Crude Oil splash in cross-country crude oil pipeline.

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1.0 THE INCIDENT:

An incident of Crude Oil cross-country pipeline failure took place during an afternoon in the month of January at about 1 Km downstream of the pipeline pump station. Due to high pressure, the pipeline burst and crude oil sprayed into the adjacent mustard field covering a radius of around 1 Km that destroyed the harvest. There was no fire or injury due to the incident.

2.0 THE RUPTURED PIPE:

The pic below depicts the fish mouth opening of the pipe between 12 to 1 o'clock position near HAZ of the weld seam. The dimensions of the ruptured pipe are L=1.080 mm; maximum opening in the middle of rupture ~14 mm; metallurgy of pipe LSAW 22" OD, 0.25" WT, API 5l-X-65 grade; provided with Coal Tar Enamel (CTE) coating.

Fish mouth opening of the crude oil line at 12 to 1 O'clock position

UT thickness measurement of the ruptured pipe was taken at different points and general pipeline thickness loss was not observed.

3.0 AFTER-EFFECT OF THE INCIDENT :

Due to the incident, crude oil delivery to the Refinery stopped. The area near the leak, about 1 Km radius of mustard filed, was seriously affected due splash of crude oil.

4.0 SEQUENCE OF EVENTS:

The data from Supervisory Control and Data Acquisition (SCADA) System depicted:

- Prior to the pipe rupture, the last pump station was running at suction pressure= 4.7 kg/cm^2, discharge header= 66.4 kg/cm^2, M/L Pressure (station outlet) = 64.7 kg/cm^2 and station flow = 1293 kl/hr. At that stage, receiving terminal station (at refinery location) was having inlet pressure = 4.7 kg/cm^2 with Station flow= 1300 kl/hr.

- Inadvertently ESD was activated at **terminal station** at 1604 hrs, resulting in following actions
  - Interlinked tank inlet valve (closure time 1 minutes) of terminal station closed at 1605 hrs
  - Surge line before tank inlet operated at 1607 hrs at set pressure of 20 kg/cm2
  - Due to higher closer time (3 minutes), the other ESD linked station inlet valve closed at 1608 hrs.
  - Due to closure of station inlet valve, mainline got isolated from surge system which is installed at the Terminal station and the pressure suddenly shot up from 64.47 kg/cm^2 to 71 kg/cm^2 during the period of 1608 hrs to 1613 hrs kg/cm^2.

- As per documents, design pressure or MAOP (Maximum Allowable Operating Pressure) of that section of pipeline was 74 Kg/cm^2; discharge header pressure trip setting at pumping station was 74 Kg/cm^2. As per SCADA event list, both the pumps at intermediate running station tripped just before high discharge header pressure setting i.e. at 73.78 Kg/cm^2.

- It is pertinent to mention that the pipeline was originally designed to operate for product service, which was later converted to crude oil service. Subsequently, the pipeline now is being used to transport a blend of several types of crude oils including high S crude from port to refinery.

5.0 INCIDENT ANALYSIS :

- As per the SCADA event list, ESD was activated at Terminal station at 1604 hrs. Due to ESD operation, inlet valve (MOV 07 – with 60 seconds closure time) of crude tanks got closed at 1605 hrs. Thereafter, pressure before MOV07 increased from 3.5 kg/cm^2 to 19.1 kg/cm^2 at 1606 hrs. and consequently the surge relief system operated at 1607 hrs. Thereafter, the station inlet valve (MOV 01 – with 180 seconds closure time) also got closed at 1608 hrs., which isolated the mainline from the surge relief protection system installed in low pressure zone at Terminal Station. Consequently at 1613 hrs, pressure at terminal station inlet reached 69 Kg/cm^2. Sketch enclosed at Annexure “A”.

- Due to parallel closure command to MOV-07 and MOV-01 after sensing the ESD at Terminal Station and a delay of 5 minutes in communicating to upstream Pumping Station for activation of ESD, resulted in generation of excessive pressure/ stress and as a result the failure or rupture of the pipe from the Heat Affected Zone of the pipe weld seam (between 12’O clock to 1’O clock position) at the downstream of pumping station.

- Change of service i.e. from cleaner products to dirty high S crude oil transportation (high Sulphur e.g. MAYA, QTR LS CON etc.) aggravated the material degradation resulting into such devastating failure.

6.0 ROOT CAUSE OF THE INCIDENT:

The probable causes of pipe failure / rupture of such magnitude are attributed to:

(a) Parallel closure of MOV-07 and MOV-01 after sensing the ESD command at Terminal Station and a delay of 5 minutes in communicating to upstream pumping station regarding ESD of terminal station, might have resulted in excessive pressure/ stress generation at the point of failure because of surge. Surge increases the pressure in the pipeline several folds which got released from the HAZ section of the weld seam.

(b) Corrosion / any other failure of the pipe due to change of service i.e. handling cleaner product to High S crude oil. Literature survey suggest that High "S" in the crude oil corrodes the HAZ zone near the seam as a result weakens the section thereof.

(c) Poor quality of pipes, Manufacturing defects, weld seam joints etc. could be one of the probable cause for the failure.

(d) Fatigue failure of the pipe on account of cyclic loading could also contribute to the failure.

Failure of such magnitude & nature in the pipeline is attributed to combination of reasons as discussed above.

7.0 LEARNINGS :

To prevent recurrence followings are recommended:

(1) The ESD logic need to be carefully examined in light of the incident and may be further improved by giving a time lag of approx. 10 minutes between the closure of MOV-07 and MOV-01 so that MOV-01 should start closing after a gap of 10 minutes w.r.t. MOV-07, which will provide sufficient cushion for releasing the increased pressure in the line due to the impact of surge.

(2) The surge relief tank capacity may be increased to 500 KL or a separate crude tank may be identified for taking the surge material with a minimum ullage of 500 KL at any given point of time.

(3) Before changing the service in the instant case from product to high S crude, study must be carried out to ascertain the impact of such a change. Multi-disciplinary team must undertake such study as per MOC.

(4) Surge analysis may be carried out preferably considering DRA (Drag Reducing Agent) injection.

(5) As a preventive measure, it is recommended to carry out IPS (Intelligent Pig Survey) once again for that section of pipeline to re-confirm the sound health of the pipeline.

(6) Detailed metallurgical / chemical analysis of the ruptured section of the pipe may be carried out from a reputed lab to ascertain the presence of any weld defects such as undercut, porosity, slag inclusion, plate offset, weld seam misalignment etc.,

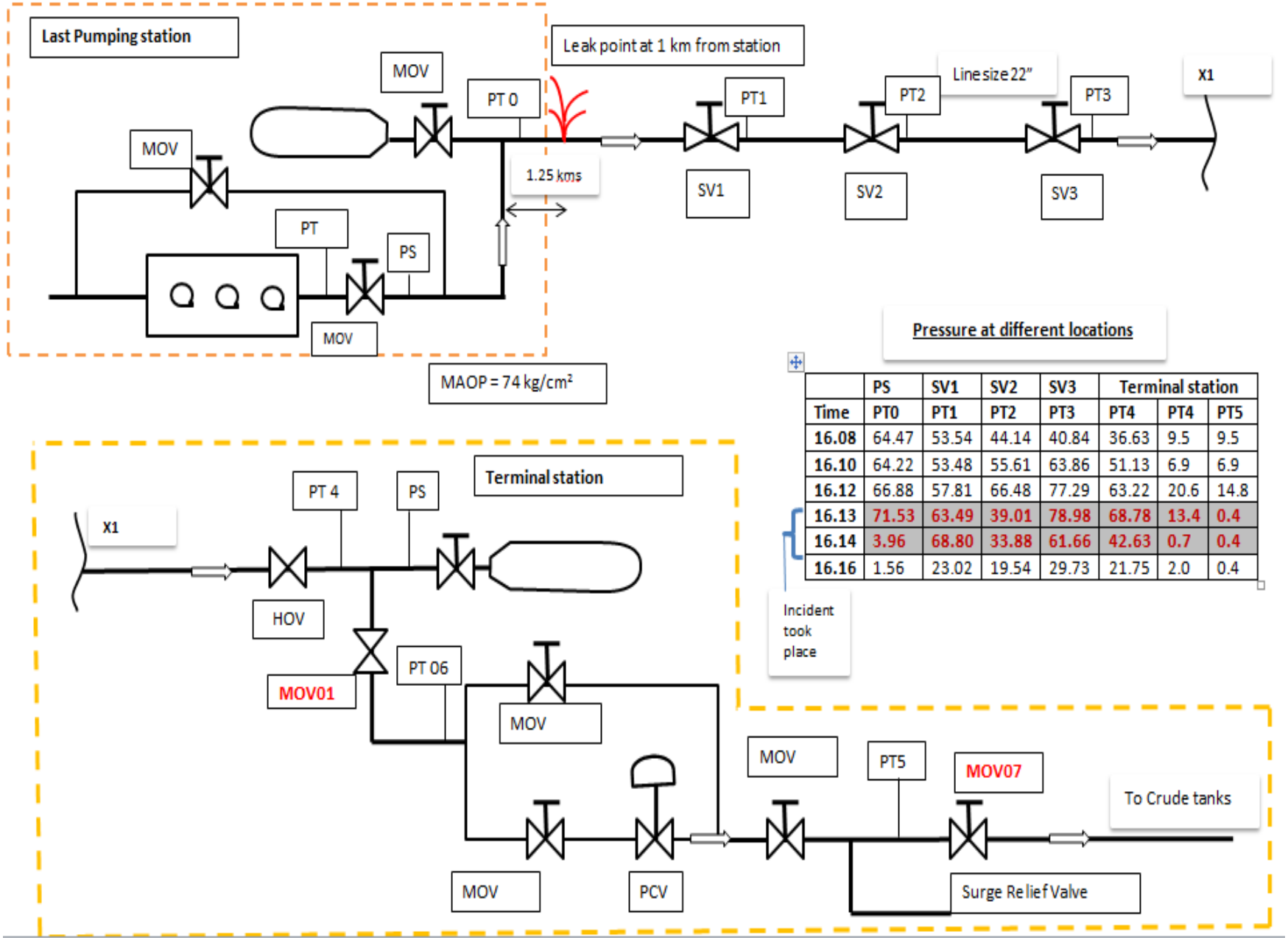
(7) Testing/ inspection procedure of pipe weld seam being followed at pipe mill for new pipeline may be critically reviewed and modified, if required.

(8) Personnel at Terminal Station Control Room undertake various critical operations like receipt of crude in Tank farm, pumping to Product lines in five directions with different sets of pumping units etc. and these operations from Control Room is complex in nature. Thus it is recommended that experienced operators / personnel must carry out such operations else should be done under the supervision of experienced personnel.

(9) The additional tests viz. failure of Sulphide Stress Corrosion Cracking (SSCC) and Hydrogen Induced Cracking (HIC) mechanism must be carried out for the pipeline.

Schematic diagram of pipeline section of a cross-country crude oil pipeline

Annexure 'A'



Pressure at different locations

	PS	SV1	SV2	SV3	Terminal station		
Time	PT0	PT1	PT2	PT3	PT4	PT4	PT5
16.08	64.47	53.54	44.14	40.84	36.63	9.5	9.5
16.10	64.22	53.48	55.61	63.86	51.13	6.9	6.9
16.12	66.88	57.81	66.48	77.29	63.22	20.6	14.8
16.13	71.53	63.49	39.01	78.98	68.78	13.4	0.4
16.14	3.96	68.80	33.88	61.66	42.63	0.7	0.4
16.16	1.56	23.02	19.54	29.73	21.75	2.0	0.4

Incident took place