International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 8 Issue 11 ǁ 2020 ǁ PP. 33-37

Radiation Based Advanced Leak Detection Technique for Indian Refinery

P B Walinjkar*, V N Yelgaonkar
*[*1]Radiochemistry & Isotope Group, Bhabha Atomic Research Centre, Mumbai*
[2]Isotope Application Section, BRIT, Navi Mumbai
Corresponding Author: P B Walinjkar

Abstract
This paper demonstrates the application of a radiation based technique called the radiotracer method to correctly identify the leaky heat exchanger from a bank of six bench-lock heat exchanger of Diesel hydro treating (DHDT) unit in the Indian refinery. The Mo-99 radiotracer injected at the shell side inlet of the DHDT unit, without disturbing its process and radiation counts are monitored at the tube side of each heat exchanger over a period of time. The data of all detectors is then analyzed to derive the important decision of identification of leaky heat exchanger. It is ensured that no leakage in the five heat exchangers out of six. The radiation peak is observed in the data plot of heat exchanger 04B; which not only confirmed the leakage but also identified the leaky heat exchanger correctly.

Keywords: *Radiotracer, DHDT unit, bench-lock heat exchanger, leakage*

Date of Submission: 28-10-2020 Date of acceptance: 09-11-2020

I. INTRODUCTION

Radioisotopes are used widely for industrial troubleshooting and optimization of industrial processes. The deviation in product quality, indicates some abnormalities in plant operation. The operating parameters can suggest some possible cause of the trouble, but it is not easy to pinpoint the faulty component that causes the abnormality [1]. A diesel hydro-treating (DHDT) unit is generally designed for desulphurization by treating a mixture of high sulfur distillates and cracked feed streams in a petroleum industry. It also improves the cetane of the feed using catalytic hydrogenation significantly [2]. Heat exchangers are the closed, completely sealed vessels which are the most important components of the DHDT unit. In a heat exchanger (HX) system, an enormous amount of heat produced during the catalytic reaction in the reactor is utilized for preheating of the feed. Any leakage in heat exchangers proves expensive as it degrades the quality of the final product [3]. The various conventional techniques like visual inspection, pressure change method, chemical reagent test, dye penetrant test, and acoustical leak detection used for the identification of leaks in heat exchanger systems are offline techniques that are not suitable for online measurement [4,5].

Bongaigaon Refinery found higher Sulfur content in rundown diesel of the DHDT unit, which indicated a leak, from feed (shell side) to the reactor effluent side (tube side), in one or more than one breech-lock heat exchangers. For the efficient heat transfer, the six breech-lock heat exchangers were installed in the series, thus it was difficult to find out which one is leaky. It is essential to know, in advance, which of the six heat exchangers is leaking, to reduce the downtime of the plant by attending the leaky heat exchanger, as a specified target during the maintenance. Conventionally, the leaky heat exchanger is identified with the help of hydro-testing of the individual heat exchanger. This requires a long shutdown, hence it is not desirable. Thus, the refinery preferred to carry out a radiotracer study to identify the leaky heat exchanger of the DHDT unit online, without taking shutdown.

The principle of leak detection in heat exchangers is based on differential pressure. In a leaky heat exchanger, the fluid from the high-pressure side leaks into the low-pressure side. In shell-tube type of heat exchangers used in petroleum refineries, the cold feed is pumped to the tube side of the reactor and is heated up by the high-temperature effluent flowing out of the reactor from the shell. This radiation-based advance leak location technique is based on the principle of gamma-ray transmission. In this method a radiotracer is injected as a pulse, into the fluid at a higher pressure in industrial system. Collimated radiation detectors are placed on the outlet pipe of the fluid in which ingression is suspected, to record radiation counts (D-2 in figure 1). A rise in count-rate indicates the presence of radiotracer and thereby confirm a leak from the fluid at higher pressure to the fluid at lower pressure. The detectors D1 and D3 are used to ensure the instantaneous injection, and exit of the radiotracer from the HX system under test. Scintillation detectors of very high sensitivity are used, to detect the presence of the radiotracer in minimum possible time, and with high accuracy. The obtained data can be analysed quickly to identify a leaky heat exchanger. The application of radiotracer technique to find out leaky heat exchanger renders huge economic benefits, by minimizing the downtime of the large capacity petroleum refineries [6].

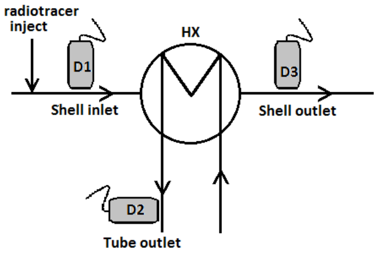

Figure 1: Principle of leakage detection

Radiotracer technique shows numerous advantages over other techniques, such as higher sensitivity, in situ detection, physical chemical compatibility, limited memory effect, unambiguous detection and quick results [5]. The radiotracer technique has unique advantage that the investigation is carried out online i.e. without disturbing the production process [1,5]. Using conventional methods identification of the leaky HX is difficult though they can provide rough idea about the existence of leakage in a train of heat exchangers [7]. Some disadvantages of the radiotracer technique are, proper knowledge of radiation safety and the requirement of trained man power for safe handling of radioisotopes.

II. EXPERIMENTAL

Bongaigaon Refinery having a capacity of 1.2 MMTPA is designed to operate in Diesel mode, as well as in Kerosene mode, for production of diesel with Cetane no. of 52, and to improve smoke point of kerosene (ATF) to 21mm. Diesel hydro-treatment is catalytic refining process employing a selected catalyst and hydrogen rich gas stream to remove organic sulfur, oxygen and nitrogen compounds contained in hydrocarbon fractions. The Diesel Hydro-treatment (DHDT) unit of the refinery is designed to remove sulfur from diesel feed from about 1800ppm to maximum 40ppm, for meeting Euro-IV specifications. The recovery of heat from the reactor effluent, as well as preheating of the feed is accomplished in a series of six breech-lock type heat exchangers. The schematic diagram of the heat exchanger system is shown in Figure 2. The heated desulfurized reactor effluent flows through the tube side of the heat exchangers, transferring the heat to the incoming feed, flowing counter-currently through the shell side of the heat exchangers. The experimental arrangement of the study is shown in figure 2 below. Six sodium iodide scintillation detectors (D2 to D7 shown as red dots) of 2-inch diameter were placed on the outlet pipe of the tube side, of each heat exchanger (HX), for monitoring passage of radiotracer. Two more detectors were placed on the inlet of the shell side of first HX 81-E-001B (D1) and shell outlet of the last HX 81-E-005A (D8) respectively.

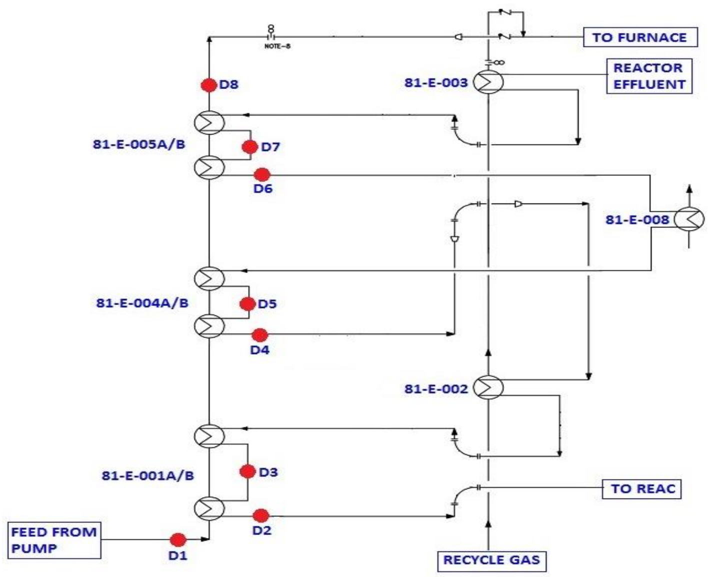

Figure 2: Schematic of experimental setup

Bromine-82 is most commonly used radiotracer for such study, due to higher energies of gamma [2]. However, the study was carried out, by injecting a newly developed industrial radiotracer Mo-99-ABO complex (~250mCi, T1/2: 66h, Eγ: 740keV) in organic form, at the suction end of the pump (before D1) [6]. The injection was carried out using specially fabricated injection system, as shown in the figure 3.

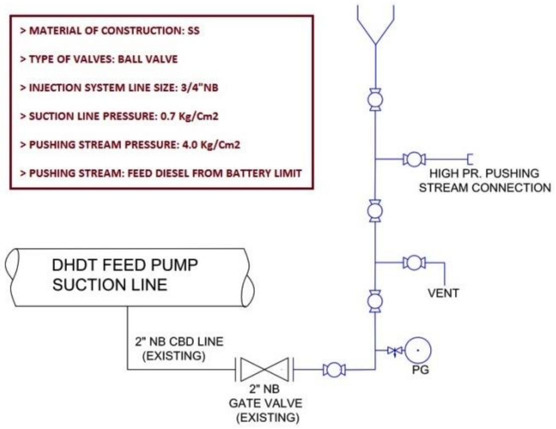

Figure3: Schematic of radiotracer injection apparatus

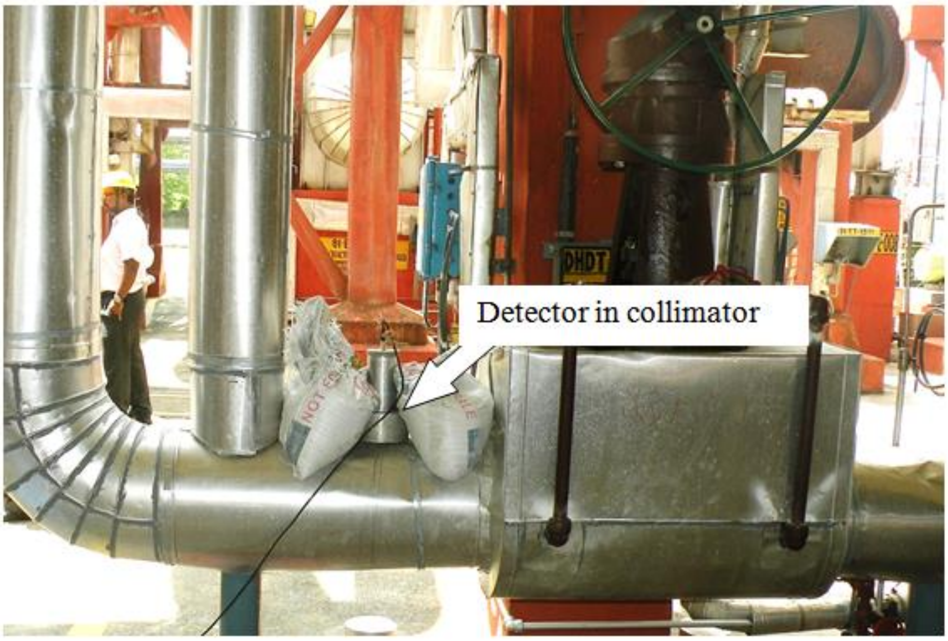

Figure4: Photograph of arrangement of detector

Each detector is shielded using 2-inch thick lead collimator to reduce background radiation. A thermal insulation is provided by Bakelite for proper operation of detectors at high temperature. Additional sand bags were placed on both the sides of the collimator as seen in the photograph (refer figure 4). All the detectors were connected to multi-input data acquisition system (MIDAS) and to a Laptop PC to store the data. Each data point acquired was for 20 milliseconds and total 1636 data points were acquired. Data of each detector is plotted and analyzed carefully to obtain the results.

III. RESULTS AND DISCUSSION

The results are derived from the data generated by the injection of Mo-99 radiotracer. The data of the detectors, placed on shell side inlet of the first heat exchanger (81-E-001B) and shell side outlet of the last heat exchanger (81-E-005A), is plotted as shown in figure 5.

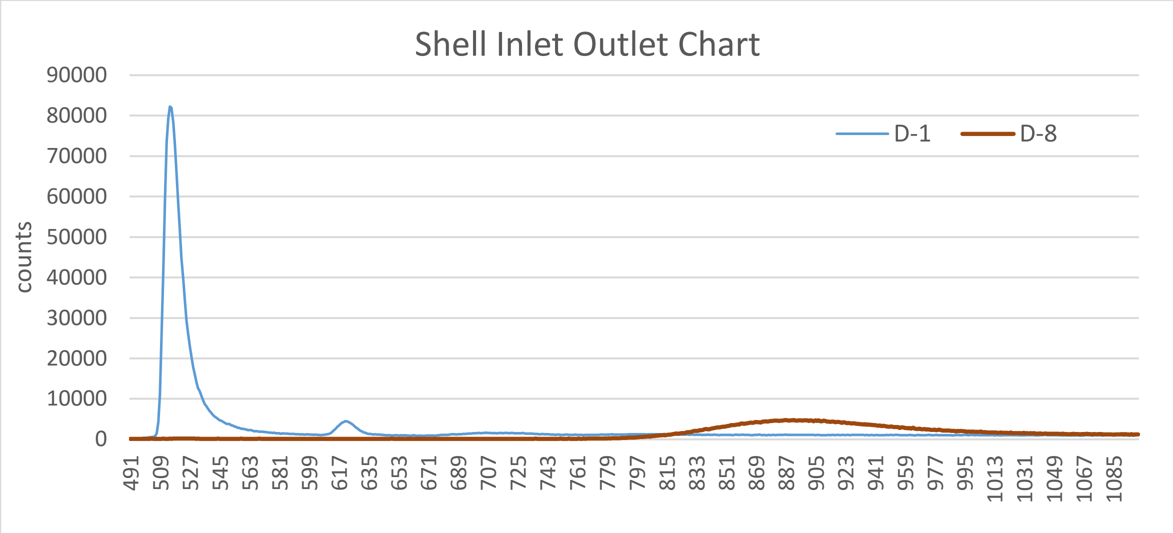

Figure.5: Plot of counts Vs. event (per 0.02sec) of shell side inlet of 01A(D1) and shell side outlet of 05B(D8).

A plot in Figure5 shows the signal picked by detector D1 placed on the inlet pipe of the shell of HX 81-E-001Band the signal picked by the detector D8 placed on the outlet pipe of the shell of the last HX 81-E-005A. The plot clearly shows the instantaneous injection carried out by the injection system as per the requirement. It also shows that the injected radiotracer has moved out of the sixth HX successfully.

Table 1: Placement of detector at respective outlet of heat exchangers

Sr No	Detector ID	Location and HX
1	D2	81-E-001B TUBE OUTLET
2	D3	81-E-001A TUBE OUTLET
3	D4	81-E-004B TUBE OUTLET
4	D5	81-E-004A TUBE OUTLET
5	D6	81-E-005B TUBE OUTLET
6	D7	81-E-005A TUBE OUTLET

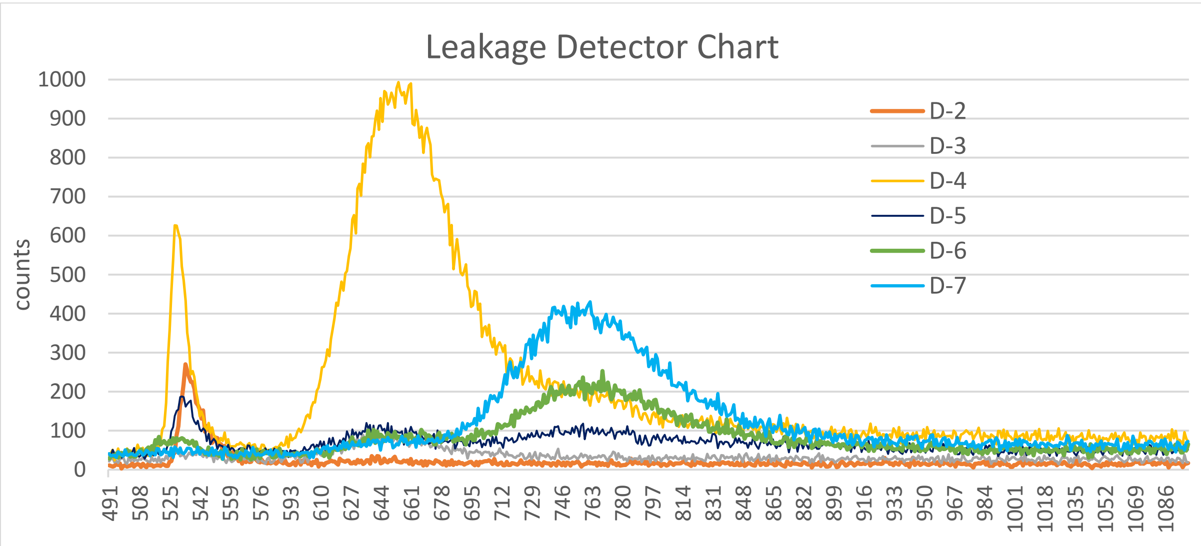

Figure.6: Plot of counts Vs. time (sec) of tube side outlet of six heat exchangers.

Figure 6 shows the plot of the remaining six detectors namely D2 to D7, which were sequentially placed on the tube outlets of the heat exchangers as presented in the table 1. It is observed from the plotted graphs that as soon as the pulse entered in the shell side of the HX-001A, the signal was picked up feebly by almost all the detectors, placed on the tube side outlets (first peaks in Figure 6) since the radioactive intensity was very large.

Hence, the peaks observed at the time of appearance of radiotracer at shell inlet were omitted (on the x-axis 508-558 figure 6) during data analysis. Plot of data obtained by detectors 2 and 3, which were placed on tube outlets of HX-001A/B, shows no peaks i.e. no significant rise in count-rate. This clearly indicates, there is no leakage in the HX-001A/B. Very small peaks observed at the tube outlets of HX-005A/B (D-6 and D-7) shows that both appeared at the same time, which indicated these are false peaks. In case of leakage, both the peaks will not appear simultaneously on the time scale, hence it is concluded that it must be a pickup during the passage of radiotracers through the shell side of HX-05A/B. A peak observed at the tube outlet of the HX 81-E-004B (D-4) indicates a radiotracer leaked out from the shell side into the tube side. Even though the peak height is very small (up to 1000 counts in comparison with 80000 counts at the shell inlet) it is distinct, and clearly seen in figure 6. From the single maximum peak of the curve shown in Figure 5 and figure 6, the leak rate is roughly estimated as 3.88% within the accuracy of ± 15% as shown in table 2.

Table 2: Leak rate estimation using area under the curve

Peak at	Data points considered	Sum Y	% leak rate
Shell side 81-E-001A	Whole peak (491-1100)	1879141	
81-E-004B	Whole peak (593-730)	73122	3.88

IV. CONCLUSION

From the results, it is concluded that there is a leakage in81-E-004B Heat Exchanger. It is also concluded that there is no leak in the other five heat exchangers connected in series. Radiotracer technique is successfully applied to identify the leaky heat exchanger.

REFERENCES

[1]. Charlton JS (1986) Radioisotope Tracer techniques for problem solving in industrial plants. Leonard Hill, Glasgow

[2]. Samantray, J.S., Goswami, S., Sharma, V.K. et al. Leak detection in a high-pressure heat exchanger system in a refinery using radiotracer technique. J RadioanalNuclChem 302, 979–982 (2014). https://doi.org/10.1007/s10967-014-3369-6

[3]. Tong, Yungchien, & Chung, Showen . (1992). The application of radiotracers in the leak detection of underground pipes. Transactions of the American Nuclear Society, 65(1), 44-45.

[4]. International Atomic Energy Agency (IAEA) (2009) Training course series No. 38. Guidebook on leak detection in heat exchangers and underground pipelines using radiotracers, Vienna, Austria

[5]. Radiotracer Applications In Industry — A Guidebook, IAEA; 423. June 2004

[6]. Sharma, A.K., Agrahari, G., Tiwari, C.B. et al. Development of 99Mo-alfa-benzoin oxime complex as industrial radiotracer for identification of leaky heat exchanger and its validation with 99mTc. J RadioanalNuclChem 323, 143–149 (2020). https://doi.org/10.1007/s10967-019-06840-y

[7]. Sharma, V.K., Biswal, Jayashree, Goswami, Sunil, & Pant, H.J. (2018). Leak detection in a shell-tube type heat exchanger system using radiotracer technique. India: National Association for Applications of Radioisotopes and Radiation in Industry.