ENERGY SAFETY CANADA

# FIRE AND EXPLOSION HAZARD MANAGEMENT

Toolbox Talk – Practical Applications (Part 2)

# WHAT SHOULD I KNOW ABOUT FIRES AND EXPLOSIONS

- One-size-fits-all solution does not exist
  - Oil and gas operations, their various workplaces, and a range of products both produced and used are much too diverse

- Site specific strategies for each particular operation and situation are required
  - Equipment, operations, substances and worker competency may be different each time

- Most significant risk factors are:
  - Competency
  - Not recognizing the risks and warning signs (complacency)
  - Normalizing the risk (we've always done it this way)

# FIRE TRIANGLE

» A fire requires three ingredients:

- Fuel source
- Oxygen source
- Ignition source

# PRESSURE AND AEROSOLS

- Pressure can make something that is non-flammable become flammable
- Pressure reduces the auto-ignition temperature and expands the upper explosive limit (UEL)
  - Auto-ignition temperature is when the fuel will ignite without an external ignition source
- Examples where pressure increases flammability:
  - Diesel fuel in your truck engine
  - Hydraulic fluid in a track hoe or pumping truck (e.g. 5,000 psi)
- Related to pressure is the creation of aerosols
  - Aerosols (mist) can be more flammable than the liquid they originate from
    - e.g. cleaning an oil spill with a pressure washer using water
- Could this exist in your work sites?

# VOLUME OF FLAMMABLE MATERIALS

- Larger volumes of flammable materials means more risk
- Vapours are generated from the surface of liquids
  - What implications could this have?
- In relation to the volume of condensate (Cat 2), what risk level would you assign when pouring into an open-top container?

| *Volume | Risk Level |
|---|---|
| Milliliters | ? |
| Liters | ? |
| Cubic meters | ? |

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| *Volume | Risk Level and Control Strategy |
|---|---|
| Milliliters | Medium - Engineering Controls |
| Liters | High - Containment |
| Cubic meters | Extreme - Expert Advice |

- See the Controlling Chemical Hazards Guideline for more information

*The following is provided as a comparative analysis of risk. Flammability risks should always be reduced to as low as reasonably possible.

# IS THIS RELEVANT FOR MY WORK SITE?

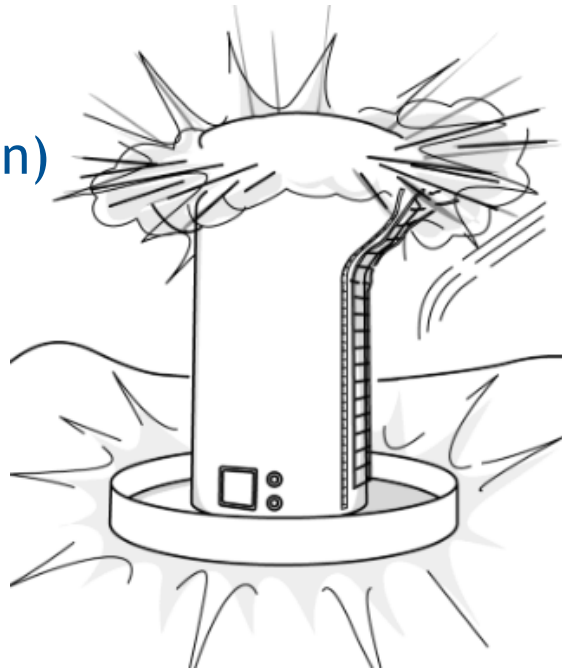
- Think about your work sites and the various tasks you conduct either routinely or infrequently (maintenance or upset)
- Where or when do you encounter uncontained larger volumes of flammable liquids?
- Ask yourself if you have normalized this risk?
- Investigate safer options to eliminate the presence of flammable atmospheres in your work environment

# COULD THE INSIDE OF A FULL LIQUID TANK BE FLAMMABLE?

» Generally, if sealed, the vapours in the headspace of the tank will be too rich for most flammable liquids

» However, there are some exceptions such as:
- Methanol (LEL 6.7% – UEL 36%)
  - For this fuel the headspace in the tank may often be inerted (such as with nitrogen)

» How could oxygen get inside a tank?
- What happens when you drain a tank?
- What happens when the tank contents are cooled?



https://www.worksafebc.com/en/resources/health-safety/hazard-alerts/

# STATIC ELECTRICITY

- Most gases and vapours of hydrocarbons require about 0.25 millijoules (mJ) of energy for ignition. 1,000 mJ light a 1-watt LED bulb for 1 second
  - Methane – 0.21 mJ
  - Methanol – 0.14 mJ
  - $H_2S$ – 0.068 mJ

- 20 mJ to 30 mJ is the typical spark from a human body
- Potential energy of static electricity on the human body is 10,000 volts to 15,000 volts
- There is enough energy on a balloon that has been rubbed on your hair to momentarily light a fluorescent light bulb!

NFPA 77

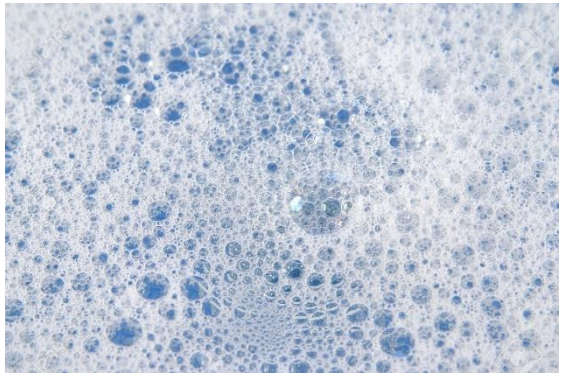
# MITIGATING THE RISK OF FIRE OR EXPLOSION

- If any one of these three elements is missing, fire cannot be created
- On the other hand, even if all elements of the triangle are present in the right amounts and in the vicinity of one another, it does not necessarily guarantee that a fire or explosion will occur
- By removing or minimizing any of the three elements of the fire triangle, you can minimize or eliminate the risk of a fire or explosion

# AGITATION AND LEL INHIBITION

» Agitating liquids, such as with a pressure washer, will increase vapour generation (e.g. tank cleaning)

» Surfactants can help reduce vapour generation
  - They create emulsions thereby reducing the concentration of the hydrocarbon liquids at the surface
  - This can result in reduced vapour generation



» Use surfactants that do not form suds (bubbles) such as dishwasher detergents
  - Verify compatibility with vessel and tank coatings, etc.
  - Verify they do not create other health and safety hazards (skin, eye irritation, etc.)

# BENEFITS OF NITROGEN GAS

» Nitrogen gas is inert and non-flammable, but can displace air and therefore its use represents a potential asphyxiation hazard

» Examples of where nitrogen may be used:

- To purge equipment of toxic atmospheres such as $H_2S$
- As a blanket of gas above liquids that have an elevated upper explosive limit (UEL) or for elevated $H_2S$ containing liquids
- As a blanket of gas to prevent oxygen from reaching substances that can spontaneously combust like iron sulphide

# BENEFITS OF NITROGEN GAS

- To prevent flammable atmospheres that cannot be easily managed by the worker through procedures or body positioning
  - These issues occur when workers cannot remove themselves from the atmosphere or when dilution is not effective
  - Such as working in close proximity to large vapour sources
  - Where might this exist in your work sites?

# PURGING WITH METHANE VS NITROGEN

- Equipment is often purged with methane, but when should nitrogen be considered in relation to flammability?
- The hazard with nitrogen is that it displaces air (atmosphere $O_2$ 21%)
- The hazard with methane is that it displaces air and is flammable (LEL 5%)
- What hazard will be reached first with methane - oxygen deficiency or flammability?
  - The answer is flammability
- There is greater than a seven times safety margin with purging with nitrogen compared to methane (7.5% verses 1% to reach unsafe criteria)*

*See notes at end of slides for additional details and calculations

# DO YOU KNOW WHAT THE RESIDUAL RISK IS?

- The risk with $O_2$ deficiency can be mitigated with self-contained breathing apparatus (SCBA)
- The risk with flammability can not be mitigated with SCBA!
- LEL data logging monitors
  - Download and investigate elevated levels (e.g.10% LEL and above)
- Do you measure LEL when wearing an SCBA for protection against $H_2S$?

Photo provided courtesy of Honeywell

# CONDUCTIVE VERSES NON-CONDUCTIVE MATERIALS

» Materials vary in their ability to conduct or transfer electricity

» Conductors transfer electricity well
  - Most metals are good conductors such as copper, iron, steel, etc.

» Insulators do not transfer electricity well
  - Wood, glass, ceramics and plastics
  - Static electricity can build up on insulting materials such as plastic piping, hoses and other equipment

» As a result, thoughtful selection of materials used in the design is required to avoid creating static ignition sources

# BONDING AND GROUNDING

- Bonding means establishing a connection between two pieces of equipment
  - Bonding equalizes an electrical potential
  - Hoses and pipes that are not made of conductive materials (metal) must be designed with a built-in wire to accumulate and transfer static charge that may build up

- Grounding means establishing a connection between one piece of equipment and the ground
  - Grounding removes any electrical potential

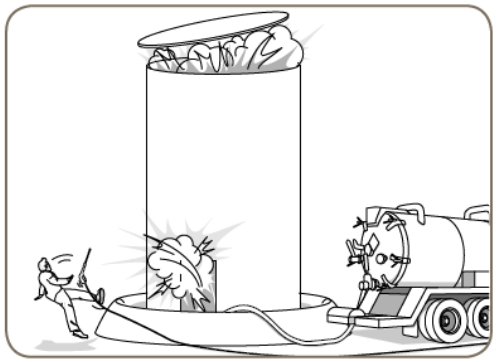
# BONDING AND GROUNDING

- Know when bonding and grounding are required
- Ensure attachment points are free from rust build-up and are not painted! This includes the clamp.
- Verify the quality of this control
  - Use an ohm (Ω) meter to measure if you have an adequate bond or ground
    - Ohms are a measure of electrical resistance
  - A good bond will exhibit low resistance such as less than 10 ohms*
  - Ensure that if measurement is occurring in a potentially hazardous location that an intrinsically safe meter is used or that the work is conducted under a hot work permit and associated controls
  - Include ohm measurement as part of your maintenance checks

*API Recommended Practice 2219, Section 5.4

# PRESSURIZED WATER AND STEAM WASHING

- The use of pressure washers and steam wands can generate significant static electricity
- It may surprise you that water can generate static electricity, but the movement of most products will generate static charge
  - Think about clouds and lightning!
- Manage this by ensuring the pressure washer is bonded to the production tank and that any attachments to the wands are made of conductive materials bonded to the pressure washer



https://www.worksafebc.com/en/resources/health-safety/hazard-alerts/hydrocarbon-storage-tank-explosions-static-electricity
https://commons.wikimedia.org/wiki/File:Lightning_Pritzerbe_01_(MK).jpg

# COMPONENTS OF A FIRE AND EXPLOSION HAZARD MANAGEMENT PLAN

1. Define the strategy and scope of operations and the roles and responsibilities of workers and supervisors

2. Assess fire and explosion hazards for your particular operations

3. Identify appropriate hazard controls and prepare fire and explosion prevention plans

4. Identify the training requirements for workers and supervisors

5. Implement fire and explosion prevention plans and monitor for effectiveness

# ADDITIONAL RESOURCES

- Fire and Explosion Management Toolbox Talk – The Basics (Part 1)
- Fire and Explosion Hazard Management Guideline
- Flame Resistant Workwear (FRW): A Program Development Guide
- Controlling Chemical Hazards (CCH)- A Program Development Guideline
- NFPA 77 Recommended Practice on Static Electricity
- HSE - Generation of Flammable Mists from High Flashpoint Fluids
- Drilling and Completions Committee (DACC) Industry recommended practices
  - IRP 4: Well Testing and Fluid Handling
  - IRP 8: Pumping of Flammable Fluids
  - IRP 14: Non-Water Based Drilling Fluids
- ESC Safety Bulletin
  - Positive Air Shutoff
- WorkSafeBC Alerts
  - Non-bonded fuel hoses
  - Pyrophoric materials
  - Hydrocarbon storage tank explosions and static electricity

# NOTES FOR SLIDE 14

- Unsafe criteria:
  - 19.5% $O_2$ (defined as oxygen deficient atmosphere)
  - 20% of the LEL (common regulator criteria, 10% or lower should be considered)
- Atmosphere is 21% $O_2$, a drop of 1.5% is required to reach 19.5% $O_2$
- Because air is only 21% $O_2$, 7.5% air will have to be displaced to reach an oxygen deficient atmosphere [1.5% X (100% Air/21% $O_2$) = 7.5%]
- Methane has a LEL of 5%
  - 20% of 5% is 1%
- There is greater than seven times a safety margin with purging with nitrogen compared to methane (7.5% verses 1% to reach unsafe criteria)