AGC Hydrogen Production and Analysis Solutions

Gas Analysis at %, ppm and ppb levels

Hydrogen, with its vast array of industrial uses, is primarily used in the following processes:

Ammonia Production:	H_2 reacts with N_2 in an iron catalyst at 450°C and 20MPa pressure
Refinery Process:	Used in the removal of sulphur contained in crude oil in order to create various products such as gasoline, jet fuel and heating oil
Electronics:	Used as a carrier gas for active trace elements (arsine and phosphine)
Glass:	Required to prevent the oxidation of the large tin baths
Food:	Hydrogenation of liquid oils to convert them to semi-solid materials
Metal Sintering:	Pure H_2 is often used for the high-temperature sintering (i.e. the thermal fusing of powders in compaction to form a solid) of many powder metallurgy parts.
Energy:	Hydrogen Cell Technologies and Space Propulsion
Scientific Use:	Laboratory Based Usage

novaPRO 9000

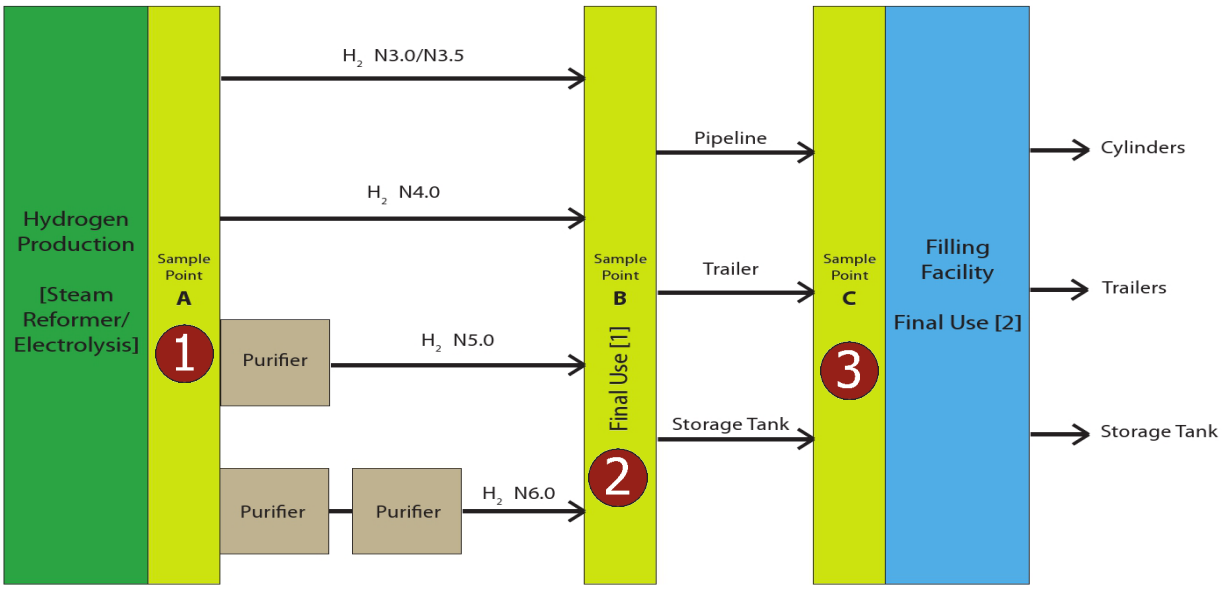
Process Gas Chromatograph

Hydrogen can be produced in several different ways but, economically, the best processes involve the removal of hydrogen from hydrocarbons. This is done primarily by 'Steam Reforming' of natural gas by reacting natural gas or methane (CH_4) with steam in a reformer.

Steam Reforming Production of Hydrogen typically involves:

1. Feed Pre-treatment ('desulfurisation' or 'hydrodesulfurisation')
2. Pre-Reforming (Optional-For Conversion of higher-molecular hydrocarbons)
3. Steam Reforming (Steam reacts with methane to yield carbon monoxide and hydrogen)
4. Shift Conversion (Removal of CO)
5. Pressure Swing Adsorption (Hydrogen Separation/Purification)
6. The H_2 gas produced is then purified to the standards required.

In the process of reforming natural gas or methane to hydrogen, carbon monoxide (CO) and carbon dioxide (CO_2) are created as by-products. Both CO and CO_2 adversely affect catalysts in many refining and chemical processes. Therefore, the removal and measurement of CO and CO_2 on a continuous basis is required before the hydrogen can be used in these processes. AGC Instruments can supply either Gas Analyser or Gas Chromatograph/Process Gas Chromatograph solutions with purge/pressurisation systems (for hazardous Zone 1 and Zone 2 applications) to monitor these impurities at all stages of this process. These analytical solutions will ensure increased efficient production and higher quality product thereby reducing downstream problems.



AGC INSTRUMENTS
Gas Chromatography since 1965

www.agc-instruments.com

Sample Points Analysis Overview

Sample Point A - Stream Analysis (Production Process & Distribution)

N3.5 up to N5.0 H_2

- Direct Response
- Shortest Possible Reaction Time
- Limited Number of Impurities

Wall Mount Gas Analyser

novaSTREAM 6000

Model & Typical Range	N_2	THC	CO	CO_2	O_2 / H_2O
NovaSTREAM 6000-TCD (% Analyser)	✓		✓		Different Monitors Available Upon Demand
NovaSTREAM 6000-TCD (500 ppm to low %)	✓				
NovaSTREAM 6000-TCD (2 - 500 ppm)	✓				
NovaSTREAM 6000-FID (Low %)		✓			
NovaSTREAM 6000-FID (ppm)		✓			
NovaSTREAM 6000-FID (ppm with methaniser)		✓	✓	✓	

*Other Ranges available on demand

Sample Point B & C - Stream Analysis (Production Control)

N3.5 up to N5.0 H_2

- Direct Response
- Shortest Possible Reaction Time
- Limited Number of Impurities

Rack Gas Analyser

novaSTREAM 6000

Model & Typical Range	N_2	THC	CO	CO_2	O_2 / H_2O
NovaSTREAM 6000-TCD (500 ppm to low %)	✓				Different Monitors Available Upon Demand
NovaSTREAM 6000-TCD (2 - 500 ppm)	✓				
NovaSTREAM 6000-FID (ppm)		✓			
NovaSTREAM 6000-FID (ppm with methaniser)		✓	✓	✓	

*Other Ranges available on demand

Sample Point B & C - Gas Chromatography Analysis (Production Control & Distribution)

N3.5 up to N5.0 H_2

- Detection of Specific Impurities
- Typical Analysis Time: 3 - 5 Minutes
- No interference by Matrix Gas and Moisture when combined with stream analysers

Gas Chromatograph

novaCHROM

Model	Ar / O_2	N_2	CH_4	CO	CO_2	O_2 / H_2O
NovaCHROM/PRO FID (ppm)			✓	✓	✓	Different Monitors Available Upon Demand
NovaCHROM/PRO TCD (ppm)	✓	✓	✓	✓	✓ *Extended Run Time	

Sample Point B & C - Gas Chromatography Analysis (Production Control & Distribution)

N5.0 up to N6.0 H_2

- Trace Level Detection of Specific Impurities
- Typical Analysis Time: 5 - 10 Minutes
- No interference by Matrix Gas and Moisture

Process Gas Chromatograph

novaPRO 9000

Model	Ar / O_2	N_2	CH_4	CO	CO_2	O_2 / H_2O
NovaCHROM/PRO DID Low ppb to Mid ppm	✓	✓	✓	✓	✓	Different Monitors Available Upon Demand
NovaCHROM/PRO FID Low ppb to Mid ppm			✓	✓	✓	
NovaCHROM/PRO TCD ppm	✓	✓	✓			

Gas Chromatography Analysis Overview

N3.5 / N4.0 / N5.0

- Single Run or Automated Analysis
- Specific Impurities

Model	Impurities Measured	Analysis Time	Minimum detectable level (MDL)
NovaCHROM/PRO FID	CH_4, CO , CO_2	≤ 5 minutes	++
NovaCHROM/PRO TCD	Ar , N_2, CH_4 , CO	3 - 5 minutes	+
NovaCHROM/PRO FID-TCD	Ar , N_2, CH_4 , CO , CO_2	5 minutes	++

N5.0 / N6.0

- Single Run or Automated Analysis
- Specific Impurities
- Low ppb MDL

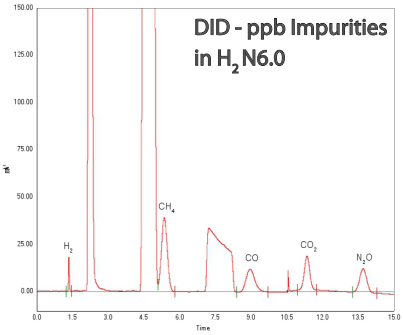
Model	Impurities Measured	Analysis Time	Minimum detectable level (MDL)
NovaCHROM/PRO DID	Ar/O_2, N_2 , CH_4 , CO , CO_2	≤ 12 minutes	++
NovaCHROM/PRO DID-DID	Ar/O_2, N_2 , CH_4 , CO , CO_2	≤ 5 minutes	+++
NovaCHROM/PRO DID-FID	Ar/O_2, N_2 , CH_4 , CO , CO_2	≤ 5 minutes	+++
NovaCHROM/PRO DID-FID	Ar/O_2, N_2 , CH_4 , CO , CO_2, THC	≤ 10 minutes	+++

Detectors

Discharge Ionisation Detector (DID)

Based on using a non-radioactive, universal and concentration-dependent design, the detector generates high energy photons through an electrical discharge in Helium. The metastable Helium then ionises all components except Helium.

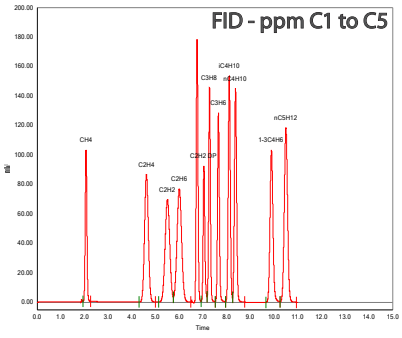
Typical Carrier Gas: He
H_2 Applications: ppm , ppb (by using single or multiple column ovens and specific chromatography techniques)



Flame Ionisation Detector (FID)

The presence of hydrocarbons is detectable by burning the sampled gas in an air-hydrogen flame. Burning just pure hydrogen with air produces only small amounts of ionisation and thus the presence of hydrocarbons causes increased levels of ionisation. A catalyst such as a Methaniser Module can be used for CO / CO_2 readings.

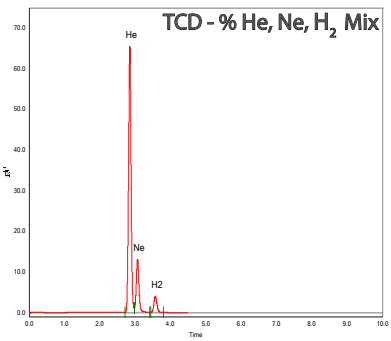
Typical Carrier Gas: H_2 , Ar (recommended) or He (if combined with a DID)
H_2 Applications: ppm , ppb (by using single or dual column ovens and pre-column techniques)



Thermal Conductivity Detector (TCD)

Four sensing elements are connected to form an electrical Wheatstone bridge circuit. An electrical current from a regulated power source heats the elements and changes in thermal conductivity of the sample gas result in an output voltage change.

Typical Carrier Gas: H_2 N5.0 (for % to high ppm range)
or H_2 N6.0 (for low ppm range)
H_2 Applications: % and ppm using single or dual column oven techniques.



The individual brochures and data sheets for each of the products mentioned can be found on the AGC Instruments website.

AGC Technology

Pre-Column Technique

Prevents contamination by moisture or less volatile impurities (e.g. a leaking compressor) to protect analytical columns. Used for all Process Gas Chromatographs.

Backflush Technique

Speeds up analysis by back-flushing unwanted components and sending the components of interest straight to the detector.

Heartcut Technique

The Heartcut technique removes the matrix gas (H_2) from the trace DID detector as opposed to all the analytes being sent to the analytical column(s) and then into the DID detector.

Hydrogen Removal System

Using a palladium membrane technology, the AGC Hydrogen Removal System removes Hydrogen from a sample stream and is an alternative to the Heartcut technique and by default is used for the analysis of H_2 to N6.0 purity.

TrendVision PLUS Software

TrendVision PLUS is the latest version of the well recognised Chromatography Data Capture Software from AGC Instruments. It has been developed following careful consultation with our customers so that it is easy to use and set up.

Rugged industrial level modular and scalable hardware is used with an Embedded Windows Operating System. Once your system is installed, usage in the daily environment is very easy with minimal training required. It encompasses all the important functions required in this demanding gas analysis environment, enabling many standard features to provide excellent chromatography results and straightforward reporting. Furthermore, the ability to integrate outputs from third party gas analysers offers much flexibility for reporting.

TrendVision PLUS provides a unified chromatography method whereby all settings are contained in a single method, including event tables, calibration tables and integration settings. In addition, this software enables the GC systems to run in a fully unattended mode. It can also take control of the GC systems and automatically perform the required analysis using the pre-programmed methods. This is coupled with the ability to send results back to a DCS or control room using fieldbus protocols or traditional 4-20 mA signalling. If On-Line operation is not required then the software runs equally well in its Stand-Alone mode with the same functionality and ease of use.

Company Profile

AGC Instruments

AGC Instruments is a leading manufacturer of Gas Analysis Solutions to all users requiring a Quality Control or identification of their gas stream. We have over 50 years experience in providing our customers with their "Total Gas Analysis Solutions".

Zone 1 ATEX Certification

Certificate Numbers:	CSANe 20ATEX1111X CSANe 20ATEX1120X
Certifying Body:	CSA Group Netherlands
Equipment Marking:	Ex II 2G Ex pxb IIB+H2 T3 Gb CE 2813

Zone 2 ATEX Certification

Certificate Number:	CSANe 20 ATEX M803
Certifying Body:	CSA Group Netherlands
Equipment Marking:	Ex II 3G Ex pzc IIB+H2 T3 Gc CE

Zone 1 & 2 IECEx Certification

Certificate Numbers:	IECEx SIR 20.0039X IECEx SIR 20.0040X
Equipment Marking Zone 1:	Ex pxb IIB+H2 T3 Gb
Equipment Marking Zone 2:	Ex pzc IIB+H2 T3 Gc

Typical Analytical Shelter

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