Intermodal Shipping Container Fire Safety

A Way Towards Better Practices

Don Delcourt and Len Garis

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UNIVERSITY OF THE FRASER VALLEY
CENTRE FOR PUBLIC SAFETY & CRIMINAL JUSTICE RESEARCH

Dedication

This study is dedicated to Captain Daniel Botkin, who died in the line of duty in Enderby, British Columbia on December 29, 2011. Captain Botkin was killed when a shipping container adjacent to a burning structure exploded unexpectedly. Captain Botkin, members of the fire service, and the owner of the shipping container were unaware of the potential for catastrophic failure of shipping containers when they are exposed to high temperatures.

Captain Botkin was the fire department's training officer. He had dedicated his fire service career to the safety of others, especially firefighters. He died heroically serving his community and watching over his fellow firefighters.

In dedicating this document to Captain Daniel Botkin, the authors acknowledge the loss of Captain Botkin, and the loss to his family, friends and community. This document is published with the hope that in learning from the tragic circumstances that led to the death of Daniel Botkin, others may live.

Executive Summary

1. More than 16 million shipping containers are being used to transport goods around the world, and millions of these containers become surplus every year and are repurposed as buildings or structures.
2. The surplus containers are popular for use as temporary or permanent structures because they do not need assembly and are inexpensive, weather resistant, structurally strong, sealed and theft-resistant. They are used for a wide range of purposes, including construction offices, electrical rooms, and storage of various items, including flammable gases and liquids.
3. Fire and explosion incidents, such as the line-of-duty death of a Fire Captain in Enderby, British Columbia in 2011, have drawn attention to the need to recognize and mitigate the fire hazards related to shipping containers. In that incident, a fire in an adjacent building caused a low-speed explosion in a shipping container in which small volumes of flammable liquids were stored. The explosion blew out the container doors, one of which struck and killed the Fire Captain. In a 2013 incident in Saanich B.C., a leaking barbecue propane tank stored in a shipping container caused an explosion that destroyed the container, but luckily did not cause any serious injuries.
4. The steel shipping containers are constructed to withstand being loaded, stacked, twisted and dropped, and their walls are built to handle shifting loads. As a result, they can withstand a considerable build-up of internal pressure before they fail catastrophically.
5. A number of jurisdictions around the world have developed regulations to address the increased use of shipping containers as structures and their unique safety hazards.
6. Best practices suggest that key mitigation strategies include:
    - Regulating the use, allowed contents and any potential fire risks,
    - Weakening the structure to prevent high pressures from building up inside (e.g. by installing explosion-relief panels, replacing doors with lightweight walls or installing conventional doors and windows),
    - Providing openings to vent smoke that will help those outside the container identify potential issues inside the container, and
    - Developing of standard operating procedures for shipping container fires that address incident size-up, hot and exclusion zones, and fire attack planning.
7. To ensure the safety of the public and firefighters, the following actions are recommended:
    - Communicate the fire safety hazards of shipping containers,
    - Put in place national, provincial and local government regulations of the use of shipping containers as temporary buildings and structures,
    - Regulate the materials stored in shipping containers,
    - Provide information on how shipping containers can be modified to be safer, and
    - Introduce operating procedures that can be used by the fire service to safely deal with shipping container fires.

Purpose of the Study

The purpose of this Study is to help to understand the fire hazards related to using shipping containers as temporary or permanent buildings and help prevent injuries to the public and the fire service. The study intends to raise awareness of the hazards and describes recommended practices and actions, including increased regulation of the use of shipping containers as buildings and the materials stored in them, modifications to make shipping containers safer, and procedures for the fire service in managing shipping container building fires. To prepare this study, research was conducted into shipping container fires and regulations governing the use of shipping containers in Canada and abroad.

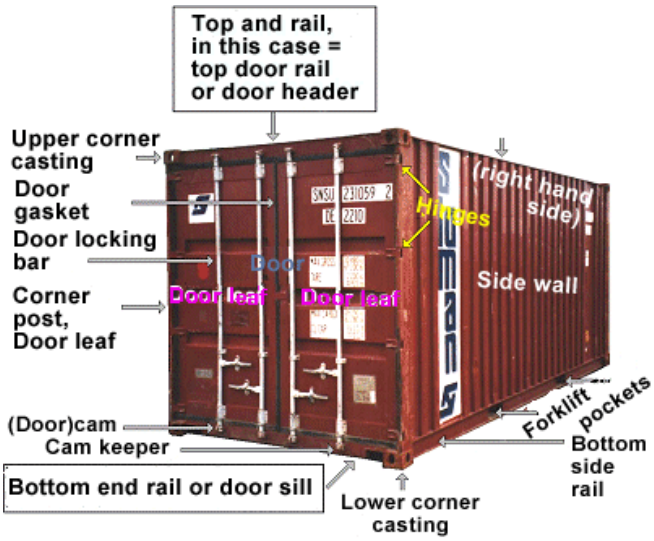
Background

More than 16 million shipping containers are being used around the world to transport goods and materials on ships, trains and trucks. Millions of these containers become surplus every year and are repurposed as buildings or structures.

The 2011 line-of-duty death of volunteer Fire Captain Daniel Botkin in Enderby, British Columbia was a wake-up call for the fire service about the fire hazards of using shipping containers as temporary or permanent buildings. In this incident, it was determined that a fire in a building adjacent to a container that was storing small volumes of flammable liquids caused an internal low-speed explosion that blew out the container doors. One of these doors struck and killed Fire Captain Botkin.

In a more recent incident, a leaking barbecue propane tank stored in a shipping container in Saanich, B.C. exploded in April 2013 and destroyed the container. Parts of the container landed 274 metres [300 yards] away and the walls were flattened. Luckily, no one was seriously injured in this incident.

2013 shipping container explosion in Saanich B.C.



Container features

Shipping containers are made of steel and range in size from 1.5 to 16 metres [five to 53 feet] long. The containers are 2.4 metres [eight feet] wide and 2.6 metres [8.5 feet] high, with steel doors at one end. Some containers have small vents on the ends at the top for air pressure equalization, due to changes in the ambient air temperature. These vents are a series of three rows of three 3.2 to 6.4 millimetre [1/8 to 1/4 inch] holes cut through the steel wall and covered by a metal or plastic outer cover. Depending on their size, containers have two, four or six of these vents.

Typical containers are designed to be stacked six to nine high and to hold weights of 32,205 kilograms [71,000 pounds]. The side walls are designed to withstand shifting loads of up to 60% of the permitted load, and the end wall and doors are designed to withstand 40% of the permitted load. As a result, internal pressures can build to the point that the containers fail catastrophically.

Ultimately, the features that make shipping containers secure from theft and structurally sound also make them a fire safety hazard.

Enderby Line-of-duty Death Incident – Summary

At 3:51 a.m. on December 29, 2011, a fire at a log construction facility in Enderby, B.C. was reported to 911. At 4:01 a.m., the first fire truck arrived on site with 15 firefighters (including the Deputy Fire Chief and four Fire Captains), along with two pumpers and a rescue truck. The fire had apparently started in a modular trailer and spread to the large production building where log structures were assembled.

A shipping container that held gas-powered tools and about a litre of flammable liquids was exposed to extreme heat when the building next to it caught fire. The evidence indicates that the flammable liquids vaporized and exploded, blowing off the container doors.

A shipping container was being stored under a roofed addition to the production building and sat about two metres (6.6 feet) from the burning building. The container was 2.4 metres (eight feet) wide, 2.6 metres (8.5 feet) high and 12 metres [40 feet) long. At several times during the fire, smoke was seen coming from the equalization vents and overheating door gaskets, and water was directed onto the container or its area.

At about 5:05 a.m., a Fire Captain climbed on top of the container to attack the fire in the production building. At the time, he did not find the roof to be hot. The Incident Commander grew concerned about the possible failure of the production building structure and pulled the firefighters away from the building and shipping container. The operation went into the mop-up stage.

The photo above shows the bending of one of the container doors that was blown off in the explosion.

At 5:15 a.m. the shipping container ruptured and:

- One side of the shipping container along the roof line tore along the length,
- The container roof along the production building was torn and bent upward,
- The sides and end of the container were bent outward, and
- Both of the 113 kilograms [250 pound] metal doors were blown off.

One of the doors struck Fire Captain Botkin and landed 41 metres (135 feet) southwest of the container and the second door was found 54 metres (177 feet) northwest of the container. Fire Captain Botkin died at the site.

Analysis

The various investigation reports indicate the explosion was caused by 0.5 to 1.5 litres (0.13 to 0.4 gallons) of gasoline/oil from two chainsaws and 0.5 litres (0.13 gallons) of methyl hydrate. Witnesses advised that the fire impinged on the shipping container for 45 to 55 minutes before the explosion. As noted above, 10 minutes before the explosions a Fire Captains was on top of the shipping container directing a hose line at the production building fire, but did not find the top of the container steel to be warm.

The WorksafeBC and the Office of the Fire Commissioner reports identified the specific fuels that could have been involved in the Enderby incident, but they had difficulty identifying the ignition scenario. An NFPA advisor helped form the conclusion that a "low volume detonation" occurred.

Some information is available on the ISO construction standards for shipping containers when used for their original purpose of transporting goods and materials. These standards have been changing to consider the containers' operating conditions. The older container had fewer air compensating vents compared to the newer containers, and the range of sizes of shipping containers has also increased.

The only document that could be found on the fire testing of shipping containers is the 1977 US Coast Guard report "Fire Performance of Intermodal Shipping Containers." The report looked at both fires in the containers and exposure fires impacting the containers. The internal testing involved a wood crib fire inside the container that vitrified or consumed the internal oxygen before all the wood was consumed. The air compensating vents did not affect the test results. The second exposure tests involved 65m^2 JP5 spill fires exposing single and stacked containers. These tests indicated that the internal temperatures reached 230˚C in four to nine minutes. The conclusion was there was a potential for "ignition or charring" of Class A materials within five minutes.

Fuels

The general conclusion is that the fuels involved in the Enderby incident were 500 millilitres (0.13 gallons) of methyl hydrate (methanol), or approximately one litre of gasoline and oil mix (0.4 gallons), or the combination of the two. The following tables provide information on the characteristics of the methanol and gasoline, and propane and hydrogen for comparison.

Characteristics of Common Fuels

Properties	Hydrogen	Propane	Methanol	Gasoline
Flammability limits				
LEL (%)	4.1	2.2	6	1.4
UEL (%)	74	9.5	36.5	7.6
Stoichiometric air/fuel ratio (weight)	34.3	15.7	6.45	14.7
Min. ignition energy	0.017	0.03	0.14	0.2
Auto-ignition Temperature (˚C)	400	450	385 to 464	232 to 280
Vapour density	0.067	1.5	1.1	3 to 4
Burning velocity (cm/s)	312		56	40
Gross combustion energy			17.9 MJ/litre	34.8 MJ/litre

Key information from this table:

- When heated, the methanol vapours could rise and the gasoline vapours will still stay low,
- Methanol's auto-ignition temperature (AIT) is significantly higher than that of gasoline,
- The flammability ranges of methanol and gasoline are close, and
- Gasoline's combustion energy is significantly greater than that of methanol.

The temperature at the ceiling of the shipping container will also be higher than at the floor, which will result in lower minimum ignition energy. For example, the minimum ignition energy (MIE) for ethanol at 25 C is 0.40 mJ, but at 100 C the MIE is 0.21mJ. Also, the AIT will rise if there is an increase in pressure within the container.

Ignition Sources

The most difficult element to determine in the Enderby incident is the ignition source. Although the side of the shipping container facing the production building was exposed to direct flame that could have heated the steel to above the ignition temperature of the fuels, the fire captain who was on top of the container 10 minutes before the rupture indicated the roof was not hot. The report's key temperature indicator is that the plastic gas tanks had melted on two chainsaws hanging on the inside wall of the shipping container closest to the burning building. The chainsaw manufacturer advised WorkSafeBC that the melting temperature of the chainsaw plastic is approximately 200˚C. This would indicate the spilling or boiling off gasoline was exposed to at least 200˚C, and the AIT of gasoline is 232˚C.

The US Coast Guard exposure tests had indicated that the container ceiling and at the two metre level temperatures were approximately 360˚C within six minutes of the start of the test fire. Witnesses in the Enderby incident indicated there was flame impingement on the side of the container for 45 to 55 minutes.

Using the fire testing as a baseline, it could be concluded that the temperature near where the chainsaws were located (and losing gasoline and oil mix) could have been at least 200˚C or considerably higher. It could then be theorized that this area of the interior of the container was heated by radiation, conduction and convection to above the auto-ignition temperature of the gasoline and possibly the methanol.

Container Characteristics

The US Coast Guard fire tests provide some background on the characteristics of shipping container fires, but do not give any critical information on the strength and venting of the performance. Based on published wall-loading information, a calculation of a conservative low estimate of the wall strength determined that the yield strength of the walls could be 7.0 kPa (1.0 psi) and the bursting strength of 8.4 kPa (1.22 psi). This is lower than the rough estimate of the container strength, but it is useful to determine the relative area of typical explosion relief panels.

The air compensating vents are designed to deal with climatic temperature changes without causing damage to the container. If the vents were not installed then small changes in temperature could dramatically increase the internal container pressure.

Using the Ideal Gas law and assuming that the container was not vented, the following table shows increases in pressures that could occur.

Pressure Increases Based on Temperature

Temperature above ambient	Resulting pressure increase
20^0C	7.1 kPa (1.03 psi)
40^0C	15.2 kPa (2.2 psi)
60^0C	22.3 kPa (3.2 psi)
100^0C	37.5 kPa (5.4 psi)

These vents will not bleed off sufficient pressure fast enough during a fire because the vents only amount to 0.0079% of the wall and roof area of a typical shipping container.

Venting Scenarios

In order to prevent a shipping container rupture similar to the Enderby incident, with similar fuels, calculations were made in accordance with NFPA 68-2012.

The following table indicates the required area of the explosion venting for the various fuels for standard 12-metre long containers that can withstand 7.0 kPa (1 psi) of internal pressure.

Required Area of Explosion Venting Based on Fuel

Fuel	Fuel volume causing the explosion	Maximum unvented pressure (Pmax)	Area of explosion vent	Percentage of the explosion vent area versus the area of the walls, doors and the roof
Methanol	0.5 litre (0.4 kg)	750 kPa (109 psi)	26 m^2	36.4 %
Gasoline	1.0 litre (0.72 kg)	780 kPa (113 psi)	25.9 m^2	36.3 %
Propane (for comparison)	1.0 kg	790 kPa (115 psi)	32.5 m^2	46 %

These vent areas are only for comparison because the key calculation factor of container strength is only a rough calculation.

The key conclusion is that even very small unregulated volumes of flammable liquids or combustible gases in shipping containers can possibly create a low energy explosion and the rupture of a shipping container.

Hazard Awareness and Regulation

Shipping containers are recognized as a safety concern when they are used to ship various goods and materials, including dangerous goods, on the roads, rail and ships. However, when they are used as buildings or structures, we do not recognize them as being a fire safety hazard. The Enderby and Saanich incidents are two examples of the fire safety hazard they can create.

Examples can be found of shipping containers being used for a variety of applications, including:

- Storage of fireworks,
- Storage of flammable gases and liquids at construction sites,
- First aid buildings at construction sites (with supplies of antiseptic alcohol or oxygen bottles),
- Construction offices,
- Recharge of hunting ammunition by hobbyists, and
- Electrical rooms or electrical vaults at construction sites (with the accompanying arc blast risk.

The key reasons shipping containers are used as temporary or permanent structures is that they are cheap to purchase, do not need assembly, are weather resistant, are structurally strong, are a sealed container, and are secure from theft. Also, these containers are not looked upon as buildings or structures, therefore skirt the building and fire approval requirements.

Shipping Container Regulation

A number of jurisdictions around the world have adopted planning or building bylaws and provincial bulletins to regulate the use of shipping containers. The following are some examples.

Canada

Vermillion, Alberta

- Containers are addressed in Bylaw #6-2010 Land Use Bylaw.
- Based on other Alberta land use bylaws.
- Defined as a structure (accessory building).
- No dangerous or hazardous materials or containers are permitted.
- No connected services are permitted.
- Permit requires compliance with the Alberta Building and Fire Codes.
- Containers are restricted to specific zoning.

City of Burnaby, British Columbia

- Shipping containers are defined as permanent buildings.
- Containers must comply with the British Columbia Building Code, and the design and field review must be performed by an architect or professional engineer.

Township of Laurentian Valley, Ontario

- Shipping containers used to store flammable and/or hazardous materials must be properly ventilated and placarded to identify the stored materials.
- Fire extinguishers must be installed in accordance with the Ontario Fire Code.
- A maintained road capable of withstanding the weight of firefighting equipment to within 45m of the container must be provided.

United States

Riverside, California

- Containers are defined as an accessory building.
- Building permit is required.
- One container is permitted per acre, to a maximum of two.
- No windows, plumbing, electrical and mechanical improvements are allowed.

Bellflower, California

Planning Department requires:

- Storage of materials must be approved by the Los Angeles Building Department and Los Angeles County Fire Department.
- Only one container is permitted for each 15,000 square feet of lot area.
- Compliance with Ordinance No. 853 is required.

County of Los Angeles, California

- A miscellaneous permit must be obtained with approvals from the fire department, etc.
- No flammable or combustible liquids or hazardous materials may be stored.

Sonoma County, California

- Different requirements are in place for temporary and permanent use for storage.
- Permit is required.
- For permanent non-storage use, sprinkler protection is required.

City of Santa Rosa, California

- Temporary storage use requires a temporary use permit.
- Permanent storage use requires a building permit, fire sprinklers and a hazardous materials management plan for HAZMAT use.

New York State

- Containers are defined as storage buildings and must meet the New York State Uniform Fire Prevention and Building Code
- Building permit is not required, but a fire safety inspection and a certificate of occupancy are required.
- Exit doors and a ventilation louver on one side must be installed.

Airway Heights, Washington

- Shipping containers are prohibited as accessory buildings or storage buildings except under permit.

International

Te Tari Kaupapa Whare, New Zealand

- Analysis has determined that shipping containers are buildings.

Department of Building and Housing, New Zealand

- Shipping containers are defined as buildings.

Cooma-Monaro Shire, New South Wales, Australia

- Shipping containers are considered as buildings.
- Exemptions exist for construction sites and farms.

Recommendations

Required Regulation

In order to regulate the fire safety of shipping containers, the following steps should be put into place:

1. Recognition in the National Building Code that shipping containers are regulated buildings or structures when they not used for the transport of goods and materials.

2. Recognition in the National Fire Code of the fire safety hazards of storing small volumes of dangerous goods in shipping containers. This can be accomplished by modifying Section 3.3 Outdoor Storage 3.3.1.1. Application 3.3.1.1. 2) c) "Intermodal shipping containers, except when containing dangerous goods" to clarify the shipping container fire and explosion hazards.

3. BC Building and Safety Standards Branch should issue a bulletin or advisory to:

    a. Define shipping containers as buildings under the BC Building Code (similar to the March 2010 Shipping Container Advisory from the Government of Saskatchewan) and,

    b. Change the BC Fire Code to recognize and attempt to mitigate the fire and explosion hazards caused by the storage of very small volumes of dangerous goods in shipping containers.

4. Local governments need to adopt bylaws to regulate the use of shipping containers as buildings within their jurisdiction. See Appendix A for a sample shipping container fire safety bylaw.

Mitigation and Prevention

Key mitigation strategies for shipping container fire safety are as follows.

1. Regulate

As noted above, it is key to regulate:

- What shipping containers are used for,
- What contents can be safely stored in them, and
- Potential fire risks the container may either be exposed to or may create for other critical structures or access points on the site.

Suggested solutions include a lower ventilation opening in the lower door (above) and an upper ventilation opening and wind vent (below).
Photos courtesy of BC Hydro Fire Marshal's office.

2. Weaken

Shipping containers should be weakened to prevent high pressures from building up that exceed their rupture strength. Currently, standard shipping containers are very strongly constructed in order to prevent theft and to withstand cargo loading and being stacked, twisted and dropped on ships, trucks and trains.

The containers can be weakened by:

- Installing explosion-relief panels that may have to exceed 25% of the wall surface,
- Replacing the end doors with lightweight walls, and
- Installing conventional doors and windows in the sides.

The degree to which the container has to be weakened depends on its use. If dangerous goods are to be stored, specially designed relief panels will have to be determined by a professional engineer. Small top and bottom vents can also create some low-level weakening and provide ventilation.

3. Venting

The lack of indication of what is happening inside the shipping container was one of the key issues with the Enderby incident. The firefighters were not fully aware of the hazardous conditions building inside the shipping container. The provision of the top and bottom-level openings at opposite ends of the container may have revealed the hazardous conditions by emitting smoke from the container. This may have allowed them to change their tactics.

4. *Incident safety*

Fire departments should consider having standard operating procedures in place that cover the incident size-up, hot and exclusion zones, and fire attack planning. Appendix B provides the framework for a typical Shipping Container Standard Operating Procedure.

Required Actions to Prevent Injuries from Shipping Containers

In order to prevent injuries to the public and the fire service, we must:

- Communicate the fire safety hazards of shipping containers,
- Put in place national, provincial and local government regulations of the use of shipping containers as temporary buildings and structures,
- Regulate the materials stored in shipping containers,
- Provide information on how shipping containers can be modified to be safer, and
- Introduce operating procedures that can be used by the fire service to safely deal with shipping container fires.

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BC Office of the Fire Commissioner (December 2011). Fire Investigation Report 2011-12-29-01.

WorkSafeBC. Incident Investigation Report NI 2011116120216

WorkSafeBC (April 2012). "Firefighter killed in explosion involving flammable liquids." Hazard Alert.

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Authors' Biographical Information

Don Delcourt is the BC Hydro & Power Authority Fire Marshal, the Industrial Director for the Fire Chiefs Association of BC, and an Engineering Licensee with the Association of Professional Engineers and Geoscientists of BC. Contact him at don@enfireintel.com.

Len Garis is the Fire Chief for the City of Surrey, B.C. and is an Adjunct Professor in the School of Criminology and Criminal Justice at the University of the Fraser Valley, Affiliated Research Facility at the John Jay College of Criminal Justice, New York, and a member of the Institute of Canadian Urban Research Studies, Simon Fraser University. Contact him at LWGaris@surrey.ca.

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Appendix A – Sample Bylaw

Shipping Containers – Minimum Standards for the Use of Shipping Containers as Storage Buildings

Issue

Shipping containers are designed for overseas storage and shipping of material, equipment and hazardous material. These containers are normally poorly vented and are therefore able to build internal pressure. The containers easily behave like a closed vessel.

In December 2011, a B.C. firefighter was killed as a result of the catastrophic failure of shipping container exposed to an external fire. This container contained some minor amounts of flammable liquids (less than two litres was involved) and, as designed, had very little venting since the doors were closed and latched. The adjacent fire heated the container and contents, which resulted in a build-up of flammable vapours and pressure inside the container. Ultimately, the shipping container ruptured, tearing one of the top seams of the container and blowing out the latched and locked doors. One of the doors struck a firefighter standing about 10 metres away and the firefighter sustained fatal injuries.

In *<input name of local government>* shipping containers located within/on properties subject to fire inspections will be inspected for compliance. Shipping Containers used for storage of any flammable or combustible liquids, or combustible materials and other long term uses, will be considered as permanent buildings and therefore must meet the requirements of the BC Building and Fire Codes as well as *<input name of local government>* Bylaws.

Code Compliance

The container must meet, or exceed as indicated, all relevant requirements of BC Safety Codes such as, but not limited to:

- Division B – Part 3 & Division B – Part 4 of the BC Fire Code will apply in all cases
- There will be no electrical service to the container unless it exceeds all requirements of the BC Building, Fire and Electrical Codes for explosive/moist/wet environments. It must be fully explosion-proof and tested regularly to ensure compliance.
- The Dangerous Goods storage shall be restricted to materials that are declared at the permit stages. Any changes to the types of dangerous goods must be approved by the *<input local fire services name>*.
- No smoking shall be allowed in shipping containers.
- Where flammable liquids and combustible liquids are stored in the container, combustible construction shall be removed, provisions for spill containment installed, and the container shall be grounded. The dispensing of flammable liquids and the storage of open containers shall be prohibited in the shipping container.
- Compressed gases shall not be stored in the shipping containers. Limited amounts of aerosols shall be stored in the shipping containers and only when stored in metal cabinets.
- Shipping containers shall not be installed under power lines.

Location

The container must be positioned such that:

- There is a minimum separation of 1.5-3 metres between any non-combustible structure and the container to allow for firefighting access to the exposed structures.
- The shipping container must be located at least 6 metres from exits, windows or unprotected openings in the exposed building.
- Greater separation distances will be required based upon exposure to any combustible materials or structure.
- The container doors are positioned such that they face away from any other structure.
- The container doors must be positioned such that they face away from any means of road access to the container for fire personnel.
- No combustible materials may be placed near the container.

Identification

The container must be identified such that:

- UN Placards for all stored Dangerous Goods must be visible on the two container sides most visible to emergency responders.

- The name of the company/person responsible for the storage and an emergency telephone contact number must be marked on the container in lettering visible from 10 metres.
- The container and contents must be identified in the Fire Safety Plan.

Safety Features to Be Added

The container must have the following safety features in place prior to any use for storage:

- One ventilation opening must be added within 150 millimetres of the floor in the container door primarily used for opening.
- One ventilation opening must be added within 150 millimetres from the top of the container on the opposite end from the doors for cross ventilation.
- The high ventilation opening cannot be directly venting toward a structure.
- Neither ventilation opening can be obstructed by stored materials at any time and must be kept clean of internal and external debris.
- The additional ventilation openings must be constructed based upon the following minimums:
    - Two – 0.3 x 0.3 metre openings for containers six metres or less.
    - Two – 0.5 x 0.5 metre openings for containers over six metres.
    - Both openings will be covered by open grate wire mesh with greater than 50% free area.
    - Higher opening will also have a wind vent device, designed to generate a venturi effect during low wind speeds.
- Where heavier than air flammable and combustible liquids are stored in the container, a ventilation opening at low level should also be installed at the opposite end from the doors.
- Where 1A flammable liquids in quantities greater than four litres are stored in the shipping container, then provisions shall be made to comply with the requirements for withstanding an internal explosion as per the BC Fire Code, BC Building Code and NFPA 68.
- Alternate engineered solutions for ventilation and explosion protection will be considered.

NOTE: ***Standard existing environmental vents normally built into shipping containers ARE NOT ACCEPTABLE as ventilation openings for land-based storage applications. These were designed for air movement based upon atmospheric weather changes only and do not provide adequate air flow***

Appendix A References

BC Hydro (2013). "Fire Marshall's Fire Safety Bulletin on Shipping Container Fire Safety."

WorksafeBC. Incident Investigation Report #2011 – 1476

Pitt Meadows Fire & Rescue Service. Draft Shipping Container Fire Safety Standard.

Appendix B – Sample Standard Operating Procedures

Shipping Container Fires – Standard Operating Procedures

Purpose: To provide tactical safety procedures for fire department response to a fire involving intermodal shipping containers.

Scope: Fire Department Personnel and Other Emergency Personnel

General Information:

The use of shipping containers as buildings and structures has become widespread, but these uses and applications have not always been regulated from the fire safety perspective. These containers can create significant fire hazards to fire responders when there are fires adjacent to them or inside them. The 2011 Enderby firefighter line-of-duty death is an example of the exposure fire and explosion hazard created by the containers, and the 2013 Saanich explosion related to propane storage is another indication of the pressure build-up explosion that can occur.

These shipping containers are commonly being used as permanent, long term and temporary buildings and structures at farm sites, construction sites, industrial sites, commercial sites and residential sites. Their uses are only limited by the imagination of the end users. Examples of common uses are offices, first aid buildings, electrical rooms, storage buildings for all sorts of hazardous and non-hazardous materials, and shops for various uses, including an example where containers were used to store and reload ammunition. Some local governments have tried to control the use and application of these containers but there is little control over their sales and installation, therefore fire department responders must recognize the possible hazards they can create and take appropriate tactical safety precautions during a response to a location where they are located.

Shipping containers are designed to be very durable and very secure. They are designed to be stacked one on top of each other on container ships or to withstand being dropped, hit or subject to the pitching, rolling or vibration of a ship. One of the major advantages of shipping containers is they are very secure, which also becomes an issue when they are involved in a fire. The structural strength, secure nature of the doors and lack of venting make the containers a quasi-pressure vessel, therefore they can build up high pressure before they explode. As a result, an explosion or rupture can blow out the doors and tear apart the container. The Enderby incident has been theorized to have been caused by as little as 0.5 to 1.5 litres of gasoline and approximately 0.5 litres of methyl hydrate. This small volume of hazardous material caused the container doors to be torn off the hinges and container to be torn along one of the top steel seams. Shipping containers exposed to external fires or internal fires can result in a rupture or explosion caused by non-regulated volume of flammable liquids, and can create safety issues to first responders.

Procedures:

1. Upon arriving at a site with one or more shipping containers, the first incoming company should try to determine whether the incident has been initiated by a fire in the shipping container or whether a fire will expose the shipping container.

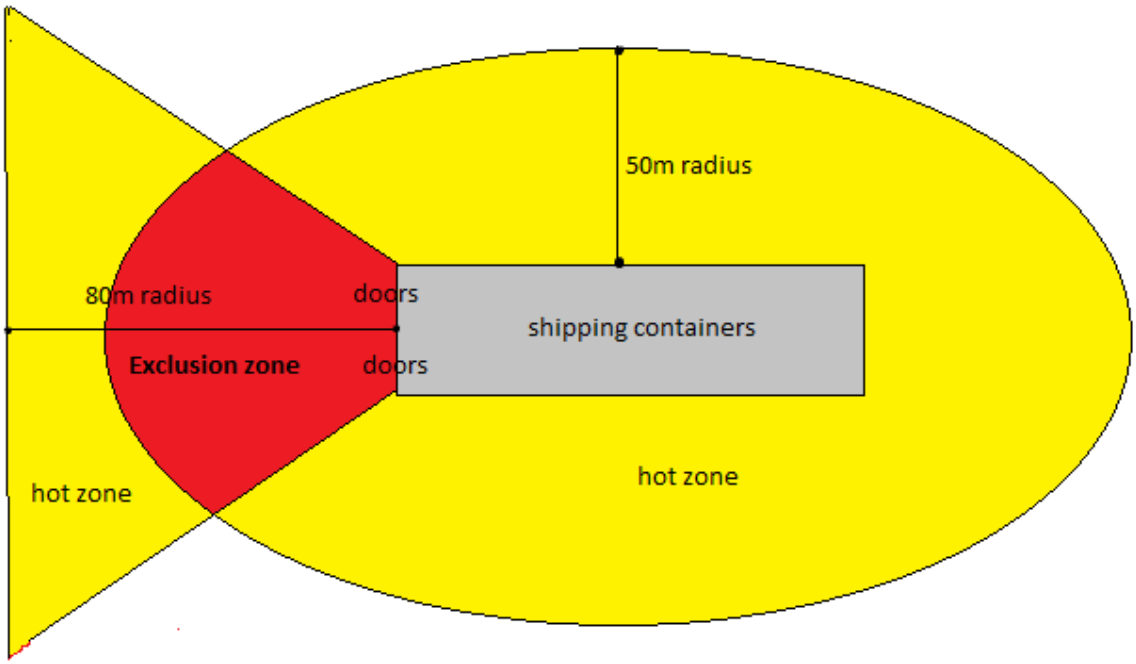
2. If the shipping container is exposed or involved in the incident, the company officer should maintain a 50-metre radius hot zone around the container and a 80-metre radius quadrant in front of the doors with limits of 45 degrees from the corners of the containers.

3. If the explosion has blown the roof off or the doors out, or has ruptured the container, then the hot zone can be reduced at the discretion of the senior officer.

4. A priority should be put on suppressing any fires that are adjacent to or against the shipping container while trying to keep out of the hot zone.

5. If the container must be approached in the hot zone, consider approaching the container at 45 degrees to the corners of the end opposite the doors.

6. To lessen the risk, unmanned oscillating ground monitor should be used.



7. Careful observations should be made of the involved container to determine the interior conditions of the container.

8. There may be UN placards or information in the prefire plan.

9. Information on the container contents may be available from the property owner of representative. Binoculars should be used to see if there are any of the following indications of internal heating within the container:

    - Smoke from the heating gaskets.
    - Smoke from the small atmospheric vents at the corners of the container.
    - Smoke from any larger vents that have been added to the container.
    - Indications of heat on the top or sides of the container, such as scorching or burn marks in the paint.
    - Any warping or bulging of the container.

    These observations may indicate there is a build-up of hot gases or flammable vapours that may lead to an explosive rupture.

10. Spray of water can be discharged onto the metal exterior to determine if there are any hot spots and their location.

The senior officer should then determine a fire attack plan based on any exposure fires, heating within the container and the criticality of the container risk within the fire ground. An aggressive attack may involve the insertion of a piercing lance through the container wall or through any large vents that have been added. A less aggressive attack would be to cool the roof and sides of the container down with a manned or unmanned hose line, until the container steel is no longer boiling off the water, and then access to the interior of the container.

Appendix B References

WorksafeBC (April 2012). "Firefighter killed in explosion involving flammable liquids." *Hazard Alert*.

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