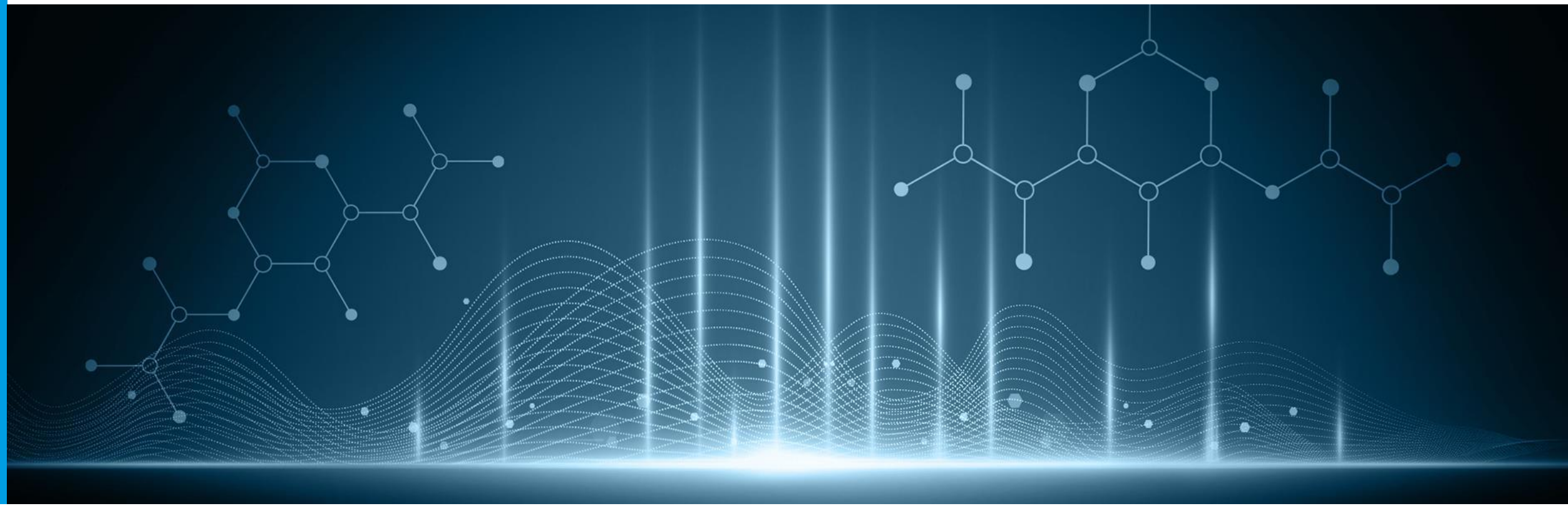
Introduction to Endress+Hauser Optical Analysis

Optical-based analytical solutions for Cleaner Industries (LNG, H2 and CCUS)

Sachin Samel, General Manager (Asia Pacific) – Analysis



Agenda

- Introduction to Endress+Hauser Optical Analysis
- Technology & Product (TDL, QF) Overview
- Success Stories – TDL, QF (Green Hydrogen, CO2 Capture)
- Technology & Product (Raman) Overview
- Success Stories – Raman (LNG, Green Ammonia, Hydrogen / Natural Gas Blend, CCUS)
- Q&A

Presenter Profile

Sachin Samel

Current Role

- General Manager (Asia Pacific) – Analysis based in Singapore
- Commenced role 1st January'21

Previous Role

- Various position at ABB & Local System Integrator based in Melbourne, Australia
- Last Role as General Manager (ABB) – Measurement & Analytics Business Unit in Australia

Experience

- Over 20+ years of experience in various analytical technologies such as Gas Chromatographs, Continuous Gas Analysers, Liquid Analysers, Sample Conditioning System

Notable Projects

- INPEX Ichthys Project, Darwin, Australia
- Queensland Gas Company LNG (QGCLNG), Australia Pacific LNG (APLNG), Karratha Gas Plant Expansion, Woodside, Australia
- Linc Energy Underground Coal Gasification

Professional Memberships

- Instrument Society of America (ISA)
- Institute of Engineers Australia & qualified as "Chartered Engineer" in Australia under ASCO 2129-70

Educational Qualification

- Master of Business Administration (Marketing & Finance)
- Bachelor of Engineering (Instrumentation)

The world of Endress+Hauser

Our product offerings

- Level measurement
- Flow measurement
- Pressure measurement
- Analytical measurements
- Temperature measurement
- System products and data managers
- Software solutions

Endress+Hauser Process Analyzers Overview

Endress+Hauser Liquid Analysis

Headquarter: Gerlingen (near Stuttgart)
- Production: Electronics, metal cutting, measuring systems, assemblies
- R+D, Marketing
- Management

- Founded in 1970
- Integration into E+H 1977
- > 1.000 employees
- > 1.000 patents and patent applications

Waldheim / Saxony
- R+D
- Production

Groß-Umstadt / Hesse
- Analysis support
- Engineering

Suzhou / China
- Production

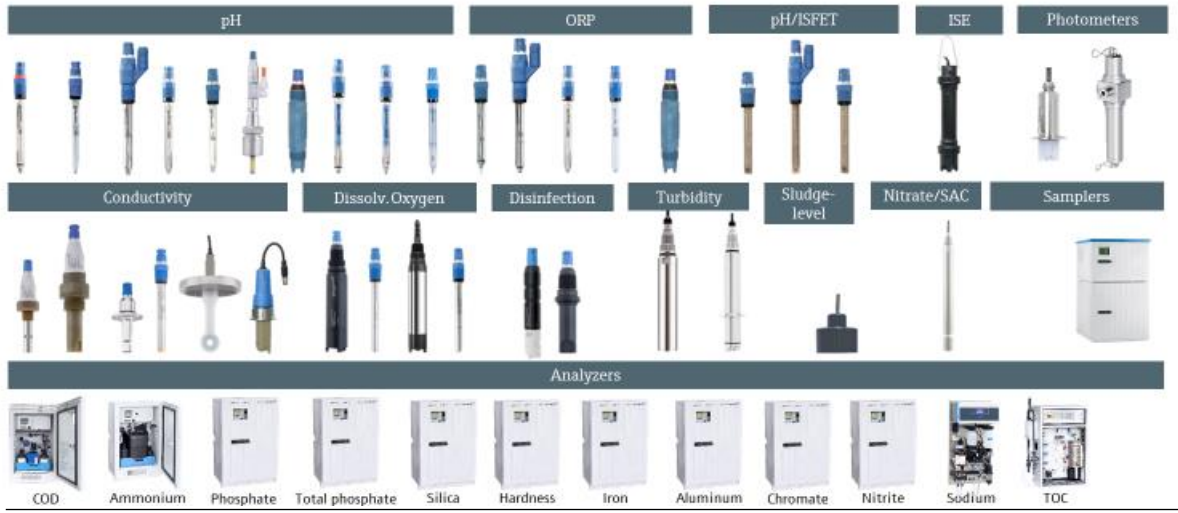
Anaheim / California
- Production
- R+D

Endress+Hauser Optical Analysis

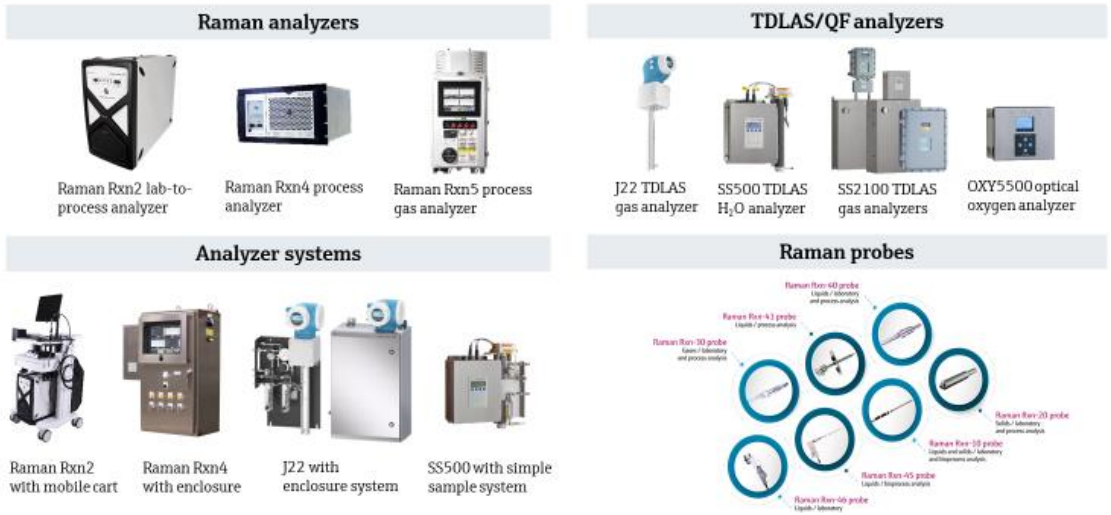
Ann Arbor, MI USA
Headquarters & Raman center of excellence

Rancho Cucamonga, CA USA
TDLAS center of excellence

Liquid Analysis Products offerings



Optical Analysis Products offerings



Endress+Hauser Optical Analysis - History

SpectraSensors

1999
SpectraSensors Inc. formed

1999
NASA Space Qualified TDLAS Technology, launched on the 1999 Mars Lander

2001 -2008
Launched H2O /H2S in Natural Gas

Founded
Michigan, USA
1979

Notch Filter, holographic
1990

1993
Introducing Raman Analyzer
(HoloProbe)

European Office
1998

2005
ISO 9001 Registration

2013

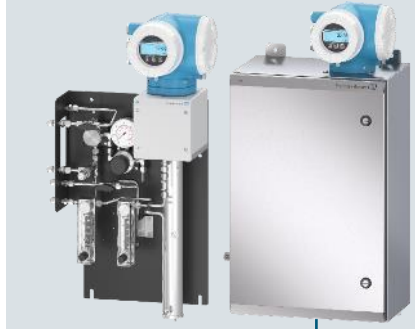
2009
Awarded Technology Innovation of the Year by Frost & Sullivan

2013
Endress+Hauser acquires Kaiser Optical Systems.

2012
SpectraSensors Acquired by Endress+Hauser

Endress+Hauser

2018
Installed base 10,000+ TDLAS analyzers globally



2021
Launch of J22 TDLAS Gas Analyzer

2022
Formation of New company in EH

Endress+Hauser
Optical Analysis

Endress+Hauser

E+H Optical Analysis Portfolio – Kaiser Raman and Spectrasensors TDLAS

E+H Optical Analysis Product Portfolio

E+H Solutions Portfolio

Analyzer (spectrometer)

- Standard and TSP
- Documentation
- Services

Analyzer Systems

- Standard and TSP
- Documentation
- Services

Analyzer Measurement Solutions

- Sunshade Racks, Cabinets and Shelters
- Concept to Execution
- Power and communications Distribution
- Calibration Gases
- PLC's and Stream Switching Systems
- Sample Extraction Probes
- Sample Transport & Preconditioning
- Documentation
- Services

Optical Analysis Technologies

Endress+Hauser Optical Analysis

TDLAS
Technology Center (RC)

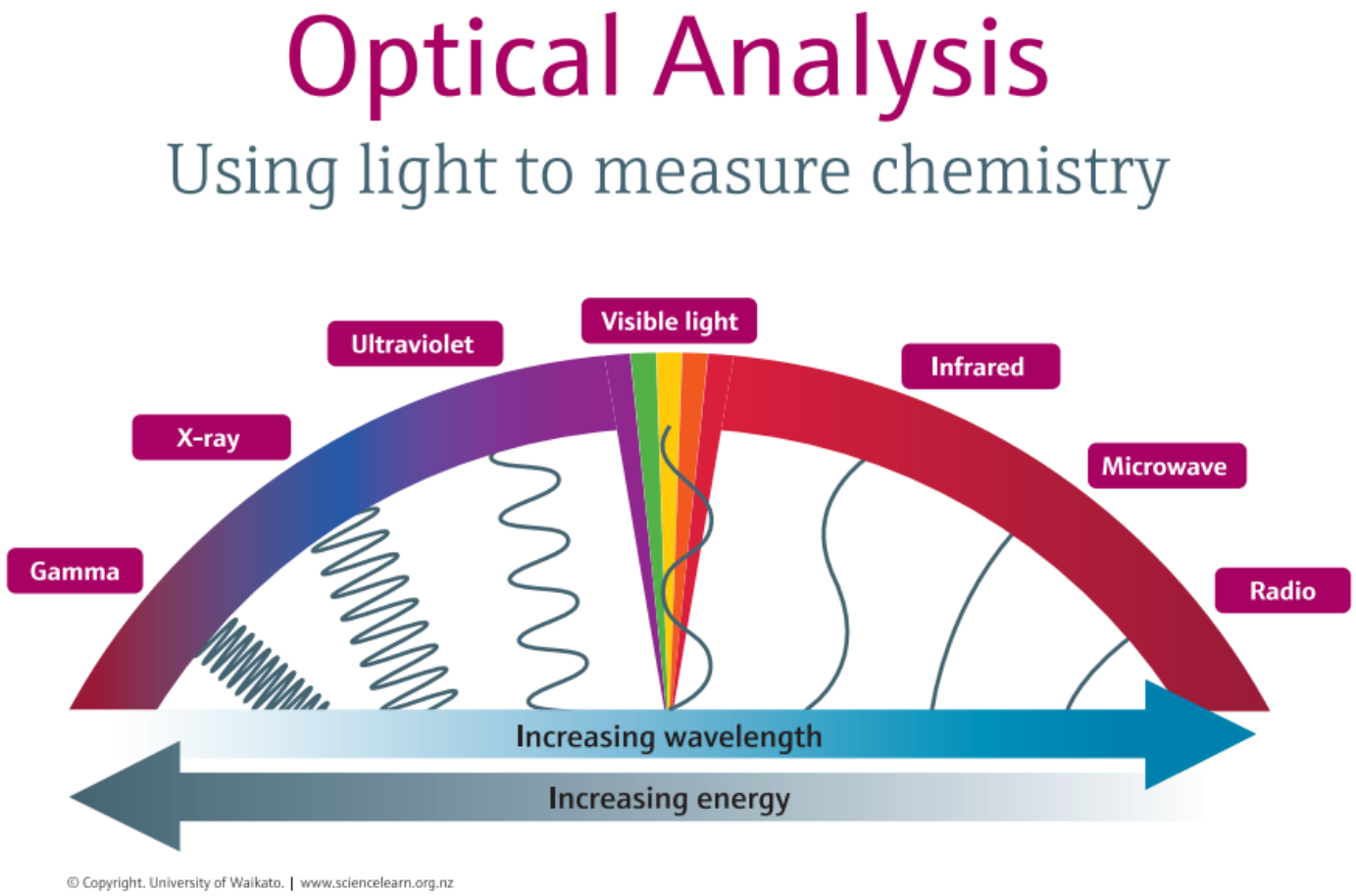
- TDLAS (Gas)
- QF (Gas)

Raman
Technology Center (AA)

- Raman (Liquid, Gas, Solids)

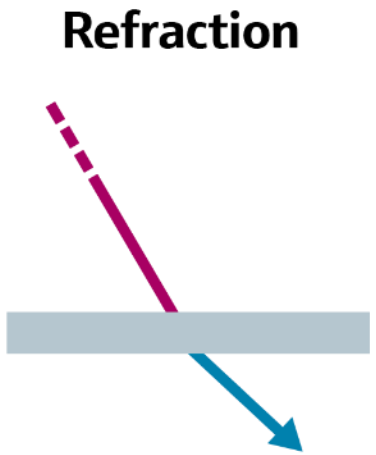
- 3 Different Technologies
- Individual Analyte
- Composition Measurement
- Liquid Phase
- Gas Phase
- Solid Phase
- 4 Core Industries

Light measurement technologies

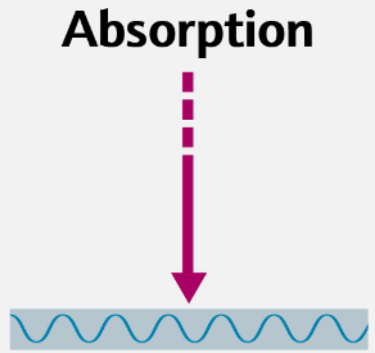


Reflection, Scattering, Absorption, Refraction, Thermal Emission, Fluorescence, Raman

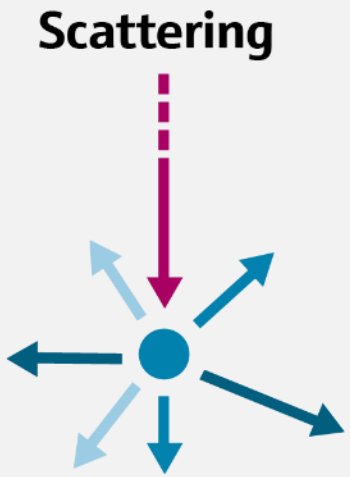
What happens when light interacts with matter?



Refractive Index (RI)



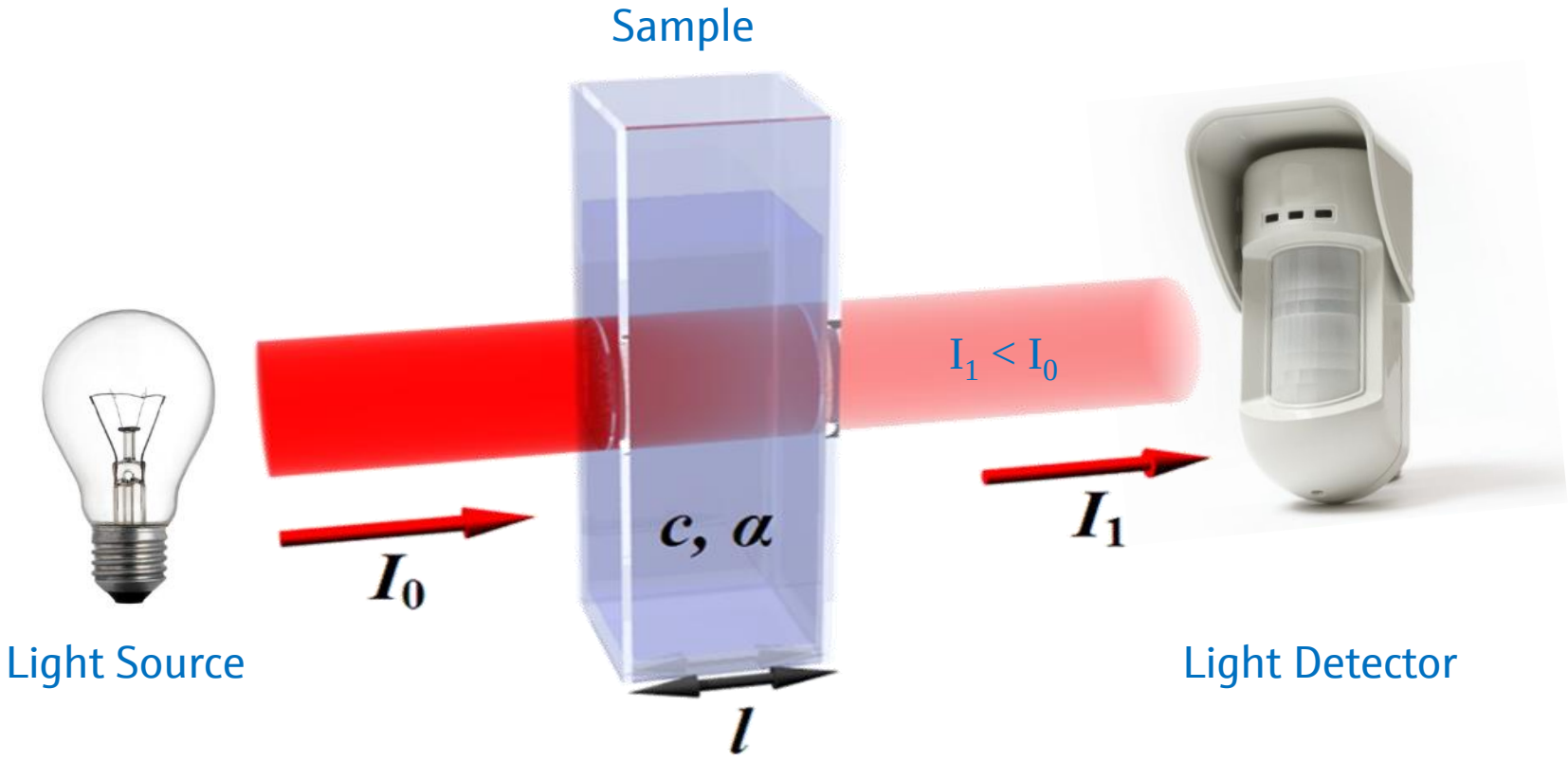
UV/VIS & TDLAS



Raman spectroscopy

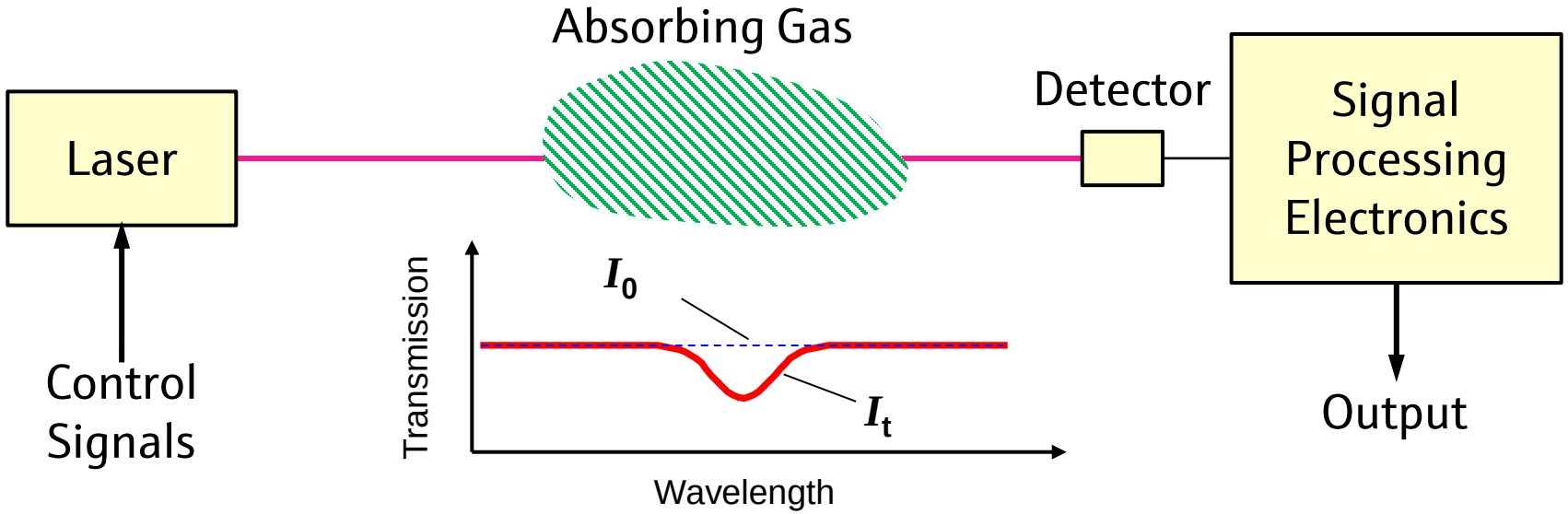
Absorption Spectroscopy

- Absorbance is a function of (concentration, path length, and absorptivity)
- Concentration (c) increases → Absorption increases
- Path length (l) increases → Absorption increase

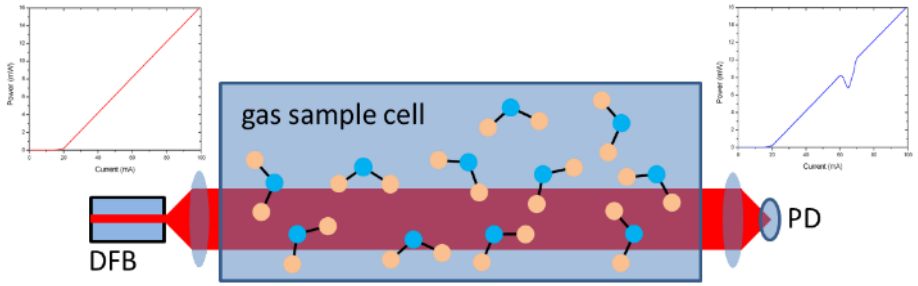


What is TDLAS? & How Its works ?

- **T**unable **D**iode **L**aser (the light source)
- **A**bsorption **S**pectroscopy



- Infrared Analyzer → TDLAS analyzers use a focused laser beam
- Light travels through gas → Interaction Length (L) affects sensitivity



- Transmitted Light (I_t) reflects back to a solid-state detector
- Transmitted Light (I_t) is measured with respect to Initial Light (I_0)
- Absorbed light is used to determine concentration

J22 TDLAS - The “Award-winning” Product

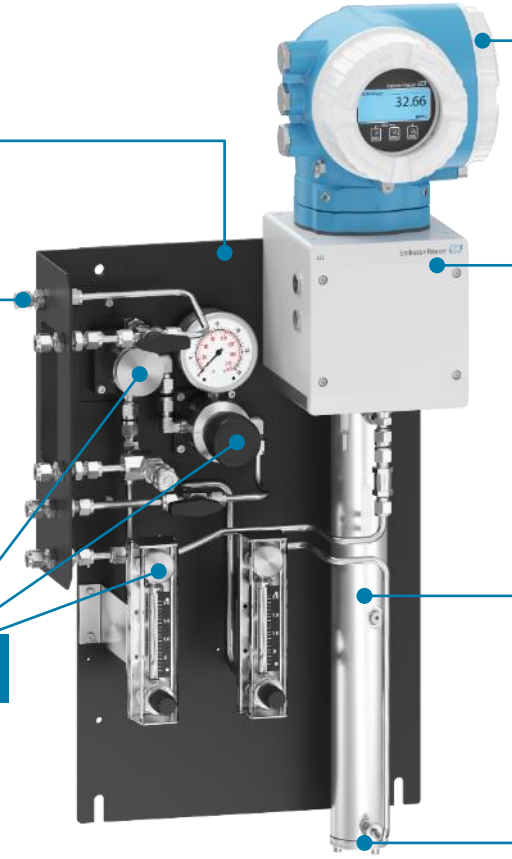
Panel mount

Gas connections

- Sample in/out
- Verification
- Bypass out
- Relief vent*
- Safety purge*

Sample conditioning

- Bypass*
- Filtration
- Flow control**
- Pressure control
- Pressure relief*



Controller

- Power & I/O**
- User interface

Optical housing

- Laser
- Detector
- Pressure and temperature sensor

Sample cell

- Gas flow cell

Flat mirror

Enclosure

- 304 stainless steel
- Insulation*
- Heater with temp control*

Heater power

* Optional
**Upgraded 2-22-2022

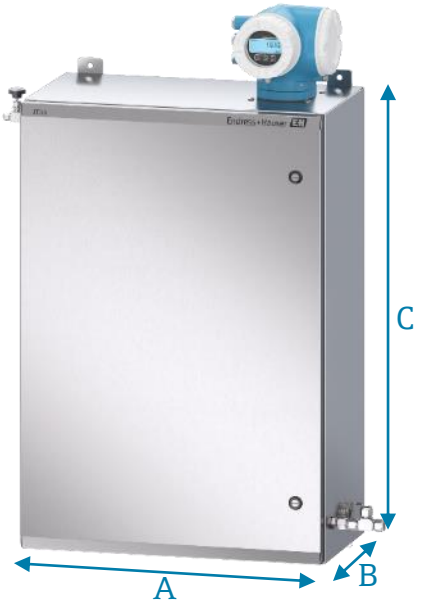
Resistance to contamination - measurement method comparison

Gas phase contaminant	Al_2O_3	P_2O_5	Quartz crystal	Chilled mirror	TDLAS
Methanol	◗	◗	◗	◗	✓
Glycol	◗	◗	◗	◗	✓
Amine	◗	◗	◗	◗	✓
Mercury	●	✓	✓	✓	✓
Hydrogen sulfide	●	◗	◗	●	✓
Hydrogen chloride	●	◗	◗	●	✓
Chlorine	●	◗	●	●	✓
Ammonia	●	◗	●	●	✓

✓ = Analyzer unaffected ● = Can cause permanent damage to sensor ◗ = Can cause slow or inaccurate readings

JT33 TDLAS gas analyzer for H_2S measurements

- Familiar look, overall structure, look & feel as J22 but with an increased sample conditioning system box

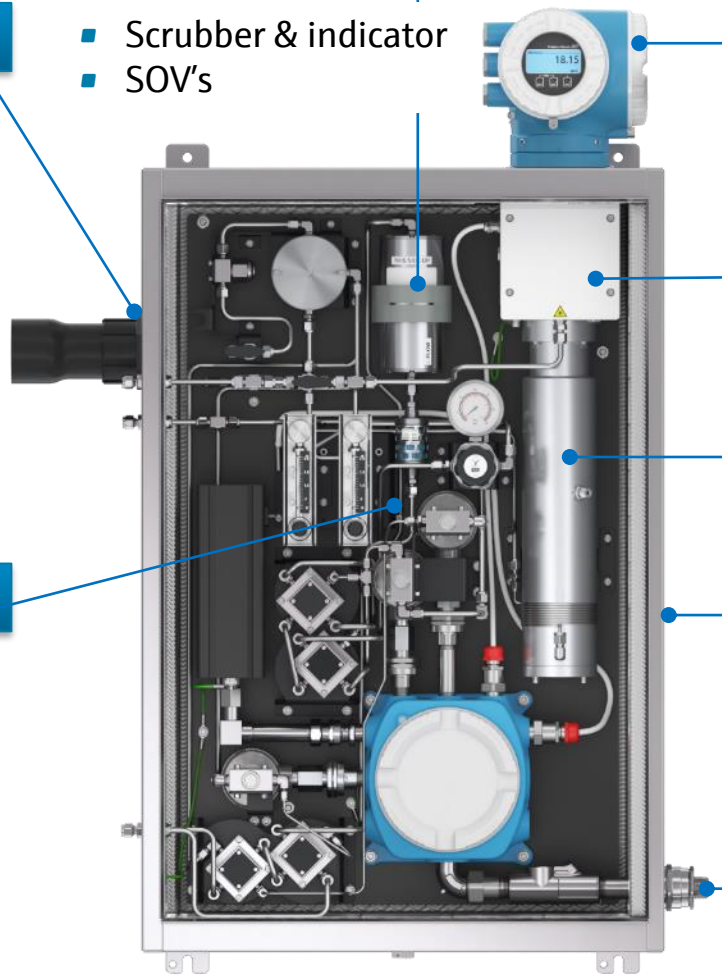


	J22	JT33
A	406mm (16 in)	610mm (24 in)
B	229mm (9 in)	332mm (13 in)
C	610mm (24 in)	914mm (36 in)

JT33 TDLAS gas analyzer system - architecture

Differential components
- Scrubber & indicator
- SOV's

Gas connections
- Sample in/out
- Relief vent
- Verification
- Bypass out
- Safety Purge*



Controller
- Power & I/O
- User interface

Optical Housing
- Laser & Detector

Sample Cell
- Gas flow in Herriott cell

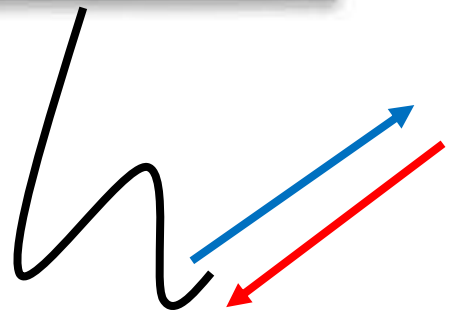
Sample Conditioning
- Bypass
- Filtration
- Flow control
- Pressure control
- SOV's for differential and validation

Enclosure
- With heater for temp control

Accessory Power

*optional

Quenched Fluorescence O_2 Analyzer – Principle of Operation



Fiber Optic Probe

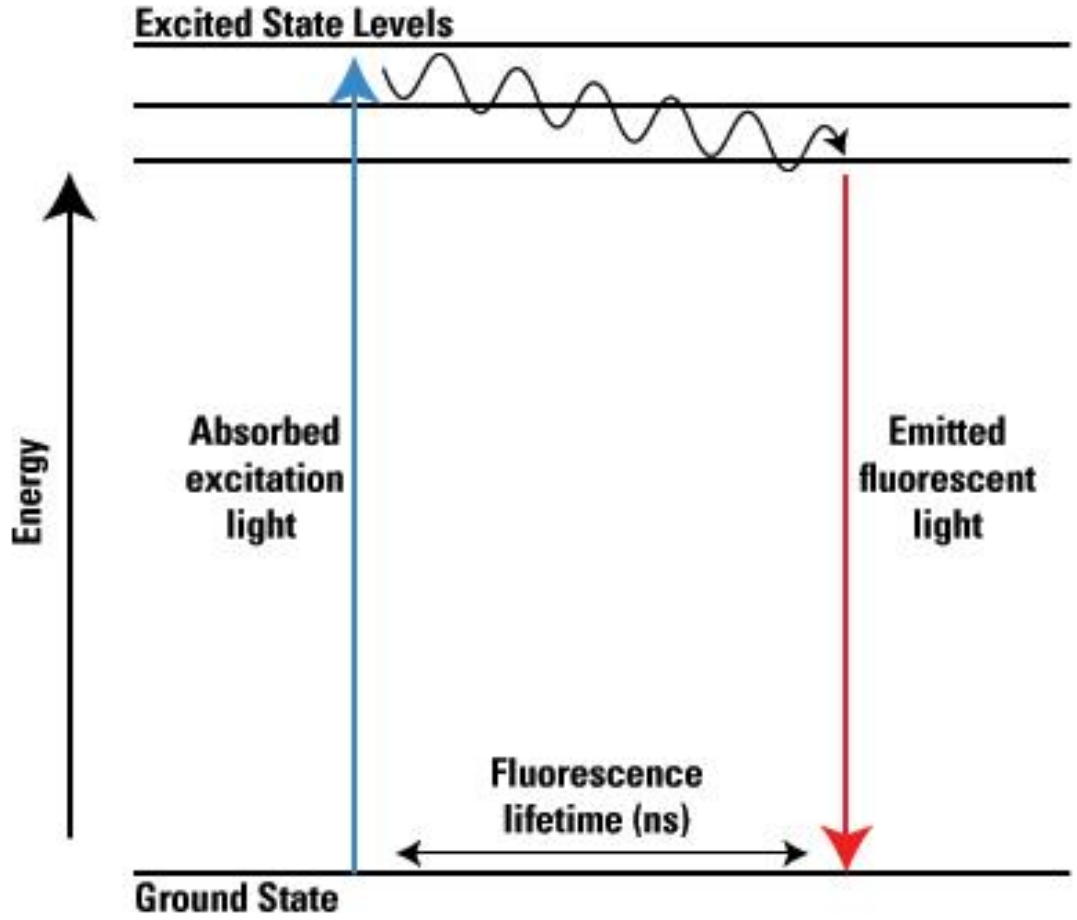
Optical transmit and receive signals to analyzer

Fiber Optic Probe

Sensor at tip of Fiber Optic Probe

O_2 Molecules

Jablonski Energy Diagram Depicting Excitation and Emission



- Light from a **blue** light emitting diode is strongly absorbed by the dye around 450 nm
- Fluorescent (**red**) light is emitted around 600 nm

E+H OXY5500 O_2 Analyzers

- Introducing the OXY5500
  - Immune to H_2S!
  - No H_2S Scrubbers required
  - No Interferences in Natural Gas
  - Lower Cost to Operate (Long Sensor Life)
  - Reliable - Minimal Maintenance
  - Faster Response Time versus other O_2 analyzers
  - Wide ranges available:

SpectraSensors
OXY5500

	OP-9	OP-6	OP-3
Measurement Range	0-300 ppm	0-5%	0-50%

E+H J22 & OXY5500 in H2 Production (US & EU)

Enapter Invenergy

Client's challenges

Client is Global Electrolyser Manufacturer for Green Hydrogen. Need for quick breakthrough of contaminants, mainly H2O and O2 in H2 purity.

The objective

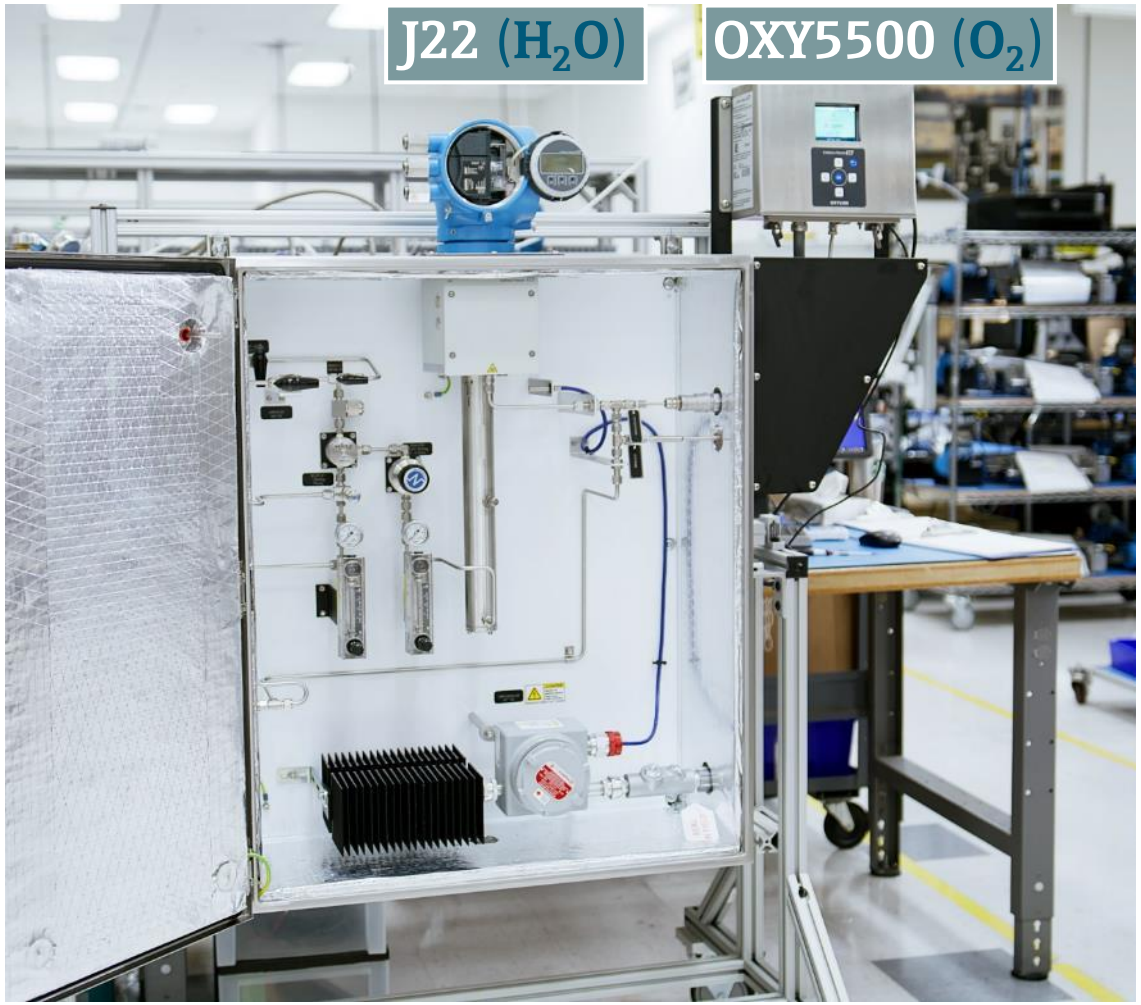
Speed of Response, Analyser availability & Analyser Performance

The E+H Solution

J22 H2O, OXY5500 O2 along with Sample System

The outcome

First PO received with intentions to standardize on subsequent packages.



Reliable Analysis on FPSO – 13 Systems in 2 years (5-Malaysia/8-Singapore)

Client's challenges

Accessibility is an issue always as this is remote, hence Customers are looking for drift free, reliable analyzers.

The objective

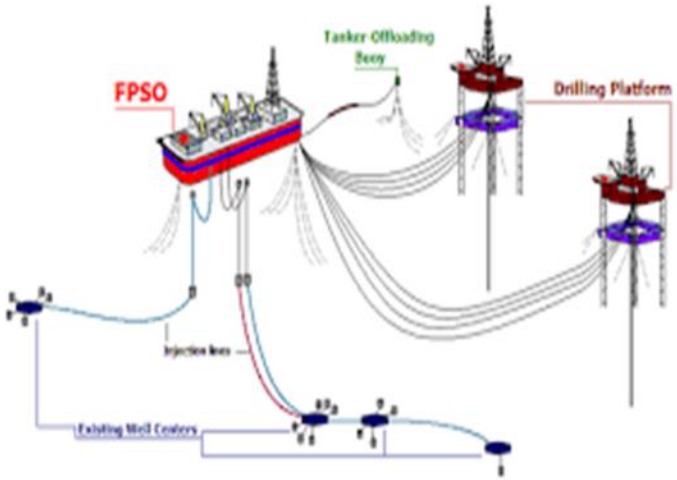
To achieve better control and optimize Amine treatment process is challenge without reliable Advanced analyzers.

The E+H Solution

SS2100i-2 Combo unit to measure H2S and CO2 in one package. The whole package including sampling system and accessories are supported by E+H.

The outcome

Several analyser systems have been successfully supplied on multiple FPSO projects which are being executed out of Asia Pacific.

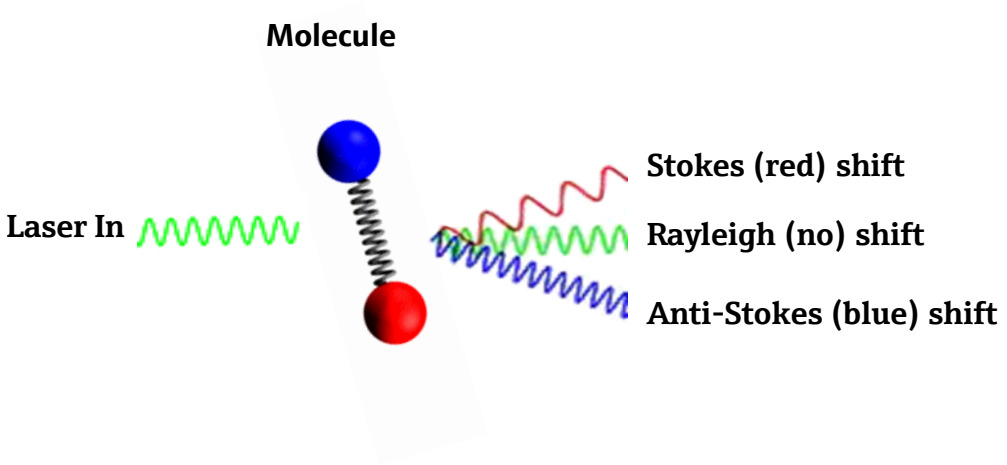


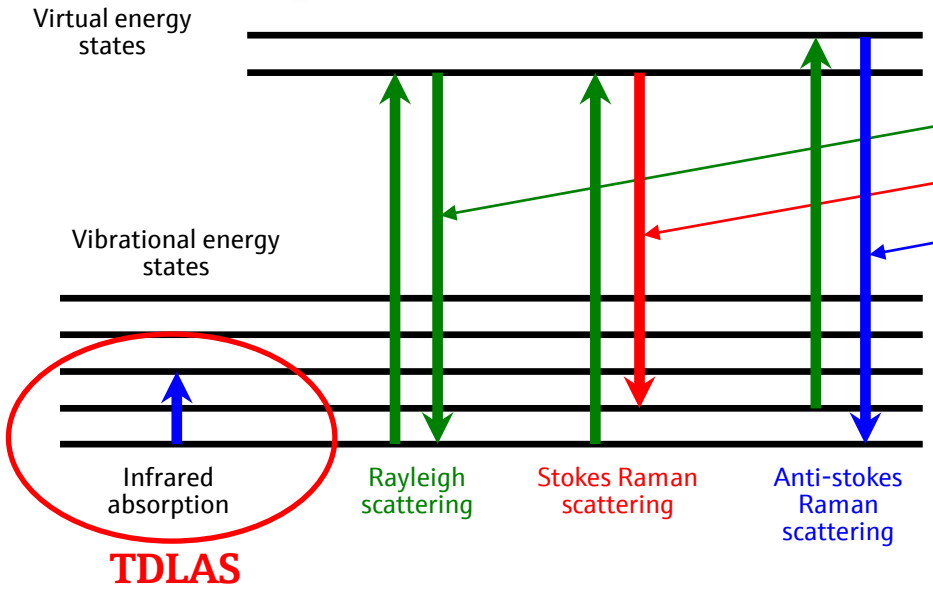

Malaysia


Singapore


Malaysia

Basics of Raman Spectroscopy

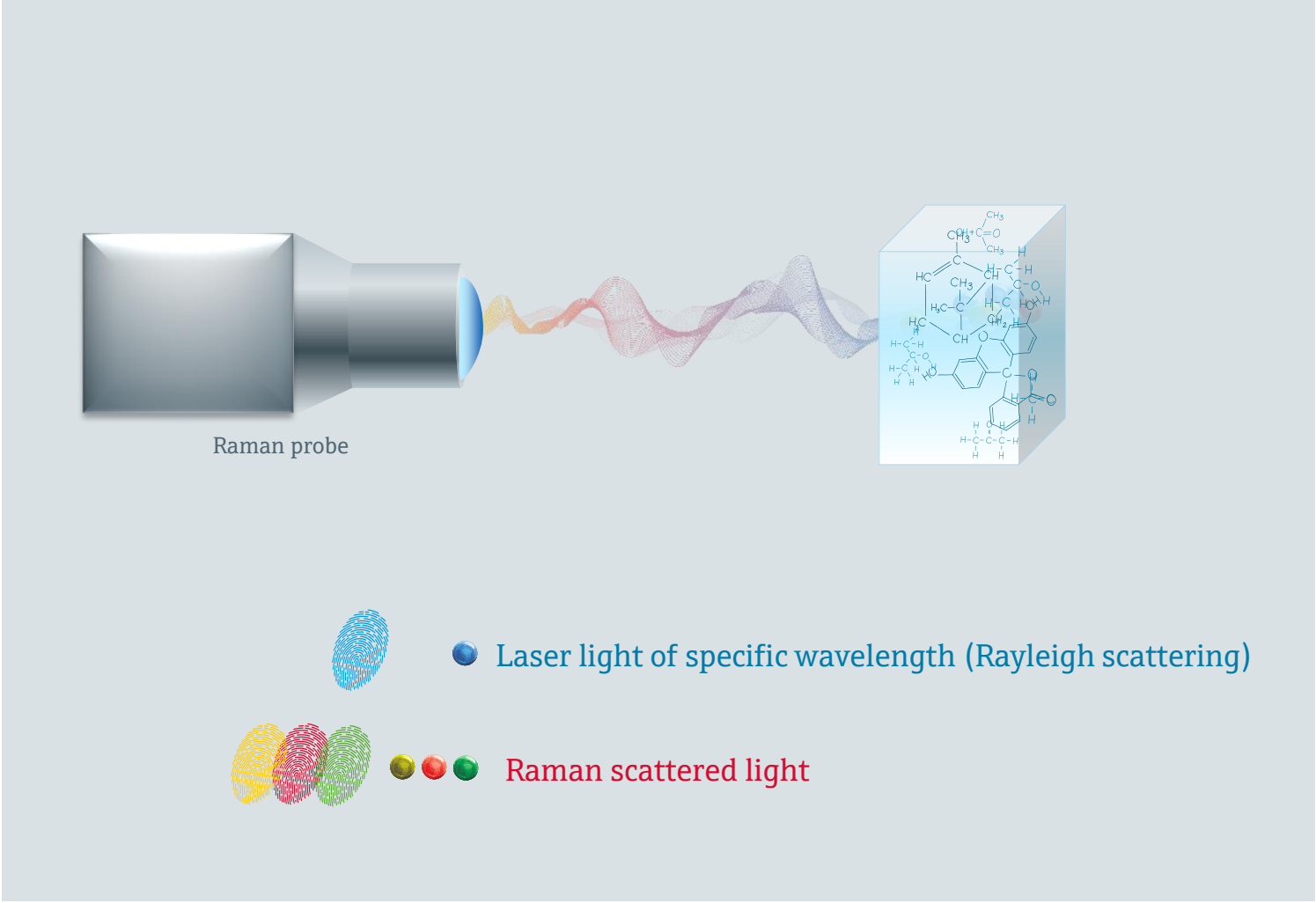




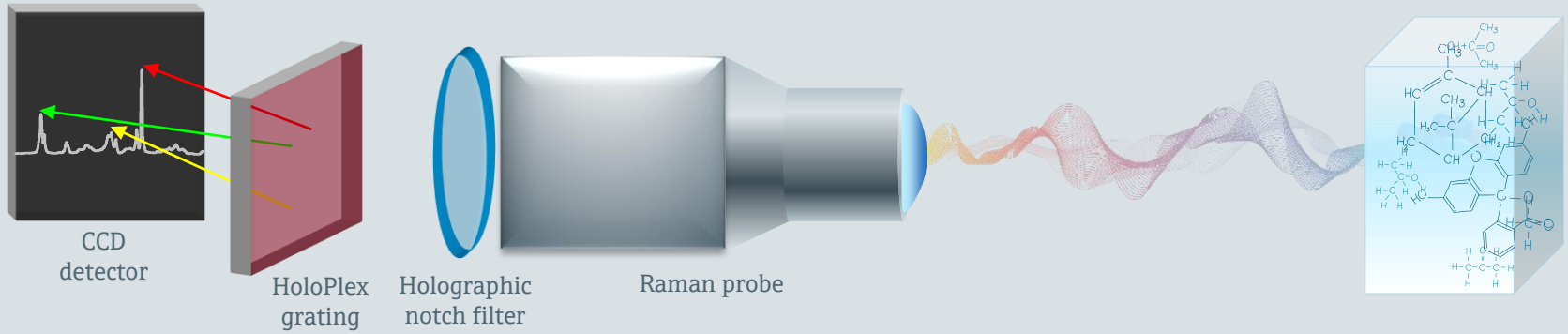
- Molecular bonds vibrate
- Different bonds have different strength, or energy
- Raman scatter involves the transfer of energy of the laser to these bonds
- There are three main types of Raman scattering
  - Rayleigh - No change in wavelength
  - Stokes Raman – Shift to lower energy (red-shifted)
  -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

The principle of Raman

- Laser light of specific wavelength interacts with molecules which causes scattering
- 1 out of 10^8 photons is frequency-shifted due to specific energy transfer (Raman shift)
- Result: specific photons allow identification and quantification of materials (solvent, products, substrate)

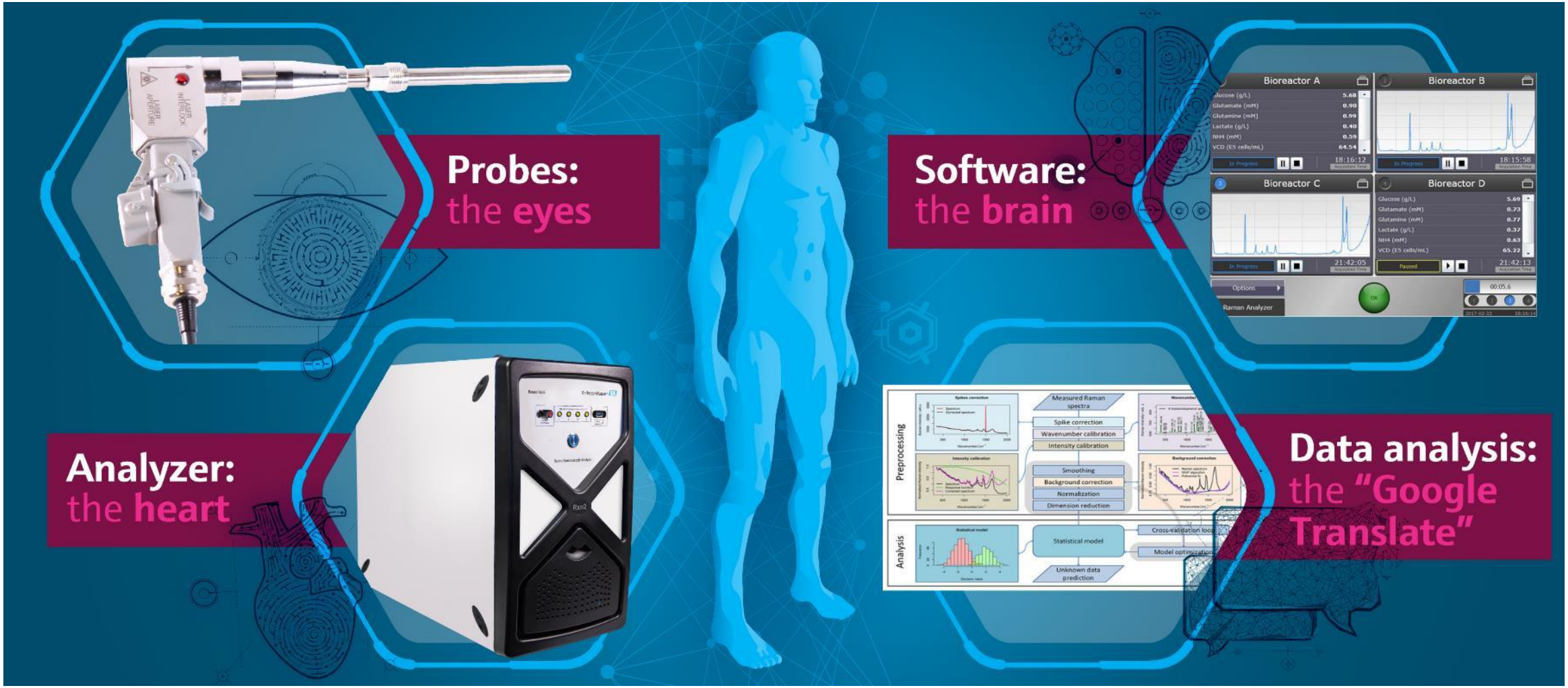


Raman technology illustrated



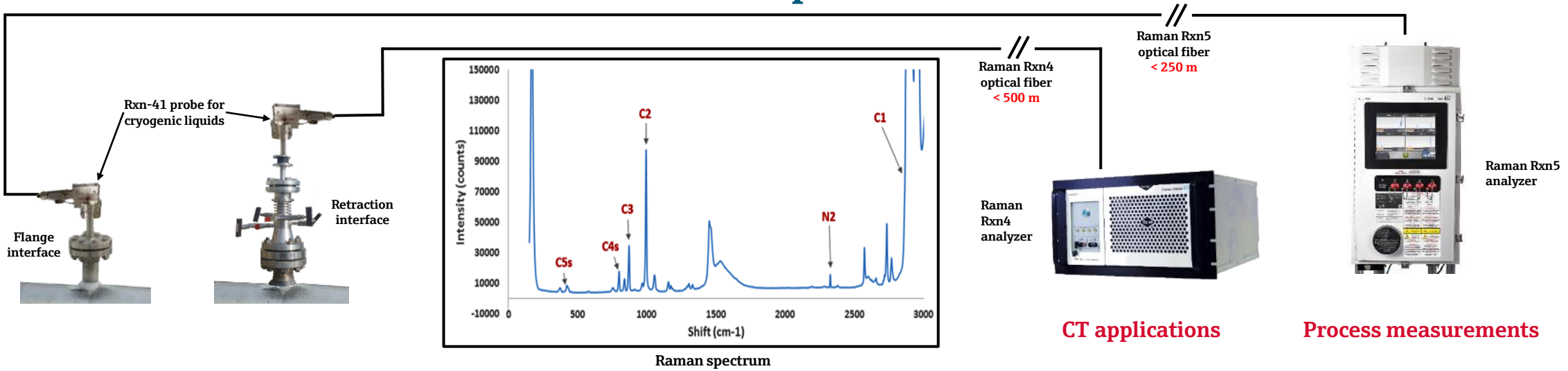
The collected light is interpreted as a spectrum by the camera, creating a “molecular fingerprint” of the material that you are sampling.

Components of our Raman analyzer systems



E+H Raman solutions measure directly in cryogenic liquids

LNG example



Raman spectrum

Sample streams

- Installed at the sample tap
- Raman Rxn4 analyzer for custody transfer **(CT)**
- Raman Rxn5 analyzer for process measurements
- Sample streams include
  - LNG custody transfer
  - LNG truck loading
  - LNG bunkering
  - LNG quality adjustment
  - LNG rundown
  - Mixed refrigerants

Sample interface

- Rxn-41 cryogenic insertion probe for liquids
  - Direct flange-coupled
  - Retraction Interface option
- All SS design for corrosion resistance
- Rxn-30 probe for gas streams
- Measure LNG as a cryogenic liquid
- Class 1/Div 1; Zone 1

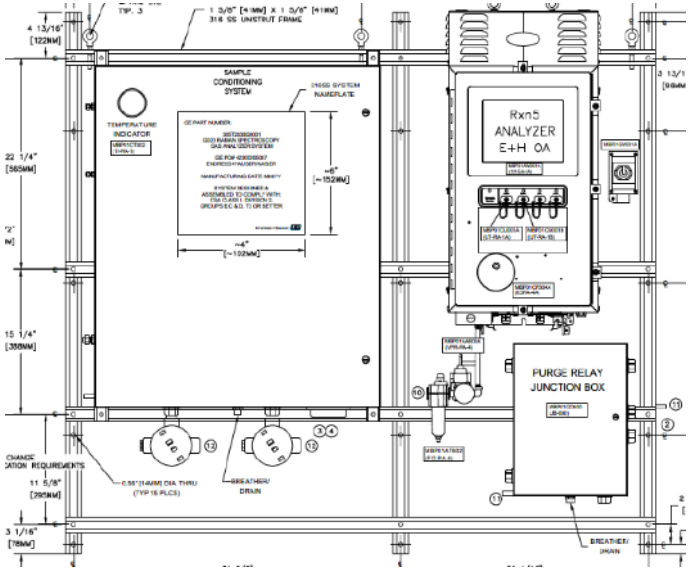
Analysis result

- 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 vaporizer for LNG
- No columns or carrier gas
- No sample transport
- Analyze 4 streams sequentially (Raman Rxn4) or simultaneously (Raman Rxn5)
- Raman Rxn4: general purpose (GP) Area
- Rama Rxn5: Class 1/Div 2; Zone 2

E+H Raman solution for Hydrogen / Natural Gas Blend Control



Blend Validation

- Monitoring %Hydrogen in Natural Gas
- Calculated Heating Value by ISO 6976
- 30 Second System response time at sample inlet

Fuel Mix	Location
Off Gas / Propane	Panama
Off Gas / Propane	Philippines
Off Gas / Propane	Bangladesh
Hydrogen / NG	USA
Hydrogen / NG	China
Hydrogen / NG	Australia
Hydrogen / NG	4 others

https://www.endress.com/en/endress-hauser-group/Case-studies-application-notes/hydrogen-blending-for-natural-gas-fired-turbines-casestudy

E+H success at World's largest Green Hydrogen Project

Client's challenges

Project - $5B Green Ammonia Project in Saudi Arabia (Air Products / NEOM) Licensor (Topsoe). Challenges – Speed of Response, Tighter Control of H2/N2

The objective

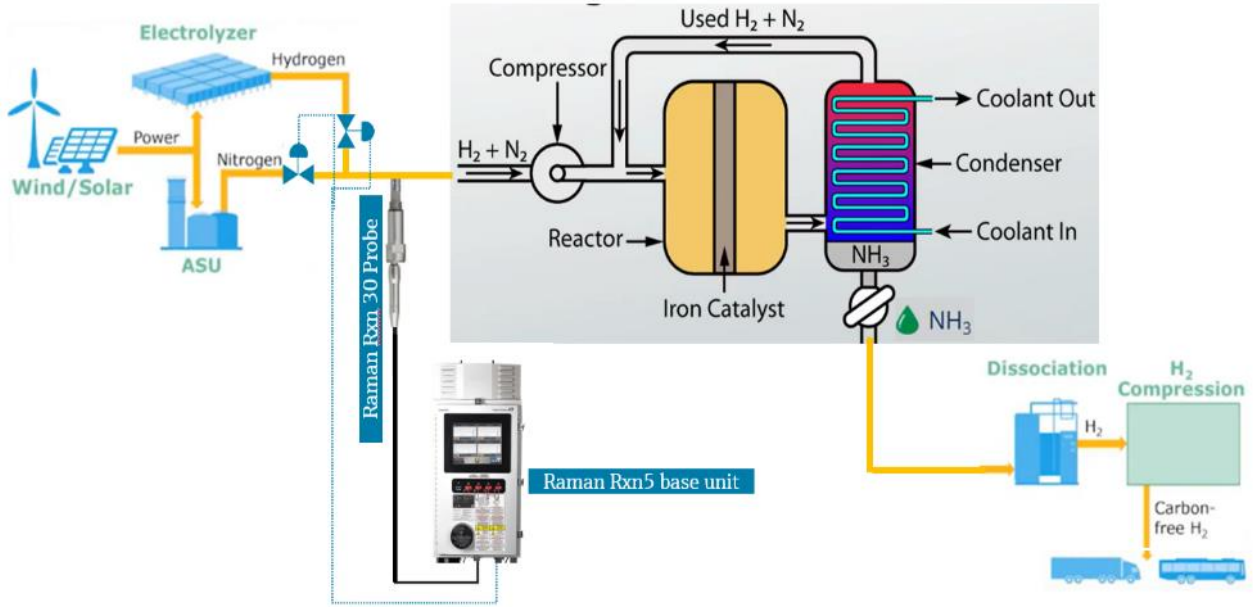
To improve response time, analyser performance & reliability. Preference to adopt technology limiting use of utilities (e.g., N2, Air – typically used by Process GC)

The E+H Solution

E+H RXN-5 Raman Analyser along with Analyser Measurement Solution offering fast response, not requiring utility consumption (as compared to GC), higher availability (as compared to GC)

The outcome

Licensor (Topsoe) & Client (Air Products) convinced on Technical Benefits of Raman over GC. Endress+Hauser awarded contract for supply of Rxn-5 / Analyser System.



Quantitative in-line measurement of Amine Solutions in CCUS

Client's challenges

Manual Sampling, Long time for Analysis Results, Inaccurate Readings, Low Efficiency of Gas Scrubber Operation

The objective

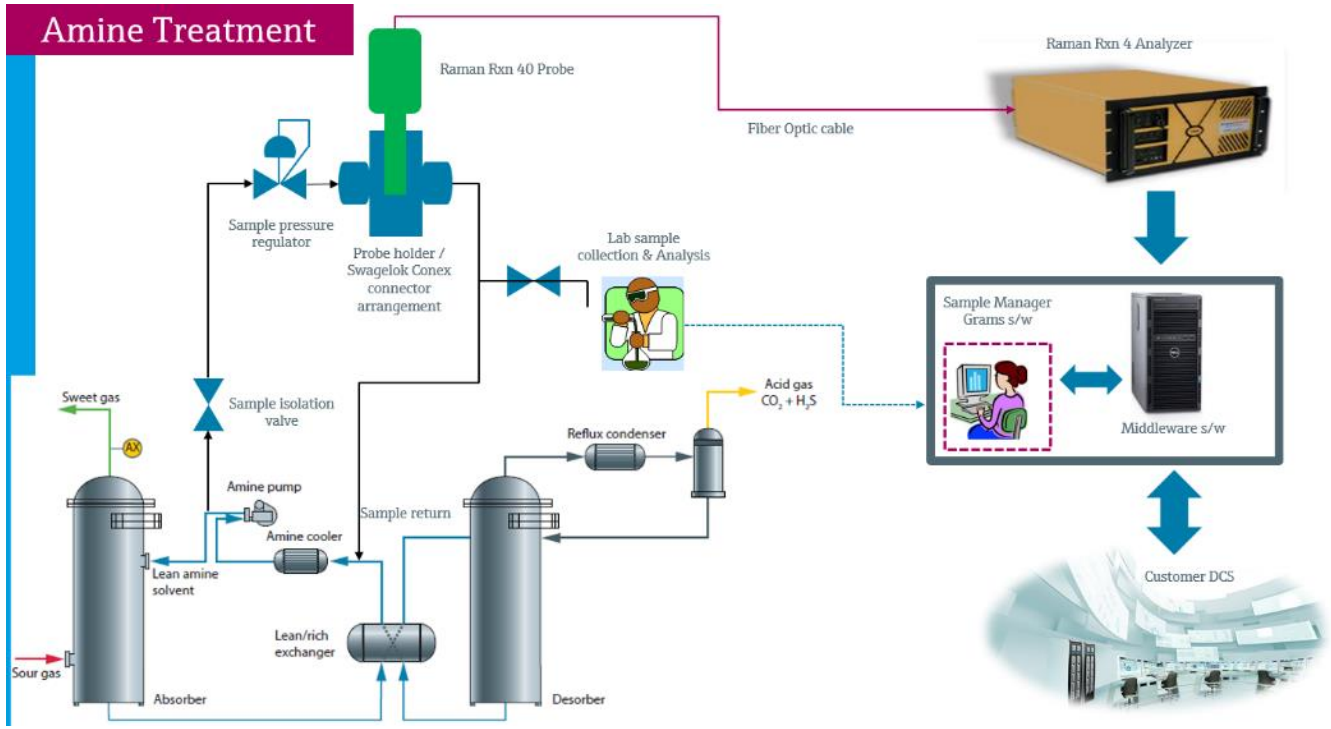
To achieve better control and optimize Amine treatment process is challenge without reliable Advanced analyzers.

The E+H Solution

E+H Raman Analyser Solution was offered to measure CO2 and aqueous amine solutions (MDEA, MEA, DGA)

The outcome

Optimisation of Gas Scrubber Operations, In-line / Realtime monitoring of liquid phase during absorption & regeneration, quantification of CO2 loading



Introduction to Endress+Hauser Optical Analysis

Thank you for your attention! Questions?