Innovative Energy & Research
ISSN: 2576-1463

Dhuhoori, Innov Ener Res 2018, 7:3
DOI: 10.4172/2576-1463.1000213

Review Article | Open Access

# Failure Analysis and Failure Investigation of UZ/ACPT1 SS SIDUM Ejector Condenser

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**Abstract**

The Desalination Unit in ACPT1 is designed to produce fresh or potable water with a maximum salinity of 8 ppm for the use of accommodation platform. There are 2 desalination units in ACPT1 both are in duty except when any one unit is taken for maintenance. The same manufacturing design of desalination unit (Sidem 2T50 evaporators and Electric Boilers) are installed in ACPT2 to produce fresh potable water each able to produce 50 $m^3$/day.

In the past 4 years a frequent failure were reported for the SS Ejector Condenser. Upon inspection visual and DP inspection finding revealed that: severe corrosion takes place on 3” Nossel, Chloride SCC is proposed as one of Corrosion mechanisms, surface cracks are also observed on the shell surface and weldment areas. Due to the frequent failure of ejector condenser, a failure analysis shall be conducted to investigate reasons of failure and draw a recommendation accordingly. According to the analysis conducted and investigation done the recommendation is drawn to change the material of ejector condenser to SMO254 CRA MATERIAL.

**Keywords:** Kiln; Gambit and fluent; Adiabatic; Conduction; Convection

## Introduction and Scope

The scope of this report is to analyze and investigate the frequent failure of UZ/ACPT Stainless Steel SIDUM Ejector Condenser. Recommendation is also drawn off for solving the problem based on technical and experienced data.

## Background

### Steam circuit and process flow

Steam produced in the boiler passes through Boiler Valve 90-11 before passing to the Hogging Ejector 45-01. The hogging ejector removes the air in Cell 2 and discharges to atmosphere. The ejector is only used during start-up of the evaporator. After start-up, the vacuum is maintained by two ejectors, whose motive force is steam produced by the boiler *via* Regulating Valve 90-01. The downstream ejector removes non-condensables to the first stage of the ejector condenser. The exhaust steam is condensed in the second stage ejector condenser and the non-condensables are vented to atmosphere. The upstream ejector removes air from Cell 2 of the evaporator. The exhaust steam is condensed in the ejector condenser. The condensed water from the second stage flows to the first stage of the ejector condenser *via* Isolation Valve 40-08 and a Trap 40-04. This trap can be bypassed if necessary. The common distilled water passes through Trap 40-07 and Isolating Valve 40-12. The trap can be bypassed to the heating bundle of Cell 1 of the evaporator. The thermo compressor steam is supplied *via* Isolation Valve 90-02. The thermo compressor removes the remaining vapour from the top of Cell 2, compresses it and discharges to the heating bundle, where the vapour is condensed releasing sufficient heat for the seawater to be vaporized. A temperature switch set at 100°C monitors the temperature at the outlet of the thermo compressor. If the temperature exceeds 100°C Steam Valve 90-01 closes and a High Temperature Alarm TAH-60-10 is generated. Figure 1 shows the Desalination Unit and steam path to the hogging ejector and ejector condenser.

### Ejector condenser

The ejectors are operated to maintain the vacuum in Cell 2. The ejector condenser consists of two stages. The downstream ejector removes non-condensables to the first stage of the ejector condenser. The exhaust steam is condensed in the second stage ejector condenser and the non-condensable are vented to atmosphere. Refer to Appendix 1 and 2 which shows the mechanical as built drawing of the ejector condenser (Figure 2).

### Ejector data

Ejector data is presented in the following Table 1.

### Ejector condenser data

Ejector Condenser data is presented in the following Table 2.

## Failure History of Ejector Condenser

Frequent failure are taken place for the SS ejector condenser, upon visual examination, Crack like damages are commonly taken place on the 3” 2nd stage Nossel, and near weld areas of the condenser associated nozzles. The Table 3 shows the Inspection history findings and recommendations. Inspection history shows that almost all the ejector condensers in SIDUM desalination Plant in ACPT has failed, by frequent leak reported, and claimed that chloride SCC is the damage mechanism of shell as detailed below.

## Chemical Composition Analysis of 354B04C

Chemical Composition analysis of 354B04C-Sidem Ejector Condenser as it is last inspected on 21/05/2013 (Table 4).

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**Received** August 02, 2018; **Accepted** August 15, 2018; **Published** August 20, 2018

**Citation:** Dhuhoori AA (2018) Failure Analysis and Failure Investigation of UZ/ACPT1 SS SIDUM Ejector Condenser. Innov Ener Res 7: 213. doi: 10.4172/2576-1463.1000213

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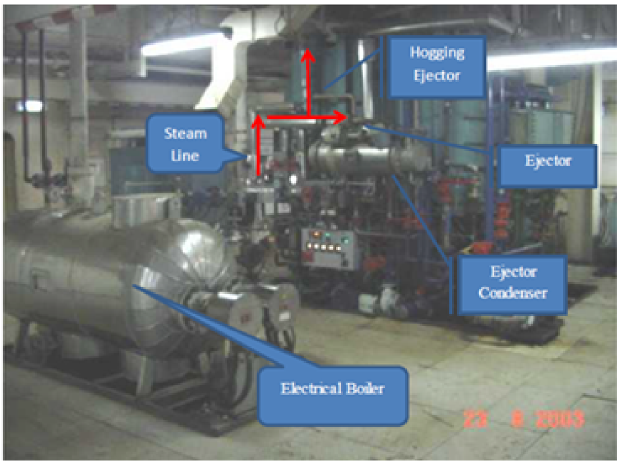


**Figure 1:** ACPT Desalination Unit.

**Figure 2:** ACPT SIDEM Ejector Condenser.

| Parameter | Data |
|---|---|
| Material | Stainless Steel |
| Steam Consumption | 20 kg/hour each |
| Steam Pressure | 12 bar g |

**Table 1:** Ejector data.

| Parameter | Data |
|---|---|
| Number of Tubes | 72 |
| Tube Length | 1000 mm |
| Tube Internal Diameter | 14 mm |
| Tube External Diameter | 16 mm |
| Tube Material Cupro-Nickel | 90/10 |
| Tube Plate Material | Stainless Steel |
| Water Box | Stainless Steel |

**Table 2:** Ejector condenser data.

## General Background about Ejector Condensers

Barometric type (direct connections) are usually employed. The components vulnerable to corrosion attack are: body, nozzles and piping. Body of the ejector condenser (CS cladded with SS, Ti, Cu-Ni) sometimes showing metal loss has now been replaced by Fiber Reinforced Plastic (FRP) in new plants. Nozzles (SS 304 or 316) and condenser piping (316L or Cupro-nickel) are most affected by pitting, the attack is more prominent at the welded seams. On the after condenser (steam/vapor inlet pipe) severe Cl- induced S.C.C. was noted which was attributed to high operating temperature and salt deposition. The 316 L pipe was replaced by Incoloy 825. Presence of 0.1-0.2 ppm chloride in the uncondensed gases is sufficient to produce corrosion. Cupro-nickel and SS are replaced by 254 SMO as an ejector condenser material in some of the plants in Qatar and Abu Dhabi due to their poor performance [1].

## Chloride SCC

Welds in the 300-series austenitic stainless steels, contain a small amount of β-ferrite to prevent hot cracking during weld solidification. In hot, aqueous chloride environment (the same environment as for ejector condenser), these duplex weldments generally shows a marked resistance to cracking, while their counterparts crack readily. The generally accepted explanations for this behavior is that the ferrite phase is resistant to chloride SCC and impedes crack propagation through the austenite phase. Electrochemical effects may also play a part however, under sufficient tensile stress, temperature and chloride concentration, these duplex weldment will readily crack (Figure 3).

### Methods for controlling chloride SCC

Chloride SCC to occur it requires a chloride concentration and tensile stress focused together to cause both intergranular and transgranular cracking. This produce weakening of the metal and eventual failure. Experience indicates that the concentration of chloride in the water contacting the stainless steel is not the critical factor [2]. The main factor in the existence of conditions that allow chloride concentration cells to develop in the absence of concentration cells or stress, chloride levels in excess of 1000 mg/L have not caused stainless steel to crack. Some desalination plants where chloride concentrations exceed 30000 mg/L have not experienced failures, when properly annealed stainless-steel construction was used. The key to preventing stress corrosion cracking is eliminating deposits and designing and fabricating stress-relieved 16 equipment that does not allow concentration cells to occur. 2 out of five methods of controlling CLSCC is addressed here in which are 1. Changing material 2. Changing design, the rest of five are not applicable in the case of Ejector condenser due to cost, operational constrain and ease of apply which are Change the Environment, Coating and electrochemical Techniques.

**Change in the material:** A common fix or solution of a stress corrosion cracking problem is to subtiture a more resistant alloy for the one that failed. N06600 (Alloy 600), a chromium-bearing nickel alloy, has greater resistance to cracking in high temperature chloride environments than does S30400 (AISI 304) Austenitic stainless steel, and is often used to replace stainless steel components that fail by chloride stress corrosion cracking [3].

It is important to identify the critical species causing the stress corrosion cracking. For example, N08800 (Alloy 800) is a suitable replacement for S30400 (AISI304 when chloride is the causative agent, but will fail as readily as the latter in hot caustic is the cracking agent, although it too can crack in that servise. Alloy 600 expansion joints are commonly used in chloride-and caustic-contamination steam service, despite occasional failures, because it can offer a favorable cost: Life benefit.

**Changing in the design:** The primary role of design changes for control of tresses ntal cracking is to lower the tensile tresses to below the threshold stress or to a level significantly less conductive to cracking. If cracking is to be alleviated. The total resultant stress from residual stresses. Thermal stresses and stresses from operational stresses, thermal stresses and stresses from operational loads abd oressyre must be considered.

Residual stresses from metal fabrication and unit construction are reduced by two principal methods:

a) A stress relieving heat treatment

b) Shot-peening, sometimes reffered to as mechanical stress relief.

In the first case, a fabricated item is heated to a temperature high enough for relaxation of the residual stresses, and slowly cooled. In the second case, the metal surface is mechanically peened at an intensity sufficient to result in residual compressive stress at the surface.

A second design consideration for control of environmental cracking is to avoid geometries in which solutions accumulate. Dead spaces where steam blanketing or water evaporation can occurs are potential failure sites. Solutions with chloride concentration of 1 ppm can become concentrated to high chloride levels in crevices and other restricted geometries.

A third design consideration is the compatibility of materials throughout the system. Contact of dissimilar metals can polarize one into the potential range for environmental cracking. Chlorides leached from insulation or formed by hydrolysis of organic chlorides in elastomeric seals or plastic devises can cause stress corrosion cracking of austenitic 18-8 type stainless steels. Ammonia introduced to control pH and minimize the corrosion of steel can promote stress corrosion cracking of copper alloys in adjacent equipment 17.

The overall design should be reviewed for materials compatibility if a fix for corrosion in one part of the process is not to cause environmental cracking elsewhere in the system.

### Performance of Alloy grouping

The susceptibility of the respective groupings to specific environmental cracking is summarized in Table 5.

## Analysis of Data and Recommendations

Reveling to the historical data, it shows that almost all the ejector condensers in SIDUM Desalination Plant in ACPT has failed, by frequent leak reported. The failure is almost located 18 3" Ejector condenser Nossel/stub inlet of steam. The 3" Nossel ejector condenser original design is CS material, as it is mentioned in inspection reports, whoever failed SS nossels was installed and then recommendations are set to replace it with CS by filler material ER309 due to the frequent failure. The CS showed a better resistance to corrosion as per inspection report , however another corrosion mechanism takes place due to dissimilar metal in contact which caused galvanic attack. The last inspected CS condenser stub showed sever oxidation deposits which caused perforation, Refer Photo of UZ/OSFIP/292/13, 354B04C-Sidem Ejector Condenser. Figure and photos shows that almost all condensers had failed on the left side 3" stub condenser rather than the right side which is still intact. Wrong design may be attributed or Material problem in which CS is failed. Crack Flaw indications was observed by DP inspection which may be attributed by Chloride SCC.

In Summary, It found that the Ejector Condenser in SIDEM Desalination Plant in ACPT had experienced frequent failure, in which it may contributed to deferent Corrosion Mechanisms. Chloride SCC may one of reasons on failure, however we still have lack of information to assess for CLSCC. Information needed are: Temperature, Chloride content pH and Oxygen level, Material is stress relived or not. Thus boiler sample is to be collected and sent to FDS Lab for Water Analysis.

### Assessment the susceptibility of CLSCC

Susceptibility to CLSCC is usually assessed from knowledge of environmental variables, i.e. temperature, chloride content, temperature, pH and oxygen level. Condensed water samples collected from Ejector Condenser body. Sample sent to FDS Lab for analysis, Appendix 3 and 4 shows water analysis results collected from ACPT1 (ejector Condenser A/B) and ACPT2 (ejector Condenser C). Samples could not be collected from ACPT2 ejector condenser A/B due to operational constrains. The following Table 6 shows the analysis results. In analysing the susceptibility of CLSCC we use the assessment by API RP 581 'Risk- Based Inspection Technology Part 2 [4] which is shown in Table 7 bellow.

Table 7 proposed scheme for CLSCC susceptibility categories in aqueous media where pH ≤ 10, and in conditions where chloride deposits may form by drying out or by deposition.

From Table 8 it shows that within Chloride Concentration 1 to 10 ppm and temperature range >66 to 149 the CLSCC category is Medium.

| Year | # | Inspection Report # | Tag of Ejector Condenser | Inspection Findings |
|---|---|---|---|---|
| **2010** | 1 | FIP/PRE/10/001 | Ejector Condenser of SIDEM-C | Sever External Corrosion Was found in 3" Nossel. Reason of Sever corrosion may of CUI. |
| | 2 | FIP/PRE/10/057 | Ejector Condenser of SIDEM-B | Server Internal/External Corrosion was found on 3" Nossel |
| | 3 | FIP/PRE/10/066 | Ejector Condenser of SIDEM-C | 4" nossel was found cold repaired by metal putty, and previously changed the material to CS. ¾" nossel attached to the shell found corroded. 4 tubes were plugged. |
| | 4 | FIP/PRE/10/240 | Ejector Condenser of SIDEM-B | Sign of leaks observed in 4" Nossel during pressure testing. It is claimed that chloride SCC is the damage mechanism of shell, and the original design of with CS nossel is performing much better than SS nossels. Corrosion Pits observed in Inlet/Outlet |
| | 5 | FIP/PRE/10/260 | EJECTOR CONDENSER of SIDEM-B | Inspection carried out for the ejector condenser according to the recommendation mentioned in previous report. |
| **2011** | 6 | UZ/OSFIP/176/11 | Ejector Condenser from SIDEM-B | The 3" nossel found with previous cold weld repair. The original design of ejector condenser is SS shell with CS nozzels, and performing better than new SS nossels.<br>Minor leaks observed on both end covers to shell flange connection. |

| | | | | |
|---|---|---|---|---|
| **2012** | 7 | UZ/OSFIP/525/12 | Ejector Condenser from SIDEM-A, 354B04A | Two nos. cracks, approx. 160 mm and 270 mm long were observed on the 3" downstream ejector nozzle.<br>Other SS ejector condensers fabricated in Mussafah was suffering from pre-mature failures on the same stainless steel ejector nozzles as previously reported. The original design of the ejector condenser has SS condenser shell with CS nozzles and performing much better that the new SS nozzles.<br>Condenser was installed/commissioned in 15/12/2011 and in service for only 8 months.<br>Aftab comment on march 2010: (the failure phenomenon of 3 "SS316 Nozzle is Chloride stress corrosion cracking. As in addition to corrosion, cracking is also clearly visible on 3" Nozzle. Austenitic stainless steel 304 and 316 are highly susceptible to Chloride stress corrosion cracking at temperature above 600°C. Our seawater chloride concentration is around 25,000 PPM, the operating temperature of the Nozzle is around 800°C to 900°C, presence of oxygen in the seawater and crevice in the nozzles accelerate chloride stress corrosion cracking of these nozzles. For the operating condition of ejector condenser (temperature, pressure and chloride concentration) in my opinion the suitable recommended materials are 6% Mo super austenitic stainless Steel or 6% Mo<br><br>Supper duplex stainless steel).<br>Gutham Gosh comments on 7 march 2010: (Chloride stress corrosion cracking cannot be ruled out for the Stainless steel 316 (weld) in the given condition. Primarily to ensure the same, arrange to clean the surface and carry out DPT on the surface.<br>Pl provide process details and complete water analysis to decide material for the same)<br>Mathews comments on 05/01/2010. (There is no internal corrosion on nozzle or the shell. The shell and nozzle suffered from external corrosion due to CUI even though Al coating was provided) |
| | 8 | UZ/OSFIP/538/12 | UZ/OSFIP/538/12 | As per Inspection Report No.: UZ/OSFIP/525/12 recommendations, the 3" downstream nozzle of the above ejector condenser was sweep blasted for thorough inspection of the reported cracks on the nozzle.<br>100% dye penetrant inspection was carried out on the ejector condenser 3" downstream nozzle. Total 2-nos circumferential cracks were observed. The approximate length of the cracks is 260.0 mm. and 280 mm. (previously reported as 160.0 mm and 270.0 mm.) |
| | 9 | UZ/OSFIP/603/12 | 354B04A Ejector Condenser (Spare) | A circumferential crack was observed on the 4" diameter nozzle.<br>It is recommended to replace the nozzle with carbon steel grade material based on the manufacturer material of construction |
| | 10 | UZ/OSFIP/742/12 | 354B04A-Sidem Ejector Condenser | The ejector condenser insulation was removed and revealed that the shell and stub-in nozzle was covered with metal putty. Approximately 40% of the shell section was covered with metal putty.<br>Total 2-nos. welded patch repairs are evident on the Shell surfaces at different locations.<br>Moderate to severe numerous cracking was observed on the ejector condenser 4" stub in nozzle which cause the leak in service.<br>Isolated crack like indications was also noted on the ejector condenser shell welded patch plates.<br>Moderate to severe crevice corrosion was also observed on the tube sheet circumferential weld.<br>One tube was found leaking and was plugged accordingly. |

| | | | | |
|---|---|---|---|---|
| **2013** | 11 | UZ/OSFIP/292/13 | 354B04C-Sidem Ejector Condenser | The ejector condenser was removed from service and spare refurbished ejector condenser was installed<br>The insulation of the ejector condenser was removed. Previous temporary repair was evident by replacing the corroded SS outlet nozzle with CS material Welded patch plate was also observed on the shell around the outlet nozzle<br>The top portion of the shell adjacent to the 3" inlet nozzle was covered/repaired with metal putty. Upon removal of insulation, hole was observed on the 3" CS outlet nozzle and affecting the SS shell plate. The size of hole is approx. 160 mm x 25 mm. The external surface of the condenser was sweep blasted. 100% dye penetrant test was carried out on the external surface of the condenser shell. Several cracks were noted on the shell with length ranges from 5 mm to 35 mm. Crack, approx. 10 mm long was observed in Nozzle #2<br>Approx. 60 mm long crack was observed in Nozzle #9. |

**Table 3:** Inspection history findings and recommendations.

| **Body Material (SS316)** | | | **Replaced /Corrosion Condenser Nossel (CS)** | | |
|---|---|---|---|---|---|
| **Element** | **%** | **STD** | **Element** | **%** | **STD** |
| Fe | 69.2 | 0.33 | Fe | 94.5 | 0.32 |
| Cr | 16.5 | 0.16 | Zn | 5 | 0.08 |
| Ni | 10.2 | 0.14 | Mn | 0.5 | 0.04 |
| Mo | | 2.2 | | 0.03 | |
| Mn | | 1.6 | | 0.15 | |
| Zn | | 0.4 | | 0.03 | |
| Pitting Resistance Equivalent Number (PREN) $=Cr+3.3Mo+16N$ | | | Pitting Resistance Equivalent Number (PREN) $=Cr+3.3Mo+16N$ | | |
| PREN=16.5+3.3 x 2.2+16 x 0 | | | PREN=0+3.3 x 0+0 | | |
| PREN=23.76 | | | PREN=0 | | |

**Table 4:** Chemical Composition analysis of 354B04C.


**Figure 3:** Chloride SCC of type 304 stainless steel base metal and type 308 weld metal in an aqueous chloride environment at 95°C (200 F). Cracks are branching and transgranular.

Then the susceptibility is modified for additional factors in which the factors in yellow marks are factors attributed for the case of SIDEM Ejector Condenser. In conclusion and reveling to the assessment of susceptibility of CLSCC by API RP 581 'Risk-Based Inspection Technology Part 2. It can be concluded that the susceptibility 20 Category to Chloride Stress Corrosion Cracking of All Ejector Condenser in ACPT 1/2 are High.

## Conclusion and Recommendation

The result from the water analysis of ejector condenser shows that

| **Group** | **Alloys** | **Stress Corrosion Cracking** |
|---|---|---|
| 1 | Magnesium Aluminum | Aqueous Cl-Plus Oxidants, Aqueous Cl- Plus Oxidants |
| 2 | Carbon Steels High Strength Steels 18% Maraging Steel | NaOH, $NH_3$, $NO_3$-, CN-, $HCO_3$, $CO/CO_2/H_2O$ See Carbon Steel Above No Information |
| 3 | Martensitic S.S Ferritic S.S Austenitic S.S | NaOH, NaCl NaOH, Marine Tropical Atmospheres Cl-, Cl-/$H_2S$, NaOH, $H_2S_2O_6$, Supercritical Water Plus $O_2$ |
| 4 | Lead, Tin, Zinc | No Information |
| 5 | Copper Alloys | $NH_3$, $HNO_3$, $SO_2$ Steam *vs.* Si Bronze |
| 6 | Nickel N02200 Monel N04400 Alloy B, N10001 | HF plus $O_2$, $H_2SiF_6$ HF plus $O_2$, $H_2SiF_6$ Azo dyes, Supercritical water plus $O_2$ |
| 7 | Inconel N06600 Alloy C N10002 Alloy C276 N10276 | NaOH (3000°C), $AlCl_3$, Supercritical Water plus $O_2$ $FeCl_3$, Supercritical Water plus $O_2$. Supercritical Water Plus $O_2$ |
| 8 | Vitallium (Cobalt) | Magnesium Chloride, NaOH |
| 9 | Titanium Zirconium | NaCl (>2750°C), 10% HCl, Chlorinated or fluorinated solvents, methanol $FeCl_3$ ,$I_2$, HCl + Fe+++ (250 ppm) |
| 10 | Silver, gold, platinium | No identified species |

**Table 5:** Performance of Alloy grouping.

Chloride content varies from 2 to 5 ppm. Susceptibility assessment is studied b API RP581(2008), and it is shown that the ejector condenser

| Location | PH | Meas Conductivity (Ms/cm) | Chloride (Mg/l) or ppm |
|---|---|---|---|
| ACPT1 Ejector Condenser A | 6.78 | 0.0271 @ 68.3 F | 3.69 |
| ACPT1 Ejector Condenser B | 6.43 | 0.0147 @ 69.0 F | 2.19 |
| ACPT2 Ejector Condenser C | 6.37 | 0.01610 @ 68.8 F | 5.56 |

**Table 6:** Assessment the susceptibility of CLSCC.

| Temperature°C | Chloride concentration, ppm | | | | Drying out /deposition |
|---|---|---|---|---|---|
| | 1 to 10 | 11 to 100 | 101 to 1000 | >1000 | |
| 10 to 38 | Low | Low | Low | Medium | High |
| >38 to 66 | Low | Medium | Medium | High | High |
| >66 to 93 | Medium | Medium | Medium | High | High |
| >93 to 149 | Medium | High | High | High | High |
| Note: The pH, temperature, chloride concentration and drying out/deposition rankings should be based on the worst-case scenario including up-set conditions and short-term excursions during operation, shut down, or maintenance. | | | | | |

**Table 7:** Proposed scheme for CLSCC susceptibility categories in aqueous media where pH ≤ 10, and in conditions where chloride deposits may form by drying out or by deposition.

| Increase susceptibility category | Decrease susceptibility category |
|---|---|
| Sensitization is likely | Coating or wrapping with aluminium foil |
| History of progressive cracking where mode has not been established | Continuous control of chloride level, pH, or temperature during all operational and non-operational periods. |
| Poor surface finish | Continuous dosing with appropriate corrosion inhibitor during all operational and non-operational periods |
| Surface contamination with iron Steel manufactured before 1970 | |
| Highly cold worked and/or freemachining steel | |
| Pits and/or crevice corrosion already exist | |
| Crevice-like design features, e.g. roots of partial penetration welds | |
| Galvanic coupling to a more noble Metal | |
| Cyclic conditions-temperature or stress | |

**Table 8:** Change in susceptibility category for additional factors.

| Alloy | Fe | C | Cr | Cu | Mn | Mo | N | Ni | P | S | Si | Al | Ti | Pitting Resistance Equevelant Number (PREN) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Zero n 100 | | - | 25 | 0.7 | 1.0 max | 3 | 0.25 | 6 | 0.035 max | 0.010 max | 0.8 max | - | - | (PREN) $=Cr+3.3Mo+16N$<br>PREN=25+3.3 x 3+16 x 0.25<br>PREN=38.9 |
| 254 SMO | bal | 0.020 max | 19.5 | - | 1 max | 6 | 0.18 | 17.5 | .03 max | 0.010 max | 0.80 max | - | - | (PREN) $=Cr+3.3Mo+16N$<br>PREN=19.5+3.3 x 6+16 x 0.18<br>PREN=42.18 |
| 625 Alloy | 5.0 max | 0.10 max | 20 | - | 0.50 max | 8 | - | bal | 0.015 max | 0.015 max | 0.50 max | 0.4 max | 0.40 max | (PREN) $=Cr+3.3Mo+16N$<br>PREN=20+3.3 x 8+16 x 0<br>PREN=46.4 |

**Table 9:** Alloys Chemical Composition.

susceptibility category to ClSCC is medium, then additional factors is considered to change the susceptibility category, and it is shows that considering the additional factors, the susceptibility of ClSCC for the ejector condenser is High. Another Damage mechanism is attributed to the Ejector Condenser is galvanic corrosion in which CS Nossel/Stub is attached to SS condenser shell (Design malfunctioning) [5,6].

Avoiding ClSCC by changing the environment is not practical, because deposition of Chloride is possible either on the outer shell of condenser (CUI), nor inside the shell by vapor drying out. In addition deploying Cl scavenger chemical may affect boilers performance. 2 control methods shall be applied to control the failure of ejector condenser.

1. Changing the material to more cracking risistant alloy such as Duplex Stainless steels S32760 (Zeron 100) S31254 (254 SMO), or N06625 (625 Alloy). Alloys Chemical Composition is shown in Table 9. Referring to approximate relative pipe cost assuming that it is applicable

to exchangers also, it is noticed that Alloy 625 has much higher relative cost (22.8) compared with 254SMO alloy (9.2) and Ziron 100 (6.8). Alloy 254SMO has better pitting resistance than Ziron 100, and thus it is recommended to use Alloy 254SMO as a condenser material.

2. Residual stresses from metal facricatrion and during constructin is to be reduced by stress releiving heat treatment and shot peening the metal surface is mechanically peened at an intensity sufficient to result in residual compressive stresses at the surface. A good insulation application is to be applied on the outer shell of condeser as per ZADCO Spec for Hot Insulation, to avoid chloride penetration and deposition on the outer shell. It is recommended to monitor the corrosion of the condenser by conducting regular inspection (6 monthly is preferable).

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