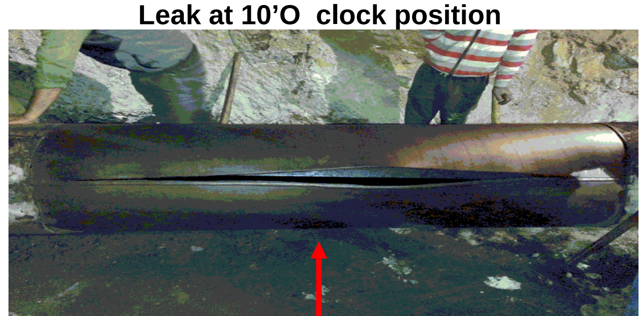
CASE STUDY- CRUDE OIL PIPELINE FAILURE

INTRODUCTION:

One of the cross country pipelines was designed initially to operate for petroleum product services with API 5L-X-65 grade. This pipeline was later converted into crude oil transportation pipeline.

Recently pipeline failure incident occurred. Due to high pressure in the line, crude was sprayed in an area of approx. 200 sq. meter around the leakage point, fortunately there was no habitation in the adjoining area. Also there was no fire or injury due to the above incident. The history of the failures shows that the failure is repetitive failure from the HAZ of the welding joints and reliability of the pipeline is poor for sustained and safe operation of crude oil pumping.

OBSERVATIONS:

(i) Crude oil sprayed due to rupture of pipeline. The leak position was at about 10' O clock position at HAZ of pipe seam. The pipe is LSAW, API 5L-X-65 grade coating is 3 LPE coating.	**Leak at 10'O clock position** 
(i) Dimensions of pipe rupture are L= 1525 mm and maximum opening in the middle of rupture is 100 mm. (ii) The failure initiated from HAZ (Heat Affected Zone) near the weld seam and extended parallel to the seam and finally took a fish-mouth opening shape. (iii) Bulging was observed at the ruptured location.	**View of ruptured pipe** 

Ruptured pipe removed from M/L

View of pipeline repairing job

(iv) It has been noted that upon approval, pressure settings of various set points were reviewed and trip setting of station outlet pressure was marginally increased from 74.8 kg/cm^2 to 74.9 Kg/cm^2.

(v) After second failure of pipe, pipeline was de-rated with revised MAOP of 60 Kg/cm^2.

(vi) It is pertinent to mention that the pipeline was originally designed to operate for product service, which was converted to crude oil. Subsequently, the pipeline now is being used to transport a blend of several types of crude oil. In this regard, evidence for MOC (Management of Change) was not available.

(vii) As per records, blended crude oil in different percentages is being transported. The type of crudes are as follows:

S.No.	Types of Crude
1.	KEC
2.	QTR LS CON +
3.	BASRA LT
4.	MAYA
5.	IRAN L
6.	IRAN H
7.	ISTHMUS
8.	MURBAN
9.	IRAN MIX
10.	ARAB MIX
11.	Mangla

(viii) Mainline discharge pressure tripping was set at 60 kg/ cm^2. As per SCADA it was found that the Mainline engines tripped due to low suction. Mainline maximum discharge pressure was recorded as 58.5 Kg/cm^2, which is less than the MAOP i.e. 60 kg/ cm^2.

(ix) UT thickness measurement of the pipe around the rupture was taken at different points and thickness was recorded in the range of 6.6 mm to 7.1 mm as against the original pipe thickness of 6.4 mm.

(x) Corrosion coupon to be installed at nearby pump station.

(xi) IPS of pipeline was done in January, 2012. As per the summary of the report no repairable anomaly was indicated for nearby area of leak location.

(xii) Coating condition of the pipe near leak location was found satisfactory.

(xiii) Surge analysis before the change of service was not available.

(xiv) Sectionalising valves in upstream of pump station could be closed in local mode as that was found not working on remote from SCADA.

ANALYSIS:

(1) As per SCADA history records, at the time of incident, the Mainline Pumps tripped due to low suction. During that time maximum discharge (mainline) pressure was recorded as 58.5 kg/cm^2 (g) as against the set pressure of MAOP 60 kg/cm^2(g). So the pipe got burst at a pressure less than the de-rated MAOP of 60 Kg/cm^2.

(2) UT thickness measurement of the pipe around the rupture location was recorded in the range of 6.6 mm to 7.1 mm as against the original pipe thickness of 6.4 mm. No apparent reduction in pipe thickness was observed.

(3) During visual observation of the pipeline at rupture location, it was observed that the failure had initiated from HAZ (Heat Affected Zone) near the weld seam and extended parallel to the seam and finally took a fish-mouth opening shape. The pattern of present failure is same to the earlier three failures. It indicates that the reason of failure may be similar.

(4) Repetitive failure of the pipe of similar nature at weld seam establishes that there might be some inherent problem of the pipe related to welding quality at the manufacturing stage and might have been grown during subsequent operations mainly due to cyclic loading in stressed condition.

(5) The failure analysis of the failed pipe collected from the previous failure was carried out by WRI, BHEL Trichy. In the it has been concluded that failure of the pipe took place due to weld failure and there are a few abnormal observations at the weldment like flat weld profile, improperly repair weld, undercut, unfused spots, significant misalignment beyond permissible limit, higher hardness than acceptable limit etc. This indicates that the overall quality of long seam welding joint of the pipes seems to be not satisfactory at the manufacturing stage.

(6) As the operating pressures of the pipe in 1st and 2nd failure cases did not cross the original MAOP of 74 Kg/ Kg/cm^2 and in 3rd and 4th failures cases also did not cross the de-rated MAOP of 60 Kg/cm^2 it is evident that the strength of the welding joint of the pipe at HAZ is not adequate to sustain the de-rated MAOP.

(7) Change of service from product transportation to crude oil transportation (high sulphur e.g. MAYA, QTR LS CON + etc.) may also have aggravated the material degradation resulting into failure.

(8) Intelligent Pig Survey of this pipeline was earlier carried out by using MFL tool in the year 2012 and reported all the anomalies had already been repaired. However, the same could not prevent the repetitive pipe failure during operation.

(9) At the time of 2nd pipeline failure, hydro testing of the pipeline was recommended by OISD. Subsequently, Operator opined that as an alternative of hydrotest, IPS may be carried out with crack detection tool because it is a better inspection methodology. However, OISD suggested that if the test method is found to be not reliable, Operator shall revert to the hydrotest as per earlier recommendations. This option was agreed by Operator.

During investigation of the present failure incident, Operator informed that IPS with crack detection tool of the pipeline has already been carried out by an expert agency and the preliminary report provided by the party, which does not reveal any defect between this section of the pipeline. This may be looked into.

REASONS OF FAILURE/ ROOT CAUSE :

Based on the above analysis, the following may be the probable causes of this incident:

(1) Some inherent problem of the pipe related to weld seam at the manufacturing stage and might have been grown during subsequent operations mainly due to cyclic loading.

(2) Corrosion or other failure mechanism of the pipe due to change of service from product to crude oil.

(3) A combination of the above.

LEARNINGS:

To prevent recurrence of such incidents following are the recommendations:

(1) During the last pipeline failure, hydro testing of the pipeline was recommended by OISD. Subsequently, Operator opined that as an alternative of hydro test, IPS may be carried out with crack detection tool because it is a better inspection methodology. Accordingly, Intelligent Pigging Survey (IPS) has been carried out recently with crack detection tool but preliminary report does not reveal any considerable defect. The agency needs to be instructed to review/ relook the entire data thoroughly before submission of the final report.

(2) Repetitive failure of pipe at weld seam in some of the sections indicates that the health condition of the pipeline is not reliable for sustained and safe operation and calls for replacement of the pipes of the affected sections to avoid recurrence.

(3) Alternatively, these sections of the pipeline need to be pressure tested at 1.25 times the maximum operating pressure. Test shall be held for 24 hours as per OISD-STD-141 (clause 17.5 b) to assess integrity of pipeline in line with our earlier recommendation of incident report.

(4) The service change of the pipeline from product to crude oil should undergo a Management of Change as per OISD-GDN-178.

(5) Surge analysis must be carried out as per OISD-STD-141 clause 5.1.9 for applicable conditions.

(6) Functioning of corrosion monitoring coupon/ probe needs to be ensured.

(7) The additional tests for failure owing to Sulphide Stress Corrosion Cracking (SSCC) and Hydrogen Induced Cracking (HIC) mechanisms, as mentioned in OISD-STD-141 (clause 9.3.2 b) must be carried out with pipe samples.

(8) Remote operation of sectionalizing valves (Motor Operated Valves) of the pipeline must be ensured so that they can be operated from SCADA, in case of emergency.

(9) In addition to the above recommendations, a comprehensive integrity/ health assessment study of the entire Crude pipeline to be undertaken by operator to assess integrity of pipeline considering suitability of different crude oil used, particularly for high sulphur crudes, surge analysis, change of service, finding/ reviewing of IPS (with Crack detection tool) report, etc. by engaging an expert agency/ consultant.