BRUKER

Carbon   Sulfur

G4 ICARUS Series 2

Carbon and Sulfur Determination by Combustion

Innovation with Integrity

G4 ICARUS Series 2 –
Outstanding Performance, Industry-proven Usability

### Simultaneous carbon and sulfur analysis by combustion

The elemental content of carbon and sulfur within a material has a great impact on its physical properties. In steels, the carbon content determines properties like hardness, ductility, brittleness and magnetism and determines the actual grade of low alloy steels. Due to their impact on the material properties, carbon (C) and sulfur (S) are monitored along the whole production process. The need for fast and reliable CS analysis is not limited to iron and steel but also applies to ferrous and non-ferrous metals, their alloys, ceramics, ores, cement, limestone and numerous other inorganic solids.

Industry requirements

The quality control of industrial processes places high demands on analytical speed, stability and uptime, ease-of-use and maintenance. Versatility is an additional key requirement if sample matrices change each day like in a contract lab.

Combustion analysis with the G4 ICARUS Series 2 meets and exceeds all these demanding requirements. The combustion technique is known to be free of matrix effects, unbiased, accurate and fast. Combustion analysis is also used to confirm purity in incoming materials inspection due to its high speed and independence of sample mass. Even in difficult matrices like grey cast iron, where carbon is unevenly distributed in the form of graphite flakes, combustion analysis delivers accurate results because it is a volumetric method, analyzing the entire sample mass. This makes combustion analysis the reference method for precise and flexible carbon and sulfur determination.
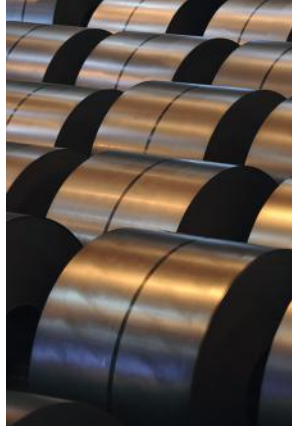
Principle

The solid sample, placed in a ceramic crucible together with accelerator material, is heated directly using a sealed high-frequency (HF) induction furnace. The molten sample is combusted in a flow of pure oxygen. The pressurized oxygen flow in combination with Bruker's unique ZoneProtect™ ensures a complete, clean combustion without undesirable side effects. During combustion carbon and sulfur components in the sample are converted into CO_2 and SO_2. Traces of CO are oxidized downstream to CO_2. These combustion gases are transported with the oxygen carrier gas for detection by advanced solid-state detectors.

A rapid and complete combustion process always creates residuals, especially oxide dust that builds up on affected parts of the combustion zone. Dust contaminants can trap or retain the liberated combustion gases, even if the combustion itself is complete. Hence a contaminated combustion chamber can adversely affect the results of subsequent analysis. This makes dust-handling a vital point, especially when trace level concentrations need to be determined.

The G4 ICARUS Series 2 avoids contaminations right from the start

Its entire flow path consits of chemically inert polymer tubing to avoid "hang-up" or "carry-over" effects and corrosion. The superior ZoneProtect delivers more precise analytical results in combination with increased productivity and cleanliness.

ZoneProtect™ –
# Clean, Fast & Efficient Combustion

Bruker's unique ZoneProtect design ensures a long lasting combustion tube and virtually eliminates any maintenance on this vital part. ZoneProtect further shields the entire combustion zone against splatters and dust deposits and supports a complete combustion. Unlike conventional designs operating with a lance, blowing oxygen over the sample or using proprietary high crucibles with slow combustion, the innovative principle of ZoneProtect knows no compromises.

The G4 ICARUS Series 2 with ZoneProtect™ combines speed and outstanding analytical performance with minimum maintenance

The ceramic crucible containing the sample and accelerator is positioned close below a gas extraction nozzle. The oxygen gas – needed for the combustion process – is supplied from the outside and flows through the annular flow gap formed between the crucible and extraction nozzle. This creates a vortex that ensures an optimal, surplus supply of oxygen to the molten sample. Liberated combustion gases and dust particles are instantly purged through the extraction nozzle, while its collar shields the quartz tube from splatters of the liquid sample. After the analysis, during the cleaning, the crucible acts as a waste bin. This unique construction leads to:

- More efficient, faster combustion on a wider variety of samples

- Superior gas flow: Instant removal of combustion gases without further dilution for fast and clean analysis

- Eliminating splatters and minimizing dust, thus maximizing productivity, component lifetime and analytical quality

- Vacuum- and noise-free dust removal system integrated into the combustion zone
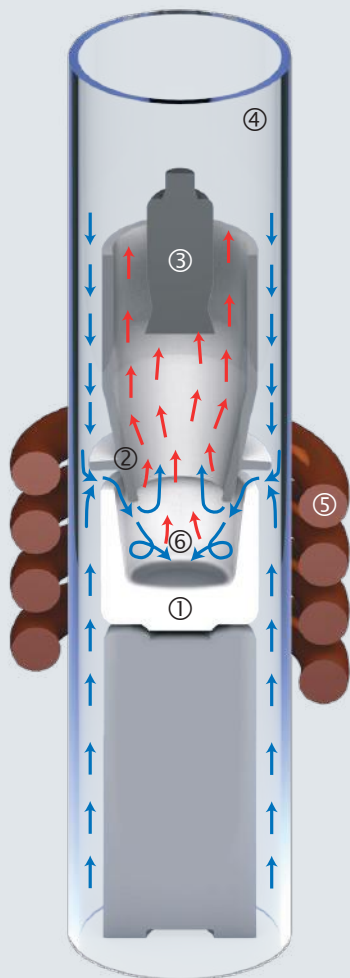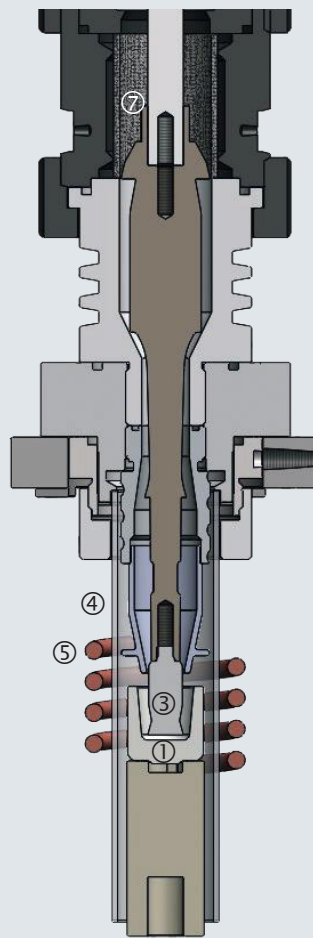
ZoneProtect (I)

① Ceramic crucible with sample and accelerator

② Gas extraction nozzle with collar

③ Tip of cleaning plunger

④ Quartz combustion tube

⑤ Induction coil of HF-furnace

⑥ Vortex of oxygen

⑦ High-efficiency dust filter

———— Oxygen

———— Combustion gases

ZoneProtect (II)

The integrated and fully automatic cleaning system ensures a silent, fast and **vacuum-free** disposal of dust and splatters created during the combustion.

After the analysis the furnace remains closed and is depressurized through the temperature-stabilized, high-efficiency dust filter. The solid plunger, equipped with several wiper edges, secures simultaneous cleaning of the inline dust filter and the extraction nozzle. The plunger pushes the waste directly into the used crucible supported by a sweep of oxygen.

The unique ZoneProtect creates unrivaled performance with unmatched cycle times – purge, analysis and cleaning in below one minute.
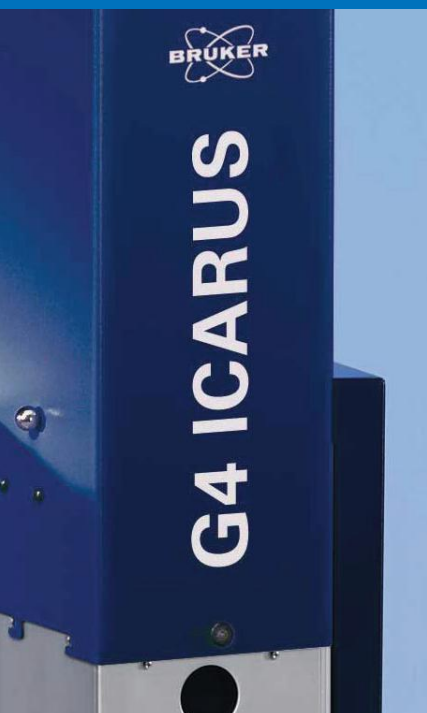
HighSense™: High-performance UV-Absorption for SO$_2$

The latest innovations in the field of high-performance light-emitting diodes (UV-LED), enabled the development of an SO$_2$ detector with outstanding performance. Non-dispersive UV absorption photometry (NDUV) utilizes electronic transitions within the molecules to measure the SO$_2$ concentration. As UV absorption is much more efficient than IR absorption, this results in lower detection limits suitable even for trace analysis. In addition, this kind of gas analysis is not affected by interferences of water molecules or thermal fluctuations. Operating the UV-LED under low power conditions ensures a typical lifetime of 10 years or more.

The new HighSense™ platform comes with a dedicated reference channel to eliminate drifts and provide baseline and calibration stability. The measuring cell is equipped with an inert coating to avoid "carry-over" effects and corrosion. The result is an SO$_2$ detector that outperforms the NDIR technique in every single aspect:

- 10 times better signal-to-noise ratio for highest sensitivity
- Drift-free baseline for long-term stability, not affected by temperature variations
- Ultra-wide linear dynamic range of 5 decades for application flexibility and easy calibration
- Staggering selectivity without any cross sensitivity to other combustion gases for accurate results
- Longest lifetime of light source for long-term stability with low operational costs
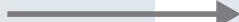
Combustion Gas

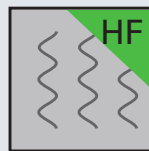# HF-induction furnace

Moisture Removal

ZoneProtect™

Carrier Gas:
Pure Oxygen

Carrier Gas

HF Furnace

HF

H_2O

CO

SO_2

CO_2
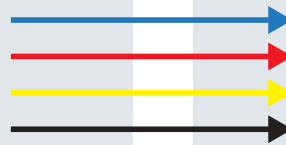
Sample

Remove
moisture

- High precision, ultra-fast Mass Flow Controller (MFC) for absolute flow stability
- Adjustable purge and analysis flow rate for application flexibility
- Gas saving design with zero-flow in idle or stand-by mode
- Integrated carrier gas pre-cleaning
- Chemically inert flow path for high analytical precision, speed and corrosion resistance

- Advanced, power-adjustable HF-induction furnace with long-life oscillator tube and quiet cooling
- **High efficiency, integrated dust filter** with 3 μm pore size for a cleaner environment and improved stability
- Integrated viewport for direct observation of combustion process

ZoneProtect™
- Innovative **lance-free** furnace design with gas extraction nozzle for combustion without compromises
- **Vacuum-free** cleaning system with waste disposal into the crucible
- **Brush-free** cleaning operated by a solid plunger

Extra-long high-efficiency reagent tubes
- Efficient usage of reagents
- Flexibility for a mixed material packing without additional hardware (e.g. halide trap)
- Additional in-line membrane dryer available for hydrated samples

Particle filter inserts
- Protect delicate components from particles
- Act as reagent stop for easy maintenance
- Laminar flow element for high fluidic precision

HighSense™ Detector (NDUV)

S

high ng/g (ppb) to %

NDUV Detectors + Reference Channel

Wide range | Extended high range[1]

UV — SO_2

UV — SO_2

REF

HighSense™ SO_2 detector

- Next Generation **LED-powered** detection technology working by **UV-absorption** for unmatched sulfur performance
- Drift-free due to reference channel
- Ultra-wide linear dynamic range with unrivaled signal/noise ratio. Extended high range[1] for ores or sulfides
- Chemically inert cell coating
- Reliable technology without moving parts or thermal fluctuations

[1] Available as option

Catalytic Conversion

1:1 Carbon

Utmost selectivity

Convert CO to CO_2

Heated Catalyst Furnace

Oxidation
CO → CO_2 (quantitative)
SO_2 → SO_3 (partially)

Trapping
- SO_3 (on cotton wool)

- Long life catalyst ensures CO and volatile organic compounds are converted for a true total carbon result
- No unpublished algorithms or corrections to calculate the total carbon value
- Chemically inert end-caps on the oxidation furnace ensure extreme durability

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Nondispersive Infrared Detector (NDIR)

C

high ng/g (ppb) to %

NDIR Detectors + Reference Channel

Low range | High range

IR — CO_2

IR — CO_2

REF

- Proven NDIR technology with latest generation micromechanical IR-emitter chips
- Drift-free due to reference channel
- Two measuring ranges as standard with electronic range selection for utmost application flexibility
- Reliable technology without moving parts

Overview of Features and Benefits

	Specification	Benefit
Samples Sample Types	Inorganic, dry, any form or shape	Flexibility
Typical Samples	Ferrous and nonferrous metals and their alloys, ores, cement, limestone, glass, ceramics, soils	Wide variety of sample materials
Sample carrier	Ceramic crucibles (standard form)	Usage of industry standard consumables, lower cost, security of supply
Sample weight	0.1 – 1 g (typical 0.5 g)	
Furnace	High frequency induction furnace, power adjustable with ZoneProtect™	More efficient, faster combustion with maximum productivity
Detectors Sulfur	HighSense™ NDUV[2] detector with reference beam path	Unique wide range performance with unrivaled signal/noise without drift
Carbon	Dual-range NDIR detector with reference beam path	Reliable, maintenance-free performance without drift
Carrier Gas	Oxygen 99.95% purity (99.995% required for trace carbon) 3.5 bar (50 psi) min. pressure	Standard gas purity sufficient
Compressed air	5 bar (72.5 psi) min. pressure, oil-, water- and particle-free	
Speed Analysis Time	40 s (nominal)	Fast, simultaneous analysis
Complete Cycle Time	< 1 min (typical)	High productivity and throughput with waste disposal into crucible
Noise Emission	< 50 db	Enjoy the silence
Calibration	Single and multipoint calibration with solid standards	
Reagents	• Magnesium perchlorate • Sodium hydroxide on support • Platinized silica	
Power Supply	230 VAC (± 10 %); L1 N; 208 VAC (± 10 %); L1 L2; } 50-60 Hz; 16 A; 2.7 kVA	Industry standard power and current configurations

[2] NDIR-based detector available on request

64 cm

G4 ICARUS

78 cm

48 cm

Depth 77 cm

~ 75 kg
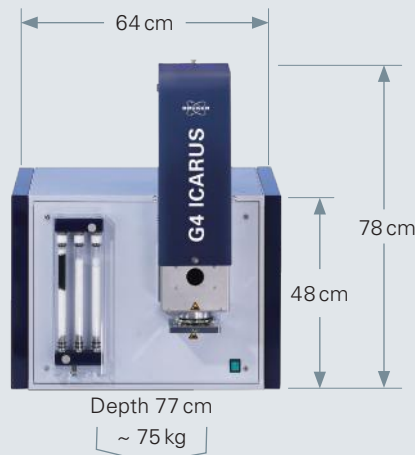
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