ANALYSIS OF INSPECTION PLAN OF AIR COOLED HEAT EXCHANGER FOR NEEDS OF MAINTANCE AND SAFETY OF OIL&GAS PLANTS

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Abstract: The paper shows preparation of inspection plan for air cooled heat exchanger in refinery. The importance of proper inspection, traceable prepared plan of inspection is discussed. The inspection of heat exchanger, according to the presented plan, includes visual testing - internal and external, ultrasound testing and liquid penetrate testing. The inspection plan is essential for maintenance the pressure equipment in refineries and is performed according to API 572 and API 510. The inspection of air cooled heat exchanger shows satisfactorily results.
Key words: heat exchanger, visual testing, inspection plan, API 572, API STD 510

1. INTRODUCTION

An air cooler is a unit of pressure equipment containing an open bundle of tubes housed in a steel frame. The air cooler uses air as a working, cooling medium, which is circulated by a fan placed above or below the tube bank [7]. The design of the air cooler uses standards such as API 661[6] and API 660 [5], EN 13445 and covers minimum requirements for design, materials, manufacturing, inspection, testing and preparation for initial delivery. In-service inspection of air-cooled heat exchangers is similar to other pressure vessel inspections and is performed according to API STD 510 [1] or according to standard EN 13445 and the Ped directive. During the inspection plan, it is preferable to use API RP 572 [3], API RP 577 and/or API RP 571. The inspection is applied primarily to determine the physical condition of the pressure vessel, as well as the type of damage, the speed at which the damage progresses in order to maintain the safety of the cooler itself, but and the entire plant. It is necessary to document all data obtained from the inspection, as well as data on replacement parts, reparation, rehabilitation, in order to track the history and assessment of the risk-based inspection (RBI). Safety and maintenance of the entire facility are the primary reasons for carrying out periodic inspections, which identify damages and take further steps to eliminate them, and thus prevent incidents of a larger or smaller scale.
The paper is organized in three parts: the first part describes the importance and the aspects of inspection planning, the second part shows inspection plan made for the air-cooled heat exchanger in the upstream plant and the third part shows results of its inspection.

2. INSPECTION PLANS

Several criteria should be considered when developing an effective inspection plan. The primary goal of the plan is to organize inspections (and supporting activities) that enable the owner to assess the condition of the pressure vessel.
Care should be taken to ensure that the inspections provide the information required to perform any applicable analyses, in a timely fashion, without imposing detrimental effects on the equipment
The frequency with which a pressure vessel should be inspected depends on several factors, including the rate of damage, the corresponding remaining useful life, and the risk of failure.
Maximum internal or external inspection intervals should be in accordance with API 510. Scheduling of shutdowns for maintenance or inspection is usually arranged through the collaboration of process, maintenance, and inspection groups.
The actual time for inspection will usually be determined through the collaboration of process, mechanical, and inspection groups, or by the mandate of a jurisdiction.

3. INSPECTION BOOK OF AIR COOLED HEAT EXCHANGER

This recommended procedure, standards, codes, and practices covers the inspection of pressure vessels. They include a description and the reason for inspection, cause of deterioration, frequency and methods of inspection, records and reports.

3.1. Main standards and procedures

Standards and procedures used for heat exchanger's inspection planning are se following:
Internal Procedure for Plant Inspection Philosophy
Internal Procedure for Visual Inspection - General Principles
Internal Procedure for Magnetic Particles Inspection
Internal Procedure for Liquid Penetrant Test
Internal Procedure for Visual Inspection of Pressure Vessels
Internal Procedure for Ultrasonic Thickness Examination Procedure
Internal Procedure for Safety
Internal Procedure for Measuring Thickness by Manual Ultrasonic Pulse Echo Contact Method
Guideline for repairing - inspection and maintenance work book
API STD 510 Pressure Vessel Inspection Code for In-service Inspection, Rating, Repair, and Alteration
API RP 572 Inspection of Pressure Vessel (Towers, Drums, Reactors, Heat Exchangers, and Condensers)

3.2 Inspection plan for air cooled heat exchanger

The plan of inspection of air cooled heat exchanger is presented in Table 1. This plan is applicable only to this particular exchanger and is made according to the inspection history, the internal procedures of the refinery where it is located and the project documentation.

Table 1. Inspection plan of air cooled heat exchanger

	Reference/ document	Acceptance/ Criteria	Verify/ document	Inspection level		
				Req*	CLI	CA
1.0						
Review Document						
Drawing, Design/Catalogue & Datasheet	ASME Sec. VIII	ASME Sec. VIII	General Drawing & Datasheet	Yes	R	R
NDT Equip. Calibr.	ASME Sec. V	ASME Sec. V	Calibr. Cert.	Yes	R	R
Previous Inspection Record	API 510	API 510	Inspection Workbook	Yes	R	R
Corrosion & Failure Threat	API 510	API 510	Corrosion Assessm.	Yes	R	R
Advance NDT Procedure			NDT Procedure	No	A	R
Repair of Pressure Vessel			Repair Procedure	No	A	R
Safety Precaution			Work permit & Risk Asses.	Yes	A	R
Review Document			General Drawing & Datasheet	Yes	R	R
Drawing, Design/Catalogue &			Calibr. Cert.	Yes	R	R

Datasheet						
2.0						
Visual Inspection						
External	Internal Procedure	API 510	Visual Inspection Report	Yes	P	M/R
Internal	Internal Procedure	API 510	Visual Inspection Report	Yes	P	W
3.0						
Extended Non-Destructive Test						
Scanning Wall (shell, head)	Internal Procedure	ASME Sec. V	NDT Report	No	P & T	M/R
Wall Thickness Check (Localized Scan)		API 510	NDT Report	Yes	P & T	M/R
Hardness		ASME Sec. II	Hardness Report	No	P & T	M/R
MT or PT on selected W. joints	Internal Procedure	ASME Sec. V	NDT Report	Yes	P & T	M/R
Other Advance NDT (TOFD; Acoustic Emission PEC; CHIME; etc)	API 510	ASME Sec. V	NDT Report	No	W	W
4.0						
Calculation Check						
Corrosion Rate Calculation	API 510	API 510	Calculation Report	Yes	P	R
Remaining Life Calculation	API 510	API 510	Calculation Report	Yes	P	R
MAWP Calculation (if derated)	API 510	API 510	Calculation Report	No	P	R
5.0						
Hydrotest	Internal Procedure	ASME Sec. VIII	Hydrotest Report	No	P & T	W
6.0						
Completed Pressure Vessel Inspection Work Book Report				Yes	P	R

3.3 Corrosion threats

Service fluid is Raw Gas operating at temperature 134°C, while design temperature is 170°C. Operating pressure is 25.6 bar, and design pressure is 39 bar. There is no protective internal lining. General corrosion and pitting or localized corrosion may be found on the internal surface of the air cooler.

3.4 External visual inspection instruction

1.Before starting the inspection of a vessel, especially one in severe service, the inspector should determine the pressure, temperature, and service conditions under which the vessel has been operated

since the last inspection. The inspector should also be aware of equipment construction details including materials of construction, the presence of internal attachments, and weld details.
2. A careful visual inspection should be made for corroded or broken parts, cracks, the tightness of bolts, the condition of paint or galvanizing material, the wear of ladder rungs and stair treads, the security of handrails, and the condition of booring on platforms and walkways.
3. Foundations of vessel are from structural steel fireproofed with concrete. They should be inspected for deterioration such as cracking, settling and spalling.
4. The nuts on anchor bolts should be inspected to determine whether they are properly tightened.
5. If any settling of the vessel has occurred, nozzles attached to the vessel should be inspected for distortion and cracking distortion. If there is any evidence of distortion or cracks in the area around the nozzles, all weld joints in this area should be examined for cracks.
6. Grounding connections should be visually examined to verify that good electrical contact is maintained. These connections provide a path for the harmless discharge of lightning or static electricity into the ground. The continuity of all ground wires should be checked.
7. Auxiliary equipment, such as gauge connections, may be visually inspected while the unit is in service. Undue vibration of these parts should be noted.
8. Certain types of corrosion may be found on external surfaces of a vessel. Among these are atmospheric corrosion, hydrogen blistering... In humid areas and in areas where corrosive chemical vapors are present in the air, corrosion of external surfaces may be a problem.

3.5 Results of external visual inspection

External inspection was conducted on the air cooled heat exchanger. External inspection covers the condition of the external metal surfaces and its external components.
Visual inspection is performed in accordance to internal procedure. Results are as following:
Ladders, Stairways, Platforms, and Walkways were found in good condition.
Foundations, Anchor Bolt, concrete/steel supports and nozzles were found in good condition.
Grounding Connection were found visually in good condition in time of inspection. Measured value of grounding connection electrical resistance was 0.32 Ohm. These values are under the standard values and additional checking and analyze is recommended in the future.
Auxiliary Equipment and protective coating were found in good condition.
External Metal Surfaces / External Evidence of Corrosion External metal surfaces were found in good condition. Corrosion was not observed on them in time of inspection.
Figure 1 and Figure 2 present air cooled heat exchanger from front side and from the back side respectively.

Figure 1. Air cooled heat exchanger (view from the front side)

Figure 2. Air cooled heat exchanger (view form the back side)

3.6 Internal visual inspection instruction

1. Inspectors should understand the function of the vessel internals and each nozzle to assess findings. The internal inspection of vessel shall be made in accordance API RP 572.
2. All areas of the vessel should be inspected after removing of plugs at inlet and outlet chamber. Especially attention shall be carried out at inspection of tubes at connection to tube sheet. The borescope should be used for this activity.
3. Welded joints in inlet and outlet chamber of air cooler should be closely checked. The borescope should be used for this activity.
4. General corrosion and pitting or localized corrosion may be found on the internal surface at inlet and outlet chambers.

3.7 Results of internal visual inspection instruction

Internal visual inspection has been performed by industrial borescope according to standards API 570[2] and API 574 [4].
Internal surfaces and tubes were inspected with the borescope and they were found in good condition in time of inspection.
Interior of header (Figure 3) and tubes was found in good condition. Corrosion in them was not observed in time of inspection.
All inspected tubes were found in good condition in time of inspection. Corrosion in the tubes was not observed in time of inspection.

Figure 3. Interior of the header was found in good condition in time of inspection

3.8 Results of UT and PT

Liquid penetrant testing shows no cracks in air cooled heat exchanger (Figure 4).

The results of UT thicknesses measurements correspond to the design values so corrosion rate cannot be determinate. Hence remaining life is also undetermined. Table 2 presents design thickness of air cooled heat exchanger parts, and Figure 5 presents results of UT thickness measurements. UT thickness measurements confirmed no corrosion appeared.

No	Item	Material	Design thickness (mm)
1	Tube plug sheet	SA-240-316	22.00 mm
2	Top/Bottom plate	SA-240-316	12.00 mm
3	End plate	SA-240-316	12.00 mm

Table 2. Design thickness of air cooled heat exchanger parts

Figure 4. Results of PT testing of the weld joints

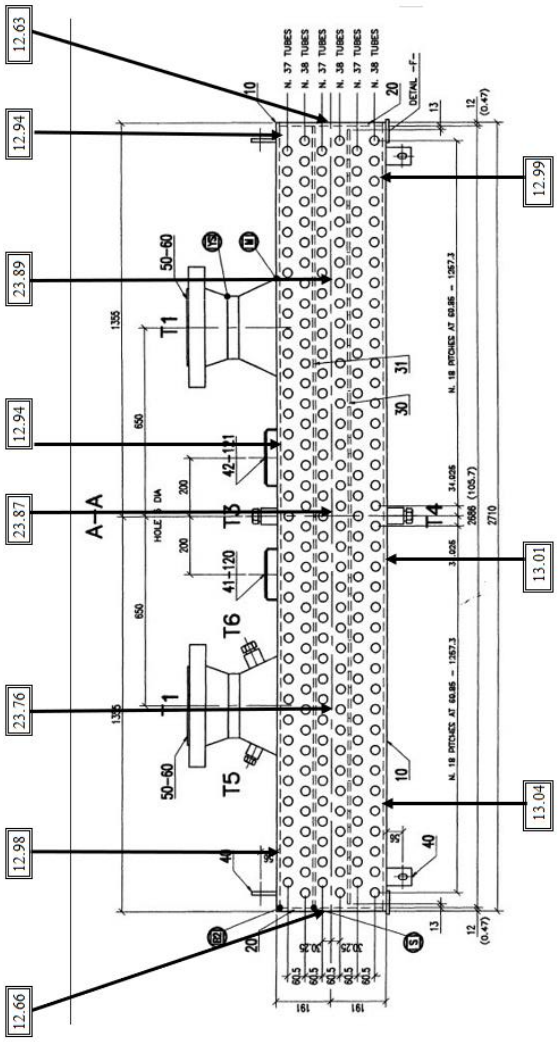

Figure 5. Results of UT thickness measurements

4. CONCLUSION

All of the essential sections/components of the air cooled heat exchanger are safe to operate until next scheduled inspection.
Next external inspection, internal inspection and ultrasonic thicknesses measurements at the same position should be performed within next five years.
All of the essential sections/components of vessel are safe to operate until next scheduled inspection.

REFERENCES

[1] API 510 Pressure vessels inspection code;
[2]API 570 Piping inspection code;
[3] API 572 Inspection practice for ;ressure vessels
[4] API RP 574 Inspection Practices for Piping System Components
[5] API 660 Shell-and-Tube Heat Exchangers
[6] API 661 Petroleum, Petrochemical, and Natural Gas Industries Air-Cooled Heat Exchangers
[7] M M Muhsen *et al* 2021 *IOP Conf. Ser.: Mater. Sci. Eng.* 1067 012112