

TRAINING MODULE ON FIREFIGHTING FOR DISASTER MANAGEMENT OF OIL INSTALLATION IN HYDROCARBON SECTOR



National Institute of Disaster Management
(Ministry of Home Affairs, Government of India)



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Training Module on

FIREFIGHTING FOR DISASTER

MANAGEMENT OF OIL INSTALLATION IN

HYDROCARBON SECTOR

National Institute of Disaster Management
(Ministry of Home Affairs, Government of India)

Training Module on Firefighting for Disaster Management of Oil Installation in Hydrocarbon Sector

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कार्यकारी निदेशक

Madhup Vyas, IAS

Executive Director



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FOREWORD

Disasters pose significant threats to lives, livelihoods, and the socio-economic structure of the affected communities. In the wake of such events, the ability to respond swiftly and effectively becomes paramount. The collaboration between the National Institute of Disaster Management (NIDM), Ministry of Home Affairs, Government of India, and Ministry of Labour & Employment (MoLE), Government of India as per the mandate of DM Act 2005 underscores the government's commitment to foster a culture of resilience and preparedness across all sectors including labour and employment.

An integrated approach for preparedness is required in order to prevent and minimize casualties. NIDM is delighted to present the Training Module on Firefighting for Disaster Management of Oil Installation in Hydrocarbon sector that aims to enhance the resilience in the face of adversity. By equipping organizations with the knowledge and resources needed to prepare for risks and enhance their disaster response capabilities, we are laying a strong foundation for a safer and more resilient India.

Mr. Rajendra Ratnoo, Former ED NIDM and his team deserve compliments for the successful completion of the document, and I am grateful to the reviewers who have played a pivotal role in the development of this handbook. I am confident that it will serve as a valuable resource for organizations seeking to strengthen their disaster preparedness efforts. Together, let us work towards disaster free and resilient nation.

(Madhup Vyas)

आपदा प्रबंधन महाविचार: पूरा भारत भागीदार



FOREWORD

In an ever changing world of business strategies, training and re-training of its employees are imperative and holds the key to better bottom lines of any industry.

The NIDM, Delhi and ATI, Goa are engaged in imparting various training services in the areas of Health, Safety and Environment in oil industry. The Training Module on Firefighting for Disaster Management of Oil Installation in Hydrocarbon sector, being offered by the institutes have always been under greater focus within the organization.

As a part of continuous efforts to update and standardize the training technique and tools, NIDM and ATI are endeavored to bring out the present Training Module on Firefighting for Disaster Management of Oil Installation in Hydrocarbon sector on the subject and in the process, every effort has been made to ensure that the module is consistent with the best available information on current fire prevention and protection practices in Oil and Gas industry. ONGC who had spent its valuable time in perusing the inputs and shaping the document as a standard resource manual/ hand-book on the art in fire protection and prevention practices.

I am sure that this module will also be a good study material for the benefit of all ONGC Fire personnel in particular and other employees in general.

With Best Wishes.

Saket Gupta
(Saket Gupta)
Executive Director & Chief
Advanced Training Institute (ATI), Goa



Preface

The Advanced Training Institute (ATI) plays a pivotal role in safeguarding the well-being of workers and ensuring the resilience of workplaces in the face of adversity. As part of its commitment to fostering a culture of preparedness and resilience, the National Institute of Disaster Management (NIDM), Ministry of Home Affairs, Government of India in Collaboration with ATI, Goa takes this opportunity to present this module on preparing disaster management plans tailored specifically for organizations under the horizon of the ATI.

Crafted with meticulous attention to detail and drawing upon the expertise of professionals in disaster management, this module serves as a comprehensive guide for organizations to navigate the complexities of disaster preparedness, response, and recovery. It is designed to equip stakeholders with the knowledge, tools, and strategies necessary to develop robust disaster management plans that prioritize the safety and well-being of workers, protect critical infrastructure, and ensure continuity of operations in the aftermath of a disaster.

Through a systematic and practical approach, this handbook would provide ATI and its staff with the essential components of disaster management planning, including mitigation, preparation, emergency response procedures, communication strategies, resource mobilization, and post-disaster recovery efforts.

The institute is committed to support organization in their efforts to strengthen disaster preparedness and work toward a more resilient future. Institute extend sincere gratitude to all the contributors, experts, and stakeholders who have generously shared their insights and expertise to make this handbook possible. It is hoped that this resource will empower organizations to effectively navigate the challenges of disaster management and emerge stronger in the face of adversity.



Surya Parkash

Prof. & Head CBRN, Centre for Industrial and Cyber DRR & GMRD Division
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Acknowledgement

I extend my heartfelt gratitude to Mr. Saket Gupta, Executive Director & Head Advanced Training Institute (ATI), Goa, Shri Madhup Vyas, IAS, ED, NIDM, for their unwavering support and kind encouragement in the development of the Training Module on Firefighting for Disaster Management of Oil Installation in Hydrocarbon sector. I express my gratitude to Col. Manoram Yadav, SM, JD, NIDM for providing the administrative support required for the module successful completion. I would like to acknowledge the important contributions made by various resource person who shared their knowledge, insights, and inputs in the document.

Thank you for your invaluable help and collaboration in the preparation of this module, Mr. Alok Kumar, Safety & Fire Engineer and Chief Manager (Fire Services), ATI ONGC, Goa as well as my colleagues Mr. Sandeep Singh, Dr. Ravinder Singh, Mr. Vimal Tiwari, Ms. Karishma Choudhary, Ms. Stanzin Tsela, and Ms. Pallavi, Dr. Kundan Deval for providing review assistance. I am happy to thank Mr. S. K. Tiwari, Librarian, NIDM, and Ms. Karanpreet Kaur Sodhi, Jr. Consultant, Publication Cell for providing essential support in printing this handbook. Additional gratitude is owed to Ms. Amrita Gupta, PA to ED, NIDM and Mr. S.S. Bisht from the accounts section, Mr. Hemant Kumar and Mr. Rajiv Kumar from IT section, NIDM administration, and other supporting personnel for their many contributions of assistance throughout the processing, production, and printing of the handbook.

Finally, but just as importantly, I want to thank my wife Reeta and my daughter Rasika, without whose unwavering logistical and moral support I could not have dedicated the necessary time and attention to this task. I owe them a debt of gratitude for putting up with me when I was too preoccupied with the preparation of manual-related work to offer them the proper care and attention.

Lastly, I want to express my gratitude to the Almighty, for the kind opportunity to complete this duty successfully.



Prof. Surya Parkash

About the module

This module focuses on Disasters in Oil Installations along with the impacts and lessons learned to formulate and implement strategies, policies, plans, procedures, etc. for risk reduction and resilience in the oil and gas sector by adopting Advance Fire Fighting Training.

India is the third largest consumer of crude oil in the world, after the United States and China. Oil & Gas is the greatest source of energy in the country. It is a very useful issue and highly beneficial to reduction if it is used in a controlled manner otherwise it can lead to a disaster and create huge fire & explosion. Although the module is useful for any industrial disaster, it specifically addresses the loss of human lives financial, and environmental losses due to fire explosion incidents in oil & gas industries.

Several case studies like the Piper Alpha Disaster due to Explosion and Fire happened on 6th July 1988 in Piper Oil Field (North Sea), UK (offshore Scotland), and the MHN Platform Fire & Explosion due to Explosion and Fire, which happened on 27th July 2005 India (offshore) Mumbai High North Oilfield (Arabian Sea), etc.; have been considered to draw lessons learnt from these events.

A good and comprehensive disaster/emergency preparedness plan can help to educate all stakeholders as well as employees to minimize casualties and damages through well-conceived evacuation, rehabilitation, and recovery programmes. This module covers the required learning of disaster management in the oil & gas industry and varies among different phases i.e., Prevention, Mitigation, Preparedness, Response, Recovery & development. The chapters in this module have been written in a matter to incorporate these into other curricula and are designed to meet the requirements of the expected outcome, targeted audience, and time frame.

Training is a vital element of emergency preparedness and disaster management which continually improves the safety standard of an organization. The module can be used as a resource for the development of disaster-resilient infrastructure and to save a life by taking simple actions immediately.

Abbreviations & Acronyms

AFFF	Aqueous film forming foam
AFS	Aviation Fuelling Stations
API	American Petroleum Institute
ARSFPS	Automatic Rim Seal Fire Protection System
ATI	Advanced Training Institute
BA	Breathing Apparatus
BIS	Bureau of Indian Standards
BLEVE	Boiling Liquid Expanding vapor Explosion
CABA	Compressed Air Breathing Apparatus
CSP	Code of Safe Practices
CTF	Central Tank Farm
CVCE	Confined vapor Cloud Explosion
EFR Tanks	External Floating Roof Tanks
EN	European Norm
EPS	Early Production Set-up
ERT	Emergency Rescue Tenders
ESDVs	Emergency Shutdown Valves
FFFp	Film forming flour protein foam
FFS	Fire Fighting System
FP	Fluoro Protein
FM	Factory Mutual
FWN	Fire Water Network
FWP	Fire Water Pumps
GCP	Gas Compression Plant
GCS	Gas Collecting Station

GGS / OCS	Group Gathering Station / Oil Collecting Station
HGVs	Hydrocarbon Gases and vapors
IFR Tanks	Internal Floating Roof Tanks
IRS	Incident Response System
IPSHEM	Institute of Petroleum Safety, Health, and Environment Management
ISD	Inherently Safer Design
LDV	Lung Demand Valve
LEL	Lower Explosive Limit
LOE	Low Oxygen Environments
LOPC	Loss of Primary Containment
MEF	Medium Expansion Foam Generator
MFT	Multipurpose Fire Tenders
MSV	Her Majesty's Stationery Office
MSV	Multi-purpose Support Vessel
NFPA	National Fire Protection Association
NIOSH	National Institute for Occupational Safety and Health
NORM	Naturally Occurring Radioactive Material
OIM	Offshore Installation Manager
OMR	Oil Mines Regulations
PSV	Pressure Safety Valve
QPS	Quick Production Set-up
RRL	Reinforced Rubber Lined
SAR	Search & Rescue
SCBA	Self-Contained Breathing Apparatus
SOP	Standard Operating Procedure
SSIVs	Sub-Sea Isolation Valves
TEC	Ternary Eutectic Chloride

TFP	Trailer Fire Pump
TSRs	Temporary Safe Refuges
UEL	Upper Explosive Limit
UL	Underwriters Laboratories
UVCE	Unconfined vapor Cloud Explosion
WFM	Water cum Foam Monitor
WHI	Well-head Installation
WPS	Water Spray System

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Glossary

Advanced Fire Fighting Training: A training program designed to establish an auxiliary fire force among on- site personnel engaged in drilling rigs, workover rigs, and surface installations in the oil and gas industry. The training aims to equip field personnel with fundamental firefighting knowledge and practical skills to respond effectively to fire emergencies.

Auxiliary Fire Force: A designated group of on-site personnel trained to respond promptly to fire- related emergencies in the absence of professional firefighters. The goal is to mitigate fire incidents in the field and prevent them from escalating into disasters.

BLEVE (Boiling Liquid Expanding vapor Explosion): BLEVE is caused by the rupture of a vessel containing pressurized fluid (e.g., LPG) above its boiling point. The rupture is often triggered by a flame impinging on the surface of the vessel. This leads to a violent explosion, with large fragments of the vessel projected at significant distances. The released liquid undergoes rapid boiling, and the resulting vapors can explode when ignited.

Chemical Hazards: Potential threats associated with the use and production of hazardous chemical materials in oil and gas well drilling and servicing activities.

Collision Risk Management: The process of identifying, assessing, and mitigating the risks associated with collisions between vessels and offshore platforms.

Crisis: Crisis may be defined as “an emergency situation arising out of natural or human activity which poses a threat to human life and property or leads to large-scale disruption of normal life”.

Deflagrations: Propagating chemical reactions with a propagation rate below the speed of sound. Deflagrations generate pressure but at a slower rate compared to detonations.

Deluge Systems: Fire protection systems that use open nozzles to distribute large volumes of water over a wide area in the event of a fire.

Detonations: Extremely fast reactions where the reaction velocity exceeds the speed of sound. Detonations generate a shockwave with pronounced blast effects in close proximity.

Disaster: A catastrophe, mishap, calamity, or grave occurrence in any area, arising from natural or man-made causes, or by accident or negligence which results in substantial loss

of life or human suffering or damage to, and destruction of property, or damage to, or degradation of the environment and is of such a nature or magnitude as to be beyond the coping capacity of the community of the affected area.

Drilling Rigs: Compact mobile units for drilling operations, including a derrick structure, power unit, mud preparation unit, and associated equipment.

Emergency: Emergency is any natural or man-made situation that may result in substantial harm to the population or damage to property (Shen & Shaw, 2004, p. 2110). Emergency can be defined as "an imminent or actual event that threatens people, property or the environment and which requires a coordinated and rapid response."

Emergency Preparedness Plan: A comprehensive strategy outlining procedures and actions to be taken in the event of an emergency crisis or disaster to minimize damage and ensure the safety of individuals and assets.

Evacuation, Rehabilitation, and Clean-up Programmes: Strategies and actions designed to safely move people away from danger, restore affected areas, and clean up after a disaster, contributing to minimizing casualties and damages.

Fire Prevention & Protection Philosophy: The principles and strategies employed to prevent and protect against fires in the oil and gas industry. Classroom training on this philosophy aims to reduce vulnerability, risks, and prevent future emergencies by imparting knowledge and practical experience to field-going personnel.

Fire Tetrahedron: An extension of the fire triangle, adding a fourth element known as the chain reaction. Represented in a tetrahedron, it signifies the sustaining role of chain reactions once a fire is initiated.

Fire-Resistant Insulation: Insulation materials are designed and used to resist ignition reduce the rate of the spread of fire and providing protection against heat and flames.

Guidelines for Ship/Installation Collision Avoidance: A set of recommendations or standards provided by the United Kingdom Offshore Operators Association to avoid collisions between ship sand offshore installations.

Hazards: Hazards may be considered as probability of occurrence of given factors, conditions, activities, phenomena, operations, processes, people or properties or products that have the potential to cause substantial damages & losses pose risks to human lives, the economy, resources, infrastructure, assets, and the environment when expected within a given space and time.

Hyperbaric Evacuation Points: Designated areas equipped to facilitate the evacuation of divers in a hyperbaric chamber in case of emergency.

Natural Gas Industry: The industry involved in exploring, extracting, and processing natural gas resources.

Natural Hazards: Hazards caused by natural forces, such as cyclones, earthquakes, floods, lightning, etc., that can pose a threat to industrial operations and other elements exposed to it.

Petroleum Industry: A sector encompassing the exploration, extraction, refining, and marketing of petroleum products, including oil and natural gas.

Safety Case: A comprehensive document submitted by owners/operators of offshore installations to regulatory authorities. It details how major accident risks and the safety of personnel during evacuation, escape, and rescue are managed.

Slop-over: Slop-over is the overflow of the contents of a tank. It occurs when a water stream is applied to the hot surface beside fuel, temperature, and O₂ of viscous burning oil, and the temperature exceeds the boiling point of water. The water sinks into the heat wave, converts into steam, forms a foam, and expands the hot oil in the heat wave, causing it to spill over from the top of the tank.

Subsea Pipeline: A pipeline installed on the seabed to transport oil, gas, or other fluids from offshore facilities to onshore locations.

vapor Cloud Explosion [Unconfined vapor Cloud Explosion (UVCE) & Unconfined vapor Cloud Explosion (CVCE)]: vapor Cloud Explosions arise from the loss of containment of hydrocarbons. They occur when a large quantity of flammable gas or vapor is released into the air and mixed within flammable limits.

Work-Over Rigs: Compact mobile units used for oil and gas well servicing, equipped with a derrick structure and necessary equipment for work-over fluid preparation.

(A) Fixed Installations (Surface Installations):

Central Tank Farm (CTF): Facility receiving petroleum from various GGSs, storing, processing, and transferring it to designated refineries.

Chemical/Water Injection Plant: Plant for injecting water/chemicals into wells to enhance productivity.

Compressor Stations: Installations with compressors to boost gas pressure before transmission.

De-salter Plant: Facility for treating crude oil to remove salt before dispatch to the refinery.

ETP (Effluent Treatment Plant): Plant for treating produced water to meet regulatory requirements.

Gas Collecting Station (GCS) and Gas Compression Plant (GCP): Facilities for receiving, separating, dehydrating, and compressing gas for transmission.

Group Gathering Station / Oil Collecting Station (GGS/ OCS): A production installation where crude oil from multiple wells is collected, separated, and processed before dispatch.

Petroleum Depots & Terminals: Facilities for receiving, storing, and blending petroleum products for distribution.

Well Head Installation (WHI): A production installation for collecting and temporarily storing crude oil from wells.

(B) Codes and Standards:

Code of Safe Practices (CSP): Internal code for ensuring safety in operational activities, covering onshore and offshore operations in two volumes.

Fire Fighting Resources:

Oil Mines Regulations (OMR) – 2017: Statutory regulations for protection against gas and fire in oil mines.

OISD Standards: Recommendations for onshore and offshore areas, covering various aspects like refineries, depots, terminals, drilling rigs, etc.

Other Standards: Referring to standards from organizations like BIS, NFPA, API, FM, UL, EN.

Production Installations: Portable fire extinguishers, fixed firefighting systems, and mobile fire appliances.

Salient Features of Design Criterion for Fixed Fire Fighting System at Production Installations: Outlines design criteria for fire protection facilities at production installations, including system capacity, pump specifications, network layout, and safety measures.

SOP for Conducting Mock Drills: Guidelines for conducting mock drills, including assigning responsibilities, action plans, communication, firefighting, and coordination with external agencies.

SOP for Giving Fire Calls Message to Fire Station: Steps to follow when giving a fire call/emergency message to a fire station, emphasizing calm communication and providing essential information.

(C) Control Methods for Pipeline Leakage:

Alcohol-Resistant Aqueous Film-Forming Foam (AFFF): A type of foam used in firefighting, specifically designed to handle fires involving polar solvents like ethanol. AFFF is resistant to the effects of alcohol-based fuels.

Approach Suit: A protective suit worn by the operational team when approaching a fire, designed to shield against heat.

Aspiration: The process of drawing air or a substance into a device, in this context, ensures that holes in the nozzle are not blocked during foam application.

Backdraft: A sudden and dangerous event can occur when oxygen is reintroduced to an oxygen-depleted, smouldering fire, leading to an explosive ignition of accumulated flammable gases.

Backpack Method: A method of donning the SCBA set where the harness is positioned on the back. While not explicitly mentioned in the glossary, it may be inferred as an alternative method of donning the SCBA set.

Blowout Preventers: Safety devices installed on oil and gas wells to control or prevent the uncontrolled release of pressure, often in the form of crude oil or natural gas. Blowout preventers aim to prevent blowouts and subsequent fires.

Breathing Apparatus Set (SCBA): A Self-Contained Breathing Apparatus (SCBA) is a device worn by rescue workers, firefighters, and others to provide breathable air in environments where the atmosphere is contaminated or oxygen-deficient. It typically includes a face mask, a high-pressure tank of compressed air, and associated equipment.

Breathing Apparatus Sets: Devices worn to provide breathable air in atmospheres that are immediately dangerous to life or health, are commonly used in firefighting.

Buddy System: A safety practice in which individuals work in pairs or small groups to provide mutual assistance and support. In the glossary, the buddy system is mentioned in the context of participants working together in groups of 4-6 persons during the exercise.

Centrifugal Fire Pumps: Pumps used in firefighting systems are designed to provide variable flow at a constant pressure.

Charged Line of Hose: A hose that is pressurized with water or another extinguishing agent, ready for immediate use. The glossary mentions the use of a charged hose with a water spray pattern to cool the team and protect them from potential flash fires.

Compressed Air Breathing Apparatus (CABA): An alternative term for Self-Contained Breathing Apparatus (SCBA), emphasizes that the device utilizes compressed air as a source of breathable air.

Crawling: Moving on hands and knees or with the torso close to the ground. In the glossary, the recommendation to stay as low as possible and crawl during evacuation is provided to minimize exposure to smoke.

DCP Type Extinguisher, Foam Type Extinguisher, Water Mist Fire Extinguisher, and High-Pressure

Debriefing Session: A meeting or discussion held after an emergency operation to review actions taken, assess performance, and discuss lessons learned.

Demonstration Assistant: An individual responsible for conducting and guiding demonstrations, such as the simulation involving the LPG cartridge. The demo assistant is trained to handle the simulation safely and to provide information to observers.

Depressurizing Line: The process of reducing pressure in a pipeline to control or stop the leakage.

Detection: Although spillages are in fact very rare, leak detection systems are installed to detect and locate a leak as soon and as accurately as possible.

Doffing: The process of removing or taking off a piece of equipment or protective gear. In the glossary, doffing is explained in the context of removing the SCBA set after use, including the steps to disconnect, release, and carefully remove the apparatus.

Donning: The process of putting on or wearing a piece of equipment or protective gear. In the glossary, the term is specifically used in the context of donning the SCBA set, outlining the steps to properly wear the apparatus.

Double-Headed Hydrant: A hydrant with two outlets, typically provided in facilities like Group Gathering Stations (GGS) and Central Tank Farms (CTF) for more versatile firefighting capabilities.

Drilling & Work Over Rig: A specialized structure and set of equipment used in the oil and gas industry for the drilling of wells or conducting workover operations to enhance, repair, or stimulate the production of hydrocarbons.

ERP (Emergency Response Plan): A plan outlining actions and responsibilities during emergency situations, including firefighting operations.

Evacuation Procedures: A set of organized actions and guidelines designed to safely move individuals from a dangerous or hazardous area to a place of safety. In the glossary, evacuation procedures are emphasized during Stage II of the training, focusing on safe evacuation from smoke-filled areas in a building.

Explosion Force: The powerful force generated during a BLEVE when the weakened vessel ruptures, releasing gas and creating a large fireball. The explosion force can propel splinters over long distances.

Fire Hose & Nozzle: Fire hoses are flexible hoses that convey water or other firefighting agents from a water source to the fire. Nozzles are devices attached to hoses to control and direct the flow of water. They are essential firefighting tools.

Fire Hose Drill in a Team: The practice of using fire hoses in a coordinated team, often involving multiple individuals to enhance efficiency and effectiveness during firefighting operations.

Fire Hose Drill in Dry Condition: A training exercise where participants practice using fire hoses in a dry condition, simulating firefighting scenarios without the presence of actual fire or water.

Fire Hose: A flexible tube designed to carry pressurized water or other firefighting substances to a fire scenario. In the described module, participants are taught the basics of handling pressurized firehoses.

Fire Monitor & Hydrant: Fire monitors are devices that discharge water or other firefighting agents over a long distance. Hydrants are fixed outlets connected to a water supply for firefighting. Both are part of the fire protection system on the rig.

Fire Proximity Suit: Specialized protective clothing designed to shield firefighters or emergency responders from high temperatures, radiant heat, and flames. The glossary indicates that the team involved in the operation will use fire proximity suits for protection.

Fire Proximity Suit: Specialized protective clothing worn by firefighters to protect against high temperatures and flames.

Fire Safety: Measures and protocols implemented to prevent and mitigate the impact of fires. The glossary underscores the prime importance of fire safety, particularly in high-rise buildings.

Fire Water Network Line: A network of red-colored pipes with various diameters, transporting fire water from the pump discharge header to different units in an installation for comprehensive fire protection.

Fire Water Pump: A pump designed to supply water at high pressure for firefighting purposes. It is a crucial component of the fire protection system on a drilling or workover rig.

Fire Water Reservoir: A storage facility for fire water, either an underground pit or an above ground tank. It plays a crucial role in ensuring a quick response to fire emergencies.

Fire Water Spray System: A system designed to discharge effective water spray before possible failures of containers of flammable liquids or gases due to temperature rise. The system operates based on need, providing water spray for exposure protection.

Fire Water Storage Tank: A reservoir designed to store a large quantity of water specifically for firefighting purposes. It provides a readily available water supply to combat fires on the rig.

Fireball: A large ball of fire produced by the ignition of a flammable substance cloud.

Firefighting Equipment and Accessories: Various tools and gear used in firefighting, including hoses, nozzles, hydrants, and other accessories. Participants familiarize themselves with these equipment during the module.

Fire-Water Hydrants & Monitor: Installations perpendicular to the fire water network line, equipped with valves and landing valves. They can discharge water for firefighting using a delivery hose with a connected nozzle. Monitors can supply water to fire tenders for continuous firefighting.

Fixed Fire Fighting System (FFS): A permanent fire protection system designed to control fires in industrial installations. It includes components like fire water reservoirs, pumps, network lines, hydrants, and monitors.

Flammable Substance: A substance capable of catching fire and sustaining combustion. The involvement of flammable substances in a BLEVE increases the risk of a subsequent fireball and fuel-air explosion.

Flange Leakage: A scenario in the simulator where oil leaks through a loose flange, creating a pool fire.

Fluor protein, Film-Forming Fluor protein (FFFp) Foam: Another type of foam used in firefighting, is effective for combating fires involving certain types of fuels. FFFF foam forms a film on the surface of the fuel, preventing the release of flammable vapors.

Foam Concentrate: A substance used to produce foam for firefighting. It is drawn into the water stream to create foam for more effective fire suppression.

Foam cum Water Monitor: A firefighting apparatus designed to discharge a combination of foam and water onto a fire scenario. In the context of the simulation, the fire caused by the LPG cartridges extinguished using a foam cum water monitor.

Foam Jet: A stream of foam is applied to a fire to suppress flames by cutting off the oxygen supply.

Foam Mist Unit: Different types of portable fire extinguishers are used for specific firefighting purposes.

Foam Pourers: Components designed for use in fixed foam firefighting systems, primarily used in the protection of flammable liquid storage tanks. Foam pourers combine a foam maker, vapor seal box, and pourer in each unit.

Foam System: A fire protection system that consists of a water supply, foam concentrate, proportioning equipment, piping system, foam makers, and discharge devices. The glossary outlines three types of foam systems and mentions their use in protecting flammable liquid storage tanks.

Fuel-Air Explosion: An explosion resulting from the ignition of a fuel-air mixture. In the context of BLEVE, the release of a flammable substance cloud may lead to a fuel-air explosion after ignition.

GGS (Group Gathering Station): A facility in the petroleum industry where petroleum products from multiple wells are gathered and initial processing, including separation of oil, water, and gas, is performed before dispatching to a Central Tank Farm (CTF).

Hazmat Call: A call or response related to hazardous materials, requiring specialized knowledge and procedures. In the context of the glossary, hazmat considerations are mentioned in dealing with tanker emergencies.

High-Pressure Blowout: The uncontrolled release of crude oil and/or natural gas from an oil or gas well due to the failure of pressure control systems. Blowouts can lead to rig fires and are often associated with drilling operations.

Hydrant Drill: A training exercise where participants practice connecting a fire hose to a fire hydrant and operating it effectively. This drill is conducted in wet conditions, possibly involving the use of water.

Incident Commander: The person in charge during an emergency situation who makes decisions and regulates operations. This role involves documenting reports of the incident.

Incident Controller: Coordinates the operation of fire teams and provides real-time reports to the incident commander.

Incident Response System (IRS): A system designed to manage and respond to incidents effectively. In the context of the glossary, it refers to the coordination and response system for handling scenarios related to fire protection on an oil storage tank.

Isolation Valves: Valves are installed at regular intervals in the fire water network line to allow for maintenance activities and to isolate sections of the line if needed.

Jet Fire: A scenario in the simulator where oil leaks from a puncture hole, creating a high-pressure jet fire.

Jet Pattern: A concentrated stream of water or foam ejected from the fire monitor, is useful for reaching specific points in a fire scenario.

Leakage Arrest: The act of stopping or preventing the escape of a substance, in this case, the leakage from the road tanker. The glossary describes the team's objective to arrest the leakage by closing the valve.

Liaising Team: Coordinates with external entities, such as the police station, health, safety, and environmental sectors, and local fire services.

Life-Threatening Emergencies: Situations that pose an immediate risk to life and require prompt action for survival.

Locking Pin: A device used to secure the vertical and horizontal direction settings of a fire monitor, preventing unintentional adjustments during operation.

Logistics Team: Provides necessary resources and equipment during emergency situations. Develop standard plans of action.

Low Frequency/High-Risk Incidents: Incidents that occur infrequently but have a high level of risk and potential severity. In the context of the glossary, tanker truck emergencies are classified as low-frequency/high-risk incidents.

Lung Demand Valve (LDV): A valve in the SCBA that delivers air to the user's mask on demand, ensuring that air is supplied when the user inhales. The glossary mentions the LDV in the context of donning the SCBA set, emphasizing the need to open it for proper use.

Metal Weakening: The process by which the metal structure of a vessel weakens due to prolonged exposure to external heat.

Mitigation: The prevention of spillage is a primary concern for every pipeline operator. However, when it does occur, rapid detection and location of the spill, coupled with well-planned control procedures will minimize the volume spilled.

Negative Suction Reservoir: An underground pit is used for storing fire water, requiring priming to initiate water flow.

Nomination Evacuation Assembly Area: A specific location designated in advance for individuals to gather during an evacuation. In the glossary, trainees are instructed to move to the nominated evacuation assembly area during evacuation procedures.

Nozzle: The part of the fire monitor that releases the water or foam onto the fire. It can be adjusted to form a jet or spray pattern of water by rotating clockwise and anticlockwise.

Off-Site Multiple Source Fire: A fire scenario involving multiple sources of ignition or fire incidents that occur away from the primary site. In the context of the glossary, trainees receive exposure and practice in dealing with fires originating from different locations off-site.

OISD Std.118: Standard set by the Oil Industry Safety Directorate (OISD) providing guidelines and specifications for fire protection in the petroleum industry.

OISD Std.189: The standard set by the Oil Industry Safety Directorate (OISD) specifies requirements for the design and installation of fixed fire protection systems.

Onlooker Control: The management and control of bystanders or onlookers at the emergency scene. Given the attention-drawing nature of tanker fires, onlooker control is highlighted as an early consideration in incident command.

Operational Team: Responsible for specific operational tasks, such as closing fuel supply valves. Members of the operational team wear fire proximity suits and breathing apparatus.

Over the Head Method: A method of donning the SCBA set where the harness is placed over the head. The glossary provides specific steps for the Over the Head Method of donning the SCBA set.

PASS (Pull Aim Squeeze & Sweep) Method: A method for operating fire extinguishers - Pull the pin, Aim the nozzle, Squeeze the handle, and Sweep the nozzle from side to side.

Positive Suction Reservoir: An aboveground tank used for storing fire water, is preferred for quick response as it does not require priming.

PPE (Personal Protective Equipment): Safety gear worn by individuals to protect themselves from workplace hazards. In this context, includes overalls, safety helmets, gumboots, safety goggles, and hand gloves.

Pressurized Liquid: A liquid stored in a vessel under pressure, where the pressure is typically above atmospheric pressure. In the context of BLEVE, the pressurized liquid reaches a temperature beyond its boiling point.

Prevention: Prevention, the first line of defence against the release of hazardous commodities, encompasses activities and solutions that seek to prevent commodity release from occurring in the first place.

Relief Valve: A safety device installed on a pressurized vessel to release excess pressure by venting gases or vapor into the atmosphere. In a BLEVE, the relief valve plays a crucial role in managing excess pressure.

Respiratory PPE (Personal Protective Equipment): Protective equipment is worn to ensure the safety of individuals' respiratory systems. In the glossary, the absence of respiratory PPE during Stage II is mentioned to enhance the confidence of trainees in encountering low visibility areas without relying on respiratory protection.

Rig Fire: A fire that occurs on a drilling or work over rig. These fires can result from various causes, including accidents, arson, lightning, or high-pressure blowouts during drilling operations.

Search & Rescue (SAR) Procedures: A set of organized and systematic actions designed to locate and assist individuals in distress or danger. In the context of the glossary, SAR procedures are part of the training objectives, emphasizing the importance of efficiently conducting search and rescue operations in challenging environments.

Secondary Fire: A fire that occurs as a result of the dispersal of burning materials, such as splinters, during the primary explosion. Secondary fires contribute to the overall hazard posed by a BLEVE.

Shut-off Valve: A valve, often part of the Lung Demand Valve (LDV) that can be closed to stop the flow of air. In the glossary, the shut-off valve is mentioned in the context of doffing the SCBA set, indicating the steps to press the shut-off valve.

Simulator: A device designed to replicate real-world conditions for training or testing purposes. In this context, a simulator for firefighting operations in petroleum facilities.

Single-Headed Hydrant: A hydrant with one outlet, is often deployed in certain scenarios such as drilling rigs (as per OISD std. 189).

SOP (Standard Operating Procedure): Established procedures to be followed during specific operations to ensure safety and consistency.

Spectacular Scene: A visually striking and impressive scene, often characterized by the presence of smoke, flame, or other dramatic elements. Tanker truck emergencies are described as creating a spectacular scene due to their visual impact.

Spray Pattern: A dispersed pattern of water or foam ejected from the fire monitor, covering a broader area and useful for general fire suppression.

Tanker Truck Emergency: A situation involving a tanker truck transporting various types of liquid fuels that poses a potential risk due to factors such as leakage, overfilling,

collision, rollover, or ignition. The glossary emphasizes the rarity but high risk associated with these incidents.

Trailer Fire Pump: A portable pump mounted on a trailer that can be transported to the scene of a fire. Participants in the module learn the operation of the trailer fire pump.

vapor Pressures: The pressure exerted by the vapor of a substance in equilibrium with its liquid phase at a particular temperature. High vapor pressures are a factor in the occurrence of BLEVE.

Venturi: A device in the water cum foam monitor that creates a vacuum to draw in foam concentrate and mix it with water for firefighting.

Walkie-Talkie Sets: Portable communication devices are used for wireless communication between team members.

Structure of the Module

The module titled "Training Module on Firefighting for Oil installation in Hydrocarbon Sector Volume I" covers critical aspects of disaster preparedness and response specific to the oil industry. It addresses hazards and risks, fire prevention philosophy, and safety protocols at onshore installations. Practical components include hands-on training with firefighting equipment, demonstrations such as BLEVE (Boiling Liquid Expanding Vapor Explosion), fire hydrant operation, communication methods, use of self-contained breathing apparatus, fire management in oil storage tanks, road tanker fires, rig fires, and confined space rescue techniques.

- Hazards & Risks in Oil Sectors.
- Fire Prevention & Protection Philosophy in Petroleum Industries.
- Fire Safety at Onshore Oil Installations.
- Hands-on training on the use of different portable fire extinguishers during Oil pipeline leakages.
- Familiarization with Fire Fighting System (FFS) at Fire Fighting Training Grounds.
- Demonstration of BLEVE (Boiling Liquid Expanding vapor Explosion).
- Fire Hydrant Operating Techniques and Communication Procedures.
- Physiology of respiration, survival in smoke, evacuation procedures & Donning/Doffing procedures of Self-contained breathing Apparatus (SCBA) sets.
- Combating Fire inside Oil Storage Tank with Foam System/ available firefighting systems.
- Tackling Leakage and Fire in a Road Tankers.
- Fire Fighting and Search & Rescue operation during a fire in a Drilling / Work over Rig.

Hazards & Risks in Oil & Gas Sector:

» Understanding Oil & Gas Industry Disasters

The petroleum industry in India traces back to 1889 when the first oil stores in the country were found close to the town of Digboi in the state of Assam. The natural gas industry in India started during the 1960s with the revelation of gas fields in Assam and Maharashtra (Mumbai High Field). It is continued since then, the industry has been exposed to different

types of hazards that caused huge damage and loss in terms of human lives, the economy, resources, infrastructure, assets, and the environment. These hazards have been attributed to different factors, conditions, and processes.

» **Major Hazards in the Oil and Gas Industry are due to**

- a) Fire & Explosion
- b) De-containment of Toxic gas like H₂S
- c) Confined Spaces
- d) High Pressure lines & equipment
- e) Falls
- f) Struck-By/Caught-In/Caught-Between

» **Disaster Management in Oil & Gas Industry**

These days most oil & gas installations & refineries are looking at "Disaster Management" as part of the disaster that is struck by internal reasons of any operational failures or uncontrolled situations within the plant. It does not consider well any disaster that goes beyond its limit and or is caused by external factors.

A significant crisis can be created due to failure of operating and containment systems or due to natural hazards like cyclones, earthquakes, floods, lightning, etc. As of now, the understanding in the case of natural hazards is that not much may be possible to avoid their occurrences.

Accordingly, the on-site "Emergency Preparedness Plan" is developed, if the scenario remains within the premises. However, in an eventuality of such catastrophe spreading beyond the boundary of premise, they have off-site "Emergency Preparedness Plan" or "Disaster Management Plan" prepared. The local authorities, not only get involved to develop such a document, but ensure that such a document is developed partnering all the neighboring industries and other stakeholders. Surely, this helps in sharing of resource at the time of such disasters.

This "Disaster Management Plan" document predominantly refers to aspects of industrial disastrous situations, if misfortune, the company faces, due to its operations as well as disasters that may arise due to external factors. A good and comprehensive disaster/emergency/crises preparedness plan can help in educating all stakeholders & concerned as well as employees to minimize the damages and losses through well-conceived proactive, collaborative, and coordinated actions.

» **Stages of Disaster Risk Management:**

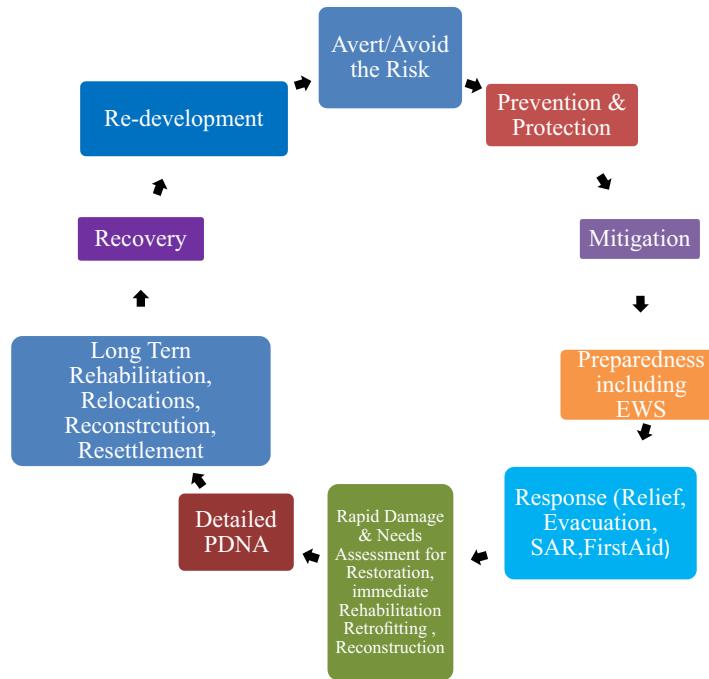


Figure 1 Stages of Disaster Management Cycle

» **Risk Management:**

1. Avoid the Risk:

- Eliminating hazards, activities, and exposures to prevent negative impacts on an organization and its assets.

2. Prevention and Protection:

- Focuses on preventing human hazards from natural disasters or attacks.
- Utilizes preventive measures for more permanent protection.
- Fire protection systems and prevention strategies are crucial.

3. Mitigation:

- Takes steps to prevent future emergencies and minimize their effects.
- Aims to reduce vulnerability to disaster impacts.

4. Preparedness:

- Takes actions ahead of time to be ready for emergencies.

- Understands potential effects on productivity and implements preparedness measures.

5. Response:

- Protects people and property immediately after a disaster.
- Occupant safety relies on preparedness levels.
- Shifts focus from immediate threats to repairs, restoration, and planning for reconstruction.

6. Rapid Damage & Need Assessment:

- Quantifies physical damage to infrastructure.
- Describes the impact on people's lives and livelihoods.

7. Recovery and Reconstruction:

- Restores the organization following disaster impacts.
- Aims for physical, environmental, economic, and social stability.
- Recovery phase duration varies based on the severity of the incident.

8. Re-development:

- Rebuilds degraded infrastructure for long-term development.

» Industrial Accidents in the Oil and Gas Sector:

The challenge of major accidents/ incidents/disasters in the Oil & Gas industry, along with the importance of risk management has been highlighted below:

» Challenges:

- The high magnitude and cost of major incidents.
- Factors include large inventories, energy intensity, hazardous materials, complex processes, and extensive transportation systems.

» Importance of Risk Management:

- Emphasizes the need for robust risk management practices in the oil and gas sector.
- Highlights the potential consequences of industrial accidents on both human lives and financial stability.

Unfortunately, industrial accidents/ incidents/disasters have occurred throughout history. Many have resulted in a tragic loss of life and significant financial consequences. The magnitude and cost of major incidents in the oil and gas sector are often very high due to the large inventories, energy intensity, and flammable/explosive/toxic nature of the raw

materials and products, the complex process technologies involved, and the diverse and extensive types of transportation, storage and distribution systems required for these hazardous materials. A few examples are as below:

1. Piper Alpha Disaster:

Incident Title	Gas Condensate Rejection Pump Leak
Incident Type	Explosion and Fire
Date	6 th July 1988
Country	UK (offshore Scotland)
Location	Piper Oil Field (North Sea)
Fatalities	167
Injuries	-----
Cost	US\$ 2.4 bn (2021) – Ref. 3
Incident Description	A standby condensate pump for reinjecting gas condensate into an oil export line on the Piper (Alpha) platform had been de-energized for maintenance. Its discharge Pressure Safety Valve (PSV) was also removed and blind flange assemblies were fitted to the open PSV pipe connections. Meanwhile, the running condensate pump failed and would not restart. Liquid levels in the gas/liquid separation system were rising and would eventually trigger a total shutdown of the platform if not reversed. Night shift operators were aware the standby pump had been taken out of service for maintenance by the day shift but believed the work had not yet begun, so they decided to re-energize and start the standby pump. Gas condensate leaked from a PSV blind flange assembly; it found an ignition source and exploded. The explosion was soon followed by an oil pipe rupture and pool fire. The incident escalated rapidly as 3 high-pressure gas lines ruptured after 20, 50, and 80 mins, respectively, creating a towering inferno. Smoke and flames outside the accommodation.
Incident Analysis	<p>The basic cause (most probable) was a Loss of Primary Containment (LOPC) of hydrocarbon condensate due to overpressure of a temporary blind flange assembly after a pump undergoing maintenance was started in error.</p> <p>Critical factors included:</p> <ol style="list-style-type: none"> 1) The platform was originally designed to produce and export oil only but was extensively modified to also enable the export of gas,

	<ol style="list-style-type: none"> 2) Gas compression and condensate reinjection facilities were retrofitted beneath the control room, electrical utility, and accommodation modules, 3) Absence of fire protection for structural steel and gas risers, 4) Continued operation of inter-connected oil production platforms after the first explosion. <p>Root causes included:</p> <ol style="list-style-type: none"> 1) Inadequate control of work (work permit systems), 2) Poor communication (shift handover and inter-platform), 3) Inadequate management of change (retrofitting a gas treatment system on a congested platform), 4) Inadequate protection (absence of automatic shutoff valves and dedicated deluge systems for gas risers), 5) Poor emergency preparedness(failure to conduct evacuation drills and to depressurize the subsea pipelines), 6) Inadequate leadership (personal safety prioritized over process safety).
Lessons Learned	<p>Offshore safety legislation should be goal-setting rather than rule-based to foster innovation and continuous improvement in installation integrity,</p> <p>Owner/operators of fixed and mobile offshore installations should submit a Safety Case document to the regulator detailing how major accident risks and safe evacuation, escape and rescue of personnel are managed,</p> <p>Production platforms should be provided with fire and gas detection systems, explosion protection, and active (water deluge) and passive (insulation) fire protection systems, Production platforms should have Temporary Safe Refuges (TSRs) which protect personnel from external fire and smoke while an emergency is assessed and/or preparations are made for evacuation, Evacuation drills should be routinely practiced.</p>
More Information/ Source of Information	<ul style="list-style-type: none"> • "Public Inquiry into the Piper Alpha Disaster, Volumes 1 and 2", Her Majesty's Stationery Office (HMSO), ISBN 0-10-113102-X (1990), • "Piper Alpha - What Have We Learned?" F. Macleod and S.M. Richardson, IChemE Loss Prevention Bulletin 261 (2018), • "100 Largest Losses in the Hydrocarbon Industry", Marsh Property Risk Consulting Practice, 27th Edition (2022).

2. MHN Platform Fire & Explosion

Incident Title	Support Vessel Collision With Platform
Incident Type	Explosion and Fire
Date	27 th July 2005
Country	India (offshore)
Location	Mumbai High North Oilfield (Arabian Sea)
Fatalities	22
Injuries	-----
Cost	US\$ 630 m (2021) – Ref. 3
Incident Description	A multi-purpose support vessel (MSV) was carrying out a medical evacuation of an injured crewmember to the Mumbai
Credit: Health & Safety Executive/ONGC	<p>High North production platform (helicopters had been grounded due to monsoon conditions. The platform Offshore Installation Manager (OIM) agreed the injured person could be transferred in a basket via a cargo loading crane. The MSV had problems with its computer-assisted dynamic positioning system, so it was brought in stern-first under manual control. During this operation, the MSV experienced a strong heave and its helideck struck one or more of the export gas-lift risers, causing a high-pressure release. An explosion and intense fire followed. The fire escalated rapidly, and the platform was abandoned. Within 2 hours, the production platform had collapsed into the sea. Adjacent platforms were severely damaged by heat radiation; the MSV also caught fire.</p> <p>After fires on the MSV had been extinguished, it was towed offsite and abandoned. Six divers in saturation chambers on the MSV were left behind but were rescued 36 hrs later. The MSV sank soon afterward.</p>
Incident Analysis	<p>The basic cause was a collision of the MSV with the production platform, resulting in the rupture of one or more export gas risers.</p> <p>Critical factors included:</p> <ol style="list-style-type: none"> 1) Risers and platform cargo loading zones were located on the prevailing weather side of the platform, 2) Risers were located outside the jacket, 3) Riser collision protection guards were only designed for smaller offshore supply vessels (not large MSVs),

	<ol style="list-style-type: none"> 4) Risers had no fire protection, 5) Alternative medical evacuation methods were not available (helicopters grounded, leeward cargo loading crane unavailable for basket transfer, etc.), 6) MSV's dynamic positioning system malfunctioned. <p>Root causes included:</p> <ol style="list-style-type: none"> 1) Inadequate design (riser location on prevailing weather side of platform and close to cargo off/loading crane), 2) Failure to apply inherently safer design (ISD) principles (locate risers within jacket or tube/caisson-type protective sleeves), 3) Inadequate procedures (ship/platform collision risk management), 4) Impaired judgment (MSV Captain and platform OIM were under extreme pressure to undertake medical evacuation as all other options were exhausted).
Lessons Learned	<ol style="list-style-type: none"> 1) India set up a regulatory body to provide oversight of offshore oil and gas production, 2) Risers are safety-critical elements (due to high inventory) and should be subjected to independent risk assessment, 3) Risers may require subsea isolation valves (SSIVs) to limit the consequences any riser damage below topsides emergency shutdown valves (ESDVs), 4) Riser fire protection should include fire-resistant insulation and deluge systems, 5) Risers should be protected against collision, 6) Risers should be located away from platform cargo loading zones, 7) Minimum separation between production and accommodation platforms should be determined by fire and explosion modelling, 8) Hyperbaric evacuation points should be provided for divers.
More Information/ Source of Information	<ul style="list-style-type: none"> • "Mumbai High North Platform Disaster", J. Daley (2013), • "Guidelines for Ship/Installation Collision Avoidance", the United Kingdom Offshore Operators Association (2010),

	<ul style="list-style-type: none"> • "100 Largest Losses in the Hydrocarbon Industry", Marsh Property Risk, • Consulting Practice, 27th Edition (2022).
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» **Hazards in Oil & Gas Industry**

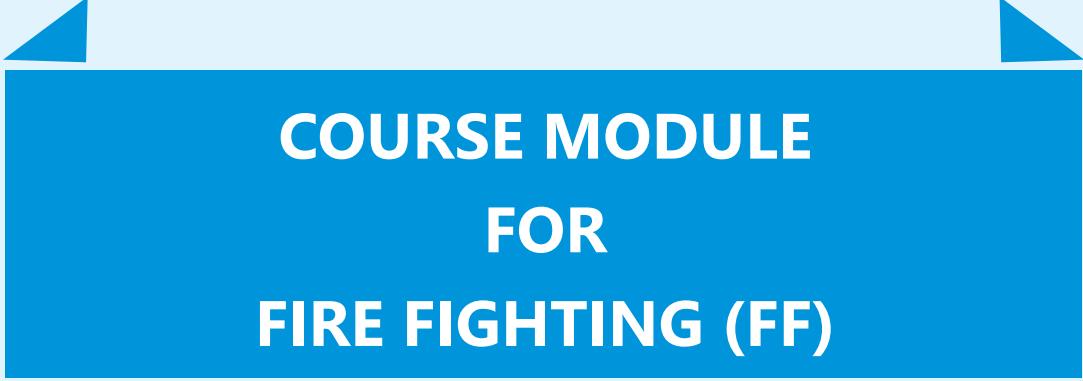
Workers in the oil and gas industries face the risk of fire and explosion due to the ignition of flammable fumes or gases. Flammable gases, such as well gases, vapors, and hydrogen sulphide, can be released from wells, trucks, production equipment, or surface equipment such as tanks and shale shakers.

• **Health Hazards Associated with Oil and Gas Extraction Activities.**

Oil and gas well drilling and servicing activities involve the use and production of potentially hazardous materials. OSHA, the National Institute for Occupational Safety and Health (NIOSH), and industry and safety groups continue to evaluate the type and extent of chemical and other health hazards across the industry.

Potential health hazards are mentioned below. The readers may refer to the Standards and Enforcement section for detailed information on the evaluation and control requirements for each:

- Diesel Particulate Matter
- Hazardous Chemicals
- Hydrogen Sulphide
- Naturally Occurring Radioactive Material (NORM)
- Silica
- Temperature Extreme



**COURSE MODULE
FOR
FIRE FIGHTING (FF)**



Fire Prevention & Protection Philosophy in the Petroleum Industry

1.1 Definition of Fire:

Fire is a chemical reaction characterized by the combination of a combustible material with oxygen from the atmosphere at ignition temperature. This process results in the release of smoke, heat, light, and fire gases. Except in cases of spontaneous ignition due to an exothermic reaction chain, the initiation of this reaction requires the application of external heat to the fuel.

1.2 Chemistry of Fire:

When a substance undergoes a chemical change involving its combination with oxygen, at a given temperature it typically produces a certain amount of heat. This chemical transformation is known as oxidation, and it is an exothermic reaction that produces heat energy. The specific form of oxidation accompanied by the release of heat and flame/light is referred to as combustion. The visible manifestation of this process is the emission of light energy in the form of a flame.

1.3 Elements of Fire

To begin and survive, fire needs 3 basic elements viz.

- Fuel
- Oxygen
- Heat



Figure 2 Fire Triangle

The above-mentioned 3 elements of fire can be represented in the form of a triangle called a Fire Triangle:

If any one of these three is not present, there will be no fire.

By the same logic, if any one of these is removed from the scene of fire, the fire will be extinguished.

1.5 Fire Tetrahedron

Once a fire is initiated, a fourth element, known as chain reaction also plays an important role in sustaining the chemical reaction. To represent this factor in "Fire Triangle" was not possible, so a new figure "Fire Tetrahedron" has been introduced.

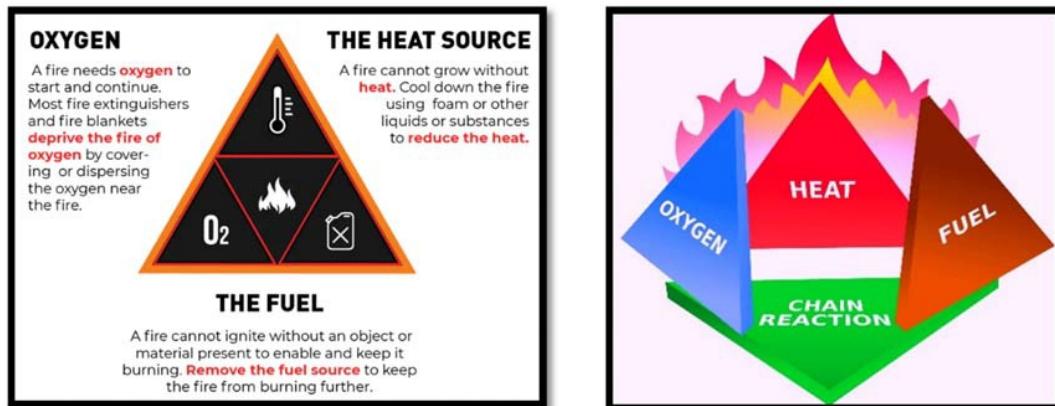


Figure 3 Fire Tetrahedron

Adding enough water to the "fire reaction" is the way to stop most fires.

1.6 Combustion

Combustion is a continuous process requiring continuous supply of new fuel and new oxidizer in the flame zone. In addition, the new fuel and new oxidizer must be brought up to ignition temperature before they react by high speed collision of their mole-clues to start the chain reaction between their free radicals which bring about the release of available energy mainly in the form of heat. Rate of combustion varies from substance and is described as slow, rapid or spontaneous.

a) Slow Combustion:

A chemical reaction accompanied by slow evolution of heat, but not light, is slow combustion, e.g. cotton waste burning in an ill-ventilated area.

b) Rapid Combustion:

A chemical reaction accompanied by a rapid evolution of heat and in many cases by an appreciable amount of light is called rapid combustion e.g. petroleum products.

c) Spontaneous Combustion:

Spontaneous combustion, also known as spontaneous ignition, is a form of combustion initiated by self-heating. This process involves an increase in temperature resulting from exothermic internal reactions. It progresses through thermal runaway, characterized by a rapid acceleration of self-heating leading to high temperatures, ultimately culminating in auto-ignition.

1.7 Fire Gases

During a fire (combustion process) besides smoke, heat, and light, various gases are also generated, these gases are collectively referred to as "Fire Gases". The presence of fire gases persists even after the combustion products have cooled to normal temperatures. These gases can have various effects on human health, with toxicity being a significant concern. Many fire gases exhibit toxic properties, with some proving lethal even in small doses. The composition of the fuel, the availability of oxygen, and the temperature reached during combustion determine the types of fire gases generated. The potential impact of these gases on human life underscores the importance of understanding and managing their presence in fire-related incidents, including:

- a. Carbon Dioxide
- b. Carbon Monoxide
- c. Hydrogen Sulphide
- d. Sulphur Dioxide
- e. Ammonia
- f. Hydrogen Cyanide
- g. Hydrogen Chloride
- h. Nitrous Oxide
- i. Nitric Oxide
- j. Phosgene
- k. Acrylic Aldehyde

Due to the production of carbon in both solid and hydrocarbon liquid fires are two gases- Carbon Monoxide and Carbon Dioxide-commonly generated in most fire incidents.

1.8 Propagation Stages of Fire:

Fire propagation typically occurs in four distinct stages, each of which can be detected using specific devices:

a) Incipient Stage:

- Only invisible combustion by-products are emitted.
- No visible smoke, flame, or heat is present.

b) Smouldering Stage:

- Combustion products become visible as smoke.
- Flame or heat is not yet present.

c) Flame Stage:

- Actual fire is now present.
- Appreciable heat is not immediately noticeable but follows shortly.

d) Heat Stage:

- A substantial amount of heat, along with smoke and toxic gases, is produced.
- Rapid expansion in space occurs.

1.9 Transmission of Heat:

a) Conduction:

- Heat energy transmission occurs point-to-point.

b) Convection:

- Heat energy is transferred through the movement of heated vapors.

c) Radiation:

- Heat energy is transmitted through electromagnetic waves.

1.10 Flash Point:

- The flash point is the lowest temperature at which a liquid releases enough vapors to form a flammable vapor-air mixture.
- It results in a momentary flash when a small pilot flame is introduced.

1.11 Fire Point / Ignition Point

It is the temperature at which, heat from the combustion of a liquid is capable of producing sufficient vapors for continuous combustion. It is also known as Ignition Temperature or Ignition point. Fire Point is always higher than the Flash Point.

1.12 Auto Ignition Temperature / Kindling Point

It is the lowest temperature at which a substance ignites spontaneously in a normal atmosphere without introduction of any external source of ignition viz. flame or spark. This temperature is required to supply the activation energy needed for combustion.

Under certain conditions some materials undergo spontaneous combustion such as coal, haystacks etc.

1.13 Difference between Flammable & Combustible Liquids

Based on their Flash Points, petroleum liquids can be categorized as:

a) Flammable Liquids:

- Flammable liquids encompass petroleum-based liquids with a flash point below 37.8°C (100°F), including examples such as petrol and naphtha.
- It is noteworthy that flammable liquids, like petrol and naphtha, are deemed more hazardous compared to combustible liquids.

b) Combustible Liquids:

- Combustible liquids are defined as petroleum-based liquids with a flash point at or above 37.8°C (100°F).
- This category includes petroleum liquids that, while still posing a fire risk, are considered less hazardous than their flammable counterparts.
- This category includes the petroleum liquids that range from 37.8°C (100°F) flash point of Kerosene to 232°C (450°F) flash point of some motor oils.

1.14 Classification of Petroleum Liquids:

Petroleum liquids are categorized based on their flash points:

- a) Class A: Liquids with a flash point below 23°C (73°F), such as petrol and naphtha.
- b) Class B: Liquids with a flash point at or above 23°C but below 65°C (150°F), including HSD, SKO, ATF, etc.
- c) Class C: Liquids with a flash point at or above 65°C but below 93°C, like furnace oil and LSHS.
- d) Unclassified: Liquids with a flash point of 93°C and above.

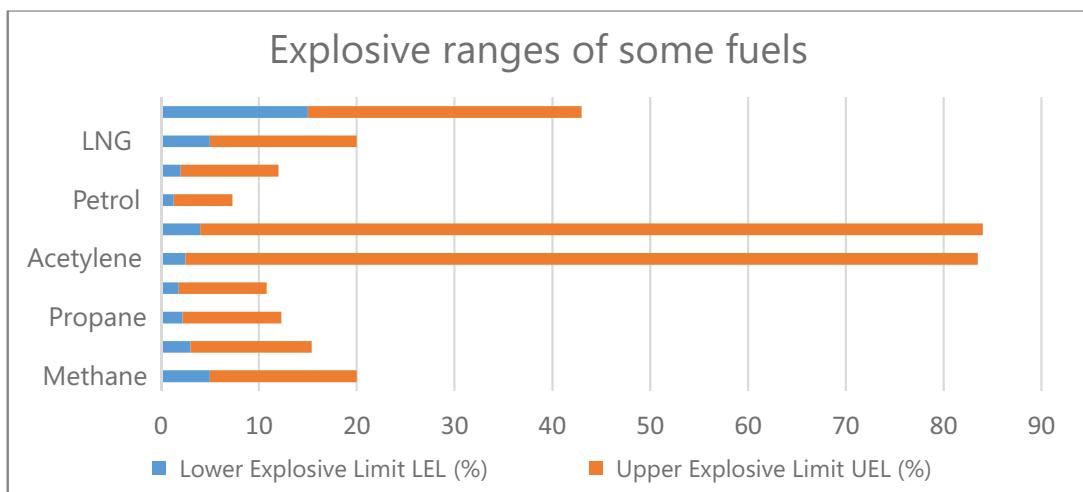
1.15 Lower Explosive Limit, Upper Explosive Limit & Explosive Range:

- a) Lower Explosive Limit (LEL): The minimum concentration of vapor in the air below which flame propagation will not occur; also known as "Lower Flammability Limit (LFL)."
- b) Upper Explosive Limit (UEL): The maximum concentration of vapor in the air in which flame propagation will not occur; also known as "Upper Flammability Limit (UFL)."
- c) Explosive/Flammable Range: The concentration of flammable vapor in the air falling between the upper and lower explosive limits is referred to as the "Explosive or Flammable Range."

For any substance, a wider range indicates a more dangerous nature.

Fuels	Lower Explosive Limit LEL (%)	Upper Explosive Limit UEL (%)
Methane	5.0	15.0
Ethane	3.0	12.4
Propane	2.2	10.1
Butane	1.8	9.0
Acetylene	2.5	81.0
Hydrogen	4.0	80.0
Petrol	1.3	6.0
LPG	2.0	10.0
LNG	5.0	15.0
Ammonia	15.0	28.0

Table 1 Explosive Ranges of Some Substances



1.16 Classification of Fire:

With the reference to IS: 2190 and based on the type of material (fuel) involved, fires are classified into the following four classes:

a) Class 'A' Fires:

- Fires involving ordinary combustible materials of an organic nature, such as wood, paper, textiles, jute, rubber, plastic, etc.

- The cooling effect of water is essential for extinguishing these fires.
- These are very slow in initial development & growth and easier to contain.
- Leaves a residue (ash) after the material has been burned out.
- Can be extinguished by water and ABC / MAP-type dry chemical powder.

b) Class 'B' Fires:

- Fires involving flammable & combustible liquids, viz. diesel, petrol, kerosene, grease, paints, etc.
- Develop and grow very rapidly.
- Do not leave any residue (ash) after the material has been burned out.
- Can be extinguished by DCP & Foam

c) Class 'C' Fires:

- Fires that involve flammable gases under pressure, including liquefied gases like methane, ethane, LPG, LNG, CNG, etc.
- Develops very rapidly
- Do not leave any residue (ash) after the material has been burned out.
- These types of fires can be extinguished by water spray and DCP.

d) Class 'D' Fires:

- Fires that involve combustible or reactive metals such as magnesium, titanium, zirconium, lithium, sodium, etc.
- These metals are usually difficult to ignite but create intense fire once started.
- These are reactive to water and other conventional fire-extinguishing agents.
- Therefore, requires special techniques and fire extinguishing media.

1.17 Fire Extinguishing Techniques

I. Starvation:

Removing the fuel or combustible material from the scene of fire. It can be achieved by:

- a) Stopping the supply of gas by closing the valves.
- b) Transferring the product from the burning tank.
- c) Isolating the fire from the vicinity of combustible material by using a water curtain.
- d) Subdividing the fire into smaller ones e.g. forest fires.

II. Smothering:

Limiting/cutting off the supply of oxygen (air) from the scene of fire. It can be achieved by:

- Decreasing the amount of oxygen content in the surroundings by stopping the ventilation of the fire area.
- Introducing an inert gas in the fire area.
- Applying the foam blanket over the burning liquid surface.

III. Cooling:

- Bringing down the temperature of the burning substance below its ignition temperature.
- It can be achieved by applying the water spray in the burning area.

IV. Chain Inhibition:

Breaking the chemical chain reaction by removing the free radicals from the flame zone, prevents further propagation of flame. It can be achieved by using the following fire-extinguishing agents:

- Dry Chemical Powder (DCP)
- HALON, FM-200 / NAF / NOVAC etc.

1.18 Fire Extinguishing Media

a) Water:

- Water stands as the oldest, most efficient, cost-effective, readily available, and relatively stable fire extinguishing medium.
- It is being applied in various forms like solid jet, spray, and very fine fog/mist.
- It has an excellent cooling property. Every gram of water absorbs 1 calorie of heat when its temperature rises by 1°C.
- When heated, it expands about 1700 times, which displaces an equal amount of air surrounding the fire thus reducing the volume of oxygen.
- Extinguish the fire mainly by cooling. And smothering & dilution to some extent.
- Most suitable extinguishing media for Class 'A' & 'C' fires.

b) Foam:

- Foam is applied to cover the burning liquid surface, creating a blanket that cuts off the supply of oxygen.
- Extinguish the fire mainly by smothering action.
- Depending upon the method of preparation, foam is of two types:

Chemical Foam

It is produced by mixing of two chemicals viz. Aluminium Sulphate with Sodium Bicarbonate solution and a foam stabilizer. Used in portable fire extinguishers.

Mechanical Foam

A readymade foam compound is proportioned with water through venturi action to produce the desired foam. Mechanical foam is of the following types:

- Protein-based foam
- Fluoro-protein foam (FP)
- Aqueous Film-Forming Foam (AFFF)
- Film-Forming Fluoro protein Foam (FFFP)
- Alcoholic-Resistant Foam (AFFF-AR & FFFP-AR)
- High Expansion Foam

* These comes in 1%, 3% & 6% concentration.

* Most suitable for Class 'B' fires.

c) Dry Chemical Powder:

- It is a dry powder mixture.
- Extinguishes the fire mainly by breaking the chemical chain reaction, and to some extent by smothering & cooling also.
- Several types of DCP are available viz. SBC, PBC (Purple-K), PC (Super-K), PBC- Urea Base, OLFEX and ABC/MAP.
- While all other types of DCP are suitable for Class 'B' & 'C' fires.
- ABC / MAP is suitable for class 'A', 'B' & 'C' fires.

d) Carbon Dioxide:

- It is a colourless & odourless gas at normal temperature and electrically non-conductive.
- Do not support combustion.
- Extinguishes the fire by diminishing the oxygen content within the fire area.
- Also produces some cooling effect.
- Leaves no residue after use. Hence best suited for electrical equipment.

e) Halons:

- HALONS are halogenated hydrocarbon compounds. It is the most effective fire-extinguishing agent than all other agents.

- It extinguishes the fire by interrupting the chain reactions, which take place at flame zone for continuance of fire.
- It is twice as effective as CO_2 on a weight basis and five times on a volume basis.
- It is non-conductive and leaves no residue or traces when applied, therefore it is most suitable for electronic & electrical equipment fires.
- Though, there are number of Halon products, but only two viz. Halon-1211 and Halon-1301 were most popular. While former is used in portable fire extinguishers, latter is used in fixed installation for total flooding systems in enclosed space.
- However, due to adverse effect on Ozone layer, these had been phased out.

f) Halon Alternatives (Clean Agents):

- (i) Halocarbon Compounds:
 - FM-200, NAF-PIV, NAF-SIII, NOVAC etc.
 - Extinguishes the fire by cooling.
- (ii) Inert Gas Mixtures:
 - ARGOTEC: Argon only
 - ARGONITE: Argon & Nitrogen
 - INERGEN: Argon, Nitrogen & Carbon Dioxide
 - Extinguishes the fire by smothering & cooling
- (iii) Water Mist / Fog Systems:
 - Very fine water droplet size of 20 to 70 microns.
 - Excellent heat extraction capabilities.
 - Extremely effective in tackling class A & B fires.
 - Extinguishes the fire by cooling & smothering.
- (iv) Aerosols:
 - Finely dispersed powder aerosols has an outstanding extinguishing capability.
 - These are generated through the reaction between an oxidizing agent and a solid fuel, resulting in the production of fine solid particulate aerosol when ignited.
 - Provides fire extinguishment similar to DCP.

g) Dry Powders:

- Also referred to as "Special Dry Powders", developed for fighting the Class D (metal) fires.

- Extinguishes the fire by smothering.
- Types of 'Dry Powders':
 - a) Sodium Chloride Base
 - b) Sodium Carbonate Base
 - c) Graphite Base
 - d) Ternary Eutectic Chloride (TEC): Mixture of 3 salts: Potassium, Sodium & Barium Chlorides.

h) Other Agents:

- (i) Wet Chemicals
 - Solutions of salts like potassium acetate + PBC/ potassium citrate.
 - Used for cooking oils / fat fires.
- (ii) Sand
 - Useful for small spill fires of flammable liquids
 - Also utilized to obstruct or conceal an oil spill.
- (iii) Steam
 - Steam works by smothering action
 - Useful in enclosed spaces
- (iv) Saw Dust:
 - Mixed with soda to extinguish small size oil fires
 - Not readily available, hence use was discontinued.

1.19 Hazards in E&P Sector

a) Definition of Hazard & Risk

Hazard: A source or circumstance that possesses the potential to induce injury, illness, death, property damage, environmental harm, business interruption, or a combination of these.

Risk: The likelihood or potential for damage, injury, liability, loss, or other adverse occurrences arising from external or internal vulnerabilities, and which can be mitigated through proactive measures.

Risk = Probability of an event x Consequence

$$R = H \times V \times E \times (value) / C$$

b) Activities in E&P Sector

Activities in petroleum sector can be broadly categorized as under:

Upstream

- Exploration
- Drilling
- Production

Downstream

- Processing / Refining
- Transportation
- Marketing

c) Activities of Oil & Gas Sector

Present day, activities in Oil & Gas Sector (ONGC) are some-what mix of above two categories ranging from "Exploration to marketing" of hydrocarbons:

- a. Exploration
- b. Drilling
- c. Logging
- d. Well Completion & Testing
- e. Production
- f. Work Over & Well Stimulation
- g. Processing / Refining
- h. Transportation
- i. Marketing
 - Each of the above activity carry one or more hazard.
 - Major hazards associated with Oil & Gas Sector (ONGC) or any other HC E&P industry are fire, explosion, sudden pressure release and toxic release etc. and out of these, fire is the most common, but explosion is significant in terms of fatality and losses.
 - Oil & Gas Sector (ONGC) encounters all types of common hazards known in the industrial operations, besides some special types of fire hazards specific to HC industry.

d) Categorization of Hazards

Based on their genesis, hazards can be broadly categorized as:

- a) Technological Hazards
 - Blow-out: Oil / Natural Gas / Toxic Gases / Water / Sand
 - Fires: Oil / Gas / Dry Vegetation / Electrical
 - Explosion: Explosives / UVCE / CVCE / BLEVE / Dust
 - Rupture: Tanks / Pipelines / Vessels
 - Leakage: Natural Gases / Toxic Gases
 - Spillage: Oil / Hazardous Chemicals
 - Over flow / Over pressure / Overheating
 - Failure of Control Mechanism
 - Static Electricity
 - Release of Radio-Active materials
 - Collisions: Road tankers / Rail Wagons / OSV / MSV / Helicopters
 - Maintenance Activities (C&M Jobs)
 - High Pressure / High Temperature
- b) Natural Hazards
 - Flood
 - Earthquake
 - Landslide
 - Lightning
 - Cyclone / Hurricane / Tornadoes etc.
 - Volcanoes
 - Tsunami
 - Land Subsidence
 - Drought
- c) Intentional Hazards
 - Pilferage attempts
 - Human error
 - Negligence

- Over-confidence
- Ignorance
- Unsafe Acts
- Sabotage
- Arson
- Terrorism
- War

1.20 Hazardous Area Classification

a) Hazardous Area:

A hazardous area is defined as a space where the presence of a flammable atmosphere is anticipated in concentrations and frequencies that necessitate special precautions in the construction, installation, and use of electrical apparatus and equipment during both normal and abnormal operating conditions.

b) Hazardous Zone:

Zone 0: An area where a hazardous atmosphere is continuously present.

Zone 1: An area where a hazardous atmosphere is likely to occur under normal operating conditions.

Zone 2: An area where a hazardous atmosphere is likely to occur only under abnormal operating conditions.

1.21 Sources of Ignition:

Ignition occurs when sufficient heat is generated to initiate combustion. The factors influencing the resulting combustion from a given ignition source include temperature, exposure time, and energy. It is always not possible in most working environments to avoid oxygen and fuel coming together to prevent fire. Therefore, quantities and locations of the fuels must be controlled and kept away from possible sources of ignition.

Ignition sources that may present in the operational area include:

a) Electrical Sparks & Arcs:

- An electrical "Spark" is the discharge of electric current across a gap between two dissimilar charged objects.
- An electrical "Arc" occurs when an electric circuit carrying current is interrupted (either intentionally by a switch or accidentally when a contact or terminal becomes

loosened, or a current-carrying conductor is broken). The electric current that is flowing through a contact will attempt to continue flowing when the contact is broken. An "Arc" travels across a wider gap than a spark.

- » Sources of electric sparks and arcs may include, but are not limited to, the following:
 - Electric Motors and Generators
 - Switches, relays & other arcing components of electric circuits under normal operating conditions.
 - Electric arc welding
 - Storage batteries
 - Fired vessel ignition devices
 - Internal Combustion engine ignition system
 - Lighting fixtures.
 - Electric powered hand tools

b) Static Electricity:

- If two objects are in physical contact and then separated, the objects may acquire an electric charge through friction or induction.
- Similar electric charges can be generated by the rapid flow of gases or liquids. If the objects are not bonded or grounded, they may accumulate sufficient electric charges to cause a spark discharge.
- The terms bonding and grounding are sometimes used interchangeably; however, they have different meanings. Bonding is conducted to eliminate a difference in potential between two objects, while grounding is done to eliminate a difference in potential between an object and the ground.
- Static electrical sparks are typically of very short duration and do not produce sufficient heat to ignite ordinary combustible materials like paper. However, they are capable of igniting flammable vapors and gases. Static electrical sparks may pose a problem in various situations such as fueling operations, filling containers, tanks, and pressure vessels, high-velocity fluid flow, drawing samples, drive belt operations, abrasive blasting, and steam cleaning.

c) Lightning:

Lightning is the discharge of an electric charge from one cloud to an opposite charge on another cloud or on the earth. Lightning can generate very high temperatures in any material with high resistance in its path. Lightning tends to discharge to high points such as antennas and flare stacks.

d) Chemical Reactions:

Some chemical reactions may produce heat capable of igniting the reacting substances.

e) Flame:

When common fuels burn, energy is released in the form of heat, typically accompanied by luminosity known as a flame. Situations where flame may be present include flaring, burners in process equipment, gas welding and cutting, engine operations, and the operation of heating, cooking, and other appliances.

f) Hot Surfaces:

Hot surfaces can serve as a source of ignition, including welding slags, fired vessel stacks, hot process and piping equipment, engine exhaust systems, frictional heat (e.g., slipping belts, unlubricated bearings), and hot metal particles from grinding.

g) Heat of Compression:

- When a flammable mixture is rapidly compressed, it may ignite if the heat generated by the compressing action raises the temperature of the vapor to its ignition point.
- Combustion due to the heat of compression may occur when hydrocarbon vapors or gases are mixed with air in situations such as improper purging of pressure vessels and other equipment during the introduction of hydrocarbons, packing or seal failure allowing supply air to mix with hydrocarbons, lubricating system failure in air compressors, and the admission of air into the suction of hydrocarbon gas compressors.

h) Manmade

- Improper house keeping
- Careless Smoking
- Vehicles without spark arrestor
- Wrong Operation
- Bypassing safety devices
- Human Failure
- Ignoring warning
- Arson
- Sabotage
- Terrorist attack

1.22 Prevention and Control Measures

- a) Utilizing electrical equipment or instruments designated for the specific zone in which they are situated.
- b) Ensuring adequate grounding for equipment.
- c) Installing a lightning protection system as a precautionary measure.
- d) Strictly follow OISD work permit system during the hot jobs.
- e) Follow good house-keeping practices.
- f) Periodic removal of wild vegetation and its proper disposal.
- g) Prohibition of smoking & use of match boxes / lighters in operational area.
- h) Where flammable materials are stored or used, ensure that:
 - Flammable materials are segregated from the source of ignition,
 - There shall be adequate ventilation, prohibit smoking and use flame proof equipment.
- i) Promptly eliminate the spillage / leakage of oil / gas.
- j) Regular inspection & maintenance, as per OEM's recommendations.
- k) Use spark arrestor, whenever vehicle is required to go inside the Installation.
- l) Ensure proper functioning of safety devices all the time.
- m) Use of non-sparking tools
- n) Take care of fire-fighting equipment; prevent its misuse.

1.23 Some Important Fire Phenomenon

a) Boil-over

Boil-over is a phenomenon observed during the combustion of specific crude oils within an open-top tank. After a prolonged burning period, a sudden escalation in fire intensity occurs, accompanied by the ejection of burning oil from the tank.

Three conditions must coexist for boil-over to take place:

- Presence of an open tank fire
- Existence of a water layer at the tank's bottom
- Generation of overheating heat waves in the fuel
- Crude oil inherently contains some entrained water and/or an emulsion layer. Additionally, crude oil tanks tend to accumulate water on uneven tank bottoms.

Boil-over is triggered when residues from surface burning become denser than the unburned oil, sinking below the surface to form a hot layer. This hot layer, referred to as a 'heat wave,' descends much faster than the regression of the liquid surface.

Upon reaching the water or water-in-oil emulsion at the tank's bottom, the heat wave causes the water to superheat, leading to boiling and conversion into steam. When water transforms into steam, its volume increases significantly (by 1700 times). Unless the steam can break out of the surface in large bubbles, it becomes entrained in the oil. The steamed oil undergoes a substantial volume increase, forcefully expelling a wave of burning oil from the tank. This burning oil erupts, subsequently falling and spreading beyond the bund walls of the tank.



Figure 4 Boil Over- Three Rivers Tank Explosion of 1990

b) Slop-over

Slop-over is not a violent eruption like a boil-over, as only surface oil is involved. It is an over flow of the contents of the tank. It occurs, when a water stream is applied to the hot surface of viscous burning oil and temperature exceeds the boiling point of water. The water sinks into the heat wave and is converted into steam. On its way out, the steam forms a froth that expands the hot oil in the heat wave to greater capacity and causes the froth to spill over from the top of the tank.



Figure 5 'Slop' Tank Catch Fire at West Tulsa Refinery

The fundamental difference between Boil-over & Slop-over is that, in case of slop-over refers to the reaction resulting from the water that has entered the tank since the initiation of the fire.

c) BLEVE

BLEVE or Boiling Liquid Expanding Vapor Explosion is caused by the rupture of a vessel containing pressurized liquid (e.g. LPG) above its boiling point. The rupture is often caused by a flame impinging on the surface of the vessel.

The vessel contains pressurized liquid and vapor above the liquid surface. The flame causes the vessel pressure to rise, and the relief valve to open to release the pressure. This causes the liquid level to drop, as it does so, the flame comes in contact with vessel surfaces above the liquid level, where there is no liquid to absorb the heat.



Figure 6 An example of BLEVE

The vessel wall begins to weaken, and it can no longer sustain the pressure, ruptures violently, causing the large fragments of the vessel to be projected at significant distances.

The released liquid undergoes rapid boiling due to pressure drop, which then releases large amounts of vapor. On contact with an ignition source, the vapor cloud will explode violently, often resulting in a large fire ball.

Fire ball can cause a wide spread damage due to flame contact & thermal radiation. Though the fireball lasts only for a brief period, its impact can be catastrophic.

d) Vapor Cloud Explosion (UVCE & CVCE)

Vapor clouds result from the loss of hydrocarbon containment, which can happen due to:

- Rupture or sudden depressurization of an LPG vessel
- Overfilling of a tank
- Evaporation of a large spillage
- Draining of an LPG vessel

When a substantial quantity of hydrocarbon, typically a low flashpoint liquid or gas, is released into the air and the mixture falls within flammable limits, all that is needed is a source of ignition to trigger a vapor cloud explosion.

e) Vapor Cloud Explosions can be categorized into two types:

- Confined Vapor Cloud Explosion (CVCE): Confined vapor cloud explosions occur in

enclosed spaces such as vessels, tanks, pipe pits, buildings, etc. The peak pressure of CVCE is considerably higher than UVCE, as seen in incidents like the Piper Alpha explosion.

- Unconfined Vapor Cloud Explosion (UVCE): Unconfined vapor clouds arise from the sudden or substantial release of flammable gas or vapor into the atmosphere. UVCE occurs when this cloud mixes with air within flammable limits and encounters a source of ignition.

Example: Finborough, 1974; Bunce field, 2005,



Figure 7 Unconfined vapor Cloud Explosion in a Refinery Complex, Venezuela

Two Dimensional Fires- These types of fires involve a single plane or flat surface where both the fire and fuel are present. Examples include tank fires, ground fires and trench fires.

Three Dimensional Fires- These are the complicated fires of falling liquid streams or fuel under pressure escaping from a container. Any fire resulting from leak of petroleum products from an elevated position falls under this category. LPG or light hydrocarbons escaping from a pressurized vessel is also a three dimensional fire.

f) Flash Fire

Flash fires occur when a cloud of flammable gas and air is ignited.

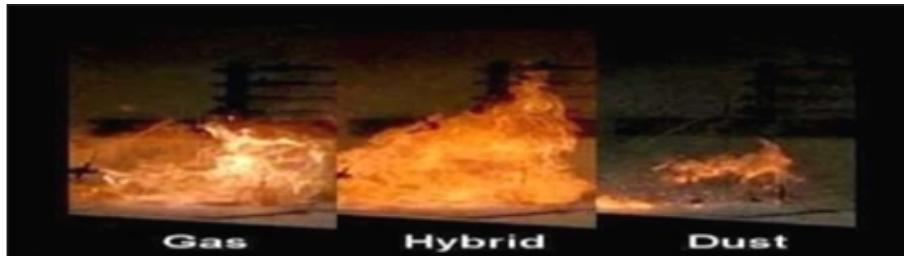


Figure 8 Flash Fires

g) Jet Fire

A jet fire occurs when a flammable liquid or gas is ignited after its release from a pressurized, punctured vessel or pipe.



Figure 9 Jet Fire

A jet or spray fire is a turbulent diffusion flame resulting from combustion of a fuel continuously released with some significant momentum in a particular direction or directions. Jet fires can arise from release of gaseous, flashing liquid (two phase) and pure liquid inventories.

Jet fires represent a significant element of the risk associated with major accidents, particularly on offshore installations. The high temperatures of burning fuels lead to structural failure of vessels/pipes and possible further escalation.

The consequence of jet fires depends on:

- Composition of the fuel,
- Conditions of release,
- Rate of release,
- Geometry of release,

- Direction, and
- Ambient air conditions

Low-velocity two-phase releases of condensate material can result in flames that are lazy, influenced by wind, buoyant, sooty and highly radiant, resembling pool fires. On the other hand, sonic releases of natural gas can lead to fires with relatively high velocity, which are less buoyant, less sooty, and consequently emit less radiant heat.

h) Pool Fire

Figure An example of Pool FireA pool fire occurs when an accumulation of liquid ignites, forming a pool on the ground, water, or other liquid surfaces. It is a turbulent diffusion fire burning above a horizontal pool of vaporizing hydrocarbon fuel with zero or low initial momentum.



Figure 10 An example of Pool Fire

The consequences of a pool fire depend on the diameter of the pool, which may rapidly spread over an area. Open fires are well-ventilated (fuel-controlled), whereas fires within enclosures may become under-ventilated (ventilation-controlled). Pool fires can be static (controlled pools) or "running" fires. They represent a significant risk factor associated with major accidents on offshore installations.

i) Deflagrations

Deflagrations are propagating chemical reactions, in which the propagation rate is well below the velocity of sound (330 m/s). In a flammable mixture in open atmosphere, the flame propagation is slow initially, but as the reaction heat causes expansion, the combustion rate is increased by turbulence in the mixture. As the confinement is weak in open atmosphere, the flame speed is unlikely to be high. In fact deflagration velocities

rarely exceed 10 m/s and due to this, pressure generated are low. However, even the pressure generated from deflagrations are strong enough to cause damage to structures.

j) Detonations

As opposed to deflagrations, detonations are extremely fast reactions; the reaction velocity exceeds the speed of sound (supersonic speed). Due to this, the blast effects of a detonation are pronounced in a zone close to the explosion. For detonation to occur in a flammable mixture, it is necessary to have some sort of confinement, which leads to the build-up of pressure. Hence, it is rare to have detonations in an open atmosphere, except under very unusual circumstances. The pressure build-up in case of detonations is at least twice as much in case of deflagration, though peak pressures will last for much shorter times.

In the case of vessels and pipes, which are likely to have flammable atmospheres, the likelihood of detonations is high, and special precautions have to be taken to prevent such occurrences. Flame speeds are to be very high approximately 2500 m/s.

In some situations, deflagrations can develop into detonations. This occurs as a result of the acceleration of the flame front, as it travels through the flammable mixture (e.g. in a confined space). If the rate of acceleration is sufficient for the velocity of the flame front to become supersonic, then the deflagration will become a detonation. Both types of explosions can have catastrophic consequences.

k) Difference between Fire and Explosion

A fire is when a substance rapidly consumes oxygen to produce heat and light.

An explosion is an event, where energy rapidly expands outward from the source, often creating a damaging shock wave.

Module- II

Fire Safety at Onshore Oil & Gas Installations

2.1 Types of Installations

» Upstream Sector

a) Mobile Installations Drilling Rigs

A streamlined mobile unit includes a derrick structure, a power-generating unit for operating the draw-works, a mud preparation unit, and other essential equipment. This setup is crucial for executing drilling operations in the Earth's crust through mechanical means, aiming to penetrate to the petroleum-bearing zones beneath the ground. The primary objective is to facilitate the exploration and development of oil and gas fields.



Figure 11 An example of Drilling Rig

Work-Over Rigs

It is a compact mobile unit comprising of derrick structure, equipment necessary for mud / work-over fluid preparation and power generation, etc. The unit is mainly used for oil and/ or gas well servicing to perform a variety of remedial operations on oil and/or gas well based on the technical requirement with the overall objective of restoring/increasing its production.



Figure 12 An example of Work-Over Rigs

b) Fixed Installations (Surface Installations)

• Well Head Installation (WHI)

It is a production installation typically established at the well site itself in the initial stage of field, where crude oil produced from well(s) is collected and stored temporarily in steel tanks for onward transportation through road tankers to the nearest GGC/ OCS.

- **Quick Production Set-up (QPS)**

A production installation typically established in new oil field areas, capable of connecting multiple wells to its infrastructure.

- **Early Production Set-up (EPS)**

Similar in nature to GGS/OCS but with smaller capacity, this production installation is usually deployed in the initial phases of oilfield development. It is designed for areas with a limited number of wells, and the aggregate petroleum storage capacity ranges from above 240 KL to 1000 KL for class A and B petroleum products.

- **Group Gathering Station / Oil Collecting Station (GGS / OCS)**

A production installation where petroleum products, particularly crude oil, are gathered from multiple wells through pipelines.

- **Central Tank Farm (CTF)**

It is a facility that receives petroleum through pipelines from different GGSs of one or more Surface Areas and stored in bigger tanks and after some further processing transferred to nearest designated refinery for final processing.

- **Gas Collecting Station (GCS) and Gas Compression Plant (GCP)**

A plant / station where gas is received, liquids separated, gas is dehydrated (if required) and gas is further compressed for onward transmission.

- **Oil & Gas Processing Plant**

A plant where oil / natural gas is collected and processed to produce Oil / LPG and other petroleum fractions. Drilling activities and facilities upstream of the Christmas tree of a well are not covered under this definition.



Figure 13 Examples of EPS / GGS / GCS / GCP

- **Plant**

- a) De-salter Plant**

A plant where crude oil is treated to remove the salt before dispatch to refinery for final processing.

- b) Chemical / Water Injection Plant**

A plant where water / chemicals injected into the wells with the help of pumps to improve the productivity.

- c) ETP (Effluent Treatment Plant)**

An establishment where effluent, specifically produced water, undergoes treatment to reduce its outlet parameters to levels compliant with applicable regulatory requirements.

- » **Downstream Sector**

- **Refinery**

A facility where crude oil is received and processed to generate various intermediates and final products.

- **Petroleum Depots & Terminals**

Locations where petroleum crude, products, and LPG are received through tankers, pipelines, tank wagons, or tank trucks. These substances are then stored or blended in bulk for distribution purposes, utilizing tankers, pipelines, tank wagons, tank trucks, portable tanks, or containers.

- **Pipeline Installations**

Facilities situated along cross-country pipelines, featuring pumping and/or delivery stations, with or without storage capabilities.

- **Lube Oil / Grease Manufacturing & Filling Plants**

The facilities meant for receipt, storage and blending of base oils & additives into finished Lube products. It includes lube-blending plants, grease manufacturing plants & small can filling plants also form part of such installations.

- **LPG Storage Depots / LPG Bottling Plant**

This facility is dedicated to the storage and filling of LPG into cylinders. The process involves the receipt and dispatch of LPG through rail, road and pipelines.

- **Aviation Fuelling Stations**

These stations handle Aviation Turbine Fuel (ATF), receiving it via tank wagons, tank trucks, and pipelines. The fuel is stored in bulk for dispatch by refuellers and pipelines. Additionally, these stations encompass the storage of Methanol, AVGAS and other additives in drums.

- **Valve Stations**

Intermediate installation, where isolation valves are provided on the cross- country pipelines to isolate a particular segment of pipeline.

- **Compressor Stations**

Any facility equipped with compressor(s) to enhance the pressure of gas to desired pressure before injecting into the trunk pipeline for dispatch to a marketing / distributing company.

- **Intermediate Compressor Stations**

These are installations equipped with compressors positioned between the originating compressor station and the terminal, final, or last delivery station on the pipeline. Their purpose is to boost the pressure of the gas, ensuring its effective transport to the subsequent station in the pipeline network.

2.2 Categorization of Upstream Onshore Production Installations

Based on storage capacity, installation can be categorized as under:

S. No.	Type of Installation	Aggregate Storage Capacity	Class of Petroleum
1.	Well-head Installation (WHI)	120 KL	A & B
2.	Quick Production Set-up (QPS)	120 to 240 KL	--do--
3.	Early Production Set-up (EPS)	240 to 1000 KL	--do--
4.	Group Gathering Station (GGS)	1000 to 5000 KL	--do--
5.	Central Tank Farm (CTF)	> 5000 KL	--do--

Table 2 Categorization of Upstream Onshore Production Installations

2.3 Codes and Standards:

a) Code of Safe Practices (CSP)

It is internal code of ONGC for ensuring the safety in its various operational activities. Earlier it was known as Recommended Code of Practices (RCP). It covers onshore as well as offshore areas. It is in two Volumes, Fire Safety Aspects are covered in Part - 5 of Volume-I:

- Volume - 1 : deals with Onshore Operations
- Volume - 2 : deals with Offshore Operations

It provides guidelines for:

- Portable fire extinguishers and other first aid fire-fighting equipment & accessories etc.
- Fixed fire-fighting system viz. fire water network, hydrant & monitors, water spray, foam system, fire water storage capacity, fire pumps etc.
- Other Fire Suppression System
- Fire Alarm & Communication system
- Inspection & maintenance of fire equipment
- Mobile Fire Appliances
- Other aspects like Contingency plan, training etc.

b) Oil Mines Regulations (OMR) – 2017

- It was enacted in 1984 by the Act of Parliament and revised in 2017.
- It is statutory in nature.
- Chapter –VIII deals with the Protection against Gas and Fire.
- Rule 100 (Chapter –VIII) describes the requirement of Fire Fighting equipment. (These shall be as per OISD Std. -116,117 & 189).
- Rule 101 & 102 describes the Fire Fighting Training and Emergency Response Plan respectively.

c) OISD Standards

- Established in the year 1986.
- Applicable for Onshore & Offshore Areas.
- Till date more than 100 std. have been formulated.
- STD - 116: Petroleum Refineries, Oil / Gas Processing Plants and LPG storage, handling, and bottling facilities situated within refineries and oil/ gas processing plants.

- STD - 117: Petroleum Depots. / Terminals and Pipeline Installations / CTF.
- STD - 144 & 169: LPG storage, handling & Bottling Plants located out-side the premises of Refinery & Oil / Gas Processing Plants.
- STD - 150: LPG mounded bullets.
- STD - 189: Drilling & WO Rigs, GGS / OCS, GCP / GCS, EPS, QPS / WHI.
- STD - 226: Natural Gas Transmission Pipelines

d) Other Standards

In addition to above mentioned codes and standards, following standards / norms are also referred:

- API : American Petroleum Institute
- BIS : Bureau of Indian Standards
- EN : European Norm
- FM : Factory Mutual, UK
- NFPA : National Fire Protection Association, USA
- UL : Underwriters Laboratories, USA

2.4 Fire Fighting Resources

a) Production Installations

• Portable Fire Extinguishers

DCP, CO₂, Clean Agent and Mechanical Foam etc.

» Fixed Fire Fighting System:

- Fire Water Network
- Fire Water Pumps
- Fire Hydrants
- Water & Water cum Foam Monitors
- Water Spray System
- Foam Pourers : Fixed / Semi Fixed type
- Automatic Rim Seal Fire Protection System

» Mobile Fire Appliances: (Available at nearby Fire Stations)

- Water Tenders / Bowsers : Only Water
- Foam Tenders : Water & Foam

- Multipurpose Fire Tenders : Water, Foam & DCP
- DCP Tender: Only Dry Chemical Powder
- Foam Nurser: For supplying the foam compound
- Emergency Rescue Tenders : Various types of Rescue Tools
- Dewatering Tender : Heavy discharge capacity water pumps for flood mitigation

b) Drilling /Work-over Rigs:

» Portable Fire Extinguishers

- DCP, CO₂, Clean Agent and Mechanical Foam etc.

» Semi-fixed Fire Fighting System:

- Fire Water Network
- Trailer Fire Pump
- Fire Hydrants
- Water Monitors
- Mobile Fire Appliances: (Same as for Production Installations)

2.5 Salient Features of Design Criterion for Fixed Fire Fighting System at Production Installations:

- Fire protection facilities shall be designed to fight two major fires simultaneously anywhere in the installation (STD: 116).
- The FW system shall be provided based on the single largest fire contingency for all locations where total tankage in the terminal is up to 30,000 KL and for two largest fire contingencies simultaneously for all locations where total tankage in the terminal is more than 30,000 KL (except for location storing class C & excluded products) (STD: 117).
- All the tank farms and other areas of installation, where hydrocarbons are handled shall be fully covered by hydrant/monitors.
- One / two (as applicable) of the largest flow rates calculated for different sections, shall be added and that shall be taken as design flow rate.
- The FW system shall be designed for a min. residual pressure of 7.0 kg/cm² at the hydraulically remotest point of application at the designed flow rate at that point.
- The effective capacity of reservoir above the level of suction point shall be minimum 4 hours aggregate working capacity of main pumps (excluding standby pumps).

- Where the rate of make-up water supply is 50% or more, this storage capacity can be reduced to 3 hours aggregate working capacity of main pumps.
- Storage reservoir shall be in two equal interconnected compartments to facilitate cleaning & repairs. In case of above ground steel tanks, there shall be min. 2 tanks each having 50% of required capacity.
- Fire water pumps shall be of electric motor & diesel engine driven horizontal centrifugal pumps or vertical turbine submersible pumps.
- Number of diesel driven pumps shall be minimum 50% of the total number of pumps (inclusive of standby pumps).
- Minimum 50% of total flow requirement should be available through diesel driven pumps all the time.
- The capacity & nos. of main FW pumps shall be fixed based on the design fire water rate, worked out on the basis of single / two largest fire scenario.
- The capacity of each pump shall not be less than 400 m³/hr. or more than 1000 m³/hr. All pumps should be identical with respect to capacity and head.
- When total no(s) of working (main) pumps work out to be 1 or 2, 100% standby pumps shall be provided. However, if the total nos. of working pumps are more than 2, 50% standby pumps shall be provided.
- FW network shall be kept pressurized at min. 7.0 kg / cm² all the time by jockey pumps. 2 (1W+1S) jockey pumps shall be provided. The capacity of jockey pumps shall be 5% min. & max. 10% of the design fire water flow rate.
- FW network shall be laid in closed loops as far as possible to ensure multi-directional flow in the system. The FW network piping shall normally be laid above ground at a height of at least 300 mm above FGL on independent sleepers.
- Isolation valves (IV) shall be provided in the network to enable isolation of any section of the network without affecting the flow in the rest. Additional valves shall be provided in the segments where the length of the segment exceeds 300 M.
- Flushing connections with IVs shall be provided at suitable locations in the fire water ring main.
- At least one DHH shall be provided at every 30 m in hazardous areas and 45 m in non- operational areas.
- The hydrants shall be located at a min. distance of 15 m from the periphery of storage tank or equipment to be protected.
- In the case of buildings, this distance shall not be less than 5m and more than 15 m from the face of building.

2.6 SOP for Conducting Mock Drills

» Remember the following steps:

- Assign the different responsibilities among the persons (including security guard) available in your shift as specified in ERP of the Installation.
- Same procedure shall be followed in other shift groups.
- Make action plans for different emergency scenarios inside your Installation and rehearse one scenario every time.
- Start the mock drill by noticing a fire / other emergency in a predetermined area by a person by shouting "Fire....Fire.... or Aag....Aag or other emergency.
- Communicate with other personnel through Fire Bell / Siren as applicable.
- Try to fight the fire with available suitable type of fire extinguisher.
- Some other person should start the fire pump.
- Inform the nearest Fire Station.
- One person should be available in C/R for coordination and communication.
- Security person should not allow unauthorized persons inside the installation, keep main gate open for approaching fire tender.
- Guide the Fire Tender and assist the fire personnel in fire-fighting operations.
- Inform the nearest doctor (if medical help is required).
- In case of major fire, inform the senior officials and take further necessary action as mentioned in ERP.

2.7 SOP for Giving Fire Calls Message to Fire Station

» When giving a fire call/emergency message to Fire Station, remember the following steps:

- Keep yourself calm & cool, don't get excited or nervous and furnish the following information.
- Intimate your name, designation and Installation / Rig etc.
- Location of fire with nearest land mark (in case of Rig).
- Type of fire / material involved in fire.
- Approximate time of fire (time of occurrence of fire).
- If any life is in danger.
- Intimate your telephone number if asked by Fire personal to verify the genuineness of the call.

“Practical training on different Fire Fighting Training Simulators at ATI ONGC, Goa”

Training is the vital element of emergency preparedness, which continually improves the safety standard of an organization. Personnel working at the site are first one to notice any fire/emergency, therefore knowing some basic skills to respond effectively to emergencies becomes imperative for safeguarding oneself and aiding others until professional responders arrive. Rapidly unfolding life- threatening situations necessitate immediate, simple actions that may potentially save lives.

Module-1: Hands on training on use of different portable fire extinguishers during Oil pipeline leakage

3.1 Brief Introduction of scenario:

An oil leak refers to the unintentional release of petroleum products from a pipeline or other containment, spreading into inhabited or hazardous areas. Petroleum products are substances derived from crude oil during the refining process. Unlike petrochemicals, which consist of well- defined and typically pure organic compounds, these materials are highly flammable in nature.

Given their inflammability, these oils pose a severe risk to public safety, as they can potentially explode when exposed to flames or sparks. Hence, this situation is extremely hazardous to the general population.

» Common causes of Pipeline Leakage:

- Mechanical Failure
- Operational Failure
- Corrosion
- Natural Hazard
- Third party activity

» Consequences of Pipeline leakage:

- Fire
- Explosion
- Environmental Hazards

- Loss of product / Financial implication
- Reputation damage

» **Control Methods for pipeline leakage:**

- Prevention:

Prevention, serving as the initial line of defense against the release of hazardous commodities, involves a range of activities and measures designed to avert the occurrence of commodity releases.

- Detection:

While spillages are infrequent, the installation of leak detection systems aims to promptly and precisely identify and locate any leaks that do occur.

- Mitigation:

While preventing spillage remains a paramount goal for pipeline operators, the implementation of rapid detection and precise location methods, combined with well-formulated control procedures, plays a crucial role in minimizing the volume of spilled material when a spillage does occur.

3.2 Brief Description & Photographs of Simulator:

This simulator has been designed as per requirement of firefighting operation in petroleum refinery, transport or handling units.

Two scenarios have been addressed in this simulator which are as follows:

- a) Leakage through loose Flange creating pool fire.
- b) Leakage from puncture hole creating jet fire.



Figure 14 Simulation of Pool fire & Jet Fire

3.3 Objective of Practical Session:

- a) To help trainees to learn and practice skills to extinguish fire with first line of defence i.e. portable fire extinguishers.
- b) To educate trainees how to approach pipeline leakage scenario considering the wind direction and line of leakage.
- c) To educate trainees about the severity of high radiation fire during pipeline leakage.
- d) To understand the importance of de-pressurizing line and arresting the leakage.

3.4 Nos. of Participants / Teams:

In this simulator, trainees are practiced with different portable fire extinguishers and operate it individually on leakage scenario.

3.5 Equipment Required:

- a) PPE (Overall, Safety Helmet, Gumboot, Safety Goggle, Hand Gloves).
- b) DCP Type Extinguisher (06 kg. / 09 kg.)
- c) Foam Type Extinguisher (09 ltrs.)
- d) Water Mist Fire Extinguisher (09 ltrs.)
- e) High pressure Foam Mist Unit (50 ltrs.)

3.6 Procedure

- In full PPE's trainees will carry the suitable fire extinguisher and approach the 1st scenario (flange leakage) in upwind direction by looking to the smoke and flame pattern.
- A safe distance of around 4-6 ft. to be maintained from the scenario to ensure the safety of the user.
- All SOP to be strictly followed while operating the fire extinguishers to ensure the safety of the user:
- Face to be kept away from cap assembly while operating the fire extinguishers.
- Discharge horn in CO₂ fire extinguishers to be held from handle to prevent cold burn.



Figure 15 Dry Ice formation from discharge horn

- Except for foam-type fire extinguishers, all others should be operated using the PASS method, which involves Pulling the pin, Aiming the nozzle, Squeezing the handle and Sweeping the extinguisher across the base of the fire

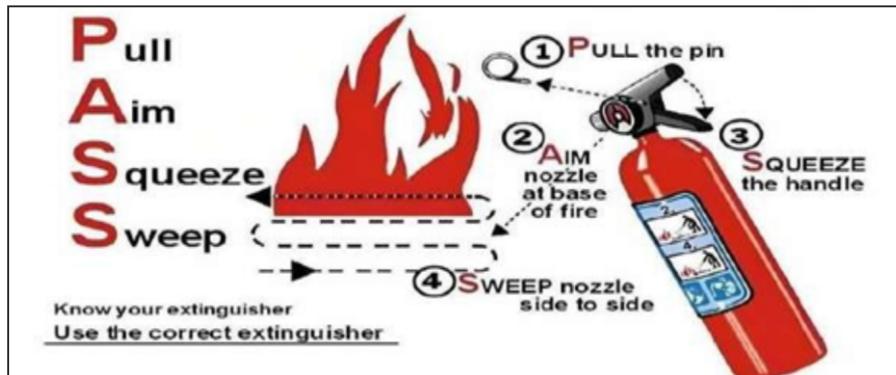


Figure 16 SOP for Fire Extinguisher

Note: For Foam Type Fire Extinguisher, any vertical wall or boundary will be attacked and subsequently, foam will cover the burning liquid.

- Portable fire extinguishers should not be applied in line of leakage to avoid any burn injury.
- Consequent upon the use of fire extinguishers, it needs to be kept in lying position on the ground and further, to be sent for refilling job.
- For attacking the jet fire from punctured hole in 2nd scenario, 50 ltrs high pressure foam mist unit is used as first line of defence.
- To operate this, 02 trainees would be required.
- 01 will operate the air cylinder valve and another person will operate the nozzle trigger after extending the entire length of discharge hose.
- The person operating the valve of air cylinder, requires keeping face away from the cap assembly to ensure the safety of the user.
- Upon opening the valve of air cylinder, the cylinder tank is left to get pressurized up to the pressure of 50 bar.
- Once pressure is developed to 50 bar then trigger of nozzle is operated by another trainees on nozzle. While operating the trigger, make it sure that holes provided in the nozzle should not be blocked as it is provided for aspiration.
- Initially, foam jet is applied at the base of the fire and gradually jet is moved upward to the source of leakage. In this way flame is cut with foam jet and fire gets doused.



Figure 17 Hands-on practice for use of Portable Fire Extinguishers

3.7 Take Away from Session:

- Learning & Identification of different Fire Extinguishers.
- Standard Operating Procedure (SOP) for operating different types of fire extinguishers.
- Safe operation of fire extinguishers to ensure the safety of user

Module- IV

Familiarization with Fire Fighting System (FFS) at Fire Fighting Training Ground

4.1 Brief Introduction:



Figure 18 Layout of Fire Fighting Training Facilities at ATI ONGC

The above layout of ATI Fire Fighting training facilities is designed in such a way that it replicates a GGS (Group Gathering Station) on a smaller scale. This module serves as orientation to the trainees with firefighting system installed at Oil & Gas production installations.

4.2 Brief Description & Photographs of Simulator:

As a fire protection facilities to a GGS, a fixed firefighting system (FFS) is installed & spreader throughout the installations covering all process vessels/units. It constitutes of following elements:

- Fire Water Reservoir
- Fire Water Pump
- Fire Water Network Line
- Fire Hydrant & Monitor

The above fire protection facilities are provided & designed as per the OISD Std.118 and OISD std. 189. The idea behind providing these FFS is to control the spread of fire, if it

cannot be extinguished with the initial use of fire extinguishers. These are meant to be used by installation personnel (first responders) till fire fighters reach the installations from nearest fire stations. Hence, it becomes crucial to maintain these FFS and keep them in ready to use condition.

a) Fire Water Reservoir

Fire Water is stored in a reservoir which may have positive or negative suction. Negative suction reservoir is called underground pit and positive suction reservoir is called over ground tank. To have quick response time during fire emergencies, over ground tanks are preferred as it does not require priming. But in few cases open sources underground pits are being used if it is available near to our installations. The size of these reservoirs depends upon the fire water demand calculated as per the OISD std. 189.

b) Fire Water Pump

It is the heart of the Fire Fighting System which pumps the fire water from reservoir to the fire water network line. Centrifugal fire pumps are mostly being used in any Industry in which we get variable flow at constant pressure. It is designed in such a way that it must maintain at least 7 kg/cm^2 pressure at the remotest point.

c) Fire Water Network Line

It is the network of pipes painted in red colour & have different diameters depending upon the fire water demand of that installations. These are provided with isolation valves at regular intervals to carry out any maintenance job in the line. The main purpose of fire water network line is to transport fire water from pump discharge header to all the hazardous process units of the installations for maximum fire protection coverage.

d) Fire Water Hydrants & Monitor

Fire Water hydrants are installed perpendicularly on fire water network line mostly on 4" T with opening through landing valve and also have an isolation valve. It can be single headed or double headed depending upon the type of installations. As per OISD std. 189, rigs are deployed with single headed hydrant but GGS & CTF are provided with double headed hydrants. These hydrants can be used to discharge water on the fire scenario with a line of fire delivery hose having nozzle connected at the end. They can also be used in GGS to supply water to the fire tender for continuous firefighting job.



Figure 19 Fire Water Hydrants

Fire Monitors are used to discharge water on fire scenario from remote point considering the safety of the user and prolong firefighting activities. Range varies from 30 to 60 m depending upon the discharge rate of the fire monitor. These monitors can be water monitor as well as water cum foam monitor (WFM). Water cum foam monitor is designed in such a way that it can discharge both water and foam on fire scenario having a pick-up which sucks foam concentrate externally through venturi. The nozzle can form both jet as well as spray pattern of water if rotated clockwise and anticlockwise. The vertical and horizontal direction can also be set in fire monitor through locking pin.



Figure 20 Hands-on practice on use of different fire monitors

4.3 Take Away from Session:

Through this session, any new person is made aware about the FFS, its locations and operating method during any emergency. If not, then there would be a delay response which can lead emergency to become a disaster.

Demonstration of BLEVE (Boiling Liquid Expanding vapor Explosion)

5.1 Brief Introduction - What is a BLEVE?

A Boiling Liquid Expanding Vapor Explosion (BLEVE) is an explosion that ensues from the rupture of a vessel containing a pressurized liquid, which has exceeded its boiling point.

If the substance involved is flammable, there is a likelihood that the released substance will ignite post-BLEVE, forming a fireball and potentially triggering a fuel-air explosion.

BLEVE incidents, characterized by the generation of substantial fireballs, typically occur when process vessels containing flammable materials with high vapor pressures are exposed to significant external heat.

» **Phenomenon occurring during BLEVE:**

- Due to heat from flame outside, temperature of the external body will rise.
- Liquid inside will start vaporizing once temperature is more than its boiling point and will exert more pressure than its design pressure.
- Relief Valve will pop-up to vent the excess pressure.
- Liquid inside will keep on boiling.
- Level of liquid will decrease and end up with only gas inside.
- Gas will occupy more volume and exert huge pressure.
- After some time, outside heat would only be utilized for heating the metal and will weaken it very badly.
- Gas will rush out from the weakest point in the form of big fire ball causing explosion.
- Explosion is so powerful that splinters fly like missile travelling more than kilometers, which can eventually cause secondary fire.



Figure 21 Pictorial description of BLEVE Phenomenon

» **BLEVE warning signs:**

- Audible pinging sounds emanating from the metal shell.
- Observable discoloration of the metal.
- Presence of flaking small metal pieces or a bulge on the container.
- Emission of steam from the tank surface.
- Shrill sounds emitted from the pressure relief valve.
- Detection of a tear in the tank surface.

5.2 Brief Description & Photograph of Simulator:

BLEVE is demonstrated in a horizontal tank (Heater Treater) at ATI, ONGC. The horizontal tank consists of a small internal tank (Vertical). This internal tank has a mixture of petrol and diesel contained in it. This mixture is heated to a specific temperature that makes it sufficient to cause fire then a cartridge is dipped inside the internal tank from a safe distance. This cartridge bursts inside the tank and leads to a fireball (only for demonstration purposes).



Figure 22 BLEVE simulator

5.3 Objective of Practical Session:

- To aware trainees of potential hazards associated with BLEVE
- To make trainees conversant with the phenomenon of BLEVE

5.4 No. of Participants:

- Nil as this is only a demonstration for sensitization purpose.

5.5 Equipment Required:

- Foam cum Water Monitor

- PPE (Overall, Fireman Helmet, Gumboot, Safety Goggle, hand gloves)
- AFFF (Aqueous film forming foam)

5.6 Procedure

To simulate a BLEVE, a vertical cylindrical container is filled with flammable liquid (100 ltrs. mixture of Diesel & Petrol). Further, the flammable liquid is ignited and allowed to be burnt for few minutes (2-3 mins). Once the liquid is heated up, a LPG cartridge (400 gm) is dipped inside the container from a safe distance and in few seconds, LPG will expand rapidly and take out the maximum burning liquid from the container in form of a big fire ball, which exactly depicts a BLEVE but in controlled manner. Here in the simulation, a BLEVE occurs in the LPG cartridge as LPG expands 250 times when it reaches to its natural state (Gas).

The simulation has been done to sensitize the people about the consequence and severity of a BLEVE situation through 400 gm of LPG cartridge. As seen in the above picture, the effect of 400 gm LPG is devastating so it can be easily imagined or visualized that LPG cylinder at our house having weight of 15Kg or at our installations where it is stored in the capacity of tons if catches fire then that would be a disaster which will result in lots of casualties and huge property loss.

At the end of simulation, the fire is extinguished with foam cum water monitor by the demo-assistant.

5.7 Take Away of Session:

Understanding the phenomenon and hazards of BLEVE and methods to prevent it. We believe what we see, therefore through this simulation people's concern for safety will improve and they will understand the need of adequate safety measures at their installations or houses to deal with a BLEVE situation. This simulation gives a sensitization to people that potential of 400 gm LPG can be itself very dangerous, hence fire in a 14 kg or tons of Kg of LPG would be a disaster or may lead to catastrophic event. Therefore, best method to control such event is always its prevention.

Module- VI

Fire Hydrant Operating Techniques and Communication Procedure

6.1 Brief Introduction:

Fire Fighting is carried out in a pressurized condition so that extinguishing media reaches the fire scenario from a safe distance. Due to high scale of fire or high radiation, fire is approached from far distance and in that circumstance, sometimes throw of fire water does not reach to the fire scenario. During such scenario, fire delivery hose is connected to the nearest hydrant and further approached with a suitable nozzles/branches connected at the end.

Since this module is more suitable for beginner handling pressurized hose for the first time therefore basic things regarding Fire Hose & its accessories are taught. This module is covered in 04 sessions of 90 minutes having following details:

- Familiarization with different fire equipment like hose & accessories and its utility in real scenario.
- Hose Drill in dry condition.
- Communication Signals & Operation of Trailer Fire Pump
- Hydrant Drill in wet condition.

6.2 Objectives:

- To develop skill & confidence to handle pressurized fire hose.
- To have hands on practice on various firefighting equipment and accessories.
- To learn safe handling of pressurized firefighting equipment.
- To enhance the capabilities for initiating a firefighting action with hydrant & Fire Hose if not doused with a fire extinguisher.

6.3 Nos. of Participants / Teams:

Hose Drill is preferably done in a team of 03 persons and Hydrant Drill is done with 04 persons in different teams.

6.4 Equipment Required:

- Fire Delivery Hose
- Short Branch

- Multi-purpose Hand Controlled Branch
- Water Curtain/Mayur Branch
- Revolving Branch
- Foam Making Branch, FB10X
- Foam Generators (MEFG)
- Portable Foam Inline Inductor
- Foam (AFFF) Jerrycans

6.5 Procedure:

(A) Familiarization with Fire Fighting Equipment



Figure 23 Fire Delivery Hose

Fire Delivery Hose comes in a length of 15 M & 30 M having a diameter of 2.5 inches. It has two ends having male & female instantaneous couplings. RRL (Reinforced Rubber Lined) Type B Hose is characterized by its outstanding heat and abrasion resistance. It demonstrates resilience against grease, oils, acids, ozone, fungus, alkalies, heat and various chemicals. The specialized design of this hose ensures an excellent grip, complete flexibility, lightweight construction, low maintenance requirements, and minimal friction loss.

- **Short Branch**

Widely adopted by most Fire Brigades, it serves as a fundamental firefighting nozzle. The smooth bore tips of this hose generate a concentrated jet pattern of water flow, maximizing reach and effectiveness in firefighting scenarios.



Figure 24 Short Branch

- **Multi-purpose Hand Controlled Branch**



Figure 25 Multi-purpose Hand Controlled Branch

This Nozzles have fixed flow setting. A bumper provides protection and makes stream selection much easier, especially with gloves. The bumper is equipped with teeth which gives a more solid fog pattern than standard nozzles. Constant Flow fire hose nozzles are adjustable to straight stream, fog patterns, and to on/off position.

- **Water Curtain/Mayur Branch**



Figure 26 Water Curtain/ Mayur Branch

This Nozzle produces a flat curtain of water projecting upward. These nozzles are used to segregate the area by creating a water curtain and hence, stopping the spread of fire from one unit to another.

- **Revolving Branch**



Figure 27 Revolving Branch

These nozzles can direct the water jet in a 360-degree pattern from each small head in both an upward and downward angle. These nozzles facilitate maximum distribution of water in hard-to-reach places. It can also be used to protect the top of fixed-roof fuel storage tanks.

- **Foam Making Branch, FB10X**

These Foam Branch pipes are designed to produce long coherent throws of low-expansion foam using all types of foam concentrates. These Foam Branch pipes are air aspirating types made of SS tube and inlet coupling.

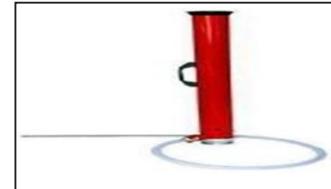


Figure 28 Foam Making Branch, FB10X with pick-up tube

- **Foam Generators (MEFG)**

Medium Expansion Foam Branch pipes is designed to produce large quantities of foam in situations requiring rapid foam cover with low water usage. It has the advantage of producing five times more foam with the same amount of water when compared to Low Expansion Foam Branch pipes.



Figure 29 Foam Generators (MEFG)

- **Portable Foam Inline Inductor**



Figure 30 Portable Foam Inline Inductor

Portable Foam Inline inductors provide a simple and accurate means of inducting foam concentrate into the water supply. These inductors are calibrated to mix foam concentrate at a present rate of 3% or 6%.

- **Foam (AFFF) Jerry cans**



Figure 31 Foam (AFFF) Jerry cans

This contains mechanical foam namely Aqueous Film Forming Foam (AFFF 3% or 6%) having the storage capacity of 20 ltrs. and 200 ltrs.

(B) Hose Drill in dry condition

To understand the handling techniques of fire hose, initially this drill is carried out in dry conditions. This drill is carried out in two steps:

- Demonstration by Fire Demo-assistant
- Hands on practice by trainees

Demonstration by Fire Demo-assistant:

This demonstration covers following:

- Lift techniques for fire hose
- Laying down of fire hose

Lifting the Fire Hose from ground



Taking position in front of each hose



Step-1



Step-2

Step-3

Figure 32 Lifting techniques for fire delivery hose

- Laying down the Fire Hose

It covers the following steps-

- Unrolling the fire hose:

While holding both lugs of female coupling, fire hose is laid down on the ground. It has to be noted that hose shall be on the right-hand side.



Figure 33 Unrolling the fire hose

- Removing the kink:

To avoid pressure loss in the line, kink shall be removed before charging the fire hose. Kink is removed from female coupling side and while removing the kink, hose shall be on right side of the user.

- Draining the water:

Once the firefighting job is completed, water shall be drained off before keeping back the fire hose in store. Water is drained from male coupling side and while draining the water, hose shall be on right side of the user.



Figure 34 Removing the Kink and draining the water

- Rolling back the fire hose:

Fire Hose shall be rolled back after completion of job in such a way that female coupling should be inside and male coupling outside. Hose shall be rolled by using both the thumbs in such a way that it should be tightened.



Figure 35 Rolling back the fire hose

Hands on practice by trainees:



Figure 36 Lifting the Fire Hose from ground



Figure 37 Rolling the Fire Hose from the female coupling side



Figure 38 Proper Handling of Short Branch by Brachman and role of supporter including connection and disconnection of branch

(C) Communication Signals & Operation of Trailer Fire Pump

Due to high noise at fire scene, it is not possible to listen to teammates and hence, following communication signals are practiced while doing firefighting job. These signals are acknowledged also for ensuring the effective communication.

- Water-on

When the branch man is ready, then this signal is passed to the hydrant operator or pump operator to start the water supply in fire hose line.

- Increase Pressure

When the throw of fire water is not reaching the fire scene, then this signal is passed to the hydrant operator or pump operator.

- Decrease Pressure

This signal is passed to the hydrant operator/pump operator when the pressure at the branch end is high & branch man feels uncomfortable due the excess pressure.

- Water-off

When fire is controlled and all clear signal is awaited from I/C. commander, then this signal is passed to the hydrant operator or pump operator to temporarily stop the water supply in the line.

- Knock-Up & Make-Up

This signal is passed after receiving all clear signal from I/C. commander and further, all branches are disconnected from fire hoses and hydrants/pumps.

Examples:



Figure 39 Trainees practicing water-on signal



Figure 40 Trainees practicing decrease pressure signal

Operation of Trailer Fire Pump

Trailer Fire Pump has a centrifugal pump directly coupled with a suitable engine and mounted on a trailer for surface transportation. This unit is designed to address fires for extended durations. This type of pump is provided at ONGC Rigs where frequent movement happens due to rig shifting.



Figure 41 Trailer Pump

Major parts of TFP:

- Pump Casing & Suction Eye
- Delivery line with landing valves

- Pressure & Compound gauges
- Throttle
- Primers

Priming

Removal of air from the pump casing to lift the fire water from open source to the suction eye. Mainly there are two types of priming system used in firefighting: (a) Automatic Priming (b) Exhaust Priming.

Standard Operating Procedure (SOP) for operating a TFP

Before starting the engine, suction Hose to be connected to the pump suction eye and other end of suction hose is connected with metal & basket strainer with the help of suction wrench.



Figure 42 Suction Wrench



Figure 43 Metal Strainer



Figure 44 Basket Strainer

Note: Don't use a metal hammer on the lugs of the suction eye and suction hose, it may damage the lugs. Always use a suction wrench to tighten the couplings. The metal strainer is put inside the basket strainer and then dipped into the open source of water.

- All joints should be tightened enough to avoid entry of air into the suction eye and pump casing.
- Close all delivery line valves.
- Start the engine and throttle to be increased little.
- Priming lever to be engaged and when water starts coming out of the exhaust, that will indicate that priming job is done and further & then all levers shall be disengaged.
- Open the cooling line valve.
- Open the delivery line valves to discharge the water.

(D) Hydrant Drill in Wet Condition

Hydrant Drill is done with 04 persons having following roles:

- Branch Man
- Supporter/Helper
- Messenger
- Hydrant Operator

During this drill, all trainees undergo hands on practice on different nozzles/branches operated with water & foam stream. They also practice to handle pressurized hose by maintaining proper body poster learnt during dry drill.



Figure 45 Activities during the Hose drill by using Short Branch

Note: If nozzle is elongated it will form jet and spray if it shortened by rotating from the end.



Figure 46 Water discharged by Jet & Spray pattern from Multi-Purpose Branch



Figure 47 Foam being discharged through FB10X



Figure 48 Foam being discharged through MEGF

Note: While handling the foam making branch, its aspiration holes shall not be blocked.

6.5 Take Away of Session:

- Learning about various firefighting equipment to be used with fire delivery hose.
- Hose Drill & Hydrant Drill.
- Handling pressurized fire delivery hose.
- Communication signals.
- SOP of Trailer Fire Pump

Module- VII

Physiology of respiration, survival in smoke, evacuation procedures & Donning/Doffing procedures of SCBA sets

7.1 Brief Introduction:

In India, every year about 20,000 persons die in fires and majority of the deaths are in building fires. Statistical data shows that in majority cases of building fire deaths, most of the people die due to inhalation of smoke rather than actual fire, when trapped in smoke filled atmosphere. Fire safety holds paramount importance in today's context, especially with the proliferation of high-rise buildings dominating the city skylines in India. The increasing number of tall structures brings with it unique features that can potentially impact the overall fire safety of a building. This is why, we need to have better preparedness in such situation and proper training will help.

7.2 Brief Description & Photographs of Simulator:

The Smoke House Simulator at ATI is DG Shipping approved simulator designed to cater the requirement of SAS, RAS & Fire Fighting Trainings. This simulator is G+1 storied building made of mild steel. It has total four interconnected compartments (C-1 to C-4), two at ground level and two at first floor level. Trainees enter from the ground floor C-1 and exits from C-4 at first floor level. When all the doors are closed there is total dark inside, similar to any smoke filled room.



Figure 49 (C1, C2, C3 & C4) building compartments

7.3 Objective of Practical Session:

- Developing confidence in trainees to confront dense smoke and learning different safe evacuation procedures.
- To make trainees conversant / proficient in use of Breathing Apparatus Set.
- To make trainees conversant with Search & Rescue (SAR) Procedures

7.4 Nos. of Participants / Teams:

Depending upon the number of trainees in a batch, trainees are divided in to 4-5 groups and each group consist of 4-6 persons. They work in buddy system during the exercise.

7.5 Equipment Required:

- a) Self-Contained Breathing Apparatus Sets (SCBA): 04-06 nos.
- b) PPE (Overall, Fireman Helmet, Gumboots, Safety Goggle, Hand Gloves)

7.6 Procedure

The training with this simulator is carried out in 3 stages as mentioned below:

- **Stage-I:** Most of the cases it has been found that residents are unaware of the structure layout especially the fire exits and escape routes, due to which evacuation becomes difficult resulting into high death tolls. To understand the importance of familiarization with unknown high-rise structure, Stage-I is performed by the trainees. In the first stage, trainees are familiarized with the escape routes and exits of the smoke house, so that in case of any contingency trainee should be able to escape to safe zone from danger zone using nearest exit.



(Entering into C-1)



(Inside C-1)



(Going to C-2 from C-1)



(Going to C-3 from C-2 through ladder)



(Going to C-4 from C-3 through manhole)



(Existing from C-4 through staircase)

Figure 50 Familiarization with G+1 smoke house

- **Stage-II:** In this stage, smoke house is completely filled with dense smoke & all exit doors are closed from outside. Further, trainees are briefed about the behavior of smoke & escape procedures from smoked filled areas in a building. Trainees are then instructed to enter the smoke house and cross all the four compartments without using any respiratory PPE. This stage enhances the confidence level of trainees to encounter the low visibility areas and search for exit routes without getting panic.

Following evacuation procedures are taught for safe evacuation:

- After hearing the fire alarm, immediately evacuate the building.
- Before attempting to exit your room, place your hand on the door, palm down. If the door feels warm to the touch within five seconds, refrain from opening it, as it indicates a potentially hazardous fire condition in the corridor.
- If the door is not warm, cautiously open it slightly to check for the presence of smoke in the corridor. Apply your weight against the door during this process to enable quick closure if necessary.
- If you perceive the corridor as usable, inform other occupants on your floor by activating the nearest fire alarm box. Subsequently, proceed promptly to the nearest exit stairway.
- If your room door is warm or heavy smoke is evident in the corridor, keep the door closed. Seal any cracks around the door and other areas where smoke is entering using wet towels, blankets, or similar materials.
- If you find yourself unable to leave your room, remain calm until rescue personnel guide you to safety. Avoid locking your door to facilitate a swift search and ensure everyone has safely evacuated the room.

Do's & Don'ts:

- Exit the building using the closest safe route.
- Cover your nose and mouth with wet handkerchief.
- Stay as low as you can be to minimize the exposure with smoke. If possible, crawling will help more.
- Move across the floor by touching the walls. This will reduce the load on floor.
- Aid in evacuating disabled occupants.
- Always move downward during evacuation.
- Do not use lifts or elevators.
- Proceed calmly to the designated evacuation assembly area and remain there until the all-clear signal is provided.



Figure 51 Practicing evacuation in smoke filled house

- **Stage-III:** In this stage, smoke house is completely filled with dense smoke & a human dummy (casualty) is hidden somewhere inside the smoke house and all exit doors are closed from outside. Trainees then assigned the task to enter the Smoke House using SCBA Sets and other PPEs to carry out the search and rescue operations. To carry out this task, first trainees are taught about the SCBA sets, its donning & doffing procedures and rescue techniques.

A Self-Contained Breathing Apparatus (SCBA), also known as a Compressed Air Breathing Apparatus (CABA) or simply Breathing Apparatus (BA), is a device designed to supply breathable air in environments that pose an immediate danger to life or health. The term "self-contained" emphasizes that the SCBA does not rely on a distant source of breathing gas, such as through a lengthy hose.

It provides the wearer with an independent and portable source of breathable air for use in hazardous atmospheres.

Major Components of SCBA Set:

A) Air cylinder



Figure 52 Air Cylinder

B) Back plate or Body Harness



Figure 53 Back plate or Body Harness

C) Face Mask



Figure 54 Face Mask

Working duration of SCBA Set (300 bar):

The following formula is used to calculate the SCBA working duration:

$$WC \text{ (kg/ltr)} \times \text{Pressure (bar)} = TV$$

$$TV / 40 \text{ (lpm)} = TD$$

$$\text{Less Safety Factor} = TD - (WC \text{ (ltr)} \times \text{Whistle (Bar)} / 40 \text{ lpm}) = WD$$

Figure 55 Formula for SCBA working duration calculation

Total Duration: 45 Mins. Safety Margin: 10 Mins. Working Duration: 35 Mins

Donning of SCBA Set

SCBA set can be donned by 02 methods namely Over the Head Method or Backpack Method. Following steps to be followed while donning:

- Donning face mask with mask connected to SCBA set, straps fully extended with Lung Demand Valve (LDV) open:
- Place harness over head
- Position mask over face
- Pull lower two straps straight back
- Pull middle two straps straight back
- Pull top strap straight back
- Secure mask to face

Doffing /Removal of SCBA Set:

- Disconnect the LDV from face mask
- Press the shut-off valve in LDV
- Loose the face mask straps & remove it from face. Further to sanitize the face mask after use.
- Release the waist belt.
- Extend shoulder straps.
- Remove the set from shoulders.
- Carefully place set down safely.



Figure 56 Faculty demonstrating & helping the trainees in donning & doffing of the SCBA



Figure 57 Demo assistants demonstrating the rescue technique of Fore & Aft method

In the Fore and Aft method, one bearer catches the patient's legs under the knees, while the other bearer passes his hands under the patient's arms and grasps his own wrists in front of the patient's chest.

Team of 04-06 person will carry out the Search & Rescue Operations with SCBA Sets. After finding the casualty, 02 person will rescue it from the nearest exit and rest will search the other compartments for any other casualty and will leave the smoke house from 4th compartment.



Figure 58 Search & Rescue Operations with SCBA Sets in smoke filled house

7.7 Take Away of Session:

- Importance of familiarization with escape routes and fire exits for any unknown high- rise structure.
- Different evacuation procedures to exit a high-rise structure during fire emergencies.
- SAR techniques with SCBA Sets (Donning & Doffing).

Module- VIII

Combating Fire inside Oil Storage Tank with Foam system/available Firefighting System

8.1 Brief Introduction:



Figure 59 Oil storage tank

An oil storage tank is a container or reservoir that temporarily holds oil in the various stages of processing into other oil products, or before it is used or consumed. Tanks for a specific fluid are selected based on the flash points of that substance. In refineries, oil installations, and particularly for liquid fuels, two main types of tanks are commonly used:

- Fixed Roof Tanks
- Floating Roof Tanks

Fixed Roof Tank

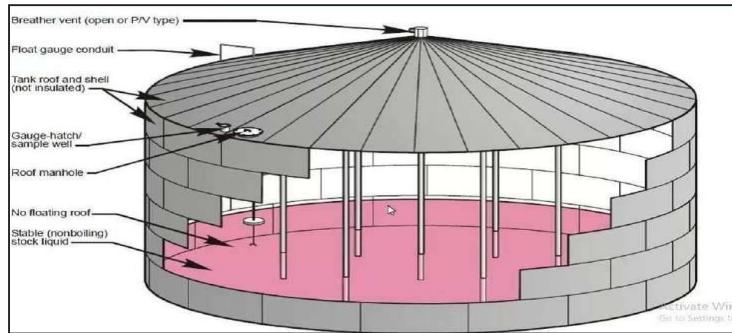


Figure 60 Schematic diagram for Fixed Roof Tank

Designed for liquids with exceptionally high flash points, such as (Fuel Oil and Bitumen), these tanks typically feature Cone Roofs, Dome Roofs, and Umbrella Roofs.

Floating Roof Tanks:

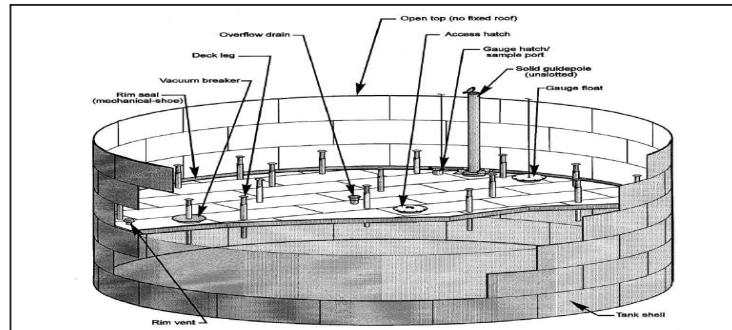


Figure 61 Schematic diagram for Floating Roof Tank

They can be broadly categorized into external floating roof tanks, commonly referred to as floating roof tanks (FR Tanks), and internal floating roof tanks (IFR Tanks).

Major Hazards

Explosions and fire pose major hazards in oil storage tanks, although they occur infrequently. When these incidents do happen, the resulting loss to property and the environment is substantial. Controlling such incidents proves challenging, demanding significant resources in terms of both manpower and equipment for successful extinguishment. Therefore, the primary solution lies in prevention to effectively manage these risks.

Causes of Oil Storage Tank Fires:

- Lightning strike during bad weather,
- Oil spillage due to failure of level controls,
- Material contact by nearby explosion,
- Static charge due to failure of safe loading practices
- Sunken of floating roof due to rain water accumulation
- Internal frothing
- Over pressurization,
- Earthquake
- Sabotage
- Ignition of vapor cloud
- Ignition Sources
- Fire in dyke

- Inadequate bonding leading to fire incidents during operator sampling,
- Utilization of mobile devices in hazardous areas,
- Generation of static charge due to improper application of firefighting foam on roof spills,
- Smoking within areas where vapor clouds are present.

Fire Protection Facilities in Oil Storage Tanks:

As per OISD std.189, following are the fire protection facilities provided to oil storage tank:

Fixed Water Spray System



Figure 62 Fixed Water Spray System

- Fixed spray water system is a fixed pipe system connected to a reliable source of water supply and equipped with water spray nozzles for specific water discharge and distribution over the surface of area to be protected. The piping system is connected to the hydrant system water supply through an automatically or manually actuated valve, which initiates the flow of water.
- Water supply patterns and their densities shall be selected according to need. Fire water spray system for exposure protection shall be designed to operate before the possible failures of any containers of flammable liquids or gases due to temperature rise. The system shall, therefore, be designed to discharge effective water spray within shortest possible time.

Foam System

The system consists of an adequate water supply, supply of foam concentrate, suitable proportioning equipment, a proper piping system, foam makers and discharge devices designed to adequately distribute the foam over the hazard. Conventional systems are of the open outlet type, in which foam discharges from all outlets at the same time, covering the entire hazard within the confines of the system. There are three types of systems:

- **Fixed Foam System:**

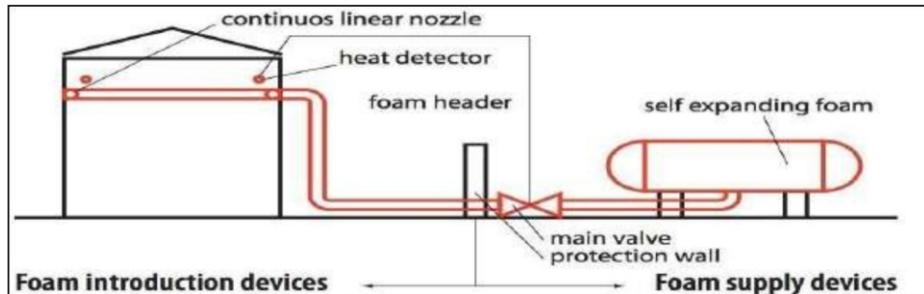


Figure 63 Fixed Foam System

This system uses fixed foam storage tank for injecting foam to delivery devices located at the top of the tank.

- **Semi-Fixed System**

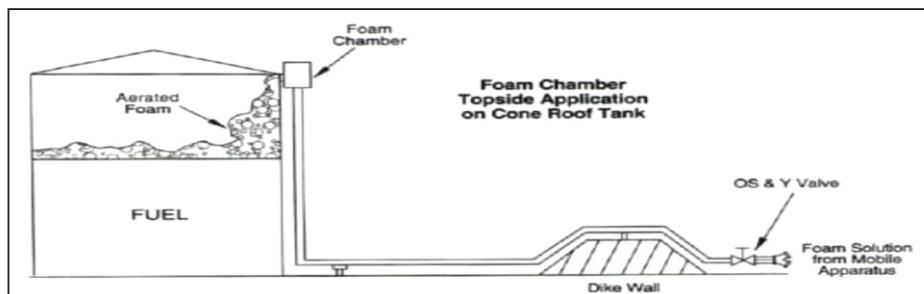


Figure 64 Semi-Fixed System

This system utilizes mobile apparatus to inject foam into delivery devices positioned at the top's section of the tank.

- **Mobile System**

The mobile system comprises a foam-producing unit mounted on wheels, capable of being either self-propelled or towed by a vehicle. These units deliver foam to the burning surface through monitors or foam towers.



Figure 65 Mobile System

- **Foam Pourer System**



Figure 66 Foam Pourer System



Figure 67 Cut Model of Fixed Roof Oil Storage Tank

Foam pourers, alternatively referred to as top pourers or foam top pourers, are integral components within fixed foam firefighting systems. Their primary application lies in safeguarding flammable liquid storage tanks. These units are designed to encompass a foam maker, vapor seal box, and pourer in a single configuration.

8.2 Brief Description & Photographs of Simulator:

Scenario:



Figure 68 Fire at Storage Tank for the activity

Striking of lightning on the roof of Fixed Roof Tank and subsequently, roof has been blown off. Due to enormous heat energy in the lightning, oil has caught fire. It has also been assumed that fire protection facilities provided to tank have been distorted due to lightning.

8.3 Objective of Practical Session:

- To familiarize trainees with all fire protection facilities provided on an oil storage tank and hands on practice on operating them.
- To help trainees to learn and practice skills to extinguish fires with line of fire delivery hose through hydrants and branches.
- To make trainees understand about Incident Response System (IRS) while handling the scenario.
- To educate trainees how to coordinate among themselves for carrying out firefighting operations.
- To make trainees conversant with Search & Rescue (SAR) Procedure.

8.4 Nos. of Participants / Teams:

Depending upon the number of trainees in a batch (Minimum 20), trainees are divided into 4-5 groups and each group consists of 4-6 persons.

Roles & Responsibilities of Different Teams:

1. Incident Commander (01 person)

The key duties and responsibilities of the Incident Commander include; determining incident objectives and priorities, establishing the Incident Command Post, forming the Incident Command Organization, ensuring planning meetings take place, approving the incident action plan, Coordinating the activities of the command and general staff, keeping the responsible official informed about the incident's status, authorizing the release of information to the media, Ensuring that adequate safety measures are in place,

2. Public Information Officer (1 person):

The Information Officer is tasked with developing and disseminating information to the news media, incident personnel, or any other relevant agencies and organizations.

3. Liaison Officer (1 person):

The Liaison Officer is typically appointed in incidents involving multiple agencies or those with a multi- jurisdictional nature. The primary responsibility of the Liaison Officer is to facilitate coordination with various agencies directly assisting or cooperating, such as providing non-critical resources to incident management.

4. Incident Controller (1 person):

The Incident Controller in the Operations Section is responsible for managing and directing all tactical actions to meet incident objectives.

Team Production/Shift In-charge (01 person)

Following are the responsibilities:

- Shutting-off the flow valve/diverting the oil flow to the other tank.
- Flow of communication to the responders and senior officials

Fire Fighting Team (04 persons)

Following are the responsibilities:

- To mitigate the fire with the help of fire hydrant, firefighting hoses, suitable nozzles, foam jerry cans, foam inline inductor and other accessories.

Cooling or Shielding Team (04 persons)

Following are the responsibilities:

- To curtail the heat radiation by actuating the cooling system of nearby tanks and surroundings.
- To provide water shielding & making safe path to the SAR team.

Search & Rescue (SAR) / Stretcher Team (02 persons):

Following are the responsibilities:

- They will carry out the search and rescue operations.
- They will have multi-role as they will also give first aid if required and transport the casualty to the ambulance.

Team Security (02 persons)

Following are the responsibilities:

- To cordon the fire scenario.
- To control and manage the crowd from entering the fire scenario.

In-charge Planning Section (01 Person)

- The Planning section holds responsibility for the collection, evaluation and presentation of incident information. This involves maintaining the status of resources, preparing the incident action plan and managing incident-related documentation.

In-charge Logistics Section (01 Person)

- The Logistics section plays a vital role in offering services and support to incident management. Its primary functions include providing support for incident facilities such as bases and camps, overseeing transportation, communication, food services, ground transportation, medical services and resource procurement.

In-charge Finance and Administration: (01 Person)

- This section is tasked with tracking incident-related costs, managing personnel and equipment records, handling procurement contracts and overseeing administrative aspects of the incident.

8.5 Equipment Required:

- Breathing Apparatus Sets
- Fire Proximity Suit

- Fireman Approach suit
- Fire Hoses
- Hand Controlled Multipurpose Branch, Foam Branch (FB10X), Foam Inline Inductor and Foam cum Water monitor
- PPE (Overall, Fireman Helmet, Gumboot, Safety Goggle, hand gloves)
- AFFF (Aqueous film forming foam): 100 ltrs.
- Walkie-talkie sets for communication

8.6 Procedure:

Alarm will be raised first by team security immediately after noticing the fire and everyone will rush to the assembly point and head count will be done.



Figure 69 Assembling of responders for Drill activity

As per ERP, everyone will initiate their jobs.



Figure 70 Turn-out of responders from Assembly point

Incident Commander, Liaison Officer, I/C. Planning, I/C. Logistics, PIO and I/C Finance & Admin will take the post in Command Post.



Figure 71 Incident Command post activity

After establishment of the Command Post, Incident Controller will reach the site along with Team Production, Cooling Team, Foam Team and SAR Team & Team Security. All teams will work on the command of Incident Controller and he will further update all actions to the Incident commander.

Team security will cordon & demarcate the area in to Hot, Warm & Cold Zones.

All teams along with the resources will wait in cold zone (Triage area) which will be ensured by Team Security.

Team Production with suitable PPE's like Proximity Suit will approach the Hot Zone with the cooling team to restrict the flow and diverting it to another tank. Cooling team will unroll 02 length of hose from hydrant in up-wind direction. Out of 04 personnel from cooling team, 01 will operate the deluge valve of cooling system and then will operate the Foam cum water monitor to cool down the nearby facilities/surroundings. Further, 01 person will operate hydrant and remaining two will hold Multi-purpose branch and establish the communication with person on hydrant.





Figure 72 Rescue by SAR Team during the drill

SAR team with SCBA sets will search the entire area thoroughly in buddy system and upon finding any casualty will request Incident Controller to send team cooling for providing safe access in close proximity of tank under fire. The same message will be passed to the Incident Commander requesting to send Ambulance.

After rescuing the casualty, it will be transported to the nearest hospital through ambulance.

Foam team will unroll 03 length of hose from hydrant in up-wind direction. Out of 04 personnel, 01 person will operate hydrant, 01 will handle Foam Inline Inductor and remaining two will hold the foam branch (FB10X) and establish the communication with person on hydrant. Foam inline inductor will be connected after first length of hose and pick up tube will only be dipped in foam jerrycan once suction is created in the holes.





Figure 73 Buddy system by SAR Team

Once the fire is extinguished and casualty is rescued, I/c Operations will again send team SAR to inspect the whole area for any casualty or sign of ignition near or around tank area. Team SAR will go in buddy system.

Both cooling & foam team will not disconnect their branch & other equipment and will wait for the instructions of Incident Controller. During this, they will cool down the nearby dry vegetation and area to prevent any ignition.

Once after receiving all clear signal from Incident Commander, all teams will make up and disconnect their equipment and come back to the assembly point for de-briefing session. To give all clear signal, team security will raise the alarm.

At the end, all teams will give a brief report of their actions to the Incident Commander and press release will be done by PIO.

8.7 Take Away of Session:

- To extinguish an oil tank fire with a line of fire delivery hoses through Hydrant.
- To work in different teams in well-coordinated way.
- How to use different fire equipment, gears & PPE's

Module- IX

Tackling Leakage and Fire in an oil Road Tanker

9.1 Brief Introduction:

Road tanker fire has always been a serious concern for the industries engaged in the transportation of petroleum products. Awareness of such fire hazards & training on how to fight such fire is of prime importance. Firefighting team responding to such fires needs practical exposure to extinguishing similar fires.

Tankers transporting various types of liquid fuels are a common sight on our roads. The many diverse locations of fuel stations across the country results in these vehicles traversing a wide variety of roads in order to service them. Fortunately, fuel tanker emergencies are rare; however, they can be diverse and can range from a leaking, overfilled vehicle with no fire to a collision or rollover with or without product ignition.

Tanker truck emergencies are classified as 'low frequency/ high risk' incidents and will almost always make for rather spectacular viewing.

Fuel tanker emergencies are, of course, not limited to fires but could also include tankers not on fire but leaking or that have been overfilled, overfilling of storage tanks, overturned tankers or tankers involved in motor vehicle accidents with or without fires.

Fuel tanker truck emergencies generally create quite a spectacular scene but, depending on its location, should not create any extraordinary risk to the firefighting teams if handled systematically with clear direction. A good working knowledge of the construction and safety features of the vehicle will contribute greatly to a calm and measured firefighting operation and early control of the incident. The amount of smoke and flame generated by a tanker fire will draw significant attention, which could add the additional burden of larger groups of onlookers and media. Onlooker control will have to be an early command consideration in such an emergency.

The type of fuel involved will also determine the choice of foam application. Fuels such as ethanol are polar solvents that will require the application of alcohol-resistant aqueous film-forming foam (AFFF) or fluoro-protein, film-forming fluoro-protein (FFFP) foam. As with any hazmat call, the first action in your SOP should be to approach the incident from upwind and uphill or upstream. Staging a safe distance away will allow you to determine the type of tanker involved, the product involved and what it is doing (spillage without ignition, fire or any other mechanical damage i.e. a road accident).

Brief Description & Photographs of Simulator:

A road tanker is used as a simulator to impart training on how to fight actual road tanker fires. An oil trays are kept in storage tank of tanker in such a manner to create real scenario of an oil spill/de- containment in a tanker.



Figure 74 Oil Road Tanker Simulator

9.2 Objectives:

- Trainees get exposure & practice off-site multiple source fire, in addition to controlling fire, trainees have to deal with constraints like facing local population & press/media etc.
- To help trainees to learn and practice skills to extinguish fires in case of tanker fires.
- To educate trainees how to coordinate among themselves for doing firefighting operations.
- Trainees get exposure & practice of off-site multiple source fire, in addition to controlling fire, trainees has to deal with constraints like facing local population & press/media etc.
- To make trainees conversant with Search & Rescue (SAR) Procedure.

9.3 Nos. of Participants / Teams:

Depending upon the number of trainees in a batch, trainees are divided into 4-5 groups and each group consists of 4-6 persons.

Roles & Responsibilities of Different Teams

• Incident Commander:

Takes decision regarding emergency situations and regulates the operation

Documents report of the incident

- **Incident Controller:**

Co-ordinates the operation of fire teams

Gives the real time report to the incident commander

- **Fire Teams:**

Fire Fighting Team

Extinguishes fire at the site

Restricts fire spread

Auxiliary Team

Backs up firefighting team by extinguishing susceptible nearby fire

Cooling Team

Cools the surrounding combustible material to prevent re-ignition

Provide shield to Operational team and Search & Rescue team

- **Operational Team:**

Valve operator, in fire proximity suit and BA set, closes fuel supply valve

Backed up and continuously drenched by the cooling team

- **Search and Rescue Team:**

Work in pairs with proper PPE

Coordinates with cooling team and searches for casualties and carry them for medical assistance

- **Security Team:**

Patrols the area

Informs incident controller about the emergency and manually initiates the alarm

Barricades and controls mob

- **Logistics Team:**

Provide resources and equipment

Makes standard plan of action during emergency situations

- **Liaisoning Team:**

Calls nearby police station
Contacts Health, Safety and Environment sectors
Informs local fire service

9.4 Equipment Required:

Breathing Apparatus Sets
Fire Proximity Suit
Approach Suit
Fire Delivery Hoses
Multipurpose Hand Controlled Branch
Foam Making Branch, FB10X
Foam Inline Inductor
PPE (Overall, Fireman Helmet, Gumboot, Safety Goggle, hand gloves)
AFFF (Aqueous film forming foam)
Walkie-talkie sets

9.5 Procedure:

Trainees are assigned different role as per the ERP during road tanker leakage followed by fire. Following actions are taken to mitigate the situation:

Initially cooling team along with the team operations (with proximity suit donned) will proceed towards road tanker to arrest the leakage by closing the valve. Charged line of hose with water as spray pattern is poured thoroughly on team operation while moving close to the road tanker. Since there was leakage and due to vaporization, there is a chance of flash fire which can result into explosion if found ignition source. Therefore, water spray will protect the team operation from getting sudden exposure to flame. Multi-purpose branch with charged hose having water supply through hydrant system is used. Team operation will use fire proximity suit for going close to leakage situation. Further, it is considered that spillage has caught fire and subsequently, the tanker is engulfed with fire.

Immediately, firefighting team comes in action and mitigate the fire with foam making branch (FB 10X) having foam inline inductor in hose line. Line is charged with water through hydrant system. Further, cooling operation is also carried out for road tanker

shell, the cabin area is thoroughly cooled down with charged delivery hose to prevent the re-ignition.

Search & Rescue (SAR) team with SCBA Sets donned will search for any casualty around the road tanker area in buddy system. Upon finding any casualty, it will be transported to the nearest hospital in the ambulance.



Figure 75 Road Tanker drill activity

9.6 Take Away of Session:

Planning and extinguishment of Oil road tanker fire.

To work in different teams in a well-coordinated way.

How to use different fire equipment, gears & PPE's.

Fire Fighting and Search & Rescue operation during fire in a Drilling/ Work over Rig

10.1 Brief Introduction:

The operation of Drilling & Work Over Rigs poses significant challenges in the context of an oil field. Rig fires, which involve the combustion of oil or gas wells, can occur due to accidents, intentional acts like arson, or natural events such as lightning strikes. These fires may manifest on a smaller scale, such as a fire ignited by an oil field spill, or on a larger scale, exemplified by geyser-like jets of flames from high-pressure wells.

One common cause of rig fires is a high-pressure blowout during drilling operations. Example



Figure 76 An example of Drilling & Over Rigs (Pasarlapudi Blowout (1995), 65 days, 200m fire column)

A drilling rig, serving as a machine for creating holes in the earth's sub-surface, can range from massive structures housing equipment for drilling water wells to those for oil wells or natural gas extraction wells.

A blowout, defined as the uncontrolled release of crude oil and/or natural gas from an oil well or gas well after pressure control systems have failed, is a significant risk. Modern wells are equipped with blowout preventers designed to avert such occurrences.

To deal with Blowout & Explosion situation, which is small in its early stage, following are the minimum statutory requirements of Fire Fighting System for DR/WOR in addition to the Fire Extinguishers:

Fire Water Storage Tank

Fire Water Pump

Fire Monitor & Hydrant

Fire Hose & Nozzle

Brief Description & Photographs of Simulator:

The simulator is designed as per actual working rig with a well head. Mock fire is conducted by creating fire at two different locations at the rig. Fire at the rig is created in the trays kept at the periphery of the well head considering a leakage situation from well head which has led to the fire in the doghouse with a casualty.



Figure 77 Set up of Rig for Mock Fire

10.2 Objectives:

- To help trainees to learn and practice skills to extinguish fires in elevated structures.
- To educate trainees how to coordinate among themselves for doing firefighting operations.
- To make trainees conversant with Search & Rescue (SAR) Procedure

10.3 Nos. of Participants / Teams:

Depending upon the number of trainees in a batch, trainees are divided into 4-5 groups and each group consists of 4-6 persons.

Roles & Responsibilities of Different Teams:

- **Incident Commander:**

Takes decision regarding emergency situations and regulates the operation documents report of the incident

- **Incident Controller:**

Co-ordinates the operation of fire teams which gives the real time report to the incident commander

- **Fire Teams:**

Fire Fighting Team

Extinguishes fire at the site

Restricts fire spread

Auxiliary Team

Backs up firefighting team by extinguishing susceptible nearby fire

Cooling Team

Cools the surrounding combustible material to prevent re-ignition

Provide shield to Operational team and Search & Rescue team

- **Operational Team:**

Valve operator, in fire proximity suit and BA set, closes fuel supply valve

Backed up and continuously drenched by the cooling team

- **Search and Rescue Team:**

Work in pairs with proper PPE

Coordinates with cooling team and searches for casualties and carry them for medical assistance

- **Security Team:**

Patrols the area

Informs incident controller about the emergency and manually initiates the alarm

Barricades and controls mob

- **Logistics Team:**

Provide resources and equipment

Makes standard plan of action during emergency situations

- **Liaisoning Team:**

Calls nearby police station

Contacts Health, Safety and Environment sectors

Informs local fire service

10.4 Equipment Required:

Breathing Apparatus Sets

Fire Proximity Suit

Approach Suit
Fire Delivery Hoses
Multipurpose Hand-Controlled Branch
Foam Making Branch, FB10X
Foam Inline Inductor
F Key for operating hydrant
PPE (Overall, Fireman Helmet, Gumboot, Safety Goggle, hand gloves)
AFFF (Aqueous film-forming foam)
Walkie-talkie sets

10.5 Procedure:

Trainees are assigned different roles as per the ERP during Rig/Elevated Structure Fires. The following actions are taken to mitigate the situation:

On spotting the fire, team security will raise the fire alarm and all persons will assemble at the assembly point. Immediately, head count will be done by the Incident Commander and all teams will get to work at the incident site and Command post.

On reaching the site, firefighting team will lay down 03 length of fire hoses from the hydrant and attack the fire from warm zone with the help of FB10X, having 02 persons on the branch in fireman approach suit, 01 (messenger) at foam Inline Inductor and 01 person as hydrant operator. Foam inline inductor will be connected after 1st length of hose and pickup tube will be dipped in the foam jerry can once suction starts. The foam should not be directly applied to the burning liquid and any metal structure above the burning liquid can be targeted which will further come down and blanket the entire pool of liquid. The application of water on blanketed foam shall be avoided. Simultaneously, cooling team will lay down 03 lengths of fire hoses from the hydrant and approach the well head from warm zone with the help of multi-purpose branch connected, having 02 persons on the branch in fireman approach suit, 01 (messenger) and 01 person as hydrant operator.

Once the branch man is ready, water on signal will be passed to the hydrant operator of cooing line. As soon as team operation reaches the site with proximity suit donned & fire gets under control, cooling team along with the team operation will proceed towards well head area having water drenched on the person in the proximity suit from back side thoroughly to mitigate any sudden explosion. While moving from warm zone to hot zone, the person in proximity suit will take the shield by standing back of branch man forming the spray pattern from multipurpose branch.

After closing the leaking valve, the water will be tuned off from the cooling line by signaling to the hydrant operator and remaining water from the line will be drained by opening the shut-off valve of the multipurpose branch. Further, cooling team along with the SAR team (with SCBA Sets donned) will proceed towards doghouse located on the derrick floor.

Once the branch man is ready, water on signal will be passed to the hydrant operator and dog house wall will be thoroughly cooled down & then taking the shield of door, it will be opened slowly to avoid backdraft. Once the door is opened, the doghouse will be cooled down thoroughly to extinguish the fire and safe access route will be provided to the SAR team. After the SAR operation, water off signal will be passed to the hydrant operator and cooling team will come back to warm zone and will wait for further instruction by Incident controller.

The casualty rescued from the doghouse will be shifted on stretcher for transporting to nearest hospital. Further, the nearby facilities will be cooled down to avoid the spread of fire. All clear signal will be given by the Incident commander after the final inspection by SAR team. Upon receiving the all clear signal, knock up and make up will be done and all teams will report back to the assembly point for debriefing session.



Figure 78 Rig Fire drill activity

10.6 Take Away of Session:

Planning and extinguishment of drilling or work-over rig fire

Firefighting at height with charged fire hose line.

To work in different teams in a well-coordinated way.

How to use different fire equipment, gears & PPE's.

Critical operations & Firefighting in vicinity of high heat radiating pressure-fed fuelled fire in a tank dyke/bund

11.1 Brief Introduction:

A bund refers to an embankment or wall constructed from materials like brick, stone, concrete, or other impermeable substances. It serves as the perimeter and floor of a compound, functioning as a barrier to contain liquids. Given that the bund is a pivotal component of a spill containment system, the entire system or bund area is commonly colloquialised as the "bund."

- Spills or leaks into a bund can result from various events, including:**

Failure of primary containment or pipework leading to a leak into the bund area.

Overfilling of the tank, with overfill ground fires being common in fixed-cone roof, internal floating roof, external floating roof and domed roof tanks.

- Boil-over of tank contents:**

Inadequate firefighting techniques for a tank fire, involving overfilling, splashing of contents, or potentially causing tank damage through inappropriate cooling actions.

Brief Description & Photographs of Simulator:

A bund has been erected around a horizontal tank.

Drainage facility is provided with a valve for its operation.

An oil transfer pump with an oil storage is installed near the dyke area.

This oil transfer pump continuously supply oil to bund area.

Fire is created in the bund.



Figure 79 Bund fire simulator

11.2 Objectives:

- To help trainees to learn and practice skills to extinguish fires in case of bund fires.
- To educate trainees how to coordinate among themselves for doing firefighting operations.
- To make trainees conversant with Search & Rescue (SAR) Procedure.

11.3 Nos. of Participants / Teams:

Depending upon the number of trainees in a batch, trainees are divided into 4-5 groups and each group consists of 4-6 persons.

Roles & Responsibilities of Different Teams:

• Incident Commander:

Takes decision regarding emergency situations and regulates the operation

Documents report of the Incident Controller:

Co-ordinates the operation of fire teams

Gives the real time report to the incident commander Fire Teams:

Fire Fighting Team

Extinguishes fire at the site

Restricts fire spread

Auxiliary Team

Backs up firefighting team by extinguishing susceptible nearby fire

Cooling Team

Cools the surrounding combustible material to prevent re-ignition

Provide shield to Operational team and Search & Rescue team

- **Operational Team:**

Valve operator, in fire proximity suit and BA set, closes fuel supply valve

Backed up and continuously drenched by the cooling team

- **Search and Rescue Team:**

Work in pairs with proper PPE

Coordinates with cooling team and searches for casualties and carry them for medical assistance

- **Security Team:**

Patrols the area

Informs incident controller about the emergency and manually initiates the alarm

Barricades and controls mob

- **Logistics Team:**

Provide resources and equipment

Makes standard plan of action during emergency situations

- **Liaisoning Team:**

Calls nearby police station

Contacts Health, Safety and Environment sectors

Informs local fire service

11.4 Equipment Required:

Breathing Apparatus Sets

Fire Proximity Suit

Approach Suit

Fire Delivery Hoses

Multipurpose Hand Controlled Branch

MEFG (Medium Expansion Foam Generator)

Foam Inline Inductor

F-Key for operating hydrant

PPE (Overall, Fireman Helmet, Gumboot, Safety Goggle, hand gloves)

AFFF (Aqueous film forming foam)

Walkie-talkie sets

11.5 Procedure:

Trainees are assigned different role as per the ERP during Bund Fire. Following actions are taken to mitigate the situation:

On spotting the fire, team security will raise the fire alarm and all persons will assemble at the assembly point. Immediately, head count will be done by the Incident Commander and all teams will get to work at the incident site and Command post.

On reaching the site, firefighting team will lay down 03 length of fire hoses from the hydrant and attack the fire from warm zone with the help of MEGF, having 02 persons on the branch in fireman approach suit, 01 (messenger) at foam Inline Inductor and 01 person as hydrant operator. Foam inline inductor will be connected after 1st length of hose and pickup tube will be dipped in the foam jerry can once suction starts. The foam should not be directly applied to the burning liquid and therefore, tank shell can be targeted. The application of water on blanketed foam shall be avoided.

Simultaneously, cooling team will lay down 03 lengths of fire hoses from the hydrant and approach the gate valve from warm zone with the help of multi-purpose branch, having 02 persons on the branch in fireman approach suit, 01 (messenger) and 01 person as hydrant operator.

Once the branch man is ready, water on signal will be passed to the hydrant operator of cooling line & depending upon the further course of action, reduce pressure will also be communicated. As soon as team operation reaches the site with proximity suit donned, cooling team along with the team operation will proceed towards the gate valve having water drenched on the person in the proximity suit from back side thoroughly. While moving from warm zone to hot zone, the person in proximity suit will take the shield by standing back of branch man forming the spray pattern from multipurpose branch.

After restricting the flow by closing the gate valve, the cooling team will cool down the nearby surroundings (dry vegetation and other process unit) as a prevention measures.

Team SAR team (with SCBA sets donned) will carry out their operation in buddy system and look for casualty around the incident site.

All clear signal will be given by the Incident commander after the final inspection by SAR team. Upon receiving the all clear signal, knock up and make up will be done and all teams will report back to the assembly point for debriefing session.



Figure 80 Bund fire drill activity

11.6 Take Away of Session:

Planning and extinguishment of bund or dyke fire.

To work in different teams in a well-coordinated way.

How to use different fire equipment, gears & PPE's.

Module-XII

Practical Training with SCBA Set in a Confined Vessel

12.1 Brief Introduction:

A confined space has limited or restricted means for entry or exit and is not designed for continuous occupancy.

Confined spaces include, but are not limited to, tanks, vessels, silos, storage bins, hoppers, vaults, pits, manholes, tunnels, equipment housings, ductwork, pipelines, etc.

Confined vessel may have following risk:

Low oxygen level

Presence of toxic gas

Presence of flammable atmosphere

The above scenarios can be best determined by using a portable multi-gas detector. This equipment gives alarm at roughly 20% of LEL/LFL



Figure 81 Multi-gas detector

Working in a confined space requires a permit to work system and for this, OISD Std. 105 is followed.

Brief Description & Photographs of Simulator:

This simulator is designed for practicing following scenarios:

Search & Rescue Operation

Critical job like closing of emergency shutdown valve

Carrying out any maintenance/repair job



Figure 82 Confined Vessel Simulator

There are 02 manholes available in the vessel. The entry manhole is available on top and exit one is available at the extreme/front of the vessel.

12.2 Objective of Practical Session:

- To understand the importance of multi-gas detector & SCBA sets while working in a confined space.
- To create oxygen deficient atmosphere and very less visibility and build the confidence for practicing search and rescue operation in oxygen deficient and obstructed space.
- To educate trainees how to coordinate among themselves for doing search and rescue operations.
- To make trainees conversant with Search & Rescue (SAR) Procedure.

12.3 Nos. of Participants / Teams:

Depending upon the number of trainees in a batch, trainees are divided into groups of 4-6 persons.

Equipment Required:

Breathing Apparatus Sets: 04nos.

Multi-gas Detector: 01 no.

PPE (Overall, Fireman Helmet, Gumboot, Safety Goggle, hand gloves).

12.4 Procedure

After forming different teams (04 members), each team is given a task to enter the confined vessel for performing search & rescue operations using SCBA Set.

Each trainee enters the confined vessel from a manhole.

Manhole is present at the top of the confined vessel with ladder attached to it.

As soon as the trainee enters the vessel, top manhole is closed for creating a dark enclosure.

Trainee has to search the short branch/foam branch present inside the vessel.

There is a life line string available inside the vessel and same has to be used while carrying out search & rescue operation. This string helps in following the direction.

After searching the foam branch/short branch, trainee leaves the confined vessel through an exit in the front of the vessel.



Figure 83 Confined Vessel entry activity

12.5 Take Away of Session:

Training for search & rescue in confined spaces with the use of SCBA Set.

To work in different teams in a well-coordinated way.

How to use different fire equipment, gears & PPE's

Conclusion

In conclusion, this training module on firefighting has equipped participants with the knowledge, skills, and mind-set necessary to address complex and high-risk fire incidents. Throughout this course, we have delved into a range of advanced firefighting techniques, strategies, and safety protocols. As you close this chapter of learning, it's imperative to acknowledge the significance of the acquired proficiency. This training has elevated your capability to address complex and high-stakes fire scenarios efficiently and effectively. As we wrap up this training.

The major key takeaways:

- Enhanced Firefighting Skills: Participants have gained proficiency in advanced firefighting techniques, including ventilation, search and rescue, incident command and the use of specialized equipment. This knowledge is essential for dealing with challenging fire scenarios effectively.
- Emergency Response Preparedness: We have emphasized the importance of rapid and well-coordinated emergency responses. Timely and organized actions are crucial to minimizing the impact of fires and protecting lives and property.
- Safety First: The safety of both firefighters and those in need is paramount. Participants have learned how to assess and mitigate risks in hazardous environments, ensuring their safety while carrying out their duties.
- Adaptation to Evolving Threats: Firefighting is an evolving field, and participants are now better prepared to handle emerging challenges, including hazardous materials incidents, urban search and rescue and wildfire response.
- Effective Incident Command: Effective leadership and incident command are essential for successful firefighting operations. Participants have learned the principles of incident command, ensuring efficient and coordinated responses to fire emergencies.
- Continuous Learning: Firefighting is a dynamic profession and the knowledge gained in this module is just the beginning. It is crucial to continue learning, staying updated on the latest techniques and technologies in firefighting.
- Teamwork and Communication: This training has highlighted the importance of teamwork and effective communication within firefighting teams. Collaborative efforts are vital for managing complex fire incidents.
- Advanced firefighter is paramount in safeguarding lives, preserving property and ensuring the well-being of our communities. The training has not only fostered your

technical skills but also highlighted the critical elements of teamwork, clear communication and adaptive leadership components that are the bedrock of successful firefighting operations.

However, the journey doesn't end here. The firefighting profession is ever-evolving, and to stay at the forefront of this dynamic field, continuous learning and professional development are essential. By embracing this knowledge and applying it in the field, you're poised to make a profound impact in the face of adversity.

This firefighting training has provided participants with the critical skills and knowledge necessary to confront complex and high-risk fire emergencies with confidence and competence. By applying the principles and techniques covered in this module, you play a critical role in protecting lives, property and the environment. Remember that your dedication to continuous improvement and commitment to continuous learning, safety are the cornerstones of an effective firefighting team. Thank you for your commitment to this vital profession and we wish you success in your future firefighting endeavors. Stay safe and be prepared to make a positive impact in the face of adversity. It will continue to shine brightly as an advanced firefighter. Stay safe, stay prepared and continue to make a positive difference.

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