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# Failure analysis of a steam condensate pipeline in 2nd refinery of South Pars Gas Complex

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**Abstract**

In this work, we were studied a failure in a steam condensate pipeline of a gaseous refinery in South Pars region in January and December 2013. Failure analysis was conducted on pipeline (16 inches) via visual/mechanical/corrosion inspection and operating history. Visual inspections showed rupture on pipeline. More inspections showed the rupture is caused because of corrosion inside pipeline. The study of mechanical aspect was demonstrated the vibration in pipeline. The morphology of split pipeline at 6 o clock showed synergy of Oxygen, dioxide carbon corrosions. As well as, cavitation caused other failure on tee of pipeline.

**Key words:** steam condensate, oxygen corrosion**,** dioxide carbon corrosion, inspection

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## 1. Introduction

The Steam is primarily used in industries for heating process fluids, distillation operations, as well as being used for the generation of power. Steam condensate is either discarded or recovered and reused. The recovery of process condensate for reuse depends on various factors such as process contamination, economics of recovery and availability of spent condensate. In petroleum and gas refineries; control of corrosion damage by steam is an important aspect to prevent corrosion leaks in condensate and steam pipelines. The presence of aggressive impurities like $O_2$ and $CO_2$ may lead to catastrophic corrosion failures in condensate and steam pipelines, and may ultimately contaminate the condensate with ionic impurities and corrosion products [1, 2]. Sources of corrosive are boiler feed water (BFW), entry of gases through flanges and leakage of condenser. In post-boiler corrosion, the return of corrosion products along with the condensate can result in the deposition of metal oxides on boiler heat-transfer surfaces [3]. These deposits have poor thermal conductivity which leads to energy losses. Therefore, steam and condensate pipelines are required to be perfectly protected by controlling the quality of steam.

Steam purity is primarily maintained by effective de-aeration of BFW and chemical treatments through the use of oxygen scavengers and volatile amines and effective monitoring of steam-condensate quality .As well as, neutralizer and filming amines are injected into steam in the post-boiler section to prevent corrosion in steam condensate systems [4].

The aim of this work is the study of failure in steam condensate system of 2nd refinery of South Pars.

## 2. Process description

The South Pars zone is located in the south of Iran on shore of Persian Gulf. There are many gaseous refineries in the South Pars that supply sweet gas as energy for people consumption. Our study was performed in the 2nd refinery.

Steam generation unit in the 2nd refinery is entitled unit steam generation (unit 121) that it supplies steam for using in refinery. The steam is delivered to process units for consumption. After the use of steam by process units, the Steam as condensate is returned to unit 121 via some pipeline. In the 2nd refinery, Steam condensate is returned as the following:

1) Amine steam condensate returns from sweeting unit.
2) Flashed High pressure condensate returns from high pressures consumers.
3) Clean low pressure condensate returns from low pressures consumers.
4) Suspect low pressure condensate returns from reception unit of gas.
5) Polluted condensate returns from all consumers.

Above streams are sent to storage tanks in normal conditions. When the streams are abnormal, they are delivered to wastewater treatment unit finally.

## 3. Experimental

### *3.1. Visual inspection*

Failure of a pipeline (line no: 16”-CP-160-12101-B01-N) was reported in January 2013. Visual inspection showed a leakage on pipeline. A groove on pipeline was observed as well as, the concrete support was damaged. For more investigation, the pipeline was cut. Figure 1 showed a rupture on the pipeline and damaged support after cutting of the pipeline.

### *3.2. Inspection for Mechanical damage*

Mechanical inspection of failure was performed. Pipeline properties are presented as the following:
Diameter: 16 inch
Schedule: 10
Ends: BE (Bevel End)
Material Specification: API 5L Gr. B Seamless
The concrete supports of pipeline were damaged. The pipeline was rubbed on adjacent pipeline and support. Figure 2 shows the damage on pipeline because of erosion on adjacent pipeline.

### 3.3. Inspection for Corrosion damage

The damaged section of the pipeline was selected for corrosion investigation. The pipeline was split and its inner surface was carefully studied. The inner surface of pipeline is shown in Figure 3. On The inner surface was observed yellowish and greyish-black deposits. Some points were covered with shallow pits over the surfaces. General thinning and extensive pitting were found at 6 O’clock position. Thickness Measurement of pipeline wall was done using ultrasonic thickness measurement (USTM). The reduced thickness was 2.5 mm. Figure 4 shows the groove on the surface of pipeline.

## 4. Results and Discussion

### *4.1 Mechanical damage*

The pipeline supports were located in improper conditions. The piping should be worked according to ASME B31.3 (pipe support criteria for the above ground piping). The support of pipe should be able to absorb the loads arisen from fluid vibrations. Unfortunately, pipeline supports were not properly performed. As well as, improper function of the expansion loops led to move the load to the pipelines. The increase or the decrease in flow velocity can cause pressure vibrations. The changes of flow velocity can be caused by sudden closing of valves, start up and stop of pumps, control process, and pump power failure. As well as, the loads of steady state conditions, the pipeline, and affiliated equipment have a heavy dynamic loading. Pressure changes lead to vibration in pipelines. Vibration phenomenon in pipeline is called Hammering. Due to hammering phenomenon, many parts of the pipeline were severely damaged. Also, adjacent pipelines were affected by hammering phenomenon. In order to remove hammering effect, the installation of fix support (anchor type) is necessary. Fix supports (Anchor type) restrict pipeline expansion in the expansion loop. As well as, they remove longitudinal displacements. So, the installation of fix support leads to high efficiency of expansion loops.

### *4.2. Corrosion analysis*

In order to investigate oxygen attack, the quality of feed water of boiler was measured. Figure5 shows the concentration of oxygen in boiler feed water. The results show that oxygen concentration is allowable according to Maximum allowable concentration of oxygen (7 ppb). For more investigation, some points inside steam condensate system should be measured for studying of oxygen concentration. Unfortunately, any data were recorded as daily for monitoring oxygen in the polluted steam condensate. Therefore, we cannot use experimental data for analysis. The concentration of oxygen should be sampled on site. Also the sample should be cooled for measurement.
Other failure of this pipeline was reported in December 2013. Two points were failed. One point was on straight stream of pipeline and other was a tee. We were investigated morphology of corrosion after cutting of pipeline. Figure 6 shows the pitting on inner surface of straight stream of pipeline. As seen from this figure, the morphology of pitting looks likes oxygen attack. As well as, yellowish deposits demonstrate this case.
Figure7 shows inner surface of tee. As seen from this figure, morphology of corrosion is similar to cavitation. As well as, this morphology in tee section was occurred and in service time, pipeline had vibration. Therefore, it is clear that cavitation phenomena have significant effect on this failure.


Figure1. Damaged support (left) and rupture on pipeline at 6 o’ clock position (right)


Figure2. The erosion of pipeline 16 inches on adjacent pipeline

Figure3. The inner surface of pipeline

Figure4. Groove on the surface of pipeline

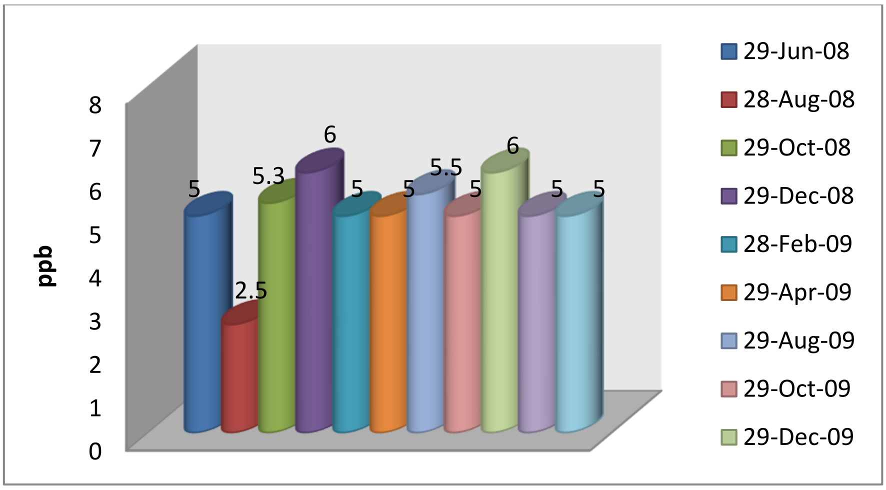


Figure5. Concentration of oxygen in BFW

Figure6. The pitting on inner surface of straight stream of pipeline

Figure 7. Inner surface of tee

Figure 4 showed a grooving morphology. Grooving corrosion in steam and condensate streams is caused by synergy of two or more corrosion mechanism such as carbon dioxide and oxygen. Therefore, the groove on pipeline was caused by $Co_2$ and $O_2$ attacks.

## 5. Conclusion

The following cases can extract from this study:

1- Two failures on pipeline 16 inches of steam condensate were studied.
2- The inspection was done via visual, mechanical and corrosion aspects
3- The pipeline in start-up time had vibration because of improper action of supports.
4- The synergy of $Co_2$ and $O_2$ in straight stream caused corrosion.
5- The Cavitation in tee stream had a key role in failure of pipeline

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