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Integrity Assessment Of Underground Underwater Pipeline Using Radiotracer Technique

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Abstract:
The energy sources such as oil and gas are transported through underground pipelines. This is the most economical and safest mode of transportation. Leakage is one of the main causes of heavy product losses. It disturbs the normal operation of the pipeline, pollutes the environment, and threatens personal safety. Corrosion of pipelines transporting oil and gas resources leads to product leakage and affects the economy. Other significant causes for pipeline leaks are damage by excavation equipment, accidents, theft, earth movement, etc.
There are many available technologies in the field of leak detection of underground pipelines such as fiber optic cable, sensor hoses, acoustic sensors, smart pigging, pressure point method, RTTM-based system, etc. Radiotracer techniques are very helpful in the leak detection of long underground pipelines due to their high sensitivity and accuracy. A suitable radiotracer is injected into the pipeline and detection of the leaked radiotracer is performed from the ground surface, by placing the detectors in dug pits or by launching a PIG equipped with data logger. Tracer patch migration, velocity drop, and detector-PIG are a few of the methods to detect and locate the leak in underground pipelines.
In a cross-country product pipeline of a leading refinery of India, leakage was suspected in the section located below the river bed. A very small amount of compatible radioisotope was injected as a radiotracer into the pipeline to test its integrity. The outlet valve located downstream was closed to pressurize the pipeline. It was planned to detect the leaked radiotracer by radiation survey of the water body as well as sample analysis in the laboratory. This paper presents the case study on the leak detection method of buried pipelines under a water body including outcomes and benefits to the refinery.
Keywords: *pipeline, radiotracer, data logger, sample analysis*

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I. Introduction

Radiotracer technique is playing an important role in industry. It is used to diagnose specific causes of malfunctions in a plant or process operation and to generally investigate processes in industries and those related environments where a great cost-benefit ratio can be generated from process optimization and troubleshooting, such as leakage detection in underground pipelines, Identification of leaky heat exchanger, transport of sediments etc. [1-4]. It is expected that this important role will continue to expand in India, especially if refinery engineers will get aware about these activities. Major advantage of radiotracer study is its utility without disturbing the process i.e., it is carried out online. Conventional methods of troubleshooting like pressure drop studies, viscosity measurements, sampling etc. can provide rough idea about the problem in the system but they cannot pinpoint the problem area [5]. Whereas, tracer applications are widely used for effective trouble shooting and to arrive at exact problem location. These methods require trained manpower, additional training for handling of radioisotopes and knowledge of radiation safety. A significant number of underground pipelines are installed for the transportation of water, oil, and gas. Leakage within these pipelines not only reduces their transport capacity but also results in significant environmental pollution. The detection of leaks in buried pipelines presents a considerable challenge due to limited access. The radiotracer method has demonstrated effectiveness in locating leaks within such pipelines. Radiotracer techniques offer significant advantages in detecting underground pipe leaks due to their superior sensitivity and accuracy compared to conventional NDT methods. The process involves injecting a suitable radiotracer into the pipeline and applying specific pressure to facilitate potential tracer leakage. If leakage occurs, the tracer may migrate towards the ground surface or become adsorbed on the soil or thermal insulation surrounding the leak point. Leak detection is achieved by surveying the radioactivity emitted by the leaked radiotracer[2,7,9].

In a leading petroleum refinery of India, leakage was suspected in their cross-country pipeline situated beneath a river between their sectionalizing valve stations (SV-3 & SV-4). Oil bubbles were observed on the surface of the water body near a bridge. As this pipeline was the sole available option with no viable alternatives, it was imperative to verify the integrity of the pipeline. Any leakage would necessitate labor-intensive and costly repair procedures. Therefore, it was decided to conduct an integrity assessment of this pipeline using a radioactive isotope based survey. In response to this novel challenge, an experimental plan was devised utilizing the radiotracer technique, which was subsequently implemented successfully to evaluate the pipeline's integrity.

II. Experimental

Pipeline Details

The particulars of the pipeline under investigation are delineated in Table 1, while the layout is depicted in Figure 1.

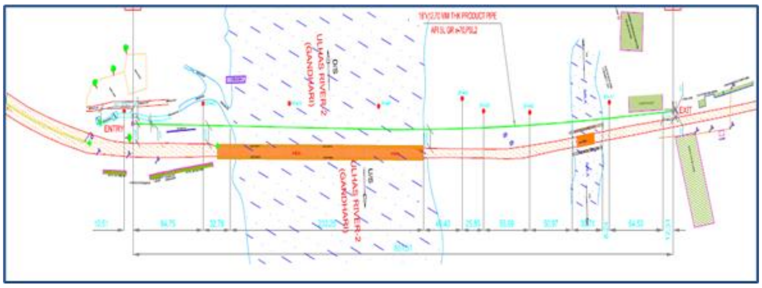

Fig.1: Schematic view of pipeline located under Gandhari River

Table 1 Opeartional details of the pipeline

Length & diameter of the pipeline under study	650 m under river bed / 18 inch
Operating flow rate	Max. 1200 kL/h Min. 600 kL/h
Operating Pressure	Max. 47 kg/cm^2 Min. 32 kg/cm^2
Nearest Injection Point	Mumbai dispatch terminal (50 Kms)
Arrival time	6.45 hrs. with max. flow rate

III. Methodology

Fig. 2 states the principle of radiotracer method for leak detection in buried pipeline under the river bed. A very small amount of a compatible radioisotope was injected as a radiotracer into the pipeline. The outlet valve at the downstream was closed to pressurize the pipeline. The leaked radiotracer can be identified by underwater radiation survey of the surrounding area in the river as well as sample analysis in the laboratory.

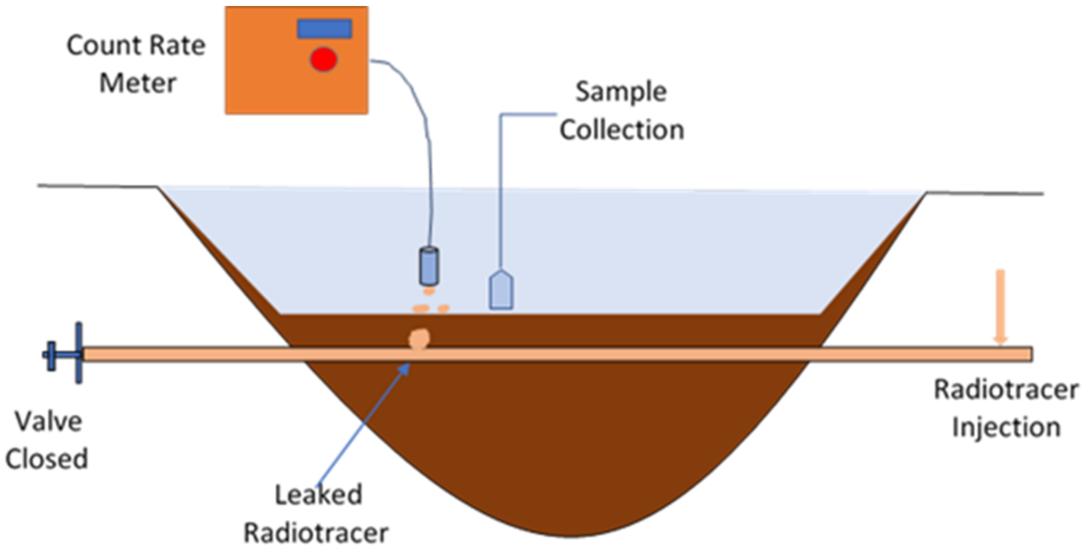

Fig.2: Leak detection principle by radiotracer method

Job Execution

Considering the urgency of the job, prompt response was taken to conduct the radiotracer study. It was decided to carry out the radiotracer study by injecting 02 Ci of Mo-99 (half life: 66 hrs & gamma energy: 760 keV) as organic sodium molybdate[6]. Around 21:00 pm, radiotracer was injected into the pipeline through chemical dosing pump at dispatch terminal. Entry of the radiotracer into the pipeline was confirmed through RadEye survey meter (SN 31477). The radiotracer was expected to arrive near the bridge in 06.45 hrs after injection from the terminal. The passage of the radiotracer through SV-3 (near bridge) was confirmed around 04:00 am. After confirmation, SV-4 was closed and pipeline was pressurized up to 40 kg/cm^2 to allow maximum possible flow of radiotracer through leakage. For confirmation of leak, radiation survey of the water body through underwater radiation monitoring system was started around 06:00 am. Readings were recorded at different strategic locations along the bridge. Total 14 nos. of water samples were collected from multiple locations of the river. The samples were sent to Radio Analytical Laboratory (RAL), BRIT for its analysis to verify the presence of injected radioactive isotope.

Fig.3: BRIT team performing radiotracer injection

Fig.4: Confirmation of radiotracer passage at SV-3

Fig.5: Survey area of the river near a bridge

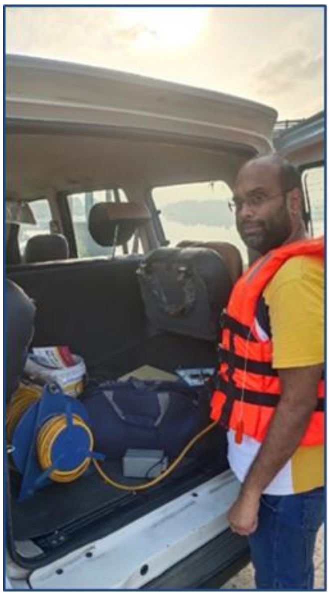

Fig.6: Underwater radiation monitoring system (left) and water sampler unit (right)

Fig.7: Water bubbles observed during radiation survey in the river

Safety Issues

Radiotracer used for leakage detection in this study was Mo-99 as sodium molybdate in organic phase. This is having gamma energy of 760 KeV and half-life of 66 hrs. Total activity used for this study was around 2 Ci (74 GBq). This activity is not as hazardous as the intensity of a radiography sources which is usually more than 10 Ci (370 GBq). In case of radiography being carried out, the surrounding area needs to be cordoned off.

In general, criteria of time, distance and shielding needs to be observed while handling radioisotopes. Time taken to handle the radioisotope or when in vicinity should be minimum, the radioisotope should be handled from a distance as far as possible or one should keep away from the source and the radioisotope needs to be adequately shielded for handling i.e., surface dose rate on the transport container should be less than 200 mR/hr[10].

All these factors were strictly taken into account while carrying out the radiotracer injection and it was carried out by trained and experienced professionals from BRIT by following the principles of ALARA (As Low as Reasonably Achievable). All the radiation safety PPEs were used such as gloves, mask, tongs, TLD etc. while injection and safety jacket during radiation survey in the river. It was assured that general public / plant staff and workers do not get in the vicinity of the radioactivity except those involved in the direct handling.

IV. Results & Discussion

After the injection of a radiotracer and pressurization of the pipeline, two distinct criteria were implemented to verify the existence of a leak. Firstly, any increase in radiation levels surpassing background readings in underwater areas adjacent to the pipeline was monitored. Secondly, detection of the injected radioisotope Mo-99 or its daughter element Tc-99m within water samples, collected from the river. Concurrently, oil bubbles observed on the water surface during radiation survey were collected and examined in the laboratory to confirm the presence of radioisotopes.

The underwater radiation monitoring system comprised of a waterproof sodium iodide scintillation detector, which was connected via a 100-meter-long cable spool to a count rate meter. A boat was used to reach at different locations in the river. A background survey conducted on the river revealed a count rate ranging between 80 to 100 counts per minute (cpm). Additionally, a sampling procedure was executed to collect water samples before radiotracer injection, facilitating background counting in the laboratory.

Throughout the radiation survey, the scintillation detector consistently recorded counts between 80 and 100 counts per minute (cpm) as it was submerged in the river water, indicative of background radiation levels. This trend persisted even upon the detector making contact with the river bed. It was observed that oil bubbles were appearing near first pillar of the bridge from SV-3 location. This area was surveyed carefully. However, No significant rise from the background radiation level was observed at any of the location in the Ulhas River.

Fig.8:Sample analysis setup at RAL, BRIT-Vashi

Conversely, water samples were marked carefully and immediately subjected to analysis using a high-purity germanium (HPGe) detector to detect the injected radioisotope Mo-99 (energy: 760 keV) and its decay product Tc-99m (energy: 140 keV)[8]. However, no peak of Mo-99/Tc-99m was detected in the water samples. Sample analysis results are shown in the Figure 9.

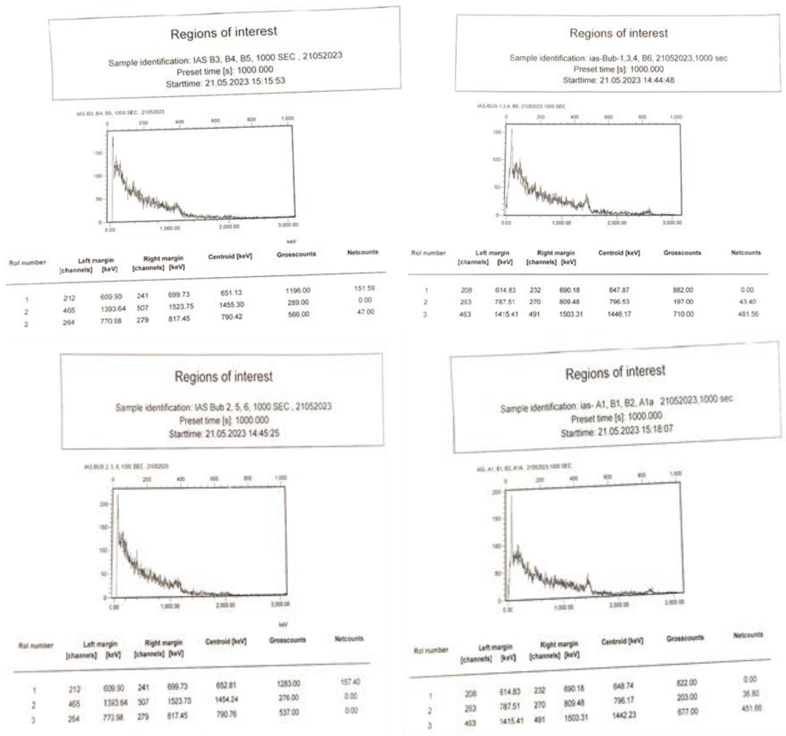

Fig.9:Sample analysis results showing no peak of Mo-99/Tc-99m

V. Conclusion

Radiotracer study was successfully conducted to assess the integrity of a 650-meter long pipeline segment located beneath a river near a bridge. The study confirmed that the pipeline was intact. The presence of oil bubbles in the river was attributed to potential leaks from another pipeline or other unidentified sources. The radiotracer study enabled rapid results without disrupting production, avoiding labor-intensive procedures and the high costs associated with a shutdown for leak confirmation. As a result, the pipeline remained in continuous operation.

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References

[1]. International Atomic Energy Agency (IAEA) (1990) Guidebook On Radioisotope Tracers In Industry, Technical Reports Series No.316, Vienna, Austria

[2]. 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

[3]. Charlton JS (1986) Radioisotope Techniques For Problem Solving In Industrial Process Plants. Leonard Hill, London

[4]. Thýn J (1989) Radioisotope Techniques For Process Optimization. Isot Environ Health Stud 25(4):144–151

[5]. Yulong Li Et Al (2020) An Underground Pipeline Leakage Monitoring And Precise Positioning Method Based On Multi-Point Signal Compensation. IOP Conf. Ser.: Earth Environ. Sci. 450 012118

[6]. Abhishek K. Sharma Et Al (2019) Development Of 99Mo-Alfa-Benzoin Oxime Complex As Industrial Radiotracer For Identification Of Leaky Heat Exchanger And Its Validation With 99mtc. Journal Of Radioanalytical And Nuclear Chemistry (2020) 323:143–149

[7]. Pant H, Kundu A, Nigam K (2011) Radiotracer Applications In Chemical Process Industry. Rev Chem Eng 17(3):165–252

[8]. Radiotracer Residence Time Distribution Method For Industrial And Environmental Applications, IAEA Training Course Series No. 31,Vienna (2008)

[9]. Thýn J (1981) Chemical Process Analysis With Nuclear Technique. Int J Appl Radiat Isot 32(10):733 746

[10]. International Atomic Energy Agency (IAEA), Safety Standard On 'Radiation Safety Of Gamma, Electron And X-Ray Irradiation Facilities', No. SSG8, IAEA, Vienna, Austria (2010).