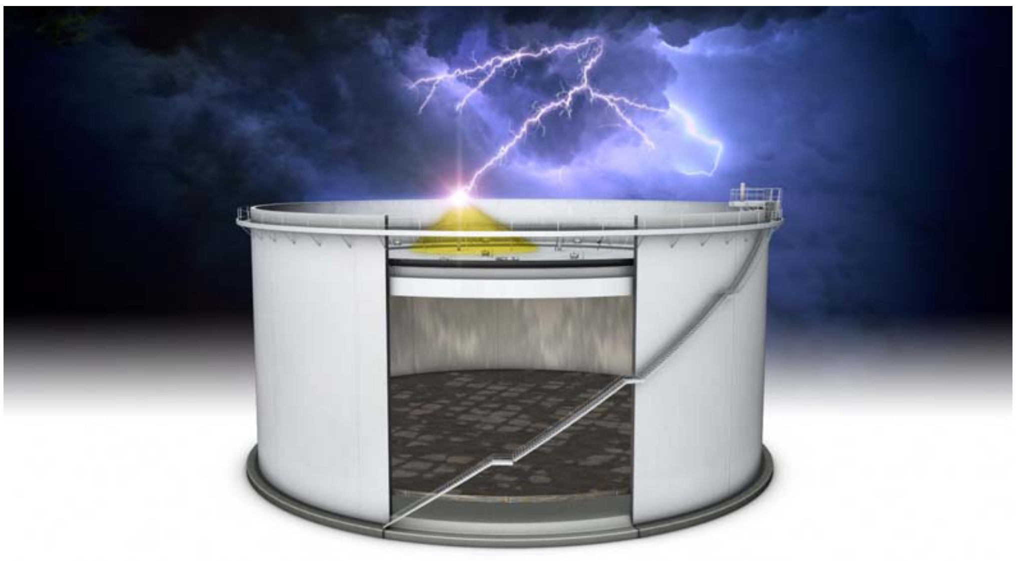
# OIL INDUSTRY SAFETY DIRECTORATE

# CASE STUDY FOR RIM SEALS LIGHTNING FIRE OF FLOATING ROOF TANKS



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## 1.0 INTRODUCTION :

There was an **incident of rim seal fire** at one of the major coastal crude oil terminal installation in western India.

The terminal consists of 18 no. of crude oil tanks of **85000 KL** capacity each, with related pumping facilities, pipelines & fire fighting facilities. Each tank is 79 Mtrs in dia & 18 mtrs shell height. All tanks are double deck floating roof tanks with primary & secondary seals. Shunts are provided above the secondary seal for electrical conductivity of lightning current across the floating roof & inner surface of shell at regular intervals of about three mtrs.

These tanks were constructed & commissioned in three phases, over a period of about 30 years. Originally there were only ten tanks. Three tanks were subsequently added and another five tanks are recently constructed & commissioned.

In addition to Semi fixed foam pourer system in tanks, each tank is provided with following type of roof mounted Rim seal fire detection and extinguishing system :

Phase-1 : Ten tanks :

Quartzoid bulb detection & Halon gas extinguishing installed outside the secondary seal. These tanks are also provided with lightning arrestors.

Phase-2: Three tanks:

Impolene tube type detection & foam extinguishing system.

Phase-3: Newly commissioned five tanks:

Hollow metallic tube type detection & foam extinguishing system.

## 2.0 THE INCIDENT:

2.1 There was heavy lightning, thunderstorm & rains in the region, and as eyewitnesses blast sound & fire was noticed in the southern region of rim seal of one of the tank during early hours of the day**.** This was followed by rim seal fire in the south-east region of same tank, about 20 to 25 mtrs. away from first location. Out of the two locations involved in fire, one location was found almost in trajectory of one of the 'lightning arrestor' installed on the tank shell top where the effect of lightning fire was most severe. Liquid level in the tank was 15.94 mtrs. at the time of fire, against the safe filling height of 16 Mtrs. Thus floating roof was almost upto maximum height. Flame height was noticed to be about 5 to 10 ft. above the tank. Fire was extinguished by foam application through foam pourers by Fire & Safety staff, by fire tenders of company and nearby mutual aid partners.

2.2 About an hour later another fire was noticed in the western portion of another located on the other side of the road. Liquid level in this tank was 15.03 mtrs ( Safe filling ht. 16 mtrs.). The floating roof was almost upto maximum height in this case also. Flame height in this case was about 3 to 5 ft above the tank. Here also the fire was extinguished by foam application through foam pourers by company staff.

2.3 Crude oil pumping from terminal was totally stopped. Fire in both the tanks was extinguished by about 08.00 Hrs. and normal operations from terminal restored by 10.00 Hrs.

## 3.0 OBSERVATIONS & DISCUSSIONS:

**<u>THOUGH THERE WAS NO FATALITY OR HYDROCARBON INVENTORY LOSS, THE INCIDENT HAD THE HUGE POTENTIAL FOR CAUSING THE MAJOR DISASTER.</u>**

Observations noticed at site are as under:

3.1 **Non performance of Halon Based suppressant system**:

(i) Both the affected tanks were provided with roof mounted Halon base (quartzoid bulb) rim seal fire protection system. In the event of heat/flame, the quartzoid bulb is supposed to give away and halon to be discharged on the source of fire/flame for its extinguishment. However, the Halon base system was not effective in this case as none of the quartzoid bulb discharge the halon since none of the bulbs broke away. In one of the tanks, one portion of the tube used for mounting quartzoid was found damaged due to blast.

(ii) The instrumentation cabling to control room for Halon Based quartzoid detection system was found dysfunctional. Although It is reported that regular monthly checking of halon pressure in cylinders is done manually, as such there was no indication at the control room about the functionality of this system.

(iii) The location of quartzoid bulb was observed to be 1.5 ft away from the shell resulting in inadequate heat/flame exposure on quartzoid bulb and the quartzoid bulb did not activate.

(iv) As such Halon base system should have been phased out with foam based application system in line with OISD STD-116 /117.

**3.2 Extent of Damage**

(i) In one tank, the rim seal area in two zones was found affected causing damage to about 20 mtrs length of seal. Out of the affected portion, 10 Mtr length of the secondary seal was found ripped apart from its original location making openings of 1 to 5 ft. 20 meter length of rim seal damage was observed in the other Tank also. As such in both the tanks seals shall need to be replaced in totality.

**3.3 Lightning Strikes on the Tank**

(i) It is clear that the source of ignition was lightning which coupled with the presence of hydrocarbon vapour in the flammability range resulted in the rim seal fire and explosion. Roofs of both the tanks were at highest elevation as the tanks were almost full during the lightning strikes. The hazards from lightning tend to be worse when the tank roof is high ***( Refer API/EI research report on Verification of lightning protection requirements for above ground hydrocarbon storage tanks -first edition 2009)*** as the lightning strike will easily jump from shell to roof, creating severe sparks at shunts which are not tightly pressing against the shell. Typical Lightning Strike when the roof is at high elevation is shown as Figure-1.

(ii) Although shunts are provided to facilitate electric continuity between the floating roof & the shell, one of the main reasons for poor contact between the shell and the shunt is the **mechanical imperfection of the tank shell such as ovality distortion –** out of roundness of the shell. Also gaps between secondary seal and the tank shell will allow lightning initiated sparks to fall into the vapour area between secondary and primary seal. Typical gaps which can cause arcing between shunt & the shell is shown as Figure-2. In case of the affected tanks (SS-004 & SS-001) gaps which were existing between the secondary seal & shell surface emitted enough vapours to get ignited because of shunt generated sparks.

(iii) Maintenance & Inspection for these tanks were carried out about ten years. It is obvious that the affected tanks had considerable vapour accumulation between primary and secondary seal due to escape of vapour from the deteriorated primary seal. This coupled with release of vapour from secondary seal from its gap at the affected locations provided easy source of hydrocarbon to catch fire from lightning strikes.

(iv) In view of inherent problems with use of shunts for earthing continuity between shell and the roof, API RP 545 suggests following provisions for external floating roof tanks:

- ✓ **Installation of submerged shunts** every 3mtrs around roof. In case of submerged shunt any sparks that occurs is within the liquid and do not have the necessary air for ignition to take place. <u>When retrofitting existing tanks with submerged shunts, the above deck shunts should be removed</u>.

- ✓ **Installation of bypass conductors** (cable providing direct connection between roof and shell) at no more than every 30 mtrs around tank circumference. Because bypass conductors will provide a positive bond between the roof and shell, the bypass conductors will present `compared to the shunts. Thus provision of by-pass conductors significantly reduces severity of sparking at the shunts. (Refer figure 3 & 3A for typical details).

- ✓ **Insulation of seal assembly** components and gauge pole, guide poles from the floating roof. **Insulation levels at all such locations be rated greater than 1 KV.**

(v) **With above provisions as mentioned in API the probability of fire because of lighting shall be substantially reduced**. However, the potential still exists considering that magnitude of strikes is very variable (5kA to over 100kA) and unpredictable. OISD standards 116 & 117 therefore stipulate the requirement of Roof Mounted Rim Seal Fire Detection & Extinguishing system **for detection & suppression at incipient stage to prevent it to escalate.**

**3.4 : HVLR's in tank farm**

(i) The subject tank farm is not provided with High Volume Long Range monitors as stipulated in OISD std. 117.

## 4.0 ROOT CAUSE OF THE INCIDENT:

The root cause of incident is the lightning initiated rim seal fire on account of spark generation at gaps between the shunt & the shell igniting vapours which escaped from the gaps prevailing between secondary seal & the tank shell.

## 5.0 LEARNINGS FROM INCIDENT:

1) As stipulated in OISD Std-116 & 117, Rim Seal Fire Detection and Foam based suppression System essentially to be installed in all Class A floating roof tanks for identification and suppression of Rim Seal Fire at incipient stage.
2) Also installation of High Volume Long Range (HVLR) monitors as per recommendations of M.B.Lal committee & OISD Std.-117, should be expedited.

3) Bypass conductors should be provided at every 30 mtrs around the roof circumference as per provisions of API:RP:545. Each conductor should have a maximum end to end electrical resistance of 0.03 Ohms.

4) All gauge & guide pole assemblies, penetrating the floating roof should be electrically insulated from floating roof. The insulation level should be rated greater than 1 KV.

5) As recommended by API, submerged shunts should be installed and the above deck shunts should be removed in the next opportunity.

6) OISD standard :GDN:180, Clause 9.1, last para quotes “A properly designed/ constructed gas tight storage tanks considered to be self-protected against lightning, provided it is properly earthed & bonded. Such a structure may not require any additional means of lightning protection”. As such the arrestors provided on the subject tanks may be removed.

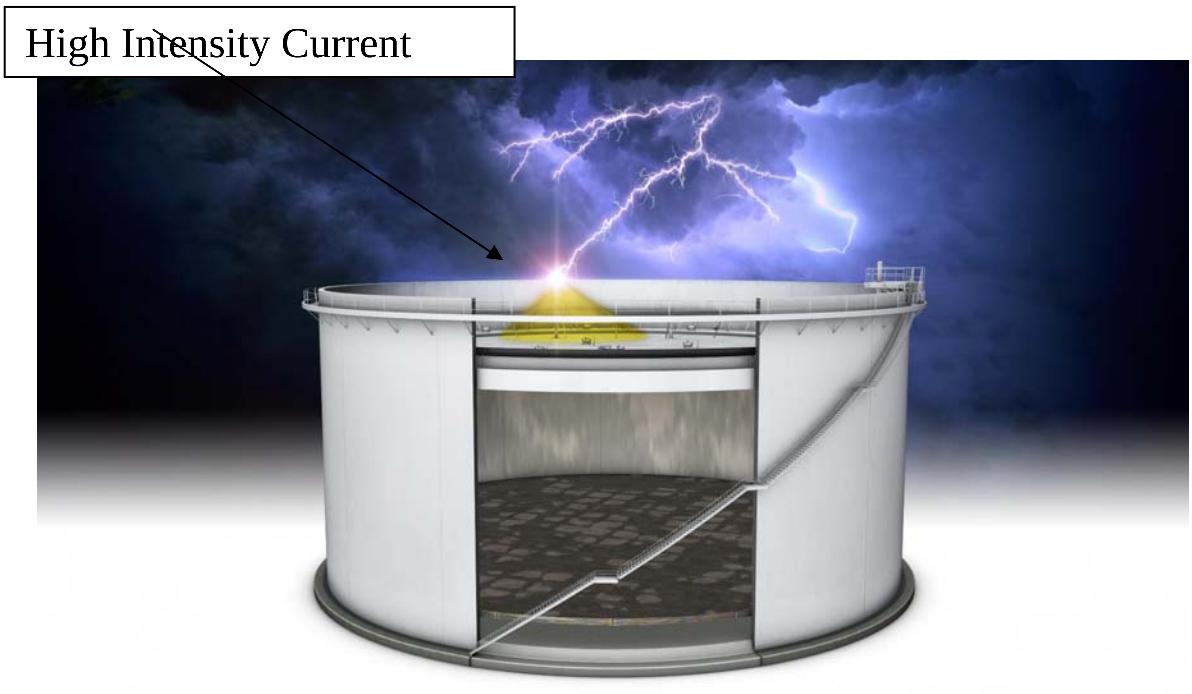


**Figure-1: Typical Lightning Strike when the roof is at high elevation**

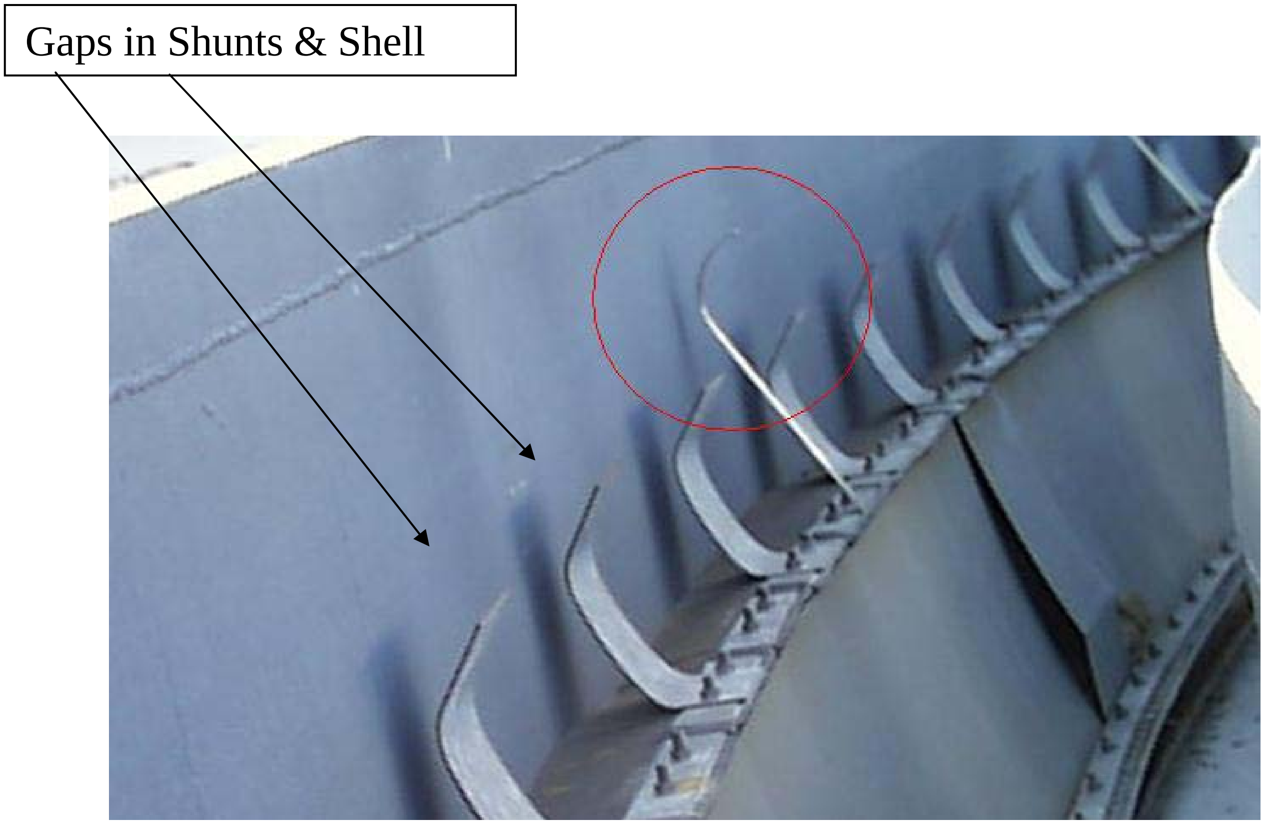


**Figure-2: Typical gaps which can cause arcing between shunt & the shell**

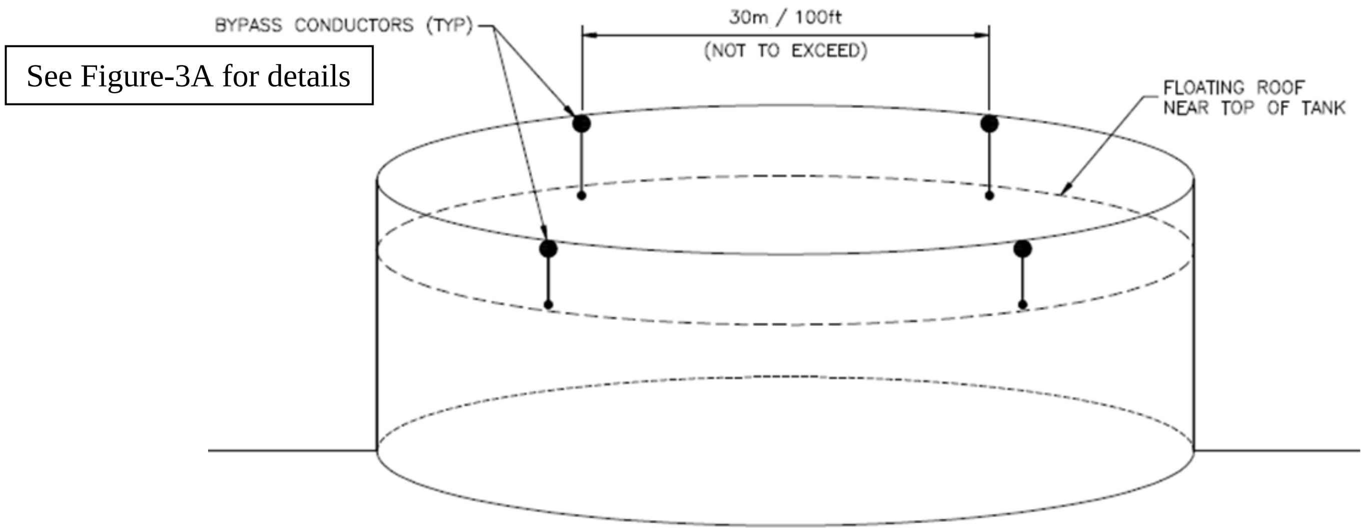


Figure-3: By Pass Conductors as per API 545

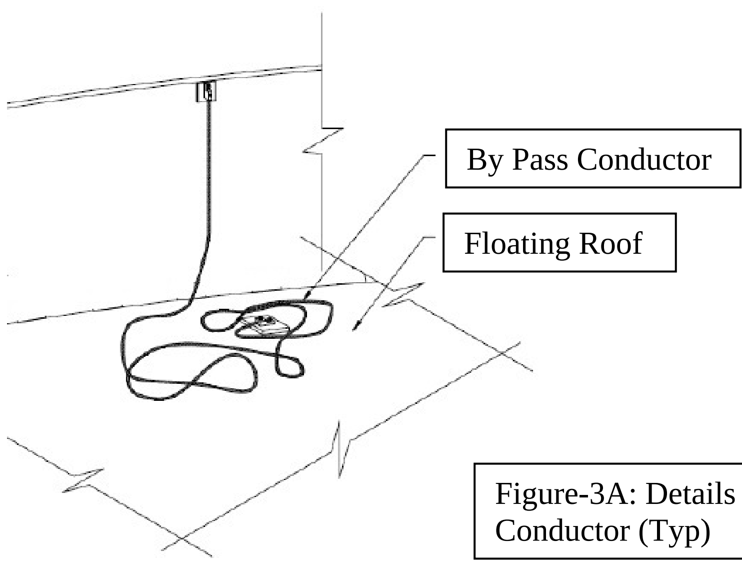


Figure-3A: Details of By Pass Conductor (Typ)