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LIQUID PETROLEUM PIPELINE EMERGENCIES On-Scene Incident Commander Field Guide

FINAL REPORT BY:

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FOREWORD

In the recent past there have been several pipeline and rail car incidents involving flammable liquids in municipalities in North America. These incidents often involve a complex interaction with municipal authorities, the fire service as the first responders, and industry personnel. Despite the extensive efforts of all parties to ensure that emergency responders are properly trained and equipped, there remain gaps in the application and use of risk-based response processes to manage these incidents. Likewise, there is no standardized template or reference point to provide emergency response agencies with emergency planning and response best practices; this challenge is shared by small and large departments alike.

NFPA 472: *Standard for Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incidents*, Chapter 8 provides requirements for competencies for incident commanders responsible for the on-scene management of hazardous materials emergencies and is the primary response industry standard. NFPA 472 is written from a broad perspective - establishing a framework that can be applied to a wide variety of incidents regardless of the hazardous material(s) that may be involved, but does not provide product specific guidance for individual products, such as the crude oil or refined petroleum products. The goal of this project is to develop a guidance document for incident commanders at flammable liquid pipeline incidents that addresses the competencies for incident commanders as outlined in Chapter 8 of NFPA 472. This document supports pre incident preparation by guiding the user to identify how a response organization agency can meet the Chapter 8 incident commander competencies, and generate a complete document that could serve as the foundation for an Incident Action Plan (IAP).

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Executive Summary:

This Guide provides tactical guidance and information for the On-Scene Incident Commander responsible for the management of pipeline emergencies involving flammable liquids, including crude oil and refined petroleum products. The application and use of a risk-based response (RBR) methodology for both planning and response purposes are critical success factors in the successful management of these pipeline incidents.

In order to safely and effectively employ risk-based processes at pipeline emergencies, emergency responders must initially be qualified at the First Responder – Operations and On-Scene Incident Commander levels, and have an understanding of the following:

- The physical properties (i.e., how it will behave) and chemical properties (i.e., how it will harm) of the materials involved.
- Basic design, construction and operations of liquid petroleum product pipelines, and their potential behavior in an emergency scenario.
- Knowledge of the strategic and tactical considerations to be evaluated at a hazardous materials incident.
- Selection, application and use of large-flow firefighting foam streams at pipeline emergencies involving Class B fuels.

Among the key factors that Incident Commanders operating at flammable liquid pipeline emergencies must know are the following:

- Flammable liquid pipeline incidents are often large, complex and lengthy response scenarios that will generate numerous response issues beyond those normally seen by most local-level response agencies. Although emergency response operations may be limited to less than 24 hours, post-response clean-up and recovery operations may continue for weeks.
- Unified command will be critical for the successful management of the incident.
- Proactive relationships and joint planning, training and exercises conducted prior to an incident between emergency responders, communities and pipeline operators have been beneficial in the safe and effective management of pipeline emergencies.
- Analysis of past pipeline incidents has shown that communication in the first critical minutes of the incident – between emergency responders and pipeline operators – is critical to determining the outcome of the incident. Incomplete, inadequate or unclear communications can result in a delayed response and can contribute to increased levels of product loss and damage.
- Flammable and combustible liquids are the most common products transported by liquid transmission pipelines. These include refined products such as gasoline, aviation gas and jet fuel, and distillates, such as home heating and diesel fuels. Intermediate products (i.e., not completely refined), such as naphtha or gas oil, may also be shipped by pipeline between refineries for final processing.
- Liquid petroleum pipeline systems can transport different grades or types of petroleum products through the same pipeline at different times in “batches” or through a “batch system.”
- Pipeline flows and conditions are monitored through computerized pipeline monitoring systems at the Pipeline Control Center (PCC). These include SCADA (Supervisory Control

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- and Data Acquisition System) and volume balance systems, and monitor the status of gates and valves, product flow, pressures, and other operating characteristics. These monitoring systems provide pipeline personnel with the ability to monitor pipeline operations and initiate emergency shutdown procedures in the event of a pipeline release.
- Emergency responders should know the following about pipelines:
 - The location of pipelines in your response area and potential high risk areas.
 - The name of the pipeline operator and how to contact them.
 - Product(s) being transported by the pipeline.
 - Shut-off valve locations. This can help emergency responders to determine how quickly the release can be stopped. **CAUTION:** Emergency responders should NEVER attempt to isolate any pipeline valves on transmission pipelines unless under the direction of pipeline operations personnel.
 - The worst-case discharge / scenario.
 - Depending upon the pipeline, the Pipeline Control Center can remotely control the pipeline flow and actuate remote pipeline valves in the event of a pipeline release.
 - Even with actions taken by the PCC to isolate the pipeline flow, depending upon the spacing between shutoff valves a significant backflow of product may continue from the pipeline breach.
 - When dealing with transmission pipelines, the backflow may continue for a period of several hours. Critical variables will include the location of the pipeline release, surrounding topography, and the proximity of both automatic and manually activated valves and pump stations to the incident location.
 - The Incident Commander must verify through pipeline industry Technical Specialists that the closest automatic and manually operated valves are isolated
 - While the exact incident timeline will vary based upon local / regional resources and response times, key incident management benchmarks within hour 1 will include:
 - Conducting an incident size-up, identification of critical incident factors, and development of initial incident objectives.
 - Establishment of command and an Incident Command Post (ICP)
 - Establishment of a unified command organization.
 - When contacting the pipeline operator, provide the following information:
 - Your name, location, organization name and telephone number
 - Location of the incident
 - Presence of smoke, fire or spill
 - Extent of damage
 - Topography
 - Weather conditions
 - Structural firefighting clothing (SFC) and positive-pressure SCBA should be the initial level of PPE selected. For scenarios that have a low probability of fire, such as spill control and clean-up activities including decontamination, chemical splash protective clothing and a compatible NIOSH-approved respirator may be required depending upon the concentrations and properties of the contaminant.
 - Spill Control Priorities – If product is being released from a liquid petroleum pipeline:
 - #1 - Keep it confined to a specific land area if safely possible.
 - #2 - Keep the product out of the water.
 - #3 - If the product is in the water, protect downstream water intakes and sensitive areas.
 - Class B foam agents are the recommended extinguishing agents for flammable liquid fires. These can include aqueous film-forming foams (AFFF) for use on hydrocarbons (e.g., crude

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oil, refined products) and alcohol-resistant AFFF concentrates for use on both hydrocarbons and polar solvents (e.g., ethanol).

LIQUID PETROLEUM PIPELINE EMERGENCIES

On-Scene Incident Commander Field Guide

I. BACKGROUND

Scope. This document provides tactical guidance and information for the On-Scene Incident Commander responsible for the management of liquid petroleum pipeline emergencies.

Purpose. The purpose of this document is to provide individuals currently trained and certified as Hazardous Materials On-Scene Incident Commanders with the requisite knowledge and information to safely and effectively manage an emergency involving a liquid petroleum pipeline.

Incident Commander pre-requisites and qualifications for liquid petroleum pipeline scenarios should include the following:

- NFPA 472, Chapter 8 – Incident Commander or NFPA 1072, Chapter 8 – Incident Commander
- ICS-300 – Intermediate ICS for Expanding Incidents or equivalent
- Knowledge on the selection, application and use of Class B extinguishing agents for large flammable liquid fire scenarios.

Background. A review of historical pipeline incidents provides the following observations:

- Oil and hazardous liquid pipelines account for approximately 190,000 miles of the 2.6 million miles of pipelines in the United States. Although most pipelines are buried, above-ground pipelines and related facilities can be found in cold weather environments (e.g., Trans Alaska Pipeline), and at pump stations, valve stations, river crossings, bridges, and plant and terminal facilities.
 - Crude oil and refined petroleum products volumes are measured in terms of barrels rather than gallons. One barrel is equal to 42 gallons.
- Proactive relationships and joint planning, training and exercises conducted prior to an incident between emergency responders, communities and pipeline operators have been beneficial in the safe and effective management of pipeline emergencies.
- Analysis of past pipeline incidents has shown that communication in the first critical minutes of the incident – between emergency responders and pipeline operators – is critical to determining the outcome of the incident. Incomplete, inadequate or unclear communications can result in a delayed response and can contribute to increased levels of product loss and damage.
- Understanding and using common and consistent terminology when reporting a pipeline emergency to Public Safety Answering Points (PSAP) and pipeline control centers is critical to ensuring the right initial actions are taken when an incident occurs.
- Liquid petroleum transmission pipeline incidents are low frequency, high consequence response scenarios. Critical response considerations will include the location of the incident, the overall size and scope of the problem, the potential for rapid growth of the fire and spill problem, and the level of resources initially available.
- Scenarios involving liquid petroleum transmission pipelines can be large, complex response incidents that will generate numerous response issues beyond those normally seen by most local-level response agencies. In addition to the inherent spill and fire control problems, response issues can include public protective actions, logistics and resource

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management, situational awareness, information management, public affairs, and infrastructure restoration.

- Early establishment of a unified command structure between emergency responders and the pipeline operator and expanding the ICS organization to include command and general staff positions will be critical in both recognizing and managing the response issues previously noted.
- While emergency response operations are often conducted within 24 hours or less, post-emergency response operations (i.e., clean-up and recovery) can extend over a period of several days and potentially weeks.

The application and use of a risk-based response (RBR) methodology for both planning and response purposes is a critical success factor in the successful management of a pipeline incident. RBR is defined by *NFPA 472 – Standard for the Competence of Responders to HM/WMD Incidents* as a systematic process by which responders analyze a problem involving hazardous materials, assess the hazards, evaluate the potential consequences, and determine appropriate response actions based upon facts, science, and the circumstances of the incident. Knowledge of the behavior of both the container involved and its contents are critical elements in determining whether responders should and can intervene.

This document is organized into the following sections:

- Section 1 - Background
- Section 2 – Liquid Petroleum Product Information
 - Petroleum Crude Oil
 - Refined Petroleum Products
- Section 3 – Liquid Petroleum Pipeline Design, Construction and Operations
- Section 4 - Understanding Pipeline and Product Behavior
- Section 5 - Incident Management Considerations
- Section 6 - Tactical Considerations – First Operational Period
 - Incident Management Principles
 - Problem Identification
 - Hazard Assessment and Risk Evaluation
 - Select Personal Protective Clothing and Equipment
 - Logistics and Resource Management
 - Implement Response Objectives
 - Clean-Up and Post-Emergency Response Operations
- Section 7 - Tactical Considerations – Spill and Fire Control
 - Operational Modes
 - Spill Control Operations
 - Fire Control Operations
 - Crude Oil Firefighting
- Section 8 - Terms and Definitions
- Section 9 – Reference Sources

II. LIQUID PETROLEUM PRODUCT INFORMATION

A. Understanding Petroleum Crude Oils

- The word “oil” in the product crude oil can incorrectly imply that this product has a high flash point liquid (like motor oil) and therefore presents a low risk of ignition. This is NOT accurate – crude oil is a Hazard Class 3 flammable liquid and can present a significant risk of ignition, especially on a warm day.
- When removed from the ground, crude oil is often a mixture of oil, gas, water and impurities (e.g., sulfur).
 - The viscosity of the crude oil and its composition will vary based upon the oil reservoir from which it is drawn, well site processing, and residence time in storage tanks.
 - When transferred into a storage tank, the liquid is often a mixture of crude oil and related constituents drawn from various locations and even different producing formations.
- Emergency responders must have a basic understanding of the physical properties (i.e., how it will behave) and chemical properties (i.e., how it will harm) of the materials involved. Key considerations should include (a) whether the crude oil is a light or heavy crude oil (in terms of viscosity), and (b) if the crude is a sweet or sour crude oil. **Table 1** (see pages 5 - 6) provides an overview of the common types of crude oils currently being encountered.
- The viscosity of petroleum liquids is often expressed in terms of American Petroleum Institute or API gravity, which is a measure of how heavy or how light a petroleum liquid is as compared to water.
 - Water has an API gravity of 10: if the gravity is greater than 10 the petroleum product is lighter and will float on water; if less than 10 it is heavier and will sink.
 - Crude oils are classified by the petroleum industry into the following general categories based upon their API gravity:

<u>Viscosity</u>	<u>API Gravity</u>
Light	> 31°
Medium	22 to 31°
Heavy	< 22°
Extra Heavy	< 10°

- Sour crude oil is a crude oil containing a large amount of sulfur (greater than 0.5% or 5,000 ppm hydrogen sulfide concentrations) and may pose a toxic inhalation hazard (Threshold Limit Value – Time Weighted Average (TLV/TWA) of 1 ppm and Immediately Dangerous to Life and Health (IDLH) exposure value of 100 ppm). Hydrogen sulfide levels can be an issue in a spill scenario.
- Shale crude oils tend to be a light sweet crude oil with a low viscosity, low flashpoint, and low benzene content. Shale crudes may also have the possibility of producing significant amount of C₆ - hexane in some locations.

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- Oil sands crude oils (e.g., Alberta Tar Sands, bitumen) tend to be a heavier crude oil with an API gravity of approximately 8°. Canadian tar sand crudes also tend to be sour unless they have been partially refined before being transported
 - Bitumen is a tar-like material that is extracted from tar sands. It is highly viscous and must be heated to make it flow. The majority of bitumen being extracted in North America originates in Alberta, Canada.
 - In order to thin bitumen enough to make it pumpable for transport, a diluent is usually added to decrease the viscosity and density of the crude oil. The most commonly used diluent is natural gas condensate (liquid byproduct of natural gas processing). Typically these mixtures are 70% bitumen and 30% diluent, resulting in a API gravity of less than 22°.
 - Bitumen that is partially refined is known as syncrude. The refining process generates a liquid material that is similar to a medium-weight sweet crude oil.
 - At a 2010 pipeline incident in Michigan involving bitumen, responders reported the presence of floating oil, submerged oil, and sunken oil. Incident experience has noted that the behavior of bitumen oils in water will ultimately depend upon the density of the oil, weathering, and the turbulence of the water.

Table 1 outlines the physical and chemical properties of crude oil and related products that may be transported via liquid petroleum pipelines.

Table 1: Physical and chemical properties of crude oil and related products that may be transported via liquid petroleum pipelines.

TABLE 1	LIGHT SWEET CRUDE OIL	DILBIT/SYNBIT (BITUMEN WITH DILUENT*)	BITUMEN (OIL SANDS)	DILUENT
TRANSPORTED AS HAZMAT	Yes - DOT Class 3, UN1267 (ERG Guide No. 128)	Yes - DOT Class 3, UN1267 (ERG Guide No. 128)	Maybe - DOT Class 9, UN3257 (ERG Guide No. 128) If shipped above 212 °F and below its flash point	Yes - DOT Class 3, UN1268 or UN 3295 (ERG Guide No. 128)
FLASH POINT	Varies: -30° F - 104° F	Range: 0.4° F (dilbit) - 68° F (synbit)	330° F	<-30° to -4F° F
BOILING POINT	Varies: PGI = <95° F, PGII = >95° F	95° F - >500° F	554° F	100 - 118°F
REID VAPOR PRESSURE	8 - 14 psi	11 psi	4 psi	8 - 14 psi
VISCOSITY** IN CENTIPOISE (CPS) @ ~75 °F:	6-8 (Low - Flowable)	60-70 (Low - Flowable)	100,000-1,000,000 (very high - semi solid when cold)	6-8 (Low - Flowable)
API GRAVITY	Bakken 40° - 43°	Will vary based on amount of diluent; approximately 20°	Approximately 8°	
SPECIFIC GRAVITY	0.80 - 0.8 (Floats on water)	0.90-0.98 Initially (Floats then sinks as light ends volatilize)	0.95 - 1.05 (Will sink in Salt Water; Likely to sink in Fresh Water)	0.480-0.75 (Floats on water)
VAPOR DENSITY	1.0 - 3.9 (Heavier than Air)	>1 (Heavier than Air)	>1 (Heavier than Air)	1.0 - 3.9 (Heavier than Air)
HYDROGEN SULFIDE	0.00001% (potential to accumulate as H ₂ S in head space of vessels) If H ₂ S concentrations ≥ 0.5% or 5,000 ppm classified as Sour Crude DOT Class 3, UN3494 (ERG Guide No. 131)	<0.1% (potential to accumulate as H ₂ S in head space of vessels)	Negligible (contains bonded sulfur, generally not available as H ₂ S)	<0.5

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TABLE 1 (continued)	LIGHT SWEET CRUDE OIL	DILBIT/SYNBIT (BITUMEN WITH DILUENT*)	BITUMEN (OIL SANDS)	DILUENT
BENZENE	Generally <1.0%	0% - 5%	Negligible (Monitor, however it should not be a concern)	0% - 5%
EVAPORATION RATE (TEMPERATURE DEPENDENT)	>1 (High Evaporation Rate)	Diluent will evaporate quickly, Bitumen will not evaporate	None	>1 (High Evaporation Rate)
SOLUBILITY	Low to Moderate	Moderate	Extremely Low	Slightly Soluble
WEATHERING	Quickly	Diluent weathers fairly quickly, will then form Tar Balls	Very Slow - Like Asphalt	Quickly
RESIDUES	Films and Penetrates	Films and Penetrates - residue is very persistent	Heavy Surface contamination - very Persistent	Films and Penetrates
AIR MONITORING	LEL (combustible gas indicator), Benzene (direct read or tubes), H₂S (direct read or tubes)	LEL (combustible gas indicator), Benzene (direct read or tubes), H₂S (direct read or tubes)	LEL (combustible gas indicator), Benzene (direct read or tubes), H₂S (direct read or tubes)	LEL (combustible gas indicator), Benzene (direct read or tubes), H₂S (direct read or tubes)
RECOMMENDED PPE	<u>Clothing:</u> Structural FF Clothing / Fire Retardant Clothing (subject to task and air monitoring) <u>Respiratory Protection:</u> SCBA/APR/Nothing (subject to Task & benzene, H ₂ S & particulate concentrations)	<u>Clothing:</u> Structural FF Clothing / Fire Retardant Clothing (subject to task and air monitoring) <u>Respiratory Protection:</u> SCBA/APR/Nothing (subject to Task & benzene, H ₂ S & particulate concentrations)	<u>Clothing:</u> Thermal Protection (if hot) / Fire Retardant Clothing (subject to task and air monitoring) <u>Respiratory Protection:</u> SCBA/APR/Nothing (subject to Task & benzene, H ₂ S & particulate concentrations)	<u>Clothing:</u> Structural FF Clothing / Fire Retardant Clothing (subject to task and air monitoring) <u>Respiratory Protection:</u> SCBA/APR/Nothing (subject to Task & benzene, H ₂ S & particulate concentrations)
COMMUNITY, WORKER & RESPONDER SAFETY	Flammability, Benzene, LEL, H ₂ S	Flammability, Benzene, LEL, H ₂ S, PAH's (poly-aromatic hydrocarbons)	H ₂ S, PAH's (poly-aromatic hydrocarbons)	Flammability, Benzene, LEL, H ₂ S

B. Refined Petroleum Products

- Flammable and combustible liquids are the most common products transported by liquid transmission pipelines. These include refined products such as gasoline, aviation gas and jet fuel, and distillates, such as home heating and diesel fuels (see below). Intermediate products (i.e., not completely refined), such as naphtha or gas oil, may also be shipped by pipeline between refineries for final processing.
- Common refined petroleum products include the following:
 - *Gasoline* is a volatile flammable liquid that is refined from crude oil. Is the most widely recognized refined petroleum product and is universally used as a motor fuel for internal combustion, spark-ignition engines.

Refined gasoline should not be confused with natural gasoline or casinghead gasoline, which is the liquid hydrocarbon that is recovered from “wet” natural gas production. Casinghead gasoline may be encountered in production facilities and operations, and may be transported in some crude or refined products pipelines.

Automotive gasoline is commonly classified as regular or premium grades according to how smoothly it burns in an engine. When transported within a liquid pipeline, gasoline will be typically shipped in one of several “generic” grades. Once this “generic” grade of gasoline arrives at marketing or distribution terminals, various dyes and additives are then added when the product is loaded onto cargo tank trucks before it is ultimately delivered to the consumer. From an emergency response viewpoint, however, all gasoline is pretty much the same once it is released from a pipeline.

To meet governmental environmental requirements, oxygenated compounds are added to gasoline to reduce the amount of carbon dioxide and other emissions that are given off as a result of the combustion process. The most common additive used today is ethyl alcohol (i.e., ethanol). With few exceptions, ethanol is not commonly shipped via pipeline and is ultimately added to gasoline at the cargo tank truck loading rack.

- *Aviation Gasoline (or Avgas)* is a gasoline fuel for reciprocating piston engine aircraft and should not be confused with jet fuel. Avgas is very volatile and is extremely flammable at normal temperatures. Avgas grades are defined primarily by their octane rating. Two octane ratings are applied to aviation gasolines - the lean mixture rating and the rich mixture rating. For example, Avgas 100/130 has a lean mixture performance rating of 100 and a rich mixture rating of 130.
- *Distillate Fuel Oils* include both diesel fuel and fuel oil. Diesel fuel is a light hydrocarbon mixture for diesel engines, similar to furnace fuel oil, but with a slightly lower boiling point. Refined fuel oil comes in two grades. No. 1 distillate, such as kerosene, is a light fuel. No. 2 fuel oil is a distillate fuel oil prepared for use as a fuel for atomizing-type burners or for smaller industrial burner units.

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- *Jet Fuel* is a highly refined kerosene petroleum distillate. There are two main grades of jet fuel used in commercial aviation – Jet A and Jet A-1. Both are kerosene distillates. Jet A is found in the United States and has a flash point above 100°F (38°C), Jet A-1 is a similar kerosene fuel that is used for civil commercial aviation internationally. Another type of jet fuel, Jet B, is a blend of kerosene and gasoline, and may be found in extremely cold climates where cold weather performance is critical (e.g., Canada).
- Military aviation fuels may include JP-4, JP-5 and JP-8. JP-4 is the military equivalent of Jet B, and is no longer in wide use. JP-5 is a high flash point kerosene blend. The most common military fuel today is JP-8, which is the military equivalent of Jet A-1.

Table 2: Physical and Chemical Properties of Common Refined Liquid Petroleum Products

PRODUCT	FLASH POINT	BOILING POINT	FLAMMABLE RANGE	SPECIFIC GRAVITY	VAPOR DENSITY	VAPOR PRESSURE
Gasoline	-45°F (-42°C)	105°F (41°C)	1.4 – 7.6%	0.8	3 - 4	190 mm/Hg
Aviation Gasoline	-46°F (-51°C)	140 - 338°F (60- 170°C)	1.2 – 7%	0.65 - 0.75	3 - 4	285 – 367 mm/Hg
Kerosene	100- 162°F (38-72°C)	175- 617°F (79- 325°C)	0.7 – 5%	0.8	5.5	.23 - 2 mm/Hg
#2 Fuel Oil (Diesel Fuel)	140°F (60°C)	325°F (163°C)	0.6 – 7.5%	.85	7	1 – 2 mm Hg
Jet A Fuel (JP-8)	140°F (60°C)	291°F (144°C)	0.6 – 4.6%	0.775	6.0	52 mm Hg

III. LIQUID PETROLEUM PIPELINE DESIGN, CONSTRUCTION AND OPERATIONS

- Liquid petroleum pipeline systems are based upon the following basic operating principles:
 1. *A liquid material is inserted into a pipe.* Common liquid petroleum products include crude oil and refined petroleum products (e.g., gasoline, jet fuels, diesel fuel, home heating oils).
 2. *The liquid product is moved from its point-of-origin to a pre-specified destination.* The product is physically moved as a result of gravity, through the use of pumps, or a combination of both. In addition, various valves and manifolds are used to control and direct the flow of the product.
 3. *The liquid product is ultimately removed from the pipeline at its destination point.* At this point, the liquid product may be placed into an aboveground storage tank, transferred to another mode of transportation (e.g., marine, rail, highway), or used.
- Liquid petroleum pipelines can vary in size from relatively small 8- to 12-inch-diameter pipelines up to 42-inch transmission pipelines. They include the following:
 - *Gathering Lines.* Small pipelines, usually 2 to 8-inches in diameter, that move natural gas or crude oil mixtures from individual wellheads and production locations to a central processing facility (often referred to as a Gathering Center or Flow Station) where the oil, gas and water are separated and processed.
 - *Trunk Lines.* Large crude oil pipelines, usually 8 to 24-inches in diameter that move crude oil from gathering centers, oil production areas and ports throughout North America to refineries.
 - *Liquid Transmission Pipelines.* Large diameter pipelines (up to 42-inches) used to move refined liquid petroleum products from refineries to marketing and distribution terminals, where the products are then loaded onto cargo tank trucks for ultimate delivery to the consumer. Pumping stations are used to boost pressures and maintain constant flows on transmission lines.
- Liquid petroleum pipeline systems can transport different grades or types of petroleum products through the same pipeline at different times in “batches” or through a “batch system.”
 - There is normally no physical separator (e.g., sphere or pig) between different products; the products are allowed to “co-mingle.”
 - The comingle interface (also known as transmix) can range from a few barrels to several hundred barrels, depending on the pipeline size and the products involved.
 - The batch shipment is verified at the destination site by examining a sample of the incoming batch for color, appearance, and/or chemical characteristics. The comingled transmix liquids may then be subject to additional treatment or may be mixed with one of the adjacent products in the pipeline.
- Pipeline flows and conditions are monitored through computerized pipeline monitoring systems at the Pipeline Control Center (PCC). These include SCADA (Supervisory Control and Data Acquisition System) and volume balance systems, and monitor the status of gates and valves, product flow, pressures, and other operating characteristics. These monitoring systems provide pipeline personnel with the ability to monitor pipeline operations and initiate emergency shutdown procedures in the event of a pipeline release.

IV. UNDERSTANDING PIPELINE AND PRODUCT BEHAVIOR

- Emergency responders should know the following about pipelines:
 - The location of pipelines in your response area and potential high risk areas. The National Pipeline Mapping System (<https://npms.phmsa.dot.gov>) is an excellent planning tool for learning about transmission pipelines in a given area or jurisdiction.
 - The name of the pipeline operator and how to contact them.
 - Product(s) being transported by the pipeline.
 - Shut-off valve locations. This can help emergency responders to determine how quickly the release can be stopped. **CAUTION:** Emergency responders should NEVER attempt to isolate any pipeline valves on transmission pipelines unless under the direction of pipeline operations personnel.
 - The worst-case discharge / scenario.
- Initial response to a pipeline release may be for a report of an unknown spill or odor in an area. Responders should be alert for the basic clues that may indicate a liquid pipeline release, including:
 - What You See
 - Dead or discolored vegetation that is otherwise green along a pipeline right-of-way.
 - Colorful sheens, stains or pools of hydrocarbon appearing on flat surfaces.
 - Colorful sheens appearing on water.
 - Pools of liquid not otherwise usually present along the pipeline right-of-way.
 - Presence of a vapor cloud or mist around the pipeline right-of-way.
 - Dirt being blown into the air.
 - Fire coming out of the ground
 - Presence of construction or excavation equipment in the area, such as backhoes, farming equipment, drilling rigs, telecommunications vehicles, etc.
 - What You Smell
 - All refined products and distillate fuels have a distinctive odor when released.
 - What You Hear
 - Unusual hissing or roaring sound along a pipeline right-of-way.
- Street smart tips for dealing with a suspected liquid petroleum pipeline incident include:
 - Crude oil gathering pipelines may transport sour crude oils with high concentrations of hydrogen sulfide. Remember – H₂S can kill in low concentrations. The TLV/TWA is 1 ppm and the IDLH is 100 ppm.
 - Gasoline is highly flammable and is easily ignited when released into air. When you are at 10% of the Lower Explosive Limit, the atmospheric concentration of gasoline vapors in air is 1,400 ppm. This is above the Threshold Limit Value / Time Weighted Average (TLV/TWA) for toxicity, and should be regarded as an unsafe environment. In addition, the TLV/TWA for benzene is only 1 ppm. Emergency responders must initially use self-contained breathing apparatus (SCBA) until air monitoring results permit the level of respiratory protection to be downgraded.
 - Distillates, such as diesel fuel and jet fuel, are combustible liquids and produce less vapors than gasoline.
 - All refined petroleum products have vapors that are heavier than air and a specific gravity less than 1.0. Vapors will collect in low areas, while spills will float on the

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- surface of water. Spills and vapors may migrate long distances through drain tiles, sewers or other conduits.
- All liquid petroleum products have increased volatility when released under pressure as an aerosol. In addition, warm weather can increase the volatility of all refined petroleum products.
 - Diesel and jet fuel vapors are not easily detected with a combustible gas indicator (CGI) due to their low vapor pressure.
- Depending upon the pipeline, the Pipeline Control Center can remotely control the pipeline flow and actuate remote pipeline valves in the event of a pipeline release.
 - Even with actions taken by the PCC to isolate the pipeline flow, depending upon the spacing between shutoff valves a significant backflow of product may continue from the pipeline breach.
 - When dealing with transmission pipelines, the backflow may continue for a period of several hours. Critical variables will include the location of the pipeline release, surrounding topography, and the proximity of both automatic and manually activated valves and pump stations to the incident location.
 - The Incident Commander must verify through pipeline industry Technical Specialists that the closest automatic and manually operated valves are isolated

V. INCIDENT MANAGEMENT CONSIDERATIONS

- Lessons learned from previous incidents shows that communities that engage in pre-incident planning, training and exercise activities with the pipeline operator and response partners establish a foundation for a safe and effective response. The importance of establishing relationships between all of the key players before the incident cannot be over-emphasized. See API 1174 – *Recommended Practice for Onshore Hazardous Liquid Pipeline Emergency Preparedness and Response* for pipeline industry practices.
- Incidents involving petroleum liquid transmission pipelines are large, complex and lengthy response scenarios that will generate numerous response issues beyond those normally seen by most local-level response agencies.
 - In addition to the hazmat issues associated with the response problem, there will be a number of other secondary response issues that will require attention by Incident Command / Unified Command.
 - These will include public protective actions, logistics and resource management, situational awareness, information management, public affairs, and infrastructure restoration.
- While the exact incident timeline will vary based upon local / regional resources and response times, key incident management benchmarks within hour 1 will include:
 - Conducting an incident size-up, identification of critical incident factors, and development of initial incident objectives.
 - Establishment of command and an Incident Command Post (ICP)
 - Establishment of a unified command organization. Unified command at this initial phase of an incident will be local-centric and focus upon the integration of fire / rescue, law enforcement and EMS resources.
- Expanding the ICS organization early to include command and general staff positions will be critical in managing the size and complexity of the incident. All-Hazard Incident Management Teams (AHIMT's) at the regional, state and federal levels can serve as an excellent resource to support unified command activities.
- Unified command will be critical for the successful management of the incident. The make-up of unified command during the early stages of the incident will likely change as the incident timeline advances, state and federal agencies arrive on-scene, and incident objectives change.
 - Initial unified command will primarily consist of local response agencies that routinely work together at the local level (e.g., fire, LE, EMS with an initial pipeline representative).
 - As the incident expands and other agencies arrive on-scene, unified command will evolve to the organizational structure outlined in the National Response Framework or Canadian equivalent for oil and hazardous materials scenarios (i.e., Emergency Support Function (ESF- 10)).
 - Under ESF-10, unified command will likely consist of the following:
 - Local On-Scene Coordinator (most likely the Fire Department during emergency response operations)
 - State On-Scene Coordinator (usually designated state environmental agency)

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- Federal On-Scene Coordinator (U.S. Environmental Protection Agency (EPA) or U.S. Coast Guard (USCG), based upon the location of the incident and its proximity to navigable waterways.
- Responsible Party or RP (e.g., Senior Pipeline Official).
- For incidents on tribal lands of Federally recognized Indian tribes, a representative from the Indian tribe should be invited to participate.
- Other local, state, federal and non-governmental organizations will work through their respective On-Scene Coordinator or the Liaison Officer to bring their issues to the table.

VI. TACTICAL CONSIDERATIONS – FIRST OPERATIONAL PERIOD

A. Incident Management Principles

- Initial site management and control will be a key benchmark in managing the problem.
 - Isolate and secure the area
 - Avoid committing or positioning personnel and units in a hazardous position. Consider escape routes out of the area if conditions suddenly deteriorate.
 - Establish an Incident Command Post (ICP)
 - Establish an isolation perimeter, access control, and inner perimeter / hot zone
 - Establish a Staging Area
- Follow initial guidance provided by the Emergency Response Guidebook (ERG). The following ERG guides pages would be pertinent:
 - Gasoline (UN 1203)– Guide Page 128
 - Diesel Fuel / Fuel Oil (UN 1202 or 1993) – Guide Page 128
 - Petroleum Crude Oil (UN 1267) – Guide Page 128
 - Petroleum Sour Crude Oil (UN 3494) - Guide Page 131
- The National Incident Management System (NIMS) should be the framework for managing incident operations. Unified command should be established that integrates those agencies and organizations with legal and jurisdictional responsibility.
- The basic approach for managing pipeline incidents is not much different than other hazmat response scenarios – do not under-estimate the need or the value of basic HazMat-101 skills. Knowledge of the product, the pipeline, incident location and exposures will be critical in evaluating response options using a risk-based response process.

B. Problem Identification

- Identify, confirm and verify the product(s) involved and the extent of the problem. This can be done through pre-incident plans, pipeline markers, detection and monitoring, and senses (i.e., physical observations, smell, etc.).
 - Pipeline markers are required where the pipeline crosses over or under roads, waterways and railroads. They may also be found at other locations, such as near buildings and structures. Although the format and design may vary, all pipeline markers are required to provide the pipeline contents, the pipeline operator, and an emergency telephone number.
- Notify the pipeline operator's emergency telephone number. This will normally connect responders to the Pipeline Control Center, which is the central communications and operations center for the pipeline operator. The PCC is typically remote from the physical location of the pipeline.
- When contacting the pipeline operator, provide the following information:
 - Your name, location, organization name and telephone number
 - Location of the incident

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- Presence of smoke, fire or spill
 - Extent of damage
 - Topography
 - Weather conditions
 - If digital pictures can be safely taken, do so and send to the Pipeline Control Center as soon as possible
- Be aware of the potential impacts a pipeline incident may have on surrounding infrastructure. For example, transportation corridors may run adjacent to or be crossed by the pipeline right-of-way. In addition, other liquid and gas pipelines and utilities (i.e., communication, fiber optics, water and sewer) may run within or be crossed by the pipeline right-of-way.

C. Hazard Assessment and Risk Evaluation

NOTE: *The level and sophistication of the risk evaluation process may vary based upon the level of hazardous materials response resources on-scene. For example, when available Hazardous Materials Response Team (HMRT) personnel, Hazardous Materials Technicians or Technical Specialists (i.e., pipeline or product specialists) can collect and interpret the pertinent hazard and response information, and then provide options and recommendations to the Incident Commander.*

- Risk-based Response - systematic process by which responders analyze a problem involving hazardous materials, assess the hazards, evaluate the potential consequences, and determine appropriate response actions based upon facts, science, and the circumstances of the incident. Knowledge of the behavior of both the container involved and its contents are critical elements in determining whether responders should and can intervene.
- Sources of hazard and response information that may be utilized to support pipeline response operations include the following:
 - *Hazardous Materials Guidebooks and Databases* – common references include the Emergency Response Guidebook, NIOSH Pocket Guide to Chemical Hazards, and the Wireless Information System for Emergency Responders (WISER).
 - *Detection and Monitoring equipment* – Equipment will vary based upon spill vs. fire scenarios, and the incident timeline. For example, emergency responders will primarily upon combustible gas indicators (CGI) used in combination with a three to five gas meter, and photo-ionization detectors (PID's) during initial response operations. During clean-up and recovery operations, more sensitive monitoring instruments will be used (i.e., flame ionization detector [FID], gas chromatograph mass spectrometer [GC/MS]).

Spill Scenario Risks

Flammability Levels (LEL/UEL)
Volatile Organic Compounds (VOC)
Hydrogen Sulfide
Benzene

Fire Scenario Risks

Carbon Monoxide
Flammability Levels (LEL/UEL)
Hydrogen Sulfide
Benzene
Volatile Organic Compounds (VOC)
Sulfur and Nitrogen Sulfides
Particulates (Smoke)

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- *Pipeline Emergency Response Guidance* – Emergency response guidance and support materials provided by the pipeline operator.
 - *Technical Information Centers*. This would include the Pipeline Control Center for the respective pipeline operator.
 - The National Response Center (NRC – 1-800-424-8802) is the federal government’s central reporting point for all oil, chemical, radiological, biological and etiological releases into the environment within the United States and its territories.
 - *Technical Specialists* – Individuals who have specialized knowledge of the product(s) or containers involved. For pipeline scenarios, these are normally representatives from the pipeline operator who can provide technical guidance on issues such as pipeline flow estimates, spill estimates, shutdown locations and backflow estimates.
- Based on the risk evaluation process, develop the Incident Action Plan (IAP). Determine whether the incident should be handled in an offensive, defensive, or nonintervention mode.

STRATEGY	OFFENSIVE	DEFENSIVE	NON-INTERVENTION
Rescue	X		
Public Protective Actions	X	X	X
Spill Control	X	X	
Leak Control	X		
Fire Control	X	X	
Clean-Up & Recovery	X	X	

Additional tactical-level information on fire control and spill control tactics can be referenced in *Section VII – Tactical Considerations: Spill and Fire Control*.

D. Select Personal Protective Clothing and Equipment

- Assure that emergency responders are using the proper personal protective clothing and equipment equal to the hazards present and the tasks being performed. Structural firefighting clothing (SFC) and positive-pressure SCBA should be the initial level of PPE selected.
 - **CAUTION:** When dealing with crude oils, levels of H₂S may pose a toxic inhalation hazard (TLV/TWA of 1 ppm and IDLH of 100 ppm). Positive-pressure SCBA should be used until the site is characterized through air monitoring.
- Any changes in the level of PPE (skin and respiratory) should be based upon the results of air monitoring operations. Continuous monitoring with a combustible gas indicator and instruments capable of detecting the toxic components of the flammable liquid (e.g., benzene) are important in ensuring site safety.
- SFC will provide thermal protection for flammable liquid fires; however, SFC is porous and will absorb liquids. For scenarios that have a low probability of fire, such as spill control and clean-up activities including decontamination, chemical splash protective clothing and a compatible

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NIOSH-approved respirator may be required depending upon the concentrations and properties of the contaminant.

- Information and guidance on the selection of PPE for oil spill response is available in American Petroleum Institute (API) *Recommended Practice (RP) 98 – Personal Protective Equipment Selection for Oil Spill Responders*.

E. Logistics and Resource Management

- Order specialized equipment and technical resources early in the incident. If unsure of your initial resource requirements, always call for the highest level of assistance available. Do not wait to call for additional resources or activate mutual aid agreements.
- Establishing and staffing a Logistics Section and a coordinated resource ordering system early in the incident will be critical in providing the necessary support, resources and services to meet incident objectives. The size, scope and resources needed to successfully manage a pipeline incident can overwhelm the capability of most emergency response agencies.
- The pipeline operator will be the primary provider of logistical support and resources as the incident timeline expands. Pipeline operators can provide emergency response resources, air monitoring and environmental response capabilities, technical specialists and contractors to safely manage the consequences of an incident.
- The total time required for assets to arrive on-scene and initiate operations must be considered, as delays will impact operational effectiveness.

F. Implement Response Objectives

- **REMINDER:** The ERG should be used by emergency responders to obtain initial response guidance for pipeline incidents.
 - Gasoline (UN 1203)– Guide Page 128
 - Diesel Fuel / Fuel Oil (UN 1202 or 1993) – Guide Page 128
 - Petroleum Crude Oil (UN 1267) – Guide Page 128
 - Petroleum Sour Crude Oil (UN 3494) - Guide Page 131
- *Traditional firefighting strategies and tactics may not be effective in these situations.* Liquid petroleum pipeline incidents, especially those involving transmission pipelines, need to be approached and managed as a hazardous materials incident to ensure that proper and appropriate technical assistance and the support of outside resources are notified and requested as soon as possible.
- The following factors should be considered as part of developing and implementing initial response strategies:

QUESTION	RESPONSE CONSIDERATIONS
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<i>Are there any life safety exposures that responders must immediately address? Can responders safely conduct evacuation or protection-in-place operations?</i>	Number of people to be protected; ability of the public to move; available time; adequate facilities to shelter evacuees.
<i>Can responders safely approach the incident?</i>	Location of the incident, including access and terrain; size of spill, leak or fire involvement.
<i>Do responders fully understand the nature and scope of the problem?</i>	Hazard assessment and risk evaluation must be completed and the results shared / coordinated with the pipeline operator.
<i>If a spill is involved, do responders have the necessary spill control equipment readily available on-site?</i>	Most public safety agencies will be limited in their spill response activities to the protection of water intakes and sensitive areas. Large-scale spill control operations will likely be delayed until the arrival of spill response contractors or Oil Spill Removal Organizations (OSRO) working on behalf of the pipeline operator.
<i>If the spill has not been ignited, can potential ignition sources be removed and/or eliminated?</i>	Vehicle traffic may need to be curtailed and ignition sources in nearby exposures controlled.
<i>Will fire extinguishment improve or worsen the incident? What are the environmental impacts of doing so?</i>	In many fire scenarios involving flammable liquids, the best and safest response option may be defensive or non-intervention tactics that allow the fires to burn out. Attempting to extinguish the fire(s) may cause additional risks to personnel and damage to the environment. The decision to protect exposures and let the product burn must be considered.
<i>If fire is involved, do responders have immediate access to sufficient Class B foam and water supplies required for effective fire control / fire suppression operations?</i>	Most fire departments will not have immediate Class B foam, water or spill control resources for an initial offensive attack on a large liquid petroleum pipeline scenario involving fire. Defensive operations will likely be required until the size of the problem decreases to the level of resources on-scene (i.e., foam, water, spill control and related support).
<i>Have appropriate agency notifications been made? Has the organization's Emergency Response Plan been activated?</i>	These incidents cannot be safely and effectively managed alone. Additional technical support and resources must be

	requested immediately in accordance with the agency's Emergency Response Plan. The pipeline operator will be the primary means of technical support and resources.
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G. Clean-Up and Post-Emergency Response Operations

- As appropriate, establish a decontamination corridor in the warm zone away from the contaminated area. Ensure proper decontamination of emergency response personnel before they leave the scene. Flammable liquid vapors can saturate protective clothing and be carried off-site. Personnel should monitor for hazardous vapors before removing PPE.
- Use water rinse on the outer shell of protective of protective clothing and contain all runoff. Maintain appropriate respiratory protection throughout the decontamination process.
- Upon the termination of emergency response activities, formally transfer command from the lead response agency to the lead agency for post-emergency response operations (PERO).
- Ensure that the following elements are documented:
 - All operational, regulatory and medical phases of the emergency, as appropriate.
 - Equipment and/or supplies used during the incident.
 - Names and contact information of all key individuals, including railroad representatives, contractors, and agency officials.
 - Emergency response point-of-contact for all post-incident questions and issues.
- Conduct / coordinate termination activities, including incident debriefing, post-incident analysis, and incident critique.

VII. TACTICAL CONSIDERATIONS: SPILL AND FIRE CONTROL

This section provides more detailed information and guidance on spill and fire control operations.

A. Operational Modes

- The IAP is developed based upon the IC's assessment of (1) incident potential (i.e., visualizing hazardous materials behavior and estimating the outcome of that behavior), and (2) the initial operational strategy. The IAP should clearly identify critical factors, the strategic goals, tactical objectives, and assignments that must be implemented to control the problem, as well as required resources and support materials.
 - *Strategic goals* are the broad game plan developed to meet the incident priorities (life safety, incident stabilization, environmental and property conservation). Strategic goals are “what are you going to do to make the problem go away?”
 - *Tactical objectives* are specific and measurable processes implemented to achieve the strategic goals. Tactical objectives are the “how are you going to do it” side of the equation, which are then eventually tied to specific tasks that are assigned to particular response units.
 - *Modes of Operation* – Tactical response objectives to control and mitigate the response problem may be implemented in either an offensive, defensive or nonintervention mode.
- *Offensive Operations* - Aggressive leak, spill, and fire control tactics designed to quickly control or mitigate the emergency. Although increasing the risks to responders, offensive tactics may be justified if rescue operations can be quickly achieved, if the spill can be rapidly contained or confined, or the fire quickly extinguished. The success of an offensive-mode operation is dependent on having the necessary resources available in a timely manner.
 - This is a high-risk operation that involves attempting to extinguish the fire.
 - Offensive operations involving pipeline isolation must be coordinated with pipeline operations personnel.
 - Flammable liquid firefighting and Class B foam operations require large water supplies to support cooling operations, exposure protection and fire extinguishment. Many pipeline corridors do not have hydrant-based water supplies immediately available. In addition, using natural water sources such as streams and rivers may not be easily and safely accessible.
 - If your agency does not have the operational capability in terms of resources (Class B foam and water), equipment (foam appliances and large volume application devices) and properly trained personnel to intervene, defensive or nonintervention strategies will likely be the preferred strategic option.
 - Well-intentioned actions to extinguish a flammable liquid fire may actually create long-term environmental impacts. The possible contamination of water supplies and sensitive areas need to be considered incident priorities.
- *Defensive Operations* - Less aggressive spill and fire control tactics where certain areas may be conceded to the emergency, with response efforts directed toward limiting the overall size or spread of the problem. Critical risk considerations will include:
 - Defensive tactics decrease the risk to responders and may be employed as methods of reducing the size of the spill or reducing the pressure of the affected pipeline.

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- Examples of defensive tactics include closing remote valves, shutting down pumps, constructing dikes, and exposure protection.
- Consider potential run-off issues when applying large flow cooling streams for exposure protection, as response operations may spread the fire or enlarge the incident footprint.
- *Nonintervention Mode* – Taking “no action” to change or influence the incident outcome. Essentially, the risks of intervening are unacceptable when compared to the risks of allowing the incident to follow its natural outcome. Critical risk considerations will include:
 - Nonintervention or defensive strategies may be required until “equilibrium” is achieved in the incident (i.e., the problem is not getting worse and has stabilized). This strategy allows the flammable liquid to burn until the bulk of the flammable liquid has been consumed, then to extinguish the remaining fires.
 - Environmental impacts may be reduced by allowing a flammable liquid fire to burn itself out. All personnel are withdrawn to a safe location, with unmanned master streams left in place to protect exposures.
- Most pipeline response operations will begin in the defensive mode of operations. Most important question the Incident Commander should ask is, “What happens if I do nothing?” Doing nothing is sometimes the best and safest option.

B. Spill Control Operations

- While not all flammable liquid releases result in a fire when the incident occurs, ignition is always a concern responders must keep in mind when developing response strategies. The guidance provided is based upon a non-fire spill scenario.
 - Continuous air monitoring is critical safety benchmark in characterizing the site and determining PPE requirements.
 - Consider water safety issues when personnel are operating in and around waterways.
- Responders will likely have environmental challenges for water-borne spill scenarios involving crude oil, especially if the incident impacts a navigable waterway. Crude oil will weather and may leave a very persistent heavy residue.
- Spill control considerations will include:
 - What is spilled and how much? NOTE: Early estimates of how much product has been spilled are often inaccurate. It is usually better to “over-react” when requesting initial resources until the situation can be completely understood and verified.
 - Where is the spill going? Will it enter a waterway?
 - How fast is the spill moving?
 - What will the spill impact and when?
 - What can responders do about it?
 - Keep it in the container
 - Keep it to as small a footprint as possible
 - Minimize the spread of the product
 - Keep it out of the water
- Spill Control Priorities – If product is being released from a liquid petroleum pipeline:
 - #1 - Keep it confined to a specific land area if safely possible.

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- #2 - Keep the product out of the water.
- #3 - If the product is in the water, protect downstream water intakes and sensitive areas.
- Spill control tactical options and considerations include:
 - Land Spills - Minimize the spread of product both horizontally and vertically.
 - Response tactics would include using dikes, berms, dams, trenches and pits, based on the available time, incident environment and available resources.
 - Water Borne Spills - First responder spill control capabilities will focus mainly on defensive tactics for non-fire scenarios to either keep product out of the water or protect downstream water intakes and sensitive areas.
 - Most first responders agencies do not have a robust spill control capability, especially when waterways are involved.
 - Response tactics will include booming operations to minimize the spread of spilled oil on water and concentrate it for recovery.

C. Fire Control Operations

- Class B foam agents are the recommended extinguishing agents for flammable liquid fires. These can include aqueous film-forming foams (AFFF) for use on hydrocarbons (e.g., crude oil, refined products) and alcohol-resistant AFFF concentrates for use on both hydrocarbons and polar solvents (e.g., ethanol).
 - The use of Class B firefighting foams in combination with dry chemical extinguishing agents (e.g., Purple K or potassium bicarbonate) will be critical tools in the controlling and extinguishing pressure fed fire scenarios (i.e., three dimensional fires).
 - Class B foam application rates will be based upon the product(s) involved. Tactical foam planning should consider the amount of foam needed for both initial knockdown and extinguishment and post-extinguishment maintenance of the foam blanket to prevent re-ignition.
- Initiating and sustaining large volume Class B foam operations at a liquid petroleum transmission pipeline scenario will be a significant operational challenge, and will likely pose significant risks to emergency responders if offensive strategies are employed.
 - In light of these risks, some jurisdictions have developed tactical pre-plans based upon local risk exposures to assess their ability to safely initiate offensive or defensive operations.
 - A critical element of this process is the identification of “go / no go” areas where tactical response operations may not be possible based upon incident location, topography and scene access.
- Formulas for calculating Class B foam concentrate requirements are referenced from *NFPA 11 – Standard for Low-, Medium-, and High Expansion Foam*, and are based upon either spill scenarios (i.e., less than 2-inches product depth) or product storage in depth scenarios.

D. Crude Oil Firefighting

- Considerable research and experience exists on crude oil firefighting, especially as it pertains to crude oil storage tank firefighting and the behavioral concepts of frothover, slopover and boilover.
 - Frothovers and slopovers can be a safety issue when applying extinguishing agents.
 - Historically, boilovers have been associated with crude oil storage tank fires and have not been associated with crude oil pipeline fires scenarios.
- Incidents involving crude oil products with varying percentages of dissolved gases have not generated significant emergency response issues in terms of fire behavior once ignition occurs.
 - Dissolved gases and light ends may facilitate easier ignition of the released product when the initial pipeline breach / release events take place.
 - There does not appear to be significant differences in fire behavior once ignition occurs.
 - Once light ends burn off, a heavier, more viscous crude oil product will often remain.
- In non-fire spill scenarios, vapor concentrations have been confirmed via air monitoring. Air monitoring at non-fire events has also shown that the light ends will boil off within several hours.
- Air monitoring results at both incidents and test fires have shown that the products of combustion (i.e., soot and particulates) from crude oil and ethanol fires have not been significantly different than those seen at fires involving Class A materials.

VIII. TERMS AND DEFINITIONS

Alcohol Resistant - Aqueous Film Forming Foam (AR-AFFF). A Class B foam concentrate that, when proportioned at the appropriate rate, forms a vapor-suppressing seal to rapidly control both hydrocarbon fuel fires (e.g. gasoline, diesel, kerosene) and polar solvent fuel fires (alcohol, ketones, methanol, and MTBE products).

API (American Petroleum Institute) Gravity. The density measure used for petroleum liquids. API gravity is inversely related to specific gravity – the higher the API gravity, the lower the specific gravity. Temperature will affect API gravity and it should always be corrected to 60°F (16°C). API gravity can be calculated using the formula - $API\ Gravity = 141.5 / Specific\ Gravity - 131.5$.

Aqueous Film Forming Foam (AFFF). A Class B foam concentrate that, when proportioned at the appropriate rate, form a vapor-suppressing seal to control hydrocarbon spill fires (e.g., gasoline, diesel fuel, kerosene).

Aviation Gasoline (Avgas). A gasoline fuel for reciprocating piston engine aircraft. Avgas is very volatile and is extremely flammable at normal temperatures. Avgas grades are defined primarily by their octane rating - the lean mixture rating and the rich mixture rating. For example, Avgas 100/130 has a lean mixture performance rating of 100 and a rich mixture rating of 130.

Boilover. The expulsion of crude oil (or certain other liquids) from a burning tank. The light fractions of the crude oil burn off producing a heat wave in the residue, which on reaching a water strata, may result in the expulsion of a portion of the contents of the tank in the form of a froth.

Crude Oil. A mixture of oil, gas, water and other impurities, such as metallic compounds and sulfur. Its color can range from yellow to black. This mixture includes various petroleum fractions with a wide range of boiling points. The exact composition of this produced fluid varies depending upon from the geographical location where it originated

Distillate Fuel Oils. Include both diesel fuel and fuel oil. Diesel fuel is a light hydrocarbon mixture for diesel engines, similar to furnace fuel oil, but with a slightly lower boiling point. Refined fuel oil comes in two grades. No. 1 distillate, such as kerosene, is a light fuel. No. 2 fuel oil is a distillate fuel oil prepared for use as a fuel for atomizing-type burners or for smaller industrial burner units.

Frothover. Can occur when water already present inside a tank comes in contact with a hot viscous oil which is being loaded

Gathering Pipelines. Small pipelines, usually 2 to 8-inches in diameter, that move natural gas or crude oil mixtures from individual wellheads and production locations to a central processing facility (often referred to as a Gathering Center or Flow Station) where the oil, gas and water are separated and processed.

Jet Fuel. A highly refined kerosene petroleum distillate. There are two main grades of jet fuel used in commercial aviation – Jet A and Jet A-1. Both are kerosene distillates. Jet A is found in the United States and has a flash point above 100°F (38°C), Jet A-1 is a similar kerosene fuel that is used for civil commercial aviation internationally. Jet B, is a blend of kerosene and gasoline,

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and may be found in extremely cold climates where cold weather performance is critical (e.g., Canada).

Natural Gas Liquids (NGL). Heavier hydrocarbon products, such as pentane, hexane and heavier gasoline-range molecules, that may be found with natural gas found in production fields. NGL's are to prevent them from condensing in the pipeline and interfering with the natural gas flow.

Pipeline Control Center. The central communications and operations center for the pipeline operator. It is the heart of pipeline operations, particularly along transmission and large distribution pipelines. Using a computerized Supervisory Control and Data Acquisition (SCADA) System, operators can monitor pipeline pressure, flow, temperature, alarms and other conditions in the pipeline, as well as shutdown the pipeline and begin to isolate the source of a leak in the event of an emergency. It is typically remote from the physical location of the pipeline.

Post-Emergency Response Operations (PERO). That portion of an emergency response performed after the immediate threat of a release has been stabilized or eliminated, and the clean-up of the site has begun.

Refined Products. Liquid petroleum products produced through the refining process. Examples include gasoline, aviation gasoline, jet fuels and distillates, such as home heating and diesel fuels.

Right-of-Way (ROW). A strip of land usually about 25 to 150 feet wide containing one or more pipelines or other subsurface utilities (e.g., communications, fiber optic cables) on which the pipeline operator has the rights to construct, operate, and/or maintain a pipeline. They may be found in urban, suburban and rural areas.

Risk-Based Response. A systematic process by which responders analyze a problem involving hazardous materials, assess the hazards, evaluate the potential consequences, and determine appropriate response actions based upon facts, science, and the circumstances of the incident (NFPA 472).

Sloperover. Can result when a water stream is applied to the hot surface of a burning oil, provided that the oil is viscous and its temperature exceeds the boiling point of water. It can also occur when the heat wave contacts a small amount of water stratified within a crude oil. As with a boilover, when the heat wave contacts the water, the water converts to steam and causes the product to "slop over" the top of the tank.

Sour Crude Oil. Crude oil with a high concentration of hydrogen sulfide.

Structural Fire-Fighting Protective Clothing (SFPC) The fire-resistant protective clothing normally worn by fire fighters during structural fire-fighting operations, which includes a helmet, coat, pants, boots, gloves, PASS device and a fire-resistant hood to cover parts of the head and neck not protected by the helmet and respirator facepiece

Supervisory Control and Data Acquisition (SCADA) System. Computerized system for monitoring and controlling pipeline operations from a Pipeline Control Center. Computer screens and analog readings provide control center operators with an ongoing display of pipeline pressure,

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temperature, flow, alarms and other conditions in the pipeline from all of the stations along the pipeline.

Sweet Crude Oil. Crude oil with a low concentration of hydrogen sulfide.

Transmission Pipelines – Liquids. Large diameter pipelines, up to 42-inches diameter, that are used to move refined liquid petroleum products from refineries to marketing and distribution terminals, where the products are then loaded onto cargo tank trucks for ultimate delivery to the consumer. Pumping stations are used to boost pressures and maintain constant flows on transmission lines.

Transmix. The point at which two liquid petroleum products meet and mix when shipped in a pipeline. May also be referred to as the interface.

Trunk Lines. Large crude oil pipelines, usually 8 to 24-inches in diameter that bring crude oil from gathering centers, oil producing areas and ports throughout North America to refineries.

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