PITTING CORROSION OF CS HEAT EXCHANGER TUBE OF PROCESS GAS COOLED HEAT EXCHANGER

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INTRODUCTION

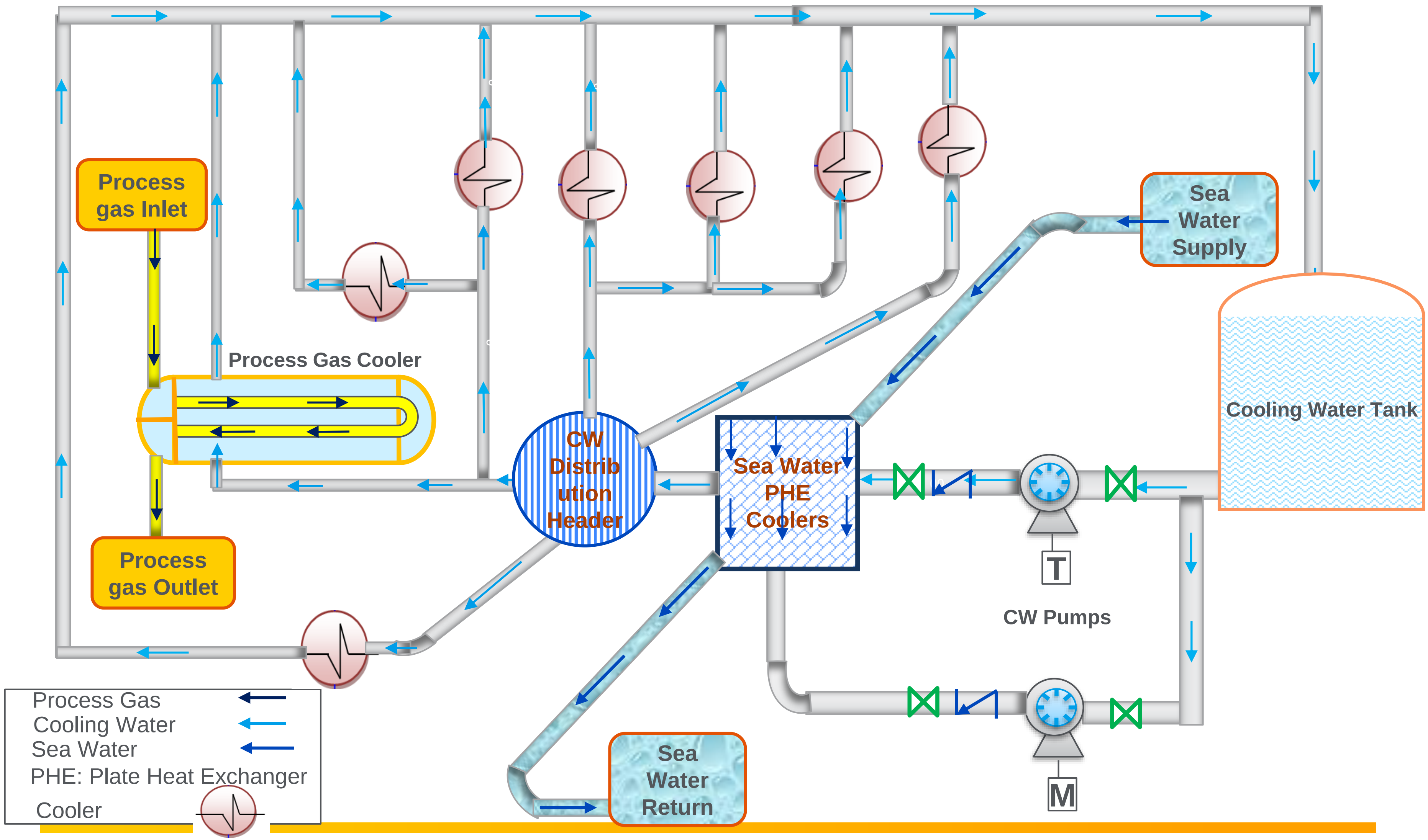
In the process industry and petrochemical plants heat exchange coolers are essential and important assets used to cool the process media by using cooling water as cooling media . Cooling water to the process heat exchane coolers is supplied from closed loop cooling water circuit in the plant. Usually, in cooling water circuits several heat exchangers are present as per process requirements where heat exchange is achieved between process media and cooling water. Heat exchange is exhibited at the heat transfer surface area of the heat exchanger bundle tubes. In the bundle tubes, process media will be flowing at one side and cooling water will be flowing at the other mating side of the tube. Process media will be cooled due to cooling temperature effect of the circulated cooling water and heat of the process media will be picked up by the flowing cooling water.

BRIEF PROCESS DESCRIPTION

The closed loop cooling water system supply cooling water to all heat exchange coolers in the plant for cooling process media as per process requirement. The system consists of centrifugal pumps, sea water cooled plate heat exchangers, cooling water tank and connected piping system. Normally the turbine driven cooling water pumps remains on line and motor driven pump remains on auto standby.

Both cooling water pumps takes water from cooling water storage tank and deliver it to different plant users through the plate exchangers, where the returned hot cooling water is cooled by exchanging heat with the sea cooling water. The cooling water system is closed loop with corrosion inhibitor. Cooling water circulation supply pressure is (3.0 - 4.0) Kg/Cm^2 and temperature is in the range of (30 - 40) °C.

SCHEMATIC FLOW DIAGRAM OF CLOSED LOOP COOLING WATER CIRCUIT



PROCESS GAS COOLER

		Shell Side	Tube Side
	Process Media	Cooling Water	Process Gas
	Operating Pressure (Kg/Cm^2)	(3.0 – 4.0)	(14.0 – 16.0)
	Operating Temperature (°C)	(38 – 48)	(161 – 46)
	Material of Construction	CS	CS
	Tube size	-	19 mm dia
	Years in service	1987	

MAIN COMPONENTS OF THE PROCESS GAS COOLER

1) Shell component

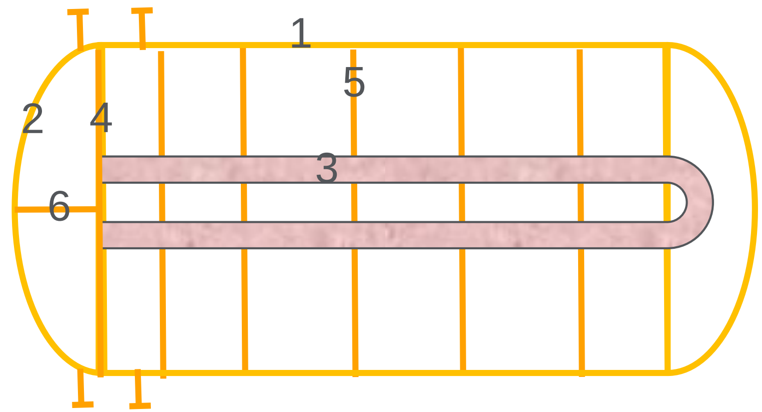
2) Channel head component

3) Heat exchanger tube

4) Tube sheet

5) Baffle plates

6) Pass partition plate for U-Tube bundle type



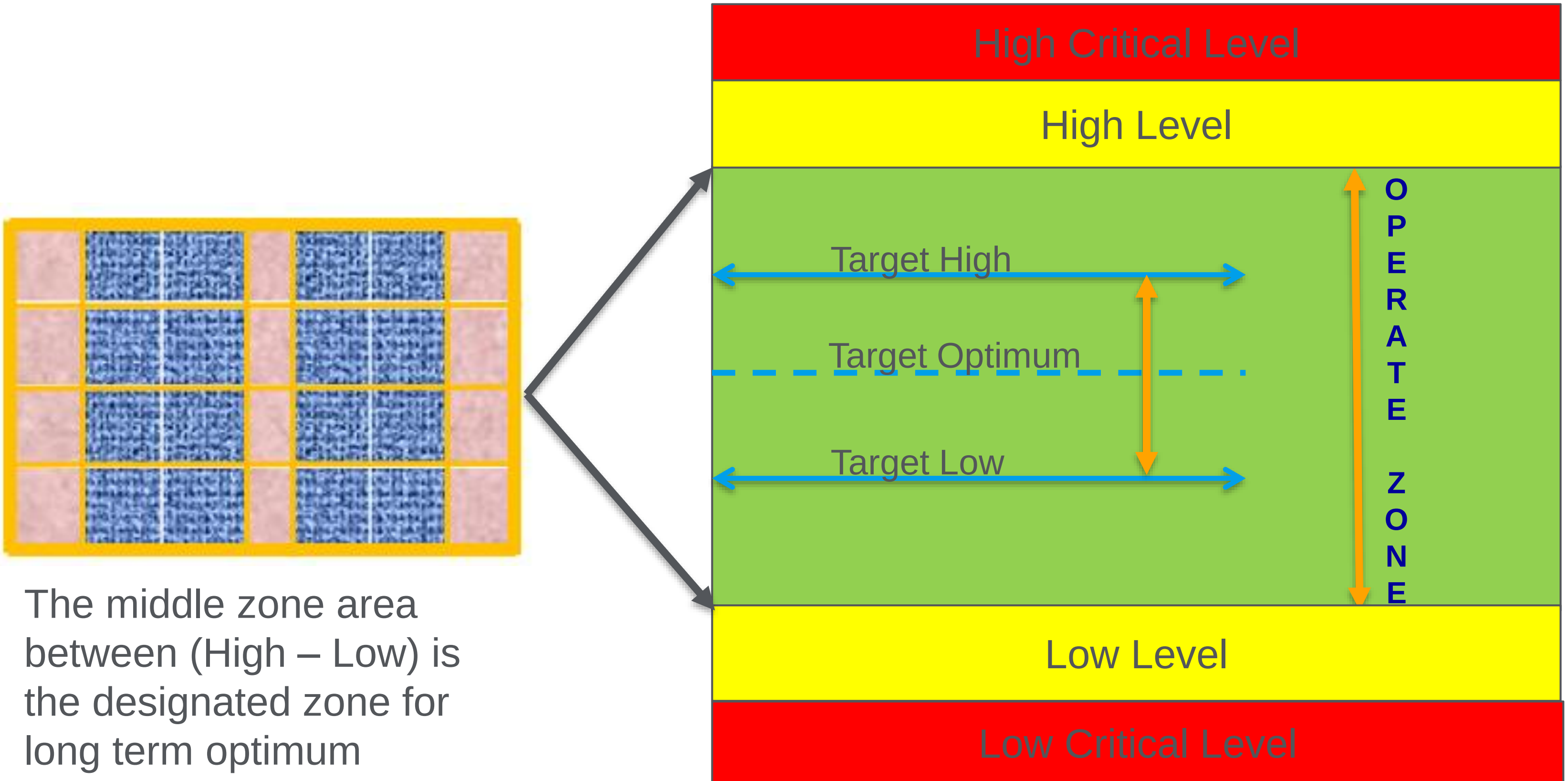
INTEGRITY OPERATING WINDOW (IOW) OF THE ASSET

Integrity Operating Windows (IOWs) are sets of defined limits used to determine the different variables that could affect integrity and reliability of the asset.

It is important to develop limits for every possible damage mechanism that is likely to affect the asset. This way, working within the limits set for the asset will be able to prevent most likely types of damages that could affect the asset integrity.

In our case, operating pressure, temperature, process gas composition, cooling water chemistry (i.e: pH, conductivity, TSS (Total Suspended Solids), corrosion inhibitor) are important factors of the operating window.

ZONE OF THE INTEGRITY OPERATING WINDOW (IOW)



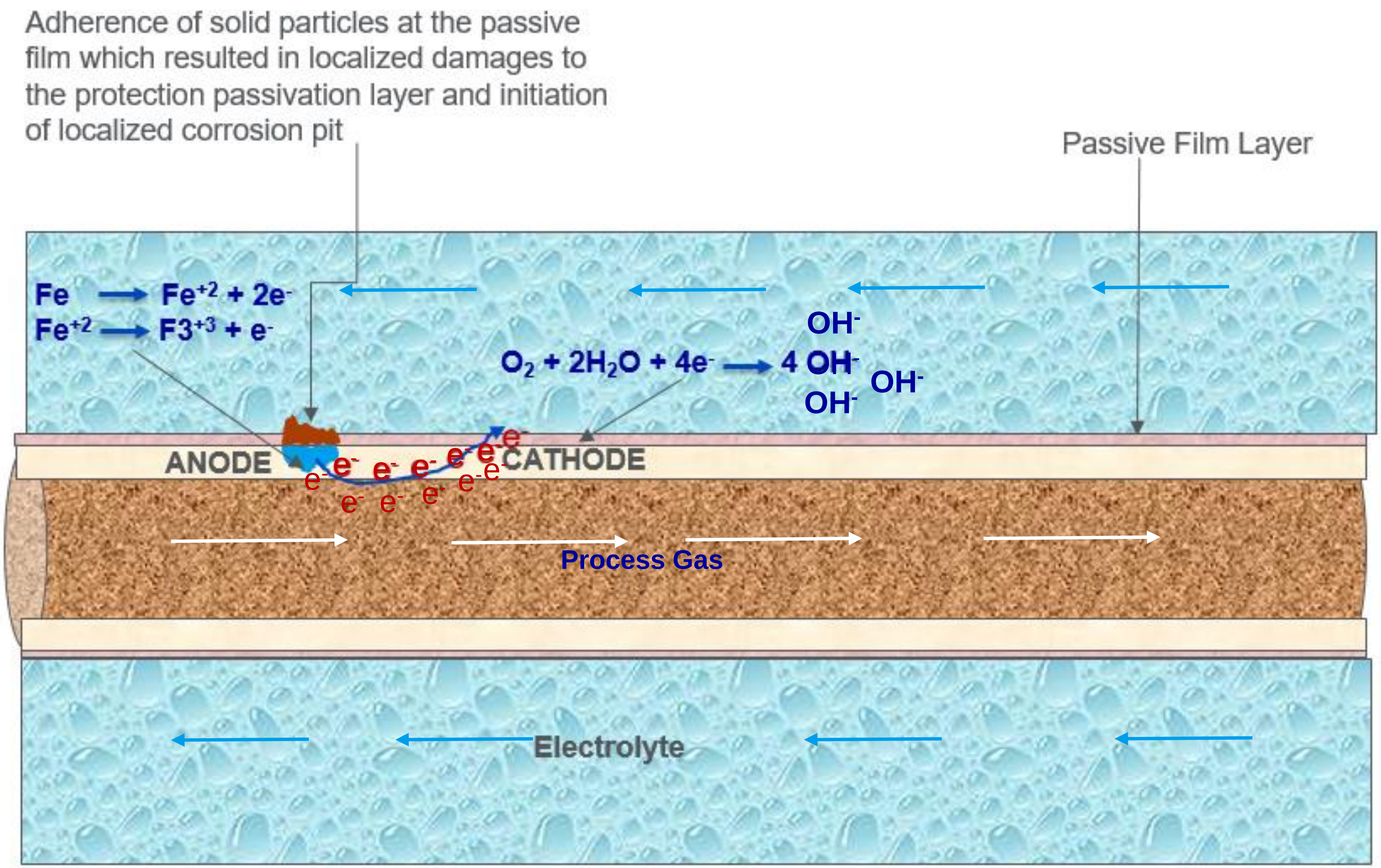
The middle zone area between (High – Low) is the designated zone for long term optimum operate zone of the asset

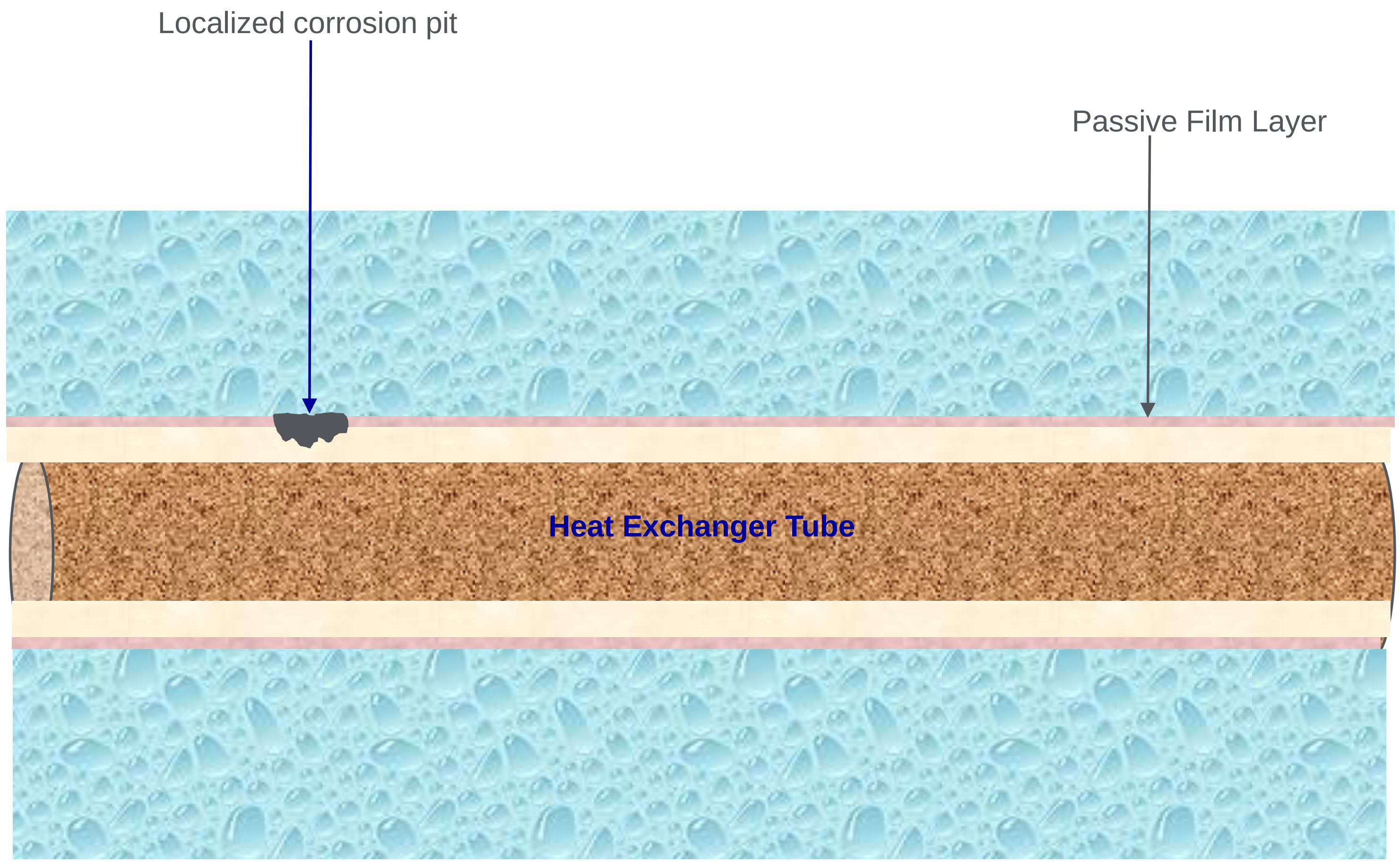
PITTING CORROSION

Adherence of suspended solids from the electrolyte at the protection passive film of the parent metal will cause localized damages to the passivation layer and initiation of localized corrosion pit. Underneath, localized pitting corrosion attack can be a particularly severe form of corrosion because of the difficulty in detection due to the corrosion occurring beneath the material. Examples of these materials could be sand particles, dirt, corrosion products “rust”, and other solid particles in the electrolyte system. Settlement of the material acts as shield and creates stagnant condition underneath similar to the crevice corrosion type attack.

Solids in suspension of the electrolyte solution tends to settle on the heating surface of the heat exchanger tube. Pitting corrosion is one of the destructive corrosion type as it can lead to equipment failure due to localized perforation with only small amount of iron weight loss.

ILLUSTRATION OF PITTING CORROSION ATTACK



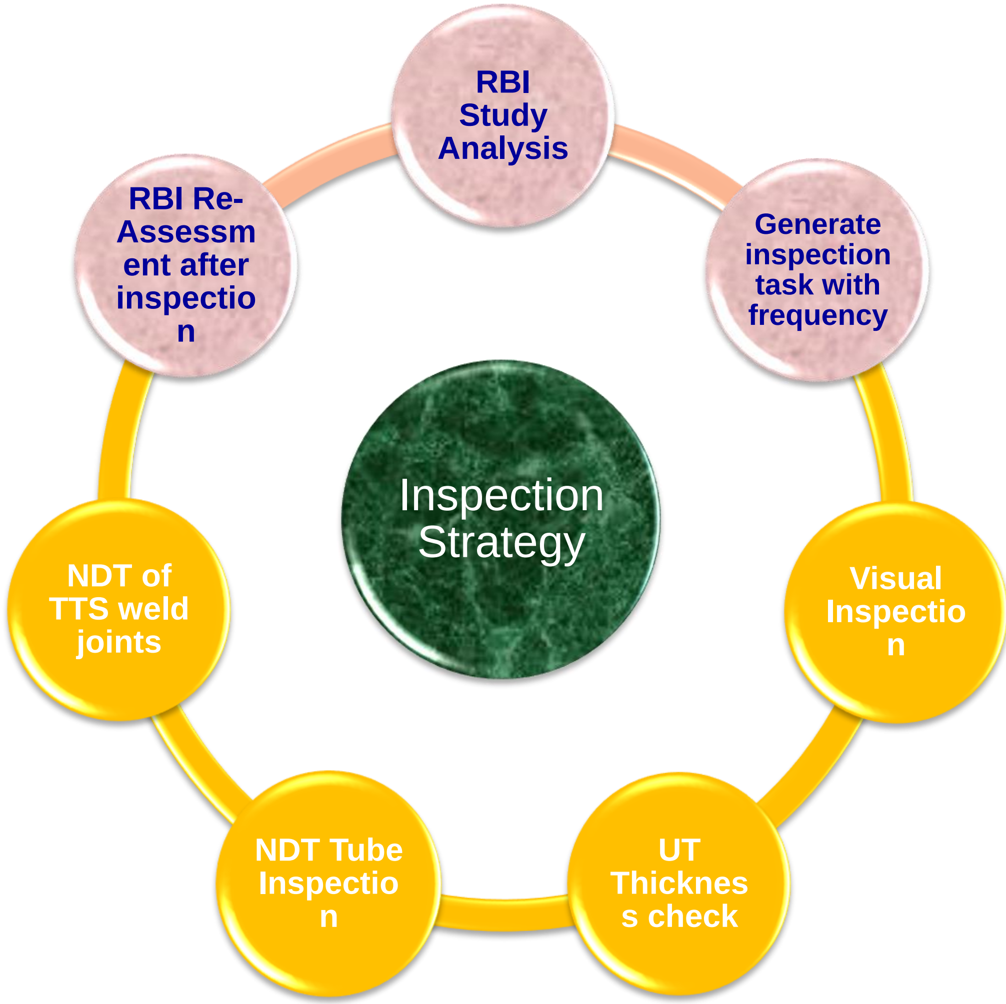

Localized corrosion pit
Passive Film Layer
Heat Exchanger Tube

PITTING CORROSION IMPORTANT REMARKS

- Pitting is a form of localized corrosion attack at the metal surface.
- The corrosion pits could be shallow in nature or large in diameter.
- Corrosion pits some times are isolated or close to each other and form together rough surface appearance.
- Pitting corrosion is difficult to detect because of small size and mostly covered with corrosion products
- It is difficult to measure quantitatively by NDT (Non Destructive Testing) technique due to small volumetric loss
- Pits usually grow in the direction of gravity
- The mechanism of pit growth is similar to that of crevice corrosion.
- Velocity effect, pitting is usually associated with low flow velocity areas.
- Increasing velocity of the circulating media often decreases pitting corrosion attack.

HEAT EXCHANGER INSPECTION STRATEGY

RBI (Risk Based Inspection) approach is used to develop inspection strategy of the asset



OBSERVATIONS DURING THE PLANNED INSPECTION

- Tube bundle was pulled out from the shell and localized pitting corrosion attack found on the tube external surface.
- Baffle plates found free from pitting corrosion
- Channel head and shell internal surface found free from pitting corrosion
- Tubes internal surface found free from corrosion attack
- Tube to tube sheet weld joints found free from defects
- Tubes were inspected by MFL NDT technique.

PITTING CORROSION OF CS TUBE

Slightly deep corrosion pits

Baffle plate w/o signs of corrosion pits

Shallow corrosion pits

SHELL INTERNAL SURFACE

Internal surface of the shell
w/o signs of corrosion pits

ACTIONS TAKEN

1) Tubes with deep corrosion pits were plugged from both sides of the tube.
2) Tubes with shallow corrosion pits were left and kept under monitoring.
3) Shell side hydro test to ensure integrity of the tube bundle.

CONCLUSION REMARKS

1) In spite of localized corrosion pits, the tube bundle of the cooler had demonstrated good service life under the operating window of the asset.

2) Operating the asset within the integrity operating window is very important and essential for reliable operation of the asset and achieve optimum service life.

3) Keeping the solid particles in suspension state can minimize the sedimentation effect at the heat transfer surface of the heat exchanger tube and consequence potential effect of localized pitting corrosion attack

4) Monitoring and maintaining water chemistry including the corrosion inhibitor within the specified limit is essential for the protection passivation layer and corrosion protection of the asset.

4) Periodic timely inspection of the asset, is important for health condition assessment of the asset.

5) Areas prone for relatively low circulation flow velocity in the circuit, shall have close attention and inspection focus.

6) Side stream filtration system can be considered and evaluated as filtration option to clean and remove solid particles from the electrolyte.

THANK YOU