Evaluation of Risk Reduction Options for Floating Roof Storage Tanks

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Abstract— Storage of highly flammable hydrocarbons such as crude oil in considerable quantity is inevitable in refineries as well as petrochemical manufacturing facilities for meeting production requirements. However, these storages pose serious threats to the safety of the installation and the environment as has been experienced during major fire incidents like Indian Oil Corporation Jaipur oil terminal fire in 2009 and IOC Hazira oil terminal fire in 2013. In order to prevent such disastrous incidents, a thorough review of the fire protection philosophy and up gradation of both hardware and software control measures are required. This project aims to evaluate the risk reduction options for floating roof tanks storing class-A hydrocarbon liquid. Here, the term "Risk" primarily intends to focus on "Fire Risk" which is the most prominent aspect of operating huge storage of hydrocarbons like naphtha and hence environmental aspects are not considered. The evaluation has been carried out by reviewing the available risk control measures on a major industrial site and analyzing improved options in the current market and international best operating practices. secure and more efficient border environment.

Key words: Fire Risk, IOC

I. INTRODUCTION

The project scope involves evaluation of the following aspects of floating roof tanks, with the objective of exploring practically feasible risk reduction options in addition to the existing control measures at the site.

1) Tank construction
2) Tank fire incident detection
3) Tank fire control and suppression

An important part of understanding the fire risk associated with large diameter tanks is recognition of the potential fire scenarios that can occur.

II. SCENARIOS

Based on experience at global level, there are six incident scenarios involving floating roof storage tanks. These are explained below, as used throughout the project documentation.

A. Spill-on-roof Fire:

A spill-on-roof fire is a fire in a liquid of limited depth on a roof that still maintains its buoyancy. It can result from a number of different hydrocarbon release and ignition events.

B. Rim Seal Fire:

A rim seal fire is one where the seal between the tank shell and roof has lost integrity and there is ignited vapour in the seal area. The amount of seal involved in the fire can vary from a small, localized area up to the full circumference of the tank. The flammable vapour can occur in various parts of the seal depending on the seal design.

C. Full Surface Fire:

A full surface fire is one where the entire surface of liquid in the tank is exposed and involved in the fire. The tank roof is assumed to have completely sunk. In practice, if a roof is partially sunk due to tilting such that a significant portion of the fuel surface is exposed and ignition occurs, this can be regarded as a full surface fire.

D. Bund Fire:

A fire in the bund is any type of fire that occurs within the containment area around the tank shell. These types of fire can range from a small spill incident up to a fire covering the entire bund area. In some cases (such as a fire on a mixer) the resulting fire could incorporate some jet or spray fire characteristics due to the hydrostatic head of the fuel source.

E. Explosion in pontoon or other confined space:

An explosion can occur if flammable vapour builds up and is ignited in a pontoon or other confined space. Such explosions can also occur when the roof is landed on its legs and air is pulled into the vapour space under the roof.

F. Vent Fire:

A vent fire is a fire in which one or more of the vents in a fixed roof tank or internal floating roof tank have ignited.

III. DESIGN AND CONSTRUCTION OF TANK

The design and construction aspects of floating roof tanks that have impact of fire safety, involve various components such as (1) Floating Roof, (2) Rim seal, (3) Roof drain, (4) Roof fittings, (5) Shell fittings and (6) Bunding. Experiences at the global level, of improvised designs of these components are summarized below.

A. Floating roof:

Three types of roof designs are possible. These are: (a) Single deck, (2) Double deck and (3) Multiple deck. Of these, the Double deck type has many advantages over other types and is the most widely used design with the best safety records.

B. Rim seal:

Different types of seal designs are: (1) Primary seals – Mechanical or Tube seals, (2) Secondary seals and (3) Weather seals. Provision of all three types can provide added levels of protection. Use of fire resistant type seal materials is an area for improvement to check the spread of rim seal fires.

C. Roof drain:

Roof drains are normally kept closed and it is manually opened during rainy seasons. A possible improvisation is the provision of a hydrocarbon sensing drain valve that closes the valve when hydrocarbon enters the roof drain.

D. Roof fittings:

The roof fittings of concern are: (1) Roof ladder, (2) Full circumference walk way and (3) Pontoon covers. Faulty roof ladder has the potential to damage the roof and cause it to sink. A full circumference walk way can of immense help during manual firefighting of rim seal fires. Loose pontoon covers can cause vapor emission and pontoon explosions. Proper design, operation and maintenance of these fittings can reduce risks considerably.

E. Shell fittings:

These include tank nozzles, sampling points, tank side valves and associated flanges, mixers, heaters etc. All of these are potential leak points and some could act as ignition sources.

F. Bunding:

Three systems of bunding to prevent loss of containment of the product are in use: (1) Double shell bund, (2) Low wall bund and (3) Remote containment basin. Remote containment basin is considered to be the best option if properly designed.

IV. INCIDENT DETECTION

Incident detection systems focus on detection of loss of containment and fire. Loss of containment detection tends to be less accepted due to inherent problems with differentiating between normal operational release levels and other releases. However, IR technology based gas detection systems Fire detection systems are highly relied up on for early warning and initiation of emergency response. Linear heat detection cables are still considered as the most convenient and reliable mechanism. Advancements in the areas of thermal imaging and video imaging are being utilized as additional layers of protection.

V. FIRE CONTROL AND SUPPRESSION

The choices of fire control and suppression systems for floating roof tanks are: (1) Foam systems, (2) Dry chemical systems, (3) Gaseous agents and (4) Water spray systems. Dry chemical systems and gaseous agent based systems are no longer considered effective on major fires. Therefore water spray systems and foam based systems of different designs are of particular interest. Of different designs, it has been recognized that the "one-shot" type of system should not be considered as a replacement for the fixed or semi-fixed type of systems. Due to this recognition and the fact that such systems pose particular maintenance problems, it is not considered necessary to install one-shot systems. The existing semi-fixed foam system being a true "NFPA 11" style system (i.e. one fed from a longer duration water source) is more effective and reliable.

VI. RESULTS AND DISCUSSION

The project outcomes suggest that there are a number of risk reduction options that can be implemented at the site as listed below.

1) Provision of portable Dry Chemical extinguishers of 10 kg capacity over the full circumference walk way to enable initial firefighting of rim seal fires. Although there are known instances of successful extinguishment using dry powder, which have not involved re-ignition, there are also known instances where re -ignition continually occurred and the dry powder extinguishing attack failed completely. Therefore, if dry powder extinguishers are to be used, foam extinguishers or foam hand line nozzles should support the dry powder knock-down operation to secure the fire area. It is important, therefore, to ensure that the dry powder used is compatible with the foam.
2) Provision of foam nozzle outlets on the risers of foam pourer system for hose connections to fight rim seal fires. Foam nozzles should be a minimum 200 lpm capacity. This size permits easy control and movement for firefighters.
3) Augmenting fire suppression capability to manage full surface fire scenario through the use of high throughput non-aspirating type foam monitors connected to a reliable foam compound supply through jet ratio controllers.
4) Switching over to 1% foam compound based fire suppression system from the current system using 3% foam concentrate. This will reduce logistical issues for mobilizing bulk quantities of foam compound.
5) Replacement of existing foam filled tube type primary seal with a fire resistant type to limit the fire spread.

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