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Investigation of Poor Performance of a Demethanizer Column using Gamma Scanning

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Abstract:
Gamma scanning is a very useful technique to monitor the health of the process equipment. It provides the insights of the equipment in operational condition which helps to decide on the shutdowns, reduce the downtime, maintain the standard quality product supply chain and thus, avoid the huge financial losses.
A Demethanizer column separates the methane from feed LNG in a petrochemical plant. The column was able to operate only at 95% of the design feed rate without disturbing the process parameters. As the feed rate was increased slightly, the pressure drop across the column was increasing drastically.
To identify the malfunctions in the column, gamma scanning was performed using 80 milli-curie of Co-60 as the gamma source and BGO scintillation detector for transmitted radiation intensity measurement. As per the trays installed in the column, it was separated in to three sections i.e., top, middle and bottom section. One scanline for top section, two scanlines for middle section and four scanlines for bottom section were recorded in the normal as well as disturbed operating condition.
The interpretations of the scan profiles revealed heavy flow of liquid from distributor above tray 1 in disturbed condition and tray 1 was found to be damaged. Uneven distribution of liquid and vapor was observed from the feed inlet device which is installed above tray 15. A portion of column was flooded above tray 31 in the disturbed operating condition.

Keywords*:demethanizer column, gamma scanning, process equipment, scanline, tray*

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I. Introduction

Performance of an industrial process column depends upon its design and process optimization. Any malfunctions in the column may affect the product quality badly. It may also lead to huge production losses that results in significant financial losses. Gamma scanning technique is a very useful online diagnostic tool to investigate such malfunctions in a process column [1-4]. These malfunctions may be mechanical in nature such as collapsed trays, broken distributor etc., or related with the process anomalies e.g., flooding, weeping, channelling and entrainment [3, 5]. Pinpointing these malfunctions before a turnaround is very beneficial in terms of reducing the downtime, predictive maintenance and sustain product supply chain which delivers huge economic benefits.

The natural gas received from wells is processed in many steps but one of the most important is distillation. Most of the natural gas is methane (80 mol %). The remainder is heavier hydrocarbons such as ethane (C2), propane (C3), isobutane (iC4), n-butane (nC4), and small amounts heavier components down to C5′s [6]. Value added petroleum products such as Ethane (C2) and Propane (C3) are extracted from Liquefied Natural Gas (LNG). These products are used as a feed stock for the polymer production. LNG processing plant mainly consists of distillation columns which separates lighter and heavier components of a feed mixture. Rich LNG is fed to the demethanizer column which separates the methane. The bottom residue of this column is fed to the deethanizer column which separates the C2 products. The bottom residue of deethanizer column is fed to the depropanizer column which separates the C3 and C4 products [7].

The role of demethanizer column becomes prominent as the biggest fraction of natural gas is methane [8]. Higher methane separation promotes higher C2+ recovery. Demethanizer column receives cold LNG feed and separates the methane as overhead vapor. There is a condenser at demethanizer overhead which partially condense the vapor and it is returned to the column as liquid reflux. Bottom and side reboiler provide sufficient heat to maintain a counter current liquid-vapor stream in the column. Liquid-vapor mixture passes through multiple trays which act as a separation stage inside the column. Lighter component as vapor leaves the liquid and it gets transferred to the next above tray. Heavier components remain as liquid and it overflows to the next tray below through downcomers [8, 9]. Uneven liquid vapor distribution leads to poor performance of the column i.e., off-spec products. Few conventional methods of diagnosing the root cause of the problems in a column are pressure drop study, physical property measurement, sample analysis etc., However, they can only indicate about the problem instead of pinpointing it. Other non-destructive tools applied in the industrial systems for online measurement such as ultrasonography testing, thermal imaging etc. lacks in accuracy due to complex design and harsh industrial environment i.e., noise, vibration & temperature etc. [2].

Gamma scanning results of a demethanizer column carried out in a petrochemical plant are reported in this paper. The scanning was performed at two different feed rates i.e., normal and disturbed operating condition of the column to compare the results and easily identify the location of the anomalies. The results of the gamma scanning were very useful for plant engineers in terms of decision making for troubleshooting and optimizing cost for repair.

II. Experimental

Principle of Gamma Scanning

The transmission of gamma radiation through any material is governed by the exponential equation $I = I_o \exp(-\mu\rho x)$, which elaborates the relation between transmitted intensity I and initial intensity I_o when a gamma radiation beam passes through a material with density ρ, mass absorption coefficient μ and thickness x [1-5].

Gamma scanning utilizes a collimated source and detector which are positioned in the same horizontal plane either diametrically or cordially opposite with the help of pulleys and wire ropes connected to a winch system which are termed as source and detector operator. The general setup of gamma scanning is shown in the Figure-1. Both the source and detector are moved synchronously upwards along the column elevation for a fixed step height and counting time from a reference plane on the column bottom. The radiation transmitted through the column is measured as count rate and plotted against the column elevation to get a scan profile. The scan profile can be interpreted with reference to the column internals, outer hardware structure and plant engineer inputs to assess the mechanical as well as operational soundness of the column.

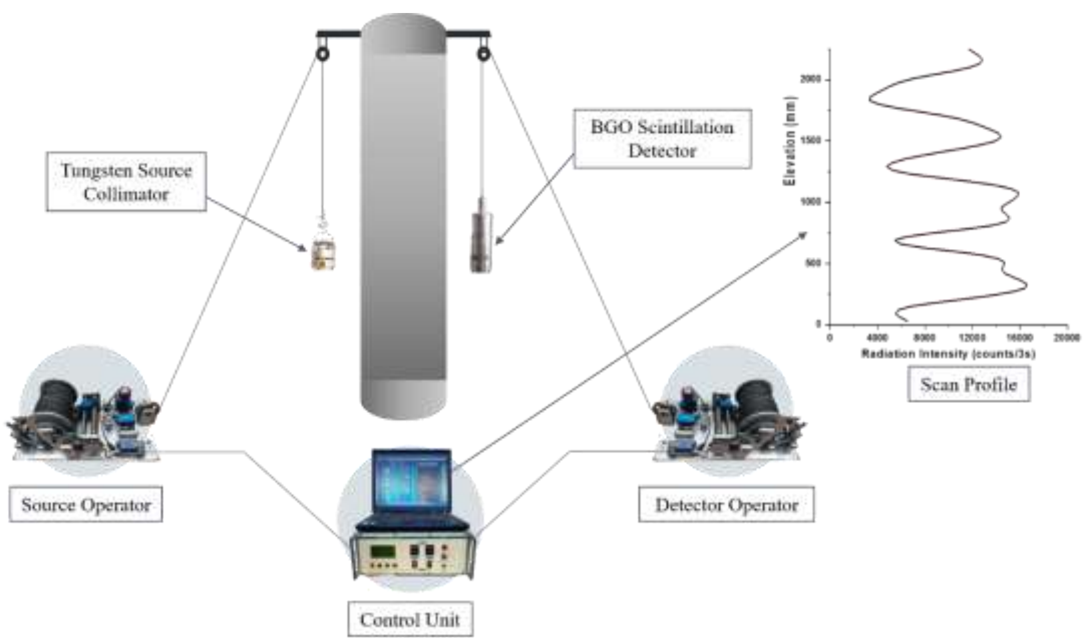

Fig.1 General set-up of gamma scanning

Demethanizer Column

The demethanizer column diagnosed through gamma scanning in this study was 4.9 meter in diameter and 33 meter in height. It consists of total 37 number of trays. Chimney trays were located above tray 15 and below tray 23 respectively. Feed was entering in to the column through a specially designed feed inlet device located below the tray 14. The column operating condition was getting disturbed with a slight increase in the feed rate. The column was provided with three different types of trays. Gamma scanning was performed on three sections of the column i.e., top section (Tray 1-14), middle section (Tray 15-23) and bottom section (Tray 24-37). General schematic of the column has been shown in Figure-2.

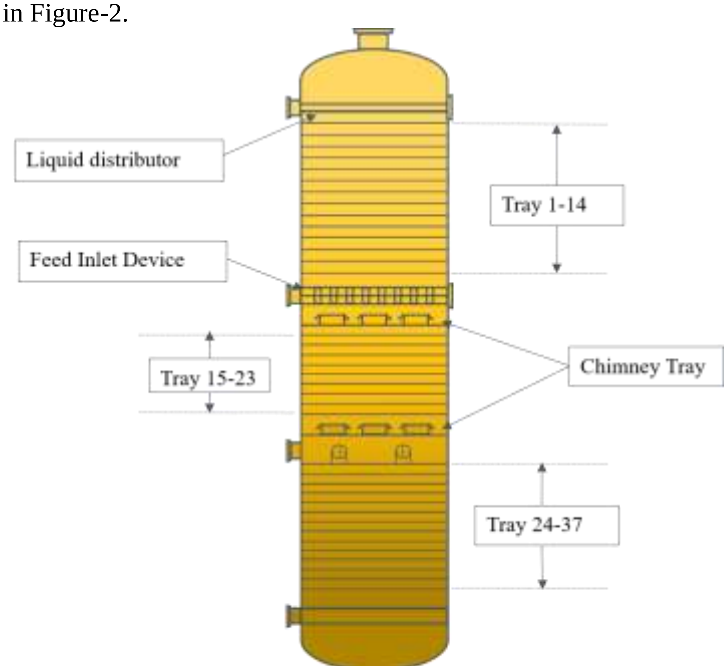

Fig.2: Schematic of the demethanizer column

Scan line orientation was decided according to the tray configuration of each section. One scan line for top section, two scan lines for middle section and four scan lines for bottom section were identified as shown in the Figure-3. It was decided to perform the scanning at two different feed rates i.e., normal and disturbed condition for better comparison of scan profiles. The column operational parameters have been tabulated in the Table-1.

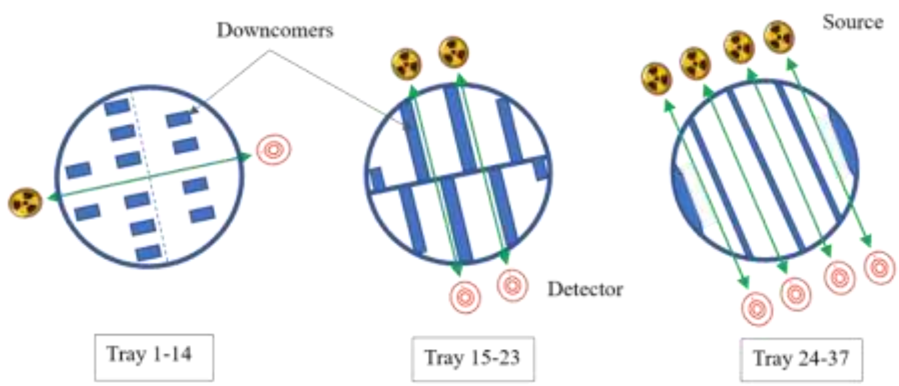

Fig.3: Scan line orientation as per the tray structure

Table 1 Opeartionaldetails of the demethanizer column

Feed	Rich LNG
Feed Temperature	-152 deg C
Normal Feed Rate	600 Tons/hour
Disturbed Feed Rate	605 Tons/hour
Top Fraction	Methane
Bottom Fraction	C2+ heavier components

Gamma Scanning Execution

As per the scan line orientation, marking on the column was carried out for mechanical fittings at the top. Wherever necessery, at some locations platform were cut to facilitate the smooth passage of source collimator and detector assembly along the column elevation. 80 milli curie of Co-60 gamma radiation source was utilized to scan the column. This much activity is sufficient to scan the column of diameter up to 5 meter. The source was kept inside a tungsten collimator. Collimated Bismuth Germanate (BGO) scintillation detector was used to measure the transmitted intensity of gamma rays across the column. BGO crystals are known for their high density, stability and non-hygroscopic nature which made it most suitable for industrial applications [10].The gamma scanning setup on the column was made as per the Figure-1. Scanning parameters are shown in the Table-2.

Table 2 Tray spacing andScan parameters

Section	No. of Scan Lines	No. of Tray	Tray Spacing (Milli-meter)	Step Height (Milli-meter)	Counting Time (Second)
Top	1 (L1)	14	1-3: 800 3-5: 790 5-12: 770 12-14: 815	30	5
Middle	2 (L2 & L3)	9	15-23: 600		
Bottom	4 (L4, L5, L6 & L7)	14	24-37: 550		

The scanning of all the section was started at normal feed condition. The radiation data from the detector was recorded through a control box and it was saved in the computer. Automatic column scanner software provides necessary control of the machine. It facilitates visualization of data and scan profile in real time which helps to track the column internals immediately. All the scans were repeated in the disturbed condition. Total 14 numbers of scan profile were generated for this column.

III. Results and Discussion

Top Section

Scan profile (L1) obtained at normal and disturbed condition of the top section of the column were superimposed on each other as per the Figure-4. These scan profiles covered trays 1 to 14 as well as liquid distributor above tray 1.

The Y-axis of scan profile corresponds to the column height and X-axis represents the radiation intensity in terms of counts per 5 seconds. Peaks towards the Y-axis indicates a tray with liquid holdup whereas, the peaks away from the Y-axis corresponds to the vapor space between trays [11].

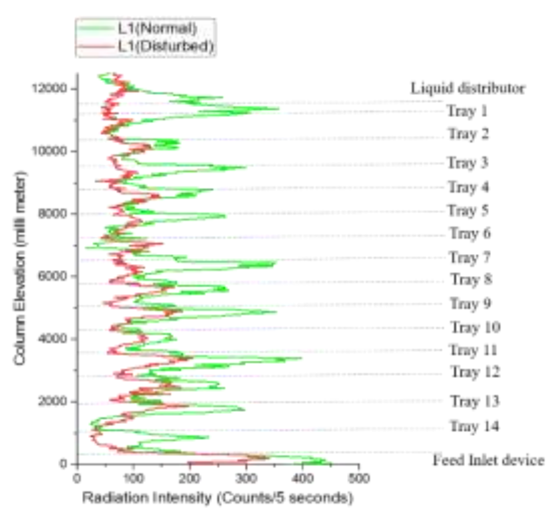

Fig.4: Superimposed scan profiles of top section (L1)

Shifting of the scan profile towards Y-axis indicates increased liquid level above all the trays in disturbed condition as compared to normal condition throughout the top section. Tray 1 seems to be damaged as there was absence of peak towards Y-axis in its location. The space between liquid distributor and tray 2 is completely submerged in liquid during disturbed condition as heavy flow of liquid was observed from the distributor. Overall liquid level on the trays 1 to 8 was increased in the disturbed condition, while these trays were showing adequate vapor space in the normal condition. Liquid level on the tray 14 was maximum in the top section as lowest radiation intensity was recorded for this tray.

Middle Section

Scan profiles L2 and L3 covered feed inlet device, chimney tray located above tray 15, trays 15 to 23 and chimney tray located below tray 23(Fig. 5).

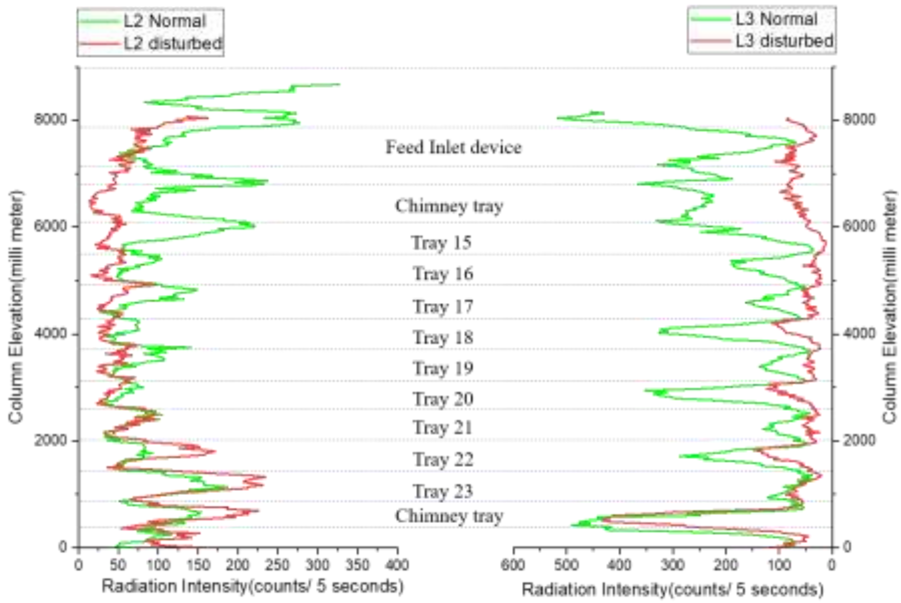

Fig. 5 Superimposed scan profiles of middle section (L2 and L3)

Liquid holdup above tray 19 was increased in disturbed condition and flooding observed above tray 17 in L3 portion. Chimney tray above the tray 15 was submerged in the liquid in the disturbed condition. Liquid level on the chimney tray below the tray 23 was almost similar in both the conditions. However, more liquid was seen falling from the feed inlet in L2 portion as compared to L3 in normal condition. It indicates uneven distribution of liquid from feed inlet device.

Bottom Section

Four pass trays were installed in the bottom section of the column. Gamma scanning covered trays 24 to 37 of the column in this section.

Comparison of scan profiles L4 with L7(Fig.6) and L5 with L6(Fig.7) was made as they were having similar chord length. Sharp peaks in the L4 scan profile shows intact trays and adequate liquid level in this portion of the tray. Shifting of these peaks towards Y-axis indicates higher liquid level. However, there are no any process related anomalies observed in L4 portion of the tray. In comparison of L4, scan profile L7 shows irregular peaks which indicates poor liquid vapor distribution in this portion. Scan profile L5 shows almost similar pattern in both the operating condition. Trays 31 and 30 were flooded in this portion. As per the scan profile L6, clear indication of flooding was observed on all the trays present above tray 31 in the disturbed condition. Extent of flooding was increased as attributed by decreasing radiation intensity from tray 31 to tray 24.

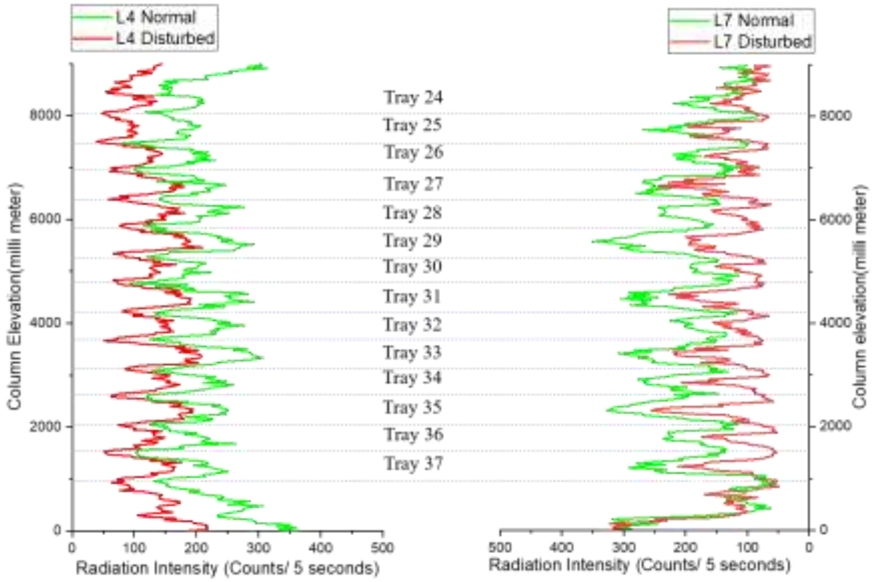

Fig. 6 Superimposed scan profiles L4 and L7 for bottom section four pass trays

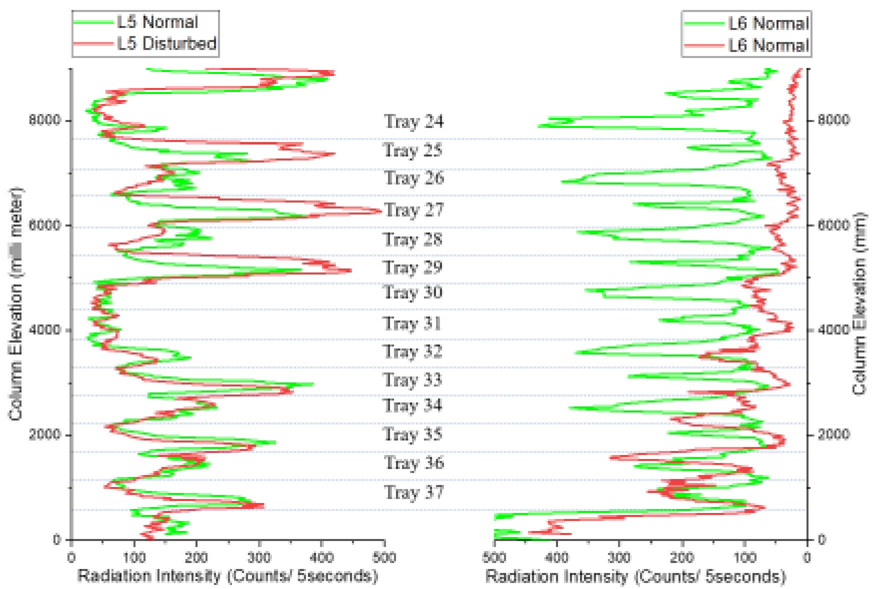

Fig. 7 Superimposed scan profiles L5 and L6 for bottom section four pass trays

IV. **Conclusion**

Gamma scanning was applied successfully to obtain an insight view of a demethanizer column. Total 14 nos. of scan profiles were obtained by scanning the top, middle and bottom section of the column at normal and disturbed condition. In the top section, Tray 1 was found damaged. Higher liquid holdup on the tray 14 could be due to uneven distribution of feed which indicates partial damage of the feed inlet device. This fact can be confirmed as the amount of liquid falling to the middle section from the feed inlet device was different in L2 and L3 portion. The entire middle section was affected with regard to liquid vapor distribution. Flooding above the tray 31 in L5 and L6 portion of bottom section could be possible due to presence of blockages in the downcomer of nearby trays.

Acknowledgements

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References

[1]. Charlton J.S. (1986), Radioisotope Techniques for Problem Solving in Industrial Process Plants, Leonard Hill, Glasgow and London

[2]. Yelgaonkar, Vivek, Agrahari, Gaurav, Vikrant, Dhakar, Prasanna, Rao and Pathak, B. K. "Flow dynamics study of catalyst powder in catalytic cracking unit for troubleshooting" Nukleonika, vol.62, no.4, 2017, pp.277-283.

[3]. INTERNATIONAL ATOMIC ENERGY AGENCY, Industrial Applications of Sealed Radioactive Sources, TECDOC Series, 2020

[4]. Jaafar D (2005) Gamma-ray scanning for troubleshooting, optimization and predictive maintenance of distillation columns. Hydrocarbon, Asia Jan/Feb, pp 62–65

[5]. Aquino, Denis D., Mallillin, Janice P., Sulit, Ramoncito F., Hila, Frederick C., Nuñez, Ivy Angelica A. and Bulos, Adelina D. M. "Performance evaluation of a rectifier column using gamma column scanning" Nukleonika, vol.62, no.4, 2017,

[6]. Luyben, William. (2013). NGL demethanizer control. Industrial & Engineering Chemistry Research. 52. 11626–11638. 10.1021/ie400454y.

[7]. Elliot, Doug & LLC, IPSI & Qualls, Wesley & Huang, Shawn & Lee, R. (2005). Benefits of integrating NGL extraction and LNG liquefaction technology. 2005 AIChE Spring National Meeting, Conference Proceedings.

[8]. Barza, Amir & Nguyen, Dinh Duc &Pirouzfar, Vahid &Su, Chia-Hung. (2020). Replacement of trays with packing for actual troubleshooting of demethanizer tower flooding in olefin plant. Case Studies in Chemical and Environmental Engineering. 100008. 10.1016/j.cscee.2020.100008.

[9]. James G. Speight,4 - Distillation, The Refinery of the Future (Second Edition), Gulf Professional Publishing,2020, Pages 125-159, ISBN 9780128169940

[10]. Tyagi, Mohit & Singh, S.G. & Singh, Awadh & Desai, D. & Tiwari, Babita&Ghodke, Shobha & P.N, Sujatha & Sen, Shashwati& Gadkari, S.C.(2015). Development of a detector setup based on BGO single crystals to measure high energy gamma spectra of neutron sources.

[11]. Elsharkawy, Z.F., & Hammad, M.E. (2018). Efficient fault detection and diagnosis of distillation column using gamma scanning. *Journal of Radioanalytical and Nuclear Chemistry, 316*, 741-752.

Gaurav Agrahari, et. al. "Investigation of Poor Performance of a Demethanizer Column using Gamma Scanning." *IOSR Journal of Applied Physics (IOSR-JAP)*, 14(03), 2022, pp. 13-19.