OIL INDUSTRY SAFETY DIRECTORATE

CASE STUDY: FLASH FIRE DURING UNDERGROUND PIPELINE REPAIR

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Background

There was a fatal flash fire at one of the crude oil pipeline terminal, during pipeline repair works. The incident happened during edge preparation i.e. grinding on the open end (plugged with bentonite clay) of the 42" NB pipe. The job was being executed on underground pipeline, around 3 m below ground level, in the excavated pit. The workers were deployed since previous night. The figure below depicts the site of the incident.

The terminal houses 18 no. of crude oil tanks of 85000 KL capacity each, with allied pumping, pipelines & firefighting facilities. There are two receiving headers (each of 42"NB) for ten tanks. One of the headers feeds all odd series tanks (i.e. tank no. SS-1, SS-3, SS-5, SS-7 & SS-9) while the other feeds even series tanks (i.e. tank no. SS-2, SS-4, SS-6, SS-8 & SS-10). The schematic arrangement indicating exact location of incident is explained in Annexure-1.

THE INCIDENT

The Incident took place at early hours in the morning while replacement/repair job on underground crude oil receiving header (42" NB) was on progress. Three workmen of execution contractor, who were present in the pit suffered serious burn injuries.

On the day of incident, the 42" NB by 24" NB spool piece (4.65 m long), downstream of the tap off point to crude tank SS-1, was being replaced as there was considerable metal loss. The incident happened during joint fit-up operation (grinding etc.), for welding of the newly fabricated spool piece with the open end of existing pipeline.

A week before the above incident, traces of oil along the road in front of tank SS1 was noted. On excavation of the area and exposure of pipeline severe loss of thickness were observed in the line between 4 o' clock to 8 o'clock orientation of the 42"NB pipeline just before the 24" valve.

It was also observed that there were two other clamps on this portion of the line downstream of the last tap off point to tank SS-1. Since this part of the pipeline holds stagnant high Sulphur crude, corrosion impact is pronounced at this location.

It was decided to replace the damaged portion of the pipe with a new piece. Towards this the following activities were planned:

- Isolation of the header by closing eight valves i.e. 5 nos. of individual odd series tanks, two nos. at the downstream manifold and one no. upstream valve (24" NB) as marked in Annexure-1.
- Evacuation of the crude from the header to tank SS-1 thru a temporary laid pipe.
- Removal of the corroded portion of the pipeline by cold cutting.
- Erection of the new spool piece (2 no. joints of 24" and 1 no. Joint of 48" NB) at fabrication yard.
- Welding of the newly fabricated spool-piece with the existing pipe end (42"NB).
- NDT of welding joint radiography and flange box up at other end with 24" NB valve.
- Charging Crude oil in the header, wrapping-coating of replaced portion and back filling.

The isolation of the crude oil header was done by a mud plug using '**Bentonite Clay'** at the open end of 42" of the pipeline. Apropos mud plugging, the plan was to weld the newly fabricated spool piece after necessary grinding, edge preparation & fit-up.

After isolating the crude header & evacuation of crude oil from the line, the cold cutting was done and the damaged portion of the pipe was removed. Thereafter the new piece was shifted to site for fit-up operation with existing pipe line.

Mud plugging with bentonite clay commenced at about 00.00 Hrs. and was completed by 02.00 hrs. in the night. The area was checked with LEL detector and clearance given for hot job. All jobs were to be done inside a pit at a depth below 3 m ground level as stated earlier. A gang of about 15 workmen of execution agency along with officials of organization were present at the worksite. Fire crew and fire tender were kept as standby.

After obtaining hot job clearance first round of grinding of open end of 42" NB existing pipe was done for edge smoothening. Two grinders were deployed for grinding operation. Other than grinders one more workman was also present near the spot of grinding.

Thereafter, the pre-fabricated spool piece was lowered with the help of hydra, in between the space of edge of existing pipe and edge of existing valve (24" NB), for fit-up checking. Hydra operation was being done from grade level and instruction to hydra operator was being given by rigger(s).

After check-up the spool piece was again lifted up by hydra, for further grinding works on the edge of pipeline. As per eyewitnesses during this grinding operation, there was flash fire inside the pipe within the pit. Three persons working near open end of pipeline got engulfed in the fire. Out of three workmen two were grinders and one was supervisor. As reported the fire incident happened at about 05.15 Hrs.

With fire on, the victims ran out of the pit. Their fire was doused by other workmen & supervisors present at ground level outside the pit.

Observations:

The 42" header and branch pipelines are in operation since last 36 years i.e. since 1978. The failed spool piece is at dead end location of pipeline. Since upstream 24" NB valve is never operated crude oil remains stagnant in this portion of the pipe.

On the failed spool piece, two nos. of clamps on 42" NB already existed. Also the 24" NB portion of said spool piece had sleeve welded on the original pipe. This indicates this small length of spool piece, about 4.5 m length, had already been earlier repaired thrice in the past.

Sample thickness surveys were done at portion A and portion B of the header during above mentioned repairs. These sample surveys indicate significant loss of metal thickness.

On review of work permit it was noted that adequate safety provisions for thorough line flushing & inertization were not done. Following items in the Hot Permit were marked as "Not required" though they should have been ensured & marked "Yes":

Item A7: Equipment properly steamed/ purged.
Item A8: Equipment water flushed.
Item B4: Checked for gas trapped behind the lining in equipment.

Grinding & fitment Jobs was carried out throughout the night.

Since the line was not water flushed, there is distinct possibility of presence of Hydrocarbon. The mud plug provided in the line cannot ensure leakage of HC vapours. Further during lowering of the new spool piece, the piece might have hit the main line on few occasions which led to damage of the mud plug.

Discussions & Root Cause Analysis

Crude Oil header isolation with a single valve does not ensure HC free environment.

Since double isolation or positive isolation has not been provided in this case more cautious approach is required wherever hot job is undertaken.

Water flushing of the crude oil header was not done for making it hydrocarbon vapour free.

The welding of newly fabricated spool piece with the open end of the 42" NB header which was not fully free of HC vapours was planned to be done by isolation of hydrocarbon vapours by mud plug at the open end of the header which does not guarantee stopping of vapour escape.

Before welding the spool piece, fit-up with the 42" open end was done which involved repeated lowering and uplifting of spool piece and grinding operations and might have dislodged the mud plug.

Job was being done in a pit at a depth of about 3 m from ground level and required precision maneuvering of spool piece (weighing about 1.13 MT) with the help of hydra crane with a boom length at about 4 to 5 m.

This being a critical operation but still was planned for execution during the night hours. Neither Job safety analysis nor the vulnerability assessment was carried out on the eventuality of accidental collapse of 'Bentonite Plug'.

The cause of flash fire incident is due to release of residual hydrocarbon vapours from the line on account of dislodgment (partly or fully) of the Bentonite Plug:

(i) Grinding operation resulted in localized heating of the pipe,
(ii) Dislodgement of the mud plug during repeated maneuvering of new spool piece for fit up checking resulted in HC vapour coming out thru the plug.

The root cause of the incident is inadequate and non-robust system & means followed in respect of isolating the crude oil line, non-flushing of the line coupled with gross inadequacies in Job Safety Analysis.

To summarize the following major deviations resulted in the incident:

- ✓ Job safety analysis was not done before job execution.
- ✓ The header was not water flushed nor inertized, prior to hot job.
- ✓ Adequate provisions were not made to ensure sealing of hydrocarbon vapours (present in the header), from source of hot job.
- ✓ Such critical job of repairing crude oil line was being carried out in the night shift.

Lessons Learnt:

Hot job on any line carrying hydrocarbon should only be done after taking all necessary precautions like adequate water flushing water, inertization etc. to ensure no HC vapors are present.

Job Safety Analysis (JSA) must be done for all critical jobs. JSA document should be approved by competent authority.

Bentonite plugs cannot guarantee positive isolation particularly in large diameter lines.

OISD STD 130 Clause 7.3 that specifies maximum interval guidelines for On Stream Inspection of pipelines carrying crude oil or products must be followed.

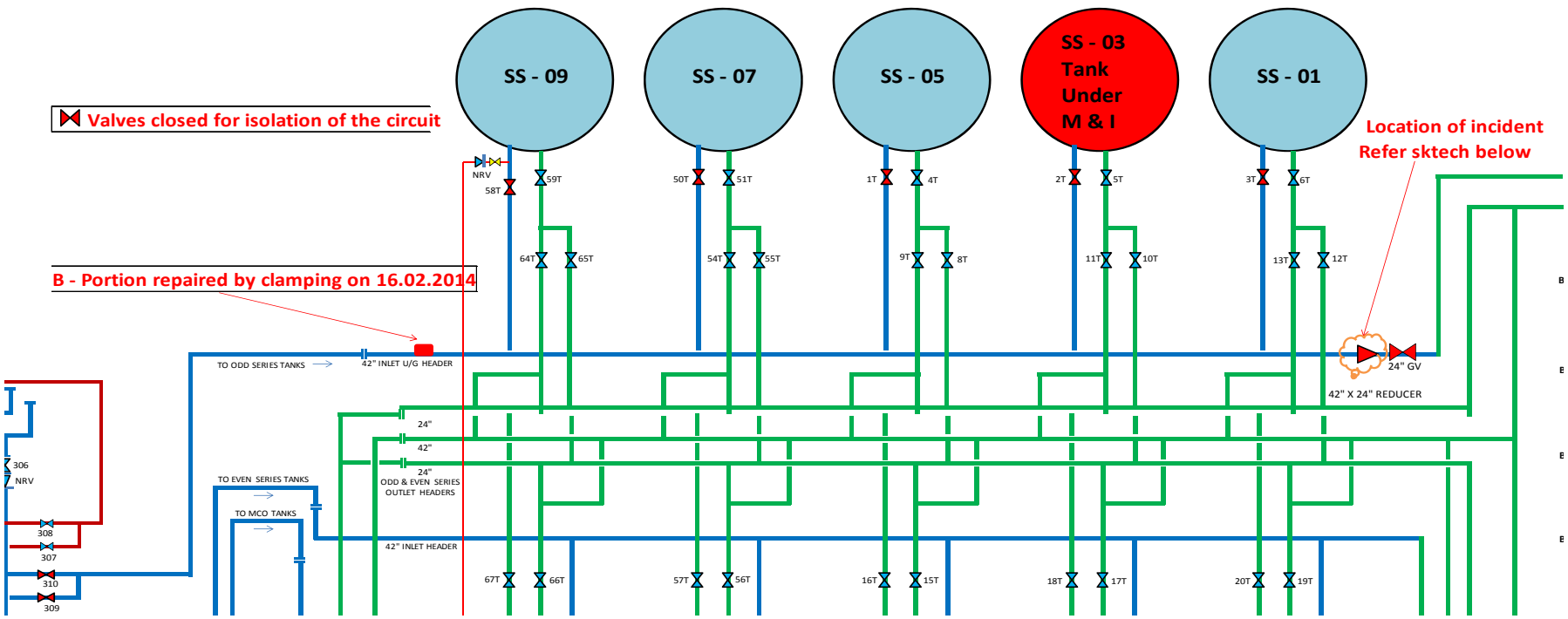
Inspection & remaining life assessment for all the pipeline should be drawn as per the frequencies mentioned in the OISD standard and records maintained. This is essential particularly because this pipeline was designed for product transportation & now used for Crude oil purpose. The subject header (42" NB) should be thoroughly inspected for its integrity and remaining life assessment.

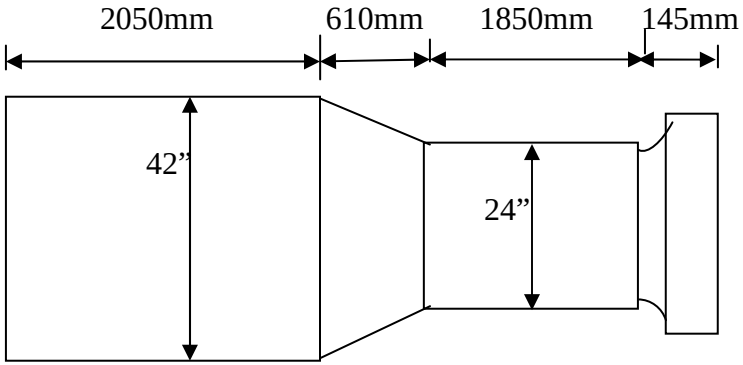
Clamp repair of pipelines should be updated in the "As Built Drawings" and records of such clamps must be maintained.

All the locations in the installation(s), where crude oil remains stagnant should be identified. Their integrity assessment should be done more frequently, on a regular basis.

It is advisable not to undertake hot work on vulnerable crude lines during night shift. It may be pertinent to mention that hot work in crude oil line is considered as highly vulnerable & may lead to untoward incident.

ANNEXURE-1





Sketch & Details of Failed Portion—Location A

Pipe assembly section	Length (mm)	Weight in kg/ 100 mm length	weight (kg)
42" dia. pipe	2050	26.06	534.38
42" to 24" reducer	610	20.43	124.61
24" dia. pipe	1850	14.79	273.6
24" flange	145		200
		TOTAL	**1132.61**

Note: - Average thickness of 24"pipe, reducer and 42" pipe is 10 mm