



## Lab Report OES 20

# Q8 MAGELLAN

- Determination of Soluble and Insoluble Aluminum in Low Alloy Steels

The demand for cleaner steels increases continuously. Aluminum plays an important role for the steel cleanliness and its detailed analysis can supply additional information about the steelmaking process and the steel purity.

Aluminum can form non-metallic inclusions (insoluble oxides) during the deoxidation step and in the secondary metallurgy. Especially low alloy, Al-killed steels, where aluminum is used for deoxidation during the steelmaking show high tendency for inclusion formation. As result of the deoxidization, steel shows some insoluble aluminum content, manifesting in form of aluminum oxide inclusions with high hardness. These inclusions lead to

defects in the final steel product, compromise the steel quality and generate extra costs. Therefore, it is important to obtain additional information about the aluminum content in the steel.

The Q8 MAGELLAN in combination with the new evaluation features in ELEMENTAL.SUITE v2.0 software allows analyzing not only the total aluminum but to "separate" this total aluminum into fractions Al-soluble (in the metal lattice) and Al-insoluble (in the form of aluminum oxides).

The Q8 MAGELLAN provides a fast analysis with no additional cost for your production, using standard sample preparation.



Figure 1: Steel quality control for every production step.

### The Principle – Single Spark Evaluation (SSE) Al-Soluble & Al-Insoluble

While analyzing the sample, the spark (one of thousands during the analysis) is attracted to the grain boundaries in the metal lattice. This is the preferred location of Al-oxides and since the Al-concentration in these oxides is much higher, compared to the bulk metal, this leads to an increased Al-signal. These high Al-signals lead to an asymmetric single spark distribution (see Figure 4) which is processed by means of a statistical filter. As a result of this evaluation, the different fractions of total and soluble aluminum can be specified. This result for the total and the soluble aluminum allows calculating the insoluble Al fraction.

The unique SSE capabilities of the Q8 MAGELLAN allow an in depth data treatment to provide these valuable additional information.

### Sampling and Sample Preparation

The chemical composition of different stages of the steel refining process and casting are monitored by determining the composition of the steel samples taken from the liquid steel.

The surface of the sample is prepared by grinding or milling to have a flat and homogeneous surface. All samples used for the data collection were prepared following standard sample preparation procedure with grinding machine, using silicon-carbide paper, BS118 P60.

### Certified Reference Material (CRM)

Certified Reference Material (CRM) is reference material characterized by a metrological valid procedure for one or more specified properties, accompanied by a certificate that provides the value of the specified property, its associated uncertainty, and a statement of metrological traceability.

## Instrument Description

### Optical System

- Paschen-Runge mount: 750 mm
- Wavelength range: 110 nm – 800 nm
- Photomultiplier Detectors
- Single-vacuum optic

### Source

- Digital generation of any discharge curve
- Current curve by programmable logic modules
- Maintenance-free, inductive ignition, integrated emergency stop
- Maintenance-free, inductive ignition
- Discharge time 10  $\mu$ s to 2 ms
- max. 200 A peak current
- max. 1000 Hz spark sequence

### Software

- Analysis software with integrated single spark evaluation (SSE)
- Material quality monitoring with dynamic internal and external limit check
- Material identification of unknown samples
- Integrated analysis management using SQL data base
- Comprehensive statistic evaluation, SPC charts (option)
- Email-supported reporting system
- Integrated systems for diagnosis and maintenance via internet or telephone provide
- Efficient Service @ short term

### Weight & Dimensions

- 970 x 1050 x 1350 mm / 38 x 41 x 53" (W x H x D)
- Weight 300 kg / ~ 660 lbs.



Figure 2: Q8 MAGELLAN with operator.

## Evaluation Sequence

- Excitation of non-metallic aluminum fractions (insoluble) and bulk material
- Evaluation of the single spark signals
- Application of a statistical algorithm to identify and quantify the “asymmetric” single spark distribution

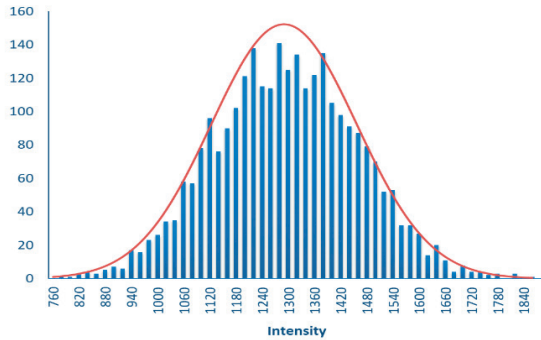


Figure 3: Symmetric Al-channel single spark distribution of clean, inclusion-free steel.

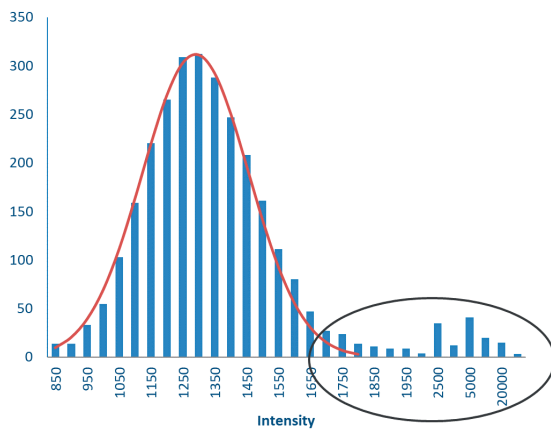


Figure 4: Asymmetric tail (at higher Al concentrations) on the single-spark distribution indicates inclusions that affect steel cleanliness.

## Performance evaluation

Measurements were made on certified reference materials from low alloy steel on the Q8 MAGELLAN. The certified element concentrations for the reference material and the measured element concentrations are given in Table 1. Plots of the certified vs. measured values for Al-total and Al-soluble (see Figure 5 and 6) show a perfect linear correlation (> 99%) with each measured value falling within the specified uncertainties of the CRM.

Table 1: Comparison of certified with measured values

| CRM  | Al <sub>tot</sub> [%] (certified) | Al <sub>tot</sub> [%] (measured) | Al <sub>sol</sub> [%] (certified) | Al <sub>sol</sub> [%] (measured) |
|------|-----------------------------------|----------------------------------|-----------------------------------|----------------------------------|
| 181A | 0.016                             | 0.015                            | 0.014                             | 0.013                            |
| 184A | 0.022                             | 0.020                            | 0.016                             | 0.019                            |
| 187B | 0.027                             | 0.023                            | 0.025                             | 0.021                            |
| 189A | 0.041                             | 0.038                            | 0.039                             | 0.036                            |
| 186B | 0.042                             | 0.040                            | 0.038                             | 0.037                            |
| 185A | 0.060                             | 0.060                            | 0.054                             | 0.056                            |
| 188A | 0.093                             | 0.085                            | 0.083                             | 0.080                            |
| 183A | 0.150                             | 0.150                            | 0.141                             | 0.141                            |

## Correlation with certified reference material

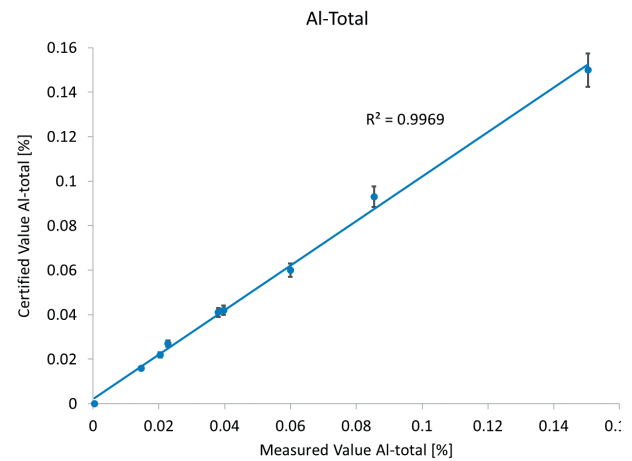


Figure 5: Linear fit between certified and measured values for Al-total.

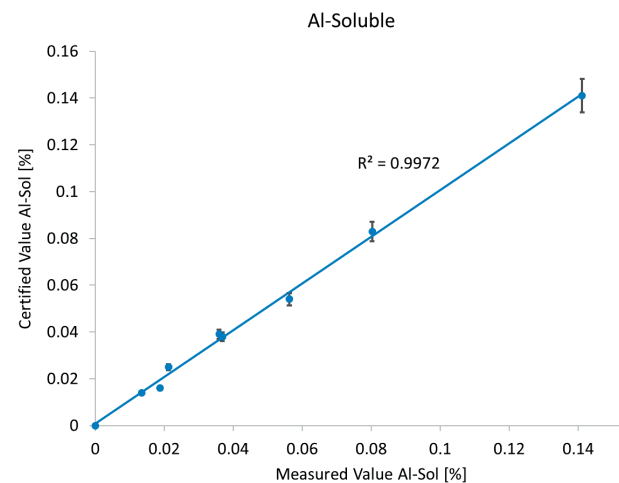


Figure 6: Linear fit between certified and measured values for Al-soluble.



ELEMENTAL.SUITE software assists you in your daily work. Automated average and limit checks ensure safe operation. Saving, printing and reporting your analyses can be done with one click.

Designed for maximum usability and flexibility, ELEMENTAL.SUITE features a plug-in based architecture to cover your analytical requirements now and in the future.

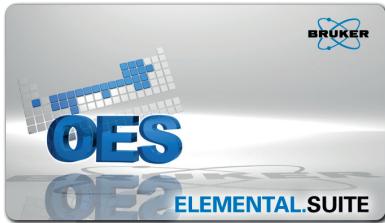


Figure 7: ELEMENTAL.SUITE.

### Conclusion

The Q8 MAGELLAN in combination with the new aluminum soluble option in ELEMENTAL.SUITE for low alloy steels, provides the answers you need fast, using the very latest, state-of-the-art technologies. It allows the determination of the aluminum soluble and insoluble concentration levels to be integrated into the normal analysis process with no extra time or special conditioning.

The analysis is fast, shows high accuracy, and is well-suited for the daily routine analysis where steel cleanliness is being an important quality criterion.



Figure 8: Spark stand of the Q8 MAGELLAN.

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