Setting the Standard for Automation™

ISA Delhi Section

FERTILIZER MEET 2017
16TH DECEMBER 2017

Advanced Analysers for Syn Gas Optimisation

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Standards

Certification

Education & Training

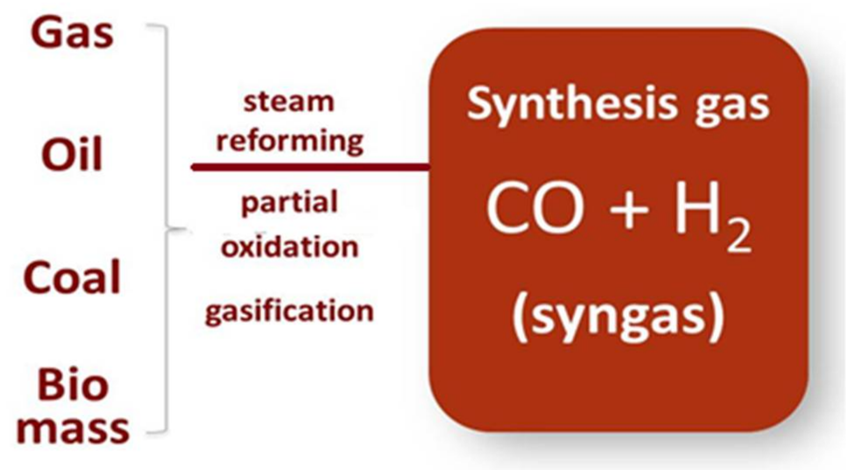
Publishing

Conferences & Exhibits

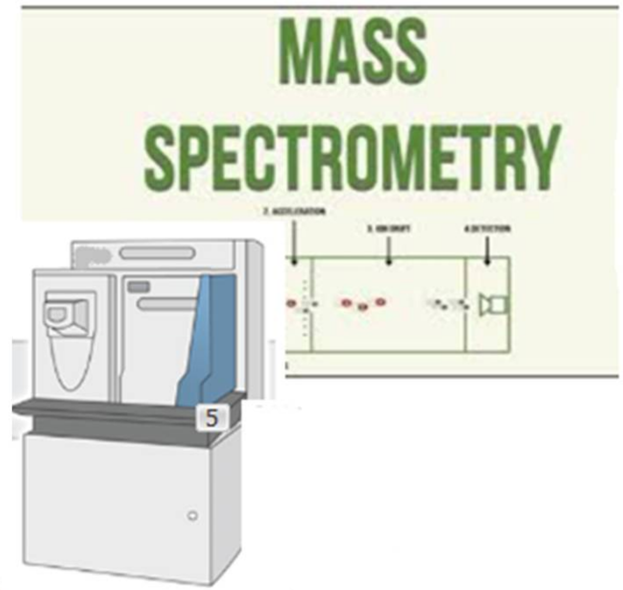
The International Society of Automation
Delhi Section

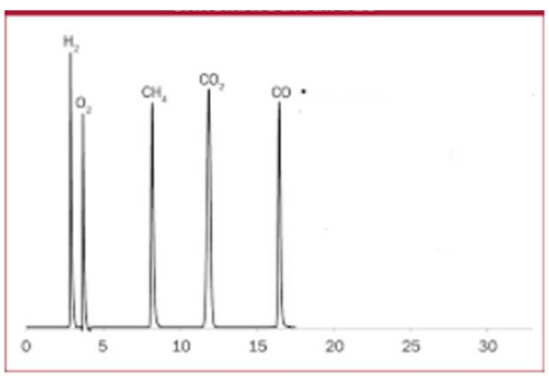
Syngas production methods

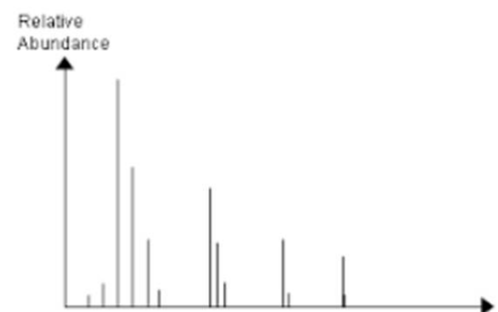
- The most common method is via reforming of natural gas
  - Steam Methane Reforming (SMR), the most common method in use
  - Partial Oxidation (POX)
  - Autothermal Reforming (ATR)
- Gasification of various feedstocks (common in areas that do not have natural gas and have high coal reserves, such as China)
  - Coal
  - Petcoke
  - Biomass



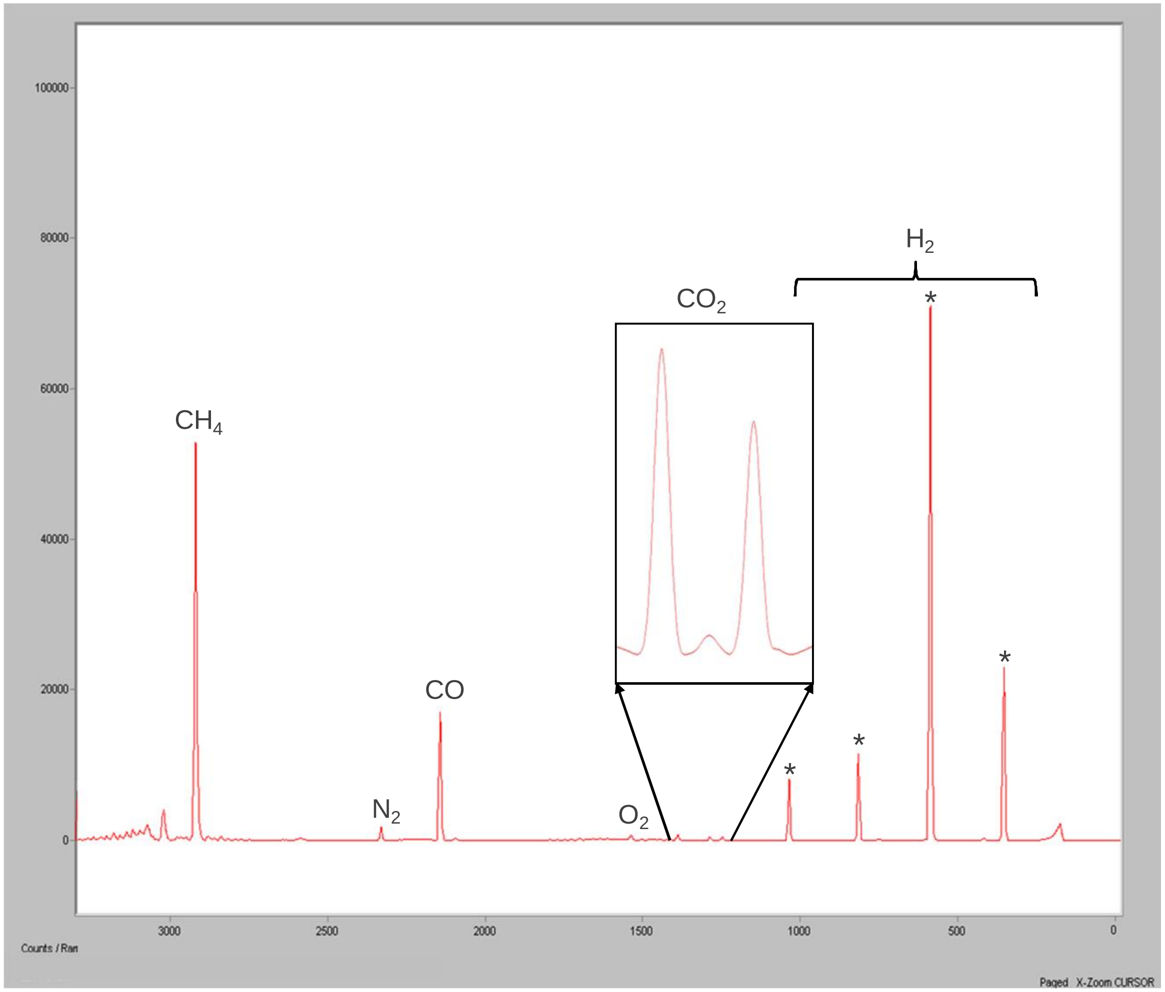
Current methods of Syn Gas analysis





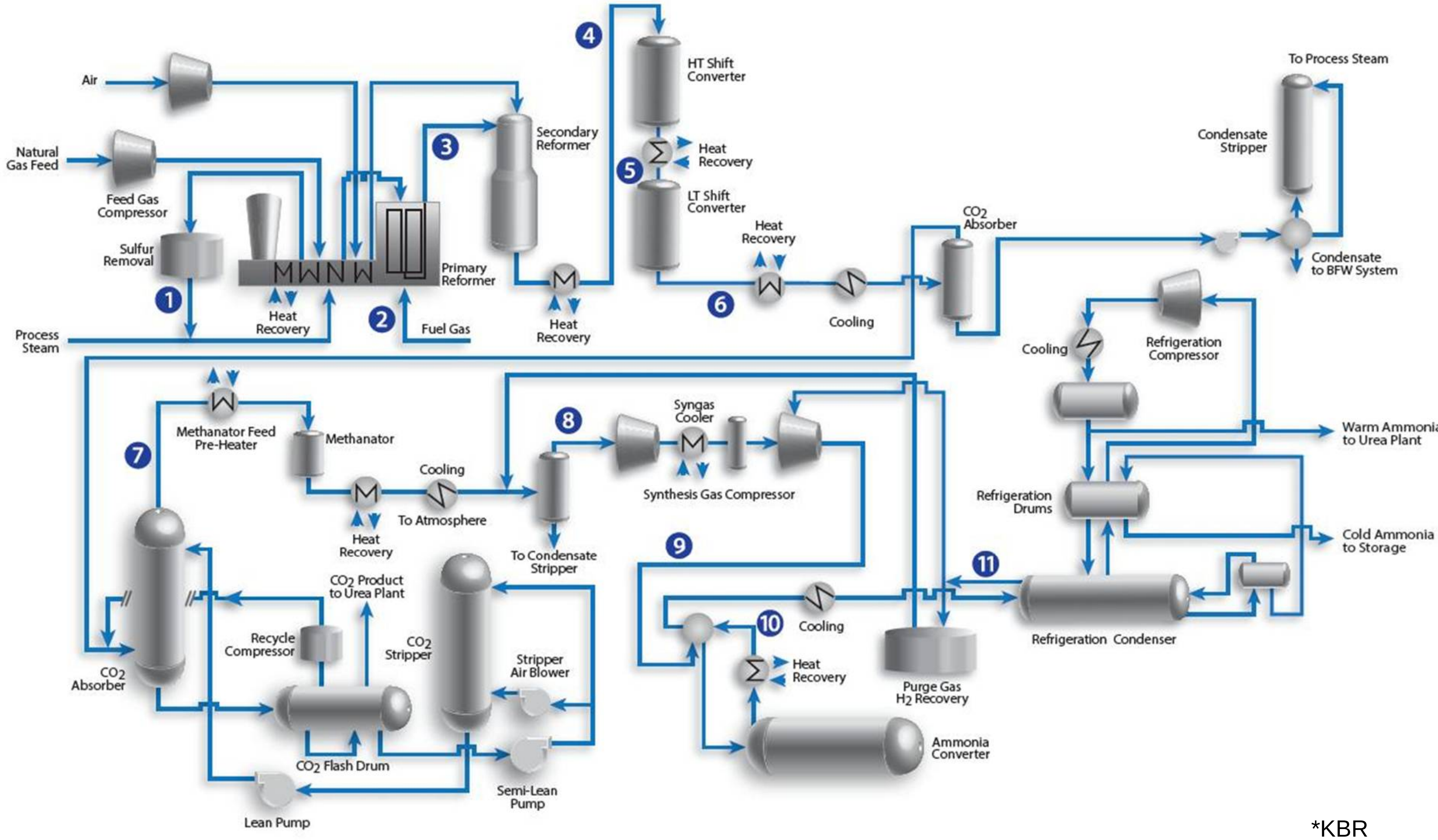


Typical composition picture for Syngas from Methane Reforming



- Single probe can do total measurement
- Only spectroscopic technique that can analyze H_2, N_2, O_2
- Complete baseline separation
- Spectrum has the simplicity of a chromatogram
- Use peak areas for concentrations (no complex models to maintain)

Applications – Ammonia Production*



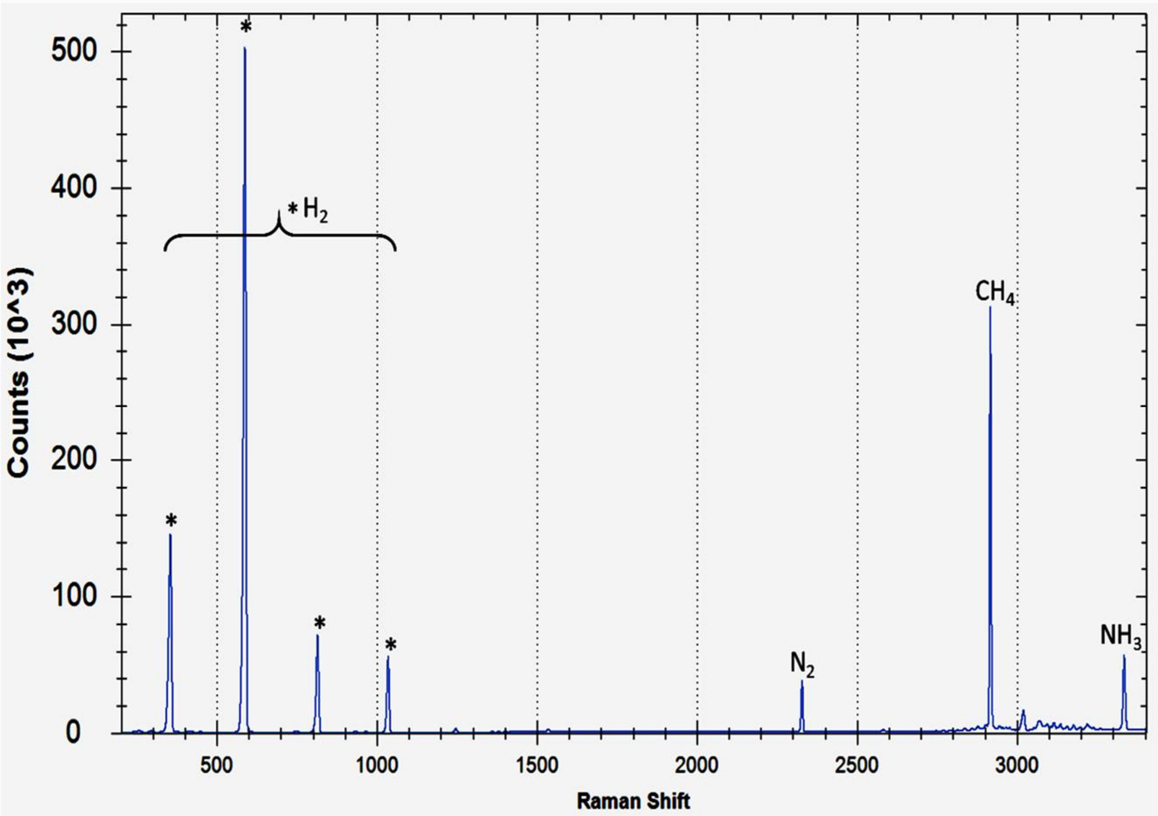
*KBR Design

Endress+Hauser

Ammonia Plant Applications

	Stream Service	Key Measurement Parameter	Pressure* (barg)	Temperature* (°C)	Recommended Sampling Interface
1	Natural Gas Feed to Reformer	Carbon Number	26	25	OptoAST
2	Fuel Gas to Reformer Furnace	BTU	6	40	OptoAST
3	Syngas from Primary Reformer	Composition/CH_4	36	800	OptoDRS
4	Syngas from Secondary Reformer/ Inlet to HT Shift Converter	Composition/CO	35	370	OptoDRS
5	HT Shift Converter Outlet/LT Shift Converter Inlet	Composition/CO	34	445	OptoDRS
6	LT Shift Converter Outlet/CO_2 Absorber Inlet	Composition/CO_2	32	220	OptoDRS
7	CO_2 Absorber Outlet/Methanator Inlet	Composition/CO_2	31	25	OptoAST
8	Methanator Outlet/Purified Syngas	Composition/H_2/N_2	30	330	OptoAST
9	Feed to Synthesis Loop	H_2/N_2 Ratio	57	400	OptoAST
10	Synthesis Loop Recycle Gas	Composition/ Impurities	220	440	OptoAST
11	Synthesis Loop Purge Gas	CH_4 Impurities	150	25	OptoAST

Typical composition picture for Ammonia Synthesis Loop Recycle



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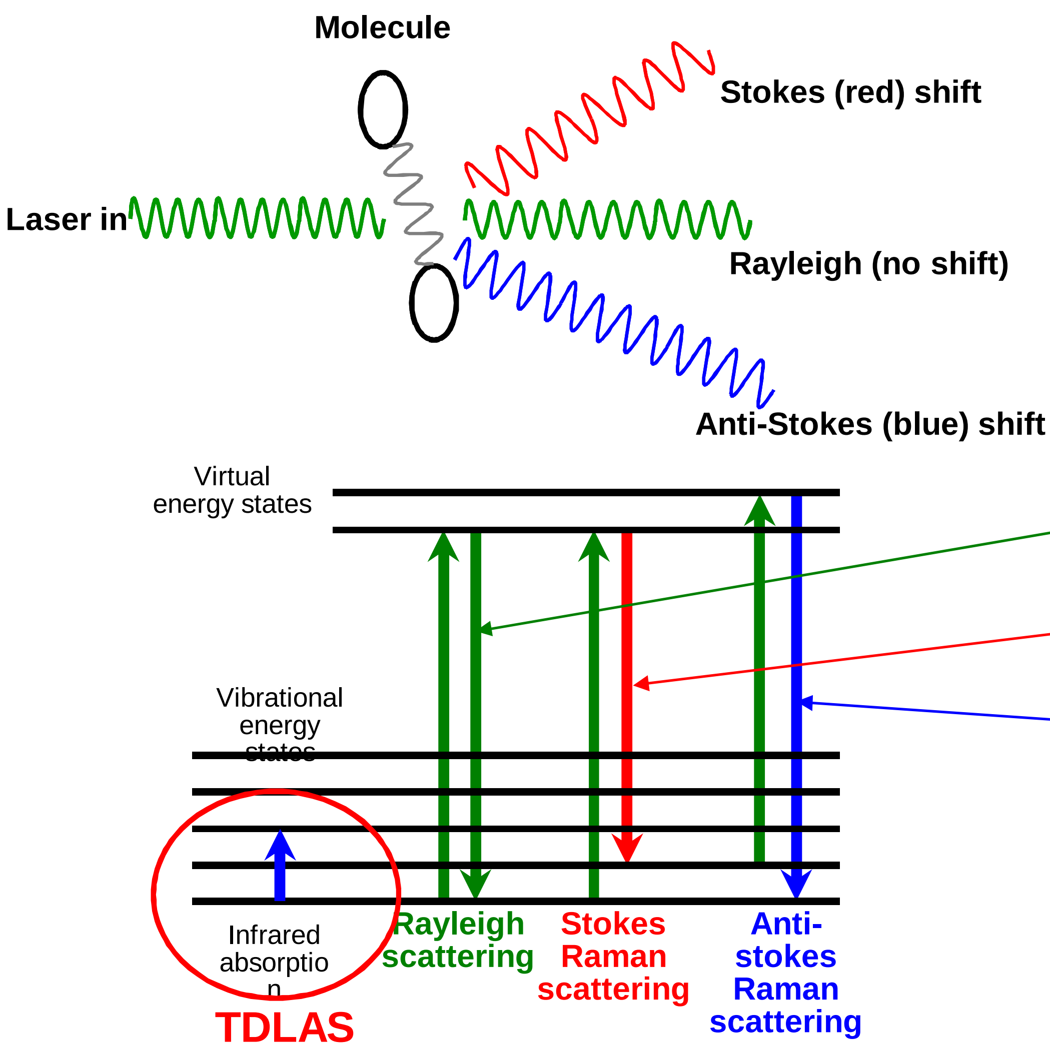
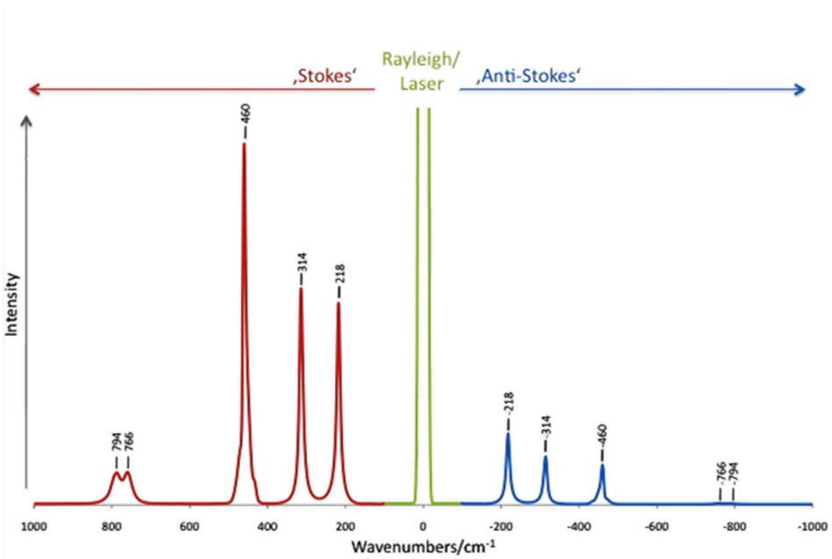
Basics of Raman Spectroscopy



- Molecular bonds vibrate
- Different bonds have different strength, or energy
- Raman scatter involves transfer of energy to these bonds
- There are three main types of Raman scattering
  - Rayleigh - No change in wavelength
  - Stokes Raman – Shift to lower energy (red-shifted)
  - Anti-Stokes – Shift to higher energy (blue-shifted)
- The color shift is unique to each chemical species
- The Optograf™ Analyzer uses Stokes Raman

What Does a Raman Spectrum Look Like?

Stokes and Anti-Stokes Raman Spectrum of CCl_4

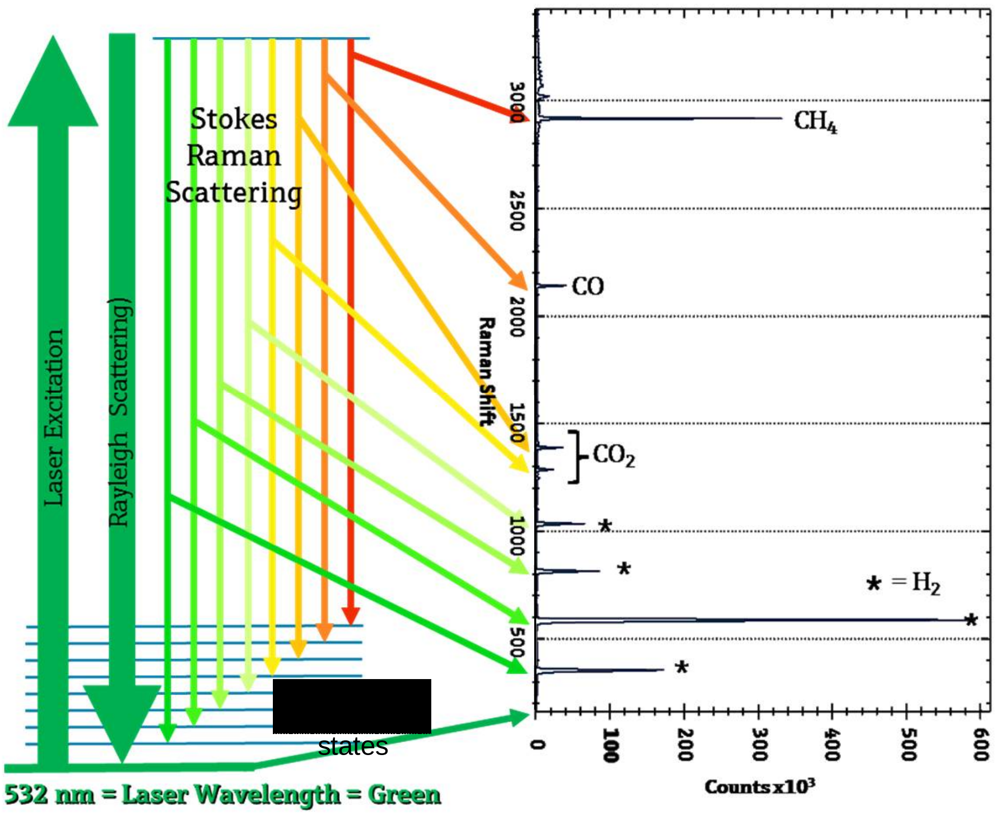


- Raman data are plotted as Raman Shift versus Intensity
- Raman shift is the amount of energy transferred to a bond
- Rayleigh scatter has no energy transfer, so has a Raman Shift of 0.
- Stokes and Anti-stokes lines have the same Raman Shift values
- Anti-stokes peaks are less intense

NOTE: Ratio of Anti-stokes to Stokes line intensities can be used to measure temperature

What about the Raman Spectrum of a Gas Mixture?

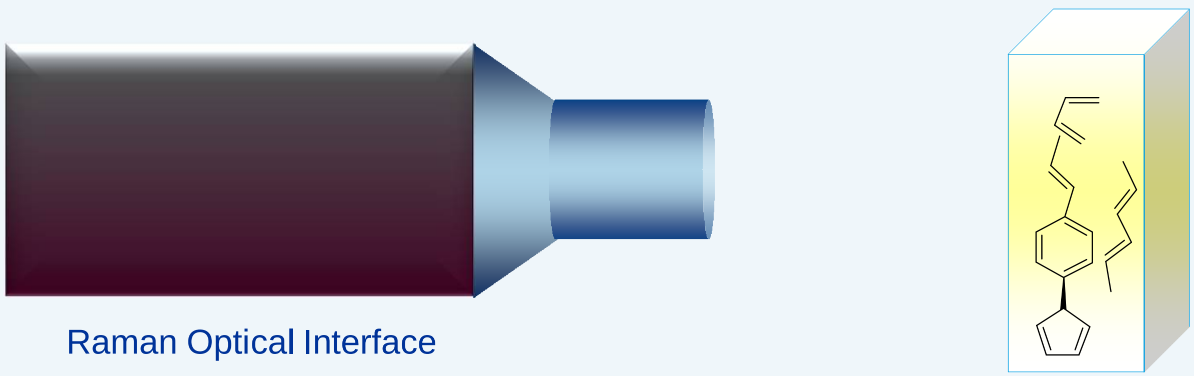
'One Color In, Multiple Colors Out'



- Simple molecular gases (e.g. CO, CO_2, H_2, N_2, NH_3) have simple Raman spectra, often a single peak
- Raman scatter from each type of molecule in the sample results in a different wavelength (color) of light emitted from the sample
- The Optograf analyzer measures all of these gases simultaneously, separating them 'by color'
- Simple spectra allow for the use of simple 'Method-based' analysis of mixtures

Raman Scattering – How is Raman Data Generated?

- Laser light of a specific wavelength interacts with molecules
- A number of scattered photons are shifted in wavelength due to specific energy transfer to molecules in the sample

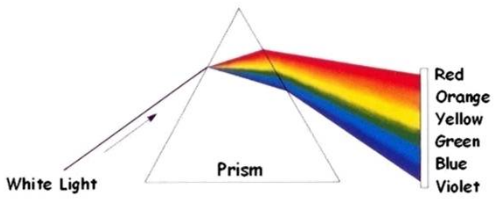


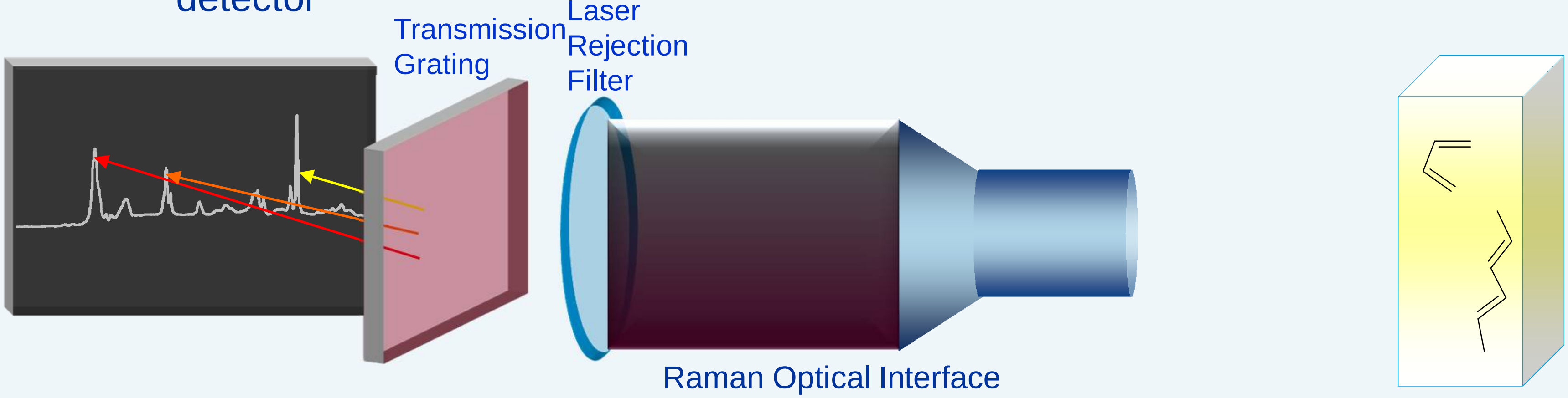
Laser light of specific wavelength (Rayleigh scattering)

Wavelength-shifted light (Raman scattering)

Raman Scattering – How is Raman Data Collected?

- Only back scattered photons are collected
- Laser Rejection Filter removes original laser light
- Light is spatially separated using a Transmission Holographic Grating, like a Prism separates sunlight into colors
- Raman photons are simultaneously detected with a CCD detector

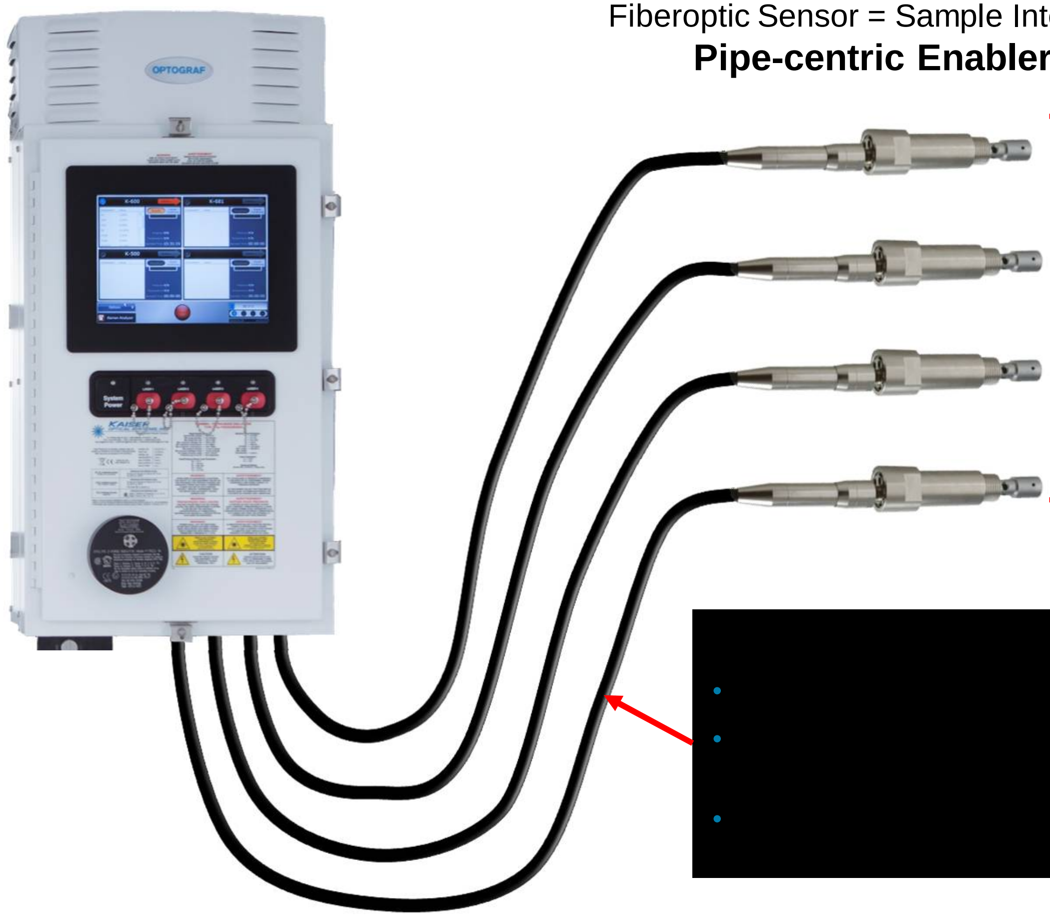




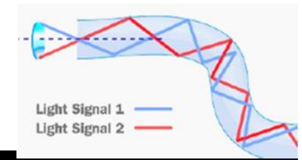
Laser light of specific wavelength (Rayleigh scattering)
Wavelength shifted light (Raman Scattering)

The Optograf Analyzer

Optograf Base Unit
(18”W x 10”D x 32”H)



Fiberoptic Sensor = Sample Interface
Pipe-centric Enabler



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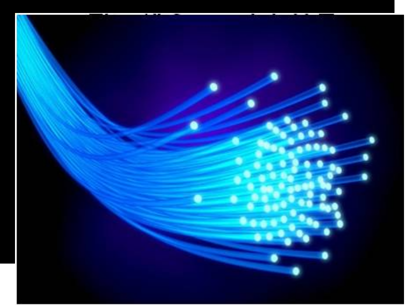


Endress+Hauser

The complete Raman solution

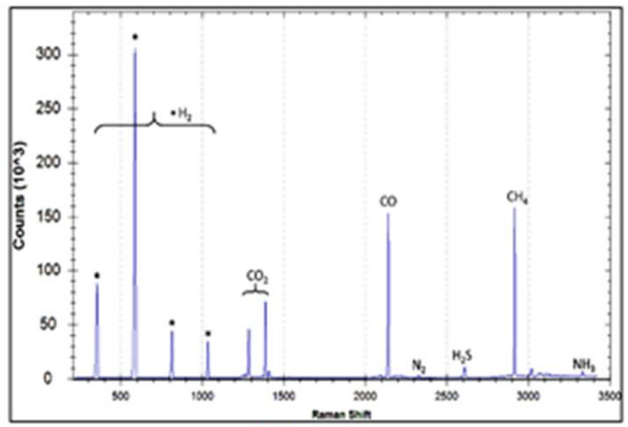
Optical fiber
<100m

Sample Probe

- Installed at the sample tap
- Sample Streams include
  - Reformers
  - Gasifiers
  - Shift Converters
  - PSA
  - Methanators
  - Synthesis Loops
    - Ammonia
    - Methanol

Sample Interface

- Non-extractive Optical Probe
- Multiple Options
  - Conventional
  - OptoAST
    - Moderate Temp and Dry
  - OptoDRS
    - Particle-laden, Hot, Wet
- Works at process P and T
- No Flare
- Class 1/Div 1; Zone 1



Optogram

Analysis Result

- Full stream composition
- Baseline peak separation
- Peak areas proportional to concentration
- Simple method-based analysis (no complex models)
- Can output BTU, Wobbe Index as derived values

Base Unit

- Laser-based analyzer
- No columns
- No stream switching
- No sample transport
- No carrier gas
- Analyze 4 independent streams at one time
- Class 1/Div 2; Zone 2

Endress+Hauser

Syngas Installation Example – Fieldside mounting arrangement of Raman Pro

Optograf Installation Example – Base Unit

Optograf™ Analyzer for Syngas – Advantages

- Reliability of a spectroscopic system (no critical moving parts)
- Unique spectroscopic capability of measuring the diatomics H_2, N_2
- Transparent to moisture vapor – streams do not have to be bone dry
- Speciation similar to a GC but without valves, columns, carrier gas
- Maintenance skill level required is less than that for a GC
- No consumables
- No time penalty for update times when analyzing multiple streams; all streams analyzed simultaneously
- No regular calibration required
- No chemometrics modelling or model maintenance is required

Syngas Pipe-Centric Analysis – Advantages

- More reliable analysis: sampling and conditioning at the sample tap (no sample transport and conditioning issues at the analyzer/shelter)
- Reduces infrastructure costs
  - Minimize sample conditioning – working at line pressure
  - Sample transport – no need heat traced tubing
  - No shelter – in many parts of the world a shelter is optional
- Sampling and measuring at line temperature/pressure provides for better opportunities to return sample to the process (no flaring)
- Analysis update times are reduced (no lag time, no sample transport)
- Improved safety, as any hazardous/explosive or toxic samples are contained at the sampling point

Thank you very much for your attention