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Inspection and Repair Quality Plan of Regeneration Gas Heater

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Abstract. Gas heaters used in oil and petrol industry transfer heat to the produced gas stream. Heaters are especially used when producing natural gas or condensate to avoid the formation of ice and gas hydrates. In this work, the inspection practices for process heaters used in petroleum refineries and petrochemical plants is presented as well as critical places for crack formation. After the inspection of the Regeneration Gas Heater the cracks were found and immediately repaired. The inspection is performed using visual, liquid penetrant and ultrasonic testing. The inspection and plan repair by welding is covered according to API 573:2013 and ASME IX:2017. In this work, the results before and after repair are presented and discussed.

1. Introduction

Gas heaters used in oil and petrol industry transfer heat to the produced gas stream. There are a variety of designs for tubular fired heaters. Some of the more commonly used designs are the box, cylindrical, and cabin designs. A box-type heater is a heater whose structural configuration forms a box. There are many different designs for box type heaters: a vertical coil heater, helical coil heaters, heater with arbor or wicket coils [1]. Beside them, there are heaters used in steam methane reforming and pyrolysis heaters. Fired heaters are frequently subjected to additional or unique degradation mechanisms due to the combination of heat, internal pressure and the various chemical characteristics of process fluids. Deterioration mechanisms occurred in heater tubes could be both internally and externally. Typical mechanisms are as follows: internal corrosion (a function of the chemical composition of the process fluid, process and tube metal temperatures, the fluid velocity and tube metallurgy), external corrosion of the tube (depends on the heater atmosphere and temperatures), creep and stress rupture (high-temperature mechanisms that depend on both the stress level and type of material), metallurgical changes (results in various conditions, including carburization, decarburization, spheroidization and grain growth), erosion (results from a combination of impingement and velocity), thermal fatigue, thermal shock (caused by a sudden marked change in temperature), liquid metal cracking and embrittlement polythionic acid stress corrosion cracking, carburization (occurs when metals are exposed to carbonaceous material or carburizing environment at elevated temperatures), metal dusting (a catastrophic form of carburization that may result in rapid metal wastage) and mechanical deterioration (materially reduce the service life of heater tubes and fittings) [2]. In this work, the inspection of gas heaters is done according to API 573 [3]. The use of corrosion-resistant alloys requires specialized inspection and operational control techniques. Inspectors need to be familiar with the history of corrosion control heatermers, past problems, and the history of furnace repair. The inspector should have experience and staff performing specific NDT methods should be trained and qualified in applicable procedures [3].

In this paper, the regeneration gas heater is inspected using nondestructive testing methods, and repair quality plan is presented.

2. Equipment Description

The vessel sketch and external appearance of gas heater are presented in Figure 1.

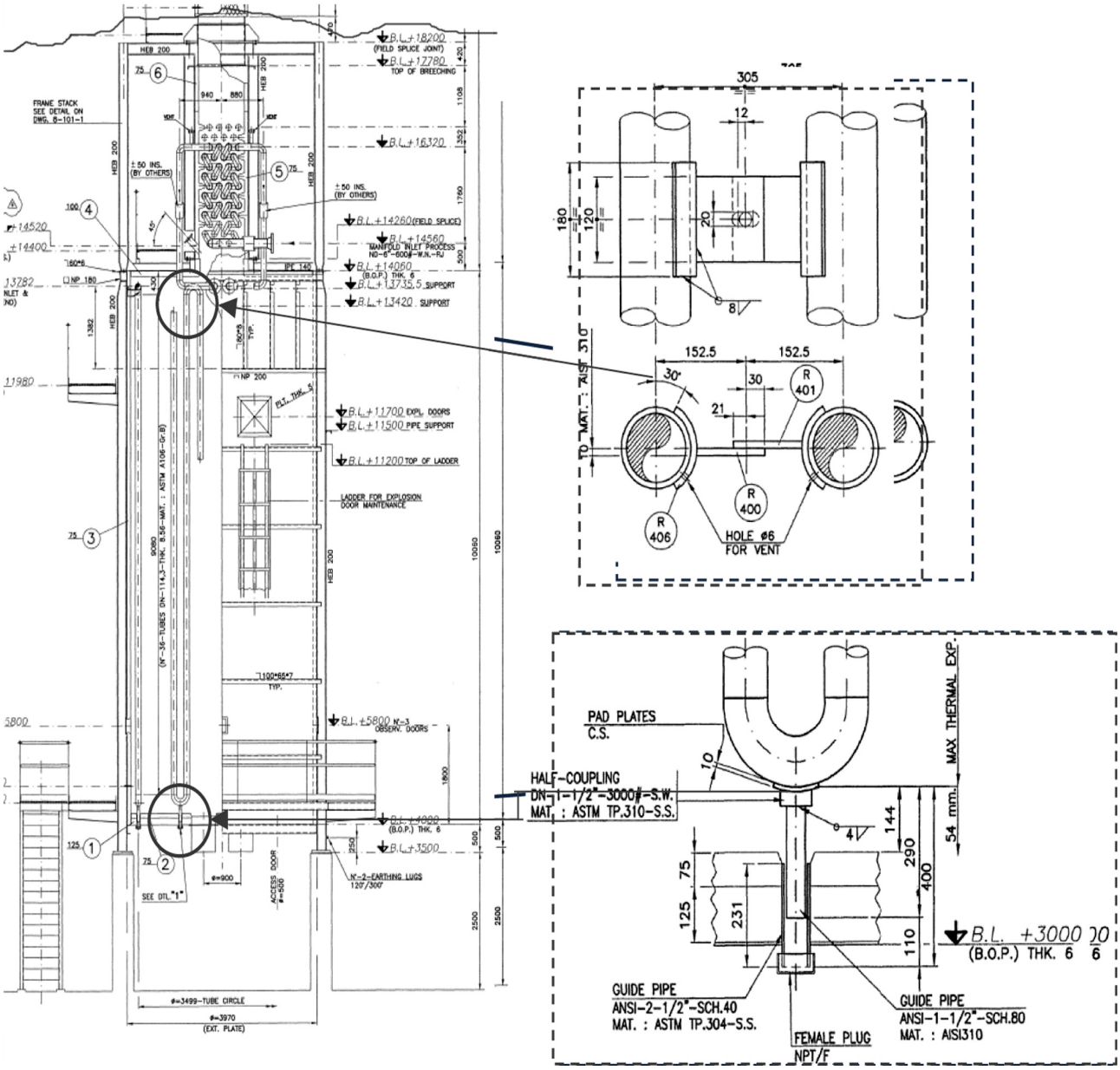

Fig 1. Regeneration Gas Heater with some critical elements susceptible to degradation

The technical data of regeneration gas heater manufactured by Linde Impianti Italia S.p.A. are listed in Table 1.

Table 1. Equipment Technical Data

	Material	*Design Thickness (mm)*
Tubes	ASTM A 106 GR.B	8.6
Profile and plates	ASTM A36	Various
Temperature [C°]	400	
Pressure [bar]	63	
Insulation	*Special temperature concrete*	

Testing of the regeneration gas heater is performed using visual inspection, liquid penetrant testing and ultrasonic testing. The reparation is done according to welding procedure specification and procedure qualification record.

3. Results and Discussion

3.1. Results of non-destructive testing

The purpose of this work is inspection of the regeneration gas heater. The internal attachment weld components, seam weld and components were intact and in good condition except the pipe in convective zone. Cause can be from low temperature of gas stream and possibility of condensation of water vapor at surface of the pipes during shut off/on, and CO2 corrosion. Detail laboratory analyses is necessary to be applied.

The external components connected to the burner grounding connections were intact and in good condition. Small general corrosion is present at ladders, platforms and supports. Small damaged areas of painting are present.

Figure 2 presents results of visual testing. according to results of VT, the pipes are in good condition.

Visual testing confirmed that the tubing inside the regeneration system seem to be in good condition. There are no visible cracks or deterioration on the shell and the heads. There are no evidence of corrosion, leaks and painting defects.

Fig. 2. Visual inspection showed that pipes are in good condition

Liquid penetrant testing has been performed at several welding joints. One defect (crack) has been found at the internal support of pipes and two cracks have been found on external side of Regeneration Gas Heater at the pipe of thermocouple gage.

UT thickness measurement has been performed together with visual inspection. Thickness is in accordance to design specification and last measurement.

Hardness measurement in Regeneration Gas Heater have been conducted on ten pipes and on three places on each pipe. Range of obtained values was between 100 and 125 HRB.

3.2. Repair quality plan

Purpose of this plan is to repair the cracks occurred on interior and exterior side of Regeneration Gas Heater and confirmed after penetrant liquid testing. This plan covers the repair by welding according to API 577:2013 and ASME IX:2017.

Plan to repair support of tubes on interior side of Regeneration Gas Heater in Train 2 includes removing of cracks or any other defects using appropriate tools. This should be followed by Liquid Penetrant Test to ensure that no any defect exist prior to repair welding activities. Further, the surface should be cleaned by well utilizing chemical solvents to remove any dirt, contaminants, etc. Welding for the repairing of the cracks was performed according to WPS list: WPS-SM-805, supported with the appropriate PQR. The welding process was GTAW + SMAW, manually; joint design groove and fillet with no backing according to ASME Sec. IX. Specification type and grade of base material was A312GrTP304, and filler metal ST 301l/S309L-16 (Hyindai Weld Co.). Preheating temperature was 10°C and interpass temperature was max. 150°C, shielding gas was argon (99,99%) with flow rate 12-20 l/min. Welding was performed in four layers, first two by GTAW welding process and last two with SMAW process. Finally Liquid Penetrant Test should be done after completion of welding activities. Figure 3. presents the repaired support of tubes.

a)  b) 

Fig. 3. Crack on support of pipe removed by grinding and repaired by welding, penetrant test was conducted after repair welding and cracks was not found at time of inspection

Plan to repair connection at thermocouple nozzles-housing of Regeneration Gas Heater in Train 2 includes removing the cracks carefully (or any other defect) using appropriate tools.

Liquid Penetrant Test carried out to ensure that no any defect existed prior repair welding activities. After that it is important to clean the surface with well utilizing chemical solvents

to remove any dirt, contaminants, etc. Welding should be performed to repair cracks following WPS list, supported with PQR. Finally Liquid Penetrant Test should be done after completion of welding activities. Figure 4. presents the repaired thermocouples.

Fig. 4. Cracks on thermocouples removed by grinding and repaired by welding, penetrant test was conducted after repair welding and cracks was not found at time of inspection

On the basis of the inspection it is considered that the item Regeneration Gas Heater satisfies the Plant Inspection Philosophy requirements for maintenance inspection/examination and is suitable to return in service.

Conclusion

In this work, nondestructive testing of regeneration gas heater was carried out. Liquid penetrant testing showed the cracks on thermocouples and support of the tube. Repair quality plan was successfully applied, and no cracks were detected.

As per Plant Inspection Philosophy, Next External Inspection, Internal Inspection, Hardness testing, Ultrasonic Thickness measurements and Penetrant Testing at the same positions, shall be performed within next 5 years. Visual inspection shall be performed within 6 months at the pipe of thermocouple gauge in the case of checks for cold cracks.

Acknowledgment.

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References

[1] The ASME Boiler and Pressure Vessel Code, 2017 ed., The American Society of Mechanical Engineers, Two Park Avenue, New York, NY 10016-5990.

[2] API RP 571 - Damage Mechanisms Affecting Fixed Equipment in the Refining Industry, Second edition, American Petroleum Industry, Washington, 2011.

[3] API 573, Inspection of fired boilers and heaters, American Petroleum Industry, Washington, 2013.

[4] M.F. Hamid, Mohamad Yusof *, M.K. Abdullah, Z.A. Zainal, M.A. Miskam, Preliminary Investigation of an Up-Scaled Gamma-Type Stirling Engine for Power Production, Applied Mechanics and Materials, Trans Tech Publications Ltd, Vol. 786, pp 220-225

[5] Rusli, Nur Balqis and Yaakob, Najmiddin and Savory, Robert Mikhail, Investigation of Corrosion Mechanisms in a Continuous Catalytic Regeneration (CCR) Platformer Unit, Material Science Technology and Global Sustainability II, Trans Tech Publications Ltd, 2019, vol. 797, pp. 393-401,