oils
Total amount (q) [tn]	1	10	10	10
Notice limit	0,1	10	10	10
Permission limit (Q)	2	100	1000	1000

	Heavy oils	Methanol	Acetylene	Lead alkyls
Total amount (q) [tn]	10	1	1	1
Notice limit	10	1	0,1	0,5
Permission limit (Q)	1000	10	2	2

FIGURE 11. Step 2 and 3: substance categories and ratios example

Category	F	F+	Xn / R10	Xi / R10	O
Total amount (q) [tn]	100	5	100	100	10
Notice limit	5	5	5	5	5
Permission limit (Q)	100	5	100	100	10
Principle document limit (Q)	5000	10	5000	5000	50
Safety inquest limit (Q)	50000	50	50000	50000	200

Permission ratio (s)	1,000	1,000	1,000	1,000	1,000
Principle document ratio (s)	0,020	0,500	0,020	0,020	0,200
Safety inquest ratio (s)	0,002	0,100	0,002	0,002	0,050

Category	C	Xn	Xi	T	T+	N / 51 - 53
Total amount (q) [tn]	1 000	1 000	1 000	10	2	50
Notice limit	10	10	10	0,5	0,1	5
Permission limit (Q)	1000	1000	1000	10	2	50
Principle document limit (Q)				50	5	200
Safety inquest limit (Q)				200	20	500
Permission ratio (s)	1,000	1,000	1,000	1,000	1,000	1,000
Principle document ratio (s)				0,200	0,400	0,250
Safety inquest ratio (s)				0,050	0,100	0,100

As seen from FIGURE 10 and FIGURE 11, the substance amounts require different actions to be taken: *notice*, *permission*, *principle document* and *safety inquest*. *Notice* of dangerous chemicals warehousing means that the substance amounts are low and so is the danger too. The notice is returned to residing city's safety official and unlike other files, this one is free.

If the warehousing amounts get bigger than *permitted by safety official*, the company needs to file down a *permission* application to TUKES instead of safety official. This permission includes personal information, general overview about operations, dangerous chemical amounts and their details, risk control plan, warehouse placement details, environmental impact assessment and finally warehouse construction details. After approval from TUKES, the operations and warehousing can start. TUKES supervises that these practices are complied, by holding inspections to premises every 5 years. Basic price for permission application is 908€ and inspection 1363€ in year 2013 pricing announced by TUKES.

Principle document has to be filed down to TUKES if the dangerous chemical amounts exceed another determined boundary. The boundaries are determined by TUKES and may differ depending from location and substances. The principle document shows how company has prepared for catastrophes and other accidents by presenting a safety plan. These plans include personnel as follows: named safety instructor and supervisor, usage supervisor who has had training conducted by TUKES, principle supervisor and finally some other persons in charge. Further down, the document states operation goals, catastrophe recognition and assessment, function control, modification control, incident preparation, performance supervision and assessment. TUKES holds inspections every 3 years to ensure compliance. Basic price for principle document's safety plan is 315€, other personnel training by TUKES ranging from 100€ to 200€ and inspection 1363€ in year 2013 pricing announced by TUKES.

Safety inquest is only applied for biggest warehouses which store maximum amount of dangerous chemicals. It includes an overview of established safety leading system, organizational division of charge, training standards, information gathering and communication overview and finally audition basis overview. Other things

mentioned are overview of the warehouse and its surroundings, chemical catalogue and details, catastrophe recognition and assessment plan, incident recognition and assessment plan, catastrophe preparation and catastrophe escalation prevention plan. TUKES holds inspections every year to ensure compliance. Basic price for safety inquest application is 908€ and inspection 1363€ in year 2013 pricing announced by TUKES.

4.4 ATEX directive

The European Union issued 94/9/EC ATEX (Atmosphères Explosibles) directive in 23rd of March 1994. This directive focuses into harmonization of equipment and protective systems intended to use in potentially explosive environments. Some spaces develop huge amounts of easily flammable dust. If these spaces hold easily flammable or explosive materials, there's a huge risk involved in form of fire outbreak. If there's a danger of explosion or ignition due to used equipment or flammable liquids, gases or dust, the ATEX directive is applicable. The directive is mainly aimed for manufacturer and import companies. The ATEX directive is one of the main regulating laws in warehouse layout design and equipment specifications.

4.4.1 ATEX equipment

The 94/9/EC directive isn't very specific about details of the mechanical machines. On contrary, specifies more about their properties. In most cases, there aren't any numbers presented, only literal machine properties. Mostly, these requirements are meant for manufacturers design principles and for end-user company's selection and comparison criteria for suitable equipment.

Directive 94/9/EC Annex 1: *Equipment group 1* consists of two subcategories. Both state requirements for equipment used for *mining operations*. *Category M1* is capable of being used in mining operations, where flammable dust is heavily present. They must be able *to function after equipment related explosion*. Other related design requirements are dust penetration protection and surface temperature during operation must be kept under surrounding dust's ignition temperature.

Category M2 is capable of being used in mining operations, where flammable dust is heavily present. Equipment should be *disconnected or shut down in event of explosion*. Related design requirements state that rough handling and environments don't expose any internal or external sources of ignition. Possible ignition sources should not be able to be opened during the operation. This concerns hatches and other openings. Hatches and locks should be designed so that they could be opened when equipment is not in use. If opening of these can only be done during device operation, manufacturer should add a warning sign.

Directive 94/9/EC Annex 1: *Equipment group 2* consists of three subcategories.

Category 1 is capable of functioning in explosive environments compromised of dust, gas or vapor for prolonged periods of time. They have to have *double protection* against the environment so that if one protection fails, the functions can still be carried on. Other requirements state that surfaces shouldn't heat up no more than the ignition temperature of surrounding dust or gas. Sources of ignition should not become active even in the event of explosion. Hatches and other openings should not be able to be opened during operation. If their opening is possible only *during* the operation, the manufacturer should add a warning sign. There should be specific points from where the dust can escape the equipment. Same requirements are applicable for cable connection points.

Category 2, capable of functioning in explosive environments compromised of dust, gas or vapor. They should be able to function even if the disturbances or faults are *frequent*. Other requirements state that surface temperature should not exceed ignition point of surrounding dust or gas. Also, they should be dust protected and have interlocking system for hatches during operation.

Category 3, capable of functioning in explosive environments compromised of dust, gas or vapor for *short periods* of time per *infrequent* instance. Protection should cover normal operation. Design should prevent possible ignition sources from igniting surrounding dust or gas mixture. Surface temperatures should be lower than the ignition temperature of outside dust or gas. The equipment should not accumulate dangerous amounts of dust or gases inside itself.

4.4.2 ATEX environment

Further down, ATEX states some requirements for warehouse setups. This ATEX chapter focuses into risk analysis, damage prevention, and classification. It is mainly aimed for companies who own the warehouse or are building one. Companies must do a risk assessment where all possible ignition starters and hazards are taken into account. The things like where and how long this dangerous air and dust mixture is formed have to take to account as well. Most common ignition starters are:

- Combustion engines
- Running and static electricity
- Sparks
- Electromagnetic radiation
- Chemical reactions

To prevent a formation of dangerous air mixtures, the space containing hazardous materials must be ventilated properly. Also, lowering the oxygen levels inside the warehouse lowers the risk of ignition. Furthermore, the accumulation of dust can be reduced by simply cleaning the premises frequently. If the forming of dangerous air mixtures cannot be prevented, additional measures should be taken into use where the ignition of these substances is prevented or lowered. This is mainly done with proper equipment selection and space division. Lastly, the explosion damage prevention should be taken into account when building up the warehouse. These measures include explosive resistant building solutions which can handle the explosion pressure, damp the explosion and prevent the damage escalation.

The warehouse spaces are divided into different hazard categories depending from the formation probability of dangerous mixtures in the air. All equipment category and subcategory details can be found from the previous chapter.

- *Environment category 0: place, where air, gas, vapor or haze from flammable substance form a dangerous, explosive mixture with air frequently and chronically.*

The appearance duration is *long*. Equipment category 2, subcategory 1 equipment should be used in these spaces.

- *Environment category 20*: place, where *air* and *dust* mixtures form explosive danger *frequently* and *chronically*. The appearance duration is *long*. Equipment category 2, subcategory 1 equipment should be used in these spaces.
- *Environment category 1*: place, where *air, gas, vapor* or *haze* from flammable substance form a dangerous, explosive mixture with air during normal working conditions *occasionally*. Equipment category 1, subcategory 1 and 2 equipment should be used in these spaces.
- *Environment category 21*: place, where *air* and *dust* mixtures form explosive danger, appears *occasionally* during normal working conditions. The appearance duration is *short*. Equipment category 1, subcategory 1 and 2 equipment should be used in these spaces.
- *Environment category 2*: place, where *air, gas, vapor* or *haze* from flammable substance form explosive mixture with air, appears *unlikely* and *occasionally* during normal working conditions. The appearance duration is *short*. Equipment category 1, subcategory 1, 2 and 3 equipment should be used in these spaces.
- *Environment category 22*: place, where *air* and *dust* mixtures form explosive danger, appears *unlikely* and *occasionally* during normal working conditions. The appearance duration is short. The appearance duration is *short*. Equipment category 1, subcategory 1, 2 and 3 equipment should be used in these spaces.

As the Ilvesvuori logistics center houses dangerous chemicals, they are prepared to them as follows:

- Section isolation during the building phase of warehouse
- Special bunker spaces to isolate dangerous chemicals from others
- Automatic sprinklers for each shelf level
- Gathering system of extinguishing water

- Extinguishing water spread restriction floor walls
- Safe lightning
- Extinguishing water and electricity self-sufficiency

5 STANDARDS AND CERTIFICATES

The International Organization for Standardization is responsible for most of the ISO standards worldwide. Their goal is the harmonization of technology and business sectors. The organization was founded in February 1947 and today, has published over 19 500 different standards. From the seller's point of view, the ISO standards mostly concern quality, environmental care and working conditions. Since the dangerous chemicals pose a serious threat to environment and workers, it's no wonder that these standards are taken into use. They also provide good advertisement for companies and help them to promote themselves as responsible and safe working place.

5.1 ISO 9001:2008

ISO 9001 standard is very well known quality management standard. Its main purpose is to introduce a quality management system with which a company can ensure satisfactory service and satisfied customers. Furthermore, it develops the quality to make sure that satisfactory quality can be retained in future as well. This ISO standard is one of the most common standards worldwide and can be found from almost every bigger company which practices import or export.

The deeper goal of ISO 9001 is to create a quality management system (QMS) for the company. This deciphers quality performance into numbers and statistics, from which the improvement is much easier to notice and develop on. When companies establish the 9001 standard, they usually follow seven steps which help to formulate goals, how they can be realized and develop in future.

1. Engage top management and define stakeholders, mission, vision, organizational values, quality policy and service objectives.

2. Point out critical processes according to 1st step and think how to improve them to meet the quality objectives.
3. Introduce QMS
4. Build QMS according to ISO 9001 requirements, make gap analysis to see if requirements are met
5. Implement QMS and train the staff
6. Monitor and measure QMS by focusing to customer satisfaction
7. If needed, certify or register the QMS

Though all ISO standards are voluntary, they can still be certified in order to make the standard visible to public as well. Public declaration of quality standard brings good company image. Certificate itself is made by the company which wants it to be published. The certificate and its stated remarks are audited and checked by an *independent* third party, which is not a part of International Organization for Standardization. The checkup is made by a company visit and audit at least. These third party companies differ much between countries and so does their audit prices. Also, these audits have to be made in certain time intervals to ensure that the requirements are met constantly. Thus, companies should be careful when choosing the auditing parties since lots of money is involved.

5.2 ISO 14001:2004

The ISO 14001:2004 is an environmental standard which introduces environmental managements system to promote sustainability and green values. As the environmental care and carbon dioxide emissions are a rising concern, this standard is very common in logistics companies which pursue to improve their green image. The ISO 14001 follows the ISO 9001 steps, but introduces an environmental management system (EMS), instead of QMS. Most common development areas are the measurement and reduction of carbon footprint, reduction of paper usage in offices, electricity usage reduction and general waste reduction. Benefits include increased business sustainability, improved company image and working conditions. The ISO 14001 in simplified way:

- Plan: evaluate which processes need improvement and are critical for environment performance. Set goals, plan how to reach and measure them
- Do: Introduce the EMS and train personnel to use it
- Check: Monitor and measure performance
- Act: Constant improvement of environmental performance according to data given by EMS

As with the ISO 9001, the certification and auditing process of ISO 14001 is handled by a third party company. The audits cost money and they have to be carried out regularly to keep the certification in effect and liable. The costs usually involve reoccurring auditing price for certification, possible consultancy for suitable EMS systems and implementation.

5.3 OHSAS 18001

Occupational health and safety assessment series 18001 is meant to be a standard to improve working conditions and reduce risks. This British standard, later recognized by United Nations, is common in any company having dangerous health risks in everyday work. It also guides for better working safety leadership, including the team leaders to safety management. Most of the management system standards nowadays follow the same plan, do, check, act principle but the area and scope are different. OHSAS 18001 establishes goals health and safety management, as the ISO 9001 establishes goals for quality control and customer satisfaction. In its most common form, the OHSAS 18001 is included in the enterprise monitoring systems alongside with other standards like ISO 9001 and 14001.

- Planning phase: determine risks and their criticality, determine how to reduce or eliminate these risks, determine safety levels and goals
- Implementation phase: establish system, introduce goals and train personnel
- Check phase: monitor performance
- Act phase: take actions to improve performance if necessary

The OHSAS 18000 standard family is small, as the International Organization for Standardization hasn't implemented it. The 18001 consists mainly of establishment rules for improved working safety and health management. The 18000 provides basis for integration and 180002 provides assistance and improvement suggestions for already established health and safety management systems.

5.4 TAPA certificate

Transported Asset Protection Association (TAPA) is an organization specialized into freight, trucking and air cargo security certification. The aim of these standards is to reduce cargo *thefts* and *improve security*. In Europe, the organization is known as TAPA EMEA which including Europe, works in Africa as well. The certification consists of freight security requirements (FSR), trucking security requirements (TSR) and TAPA air cargo security standards (TACSS). Unlike ISO standards, these certificates can only be applied for *one* warehouse at time. They don't cover whole organization. Only companies which have all of their facilities certified, can advertise themselves as TAPA certified. Like with the ISO standards, the TAPA certification is done by an third party company, but this time it has to be *approved* by TAPA first. Approved companies include Bureau Veritas Certification, Det Norske Veritas, TÜV Rheinland North America and SGS International Certification services. After the audit, the certification level is based to scores from the audit. The score might be A, B or C. From the warehousing point of view, the freight security requirements are the most important standard offered by TAPA.

The freight security requirements (FSR) states very carefully how the premises should be protected in order to prevent outsiders from entering without permission. The minimum security requirements consists of 8 areas, which are evaluated during the audit process and afterwards categorized to A, B or C. Not all of these categories are necessary to get the TAPA certificate, but in most cases all of them are required to fulfill the A grade certificate. Some of these are mandatory and some are not. Further details about these requirements and categories can be found from Appendix 2: TAPA criteria.

As not all of the requirements are mandatory to pass the A-class certificate, some are there just to bring extra security. Companies must assess if this investment is worth the effort or not. If a company gets the A-class certification, it's valid for 3 years and after that it needs to be renewed. Supplier, who is certified, needs to do self-assessment annually and submit it to the same certification company which handled the certification in the first place. The self-assessment has to be submitted within 2 weeks after the certification anniversary date. The Ilvesvuori warehouse is TAPA A classified facility.

5.5 AEO

The Authorized Economic Operator is a supplier status, which makes import and export easier inside EU countries. In nutshell, the logistics company is identified through audits and surveys as a reliable and safe partner to do business with. This way import procedures can be handled with less paperwork. The status also means that they have less irregular inspections carried out by customs security. This speeds up the logistics, saves money and increases supply chain safety and security. AEO consists of three different statuses:

- Authorized Economic Operator Customs simplifications (AEOC) *speeds up customs procedures* handling and simplifies some applications for export and import like traffic and passport permits.
- Authorized Economic Operator Safety and Security (AEOS) increases overall *supply chain safety*. It enables companies to receive foreword of upcoming customs check and therefore be prepared for it. This also helps to foresee possible delays. AEOS also lets the general notification procedure to hold less information than it normally would.
- Authorized Economic Operator Full (AEOF) offers the benefits of *both* above mentioned AEOC and AEOS.

Any company interested of AEO's benefits can apply for it. Finnish customs suggests that all new AEO applicants take free customer advice service offered by customs

first. The applicant firm gets acquainted with self-assessment form, minimum AEO requirements and descriptions and instructions required from AEO applicant. Then they fill the actual form and wait for results. If the forms are in good standing, the customs will make contact and agree inspection date. If faults are found during the inspection, the company is allowed to have some time to make proper repairs and adjustments. The AEO benefits come into effect after the inspection is passed. The AEO status is in effect as long as the company passes the inspections held by customs authority. These inspections ensure that the AEO requirements are met in the future. If the company cannot make correct adjustments inside given schedule, the AEO status is terminated.

6 RESULT: SCHENKER'S GUIDE

This thesis displays necessary theory parts needed by sellers. The result of this research actually is the *theory part*. As in seller's hectic job, they don't have time to deal with long theory parts. This led to an agreement, in which this thesis form would be left to Jyväskylä University of Applied Sciences (JAMK) and Finnish translated model made for Schenker Cargo Oy. This translated model leaves out the sixth and seventh chapters, which are demanded for Jyväskylä University of Applied Sciences thesis. Considering that those two chapters can't improve seller's theory understanding, it was obvious choice to leave them out. The translated model includes something that wasn't included to this thesis though: customer service advices. Seller needs to ask the right questions from the customer since they don't give them out, unless asked to. The advices cover normal questions asked during warehousing outsourcing, like chemical specifications, amounts and other details for pallets. Though these questions are important in working life, their value to JAMK's thesis work is not. Main reason is the absence of theory for these questions and the fact that they are directly based to company's needs. Sellers don't need to know theory behind these questions since they are self-explanatory and tailor-made for company needs *without* any theory background. Based to interview carried out with Schenker Cargo Oy's tender manager, the agreement was made to include some practical hints for normal sellers alongside the questionnaire for customers. These hints are separate sentences consisting of things that the tender manager

recommends to be brought up. The hints include time preparation suggestions for system synchronization, critical information which has to be asked and some price estimations. With these questions, the sellers can evade long processes of manual labor and resource wasting during and after the outsourcing process. An example of review questions meant for outsourcing of warehousing can be found from Appendix 4: Outsourcing questionnaire.

The exact answers for research questions couldn't be found. Like in most cases, the answers are estimations instead of precise numbers. As there are incredibly amount of things to know and all cannot be included to research, the contents were aimed for *identification of dangerous chemicals* and background *regulations* and *certificates*. The following answers to the 1st research question: What things sellers need to know about warehousing of dangerous chemicals. This answer was created with help Schenker Cargo Oy's representative contribution and results of carried out interviews.

The second research question deepens the theory part by asking what monetary sides the certificates and regulations bring. As the exact estimations are impossible to determine due to forming complexity of prices, only estimations and issues can be named. The pricing background is affected by the regulations like REACH. Depending from the amount of new chemicals and their hazardousness, the registering and safety data sheet filling can bring up some costs. Most of the dangerous chemicals warehousing prices come from the regulations like ATEX and Decree 855/2012. ATEX specifies the special equipment needs for dangerous chemicals. This special equipment can be for example spark proofed forklifts or electricity wirings. As the markets have wide supply of different priced equipment, the accurate cost effects are hard to estimate. Still, most of the pricing come from the safety requirements stated by ATEX. Decree 855/2012 specifies some of the announcement responsibilities for chemical quantities. Depending from the business size and location, the permit prices bring up the costs of warehousing. Certification for ISO 9001, ISO 14001, OHSAS 18001, TAPA and AEO bring some costs to warehousing as well. Most of the certificate costs come from inspections and certification renewals. With these mentioned background factors, the seller should be able to describe how

laws, regulations and certificates bring extra costs to warehousing of dangerous chemicals. As a rule of thumb, the dangerous chemicals about double the warehousing price, compared normal chemicals.

Most of the information was found from official internet site of EU, TUKES and Finnish Government. Only a few books are up-to-date about the laws and regulations related to warehousing of dangerous chemicals. This meant that reference compilation would have to be carried out carefully because of false internet sites. Fortunately, the information was widely available from official sources. The first problem arose with the CLP regulation. The older regulations are still in effect alongside with the CLP. Question which ones should be prioritized, became relevant. Newer regulations should be prioritized but older are in wider use, thus a compromise had to be made. In result, the newer ones were used in primary chapter and older ones left to Appendix 1: Ceding labels and categorization. This way both are available if needed. Later on more questions arose from the information depth. As the seller usually depends heavily onto some specialists, they don't need to know every single detail about the dangerous chemicals. On the other hand, JAMK's regulations demand thorough theory. The outcome was that delicate details were left out from the both thesis versions. This was done because rapidly changing information is easier to be found from the internet. The other reason is that the experts and specialists exist in Schenker Cargo Oy because they point out the details. Describing the problem for these specialists is easier with general rather than detailed view. The more details are involved with someone who has not studied them, the more confusion is brought up. One other problem which arose with the ISO standards, was the lack of examples how these standards were implemented into Schenker Cargo Oy's business model. As the necessary interviews couldn't be carried out due to communication and arrangement problems, the standardization business examples were left out. As these examples may vary between warehouses, there might be a need for some changes if this research would be used outside of its example warehouse, the Ilvesvuori logistics center.

Getting closer to finishing the research, there weren't bigger problems to face. The interviews with tender manager proved to be beneficial and they helped to guide the theory contents towards their needs.

7 DISCUSSION

Considering how a seller can utilize the presented information found from the theory part, all the chapters contain a small overview about the important topics. Both CLP and REACH familiarize the seller with chemical categorization, labeling emblems and announcement responsibilities. With this information, they should be able to recognize the most common products and their primary properties, tell can it be warehoused or not and finally describe if there are any responsibilities required by authorities. Also, the basic contents of safety data sheet can be assimilated. When REACH is involved, the safety data sheet is the requirement which concerns Schenker Cargo Oy the most. If they happen to introduce a new dangerous chemical into Finnish market, they have to compile this sheet. At the same time the new substance has to be registered to ECHA with a similar manner. As Schenker Cargo Oy is not a importing company, they need to do the safety data sheet usually only when customers request one. As these issues are the first ones to pop up during the warehousing process, according to conducted interview results, the CLP and REACH are placed as the first chapters. All of the references used for these regulations are from their official sites of EU and TUKES. As these sites are updated constantly and are upheld by government officials, the information reliability is not an issue here.

The research continues with laws and regulations, introducing both Finnish and EU based ones alike. As these introductions are fairly short ones to avoid long lists of repeating clauses, something important might have been left out. What is relevant and what is not, cannot be determined easily. This is why the law chapters are left short, so they only point out few relevant articles and then describe other topics which these laws and decrees contain. With this, the general information content can be comprehended and with references, the available sites can be found if further information is needed. Knowing generally the most important laws and degrees behind warehousing of dangerous chemicals benefits the seller's common

knowledge. It also gives an overview about regulatory authorities to which the business starting customers should turn to. As the laws are mandatory, they lay down the basics of warehousing which should be familiar to all sellers. The ATEX directive part really points out what particular equipment is needed and what extra costs this regulation brings.

The research also introduces a couple of standards and certificates common to logistics businesses worldwide. Though ISO 9001, ISO 14001 and OHSAS 18001 aren't really associated especially with dangerous chemicals, they are very widespread. As the quality and environmental management systems are company specific, they cannot be described very thoroughly. Rather, this research brings forth basic concepts of these certificates and particularly points out what costs these certificates bring due to their auditions and renewing processes. Considering the AEO and TAPA certificates, they are Ilvesvuori logistics center specific. As the other eases the customs handling and operations, the other security, knowing both is beneficial when describing the logistics center for new customers. AEO is especially beneficial if the importing customer company and Schenker Cargo Oy both have the AEO certification. This way, the general information is included, but the deeper information is still available through official internet pages. Being able to tell the extra costs which these certificates bring and their benefits, can be brought up when naming the warehousing price.

The usage of this research one entity, the laws and regulations relatively much dictate how long thesis theory parts hold their value. As the CLP regulation and older labeling regulations are both in effect until 2017, this thesis can be used even after that. Only the Appendix 1: Ceding labels and categorization will lose some of its value and the CLP labels still stand in effect after the 2017. Though the transition time is long, it doesn't guarantee that all old labels are going to vanish from the market in one night. This is other reason why the old labels were included to this research.

The Appendix 5: Chemical compatibility table left out the categorization as it was introduced in CLP regulation, because lack of reference material. The chemical incompatibility charts found were primarily made for *transportation* of dangerous

goods instead of warehousing. Threading into transportation side would have crossed the topic limit, since Schenker Cargo Oy demanded a guide for *warehousing*. A warehousing incompatibility chart with CLP labels would have been an optimal solution, but since information was not available and companies make it primarily for existing substances inside warehouse, the task proved too difficult finish. The Appendix 6: Directional chemical segregation table offers an approximation about the category segregation which the 5th appendix lacks.

The research was very educational. Anyone who doesn't know about the dangerous chemicals warehousing can learn something. It gives a glance to important topics regarding the warehousing, laws and certification. Furthermore, it marks out the detailed information sites. Though this research only shows the door to warehousing of dangerous chemicals, it still provides necessary information needed to get started, overlooking the user background or occupation.

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APPENDICES

Appendix 1. Ceding labels and categorization

The old markings can still be used alongside with the CLP markings as follows:

- *Substances* should be marked and classified by the CLP regulation after *1st of December 2010*. Substances *already in the market* before that date have to be marked with the CLP labels after *1st of December 2012*.
- *Mixtures* should be marked and classified with CLP labels after *1st of June 2015*. Mixtures *already in the market* before that date should be marked with CLP labels after *1st of June 2017*.




The R phrase is a literal expression of the hazard and one is mandatory with each warning label.

EXPLOSIVE AND FIRE HAZARD CHEMICALS



Explosive, E

- R2: Explosive when under impact, abrasion, fire contact or due to other source of ignition
- R3: Extremely explosive when under impact, abrasion, fire contact or due to other source of ignition

 <p>Oxidizing, O</p>	<ul style="list-style-type: none"> • R7: Causes fire and danger • R8: Causes fire and danger with flammable substances • R9: Explosive when mixed with flammable substances
 <p>Extremely flammable, F+</p>	<ul style="list-style-type: none"> • R12: Extremely flammable
 <p>Flammable, F</p>	<ul style="list-style-type: none"> • R11: Very flammable • R15: Releases very flammable gases with water contact • R17: Self-igniting with air contact

CHEMICALS HAZARDOUS TO HUMAN HEALTH

These chemicals are categorized by their *immediate, deferred, long term or continuous* exposure results to test subjects as follows:

- Extremely toxic
- Toxic
- Harmful
- Corrosive
- Irritating
- Sensitizing

- Cancer inducing
- Genotype damaging
- Danger to reproduction



Extremely toxic, T+

- R28/27/26: extremely toxic when swallowed/in skin contact/breathed
- R39: danger of extremely serious and permanent damage



Toxic, T

- R25/24/23: toxic when swallowed/in skin contact/breathed
- R39: danger of extremely serious and permanent injuries
- R48: Long term exposure presents a health hazard
- R45: Might cause cancer
- R49: Might cause cancer when breathed
- R46: Might cause hereditary genotype damages
- R60: May decrease fertility
- R61: Dangerous to fetus



Corrosive, C

- R35: Strongly corrosive
- R34: Corrosive

Harmful, **Xn**Irritant, **Xi**

- R48: Long term exposure presents a health hazard
- R22: Harmful when swallowed/in skin contact/breathed
- R68: Danger of permanent injuries
- R38/36/37: Irritates skin/eyes/respiratory organs
- R41: Danger of serious eye injury
- R42: Breathing causes sensitizing
- R43: Skin contact causes sensitizing
- R40: Believed to cause cancer
- R62: Possibly reduces fertility
- R63: Might present a danger to fetus

CHEMICALS HAZARDOUS TO ENVIRONMENT

Dangerous to environment, **N**

- R50: Extremely toxic to water organisms

Appendix 2. TAPA criteria

Mandatory TAPA A certificate requirements are marked with bracketed M letter after the requirement.

Perimeter security:

- Fencing and gates around the yard
- CCTV systems external all-round coverage of facility (M)
- Lightning of loading/unloading areas, dock doors illuminated, illumination supports high quality CCTV recording (M)
- All external doors are alarmed and linked to main alarm system
- All other openings like windows, main doors, roof access and exterior walls are secured sufficiently and alarmed (M)

Access control:

- Office area access control includes visitor entry point, employee entry point, access control for both to ensure authorized access only (M)

Facility dock and warehouse:

- Access control between offices and warehouse is guarded by card access, actual guard or CCTV (M)
- Access to warehouse areas is prohibited from unauthorized personnel
- High value storage is fenced, access is restricted and monitored (M)
- All external doors closed and secured
- Internal CCTV surveillance in docking area doors and buyer designated goods (M)
- Motion detection alarms when warehouse is inactive (M)

Security systems:

- Secure monitoring post from possible attacks, working all year (M)
- Real time alarms, 60 days of alarm recording, restricted access to alarm systems (M), transmitted and monitored alarms (M)
- Surveillance is digitally recorded (M), its access restricted (M) and minimum of 30 days record holding (M)

- Electronic access control systems minimum record holding is 60 days, restricted access to system functions and access reports are reviewed quarterly

Security procedures:

- Handling documents and security incidents and accident documents relayed to buyer within 12 hours
- Contact person information available for buyer in case of incident or accident
- Supplier policy statement available for employees
- Security awareness training provided for employees
- Photo identification badges issued to all personnel
- Buyer's goods are restricted from other working personnel to access
- Visitor policy (*M*)
- Information control of buyers assets (*M*)
- All drivers must be identified with driver's license (*M*)
- Key control in place where buyer's assets are
- Random trash inspections
- Security incident reporting system
- Pre-loading or post-delivery storage for buyer's assets
- Personal purses, lunchboxes, containers are controlled
- Searches and inspections performed in buyers assets location areas
- Personal vehicles access to premises is controlled
- Box/pallet condition and integrity inspect during receipt
- Cargo holding equipment control
- Container and trailer condition is verified with inspection
- Documented maintenance programs for all technical equipment (*M*)
- Uninterrupted power supply for sudden power loss
- Background check for criminal history in past 5 years (*M*)
- In case of job termination, return of all necessary and information containing equipment is ensured
- Fired employees cannot access information systems after the job termination
- Records maintained for job terminated personnel

Standard truck security requirements:

- Solid and hard sided trailers
- Security seals in carrying only Buyer's shipments
- Vehicle immobilization devices utilized to a some degree
- Two way communication for entire journey
- Truck and cab key secured from unauthorized usage
- Written reporting plans for unexpected events
- Route risk assessment in place
- Bill of lading in use during loading and unloading
- Policy that requires drivers to be present during loading and unloading

Pre-alerts:

- Pre-alert capability available
- Destination to notify origin within 4 hours of receipt

Enhanced security requirements:

- Supplier provides robbery response training and forwards details to buyer
- Security awareness training for drivers
- Truck escort capability
- Documented response procedures for truck escort personnel
- GPS tracking for trucks

Appendix 3. Safety data sheet example

SAFETY DATA SHEET

CHEMICAL SAFETY REPORT

(*) applies only for chemical safety report

(**) either 3.1 or 3.2 is filled

SECTION 1: SUBSTANCE OR MIXTURE AND COMPANY OR ENTERPRISE IDENTIFICATION	
1.1	Product identification

Market / substance name Marking code REACH registration number
--

1.2 Substance's or mixture's identified uses and usages, which aren't recommended
--

Literal use of the substance Industry code (TOL) (*) Usage code (KT) (*) Chemical can be used for common consumption (*) Chemical can be used <i>only</i> for common consumption (*)
--

1.3 Safety data sheet's deliver's information
--

Vendor (manufacturer, importer, only representative, end user, distributor), Market contributor, working in Finland (*)
--

Address Postal code and office Postal box Postal code and office Phone Email address Y-sign (*)

1.4 Emergency phone number

SECTION 2: HAZARD INDIVIDUALIZATION
--

2.1 Substance or mixture classification
--

2.2 Markings

2.3	Other Hazards
------------	----------------------

SECTION 3: COMPOSITION AND COMPOUND INFORMATION
--

3.1	Substances (**)
------------	------------------------

Main substance / substance name	CAS, EY or index number	Concentration

3.2	Mixtures (**)
------------	----------------------

Substance name	CAS, EY or Index number	REACH registration number	Concentration	Classification

SECTION 4: FIRST AID MEASURES

4.1	Description of first aid measures
------------	--

4.2	Most important symptoms and effects, both immediate and delayed
------------	--

4.3	Instructions concerning possible immediate medicine help and special care
------------	--

SECTION 5: FIREFIGHTING MEASURES

5.1	Extinguishing substances
------------	---------------------------------

5.2	Special hazards posed by substance or mixture
------------	--

5.3	Firefighting instructions
------------	----------------------------------

SECTION 6: ACCIDENTAL RELEASE/SPILL COUNTERMEASURES
--

6.1	Precautions, personnel protection and emergency measures
------------	---

6.2	Precautions concerning environment
------------	---

6.3	Methods and equipment concerning protective construction and cleaning
------------	--

6.4	References to other sections
------------	-------------------------------------

SECTION 7: HANDLING AND WAREHOUSING	
--	--

7.1	Measures required by safe handling
------------	---

7.2	Conditions required by safe warehousing, including incompatibility issues
------------	--

7.3	Special end use
------------	------------------------

SECTION 8: EXPOSURE PREVENTION AND PERSONNEL PROTECTION	
--	--

8.1	Supervision variables
------------	------------------------------

HTP values

Other limit values

DNEL values

PNEC values

8.2	Exposure prevention
------------	----------------------------

Technical countermeasures

Eye or face protection

Skin protection

Hand protection

Respiration protection

Heat hazards

Environmental exposure prevention

SECTION 9: PHYSICAL AND CHEMICAL PROPERTIES	
--	--

9.1. Basic information concerning physical and chemical properties	
---	--

State

Odour

Odour threshold

pH

Melting and freezing point
 Boiling point and domain
 Flashpoint
 Evaporation speed
 Flammability (solids, gases)
 Max and min flammability or explosive threshold
 Steam pressure
 Steam density
 Relative density
 Solubility (solubilities)
 Distribution modulus: n-octanol/water
 Spontaneous combustion temperature
 Decomposition temperature
 Viscosity
 Explosiveness
 Oxidizing effectiveness

9.2 Other information

SECTION 10: STABILITY AND REACTIVITY

10.1 Reactivity

10.2 Chemical stability

10.3 Possibility of dangerous reactions

10.4 Avoidable conditions

10.5 Incompatible materials

10.6 Hazardous decomposition materials

SECTION 11: TOXICITY

11.1 Information about toxic effects

Immediate toxicity

Skin corrosion / irritation

Serious eye damage / Irritation

Respiratory system or skin sensitizing

Sex cell genotype damaging effects

Cancer inducing effects

Dangers to reproduction

Organ specific toxicity – single exposure

Organ specific toxicity – continuous exposure

Aspiration hazard

Other information

KOHTA 12: DANGER TO ENVIRONMENT	
--	--

12.1	Toxicity
-------------	-----------------

12.2	Persistence and desintegration
-------------	---------------------------------------

12.3	Bio accumulation
-------------	-------------------------

12.4	Soil circulation
-------------	-------------------------

12.5	PBT and vPvB assessment results
-------------	--

12.6	Other harmful effects
-------------	------------------------------

SECTION 13: WASTE DISPOSAL	
-----------------------------------	--

13.1	Waste handling procedures
-------------	----------------------------------

SECTION 14: TRANSPORTATION	
-----------------------------------	--

14.1	UN number
-------------	------------------

14.2	Official transportation name
-------------	-------------------------------------

14.3	Transportation danger class
-------------	------------------------------------

14.4	Packaging class
-------------	------------------------

14.5	Environmental danger
-------------	-----------------------------

14.6	Special user precautions
-------------	---------------------------------

14.7	Transportation as separate cargo according to MARPOL 73/78 convention Appendix II and IBC regulation
-------------	---

SECTION 15: APPLICABLE LAWS

15.1	Safety, health and environmental regulations or laws concerning the stated substance or mixture
-------------	--

15.2	Chemical safety assessment
-------------	-----------------------------------

SECTION 16: OTHER INFORMATION

Changes to previous version

Abbreviation definitions

References

Class assessment method

Catalogue of R and S phrases and/or danger and safety phrases

Personnel training

Appendix 4. Outsourcing questionnaire

CLIENT:

Contact person: _____

Email address: _____

Phone: _____

Fax: _____

GENERAL:

Line of business: _____

Dispatch destinations: _____

Information transfer: _____

Client's information system: _____

Information system's integration readiness: _____

PRODUCT INFORMATION:

Warehoused products: _____

Product category division: _____

Amount of product labels: _____

Is there a barcode? If yes, then which?

Is there products categorized by chemical laws: ____ Yes ____ No

Categories and amounts/category: _____

Preservation demands: _____

Date tracking: ____ Yes ____ No, Batch number tracking: ____ Yes ____ No, Serial number tracking: ____ Yes ____ No

Other information:

RECEIVING OF ARRIVING GOODS:

Amount of arriving batches (for example: times per month): _____

Label count per arriving batch: _____

Tons per month: _____

Handling units (separate, pallets, Other): _____

Need for palletizing: ____ Yes, portion of arriving goods: ____% / ____ No

Batch distribution per day of week: _____

Demand for product inspection: _____

STORAGING

Amount of pallets in warehouse: _____

Pallet type: _____

Other need for space: _____

Inventory: _____

PICKING

Order amount (for example: amount per month): _____

Rows per order: _____

Pieces per row: _____

Picking unit : _____ Unit packaging
 _____ Bundle packaging
 _____ Pallet
 _____ Other, what?

FiFo basis: _____ Arriving date
 _____ Batch number
 _____ Expiration date _____ Other, what?

DISPATCH

Packaging need: _____

Modes of transportation: _____

Fetches from warehouse: _____

Payers of carriage: _____

ADDED VALUE SERVICES

Packagings: _____

Sticker applying: _____

Adding of working instructions, etc.: _____

Set/assortment information: _____

Other works: _____

Appendix 5. Chemical compatibility table

Categories	1. Non-oxidizing inorganic acids	2. Sulphuric acid	3. Nitric acid	4. Organic acids	5. Bases	6. Ammonia	7. Aliphatic amines	8. Amine-alcohols	9. Aromatic amines	10. Amides	11. Organic anhydride	12. Isocyanates
1. Non-oxidizing inorganic acids		x			x	x	x	x	x	x	x	x
2. Sulphuric acid	x		x	x	x	x	x	x	x	x	x	x
3. Nitric acid		x			x	x	x	x	x	x	x	x
4. Organic acids		x			x	x	x	x	C			x
5. Bases	x	x	x	x							x	x
6. Ammonia	x	x	x	x						x	x	x
7. Aliphatic amines	x	x	x	x							x	x
8. Amine-alcohols	x	x	x	x							x	x
9. Aromatic amines	x	x	x	C							x	x
10. Amides	x	x	x			x						x
11. Organic anhydride	x	x	x		x	x	x	x	x			
12. Isocyanates	x	x	x	x	x	x	x	x	x	x		
13. Vinyl acetate	x	x	x			x	x	x				
14. Acrylates		x	x				x	x				
15. Allyl compounds		x	x				x	x				D
16. Alkene oxides	x	x	x	x	x	x	x	x				
17. Epichlorohydrin	x	x	x	x	x	x	x	x				
18. Ketones		x	x				x	B				
19. Aldehydes	A	x	x		x	x	x	x	x			
20. Alcohol glycols	E	x	x	x	F	x		x				x
21. Phenols, cresols		x	x		x		x			x		
22. Caprolactam solutions		x			x		x					x

23. Alkenes		x	x									
24. Alkalies												
25. Aromatic hydrocarbons			x									
26. Separate hydrocarbon mixtures			x									
27. Esters		x	x									
28. Vinyl halogenides			x									
29. Halogenated hydrocarbons		G			H		I					
30. Nitriles		x										
31. Carbon disulfide							x	x				
32. Sulfolanes												
33. Glycol ethers		x										x
34. Ethers		x	x									
35. Nitro compounds					x	x	x	x	x			
36. Water and mixtures containing water		x										x
Categories	1. Non-oxidizing inorganic acids	2. Sulphuric acid	3. Nitric acid	4. Organic acids	5. Bases	6. Ammonia	7. Aliphatic amines	8. Amine-alcohols	9. Aromatic amines	10. Amides	11. Organic anhydride	12. Isocyanates

Categories	13. Vinyl acetate	14. Acrylates	15. Allyl compounds	16. Alkene oxides	17. Epichlorohydrin	18. Ketones	19. Aldehydes	20. Alcohol glycols	21. Phenols, cresols	22. Caprolactam solutions
1. Non-oxidizing inorganic acids	x			x	x		A	E		
2. Sulphuric acid	x	x	x	x	x	x	x	x	x	x
3. Nitric acid	x	x	x	x	x	x	x	x	x	
4. Organic acids				x	x			F		
5. Bases				x	x			F		
6. Ammonia	x			x	x		x			

7. Aliphatic amines	x	x	x	x	x	x	x	x	x	x
8. Amine-alcohols	x	x	x	x	x	B	x			
9. Aromatic amines							x			
10. Amides									x	
11. Organic anhydride										
12. Isocyanates			D					x		x
13. Vinyl acetate										
14. Acrylates										
15. Allyl compounds										
16. Alkene oxides										
17. Epichlorohydrin										
18. Ketones										
19. Aldehydes										
20. Alcohol glycols										
21. Phenols, cresols										
22. Caprolactam solutions										
23. Alkenes										
24. Alkalies										
25. Aromatic hydrocarbons										
26. Separate hydrocarbon mixtures										
27. Esters										
28. Vinyl halogenides										x
29. Halogenated hydrocarbons										
30. Nitriles										
31. Carbon disulfide										
32. Sulfolanes										
33. Glycol ethers										
34. Ethers										
35. Nitro compounds										
36. Water and mixtures containing water										
Categories	13. Vinyl acetate	14. Acrylates	15. Allyl compounds	16. Alkene oxides	17. Epichlorohydrin	18. Ketones	19. Aldehydes	20. Alcohol glycols	21. Phenols, cresols	22. Caprolactam solutions

Legend:

x = marks a dangerous combination

A = *Acrolein, crotonaldehyde and 2-ethyl-3-propyl acrolein* aren't compatible with *non-oxidizing inorganic acids*

B = *Isophorone and mesityl oxide* aren't compatible with *amine-alcohols*

C = *Acryl acid* is not compatible with *aromatic amines*

D = *Allyl alcohol* is not compatible with *isocyanates*

E = *Furfuryl alcohol* is not compatible with *non-oxidizing inorganic acids*

F = *Furfuryl alcohol* is not compatible with *organic acids*

G = *Dichloro ethyl ether* is not compatible with *sulfuric acid*

H = *Trichloro ethylene* is not compatible with *bases*

I = *Ethylene hydrazine* is not compatible with *ethylene chloride*

[illegible]

S = Must be segregated with fire and liquid proof walls