



# APPLICATION REPORT ON THE DETECTION OF METAL ELEMENTS IN MARINE FUEL OIL BY OIL SPECTROMETER

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DITEE OA800H

ASTM D6728, SN/T 1652

**KEYWORDS:** RDE-OES, Oil Spectrometer, Marine Industry, DITEE, Preventive Maintenance,  
Fuel Oil Testing, Roget Scientific

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## Introduction and Industry Testing Background

Marine fuel oil is the core power energy for various types of ships, including ocean-going vessels, inland waterway shipping, and port operations. Its importance is self-evident, and it is known as the "blood" that drives the global trade supply chain. However, out of operational cost considerations, modern large ships generally use Heavy Fuel Oil (HFO) as their main fuel. Heavy fuel oil is usually the residual oil left over after oil refineries extract light oil products through atmospheric distillation, vacuum distillation, and even secondary processing. This "innate attribute" dictates that heavy fuel oil not only has an extremely high viscosity, but during the refining process, various impurities and heavy metals within the crude oil, along with chemical substances introduced during processing, become highly concentrated within it. Therefore, in practical application, the quality risks of marine fuel oil are mainly concentrated in excessive metal element content and abnormal physical and chemical indicators. Traditional physical and chemical indicator testing (such as viscosity, density, and flash point) is no longer sufficient to comprehensively evaluate oil quality; elemental analysis at the microscopic level is becoming a core link in ensuring shipping safety.



Under complex navigational conditions, excessive metal elements are undoubtedly the primary safety hazard, directly relating to equipment failure and navigational safety. These metal elements act like "chronic poisons" hidden in the fuel and are mainly divided into the following three major sources and their corresponding destruction mechanisms:

- **Catalyst Powders (Al and Si):** In the catalytic cracking process of oil refineries, aluminosilicates are often used as catalysts. If the fuel refining and solid removal are incomplete, these extremely hard microscopic particles (known as "Cat Fines") will enter the ship's cylinders with the fuel. Aluminum and silicon particles have extremely high hardness and act as "sandpaper" during the reciprocating motion of the piston, triggering severe abrasive wear on the cylinder liner and piston rings, which leads to engine blow-by, power degradation, and even cylinder scoring and engine scrapping.
- **Culprits of High-Temperature Corrosion (V and Na):** Vanadium is a heavy metal naturally associated with crude oil, while sodium usually comes from seawater contamination or desalter residues from the refining process. When these two elements burn in the cylinder, complex chemical reactions occur, generating low-melting-point sodium vanadate ash. At high temperatures, this ash exists in a molten or semi-molten viscous state and easily adheres to exhaust valve flaps and the blades of exhaust gas turbochargers. It destroys the oxide protective film on the metal surface, triggering catastrophic "high-temperature corrosion" (also known as gas turbine disease), and can even burn directly through the exhaust valve.
- **Indicators of Abnormal Wear (Fe, Cu, Cr, Ni):** In addition to the impurities inherent in the fuel, an abnormal increase in the concentration of certain metal elements in the oil fluid is often direct evidence that the internal components of the ship's engine (such as bearings, cylinder liners, gears, etc.) are experiencing abnormal wear.

In order to provide early warning of potential heavy machinery hazards such as wear, corrosion, and coking of engine components, and to ensure the safe and stable operation of the main engine, the use of advanced Rotating Disc Electrode Optical Emission Spectrometers (RDE-OES) for rapid and accurate composition screening has become a

rigid industry demand. Through the rapid screening mechanism of the oil spectrometer from Guangdong DITEE Scientific&Technical Co., Ltd., inferior fuel oil can be detected and replaced in a timely manner, thereby effectively avoiding huge equipment maintenance costs and economic losses from suspension of navigation caused by oil quality defects. This holds extremely important strategic and practical significance for the normal and efficient operation of ships.

## Experimental Purpose and Scheme Construction

This experiment aims to systematically explore and verify the feasibility of applying the DITEE OA800H oil spectrometer for detecting metal elements within the complex matrix of marine fuel oil, thereby providing an analytical method that is both highly efficient and highly accurate for maritime monitoring and the quality control of marine fuel oil.

### Testing System and Instrument Preparation

To ensure the accuracy and reliability of the experimental results, strict standards have been applied to both the hardware and the operational procedures.

- **Core Instruments and Consumables:** DITEE OA800H oil spectrometer, rod sharpener, spectroscopically pure graphite disc electrodes, spectroscopically pure graphite rod electrodes, sample cups, and an electronic balance (accuracy 0.001g).
- **Reagents and Samples:** GT15 standard oil across various concentration gradients, and actual marine fuel oil samples.
- **Startup and Preheating:** The instrument must be powered on in advance to allow the optical system temperature to reach 35°C and stabilize for no less than 30 minutes.
- **Status Confirmation:** Once the instrument has stabilized, or if it has been idle for over 2 hours, 5 pre-sparks using blank oil are required to ensure the excitation system is stably operating in its optimal state.

- **Standard Curve Establishment:** Utilize the GT15 standard oil to establish a standard curve covering concentration points of 0, 5, 10, 30, 50, 100, 300, and 500 mg/kg.



## Core Data Validation and Analysis Presentation

This report comprehensively demonstrates the instrument's performance through four major dimensions: standard validation, actual sample testing, spiked recovery rate, and long-term continuous stability.

### Highly Repeatable Validation of Standard Oil Based on International Specifications

This section strictly follows international and industry standards such as ASTM D6728 and SN/T 1652 to conduct repeatability validation on GT15 standard oil (with concentration gradients set at 1, 10, and 100 mg/kg). For each concentration point, 20 independent excitation measurements were completed to calculate the detection average ( $\bar{x}$ ) and standard deviation (SD).

The specific operations are as follows:

1. Install a new graphite disc electrode and a sharpened graphite rod electrode onto

their corresponding clamps.

2. Adjust the analytical gap according to the instrument operation manual to meet the calibration requirements.
3. Place the disposable sample cup filled with the oil standard reference material onto the sample stage.
4. Raise the sample stage so that at least 1/3 of the graphite disc electrode is immersed in the oil standard reference material.
5. Close the excitation chamber door and press the start switch to perform the measurement.

Repeat the above steps to sequentially measure the oil standard reference materials at the three concentrations: GT15-1, GT15-10, and GT15-100, and record the concentration values of the elements measured by the instrument. Repeat the measurement 20 times for each concentration point, and calculate the standard sample average according to formula (1).

$$\bar{x} = \frac{1}{n} \sum_{i=1}^n x_i \quad (1)$$

Where:

- $\bar{x}$  ——Average value, mg/kg  
 $n$  ——Number of measurements  
 $i$  ——Measurement sequence number  
 $x_i$  ——Result of the  $i$ -th measurement, mg/kg

| Standard Oil | Concentration mg/kg | Al   | Ca   | Cr  | Cu   | Fe   | Pb  | Mg   | Ni   | K   | Si   | Na  | V    | Zn   | Mn   | Li   |
|--------------|---------------------|------|------|-----|------|------|-----|------|------|-----|------|-----|------|------|------|------|
| GT15-1       | 1                   | 0.9  | 0.8  | 0.8 | 1.2  | 0.8  | 1   | 4.5  | 0.9  | 0.6 | 0.9  | 1   | 1    | 1.1  | 1    | 1    |
| GT15-10      | 10                  | 10.3 | 10.4 | 9.8 | 10.9 | 10.8 | 9.9 | 32.4 | 11.1 | 9.6 | 10.3 | 9.1 | 10.6 | 10.4 | 10.6 | 10.3 |
| GT15-100     | 100                 | 99.8 | 98.5 | 101 | 98.6 | 99.5 | 100 | 300  | 99.2 | 97  | 101  | 100 | 101  | 104  | 99.4 | 98.1 |

Table 1. Average concentration (mg/kg) of validation concentration standard oil after 20 excitations

Repeat the above operational steps to sequentially measure the oil standard reference materials at three concentrations: GT15-1, GT15-10, and GT15-100, and record the concentration values of the elements measured by the instrument. Repeat the measurement

20 times for each concentration point, and calculate the standard deviation (SD) of the standard sample according to formula (2).

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

Where:

S — Standard deviation, mg/kg

$\bar{x}$  — Average value, mg/kg

n — Number of measurements

i — Measurement sequence number

$x_i$  — Result of the i-th measurement, mg/kg

| Standard Oil | Concentration mg/kg | Al   | Ca   | Cr   | Cu   | Fe   | Pb   | Mg   | Ni   | K    | Si   | Na   | V    | Zn   | Mn   | Li   |
|--------------|---------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| GT15-1       | 1                   | 0.02 | 0.06 | 0.13 | 0.02 | 0.07 | 0.19 | 0.08 | 0.06 | 0.08 | 0.18 | 0.26 | 0.03 | 0.03 | 0.02 | 0.02 |
| GT15-10      | 10                  | 0.12 | 0.19 | 0.26 | 0.2  | 0.26 | 0.16 | 0.61 | 0.18 | 0.27 | 0.33 | 0.48 | 0.16 | 0.37 | 0.22 | 0.28 |
| GT15-100     | 100                 | 1.36 | 2.81 | 1.33 | 2.41 | 2.77 | 1.51 | 6.16 | 2.08 | 2.79 | 1.44 | 2.82 | 1.56 | 1.63 | 2.22 | 1.63 |

Table 2. Standard deviation (SD) of validation concentration standard oil after 20 excitations

In the 20 excitations of the GT15-10 (10 mg/kg) standard oil, the core wear-inducing and corrosion-inducing metal elements all demonstrated extremely high targeted concentration reproducibility. Specifically, the average detected value of aluminum (Al) was 10.3 mg/kg, iron (Fe) was 10.8 mg/kg, silicon (Si) was 10.3 mg/kg, and vanadium (V) was 10.6 mg/kg. *(Note: The labeled concentration of magnesium (Mg) in the standard oil is 3 times that of other elements, and its actual detected average value was 32.4 mg/kg, which also fully conformed to the set ratio.)*

When measuring the above 10 mg/kg concentration, the system standard deviation (SD) of the instrument was firmly controlled at an extremely low level. Among them, the SD of aluminum (Al) was only 0.12, vanadium (V) was only 0.16, lead (Pb) was only 0.16, and iron (Fe) was 0.26.

Combining the regulatory requirements for the "calculated repeatability of heavy fuel oil at selected concentrations in Table 5" in the ASTM D6728 and SN/T 1652 standards, the validation shows that the DITEE OA800H oil spectrometer is fully applicable to the

detection and analysis of heavy fuel oil. This conclusion provides strong technical support for the testing of marine fuel oil.

### Real Matrix Anti-Interference and Actual Sample Testing

To evaluate the instrument's anti-interference (Matrix Effect) capability when facing the extremely complex hydrocarbon matrix of actual heavy fuel oil, the experiment selected three real marine fuel oil samples numbered OCF0055, OCF0072, and OCF0015, and carried out tracking measurements 3 times a day for 3 consecutive days.

Repeat the above operational steps to sequentially measure the samples, and record the concentration values of the elements measured by the instrument. Repeat the measurement 3 times for each sample, measure for 3 consecutive days, and calculate the sample average according to formula (1).

| Sample Name | Testing Day | Al  | Ca  | Cr  | Cu  | Fe   | Pb  | Mg  | Ni  | K | Si   | Na   | V | Zn  | Mn  | Li |
|-------------|-------------|-----|-----|-----|-----|------|-----|-----|-----|---|------|------|---|-----|-----|----|
| OCF0055     | 1           | 0.3 | 3.1 | 1.0 | 0.4 | 11.4 | 0.8 | 0.4 | 0.4 | 0 | 40.4 | 71.8 | 0 | 1.9 | 0.2 | 0  |
| OCF0055     | 2           | 0.2 | 3.4 | 0.6 | 1.0 | 12.4 | 0.6 | 0.4 | 1.2 | 0 | 40.1 | 81.6 | 0 | 2.3 | 0.2 | 0  |
| OCF0055     | 3           | 0.5 | 4.3 | 0.7 | 1.0 | 14.2 | 0.7 | 0.5 | 0.1 | 0 | 45.8 | 89.7 | 0 | 2.1 | 0.2 | 0  |

Table 3. Average concentration (mg/kg) of actual sample fuel oil OCF0055 excited for 3 days

| Sample Name | Testing Day | Al  | Ca  | Cr  | Cu  | Fe   | Pb | Mg  | Ni  | K   | Si  | Na   | V   | Zn  | Mn  | Li |
|-------------|-------------|-----|-----|-----|-----|------|----|-----|-----|-----|-----|------|-----|-----|-----|----|
| OCF0072     | 1           | 3.5 | 118 | 1.1 | 0   | 62.4 | 0  | 6.7 | 2.0 | 4.6 | 463 | 68.5 | 0   | 1.4 | 1.8 | 0  |
| OCF0072     | 2           | 3.3 | 102 | 0.9 | 0.2 | 58.6 | 0  | 6.1 | 2.6 | 5.3 | 434 | 68.1 | 0.3 | 1.4 | 1.6 | 0  |
| OCF0072     | 3           | 3.9 | 113 | 1.2 | 0.3 | 65.7 | 0  | 6.3 | 1.9 | 4.7 | 436 | 75.5 | 0   | 1.3 | 1.6 | 0  |

Table 4. Average concentration (mg/kg) of actual sample fuel oil OCF0072 excited for 3 days

| Sample Name | Testing Day | Al  | Ca   | Cr  | Cu  | Fe   | Pb | Mg  | Ni   | K | Si  | Na   | V | Zn  | Mn  | Li |
|-------------|-------------|-----|------|-----|-----|------|----|-----|------|---|-----|------|---|-----|-----|----|
| OCF0015     | 1           | 2.6 | 74.0 | 0.7 | 0.4 | 42.4 | 0  | 7   | 42.2 | 0 | 175 | 20.2 | 0 | 3.0 | 1.2 | 0  |
| OCF0015     | 2           | 2.1 | 64.1 | 0.8 | 0.4 | 37.9 | 0  | 6.0 | 40.3 | 0 | 158 | 17.4 | 0 | 2.8 | 1.1 | 0  |
| OCF0015     | 3           | 2.4 | 69.6 | 0.6 | 0.4 | 40.0 | 0  | 6.2 | 41.4 | 0 | 160 | 18.5 | 0 | 2.8 | 1.1 | 0  |

Table 5. Average concentration (mg/kg) of actual sample fuel oil OCF0015 excited for 3 days

Facing the high-concentration background elements inherently carried by the crude oil itself, the instrument was still able to output stably. For example, in the OCF0072 sample, the average measurement values of the ultra-high concentration silicon (Si) element for 3 consecutive days were 463, 434, and 436 mg/kg, respectively; the average measurement values of the high concentration calcium (Ca) element were 118, 102, and 113 mg/kg, respectively.

For trace elements in the OCF0055 sample, such as aluminum (Al), the averages over the 3 days were 0.3, 0.2, and 0.5 mg/kg, respectively, and lead (Pb) were 0.8, 0.6, and 0.7 mg/kg, respectively, with no abnormal sudden changes in the values.

Whether dealing with strong signal elements up to hundreds of mg/kg or weak signal elements below 1 mg/kg, the continuous monitoring data over multiple days showed no significant data drift or matrix suppression phenomenon. This proves that the instrument is fully capable of adapting to and overcoming the complex matrix interference of marine fuel oil.

## **Demonstration of Spiked Recovery and Accuracy Based on Complex Matrix**

Spiked Recovery is the golden standard for measuring the accuracy of an analytical method in quantitatively extracting and determining target analytes from real samples. In this section, a diluted solution of sample oil OCF0056 (27g mineral white oil + 3g sample) was used as the matrix base, and 50 mg/kg of GT15-100 was added as a quality control standard for mixed measurement.

The specific operations are as follows:

1. Take a clean centrifuge tube, use an electronic balance (accuracy 0.001g) to weigh  $27\text{g} \pm 0.010\text{g}$  of mineral white oil, then weigh  $3\text{g} \pm 0.010\text{g}$  of OCF0056 sample oil, and shake vigorously for 2 minutes. This sample is Diluted Sample A.

2. Take a clean centrifuge tube, use an electronic balance (accuracy 0.001g) to weigh  $5g \pm 0.010g$  of GT15-100, then weigh  $5g \pm 0.010g$  of Diluted Sample A, and shake vigorously for 2 minutes. This sample is Test Sample B.
3. Take a clean centrifuge tube, use an electronic balance (accuracy 0.001g) to weigh  $5g \pm 0.010g$  of mineral white oil, then weigh  $5g \pm 0.010g$  of GT15-100, and shake vigorously for 2 minutes. This sample is Quality Control Sample C (50 mg/kg).
4. Install a new graphite disc electrode and a sharpened or new graphite rod electrode onto their corresponding clamps; adjust the analytical gap according to the instrument operation manual to meet the calibration requirements; place the disposable sample cup filled with the sample onto the sample stage; raise the sample stage so that at least 1/3 of the graphite disc electrode is immersed in the sample; close the excitation chamber door and press the start switch to perform the measurement.

Repeat the above steps to sequentially measure the samples, and record the concentration values of the elements measured by the instrument. Repeat the measurement 3 times for each sample, and calculate the sample spiked recovery rate according to formula (3).

$$P = \frac{B-A}{X} \times 100 \quad (3)$$

Where:

P——Recovery rate, %

B——Test Sample B, mg/kg

A——Diluted Sample A, mg/kg

X——Quality Control Sample C, mg/kg

| Sample<br>Nama  | Alternative<br>Name         | Al          | Ca         | Cr          | Cu          | Fe         | Pb          | Mg          | Ni          | K           | Si          | Na          | V           | Zn          | Mn          | Li          |
|-----------------|-----------------------------|-------------|------------|-------------|-------------|------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| OCF0056         | Diluted Sample A            | 1.0         | 14.2       | 0.5         | 0           | 8.2        | 0.4         | 0.9         | 0.2         | 0           | 3.0         | 1.4         | 0           | 0.3         | 0.2         | 0           |
| OCF0056         | Test Sample B               | 55.0        | 58.8       | 56.3        | 56.0        | 57.8       | 54.3        | 163         | 54.6        | 55.9        | 56.2        | 50.7        | 56.1        | 58.5        | 56.6        | 54.7        |
| 50 mg/kg        | Quality Control<br>Sample C | 51.7        | 51.4       | 52.5        | 51.1        | 52.6       | 52.4        | 154         | 52.2        | 52.7        | 52.7        | 48.5        | 52.9        | 57.4        | 52.6        | 51.2        |
| <b>Recovery</b> | <b>%</b>                    | <b>104%</b> | <b>87%</b> | <b>106%</b> | <b>110%</b> | <b>94%</b> | <b>103%</b> | <b>105%</b> | <b>104%</b> | <b>106%</b> | <b>101%</b> | <b>102%</b> | <b>106%</b> | <b>101%</b> | <b>107%</b> | <b>107%</b> |

Table 6. Spiked recovery rate of spiked sample fuel oil excited in OA800H

The experimental data show that the spiked recovery rates of 15 key metal elements exhibit extremely high accuracy. Among them, the recovery rate of the highly destructive catalyst powder element aluminum (Al) is as high as 104%, and silicon (Si) is 101%; the high-temperature corrosion-inducing element vanadium (V) recovery rate is 106%, and sodium (Na) is 102%; the abnormal wear indicator iron (Fe) is 94%, and copper (Cu) is 110%.

Overall, the spiked recovery rates of the 15 tested elements fully converge within the narrow high-precision range of 87% ~ 110%. This not only fully meets but significantly exceeds the established "80% ~ 120%" laboratory quality control safety line in the field of marine fuel oil elemental analysis.

The extremely high measurement consistency of the quality control samples deeply confirms that these analytical conditions and excitation programs can achieve highly reliable quantitative deconstruction of target metal elements in marine fuel oil.

### **Long-Term Measurement Stability Under Continuous Operation Cycle (SR Indicator Evaluation)**

For high-frequency online or routine laboratory analysis equipment, the long-term stability of its optical system and excitation light source is crucial. The experiment selected the GT15-10 (10 mg/kg) standard oil, set a monitoring period spanning 7 days, and accumulated 6 non-continuous random inspections (with intervals > 2 hours), and used the relative range formula (4) to calculate the peak value of stability fluctuation (SR).

$$s_R = \frac{|C_i - C_1|}{C_1} \times 100 \quad (4)$$

Where:

$s_R$ —Measurement stability, %

$C_i$ —Result of the  $i$ -th measurement, mg/kg

$C_1$ —Result of the 1st measurement, mg/kg.

| Sample Name | Testing Time | Al   | Ca   | Cr   | Cu   | Fe   | Pb   | Mg   | Ni   | K    | Si   | Na   | V    | Zn   | Mn   | Li   |
|-------------|--------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| GT15-10     | 2/28 16:30   | 10.3 | 10.4 | 9.8  | 10.9 | 10.8 | 9.9  | 32.4 | 11.0 | 9.6  | 10.3 | 9.1  | 10.6 | 10.4 | 10.6 | 10.3 |
| GT15-10     | 3/4 15:06    | 10.4 | 10.4 | 10.2 | 11.4 | 11.3 | 10.0 | 33.4 | 11.4 | 10.1 | 10.6 | 10.0 | 11.3 | 11.0 | 11.4 | 10.1 |
| GT15-10     | 3/5 9:54     | 10.8 | 11.0 | 9.9  | 11.4 | 11.2 | 10.5 | 32.4 | 11.1 | 9.8  | 10.3 | 10.1 | 10.9 | 9.4  | 11.4 | 10.6 |
| GT15-10     | 3/6 13:54    | 10.8 | 11.0 | 10.5 | 11.7 | 11.2 | 10.1 | 33.8 | 11.4 | 9.5  | 10.7 | 9.8  | 11.4 | 11.2 | 11.4 | 10.7 |
| GT15-10     | 3/7 16:13    | 10.8 | 11.0 | 11.0 | 11.4 | 10.6 | 10.4 | 32.3 | 10.3 | 10.2 | 10.6 | 10.0 | 10.9 | 10.7 | 11.1 | 9.6  |
| GT15-10     | 3/8 16:07    | 10.6 | 11.4 | 10.7 | 11.2 | 10.6 | 10.6 | 32.3 | 10.4 | 9.2  | 10.2 | 8.8  | 10.7 | 11.0 | 11.1 | 9.4  |
|             | Stability    | 4.8% | 9.6% | 9.2% | 7.3% | 7.1% | 7.1% | 4.3% | 6.4% | 6.2% | 3.9% | 11%  | 7.5% | 9.6% | 7.5% | 8.7% |

Table 7. Stability of standard oil sample GT15-10 excited in OA800H

Over the 7-day operation cycle, the instrument demonstrated extremely strong drift-resistant properties. The stability fluctuation value ( $s_R$ ) of silicon (Si) was only 3.9%, magnesium (Mg) was as low as 4.3%, aluminum (Al) was only 4.8%, iron (Fe) and lead (Pb) were both 7.1%, and vanadium (V) was 7.5%. Even for the relatively active sodium (Na) element, its maximum fluctuation value was controlled at 11%.

The long-term stability fluctuations ( $s_R$ ) of all tested elements were strictly suppressed within a reasonable range (overall showing an extremely low fluctuation level of less than 10%), fully confirming that the DITEE OA800H can still guarantee highly consistent analytical results and excellent instrument reliability after experiencing long-cycle, high-frequency alternating cold and hot operations.

## Conclusion and Summary of Application Value

This experiment was core-directed at verifying the feasibility and engineering practicality of the DITEE OA800H oil spectrometer in the detection of marine heavy fuel oil. Through a systematic evaluation covering four major dimensions: "standard validation, actual sample testing, spiked recovery testing, and continuous measurement stability testing", it was comprehensively confirmed that the instrument can provide a highly efficient, accurate, and extremely reliable technical solution for the quality control of marine fuel oil. The specific experimental results and core arguments are as follows:

- **Highly compliant standard validation, precisely matching industry specifications:** Strictly in accordance with international and industry standards such as ASTM D6728 and SN/T 1652, this study conducted methodological validation on GT15 standard oil at three concentration gradients of 1, 10, and 100 mg/kg. The average concentrations and standard deviations of 15 core metal elements such as Al, Ca, and Cr after 20 continuous excitations fully comply with the stringent regulations regarding the calculated repeatability of heavy fuel oil in the standards, fundamentally establishing the high accuracy and compliance of the instrument's analytical system.
- **Stable actual matrix testing, perfectly adapting to real working conditions:** In the continuous tracking detection of three real marine fuel oil samples, OCF0055, OCF0072, and OCF0015, over up to 3 days, the measurement results of various metal elements did not show significant abnormal fluctuations. This indicates that the system has excellent anti-matrix interference capabilities and data stability, enabling it to perfectly self-adapt to the complex real-world screening scenarios of marine fuel oil.
- **Excellent spiked recovery performance, superb methodological precision:** Testing based on the real OCF0056 sample with the introduction of a 50 mg/kg quality control sample showed that the spiked recovery rates of 15 key target elements are highly concentrated in the high-precision range of 87% ~ 107%. These data fully meet and exceed the conventional laboratory quality control safety line of 80% ~ 120% in the

field of marine fuel oil analysis. The high consistency between the measured values and the standard values ensures the absolute reliability of the quantitative analysis results.

- **Outstanding performance in long-cycle operation, extremely low fluctuation guarantees consistency:** The long-term continuous testing spanning 7 days and totaling 6 frequencies conducted on the GT15-10 mg/kg standard oil liquid showed that the maximum range and fluctuation scope of all measured values were strictly controlled at an extremely low and reasonable level. This performance strongly verifies the instrument's excellent long-term operational stability, which can provide a solid guarantee of result consistency for high-frequency, large-scale daily inspections.

The DITEE OA800H oil spectrometer has demonstrated outstanding accuracy, stability, and reliability when handling the complex metal elemental analysis of marine heavy fuel oil. Its core technical indicators not only fully meet current maritime testing standards and laboratory quality control requirements, but can also achieve rapid and precise screening of fuel metal components in practical applications. The promotion and application of this technology can provide early and precise warnings for abnormal equipment wear and high-temperature corrosion caused by excessive metals, assisting operators in identifying and blocking inferior fuel oil from the source. This releases irreplaceable practical economic and safety assurance value for ensuring the safe and stable operation of marine main engines and auxiliary systems, significantly reducing the frequency of sailing suspensions, and cutting huge maintenance costs.

## Appendix

- **Compliance Declaration:** Complies with standards such as ASTM D6728 and SN/T 1652.
- **Technical Support:** Customized calibration services (contact [sales@rogetscientific.com](mailto:sales@rogetscientific.com)).