



An Experimental Evaluation of Argon as an Alternative Carrier Gas to Helium in
Nitrogen Determination of Steels Using Inert Gas Fusion Analysis

Alex Greenslade | Research Methods | May 26

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Abstract

This research investigates the feasibility of using Argon as an alternative carrier gas to Helium for nitrogen determination in steel using Inert Gas Fusion analysis. The increasing helium cost and supply concerns have encouraged investigation into alternative gases such as argon.

The study will use an inert gas fusion analyser manufactured by LECO Corporation to analyse certified reference materials containing low, medium and high nitrogen concentrations under both helium and argon carrier gas conditions. Statistical analysis, including standard deviation and ANOVA, will be used to compare analytical accuracy and precision between the two gases.

The research aims to determine whether argon can provide acceptable analytical performance while reducing operational cost and dependence on helium within metallurgical laboratories such as Tata Steel.

1. Introduction

Accurate nitrogen determination is essential within the steel industry, as nitrogen can significantly influence the mechanical properties and quality of steel products. Reliable nitrogen analysis is therefore required to support process control, product certification and compliance with customer specifications within steel manufacturing operations such as those carried out by Tata Steel (Bazaleeva, 2005).

Nitrogen analysis within metallurgical laboratories is commonly performed using Inert Gas Fusion instrumentation manufactured by LECO Corporation. These systems traditionally operate using Helium as the carrier gas. However, increasing helium costs and global supply concerns have created operational and economic challenges for industrial laboratories that rely heavily on continuous analytical testing (Helium vs Argon, 2021).

As a result, Tata Steel aims to investigate whether Argon could provide a suitable alternative carrier gas for nitrogen determination without compromising analytical accuracy or precision. Since argon is already widely available across steelmaking operations, successful implementation could potentially reduce operational costs, improve supply security and simplify gas management within laboratory environments.

This project will therefore evaluate and compare the analytical performance of helium and argon during nitrogen determination in steel using certified reference materials and statistical analysis techniques including standard deviation and ANOVA. The findings will help determine whether argon can provide a viable alternative carrier gas for routine industrial nitrogen analysis.

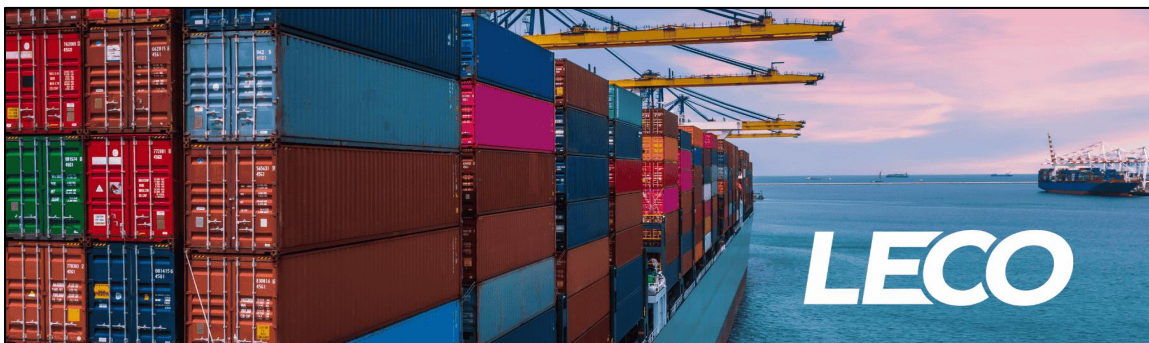


Figure 1 - LECO Shipping via Cargo (LECO, As Helium Prices Rise and Supply Shrinks, LECO Customers Have Reliable Alternatives , 2026)

2. Literature review

2.1 QUANTITATIVE METHODOLOGY

A quantitative research methodology is a systematic approach that focuses on the collection and analysis of numerical data in order to examine relationships, compare variables, and produce objective conclusions through statistical analysis. Within scientific and engineering research, quantitative methodologies are extensively utilised because they enable the generation of measurable, repeatable, and statistically reliable results (Creswell, 2015).

The present study adopts a quantitative experimental methodology through the numerical measurement of nitrogen concentrations in steel using Inert Gas Fusion analysis. The research will compare the analytical performance of Helium and Argon as carrier gases using certified reference materials containing known nitrogen concentrations. Multiple replicate analyses will be undertaken to generate measurable numerical data, which will subsequently be statistically analysed using techniques to determine whether significant differences exist between the two carrier gases.

Quantitative methodologies offer significant advantages within industrial and scientific research due to their dependence on objective and statistically validated evidence. The application of controlled experimental conditions alongside statistical analysis allows process performance to be assessed with greater reliability, repeatability, and reduced levels of subjective interpretation. In this study, the quantitative research approach facilitates a direct comparison of nitrogen analysis results obtained through the use of helium and argon carrier gases during inert gas fusion testing (Thiel, 2014).

By generating measurable analytical data, the study aims to determine whether argon can provide statistically comparable analytical accuracy and precision to helium. The findings may support Tata Steel in making evidence-based operational decisions regarding laboratory gas usage, with potential benefits including improved cost efficiency, enhanced supply security and increased process standardisation within metallurgical testing operations.

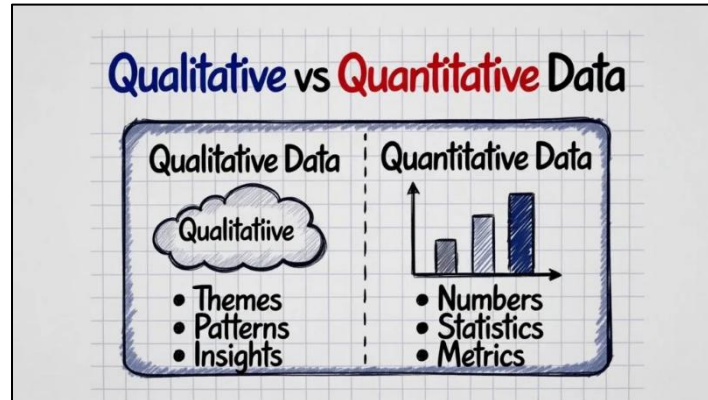


Figure 2 - Qualitative vs Quantitative Data (Slidescope, 2026)

2.2 LECO CORPORATION

LECO Corporation is an internationally recognised manufacturer of analytical instrumentation extensively utilised within metallurgical, industrial, and research laboratories for elemental analysis and materials characterisation. Established in 1936 in St. Joseph, the company initially focused on the development of rapid carbon determination equipment for the steel industry, which significantly improved analysis efficiency compared with conventional wet chemical methods. Over time, the organisation expanded its analytical capabilities to include technologies designed for the determination of carbon, sulphur, nitrogen, and hydrogen in metallic materials. Within the steel sector, LECO instrumentation has achieved widespread adoption due to its high analytical accuracy, repeatability, and ability to deliver rapid results for both production monitoring and quality control applications. (About LECO Corporation, 2026).



Figure 3 - LECO 736 Series (LECO, 736 Series Inert Gas Fusion analysis of Oxygen and Nitrogen, 2026)

2.3 NITROGEN'S EFFECT ON STEEL

Nitrogen plays a significant role in influencing the microstructural and mechanical properties of steel, functioning as both a beneficial alloying element and a potential impurity depending on its concentration within the material. When present in controlled amounts, nitrogen acts as an interstitial solute that enhances yield strength and hardness through solid solution strengthening by limiting dislocation movement within the crystal lattice. Nitrogen also functions as an austenite stabiliser, contributing to improved toughness and ductility in materials such as stainless steels and high-manganese steel grades. Furthermore, nitrogen is capable of forming nitrides with alloying elements including aluminium, vanadium, and titanium, thereby promoting precipitation strengthening and grain refinement within the steel microstructure (Bazaleeva, 2005).

Excessive nitrogen concentrations can have detrimental effects on the properties and processing behaviour of steel, leading to embrittlement, reduced formability, and the formation of coarse nitrides. Elevated nitrogen levels may reduce toughness and ductility by creating stress concentration sites that encourage crack initiation and brittle fracture, particularly in ferritic steels exposed to lower temperatures. In addition, excessive nitrogen can adversely influence rolling operations by increasing flow stress, rolling forces, and overall energy requirements (Steel, 2025).

Fast and accurate nitrogen testing is therefore essential in steelmaking operations at Tata Steel, as nitrogen levels can rapidly change during production. Accurate control is necessary because small variations can significantly affect mechanical properties and processing performance. Rapid nitrogen analysis supports real-time process control, reduces off-specification material, minimises scrap and rework, and improves overall product quality and operational efficiency (Zhao, Yang, & Mclean, 2018).

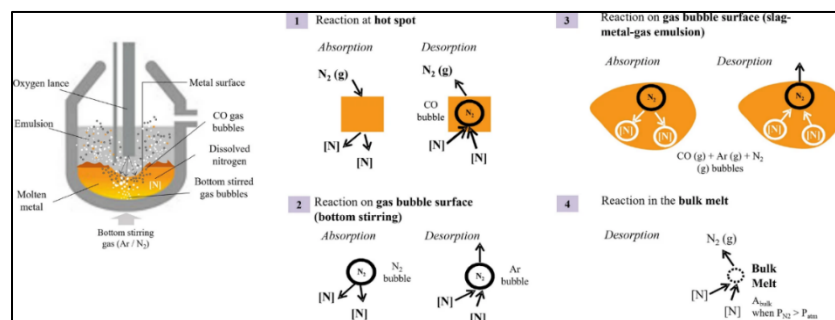


Figure 4 - Nitrogen's Effect in Steel (Chatterjee & Rout, 2025)

2.4 HELIUM

Helium is commonly employed as a carrier gas in LECO inert gas fusion analysis because of its chemical inertness, high thermal conductivity, and minimal background interference. These properties make it particularly effective for the precise determination of nitrogen, oxygen, and hydrogen in steel materials (Royal Society of Chemistry, 2026).

As a noble gas, helium remains chemically non-reactive and does not interact with the steel sample, graphite crucible, or furnace components during the analytical process. This characteristic supports analytical accuracy by minimising the risk of contamination and preventing unwanted chemical reactions during testing. Furthermore, the high thermal conductivity and low atomic mass of helium enable efficient heat transfer and rapid transportation of released gases through the analytical system, thereby enhancing extraction efficiency, analytical sensitivity, response time, and result repeatability (LECO, 736 Series Inert Gas Fusion analysis of Oxygen and Nitrogen, 2026). Helium also produces a stable, low-noise detector baseline, which is particularly important for trace-level nitrogen analysis.

Despite its analytical advantages, helium is increasingly associated with challenges relating to high cost, limited availability, and supply instability. As a finite natural resource, the global supply of helium remains restricted and is susceptible to geopolitical disruption as well as growing industrial demand from sectors including healthcare and aerospace. Consequently, these factors have contributed to substantial price increases and ongoing concerns regarding long-term supply security (Bains, 2025).

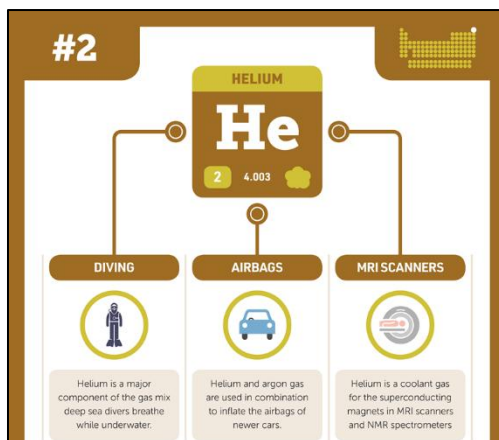


Figure 5 - Helium Chemistry (Wothers, 2009)

2.5 ARGON

Argon may be utilised as an alternative carrier gas in LECO inert gas fusion analysis because of its chemical inertness, widespread availability, and lower operational cost. Similar to helium, argon is classified as a noble gas and remains non-reactive during the analytical process, ensuring that gases measured during analysis, such as nitrogen, originate solely from the sample material itself. (Bohleber, Mervic, Dallmayr, Stremtan, & Sala, 2025).

Argon is considerably more abundant and economically favourable than helium because it is produced through the separation of atmospheric air. As a result, argon offers improved supply stability and is less susceptible to the shortages and price fluctuations commonly associated with helium availability (How Is Argon Made From Air? The Process Explained, 2025). As a result, argon offers potential cost savings and improved supply security for high-throughput laboratories such as those at Tata Steel.

Despite its practical advantages, argon presents several analytical limitations when compared with helium. The higher atomic mass and lower thermal conductivity of argon reduce heat transfer efficiency and gas transport within the LECO analytical system, which may lower extraction efficiency, analytical sensitivity, and response time. In addition, argon can generate increased detector background noise, potentially reducing analytical precision during trace-level nitrogen determination (Kaser, Kagi, Hattendorf, & Gunther, 2024).

Despite these limitations, advances in LECO instrumentation and detector technology have improved the suitability of argon for routine nitrogen analysis. Although helium remains superior in terms of sensitivity and analytical precision, argon provides significant advantages in cost reduction, availability, and supply stability.

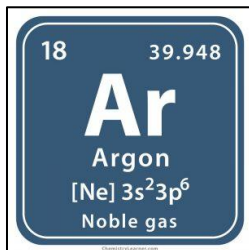


Figure 6 - Argon Chemistry (Learner, 2026)

2.6 STATISTICAL ANALYSIS

2.6.1 Mean Average

The mean average is a statistical measure used to identify the central value of a dataset by dividing the sum of all recorded measurements by the total number of observations (Williams, Sweeney, & Anderson, 2026). In a Tata Steel project involving LECO nitrogen analysis, the mean would be used to determine the typical nitrogen concentration from repeated steel sample measurements.

The mean assists in minimising the influence of random variation arising from factors such as instrument sensitivity, sample preparation, and operating conditions. It is also applied to compare different analytical conditions, including the use of helium and argon carrier gases, variations between operators, or differences in preparation methods. Notable differences in mean values may therefore indicate changes in analytical performance or underlying process behaviour (Muelaner, 2026).

In addition, mean nitrogen values can be monitored over time to identify process trends, drift, or deviations from specification limits, supporting process control and quality assurance. Overall, the mean average is an important statistical tool for assessing nitrogen content, analytical consistency, and process stability.

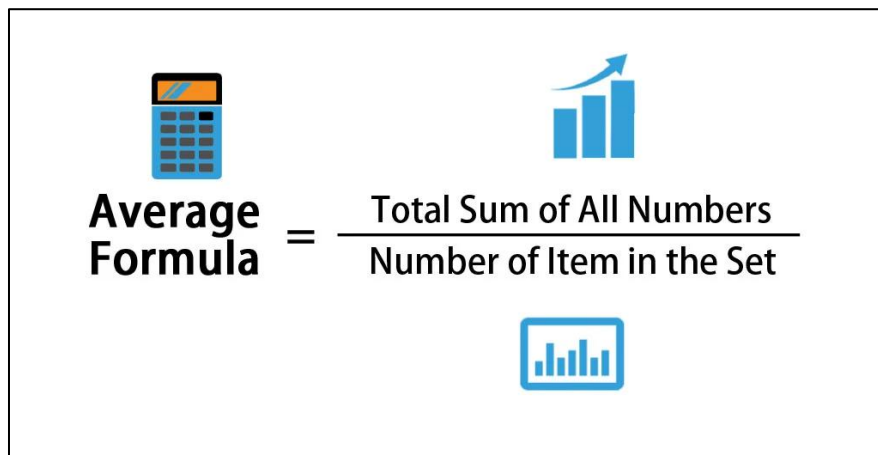

$$\text{Average Formula} = \frac{\text{Total Sum of All Numbers}}{\text{Number of Item in the Set}}$$

Figure 7 - Mean Calculation (Thakur, 2026)

2.6.2 Standard Deviation

Standard deviation is a statistical measure used to quantify the dispersion or spread of data around the mean value. A low standard deviation indicates that the results are closely clustered and demonstrate high consistency, whereas a high standard deviation reflects greater variability and reduced consistency within the dataset (Bhandari, 2024). In a Tata Steel project involving LECO nitrogen analysis, standard deviation is used to evaluate the precision and repeatability of nitrogen measurements obtained from repeated testing of steel samples and certified reference materials (CRMs).

Standard deviation is particularly important when comparing helium and argon carrier gases, as it enables assessment of which gas provides more consistent and reproducible nitrogen measurements. It also supports quality control and process monitoring by identifying variation, process drift, or instability across production heats.

Two types of standard deviation are commonly defined, population standard deviation and sample standard deviation. Population standard deviation is applied when the entire dataset or population is considered in the analysis, whereas sample standard deviation is used when only a representative subset of data is available. The sample form incorporates Bessel's correction, in which the denominator is adjusted to $n - 1$ rather than n , thereby providing a more accurate estimate of variability when working with limited data (Sample vs Population Standard Deviation: When to Use Each, 2026).

Sample standard deviation is most appropriate for this project because only selected nitrogen measurements are analysed rather than every possible measurement within the steelmaking process. The data therefore represents a sample of a larger population. The use of Bessel's correction reduces bias and provides a more reliable estimate of analytical variability when assessing the performance of helium and argon carrier gases (Zarrinmehr, 2023).

$$S = \sqrt{\frac{\sum (x_i - \bar{x})^2}{n - 1}}$$

Figure 8 - Standard Deviation Calculation (Calculator, 2026)

- s refers to sample standard deviation
- N is the number of observations
- x_i is the observed values of the sample item, and
- $\bar{x}$ is the mean value of the sample (Standard Deviation, 2025)

2.6.3 ANOVA

Analysis of Variance (ANOVA) is a statistical technique used to evaluate whether statistically significant differences exist between the mean values of multiple groups or experimental conditions. Rather than solely identifying variability within a dataset, ANOVA determines whether observed differences are attributable to genuine changes in the process or to random experimental variation (Simkus, 2022).

In a Tata Steel project involving LECO nitrogen analysis, ANOVA can be used to compare nitrogen results obtained using helium and argon carrier gases to determine whether the carrier gas significantly affects measured nitrogen concentrations. If no statistically significant difference is identified, argon may be considered a suitable alternative to helium.

ANOVA can also be applied to compare results between different operators, instruments, sample preparation methods, or production heats (Jin & Guo, 2003). The method compares variation between groups with variation within groups using the F-ratio:

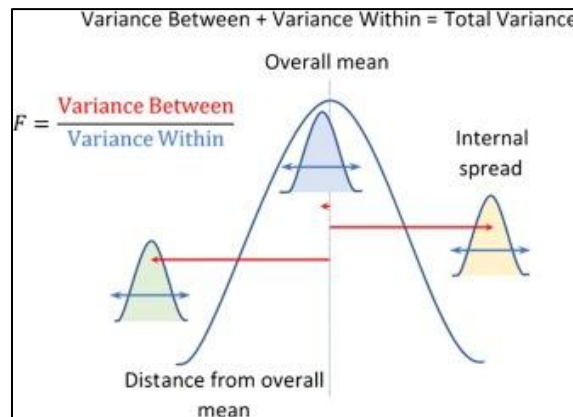


Figure 9 - F-Ratio Calculation (Lewis, Onder, & Prudil, 2021)

A larger F-value indicates a greater likelihood that differences between groups are statistically significant.

ANOVA is valuable within the project because it enables objective comparison of analytical methods and process conditions, supporting evaluation of argon as an alternative carrier gas for nitrogen analysis.

2.6.4 Tests of Normality & Homoscedasticity

Tests of normality are applied to assess whether a dataset follows a normal (bell-shaped) distribution, which is a key assumption underlying parametric statistical methods such as ANOVA (Dohm, 2024). In a Tata Steel project involving LECO nitrogen analysis, these tests would assess whether nitrogen measurements obtained using helium and argon carrier gases are normally distributed.

Two commonly used tests for assessing normality are the Shapiro–Wilk test and the Kolmogorov–Smirnov (K–S) test. The Shapiro–Wilk test evaluates the extent to which observed data conform to a normal distribution and is especially appropriate for small to medium sample sizes, making it particularly suitable for laboratory-based studies (Bobbitt, How to Perform a Shapiro-Wilk Test in SAS, 2022). The Kolmogorov–Smirnov test compares the sample distribution to a theoretical normal distribution but is generally less sensitive to small deviations from normality (Frost, 2025).

For this project, the Shapiro–Wilk test is the most appropriate because the dataset is expected to consist of a relatively small number of repeated nitrogen measurements from certified reference materials and helium versus argon carrier gas trials. This provides a more reliable assessment of normality prior to ANOVA testing.

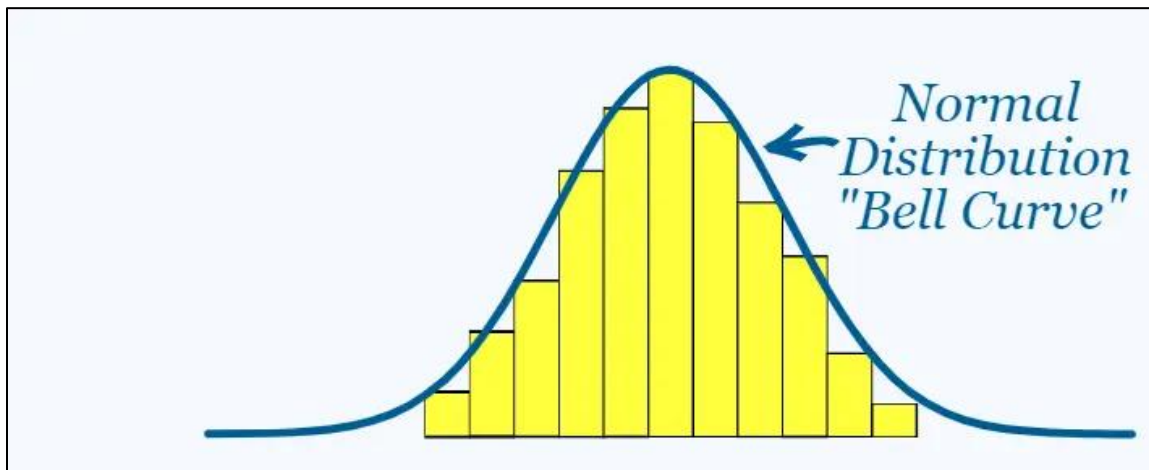


Figure 10 - Bell-Shaped Distribution (Williams G. , 2024)

Homoscedasticity refers to the assumption that datasets being compared have equal or similar variances (Frost, Jim, 2025). In this Tata Steel project involving LECO nitrogen analysis, homoscedasticity testing would determine whether the variability of nitrogen measurements using helium is similar to that obtained using argon. This assumption is important before performing ANOVA, as unequal variances can reduce the reliability of statistical comparisons.

Two commonly used methods for assessing homoscedasticity are Levene's test and Bartlett's test. Levene's test is used to determine whether there are statistically significant differences in variance between groups and is generally regarded as more robust when the data do not strictly follow a normal distribution (Bobbitt, How to Perform Levene's Test in Excel, 2020). Bartlett's test is also used to evaluate the equality of variances however, it is more sensitive to departures from normality and may produce unreliable results when the data are skewed or contain outliers.

For this project, Levene's test is the most appropriate method because the experimental datasets are likely to be relatively small and may not fully satisfy normality assumptions. Its robustness makes it more suitable for comparing helium and argon carrier gas datasets prior to ANOVA analysis.

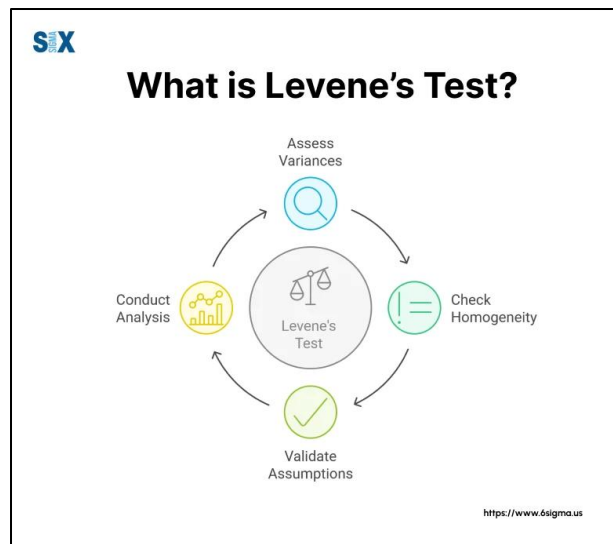


Figure 11 - Levene's Test for Homoscedasticity (Sigma, 2024)

ANOVA is based on the assumptions that the data are approximately normally distributed, that variances across groups are equal, and that observations are independent. When these assumptions are significantly violated, the reliability of the results may be compromised. In such situations, the Kruskal–Wallis test may be applied as a non-parametric alternative to ANOVA. Unlike ANOVA, the Kruskal–Wallis test does not assume normal distribution and instead compares ranked data rather than group means, making it more appropriate for datasets that are skewed or exhibit unequal variances (Nahm, 2016).

Within this project, the Kruskal–Wallis test would only be required if the nitrogen analysis data fails tests of normality or homoscedasticity. However, if these assumptions are satisfied, ANOVA remains the preferred statistical method due to its greater statistical power and direct comparison of mean nitrogen values.

Therefore the tests of normality and homoscedasticity are essential validation steps to ensure statistically reliable comparison of helium and argon carrier gas performance in LECO nitrogen analysis.

2.7 HYPOTHESIS TESTING

Hypothesis testing commences with the formulation of a null hypothesis, which assumes that no statistically significant difference exists between the groups under investigation. Experimental data is subsequently collected and subjected to statistical analysis to determine whether any observed differences are attributable to random variation or to a genuine experimental effect (Banerjee, Chitnis, Jadhav, Bhawalkar, & Chaudhury, 2009). Following statistical analysis, a p-value is calculated to evaluate the level of statistical significance. A significance threshold of 0.05 is commonly applied, whereby a p-value below this level results in rejection of the null hypothesis, while a p-value above 0.05 indicates that there is insufficient evidence to reject it (Wasserstein & Lazar, 2016).

In a Tata Steel project involving LECO nitrogen analysis, the null hypothesis would state that there is no statistically significant difference between the mean nitrogen concentrations measured using helium and argon carrier gases. The alternative hypothesis would therefore state that a significant difference does exist between the two gases.

Within ANOVA, the null hypothesis serves as the basis for statistical comparison by assessing variation between groups relative to variation within groups. If the analysis indicates no statistically significant difference between helium and argon datasets, argon may be regarded as a suitable alternative carrier gas. Conversely, if a statistically significant difference is detected, the null hypothesis would be rejected, suggesting that the choice of carrier gas has an effect on nitrogen analysis performance.

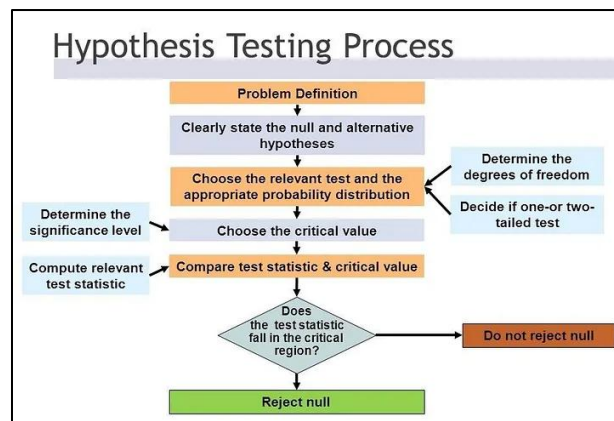


Figure 12 - Hypothesis Testing Process (Nidheesh, 2023)

3. Procedure

The process begins with preparation of a clean, contamination-free steel sample, typically between 0.5 g and 1 g, which is placed into a graphite crucible. The crucible is then loaded into the LECO furnace under an inert carrier gas atmosphere, typically helium or argon.

During analysis, the furnace rapidly heats the sample to approximately 2500–3000°C, resulting in complete melting and the release of dissolved gases, including nitrogen. The liberated gases are carried through the system by the carrier gas and pass through purification stages to remove impurities prior to detection. Nitrogen is subsequently quantified using a thermal conductivity detector, where variations in gas conductivity produce a signal proportional to the nitrogen concentration in the sample.

At Tata Steel, the comparison of helium and argon carrier gases would be carried out using certified reference materials (CRMs) with low, medium, and high nitrogen concentrations. The instrument would first be calibrated using certified standards traceable to international requirements. Multiple repeat analyses would then be conducted using helium and argon under identical conditions, ensuring that the carrier gas remains the only experimental variable.

The resulting nitrogen data would be statistically analysed using methods such as mean averages, standard deviation, and ANOVA to compare analytical performance between the two gases. The use of CRMs enables assessment of both analytical accuracy and repeatability by comparing measured results against certified nitrogen values.

Testing across multiple nitrogen concentration ranges allows evaluation of whether argon can provide performance comparable to helium throughout the full analytical range encountered in steel production. This structured approach enables Tata Steel to assess whether argon could act as a reliable and cost-effective alternative carrier gas while maintaining compliance with ASTM E1019 and ensuring effective quality control within steel manufacturing operations.



Figure 13 - Loading Graphite Crucible (LECO, 736 Series Inert Gas Fusion analysis of Oxygen and Nitrogen, 2026)

4. ASTM E1019

ASTM International ASTM E1019 is a standard test method used for the determination of carbon, sulphur, nitrogen, and oxygen in steel and other alloys using combustion and inert gas fusion techniques (ASTM, International, 2024). The standard provides internationally recognised procedures for sample preparation, calibration, instrument operation, and quality control when using analytical systems such as LECO analysers.

Within a Tata Steel project involving LECO nitrogen analysis, ASTM E1019 is important because it ensures nitrogen measurements are accurate, repeatable, and comparable across laboratories and production operations. The standard outlines requirements for contamination control, use of certified reference materials (CRMs), calibration procedures, and verification of instrument performance (ASTM, International, 2024).

Compliance with ASTM E1019 is critical because nitrogen content directly affects steel properties such as strength, toughness, ductility, and formability. Accurate nitrogen analysis is therefore essential for maintaining product quality and meeting customer and industry specifications.

The standard is also highly relevant when evaluating argon as an alternative carrier gas to helium. Any change in analytical conditions must still meet ASTM E1019 requirements for precision, repeatability, and accuracy.



Figure 14 - ASTM International (International, 2026)

5. Benefits of project

This project offers several operational, financial, and technical benefits to Tata Steel through the investigation of argon as an alternative carrier gas to helium in LECO nitrogen analysis.

One of the primary advantages is the potential for cost reduction, as argon is considerably less expensive and more readily available than helium, which is increasingly impacted by global supply shortages and price volatility. The validation of argon as a substitute carrier gas could therefore reduce laboratory operational costs while still ensuring compliance with ASTM International E1019 requirements.

The project also enhances supply security and operational resilience by reducing reliance on helium and mitigating the risk of analytical disruption associated with supply chain instability. This is particularly important in high-throughput steelmaking environments, where rapid nitrogen analysis is essential for process control and product quality assurance.

In addition, the project contributes to enhanced quality control and improved process understanding through the statistical evaluation of analytical precision, repeatability, and performance using methods such as mean averages, standard deviation, and Analysis of Variance (ANOVA). This facilitates an objective comparison between helium and argon carrier gases while increasing confidence in the reliability of nitrogen measurement results.



Figure 15 - Save Money (Insulation, 2026)

6. Project Plan

Project Name :	Owner :	Dept.	Project Status:
Argon an alternative to Helium as Carrier Gas	Alex Greenslade	Technical	Ongoing
Objectives	Scope		
1) Determine whether Argon can be used as an alternative carrier gas to Helium.	What's in	AOB	Status: N/A
	Argon Gas Cylinder Argon Gas Pipe Connections	Ensure all staff are trained and competent in LECO operation and testing procedures. Implement temporary Management of Change (MoC) procedures for the free-standing gas cylinder.	Ongoing refresher training provided for selected team members. Awaiting sign offs from some team members.
2) Determine whether Argon is more cost-effective than Helium.	What's out		
Benefits	Team Members		
1) Reduce Operating costs	Alex Greenslade	AG	
2) Increased Supply Security	Shift Managers	SM	
3) Improved Sustainability	Team Leaders	TL	
4) Improved process understanding	Team Members	TM	
Current State	Day Team	DAYS	
	All	ALL	
Ongoing			

Figure 16 - Project Planner

AP 26/27 Timeline		2026												2027				Overall Status:	N/A
What	Who	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Comments	Status	
Conduct Literature Review	AG																Literature Review ongoing, in line with project write-up		
Experimental Design	ALL																Experimental design developed to test low, medium, and high nitrogen CRMs using argon and helium carrier gases.		
Laboratory Preparation	ALL																LECO equipment serviced by external engineer; argon gas cylinder and pipe connections installed.		
Experimental Testing	AG																Not Yet Started		
Data Analysis	ALL																Not Yet Started		
Interpretation of Results	ALL																Not Yet Started		
Dissertation Writing	AG																Not Yet Started		

Figure 17 - Project Planner

The project planner currently in use at Tata Steel Port Talbot is shown in figures. This planner has been developed by the technical department over several years to ensure effective project management, traceability, accountability, and progress monitoring throughout all stages of a project. The system identifies project ownership, involved

personnel, and responsibility for individual tasks, ensuring clear allocation of duties and timely completion of activities.

The planner operates using a traffic light system, where red indicates tasks not yet started, amber represents ongoing activities, and green signifies completed tasks. At the current stage of the project, the literature review remains ongoing and is expected to continue until the dissertation write-up phase begins.

The experimental design has been established to evaluate low, medium, and high nitrogen certified reference materials (CRMs) using both argon and helium carrier gases within the LECO nitrogen analysis system. Laboratory preparation has been completed, including servicing of the LECO equipment by an external engineer and installation of argon gas pipe connections to support testing. The argon gas cylinder has also been safely installed and connected within the laboratory environment.

At the time of reporting, experimental testing had not yet commenced. Consequently, data analysis, interpretation of results, and dissertation write-up activities had not yet begun.

7. Conclusion

This project was designed to evaluate the suitability of argon as an alternative carrier gas to helium in LECO inert gas fusion nitrogen analysis at Tata Steel. At the time of reporting, experimental testing had not yet been completed; therefore, conclusions are based on the proposed methodology and expected outcomes rather than analytical results.

The study involves analysis of certified reference materials (CRMs) with low, medium, and high nitrogen concentrations using both helium and argon under identical conditions. Statistical methods, including mean averages, standard deviation, and ANOVA, are intended to assess analytical precision, accuracy, and any significant differences between the two carrier gases.

The investigation is driven by increasing concerns regarding helium cost, scarcity, and supply instability. Although helium remains the preferred carrier gas due to its superior analytical sensitivity, argon offers advantages in cost, availability, and supply security, making it a potential alternative for routine nitrogen analysis.

Compliance with ASTM International E1019 remains a key requirement throughout the project to ensure analytical accuracy, repeatability, and reliability.

Overall, the project provides a structured framework for determining whether argon can replace or partially substitute helium without compromising analytical performance, while supporting cost reduction, supply security, and operational efficiency within Tata Steel laboratories.

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