Process Insights

Premium Insights Into Process

HIGH-PERFORMANCE GAS ANALYZERS

PRODUCT BROCHURE

Advanced Spectroscopic Solutions for Fuel Cell Hydrogen Analysis

The combined portfolio of Process Insights' powerful analytic instruments for analysis of fuel-cell-grade hydrogen offers:

- Combination of three powerful analytical technologies: Cavity Ring-Down Spectroscopy (CRDS), Mass Spectrometry (MS) and Gas Chromatography (GC)
- Analysis of all critical contaminants listed in hydrogen purity standards SAE J2719 and ISO 14687: He, N_2, Ar, CH_4, H_2O, O_2, CO, CO_2, CH_2O, CH_2O_2, NH_3, sulfurs, and more
- Ideal detection limits from part-per-million (ppm) down to sub-part-per-billion (ppb) in line with requirements outlined in ISO 21087

The Easy Way to Ensure Hydrogen Quality

Hydrogen quality is vital for the performance and lifetime of hydrogen fuel cells. There are many critical contaminants for this application, causing many potential issues, including performance reduction, degradation of the proton exchange membrane, or damage to the catalyst. Process Insights offers powerful analytical tools for the measurement of trace amounts of these molecules. The instruments' ppm- and ppb-level detection limits help ensure compliance with SAE J2719, ISO 14687 and similar purity standards designed to protect fuel cell electric vehicles (FCEVs).

Based on powerful Cavity Ring-Down Spectroscopy (CRDS), all of our CRDS analyzers are free of drift, guaranteeing consistent and reliable trace detection for fuel-cell-grade hydrogen in the lab and in the field. Highly specific to the target molecule, CRDS also eliminates cross-interferences. Plus, there is no need to perform costly and time-consuming zero and span calibrations, saving both time and money with continuous, online service.

Our high-performance CRDS analyzers are used in many demanding measurement applications from ultra-high purity electronic gases for semiconductor manufacturing to industrial and medical gases. We have been working for many years with regulators, researchers, and gas manufacturers to develop measurement solutions for fuel-cell hydrogen analysis. CRDS's versatility makes it possible to use the instruments both in the lab and directly at fueling station, and anywhere along the supply chain, from manufacturing to transportation.

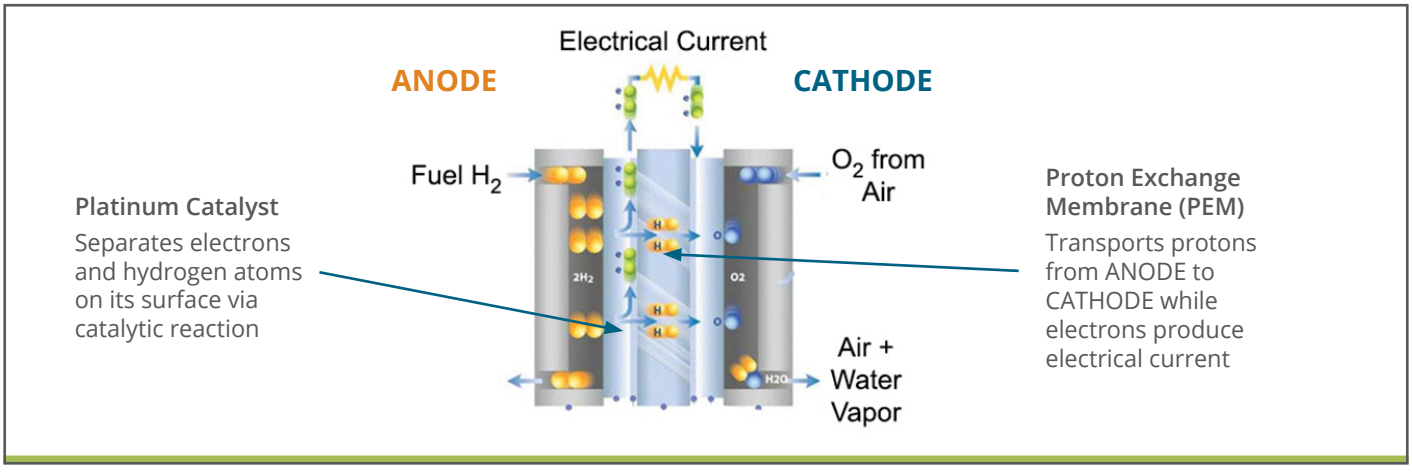
Our quadrupole mass spectrometers (MS) are geared for ultimate performance and allow the detection of multiple contaminants within seconds. With decades of excellence in industrial automation and thousands of installations worldwide, our process mass spectrometers provide the rugged stability and ease-of-use necessary for continuous operation in demanding, mission-critical environments. Offering complete quantitative stream composition measurement, total application coverage, and low cost of ownership, we deliver performance specifications superior to other mass spectrometers and commercial process technologies.

Based on cutting-edge quadrupole mass spectrometer technology, the MAX300-LG has the dynamic range to measure component concentrations from 100% down to the low parts per trillion (ppt). It provides a full composition update every few seconds to measure changes in dynamic chemical processes. The MAX300-LG has the flexibility and rugged stability necessary for real-time quantitative gas analysis in applications as diverse as catalysis R&D, ambient air monitoring, and bioreactor process control.

Fuel Cells and Hydrogen Purity

High-purity hydrogen is crucial to the performance and lifetime of fuel cells. The critical components of the fuel cell are the platinum catalyst and the proton exchange membrane (PEM). Both can experience significant loss in performance or even irreversible damage in the presence of contaminants on the anode side (hydrogen side) of the fuel cell.

Principle of a PEM Hydrogen Fuel Cell used in FCEVs



Effects of contaminants in Hydrogen on the Fuel Cell Anode

Helium (He), Nitrogen (N_2), Argon (Ar)	Dilute hydrogen fuel, compromise performance
Methane (CH_4), Hydrocarbons	Degrades performance of catalyst
Moisture (H_2O), Oxygen (O_2)	Cathode-side molecule, impedes efficiency of fuel-cell reaction ($2H_2 + O_2 \rightarrow H_2O$)
Carbon Dioxide (CO_2)	Reduces to CO and adsorbs to catalyst
Carbon Monoxide (CO)	Adsorbs onto catalyst and severely degrades performance, difficult to recover
Formaldehyde (CH_2O), Formic Acid (CH_2O_2)	Reacts with catalysts, degrades performance
Ammonia (NH_3)	Impedes conductivity of membrane, significantly affects performance, recoverable
Sulfur Compounds (H_2S, COS, CS_2,...)	Adsorbs onto catalyst and severely degrades performance, NOT recoverable

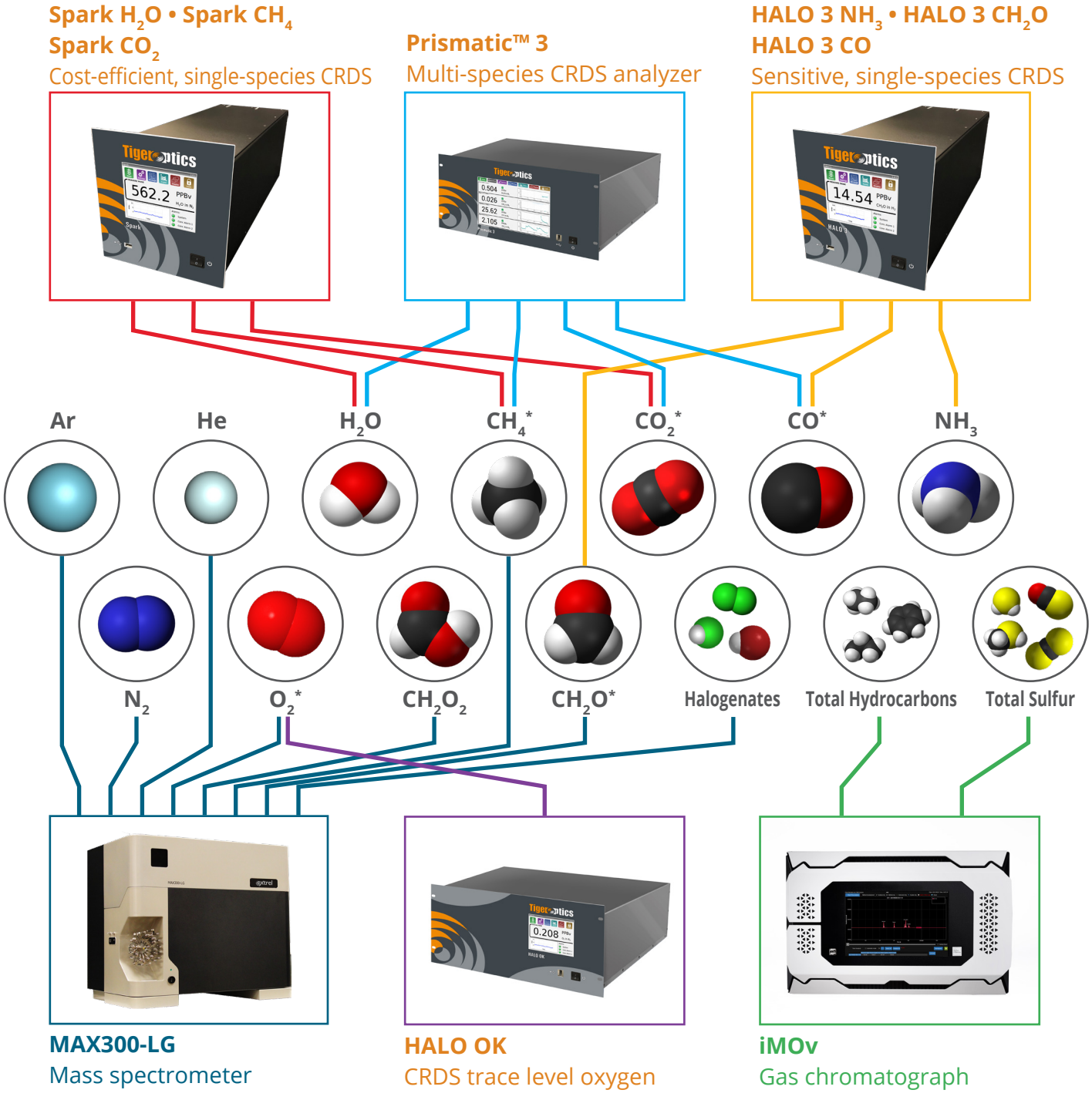
Hydrogen Purity and Measurement Standards

Most countries have adopted the fuel cell hydrogen purity standard SAE J2719, developed by the Society of Automotive Engineers, which sets limits for the species listed above, as well as several other critical contaminants. The purity specifications were also adopted by international standard ISO 14687.

We have worked with ASTM International to create a standard test method for the analysis of fuel-cell hydrogen using CRDS to allow users to take advantage of this powerful analytical method for this application. The standard was finalized in 2014 and is designated as ASTM D7941/D7941M.

Products for Hydrogen Purity Analysis

Process Insights offers six different, versatile CRDS, MS and GC platforms for single-species or multi-species detection of critical impurities in fuel-cell-grade hydrogen to assure SAE J2719/ ISO 14687 compliance.

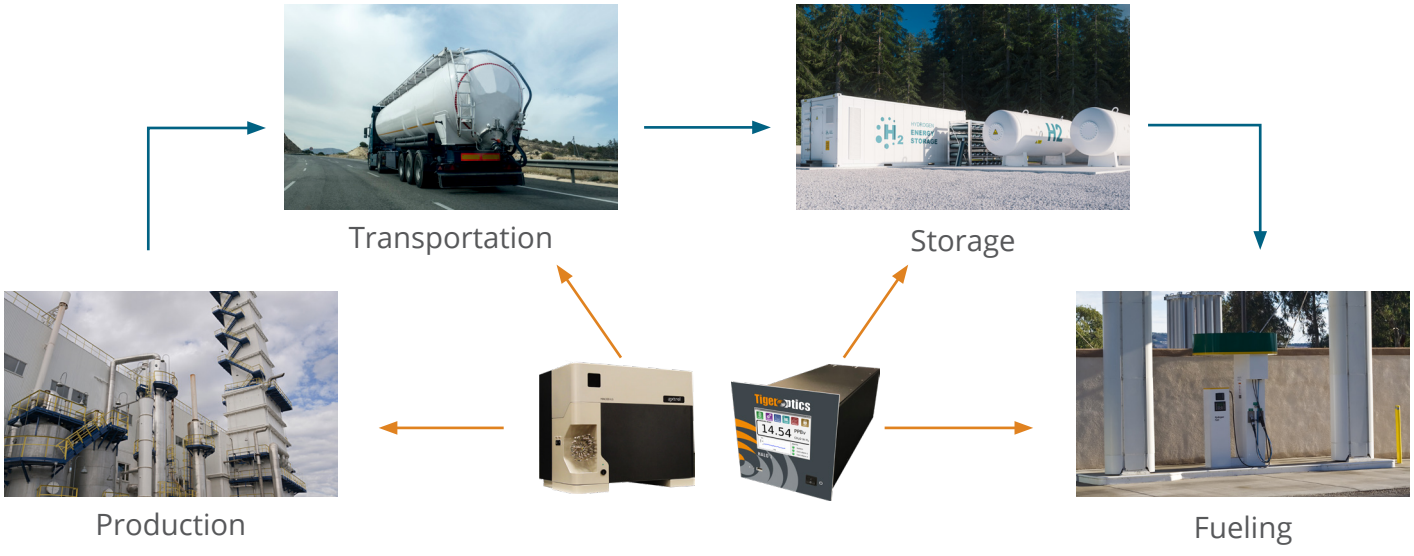


*For CH_4, CH_2O, CO, CO_2 and O_2 detection, you can choose between dedicated single-species CRDS analyzers (Spark, HALO 3 and HALO OK), the multi-species Prismatic 3, or the MAX300-LG mass spectrometer. The recommended analyzer combination depends on your specific requirements. Please contact us to discuss your optimum solution.

Products for Hydrogen Purity Analysis

Process Insights' analyzers offer detection limits that are ideally suited for the contaminant limits set by SAE and ISO hydrogen purity standards and fulfill the requirements for analytical techniques outlined in ISO 21087. All systems are also optimized for H_2 analysis according to ASTM Standard Test Method D7941/7941M.

Ensuring Contamination Control Throughout the Hydrogen Supply Chain



Summary of SAE/ISO Requirements and Analyzer Detection Limits

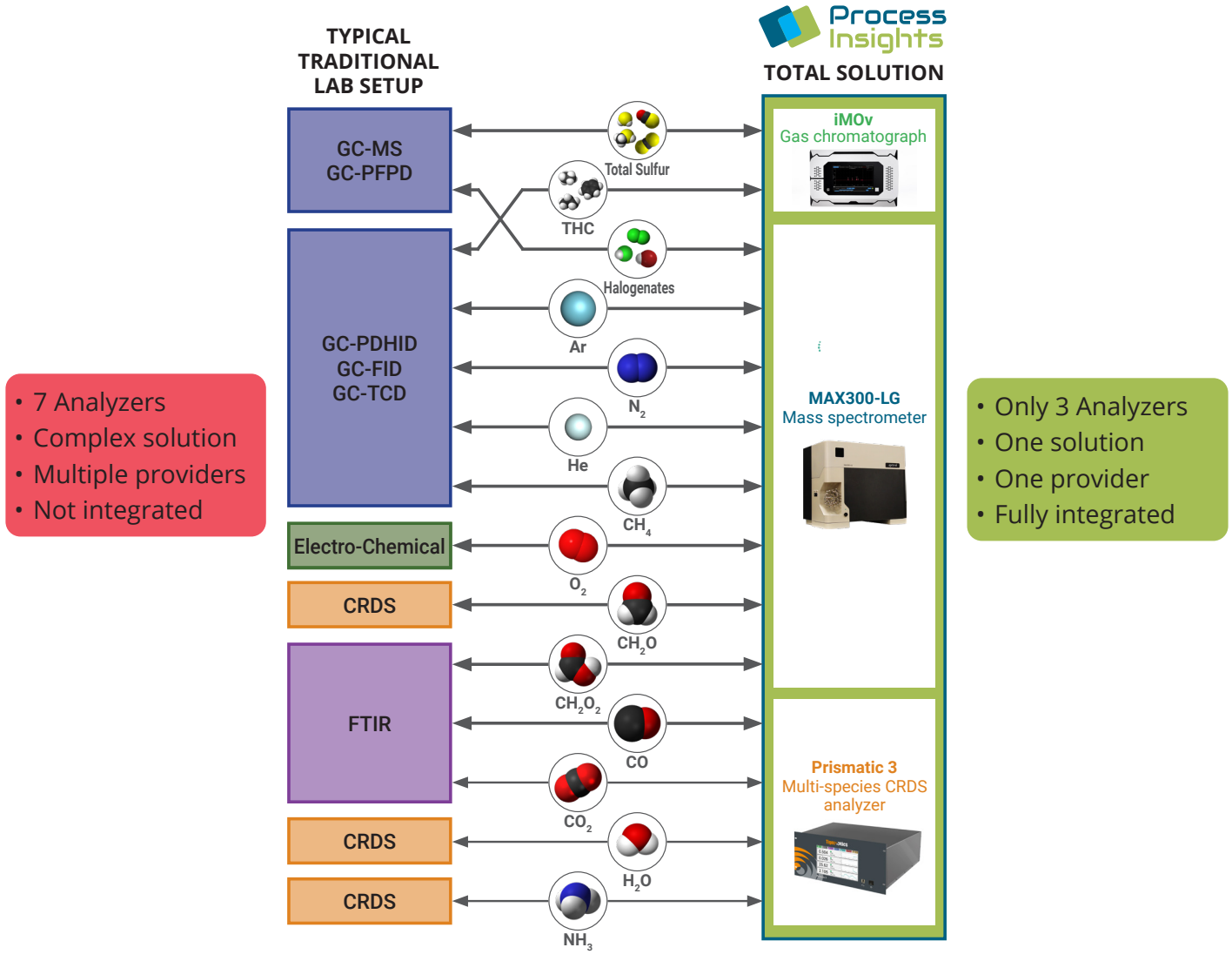
Impurity	SAE J2719/ISO 14687 Concentration Limit	Process Insights LDL (3σ)	Process Insights Analyzer(s)
Helium (He)	300 ppm	0.5 ppm	MAX300-LG
Nitrogen (N_2)	300 ppm	1.0 ppm	MAX300-LG
Argon (Ar)	300 ppm	0.02 ppm	MAX300-LG
Methane (CH_4)	100 ppm	0.2 ppm 0.1 ppm 1.0 ppm	Spark CH_4 Prismatic 3 MAX300-LG
Moisture (H_2O)	5 ppm	0.0075 ppm 0.1 ppm	Spark H_2O Prismatic 3
Oxygen (O_2)	5 ppm	0.003 ppm 1.0 ppm	HALO OK MAX300-LG
Carbon Dioxide (CO_2)	2 ppm	0.4 ppm 0.32 ppm	Spark CO_2 Prismatic 3
Carbon Monoxide (CO)	0.2 ppm	0.05 ppm 0.05 ppm	HALO 3 CO Prismatic 3
Formaldehyde (CH_2O)	0.2 ppm	0.006 ppm 0.02 ppm	HALO 3 CH_2O MAX300-LG
Formic Acid (CH_2O_2)	0.2 ppm	0.02 ppm	MAX300-LG
Ammonia (NH_3)	0.1 ppm	0.0004 ppm 0.01 ppm	HALO 3 NH_3 Prismatic 3
Total Hydrocarbons, ex. CH_4	2 ppm	0.05 ppm	iMOv
Total Sulfur	0.004 ppm	0.002 ppm	iMOv
Total Halogenated Compounds	0.05 ppm	0.01 ppm	MAX300-LG

Process Insights Total Integrated Solution

In the past, a complete monitoring solution for H_2 purity, which can cover all species listed in SAE J2719 or ISO 14687, involved a complex setup using as many as seven different analyzers from multiple providers, with no integration.

Introducing Process Insights' total solution: Only three analyzers are required, and these can be fully integrated into one single-provider system.

Comparison: Traditional Lab Setup vs. Process Insights Total Solution



Spark H_2O • Spark CH_4 • Spark CO_2

CRDS Analyzers for Moisture, Methane and Carbon Dioxide

Performance

Operating range:	See table below
Detection limit (LDL, 3σ/24h):	See table below
SAE J2719/ISO 14687 Limit	See table below
Precision (1σ, greater of):	± 0.75% or 1/3 of LDL
Accuracy (greater of):	± 4% or LDL
Speed of response:	< 3 minutes to 90%
Environmental conditions:	10°C to 40°C 30% to 80% RH (non-condensing)
Storage temperature:	–10°C to 50°C

Gas Handling System and Conditions

Wetted materials:	316L stainless steel, 10 Ra surface finish
Gas connections:	1/4" male VCR
Inlet pressure:	10 − 125 psig (1.7 − 9.6 bara)
Flow rate:	~0.7 slpm (gas dependent)
Sample gases:	Most inert, toxic, passive and corrosive matrices
Gas temperature:	Up to 60°C

Dimensions & Weight

Standard sensor:	H × W × D 8.73 × 8.57 × 23.6 in (222 × 218 × 599 mm)
Sensor rack (fits up to two sensors)**:**	H × W × D 8.73 × 19.0 × 23.6 in (222 × 483 × 599 mm)
Standard sensor weight:	32 lbs (14.5 kg)

Electrical & Interfaces

Platform	Max Series analyzer
Alarm indicators:	2 user programmable, 1 system fault, Form C relays
Power requirements:	90 − 240 VAC, 50/60 Hz
Power consumption:	40 Watts max. per sensor
Signal output:	Isolated 4−20 mA per sensor
User interfaces:	5.7" LCD touchscreen, 10/100 Base-T Ethernet, USB, RS-232, RS-485, Modbus TCP (optional)
Data storage:	Internal or external flash drive
Certification:	CE Mark

Performance, H_2	Part Number	Range	LDL (3σ)	SAE/ISO Limit
Spark H_2O	F7700	0 − 1750 ppm	7.5 ppb	5 ppm
Spark CH_4 (standard range)	F7701	0 − 80 ppm	7.5 ppb	100 ppm
Spark CH_4 (high range)	F7701-H	0 − 1000 ppm	200 ppb	100 ppm
Spark CO_2	F7704	0 − 2000 ppm	400 ppb	2 ppm

U.S. Patent # 7,277,177

HALO 3 NH_3 • HALO 3 CH_2O • HALO 3 CO

CRDS Analyzers for Ammonia, Formaldehyde and Carbon Monoxide

Performance

Operating range:	See table below
Detection limit (LDL, 3σ/24h):	See table below
SAE J2719/ISO 14687 Limit	See table below
Precision (1σ, greater of):	± 0.75% or 1/3 of LDL
Accuracy (greater of):	± 4% or LDL
Speed of response:	< 3 minutes to 90%
Environmental conditions:	10°C to 40°C 30% to 80% RH (non-condensing)
Storage temperature:	–10°C to 50°C

Gas Handling System and Conditions

Wetted materials:	316L stainless steel, 10 Ra surface finish
Gas connections:	1/4” male VCR
Leak tested to:	1 x 10^{-9} mbar l / sec
Inlet pressure:	10 − 125 psig (1.7 − 9.6 bara)
Flow rate:	~1 slpm
Gas temperature:	Up to 60°C

Dimensions & Weight

Standard sensor:	H × W × D 8.73 × 8.57 × 23.6 in (222 × 218 × 599 mm)
Sensor rack (fits up to two sensors)**:**	H × W × D 8.73 × 19.0 × 23.6 in (222 × 483 × 599 mm)
Standard sensor weight:	33 lbs (15 kg) for NH_3 and CH_2O, 28 lbs (12.7 kg) for CO

Electrical & Interfaces

Platform:	Max Series analyzer
Alarm indicators:	2 user programmable, 1 system fault, Form C relays
Power requirements:	90 − 240 VAC, 50/60 Hz
Power consumption:	40 Watts max.
Signal output:	Isolated 4−20 mA per sensor
User interfaces:	5.7” LCD touchscreen, 10/100 Base-T Ethernet, USB, RS-232, RS-485, Modbus TCP (optional)
Data storage:	Internal or external flash drive
Certification:	CE Mark

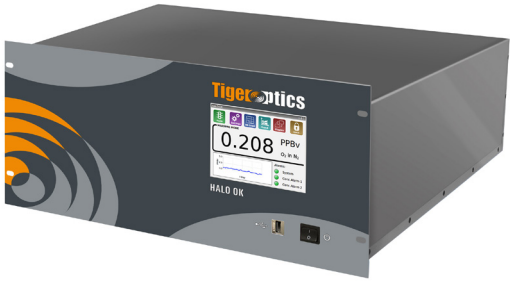
Performance in H_2

	Part Number	Range	LDL (3σ)	SAE/ISO Limit
HALO 3 NH_3:	F7617	0 − 6 ppm	0.4 ppb	0.1 ppm
HALO 3 CH_2O:	F7618	0 − 40 ppm	6 ppb	0.2 ppm
HALO 3 CO:	F7602	0 − 2500 ppm	50 ppb	0.2 ppm

U.S. Patent # 7,277,177

HALO OK

CRDS Trace Oxygen Analyzer



Performance O_2 in H_2

Operating range:	0 − 10 ppm
Detection limit (LDL, 3σ/24h):	3 ppb
SAE J2719/ISO 14687 Limit	5 ppm
Precision (1σ, greater of):	± 0.75% or 1/3 of LDL
Accuracy (greater of):	± 4% or LDL
Speed of response:	< 3 minutes to 95%
Environmental conditions:	10°C to 40°C 30% to 80% RH (non-condensing)
Storage temperature:	–10°C to 50°C

Gas Handling System and Conditions

Wetted materials:	316L stainless steel, 10 Ra surface finish
Gas connections:	1/4” male VCR
Leak tested to:	1 x 10^{-9} mbar l / sec
Sample inlet pressure:	10 − 125 psig (1.7 − 9.6 bara)
Sample flow rate:	0.5 to 1.8 slpm (gas dependent)
Gas temperature:	Up to 60°C

Dimensions & Weight

Standard sensor:	H × W × D 8.73 × 19.0 × 23.6 in (222 × 483 × 599 mm)
Standard sensor weight:	45 lbs (20.4 kg)

Electrical & Interfaces

Platform	Max Series analyzer
Alarm indicators:	2 user programmable, 1 system fault, Form C relays
Power requirements:	90 − 240 VAC, 50/60 Hz
Power consumption:	200 Watts max.
Signal output:	Isolated 4−20 mA
User interfaces:	5.7” LCD touchscreen, 10/100 Base-T Ethernet, USB, RS-232, RS-485, Modbus TCP (optional)
Data storage:	Internal or external flash drive
Certification:	CE Mark

Part Number: F7502-H

U.S. Patent # 7,277,177 • U.S. Patent # 7,255,836

Prismatic™ 3

Multi-Species Gas Analyzer

Performance

Operating range:	See table below
Detection limit (LDL, 3σ/24h):	See table below
Precision (1σ, greater of):	± 0.75% or 1/3 of LDL
Accuracy (greater of):	± 4% or LDL
Speed of response:	< 5 minutes to 95% (in 4-channel operation)
Environmental conditions:	10°C to 40°C 30% to 80% RH (non-condensing)
Storage temperature:	–10°C to 50°C

Gas Handling System and Conditions

Wetted materials:	316L stainless steel, 10 Ra surface finish
Gas connections:	1/4” male VCR inlet and outlet
Leak tested to:	1 x 10^{-9} mbar l / sec
Inlet pressure:	10 − 125 psig (1.7 − 9.6 bara)
Flow rate:	< 1 slpm (gas dependent)
Sample gases:	Inert gases and hydrogen
Gas temperature:	Up to 60°C

Dimensions & Weight

Standard sensor:	H × W × D 8.73 × 19.0 × 23.6 in (222 × 483 × 599 mm)
Sensor rack:	19” rack-mountable (483 mm)
Standard sensor weight:	50 lbs (22.7 kg) estimated

Electrical & Interfaces

Alarm indicators:	1 user programmable per channel, 1 system fault, Form C relays
Power requirements:	90 − 240 VAC, 50/60 Hz
Power consumption:	300 Watts max.
Signal output:	Isolated 4−20 mA per sensor
User interfaces:	10.4” LCD touchscreen, 10/100 Base-T Ethernet, RS-232, RS-485
Data storage:	Internal or external flash drive

Performance in H_2

	Range	LDL (3σ)	SAE/ISO Limit
Methane (CH_4):	0 − 100 ppm	100 ppb	35 ppb
Moisture (H_2O):	0 − 25 ppm	100 ppb	35 ppb
Carbon Monoxide (CO):	0 − 500 ppm	50 ppb	30 ppb
Carbon Dioxide (CO_2):	0 − 1000 ppm	320 ppb	110 ppb

Contact us for additional analytes and matrices.
U.S. Patent # 7,277,177

MAX300-LG

Mass Spectrometer for He, N_2, Ar, CH_4, O_2, CH_2O & CH_2O_2

Performance

Operating range:	See table below
Detection limit (LDL, 3σ/24h):	See table below
SAE J2719/ISO 14687 Limit	See table below
Precision (1σ):	± 0.05% relative over 24 hours
Stability (1σ):	± 0.5% relative over 30 days
Analysis rate:	0.005–16 sec per component (user selectable)
Environmental conditions:	13°C to 27°C 0% to 90% RH (non-condensing)

Maintenance and Calibration

Analyzer:	1–3 year*
Roughing pump:	6–12 months*
Calibration interval:	3–12 months (manual or fully automated)
Filaments:	Two—one active, one spare with automated switchover

Dimensions & Weight

Instrument:	H × W × D 23.0 × 26.25 × 19.0 in (584 x 667 x 483 mm)
with optional cart:	H × W × D 53.75 x 38.25 x 24.0 in (1365 x 972 x 610 mm)
Instrument weight (approx.):	165 lbs (75 kg)
Optional cart weight:	40 lbs (18 kg)

Electrical & Interfaces

Power requirements:	110 VAC ±10% 60Hz, 10A circuit or 230 VAC ±10% 50Hz, 10A circuit
Power consumption:	700 Watts nominal
System control interfaces:	Ethernet, USB
External communication:	Ethernet, Modbus serial, Digital I/O, analog I/O, OPC
Software:	Questor5 Quantitation Software

Performance in H_2

	Range	LDL (3σ)	SAE/ISO Limit
Helium (He):	0 – 100%	0.5 ppm	300 ppm
Nitrogen (N_2):	0 – 100%	5 ppm	300 ppm
Argon (Ar):	0 – 100%	0.02 ppm	300 ppm
Methane (CH_4):	0 – 100%	1.0 ppm	100 ppm
Oxygen (O_2):	0 – 100%	1.0 ppm	5 ppm
Formaldehyde (CH_2O):	0 – 100%	0.02 ppm	0.2 ppm
Formic Acid (CH_2O_2):	0 – 100%	0.02 ppm	0.2 ppm

*Application dependent

iMOv

Gas Chromatograph for Total Hydrocarbons and Sulfur Compounds

Performance

Operating range:	See table below
Detection limit (LDL):	See table below
SAE J2719/ISO 14687 Limit	See table below

Instrument Configuration

Sample gas:	Hydrogen
Carrier gas:	Helium
Detectors:	Scalable enhanced plasma discharge detector (SePdd) Enhanced flame ionization detector (eFID)
Sample pressure:	5–15 psig
Carrier/actuation gas pressure:	90–100 psig / 60–80 psig
Gas connection:	LipLOK™ (backward compatible with double ferrule standard)
Chassis configuration:	19" rackmount or benchtop

Electrical & Interfaces

Power requirements:	120/220 VAC, 50/60 Hz
Standard I/Os:	RS-232, 1x digital input, 1x digital output, ethernet (remote control, IIoT)
Optional I/Os:	Modbus, isolated 4-20 mA outputs, dry contact relays
User interface:	Embedded GC software with touchscreen interface
Compliance:	CE mark and ROHS

Performance in H_2

	Range	LDL (3σ)	SAE/ISO Limit
Total Hydrocarbons (THC):	0 – 20 ppm	50 ppb	2 ppm
Hydrogen Sulfide (H_2S):	0 – 1 ppm	2 ppb	4 ppb*
Carbonyl Sulfide (COS):	0 – 1 ppm	2 ppb	4 ppb*
Methyl Mercaptan (CH_3SH):	0 – 1 ppm	2 ppb	4 ppb*
Ethyl Mercaptan/Carbonyl Disulfide (C_2H_5SH/CS_2):	0 – 1 ppm	2 ppb	4 ppb*
Isopropyl Mercaptan (C_3H_8S):	0 – 1 ppm	2 ppb	4 ppb*
Thiophene (C_4H_4S):	0 – 1 ppm	2 ppb	4 ppb*

*Limit is given as Total Sulfur

Advanced Spectroscopic Solutions for Fuel Cell Hydrogen Analysis

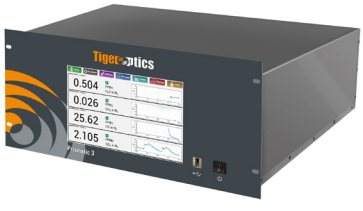
Process Insights Single-Species Systems

Spark

HALO 3

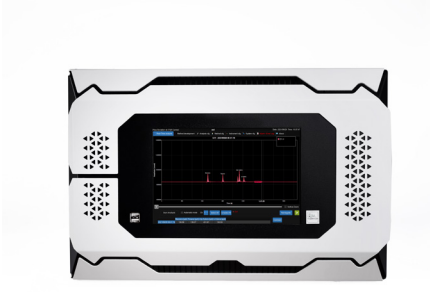
HALO OK

Process Insights Multi-Species Systems



Prismatic™ 3

MAX300-LG



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References

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HIGH-PERFORMANCE GAS ANALYZERS

GAIN REAL-TIME INSIGHT INTO YOUR PROCESS

Process Insights manufactures and delivers premium sensors, monitors, detectors, analyzers, instrumentation, and software that are mission-critical to keep your operations, personnel, and the environment safe – every day across the globe.

Get the most reliable, precision analytical technologies available on the market today. We will work to match your needs and budget, and provide the optimal, and most stable process analysis solution for your application.

CENTERS OF EXCELLENCE | PROVIDING PROVEN SOLUTIONS

Process Insights is committed to solving our customers' most complex analytical, process, and measurement challenges everyday.

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For a complete list of sales & manufacturing sites, please visit:
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