

Process Analyzer Solutions

From lab to process



Advanced process analysis moves from lab to process control

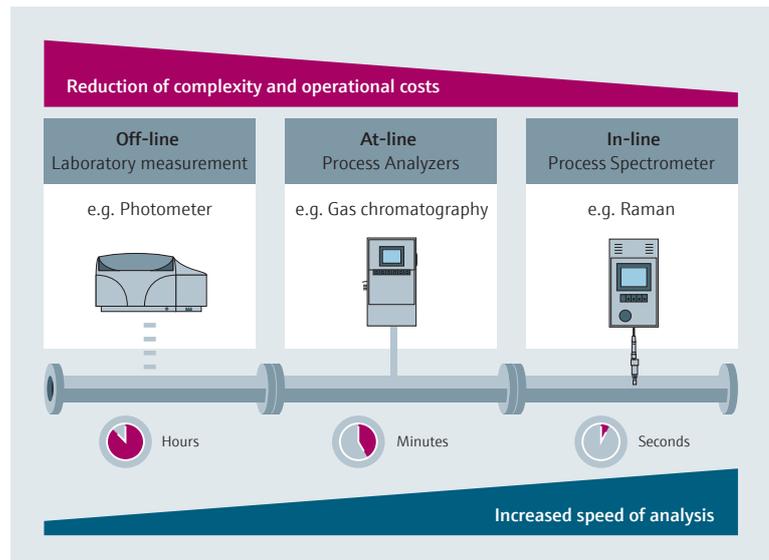
In-spec production, advanced process control and pipeline safety

Industry and technology driven trends

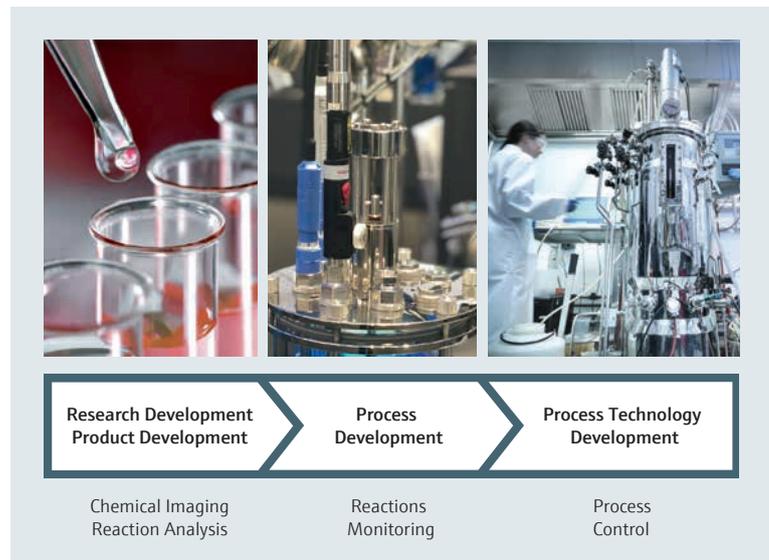
- From lab to process: for direct control tasks, increased process, yield and personal safety
- Quality by design: ensures reproducible process parameters and real-time releases
- From oil to gas: shift requires more reliable gas analysis solutions
- Regulated industries ask for transfer of data for the control of critical process parameters.

i What are Process Analyzer Solutions?

- Based on spectroscopical technologies like Raman und TDL-AS
- Integrated auto validation, safety-shutdown and retractable probe assemblies
- Individually engineered sample conditioning "vent to tab"
- Chemometric modeling services and software
- Rapid and remote after sales support



Lab to Process I: In-line spectrometers installed in the field increase speed of analysis from hours to only seconds, while also reducing complexity and broadening the range of applications.



Lab to Process II: Raman spectroscopy is an ideal fit for scale-up processes, since it ensures the integrity of the data and the transfer of models.

4 Oil and Gas Industry

Pipe-line safety, in-spec and quality production



10 Chemical Industry

Enabling advanced process control, safe and more economical production



14 Life Science Industry

From process development to compliant GMP production for up-and downstream



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Natural gas / Gas processing

Monitoring contaminants is critical for process optimization and gas quality



Tunable diode laser absorption spectroscopy (TDL-AS) analyzers from SpectraSensors perform on-line, real-time measurements of impurities such as H₂O, H₂S, CO₂ and O₂. The focus is in natural gas streams and at critical points in the gas treatment process from sub-ppm levels to percentage levels.

Improve efficiency of molecular sieve dehydration

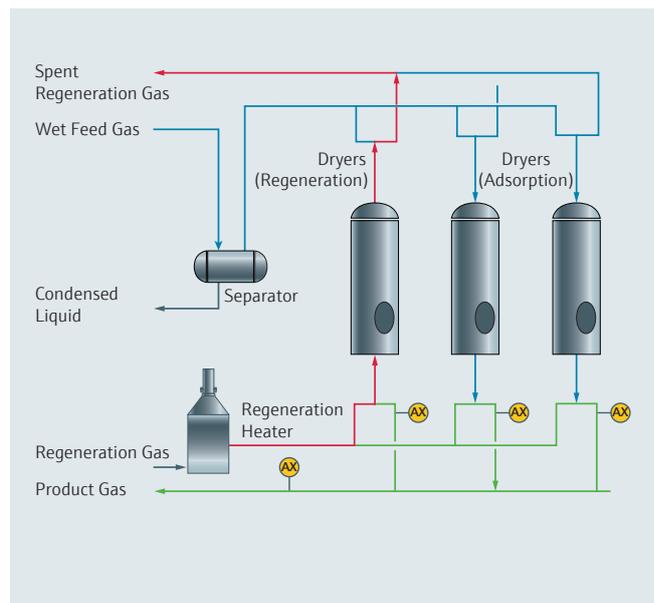
- Highly reactive to H₂O concentration fluctuations
- Patented “Differential Spectroscopy” technique measures H₂O at sub-ppm levels in natural gas
- Integrated permeation tube supports automated validation checks

i Your benefits in detail

- **Non-contact measurement** thanks to the isolated laser and solid-state detector
- Remote access
- **Immune** to interferences or background fluctuations
- Factory calibrated with **traceable and certified** blended gas to simulate process stream

24 / 7 / 365

95% or greater on-stream factor acc.
ANSI/API RP 555-2001 (Section 1.3.c)





Preventing pipeline corrosion, hydrate formation and ensuring quality specifications

- No consumables such as lamps, probes or carrier gas
- No field recalibration needed - automated validation
- No interference from glycol, methanol or amine
- No wet-up or dry-down, real-time control

Monitoring the efficiency of the amine treatment process

- Fast response to CO₂ concentration changes
- Laser based measurement is highly selective and accurate for CO₂ in natural gas
- Low maintenance and OPEX costs – no carrier gases or consumable items



LNG liquefaction and distribution

Monitoring impurities in gas feed to the cold box to ensure reliable liquefaction and accurate measurement of BTU in custody transfer



i Your benefits in detail

- **Reduced uncertainty** in BTU during custody transfer
- **Optimized** efficiency and versatility of **liquefaction trains**
- Meet pipeline quality requirements with **higher speed and precision**

SpectraSensors' laser spectroscopy analyzers perform critical measurements throughout the LNG value chain; from pre-treatment to liquefaction through to custody transfer and regasification.

Raman analyzers from Kaiser Optical Systems perform on-line composition measurement of feed gas, LNG as a cryogenic liquid, mixed refrigerants and gas following LNG regasification.

2.2 billion €

metering value per year of a large custody transfer system

Monitoring gas feed to the cold box to ensure on-time shipments

- H₂O molecular sieve outlet
- Reliable trace-level measurement
- Periodic self-validation with integral internal permeation tube avoids downstream upset
- Exceptionally fast response to detect moisture breakthrough

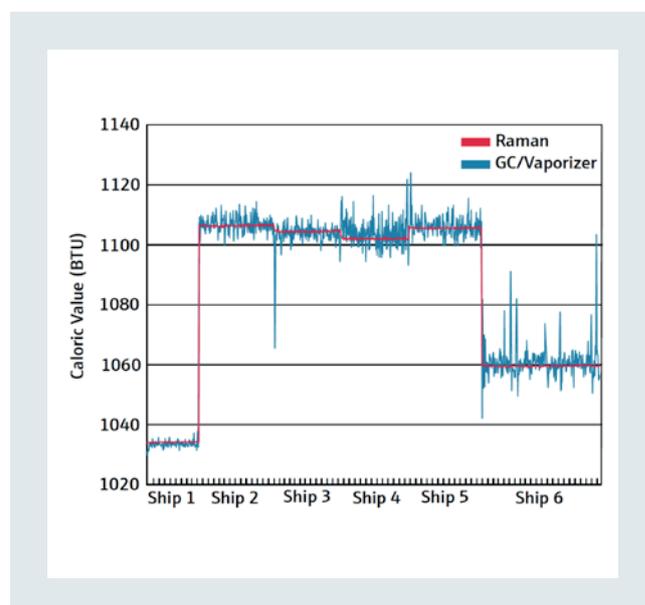


Optimize efficiency of liquefaction by composition measurement

- Provides tighter control and ability to update mixed refringent composition more rapidly
- Liquefaction can be over 50% of the CAPEX and 40% of the OPEX of a baseload LNG plant
- Changes of 0.02% in composition can save 5% in energy consumption
- No calibration, no routine maintenance

10x better proven repeatability in custody transfer of LNG

- Optical probe technology allows LNG to be measured as a cryogenic liquid
- BTU can be measured during the entire transfer period
- Real-time and accurate measurement without the need of a vaporizer





Refinery

Measuring composition and impurities in refinery gases to optimize process efficiency, hydrogen quality and management

On-line monitoring of H_2S and H_2O gives refineries the data they need to improve process control, meet product specifications, mitigate corrosion and catalyst poisoning, comply with environmental regulations, treat hydrogen and off gas streams for use in downstream refinery and petrochemical processes.

700,000 €

cost of a one-day shutdown of the catalytic reformer

i Your benefits in detail

- **Non-contact measurement** The laser and detector components are isolated and thus protected from the process gas and entrained contaminants
- **Fast response and analysis time** TDL-AS analyzers detect changes down to seconds so much faster than e.g. GCs
- **Low cost of ownership** Unlike GCs and lead acetate tape analyzers, TDL-AS analyzers have virtually no consumable components
- **Full composition** of all components with maintenance-free in-line Raman measurement

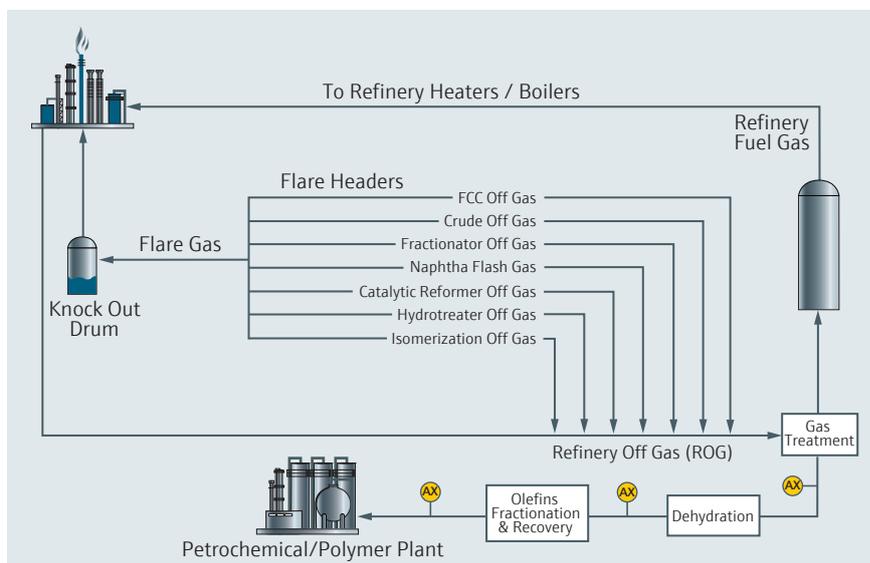
Protection of catalyst through precise H₂O-control

- Lower cost of ownership
- Safer to operate
- Differential TDL-AS Spectroscopy helps address changing fuel gas composition with automated 2-point daily validation



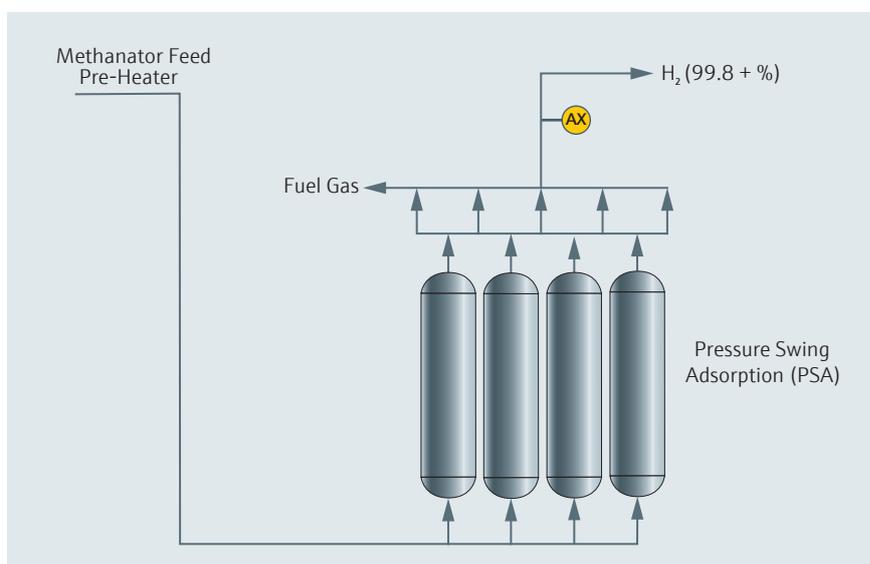
H₂S in refinery fuel gas

- Differential TDL-AS Spectroscopy helps address changing fuels gas composition with automated 2-point daily validation
- Lower cost of ownership
- Safer to operate – no disposal costs



Improve H₂ management with real-time process composition

- Run compressor closer to design value and predict long-term health
- Monitor H₂S additionally for corrosion in the hydrotreaters
- Longer catalyst life cycle
- Ability to process heavier feedstock and to use less expensive make-up gas



Petrochemicals, olefins and polymerization

Real-time measurement of impurities in C_2 streams and optimization of cracking or polymerization processes

i Your benefits in detail

- **Non-contact measurement** The laser and detector components are isolated and thus protected from the process gas and entrained contaminants
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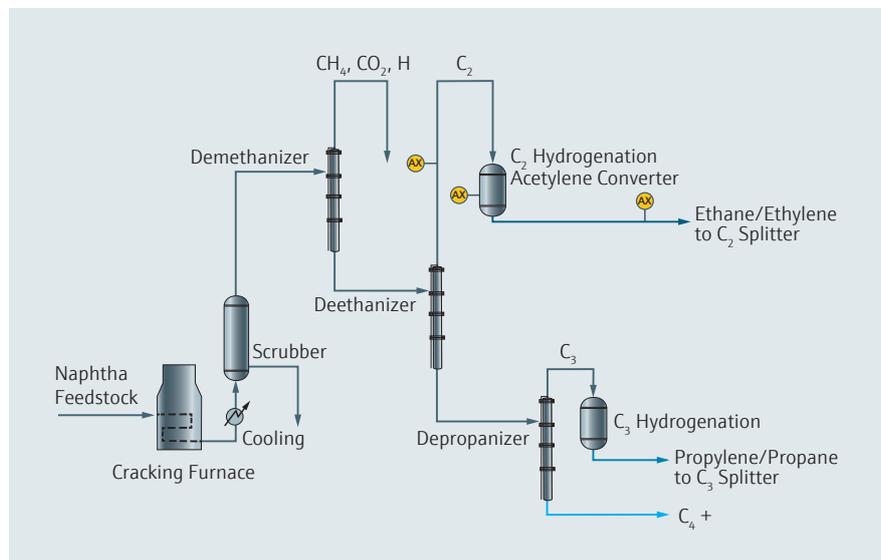
Tunable diode laser absorption spectroscopy (TDL-AS) analyzers from SpectraSensors perform on-line, real-time measurements of impurities in olefins from sub-ppm levels to low percentage levels. The unique design of SpectraSensors' TDL-AS analyzers provides significant advantages over other technologies for monitoring C_2H_2 , NH_3 , H_2O , H_2S and CO_2 in olefin process streams. In-line Raman measurements in combination with precise chemometrical modelling guarantees faster and less sensitive "in-line" composition measurement.

< 20 ppb

demonstrated analyzer LDL and repeatability

Ensure economic production "polymer-grade" in ethylene

- Real-time measurement of C_2H_2 and NH_3 compared to gas chromatographs
- Fewer conversion unit upsets with less product loss to flare





Cracker optimization by real-time P-I-O-N-A measurement

- Efficient blending of naphtha feed ensures smooth and efficient control of cracker
- Replaces combinations of “at-line” GCs with real-time measurement e.g. of double bonds of Olefins
- Reduced OPEX compared to alternative spectroscopical technologies due to less sensitivity to feed changes



In-line control of feed and polymerization progress

- Real-time polymer structure elucidation
- High pressure Raman application
- Spectral Hard Modeling for quantification
- Most reliable spectroscopically solution in case of product variations



General chemicals

In-line measurement of multiple compounds delivers real-time process monitoring, which improves yield, quality, time-savings and personal safety



i Your benefits in detail

- **Analysis time reduced** from several hours or days to minutes or seconds
- **Closed-loop control** enables APC
- **Reduced "batch to batch" time** increases productivity
- **Saves energy** by reducing stirring and heating time during offline method
- **Reduce cost** of off line sampling method, eliminate errors due to personal bias
- **Save time** in process development of up to 30% by faster analysis and flexible adaption

Competitive chemical production is highly dependent on feedstock, energy costs and availability of specialists. For specialty chemicals time to market is another key factor, putting pressure on speeding up process development. Automation concepts based on traditional control strategies are reaching limits and measuring chemical compositions, in-line opens new opportunities for applying advanced process control.

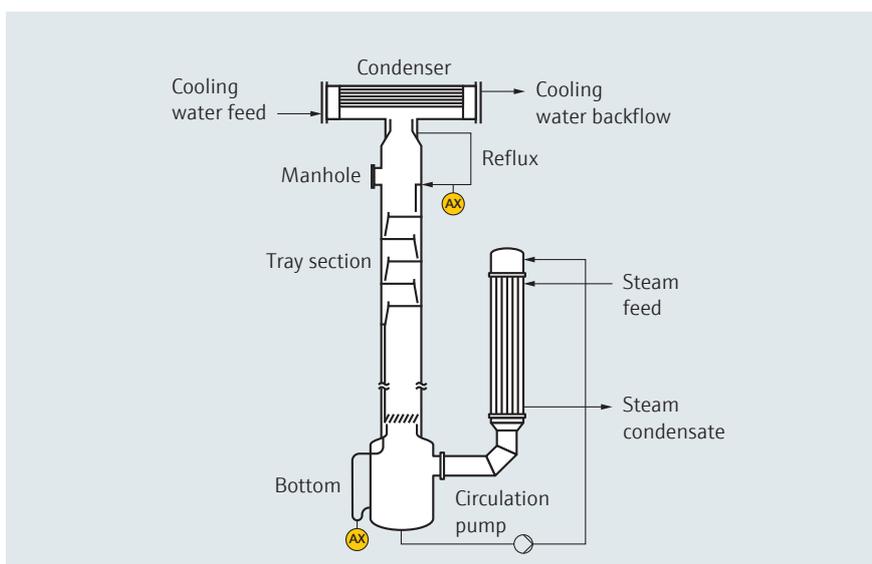
0.5%

gain of increased yield combined with reduced costs for feedstock, energy and waste add up to 600k€ per year



In-line monitoring of synthetic rubber production

- In situ conversion monitoring
- Real-time polymer structure elucidation
- High pressure Raman application
- Spectral Hard Modelling for quantification
- Most reliable spectroscopically solution in case of feed change



Distillation column performance monitoring

- Sampling-free process monitoring
- ATEX-conform process installation
- Multi-point spectroscopic measurement
- Isomer distinction



Urea production – Increased profitability with on-line multi-component measurement

- Increased yield 1–3% per year on average
- 2–5% reduced steam demand of “HP Stripper”
- Ammonia saving up to 5 kg/mtonn
- Saves critical process sampling (200°C – 180bar)



Synthetic production of APIs

Reaction monitoring “Lab to Process” – ideal scale-up process ensuring data integrity from qualitative to quantitative measurement

i Your benefits in detail

- **In-line measurement** allows non-destructive analysis of e.g. liquids and solids
- **One probe – many parameters** directly in the process
- **Easy scale-up**, transfer of data and models due to “identical technology”

Classical synthesis-based production of APIs is still widely used especially for manufacturing of generics. With the given cost pressure automation concepts applying in-line analysis with Raman spectroscopy is one answer. In particular, cases with upgrade-concepts for existing facilities can be applied.

30%

time savings during process development phase



Real-time control of polymorphism during crystallization process

- Separation process for target API
- Reduce expensive stirring and heating time during off line method and save energy



In-line monitoring of API synthesis

- Higher yield
- Less heating saves energy
- Prevention of out-of-spec batches
- Real-time data access saves post-production analysis

Improve control of tablet production

- Ensure blend-uniformity
- Validate correct API content
- Identification of targeted polymorphic form
- Maintain coating consistency



Biotechnology

In-line monitoring of bio processes to downstream applications in solid-phase with one probe ensures process and product quality

Raman provides in-situ, real-time sensing of multiple parameters for cell culture, fermentation or downstream bioprocesses. Kaiser's offering for in-situ bioprocess analytics enables advanced bioprocess control. This technology is scalable, so Raman can be used for traditional single-use bioreactors, in batch or in continuous mode. This comprehensive approach integrates high performance analyzers, in-situ sampling probes and user-friendly software into a reliable solution.

40,000 €

is the cost for lab analysis each year with HPLC

i Your benefits in detail

- **One probe – multiple compounds** e.g. glucose, lactate, titer or protein crystallization
- **Non-intrusive measurement** for SUBs (single use bioreactors)
- **Tighter control** with in-line composition monitoring in real time
- **Improved safety** and reduced chance of contamination by eliminating sampling
- **Comprehensive compliance offerings** like IQ/OQ to get lab to process analysis right the first time



Enable product and process quality with real-time measurement

- Titer increase of 30% to 85% depending on cell line as organisms are kept alive longer
- Monitoring and control of feeding strategy of mammalian CHO cells
- Closed-loop control of fermentation by measurement of e.g. glycerol, methanol and biomass



One probe – multiple measurements in SU bioreactor

- Non-invasive, re-usable Raman-based measurement with FDA-compatible window
- Prevents any chance of contamination compared to extractive sampling
- Gain same benefits in SU compared to stainless steel reactors

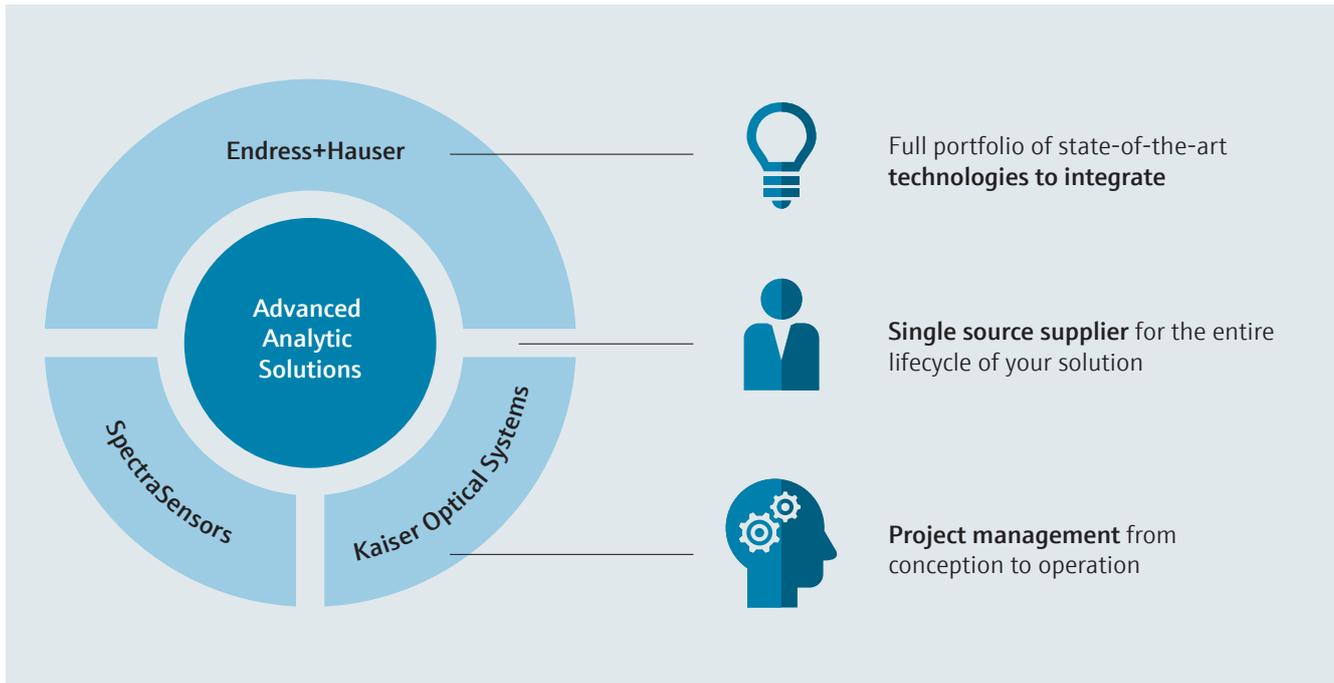


Real-time optimization of protein crystallization

- Control of salt content, temperature and time
- Amide I and III signals to differentiate sheet structures
- Utilized from “lab to process” to support scale-up
- Replaces destructive off-line analysis

Complete engineered solutions

Customized to your needs for accurate, reliable and optimized measurements. Benefit from our combined competences and experience in developing solutions across multiple applications

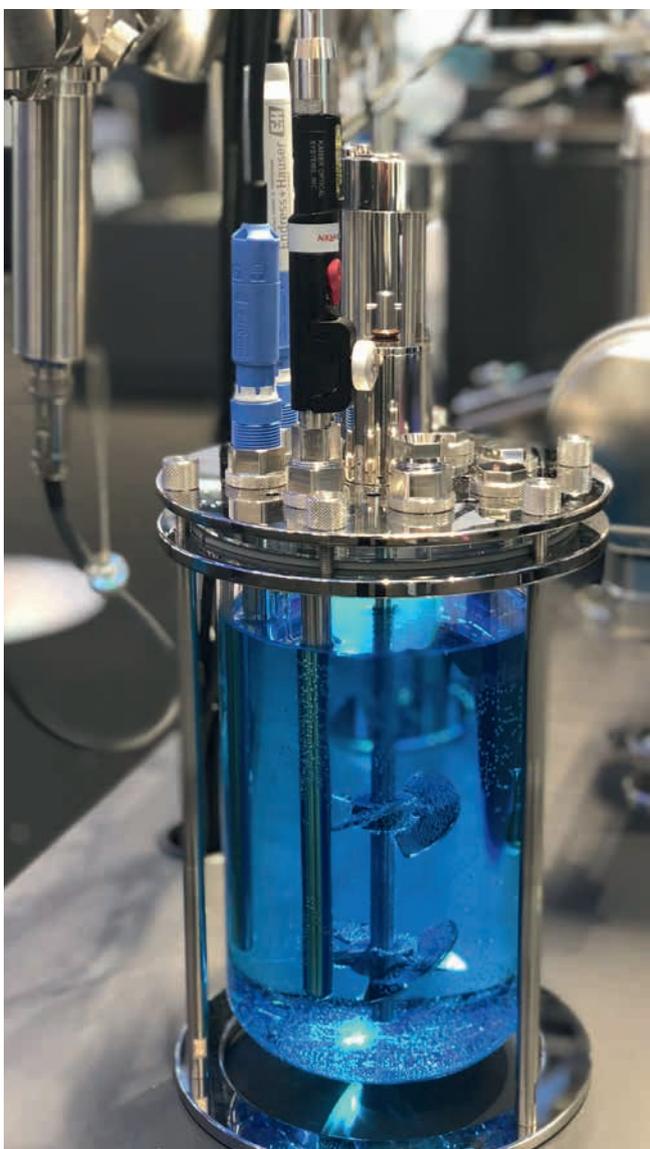


Endress+Hauser is developing regional centers of competences to better assist you during your projects. The European Advanced Analytics center located in Lyon, France can support with:

- Application specialists
- System design and integration
- Drawings and documentation
- Project oversight during production
- Factory acceptance tests

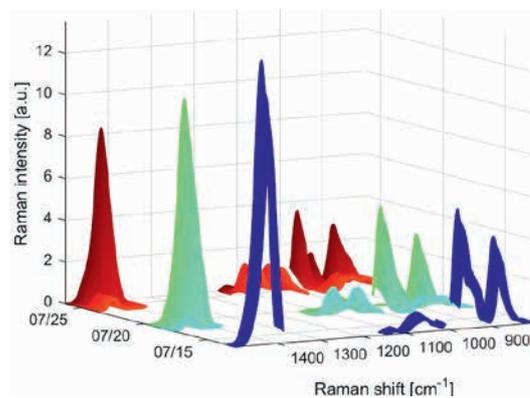
Innovative technologies

- Complete/broadest portfolio of instrumentation
- Expertise in integration of best-fit technologies
- Pioneer in most process instrumentation devices



Application models

- Chemometric expertise for model development
- Application know-how
- Optimal process control
- Database of proven models and methods



Turnkey solutions

- Support in all project phases from conception to operation
- Solutions designed to meet application requirements, industry standards and demanding environment
- More than 20 years of experience and expertise in integration of complete analytical systems from tap to vent



Maximizing the contribution of your analyzers

Benefit from our global network of highly trained engineers to ensure optimal reliability and availability of your analytical systems



Support



Maintenance



Optimization

i Your benefits in detail

- **Meet your project deadline:** We can help you through tests and commissioning while managing budget and time constraints
- **Optimize the availability of your process:** Our Services and Support teams help you define your maintenance requirements
- **Boost your competence:** Experts from our Centers of Competence are available for customized training programs

We offer a complete portfolio of services to support your activities from site acceptance tests and commissioning to preventive maintenance, diagnostics and repairs.

Our organization can provide annual and multi-year support contracts.

Feasibility studies

- Consulting for application viability
- Trial and test support



Rental and leasing options

- Flexibility through rental and leasing contracts
- Developing activities while keeping budget on track



Remote services

- Worldwide support by telephone or email through our network of service engineers
- Minimal down-time with rapid diagnostic and advice for repairs thanks to analyzer connectivity



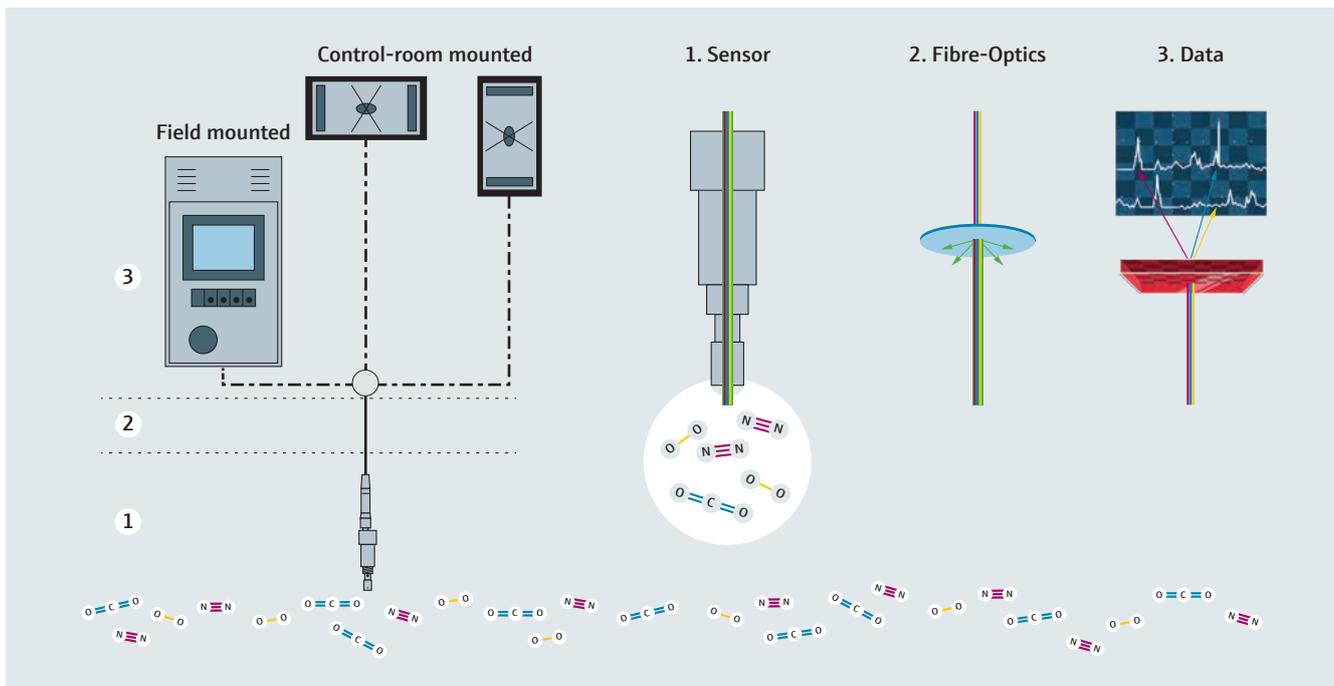
Compliance to industry standards

- Service for cGMP applications such as IQ/OQ, audit support and supplier qualification
- ATEX certified solutions, NEMAX 4x enclosure and FDA approved Raman probes
- Certified for ISO 9001 and ISO 14001



Raman Technology

Identifying molecules by providing an “optical fingerprint” of the molecules being measured



i Your benefits in detail

- **Multiple components in gas, liquid or solid** phase can be measured at a single probe point
- **Excellent signal separation**, allowing to extract more information with less intensive chemometrical calibration
- **Transferability** across instruments and operating scales by built-in reference for wavelength and intensity calibration
- **Inhouse probe design** incl. non-intrusive and non-contact versions

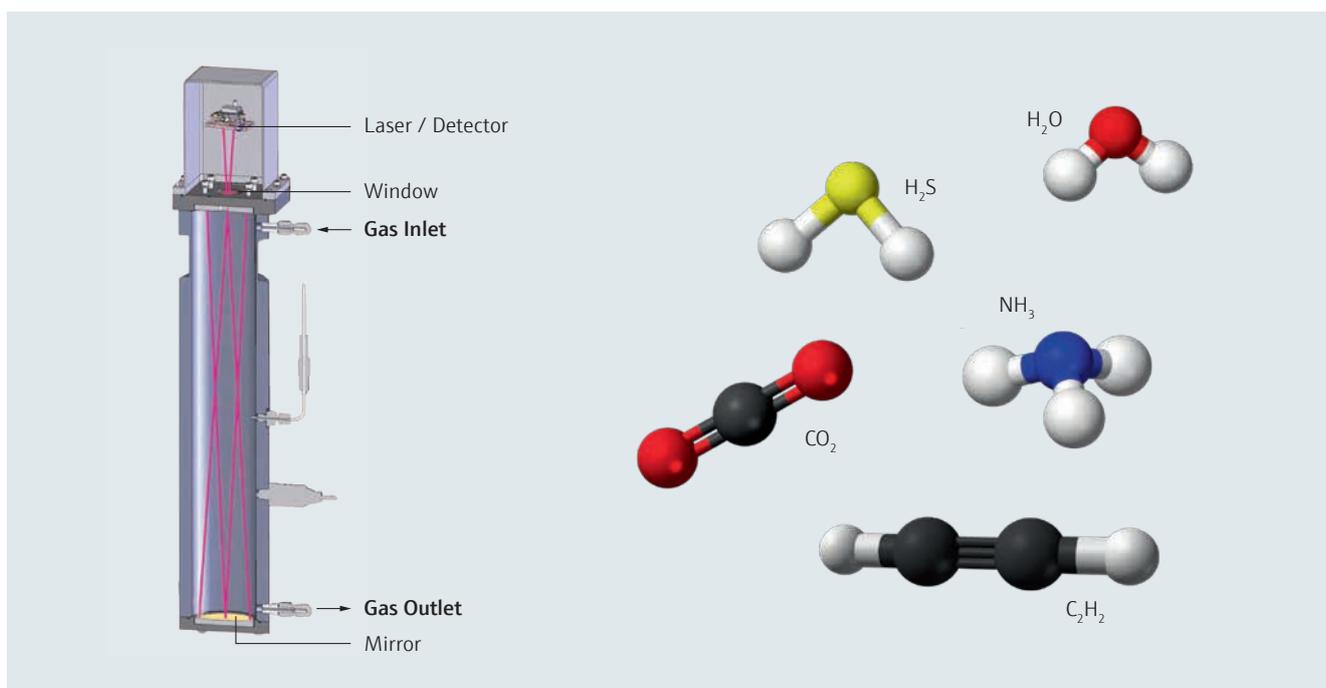
Kaiser Optical Systems is a world leader in Raman Spectroscopy, spectrographic instrumentation and applied holographic technology with more than 20 years of experience. Fiber-optic Raman sensors are designed to allow our customers to conduct effective process analysis. Robustness, reliability and performance are authentic trademarks of Kaiser's Raman technology.

> 20 years

of experience in on-line process control
at Kaiser Optical Systems

TDL-AS Technology

Measuring the concentration of analyte in a process gas stream by using laser absorption spectroscopy.



i Your benefits in detail

- **Non-contact measurement** from process gas eliminates fouling and provides reliable long-term operation
- **TDL-AS analyzers selectively** measure trace level contaminants in hydrocarbon streams
- **Real-time data** for process control and optimization with an exceptionally fast response time to changes in analyte concentration
- TDL-AS analyzers require **no consumable** items, resulting in lower costs of ownership and maintenance
- **Extractive sampling** and fast analyzer response time supports stream switching applications

SpectraSensors was the first to deploy and prove TDL-AS technology in the hydrocarbon processing industries and is today a leading global provider of laser-based on-line analyzers. SpectraSensors offers unique expertise in measuring contaminants in complex hydrocarbon gas streams. With its Centers of Competence and qualified integrators, customers get customized solutions and regional support.

10,000 +

units installed by SpectraSensors worldwide



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