Fire Protection in World’s Maiden LNG based Hydrocarbon Processing Plant Dahej, ONGC

Dinesh Kumar, P V Satyaprakash, V K Ramesh
C2-C3 Plant, Dahej, ONGC
e-mail: compoter@rediffmail.com

Abstract

Hydrocarbon processing always poses challenges of fire hazards due to the inherent flammable nature of hydrocarbon. Management of Fire hazards is even more challenging and complex when processing of hydrocarbons is done under cryogenic conditions and first ever in the world as in the case of the C2+ extraction Plant at Dahej. The cryogenic process for extraction of natural – gas liquids (NGLs; C2+) from LNG is known as COREFLUX® LNG process.

Management of fire hazards in C2+ extraction Plant requires unique fire hazards mitigation measures and fire protection equipments to operate the Plant safely.

This plant has automatic fire detection and argonite gas based fire suppression system in process control room. The argonite gas is clean & environment friendly. The C2+ Storage spheres are protected with automatic fire detection and medium velocity water spray system. All the hydrocarbon liquid handling vessels and columns are also protected with water spray system. The electrical transformers are provided with high velocity water spray system. Surveillance cameras are installed at strategic locations in the plant to monitor round the clock activities. In addition to above, Fire water net work with fire hydrants and water monitors to fight two largest fires at a time, DCP and Foam Tender, Fire alarm, smoke and fire detection, emergency siren and round the clock manned fire station by dedicated and trained fire personnel are provided in the Plant.

The handling of leakages of LNG and LNG process fire involves special equipments viz fire suit, chemical and high expansion foam generator. Each LNG process fire will be unique and requires trained fire personnel to handle when the process is the first ever in the world and cryogenic in nature.

Authors make an endeavours to present the fire protection of world’s maiden LNG based Hydrocarbon Processing Plant at Dahej, Gujarat.

1.0 Introduction

In 2003, Petronet LNG Ltd (PLL) had contracted rich LNG (LNG with a higher percentage of C2+ products) from Qatar. Subsequently, ONGC identified an opportunity to extract value added products from this rich LNG and was granted extraction rights by Ministry of Petroleum and Natural Gas, Govt of India.

C2-C3 Extraction Plant is the first LNG processing plant in the world Located in Dahej, Gujarat, India. The rich LNG sourced from Petronet LNG Ltd (PLL), a Joint Venture of ONGC and other oil companies, is located adjacent to the C2-C3 Plant. The extraction plant consists of a train of design capacity 4.9 MMTPA (612.5 ton/h) of rich LNG with a provision of an additional train. The value added products viz Ethane (C2), Propane (C3) and Butane (C4), will be feedstock for the ensuing grass root petrochemical complex (OPaL), located close to C2-C3 Plant site.
The cryogenic process developed by Toyo Engineering Corporation, Japan, known as COREFLUX®-LNG Process, for extracting Natural-gas liquids (NGLs; C2, C3, C4 and other hydrocarbons) from LNG, has been used in C2-C3 Extraction Plant.

2.0 Process Description

LNG (Liquefied Natural Gas) consisting of Methane, ethane, propane and butane is imported in marine tankers by M/S PLL situated adjacent to C2-C2 Plant Dahej. LNG from PLL’s LNG storage tanks is received in C2-C3 Plant B/L at a pressure of 4.0 Kg/cm²g and a temperature of (-) 152°C. It passes through custody transfer meter and LNG surge drum before being pumped to Dematheniser column. In Demethaniser column lean LNG (Methane) is separated and then compressed, condensed and pumped back to PLL at a pressure of 100.0 Kg/cm²g and at a temperature of (-) 100°C. The balance product goes to De-ethanizer and De-propanizer columns for extraction of ethane, propane and butane.

The products viz C2, C3 and C4 are stored in Horton Spheres. Ethane is stored in storage tank at (-) 19.2 °C and 15.3 kg/cm²g pressure. There are two spherical storage tanks for ethane each having a capacity of 4189 m³. Liquid ethane is pumped by C2 Product Pump and sent to battery limit.

Propane is also stored in two spherical storage tanks (each having a capacity of 1950 m³) at 13.0°C temperature and corresponding saturation pressure (6.0 kg/cm²g). Liquid propane is pumped by C3 Product Pump to battery limit.

Butane product is stored in two spherical storage tanks at 35°C temperature and 2.9 kg/cm²g pressure. Capacity of each butane storage tank is 1150 m³. Liquid butane is pumped to pipeline with the help of butane product pump.

The constituents of Natural Gas & process flow diagram of C2-C3 Extraction Plant are shown in Fig.1.

Fig: 1

3.0 Risk assessment & Analysis

QRA was carried out for C2-C3 Plant by ERM, Hong Kong. Recommendations of QRA were implemented in design and construction of the Plant. Integrated QRA for M/S Petronet LNG and C2-C3 Plant Dahej is under process and is planned to be completed before commissioning of Plant.

Fire and other hazards associated with the extraction of C2, C3 & C4 as envisaged in QRA study are as below;
4.0 Fire Safe Plant layout

The layout of Plant is arranged in accordance to OISD-118 to ensure adequate fire fighting access, means of escape in case of fires. The Central control room is located in a blast proof building. Segregation of facilities is also done so that the adjacent facilities are not endangered during fires. Designated assembly points are earmarked to assemble in case of emergency. The compartmentalisation of process control room is made to ensure that fire does not escalate from one room to another. External entrance and exit are fitted with blast and fire resistance doors to safeguard from external fires.

5.0 Passive Fire Protection

The Columns, Vessel, spheres, pipes and supporting structures are protected with 1 & 2 Hrs fire proofing to prevent escalation of fires and avoid collapse of structure under fire. Fire separation walls in concealed space, electrical substation, transformers yard, bays and cable galleries are provided. Pressurisation of control room is maintained and fire doors are also installed. Flare system for venting of hydrocarbon inventory in the event of process upset is installed. Fire retardant low smoke insulation cables are laid. Thermal insulation at hot surfaces (Pipe lines) is provided to prevent heat radiation hazards to equipments in the vicinity.

6.0 Surveillance with CCTV & round clock monitoring

Plant is covered with 06 nos of high resolution low light performance CCTV digital cameras installed at strategic locations for surveillance. Cameras are connected with a 21 inch colour monitor & digital recording facilities at Control room to monitor entire process area to detect any abnormal activities such as process upset, hydrocarbon release, movement of men & materials or emergency vehicles and fire.

7.0 Ambient air quality monitoring system

There are four units installed in the Plant for continuous monitoring and measuring Sulphur Dioxide, Nitrogen oxides, Carbon Monoxide, Methane, Propane and Dust in air around the Plant as well as the wind speed and wind direction, humidity, and temperature and solar radiation.

The monitoring helps to detect abnormal presence of toxic gases and hydrocarbons in ambient air and to alert the plant personnel for taking corrective and preventive action to avoid fire, explosion and minimise the adverse impact of weather.
8.0 Fire and Gas Detection System

Gas (IR absorption & catalytic), open path beam, UV/IR detectors and LHS cable are installed in process area to detect any leakage gas or fire. These are connected with Fire & Gas Panel in control room for monitoring and initiating action. Smoke and Fire detection system are also installed in Control room building, administrative building, Canteen, Laboratory substation earth station and conference room. Fire Alarm panels are installed in Fire control and process control room. Photoelectric Smokes, multi-sensors and heat detectors in buildings are connected with fire alarm & detection panel located in Fire & process control room. Coincidence actuation of any two smoke detectors or heat detector gives the alarm at repeater panel in building and Fire control from where fire personnel respond suitably.

Manual call points (MCP) are installed throughout the plant to transmit signal to fire station by breaking the glass in case of fire or emergency. The MCPs are connected with fire alarm panel at Fire Station where audio visual signal is received.

9.0 Eco friendly fire extinguishing System

Two independent Clean agent (Argonite gas) based auto extinguishing systems as per NFPA -2001 are installed in central control and Truck loading facilities buildings to protect central control room, UPS, rack room and metering rooms and also control room, UPS, Battery, electrical panel room of Truck loading facilities. The system consists of clean agent cylinders, discharge valves, hoses & nozzles, smoke & fire detectors, control panel and actuating devices. Fire extinguishing system can be released when two coincidence smoke detectors or a fire detector is actuated. F & G Panel after receiving signal from detector relay signal to annunciator audio visual alarm and to pilot cylinder installed in cylinder bank for release of extinguishing agent. The cylinders releases extinguishing agent after 30 sec pre discharge time delay as programmed to warn the occupants for evacuation. The system can also be released by remote and manual mode.

![Typical Argonite Fire Suppression System in C2-C3 Plant Dahej](image)

### Technical data of Argonite

- **Chemical formula**: blend of 50% Nitrogen and 50% Argon
- **Weight**: Varies according to design concentration
- **Volume**: Varies according to design concentration
- **Operating pressure**: 160, 200 and 300 bar
- **Minimum design concentration approx.**: 37.5%
- **Minimum discharge time**: <60 seconds
- **Extinguishing mechanism**: Oxygen depletion 43% (12% Oxygen) 52% (10% Oxygen)
- **NOAEL**: Zero
- **Global Warming Potential**: N/A
- **Atmospheric Lifetime**: Inert gas
- **Approval**: Argonite has been approved by LPCB, FMUL, NFPA, Bureau Veritas, DNV, CNPP and the Environmental Protection Agency.

![Typical argonite fire suppression system & Technical data of Argonite](image)
10.0 Water spray system

C2, C3 & C4 Product Storage spheres and truck loading facilities are protected with automatic medium velocity water spray system with application rate of 10.2 lpm/m$^2$. De-ethanizer, de-propanizer columns, flare knockout drum, de-propanizer pumps, methanol circulation pump & storage tank are protected with manual water spray system with application rate of 10.2 lpm/m$^2$. Electric transformers are also protected with automatic high velocity water spray system with application rate of 10.2 lpm/m$^2$.

11.0 Fire Pumps & Fire water network

Fire water system of the Plant is designed to fight two largest fires anywhere in the Plant. Storage spheres and truck loading facilities are two largest fires envisaged as per QRA. As per OISD -116, Water storage capacity of 16,000 m$^3$ in two equal compartments having 8,000 m$^3$ is installed based on maximum fire water flow requirement of 3800 m$^3$/hr for four hours. Accordingly, 04 nos of diesel and electrical motor driven fire water pumps of capacity 925 m$^3$/hr each and head 88 mwc and 02 nos of Jockey pumps of capacity 115 m$^3$/hr and head of 88 mwc are provided to maintain a minimum residual pressure of 7 kg/cm$^2$ at the most remote location in the fire water network. Fire water network is laid in closed loop to ensure multidirectional flow in the system. Isolation valves are also provided in the network to enable isolation of any section of the network without affecting the flow in other sections.

The entire plant area is covered with “A” & “B” types of fire hydrants at least for every 30 mtrs at strategic locations on firewater network. Delivery hoses of 15 mtrs length are provided near the hydrants for use in case of emergency.

Fire water monitors of 2580 LPM capacity are also installed at columns and spheres areas. Water cum foam monitors 2838 LPM are provided at truck loading facilities for exposure fire protection.

12.0 Fire Station

Fire station is nerve centre in case of any fire or emergency in Plant. The C2-C3 Plant has one fire station located at entrance of process area. Fire Station is equipped with fire control room, Foam and a DCP fire Tender and other fire fighting and rescue equipments. Fire and alarm panel are installed at fire station. Emergency communication such as landline, VHF, Walkie Talkie, Hot line , Radio tracking system, Fire bell, a hand operated siren and emergency siren of 1.5 KM range is available for reliable & fast communication. Pager is also provided in the process areas to communicate with fire station in case of emergency. The location of fire station is such as that entire Plant area will be covered within 02 Minutes in case of any emergency by Fire Tender. Fire Crew comprising 04 firemen, a supervisor and a pump operator/driver are ever ready round the clock to man the Fire Tender within 20 Sec in case of ringing of fire bell at Fire Station.

13.0 First aid fire and personal protective equipments:

Trolley mounted and portable Dry chemical powder, Foam and CO2 Fire extinguishers of various capacity at strategic locations in the plant are provided for incipient stage of fire fighting. Self Contained Breathing Apparatus (SCBA), Safety helmets, gloves, face masks, goggles, shoes, ear plugs, muffs and fire proximity suits are also provided to meet the emergency in the plant.

14.0 Emergency Management Plan

C2-C3 Plant will have well documented Emergency Response Plan (ERP) prepared on the basis of QRA and HAZOP study. Strategy, Action Plan and Data directory, role and responsibility of emergency coordinators and operation, maintenance and rescue teams in emergency are
documented in ERP. Emergency Response Plan is integrated with operational contingency, District Disaster Plan and ERP of neighbouring Plants. It is updated annually and distributed to all emergency co-ordinators. Drills are conducted as per ERP and lessons learnt during drills are documented and corrective action if any is implemented to improve response in emergency.

15.0 Mutual Aid

Emergency Response Plan (ERP) of C2-C3 Plant is prepared based on QRA study. ERP will be implemented in the event of any emergency and disaster in the Plant. Mutual aid with neighbouring industries in the event of disaster in Plant will always help. So, C2-C3 Plant has already processed to enter Mutual aid agreement with neighbouring industries. Personnel of the plant already participated in offsite drill conducted in M/S Petronet LNG Plant by Bharuch District Authority in January, 2010.

16.0 Training & Drill

Training & Drill are essential elements of disaster management. All personnel of C2-C3 Plant have undergone training on fire & safety of one week. As practice makes the man prefect so fire & emergency drills will be conducted involving the plant personnel to familiarise the role & responsibility as documented in ERP. Off site drill will also be conducted annually involving mutual aid partners and district authority to demonstrate the effectiveness of ERP and know the gap as lessons learnt to improve the implementation of ERP in the event of emergency in Plant.

17.0 Fighting LNG Fires

The control mechanism of LNG spill and fire are not understood clearly. When LNG burns, it is particularly destructive for surrounding property. LNG, like aluminium alkyls behaves peculiarly when spilled on water. It can “explode” in a popping fashion. Superheat –limit conditions cause two types – One harmless and other with potential for minor damage. It is under evolution stage

Foam provides adequate control of LNG fires and reduce external radiation effects to safe levels beyond one fourth or more pool dia. The 500 – 1 foam expansion ratio appears superior to higher expansion ratio such as 750:1 or 1000:1. The 500:1 foam expansion reduces steady state LNG evaporation rates.

The 500:1 foam initially provides a marked degree of buoyancy (increased boil off vapour temperatures) to the boil off vapours. The benefit period depends on the foam depth and vapour boil off rate since the boil off vapours result in freezing of the foam. This buoyancy effect will reduce the downward travel of flammable concentrations near grade level, right after an LNG spill.

A foam blanket aids in extinguishing a LNG Fire with dry chemicals. Foam quickly freezes on open cellular (form) to support several feet of additional foam without collapsing or sinking into LNG. Several feet of foam, 3 to 6 feet appear to provide a good degree of fire control. This results in a big reduction in the radiation flux level at short distances from the fire edge. High expansion foam generator is used to generate the foam with help of water, foam and air.
Conclusion: C2-C3 Plant Dahej is conceptualised as a safe, compact and zero effluent Plant. It is constructed with good engineering practices. Associated hazards in Plant as envisaged in QRA are mitigated in 4Ts (Terminate, treat, transfer and tolerate) manner. Standard Operating Practices (SOP) will be followed during commissioning and operation of the Plant. Though Fire protection systems are implemented to take the fire/emergency. The inventory of knowledge of characteristics and processing of LNG with operation, maintenance personnel and fire crew, exposure in fire fighting and skill of fire personnel blended with supervision of trained and technically qualified fire professional will be critical factors for smooth and safe operation of C2-C3 Plant and during fire & emergency.

Team C2-C3 Plant Dahej is committed to commission and operate the plant safely efficiently.

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