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Fire Inspector I

CHAPTER TWELVE

ENSURING PROPER STORAGE HANDLING PRACTICES

Part 2

Slide 1	Welcome to Part 2, Ensuring proper storage and handling practices.
Slide 2	In part 2 we will discuss: • Storage and handling of flammable liquids • Flammable liquid tank storage • Other storage of flammable liquids • Container storage in buildings • Flammable liquid storage cabinets • Handling methods for hazardous materials • Fire prevention methods • The storage of gases • Storage safety considerations • Boiling Liquid Expanding Vapour Explosion, or BLEVE • Safeguards for escaping gases • Inspection for leakage
Slide 3	• Ventilation of spaces • Controlling ignition sources • Hazardous materials storage and handling • Hazardous materials storage lockers and containers • Containers • Natural and Liquefied petroleum gases • Transportation of hazardous materials • Fire protection systems • Ensuring code compliance
Slide 4	Tanks can be installed aboveground, underground, or under certain conditions, inside buildings. Openings and connections to tanks for venting and filling can present hazards if they are not properly safeguarded. Important factors when storing flammable liquids are the characteristics of the liquid stored, the design of the tank and its foundations and supports, the size and location of vents, and the piping and its connections. In this photo, the fire inspector is discussing the underground tank venting system with the installation contractor. Venting is particularly important when the fuel company is filling the tanks. Drivers often are paid by the load so the faster they can deliver the fuel the more money they make. If they are dropping the fuel quicker than the vents can handle, an overpressure can result. Many new tank installations have two filling inlets to speed up the process. A corresponding vent capacity must be provided.
Slide 5	Flammable and combustible liquids are packaged, shipped, and stored in bottles, drums, and other containers ranging in size up to 230 L or 60 gallons. Additionally, liquids are shipped and stored in intermediate bulk

	containers up to 3,000 L or 793 gallons and in portable intermodal tanks up to 2,500 L or 550 gallons. Examples of container types used for the storage of liquids include glass, metal, plastic, and fiberglass. The maximum allowable size for the different types of containers is governed by the class of flammable or combustible liquid to be stored in it.
Slide 6	Tank installations storing Class 1,2, and 3A flammable and combustible liquids are permitted inside building when meeting the requirements of the Fire Code. Container storage of flammable and combustible liquids can be found in most occupancy classifications. Details on quantity limits can be found in the fire code. For example, the maximum quantities stored in un-sprinklered mercantile occupancies, in a single suite, must not exceed 8,000 L, provided that not more than 2,000L are Class I liquids, of which not more than 300L can be Class IA, Class IB, or any combination of these 2 classes. In sprinklered mercantile occupancies, the maximum quantity of flammable and combustible liquids in a single suite cannot exceed 24,000 L, provided that not more than 6,000L are Class I liquids, of which not more than 1,000 L are Class IA, Class IB, or any combination of these 2 classes. Any liquid-storage building or room or any portion of a building or room where containers are stored should be designed to protect the containers from exposure fires. This might require the installation of a fire wall or partitions or the separation of the containers from other storage arrangements or processes.
Slide 7	Factors to be considered when evaluating the amount of container storage in a building should be: • The risk to the occupants, exposure to other buildings, and the degree of fire protection provided. • The fire code requires that flammable and combustible liquids in mercantile occupancies be kept n closed containers. Closed containers of Class I and II liquids must not be stacked more than 1.5 m high on floors, or 1 m high on individual fixed shelves. • Flammable and combustible liquids must not be stored in or adjacent to exits, elevators, or principal routes that provide access to exits. • They must be in stable piles that will not collapse under normal operating conditions. • They should not be stored in areas where they may be subject to extreme temperatures that could cause a chemical reaction, chemical instability, or atmospheric pressure that could cause their containers to become deformed or rupture.

	• Class I liquids in closed containers are permitted to be stored in basements of mercantile occupancies.
Slide 8	Storage rooms for flammable and combustible liquids are permitted by the Fire Code in some occupancies. Where flammable and combustible liquids are stored in a room, the amount of allowable storage is based on the size of the room, its fire resistive rating, if the room is sprinklered or not, and the amount of product stored per square meter. The table shown in this slide is recreated from Part 4 of the fire code. It shows the maximum quantity allowed, the minimum fire resistive rating required, and the maximum density of product per square meter. Note that the quantity of product allowed is greatly reduced if the fire separation is reduced. If the room is sprinklered in conformance with NFPA 30 the quantities can be doubled. When dealing with Class 1 liquids, fire walls may be required, so be sure to check the requirements of your fire code.
Slide 9	Where Class IA or IB liquids are used, dispensed, or stored in open containers within a storage room, or where Class IA liquids are stored in containers exceeding 4 Litres in capacity, the room must be designed to prevent critical structural and mechanical damage from an internal explosion in conformance with good engineering practice. The pressures developed by an explosion very rapidly reach levels that most buildings and equipment cannot withstand unless specifically designed to do so. Explosion venting consists of devices designed to open at a predetermined pressure to relieve internal pressure build-up inside a room or enclosure, hence limiting the structural and mechanical damage. When designing an explosion venting system some consideration should be given to: • the product stored • the size and shape of the room, • the type of construction and its ability to withstand internal pressures • the type, size, and location of relief panels, The design should also consider the potential of injury to people in the immediate vicinity of the panels.

Slide 10	Specially designed storage cabinets, in conformance with ULC specifications, are available for storing Class 1, 2, and 3A liquids. These cabinets are typically constructed of No 18-gauge sheet steel consisting of a double wall with a 1.5 (38mm) inch air space. The door should have a three-point latch, with a sill raised to at least 2 inches (51mm) above the bottom of the cabinet to provide a space to capture any small spills or leaks. The maximum quantity of flammable and combustible liquids stored in a cabinet must not exceed 500 L. The total quantity of flammable and combustible liquids stored in cabinets in a single fire compartment must not exceed 1500 L. Additional Learning opportunity - Review Sub-section 4.2.10 of the fire code, Cabinets for Container Storage
Slide 11	Generally speaking, in industrial occupancies, the fire code allows greater quantities of flammable and combustible liquids in a single fire compartment if the total quantity stored in a group of cabinets is not more than 1,500 L and the distance between groups of cabinets is at least 30 m. In care, treatment or detention occupancies, the fire code restricts the total quantity of flammable and combustible liquids stored in cabinets in a single fire compartment to 500L. In assembly or residential occupancies flammable or combustible liquids must be stored in a fire compartment with a fire-resistance rating of at least 1 hour. When a single class of flammable or combustible liquid is stored the total quantity of liquid must not exceed: • 30 L of Class I liquids, • 150 L of Class II liquids • 600 L of Class III A liquids. The fire code provides a formula for calculating the total quantity permissible If more that 2 classes of flammable or combustible liquids are stored in the same building. Cabinets for container storage must be labelled in conspicuous lettering to indicate that the cabinet contains flammable materials and that open flames must be kept away. When a storage cabinet is provided with ventilation openings, the openings must be sealed with materials providing a fire protection rating

	at least equivalent to that required for the construction of the cabinet, or the cabinet must be vented outdoors using rated vent piping. Additional Learning opportunity - Review Sub-section 4.2.10 of the fire code, Cabinets for Container Storage
Slide 12	One of the safest methods for handling flammable or combustible liquids is to pump the liquid from underground storage tanks to the dispensing equipment located outdoors or in specially designed dispensing rooms. Such rooms should be accessible for firefighting, have the appropriated fire- resistance rating, and adequate ventilation and drainage. Ventilation is of primary importance and must be provided in conformance with good engineering practice to prevent the accumulation of dangerous concentrations of flammable vapours. Depending on the type of vapour present, there are several NFPA standards that can be referred to for examples of good ventilation practice. Make-up air for a natural or mechanical ventilation system must be taken from a point remote from any exhaust air discharge. Mechanical ventilation should be used wherever there are extensive indoor operations involving flammable or combustible liquids. References: NFC 4.2.9.4 Dispensing in rooms 4.1.7 Ventilation 4.1.7.5 Make-up Air
Slide 13	A spill of flammable or combustible liquids must be prevented from flowing outside the spill area and from reaching waterways, sewer systems and potable water sources by constructing a non-combustible barrier capable of containing the spill, or by grading the site or sloping the floor to divert the spill to a drainage system. Water-miscible effluent from spills and firefighting operations is permitted by the fire code to be directed into a sewer system provided it does not create a fire hazard or any risk to public health or safety. A fire safety plan that includes measures to be taken to direct the overflow of spilled liquids and firefighting water away from: • Buildings, • Adjoining properties • Means of egress • Air intakes or other openings

	• Fire protection equipment Fire department access must be developed, and copies must be retained onsite and be available to the authority having jurisdiction upon request. References: NFC 4.2.9.4 Dispensing in rooms 4.1.6. Spill Control and Drainage Systems 4.1.6.1. Spill Control
Slide 14	When flammable liquids are transferred from their original container, or from bulk storage such as a drum or tank, it is important that the proper type of portable container be used. Portable containers that are approved for the use and storage of smaller quantities are usually made of metal or plastic, are vapour-proof and have welded seams, spark or flame arrestors, and pressure release valves or spring closing lids with spout covers. The Occupational Safety and Health Administration (OSHA) in the US requires portable containers for flammable liquids having a flash point at or below 80o F or 26.7 degrees C, to be painted red with some clearly visible identification, either in the form of a yellow band around the can, or the name of the contents conspicuously stenciled or painted on the can in yellow.
Slide 15	A flame or spark arrestor is a small device, similar to a mesh screen, in the nozzle of the can. The screen helps prevent vapors in the container from igniting. These devices are required on metal flammable liquid cans such as those frequently used for gasoline. At the present time there is no similar requirement for plastic gasoline cans but the US - Consumer Product Safety Commission wants to see flame-arrestor safety devices added to plastic gasoline cans. A statement from the agency says the CPSC "is calling on the manufacturers to include this safety technology. The report also highlighted lab tests done by Worcester Polytechnic Institute (WPI), which found that under certain conditions the gasoline vapor mixtures can explode inside of the plastic container.
Slide 16	Dispensing of flammable or combustible liquids from containers having a capacity of more than 30 L must be by pumps or through self-closing valves, approved by testing agencies like UL, ULC, CSA or FM Global. When Class I liquids are dispensed from or into a container or a storage tank, all metallic or electrically conducting material must be electrically bonded and grounded.

	If the container is made of non-conductive material, measures must be taken to minimize the potential for a static electric charge to develop. Build-up of static electricity near the surface of liquids being poured into non-conducting containers can be controlled or eliminated by limiting the filling rate velocity, using a grounded nozzle extension to limit the free fall of the liquid, or by using antistatic additives.
Slide 17	What's wrong with this photo? Filling an ungrounded portable fuel tanks can cause spark-induced gasoline fires. For that reason, portable fuel tanks should be moved to a safe distance from the vehicle and be filled on the ground. The nozzle should be held in contact with the container while it is being filled.
Slide 18	Liquids can also be dispensed from the original shipping containers. Opens pails or open buckets should never be used for storage. Flammable liquids should always be handled and dispensed in a well-ventilated area free of ignition sources, and bonding should be provided between the dispensing equipment and the container being filled. The following video explains the importance of bonding and grounding.
Slide 19	Video
Slide 20	When flammable and combustible liquids are stored or handled, the liquid is usually exposed to the air at some stage in the operations, except when using sealed containers or a closed system. Even when the storage or handling is in a closed system, there is always the possibility of breaks or leaks, which permit the liquid to escape. It is good practice to ensure proper ventilation is in place and potential ignition sources are eliminated in places where low flashpoint flammable liquids are stored, handled, or used. The vapours from nearly all flammable and combustible liquids are heavier than air. If ventilation is inadequate, these vapours can settle and collect in low areas like sumps, sewers, pits, trenches, and basements. The vapour trail can spread far from the liquid. If this vapour trail contacts an ignition source, the fire produced can flash back to the liquid container. Flashback can happen even if the liquid giving off the vapour and the ignition source are hundreds of feet or several floors apart.
Slide 21	Flammable or combustible liquids are used in a wide range of process plants. For purposes of the fire code, a process plant is a defined term as follows “Process plant means an industrial occupancy where materials, including flammable liquids, combustible liquids, or gases, are produced or used in a process.” Some of the most common processing products include gasoline, paint thinners, cleaners, adhesives, paints, waxes, and solvents.

	It's important to check the safety data sheet (SDS) of each product to determine the upper and lower fire or explosive limits as well as it flash point. The lower the flash point the more susceptible the product is to ignition. Whenever possible, in processes that involve flammable or combustible liquids, equipment such as compressors and pumps should be in open unconfined spaces to avoid the buildup of ignitable vapours.
Slide 22	Where required by the fire code, the work area should have explosion-proof ventilation, lighting, and equipment. The risks of fire and explosion at process plants should be evaluated based on: • The material properties and quantities • Operating conditions, • Arrangement of stored materials, • Transportation of materials, • Process design, and the operating and maintenance procedures. Based on this evaluation, measures to minimize the occurrence of fires and explosions and to mitigate their effects must be identified. Where the process warrants protection, process plants must be supplied with: • An adequate water supply for firefighting Fire hydrants Standpipe and hoses connected to a permanent water supply located so that all equipment containing flammable liquids or combustible liquids, including pumps, can be reached with at least one hose stream Be sure to check the fire code requirements for the products involved and the processes being conducted.
Slide 23	We are now going to move on to the storage of gases. A gas must be stored in a container that is gastight for the range of temperature and pressure conditions present at the storage location and the conditions that will be present during transportation. The storage container should contain the source of energy needed to move the gas from storage to the point of use. This energy is the pressure of the gas in the container. Gas containers are closed pressure vessels containing various pressures per unit of volume and require careful design and maintenance. Because the containers are closed, and excessive pressures

	can develop when they are exposed to heat sources, overpressure protection is usually needed.
Slide 24	In North America, there are two types of gas containers: cylinders and tanks. Historically cylinders were small and portable, and tanks were larger and stationary, Cylinders were considered as high-pressure vessels while tanks were considered to contain low or moderate pressure. Today these distinctions have lessened so that the only real distinction lies in the regulations or codes under which the container is built. Practically all gases must be transported from the manufacturer to the user, making the safety of the container in transportation a matter of primary concern.
Slide 25	The major risk to gas storage containers is the BLEVE, or boiling liquid expanding vapour explosion. BLEVE's were discussed in detail in Chapter 4 Fire Behaviour so we will not dwell on them here save to say that the major cause of BLEVE's is fire exposure. Fire impingement can cause the gas to expand to the point that the container can no longer withstand the internal pressure and it ruptures. The basic safeguard against a BLEVE is to reduce the chances of fire exposure to the container. To do this the quantity of combustibles in the vicinity of gas containers must be limited. This applies whether the storage is indoors or outdoors. If the building that houses the storage room presents a substantial fire load, the storage room should be fire rated in conformance with the fire code.
Slide 26	The next piece in BLEVE prevention is the use of container overpressure limiting devices. These devices are vital to controlling the pressure build-up in compressed gas containers. Even though these devices cannot by themselves always prevent container failure, they can extend the time until the vessel fails. There are four basic types of pressure relief devices: • Rupture Disk Devices - A flat disk typically made of metal that is designed to burst at a predetermined pressure to permit the release of gas. The pressure rating of the disk is typically stamped onto the face of the device. Examples of gases using this type of device include compressed air, argon, helium, nitrogen, and oxygen.
Slide 27	• A Fusible Plug Devices is a plug made of fusible metal designed to melt at low temperatures, usually between 165 and 212-degrees F. The temperature rating of the fusible metal is stamped onto the face of the device. An example of a gas that uses this type of device is acetylene.

	• Combination Rupture Disks/Fusible Plug Devices - A rupture disk backed by a fusible plug. In the event of a fire, the fusible metal melts and cylinder overpressure is relieved by the bursting of the disk. The burst pressure of the disk and the melting point of the plug will be marked with the ratings. Medical grade gas cylinders typically have this type of pressure relief device. • Pressure Relief Valves - A spring-loaded valve opens when the cylinder pressure exceeds the pressure setting of the spring to discharge contents. Once the cylinder pressure decreases to the valve's pressure setting, the valve will normally reseat without leakage. It is essential that the device is not blocked closed by corrosion or paint, and they are not damaged mechanically, disabled, or removed. Portable containers should be checked for this every time they are filled and whenever they are connected to consuming equipment. More information on pressure relief devices can be found in the additional learning section of this chapter.
Slide 28	Not all compressed gas cylinders have safety devices. Some gases are so toxic that their release through a safety device would be hazardous. Cylinders for these gases are built to withstand higher pressures than normal cylinders. When these "toxic gas" cylinders are involved in a fire, the area should be evacuated. More information on pressure relief devices can be found in the additional learning section of this chapter.
Slide 29	Cylinders that contain flammable gases stored indoors should be located in a room that is separated from the remainder of the building by a 2-hour fire separation that is: • Located on an exterior wall • Can be entered from the exterior of the building • Is separated from the remainder of the building by a gas-tight fire separation • Whose closures leading to the interior of the building are equipped with self-closing devices that keep the door closed when not in use • Is constructed so as to prevent the migration of gases from the room into other parts of the building. Limited quantities of cylinders containing flammable, lighter-than-air gases are permitted to be stored outside of a room as long as the aggregate capacity of expanded gas is not more than 60 m3 in an un-

	sprinklered building of combustible construction, and 170 m3 in a sprinklered building or in a building of non-combustible construction. Reference: NFC 3.2.8.2. Flammable Gases
Slide 30	Containers of flammable gases should not be stored with oxidizing gases. Oxidizing gases, such as oxygen and nitrous oxide, increase the rate of burning of flammable gases resulting rapid fire development and spread. Explosions of flammable and oxidizing gas mixtures are possible. NFPA 55, the “Compressed Gases and Cryogenic Fluids Code,” is an example of good engineering practices that requires separation of flammable gases and non-flammable gases by 6.1 m or 20 feet or by a wall with a 1⁄2 hour fire-resistive rating. The Canadian Centre for Occupational Health and Safety has an informative Fact Sheet on the Storage and Handling of compressed gas cylinders available online and a copy is available in the additional resources section of this Chapter.
Slide 31	When inspecting areas that store compressed gases consider the following: • Cylinders should be stored in accordance with local, provincial or state, and federal regulations • Check your fire code and local bylaws for regulations regarding the storage of compressed gas cylinders in your jurisdiction • Cylinders should be stored in a clearly identified, dry, well-ventilated area that is not exposed to heat or direct sunlight, and away from doorways, aisles, elevators, and stairs • Cylinders should be protected from falling by a chain or adequate support system. Securing each cylinder separately can prevent other cylinders from falling when items are moved • Signs should identify the products being stored or used • Gases of different types should be grouped by type with incompatible gases separated from one another • “No smoking" signs should be posted in the area • Avoid storing cylinders in enclosed lockers – a leak could result in a dangerous gas buildup
Slide 32	• Full and empty cylinders should be secured in the upright position • Empty cylinders should be stored away from full ones. • Ensure valves are completely closed and protective caps are in place • For outside storage, cylinders should be placed on a non-combustible surface in a tamper-proof enclosure

	• Cylinders should be protected from contact with the ground, ice, snow, water, salt, corrosion, and high temperatures. • Keep cylinders in a location free from vehicle traffic • Oxygen and fuel gas cylinders should be stored separately Cylinders must also be kept away from flammable and combustible liquids and from materials that easily ignite.
Slide 33	It is important that the containers not be subjected to physical abuse. Although quite sturdy as a result of their design, any dent or gouge in the cylinder can reduce safety factors and shorten failure times from fire exposure or lead to impact failures upon subsequent movement. If the valve is sheared off on some compressed gas cylinders the nozzle reaction for escaping gas can be sufficient to propel the cylinder violently. The following video by Myth Busters video shows what can happen when a valve is sheared off.
Slide 34	Video.
Slide 35	Most incidents and injuries involving gas cylinders occur during handling or transportation. To help prevent incidents make sure proper storage and handling practices are in place. Staff at the facility you are inspecting should be trained to: • Handle cylinders with care and avoid dropping or hitting them against anything • Follow proper procedures and use the right equipment, including safety glasses, heavy-duty gloves, and protective footwear • Ensure safety measures, such as caps or guards, are securely installed. • Use a cart or hand truck instead of dragging or rolling cylinders • Use proper cradles, nets or platforms if using a crane • Avoid lifting cylinders by their caps or guards or with magnets or slings, which can damage the valves The protective caps are bump caps made for side pressure not for lifting and will likely fail if used for lifting.
Slide 36	The major hazards with escaping combustible gas are the possibility of a fire or explosion. All storage containers should be inspected periodically for leakage. If a cylinder is leaking people in the area should be alerted and the area should be evacuated. Only specially trained and properly equipped people should handle emergencies. Nobody else should go near the area until it is safe. Planning, training, and practicing for emergencies in accordance with the required Fire Safety Plan will help people know what to do if a leak occurs. Natural gas and LP-gas have an odorant added to them so that a leak can be detected by occupants before a dangerous

	level is reached. However, the senses of sight, smell, and sound should not be relied upon to identify leaks because of the toxicity of many industrial gases. Some gases like methane, nitrogen, and carbon monoxide, can displace oxygen which may result in asphyxiation. Many gas detection instruments are available as either built-in monitoring systems or as portable gas analyzers. Leak detection solutions are also available that, when applied to small leaks, show bubbles.
Slide 37	Cylinders of dangerous goods classified as flammable gases stored indoors must be provided with natural or mechanical ventilation. Where flammable gases are processed, handled, stored, dispensed, or used within rooms or enclosed spaces, ventilation must conform to the appropriate provincial or territorial regulations or local government bylaws, or in the absence of such legislation, to the National Building and Fire Codes. Well-designed and well-maintained ventilation systems remove gases and reduce their hazards. Ventilation air inlets and outlets within a room or enclosed space must be arranged to provide air movement in all portions of the room to prevent the accumulation of flammable vapours. Ventilation outlets should be located outdoors and should be at least 3 m from any building opening. Make-up air for a natural or mechanical ventilation system should be taken from a point remote from any exhaust air discharge.
Slide 38	Some facilities may need a complete system of hoods and ducts to provide acceptable ventilation. Others may require a single, well-placed exhaust fan. Storage facilities for particularly hazardous materials such as chlorine, may require an additional emergency ventilation system, or continuous monitoring with appropriate alarms. Other places using small amounts of compressed gases may require no special ventilation system. Make sure ventilation systems are designed and built so that they provide adequate protection for the hazard being used or stored. Some systems may require explosion-proof and corrosion-resistant equipment. Separate specialized ventilation systems may be required for some compressed gases to keep them away from systems exhausting incompatible substances. References: NFC 3.2.8 and 4.1.7 CCOHS

Slide 39	Ignition sources must be controlled in flammable gas storage areas. The vapor density of the gas, in part, determines the extent of the area in which ignition sources should be eliminated or controlled based on whether the gas is heavier or lighter than air. Electrical installations are a significant potential ignition source if they are not installed correctly. The legislated requirements concerning electrical installations in hazardous locations are contained in the Canadian Electrical Code. A typical hazardous location might be an automotive spray-painting operation, a pharmaceutical manufacturing plant, cement plant, coal processing operation or even a carpet factory. Hazardous locations also include rooms in which flammable liquids and gases are used or stored, fuel dispensing stations, and repair garages.
Slide 40	Some electrical equipment is equipment designed to be used in a specific hazardous location without presenting an ignition hazard. The Canadian Electrical Code defines three classes of hazard: • Class I – Flammable Vapours • Class II – Combustible Dusts • Class III – Ignitable Fibres and Flying's • Class I hazardous locations are identified by zones as follows: • Zone 0 — a location in which explosive gas atmospheres are present continuously or for long periods of time • Zone 1 — a location in which explosive gas atmospheres are likely to occur during normal operation, or which is adjacent to a Zone 0 location • * Zone 2 — a location in which explosive gas atmospheres are not likely to occur in normal operation, and if they do occur will last for only a short time
Slide 41	To understand the requirements for electrical equipment installations, careful analysis of the operations conducted in the space, the location of equipment, and vapour sources present, will need to be analyzed by a fire protection engineer or other registered professional qualified in the field. In addition to knowing the legislated requirements, consultants need to evaluate the physical properties of the products in use to properly determine the extent of any classified area. Careful analysis is a key component of specifying the right electrical equipment. If you have any doubts or questions about the electrical safety of the installation, you should immediately consult the electrical inspector having jurisdiction.

	For more information about Electrical Equipment in Hazardous Locations please visit the Additional Resources section of this Chapter.
Slide 42	We are now moving on to Hazardous Materials Storage and Handling Safe storage and handling of hazardous materials, including flammable and combustible liquids and gases, requires knowledge of all the hazardous properties of the material, which can be obtained from the manufacturer's Safety Data Sheets. Safe storage also depends on the quantity, size, and nature of the containers and their storage arrangement. Principles of good storage include segregating materials from one another in storage, from processing and handling operations, and from incompatible materials; protecting containers from physical damage; using a hazard identification system; and providing fire protection based specifically on the nature of the hazard.
Slide 43	A container is any vessel or receptacle that holds material, including storage vessels, pipelines, and packaging. Often, container type, size, and construction provide important clues about the nature of the substance inside. However, do not rely solely on the type of container when making a determination about hazardous materials. Some hazardous substances may be found in unmarked containers that can pose a real threat to the surrounding area. A good example would be waste materials from illicit drug labs. Portable containers hold small quantities of hazardous materials that are easily moved from one location to another. These containers are made of many different materials, including glass, aluminum, stainless steel, steel, plastic, wood, cardboard, and lead for radioactive materials.
Slide 44	One way to distinguish containers is to divide them into two separate categories Bulk storage containers and non-bulk storage vessels. Bulk storage containers, or large volume containers, are defined by the US Department of Transportation by their internal capacity based on the following measures: • Liquids: more than 450 liters • Solids: more than 400 Kg • Gases: more than 454 kg The distinction between bulk and non-bulk packaging is important in determining placarding requirements. Bulk storage containers include fixed tanks, large transportation tankers, and intermodal tanks. In general, bulk storage containers are found in occupancies that need to store large quantities of a particular chemical.

	Most manufacturing facilities have at least one bulk storage container. Often, these bulk storage containers are surrounded by a supplementary containment system to help control an accidental release.
Slide 45	Secondary containment is an engineered method to control spilled or released product if the main containment vessel fails. A large vertical storage tank may be surrounded by a series of short walls that form a catch basin around the tank. The basin typically can hold the entire volume of the tank and accommodate water from hose lines or sprinkler systems in the event of a fire. Many storage vessels, including 45-gallon drums may have secondary containment systems.
Slide 46	Large volume horizontal tanks are also common. When stored above ground, these tanks are referred to as aboveground storage tanks or AST's. If they are placed underground, they are known as underground storage tanks or UST's. These tanks can hold a few hundred litres to several thousand litres of product and are usually made of aluminum, steel, or plastic. UST's and AST's can be pressurized or non-pressured depending on the material stored. Because it is difficult to relieve internal pressure in these tanks, they can be dangerous when exposed to fire and are required to have normal venting to allow air to enter or exit as the tank is normally filled or product is withdrawn and also have emergency venting capabilities when exposed to the high heat of a fire. Typically, they hold flammable combustible materials such as gasoline, oil, or diesel fuel. Pressurized horizontal tanks have rounded ends and large vents or pressure-relief stack. Besides the specific material stored, they also contain a small vapour space; 10 to 15% of the total capacity can be vapour.
Slide 47	Another common bulk storage vessel is the tote. Totes are portable plastic tanks surrounded by a stainless-steel web that adds both structural stability and protection. They can hold a few hundred litres of product and may contain any type of chemical, including flammable liquids, corrosives, food-grade liquids, and oxidizers. In the shipping industry, the term "tote" typically refers to an intermediate bulk container, also known as an IBC tote. These containers are built to efficiently store and transport large amounts of liquids or granulated substances. Shipping and storing totes can be hazardous. They are often stacked on top of one another and are moved with a forklift. A mishap with the loading or moving process can compromise the container. Because totes have no secondary containment, any leak will create a large spill of either

	a liquid or powder. Additionally, the steel webbing around the plastic tote make leaks difficult to repair. Because the usage totes usually require shipping to and from the producer to other facilities, they can be damaged due to the normal wear and tear of shipping and use. Inspection of their condition prior to reuse is necessary.
Slide 48	Intermodal tanks are both shipping and storage containers. They can hold up to about 22,700 liters of product and can be either pressurized or no pressurized. Intermodal tanks can be shipped by any mode of transportation: air, sea, or land. These horizontal round tanks are surrounded by, or are part of, a boxlike steel framework for shipping. There are three basic types of intermodals (IM or IMO) tanks: • IM-101 containers have a 6000-gallon (22.7 kilolitres) capacity, with internal working pressures between 25 and 100 psi. These containers typically carry mild corrosives, food-grade products, or flammable liquids.
Slide 49	• IM-102 containers have a 6000-gallon **(22.7 kilolitres)** capacity, with internal working pressures between 14 psi and 30 psi. They primarily carry flammable liquids and corrosives • IMO Type 5 containers are high pressure vessels with internal pressures of several hundred psi that carry liquefied gases like propane and butane.
Slide 50	Nonbulk storage vessels are all other types of packaging or containers. Nonbulk storage vessels can hold a few **millilitres to many litres** and include drums, bags, carboys, compressed gas cylinders, cryogenic containers, and more. Nonbulk storage vessels normally hold commonly used commercial and industrial chemicals such as solvents, industrial cleaners, and compounds. The nature of the product determines the most appropriate container to use, and the maximum quantity allowed. Cryogenic containers are often called dewar containers. A cryogenic storage dewar is a specialised type of vacuum container used for storing cryogens such as liquid nitrogen or liquid helium. whose boiling points are much lower than room temperature. Cryogenic storage dewars may take several different forms including open buckets, flasks with loose-fitting stoppers and large pressurising tanks used for transport. All dewars have walls constructed from two or more layers, with a high vacuum maintained between the layers.
Slide 51	Hazardous material storage lockers have become very popular in recent years, as they meet the environment concerns dictated by special handling

	or hazardous chemicals. These lockers are moveable, prefabricated storage buildings that provide a safe and cost-effective means of storing hazardous materials. These lockers are equipped with spill containment features and can be supplied with electricity, mechanical ventilation and can be fitted with fire suppression systems. Generally, these lockers are found outside, but NFPA 30 permits the lockers to be utilized as inside storage rooms if the lockers are constructed with the fire resistive rating and requirements listed in NFPA 30. NFPA 30 limits the floor area of these lockers to 1500 sq ft (140 sq m).
Slide 52	Hazardous materials can be transported through rail, air and sea but by far the most common method of transportation is by land using vehicles. Common commodity tankers are: • MC-306 tanker; for gasoline and other flammable and combustible materials. These are non-pressurized containers usually made of aluminum with discharge outlets in the bottom of the tank • MC-307 chemical hauler; used for flammable liquids, mild corrosives, and poisons • MC-312 corrosive tankers; used for concentrated sulfuric acid, nitric acids, and other corrosive substances. The rings provide structural stability in the event of an accident.
Slide 53	MC-331 is a pressure cargo tanker that carries materials like ammonia, propane, and butane MC-338 cryogenic tanker is used for liquefied cold gases. The box like structure at the rear of the trailer houses the control valves. Tube trailers; carrying compressed gases such as liquified natural gas, hydrogen, oxygen, helium, and methane. A mixture of products can be carried as the tubes are individual containers banded together. The products contained are under high pressure in the area of 3000 to 5000 psi. Dry bulk cargo tanks are used for dry goods such as powders, pellets, fertilizers, and grain. *In all cases, the Department Of Transportation or DOT is the agency that regulates the transportation of hazardous materials*
Slide 54	We will now take a quick look at railroad transportation of dangerous goods. With over 41,000 kilometers of track, Canada has the third-largest rail network in the world. The number of carloads moving by rail has steadily increase and in 2018, 6.1 million carloads originated in Canada. With that many movements there are bound to be accidents like the one near Gogama Ontario in 2015.

	On 14 February 2015 a CN crude oil train was proceeding eastward at about 38 mph when it experienced a train-initiated emergency brake application near Gogama, Ontario. A subsequent inspection determined that the 7th through 35th cars, 29 cars in total, had derailed. Nineteen of the tank cars were breached, and about 1.7 million litres of petroleum crude oil were released to either atmosphere or surface. The released product ignited, and the fires burned for 5 days.
Slide 55	The train consisted of 2 locomotives and 100 tank cars loaded with dangerous goods. Of the 100 cars, 68 were loaded with petroleum crude oil (UN 1267), and 32 were loaded with petroleum distillates (UN 1268). The train was 6089 feet long and weighed 14 355 tons. The transportation of Dangerous Goods is governed by federal regulations in Canada and the United States (U.S.). These regulations are based on the United Nations Recommendations on the Transport of Dangerous Goods. The products being transported in this occurrence were listed as Class 3 flammable liquids, packing group (PG) I, which is the most hazardous group of products in this class. Immediately following the derailment, fire erupted and engulfed many of the tank cars that had been breached. As the fire continued to burn, 7 tank cars ruptured and released more crude oil to the environment. Luckily there were no injuries, and an evacuation was not required. If you would like to learn more about this accident, please see the Transportation Safety Board Railway Investigation Report R15H0013 which can be found below the additional resources for this chapter.
Slide 56	Railway tank cars can carry volumes up to 30,000 gallons (113.000 L) and have the potential to create large leaks or vapour clouds. Hazardous materials incidents involving railroad transportation, although rare, can be extremely dangerous. There are three basic types of tanks cars: low or non- pressurized, pressurized, or special use. Special use includes insulated or non-insulated which are designed for single or multiple commodities. Non-pressurized or low-pressure tank cars can be used to carry almost any type of material. The DOT 111 is the most common general purpose tank car, estimated to be about 78 percent of the tank car fleet in North America. It has various fittings on the top and may have fittings on the bottom. Some of the top fittings may be covered by a protective housing but some valves and fittings should be visible. General service tank cars transport both hazardous and non-hazardous products.

Slide 57	Pressurized tank cars, designated as DOT-105, 109, 112, 114, and 120 are pressurized cars used to transport liquified compressed gases, poisons/toxic inhalation hazard materials, reactive and/or corrosive materials requiring additional protection. These cars have additional safety features than what is required on DOT-111 cars. Pressurized cars have an enclosed dome protective housing on the top of the car. Loading and unloading are done through the protective housing. Tank pressures range from 100 to 600psi and are pressure- tested regularly to ensure the integrity of the tank. Unlike non-pressurized tank cars, which may be loaded or unloaded using an open system, pressure tank cars are loaded and unloaded using a closed system, so the tank is not open to the atmosphere during the process.
Slide 58	Special use tankers include insulated cars, which may also incorporate heating or refrigeration systems, and are used when the contents must be kept at a certain temperature. Classes DOT-113 and AAR-204 tank cars are a vacuum- insulated tank with an inner and outer shell designed to transport cryogenic liquids like liquid hydrogen, ethylene, oxygen, nitrogen, and argon. The space between the inner and outer shells creates an insulated vacuum. Cryogenic tank cars will normally have features or a construction style that makes them stand out from the other types of tank cars. They will normally have their loading/unloading equipment, valves, etc. inside of a compartment on the sides or end of the tank car. They will look like they have a stronger construction, because they have literally a tank built inside of another tank. For additional information on rail tanker please visit the additional resources section of this chapter.
Slide 59	Pipeline networks consist of the above or below ground pipes, pumps or compressor stations, and terminal facilities. They generally move products such as natural gas, crude oil, gasoline, and the chemicals needed in the petroleum making process. The pipeline right of way is an area, patch, or roadway that extends a certain number of feet on either side of the pipe itself. This area is maintained by the company that owns the pipeline and they are responsible for the placing of warning signs at regular intervals along the pipeline. Pipeline emergencies are complex events that require specially trained responders. You can assist the responders by documenting emergency contact, facility site plans, emergency shutdown procedures, and facility access information for your fire department.
Slide 60	Fire protection systems were discussed in detail in Chapter 9 so we will not go into a detailed description here except to say that fire and

	explosion prevention measures for hazardous materials and environments are based on one or more of the following techniques or principles: • Exclusion of sources of ignition • Safe storage of ignitable products in closed containers or systems • Ventilation to prevent the accumulation of vapor within the flammable range • Use of an atmosphere of inert gas instead of air Extinguishing methods for flammable and combustible liquid and gas fires involve shutting off the fuel supply, excluding air by various means, cooling the liquid to stop evaporation, or a combination thereof.
Slide 61	Although many flammable and combustible liquids and gases can be classed as stable, others introduce the problem of instability or reactivity. The storage, handling and use of unstable commodities require special attention. The design of fire protection systems for flammable liquids and gases is dependent on how the product is being used or stored. Either cooling, suppression of vapors, or depriving the fire of oxygen may be used to extinguish most flammable liquid and gas fires. Automatic sprinklers, and sprinklers with additives such as foam, can be used to cool and dilute the flammable vapors. Carbon dioxide systems may extinguish a fire in a localized area. These systems work quickly, efficiently, and leave no residue. Many places that have spray booths, flammable liquid storage, and dip tanks utilize this system. The major drawback to using carbon dioxide fire suppression systems is that the gaseous agent is dangerous to humans.
Slide 62	Flammable and combustible liquids and certain gases can become an explosion hazard in the right mixture. Controlling ignition sources is fundamental to preventing combustion explosions but they do happen from time to time. In addition to explosion prevention safeguards, the severity of an explosion can be reduced by structural design. The installation of explosion vents or rupture panels is a safety device to protect against excessive explosion pressure. If an explosion occurs, the vents are designed to instantly open and release the build-up of pressure. This is known as “deflagration venting”, and is covered in some detail in NFPA 68, Standard on Explosion Protection by Deflagration Venting.
Slide 63	The fire code limits the amount of hazardous materials that are allowed to be stored, used, handled, dispensed or displayed. It generally allows manageable amounts of hazardous materials to be stored and used in

	most occupancies for normal operations. These materials may also be on display in a wholesale or retail sales setting. Exceptions to this are explosives which must be stored in conformance with the Explosives Act and its Regulations and radioactive materials that must meet the requirements of the Nuclear Safety and Control Act. The fire code also establishes size restrictions for individual storage areas based on whether or not the building is sprinklered. As the complexity of the hazards increase, the fire inspector may require the help of a fire protection engineer to determine the extent of the hazard and the protection required.
Slide 64	This concludes part two of Chapter 12, Ensuring Proper Storage and Handling Practices. In this part we discussed: • Flammable liquid tank storage above ground, underground and inside buildings • Packaged flammable and combustible liquids • Storage of class 1,2 and 3A flammable liquids inside buildings • That container storage must consider the risk to the occupants, exposure to other buildings, and the degree of fire protection provided • Storage rooms that are sprinklered or not • Explosion venting • Storage cabinets • The amount of flammable and combustible liquids allowed based on occupancy classifications • handling flammable or combustible liquids • Fire Safety Plans
Slide 65	• Portable containers • Flame or spark arrestors • Dispensing of flammable or combustible liquids from containers • Bonding and grounding • Fire Prevention Methods • Storage of gases • BLEVE's • Pressure relief devices • Storage rooms for compressed gases • Flammable gases should not be stored with oxidizing gases
Slide 66	• That most incidents and injuries involving gas cylinders occur during handling or transportation • major hazards with escaping combustible gas is fire or explosion

	• Ventilation for indoor storage • Controlling Ignition Sources • electrical equipment designed for specific hazardous locations • Safe storage and handling of hazardous materials • Bulk storage containers • Secondary containment • Storage totes • Intermodal tanks • Non-bulk storage vessels • Hazardous material storage lockers • Transporting Hazardous materials by ground, rail, and pipelines • Fire protection systems • Deflagration venting And we finished the Chapter by saying that the fire inspector may need the help of a fire protection engineer to determine the extent of the hazard. Experience has shown over and over "When in doubt ask for help."