RNG AND BLENDING SOLUTIONS

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Honeywell

THE FUTURE IS WHAT WE MAKE IT

Agenda

1. RNG – Renewable Natural Gas

2. Challenges, Systems, and Solutions

3. Gas Measurement Technologies

ASTM D4150 DEFINITION OF RNG

renewable natural gas (RNG), n — a pipeline-quality gas that is all or in part from renewable sources and is fully interchangeable with geological (fossil fuel) natural gas.

DISCUSSION—RNG can be produced from biogas or other renewable sources that have been processed to purity standards and thus can be used as a fuel for internal combustion engines.

DISCUSSION—Like geological (fossil fuel) natural gas, RNG can be used for transportation purposes in the form of compressed natural gas (CNG) or liquefied natural gas (LNG).

Interchangeability – What is Pipeline Natural Gas

Natural gas is a naturally occurring mixture of hydrocarbons (HC), inerts (N2, CO2), and undesired contaminants such as H2S.

The value of natural gas lies in the energy it gives off when burned. Different mixtures of HCs + diluents (N2, CO2) release different amounts of energy when burned.

‘Pipeline quality’ gas is natural gas that meets the approved tariff standards of the pipeline.

Gas Quality Specification	Some Values Found in Tariffs
Energy Content (dry, HHV)	**950 – 1,150 BTU/scf**
Wobbe Number	**1,279 – 1,400**
Minimum Temperature	20° to 65°F
Maximum Temperature	80° to 140°F
Maximum Hydrocarbon Dew Point	0° – 25°F at either fixed or operating pressures
Cricondentherm HDP (CHDP)	15° – 20°F
C_{4+}	0.75 – 1.50%
Liquefiable Fraction (GPM) C_{5+} (6)	0.2 – 0.3 gallons/Mscf
C_{5+}	0.12 – 0.25%
Liquefiable Fraction (GPM) C_{6+}	0.05 gallons/Mscf
Maximum Water Vapor Content	4 – 7 lbm/MMscf
Maximum Total Sulfur Compounds, as Sulfur	0.5 – 20 grains per 100 scf
Maximum Hydrogen Sulfide (H_2S) (5)	0.25 – 1 grain per 100 scf
Maximum Mercaptans (RSH)	0.20 – 2.0 grains per 100 scf
Maximum Solid Particles Size	3 – 15 microns
Maximum Hydrogen	400 – 1,000 ppm
Maximum Diluent Gases Total (2, 4)	3 – 6%
Carbon Dioxide (CO_2)	1 – 3%
Nitrogen (N_2) (3)	1 – 4%
Oxygen (O_2)	0.001 – 1%

Chromatography and Natural Gas

Gas chromatography provides most gas quality measurements:

- Composition (HCs, Diluents, Contaminants)
- Heating Value – AGA-5 / GPA 2172, ASTM D3588, ISO 6976
    - Real Gas Relative Density
    - Wobbe
- Compressibility Factor Z – AGA-8
- HCDP – Through Equations of State
- and more.

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Energy Content (dry, HHV)	**950 – 1,150 BTU/scf**
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Minimum Temperature	20° to 65°F
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Maximum Hydrocarbon Dew Point	0° – 25°F at either fixed or operating pressures
Cricondentherm HDP (CHDP)	15° – 20°F
C_{4+}	0.75 – 1.50%
Liquefiable Fraction (GPM) C_{5+} (6)	0.2 – 0.3 gallons/Mscf
C_{5+}	0.12 – 0.25%
Liquefiable Fraction (GPM) C_{6+}	0.05 gallons/Mscf
Maximum Water Vapor Content	4 – 7 lbm/MMscf
Maximum Total Sulfur Compounds, as Sulfur	0.5 – 20 grains per 100 scf
Maximum Hydrogen Sulfide (H_2S) (5)	0.25 – 1 grain per 100 scf
Maximum Mercaptans (RSH)	0.20 – 2.0 grains per 100 scf
Maximum Solid Particles Size	3 – 15 microns
Maximum Hydrogen	400 – 1,000 ppm
Maximum Diluent Gases Total (2, 4)	3 – 6%
Carbon Dioxide (CO_2)	1 – 3%
Nitrogen (N_2) (3)	1 – 4%
Oxygen (O_2)	0.001 – 1%

Components of Natural Gas

C1 = Methane
C2 = Ethane
C3 = Propane
C4 = iso-, normal-Butanes
C5 = neo-, i-, n-Pentanes
C6 = Hexane, Cyclohexane, Methylcyclohexane, Benzene
C7 = Heptane, Toluene,…
C8 = Octanes
C9 = Nonanes

C6+ GC measures: N2, CO2, C1…C5. The C6 and heavier components are detected as a lump sum called C6+ with assumed physical properties.

(Note: O2 is included in N2 reading in a standard GC.)

From GPA 2145

Component Name	Index	Hv	hv	Vfact.	SF	MW
1. Nitrogen	1	0	0	0	0.00442	28.0134
2. Methane	2	1010	0	0	0.0116	16.0425
3. CO2	3	0	0	0	0.0195	44.0095
4. Ethane	4	1769.7	0	0	0.0238	30.069
5. Propane	5	2516.1	0	0	0.0347	44.0956
6. i-Butane	6	3251.9	0	0	0.0441	58.1222
7. n-Butane	7	3262.3	0	0	0.047	58.1222
8. neo-Pentane	8	3985	0	0	0.0553	72.1488
9. i-Pentane	9	4000.9	0	0	0.0576	72.1488
10. n-Pentane	10	4008.7	0	0	0.0606	72.1488
11. n-Hexane	11	4755.9	0	0	0.0776	86.1754
12. n-Heptane	12	5502.6	0	0	0.0951	100.2019
13. n-Octane	13	6249	0	0	0.1128	114.2285
14. n-Nonane	14	6996.3	0	0	0.1307	128.2551
15. n-Decane	15	7742.9	0	0	0.1556	142.2817
16. Benzene	16	3742	0	0	0.069	78.114
17. Cyclohexane	17	4482	0	0	0.0747	84.161
18. Methylcyclohexane	18	5216.3	0	0	0.0881	98.188
19. Toluene	19	4475	0	0	0.0892	92.141
20. n-Undecane	20	8490	0	0	0.1556	156.311
21. n-Dodecane	21	9235	0	0	0.1556	170.377
22. H2S	22	637.1	0	0	0.0239	34.0809
23. COS	23	620.9	0	0	0.0297	60.076
24. O2	24	0	0	0	0.0072	31.9988
25. Hydrogen	25	324.2	0	0	0	2.0159
26. Helium	26	0	0	0	0	4.0026

Biogas to Biomethane, a Renewable Natural Gas

yesterday → **today**

Raw biogas

Conversion to electricity and heat with local CHP's

electricity

↑

CHP
(combined heat & power)

↑

60% CH_4
40% CO_2
H_2S, O_2, N_2, H_2O, H_2

- Heat can not be used on many locations

Biogas Plant

98 % CH_4
2% CO_2

Bio methane → Gas grid

↑

Upgrading = removal of CO2

Gas grid ↓

electricity

heat

fuel

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Biomethane Composition & Measurement Differences

Geologic Natural Gas

- On-Line
  1. GC C6+ (N2, CO2, HCs)
  2. H2S
  3. Water (ppmv / dew point)
  4. Total Sulfur (Sx)
  5. HC Dew Point
- Off-Line
  - bacteria, particulate, and other contaminants

Biomethane

- On-Line
  1. GC (N2, CO2, Methane)
     - If LPG, then C1…4
  2. O2 (GC or stand-alone)
  3. H2S (GC or stand-alone)
  4. Water (ppmv / dew point)
- Off-Line
  - bacteria, particulate, SiOx, and other contaminants

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Composition & Measurement Differences

Landfill

Methane drawn from multiple wells via vacuum system

- Landfill must be sealed for a period of time before anaerobic CH_4-bacteria becomes dominant
  - H_2 in aerobic transition
- Over-drawing gas can pull air into the landfill
  - Excessive nitrogen
  - Low CH_4 production
- Composition can change with landfill cell
  - Higher H_2S from drywall
  - Trace Contaminants can vary with cell
- Siloxanes common
- Odor-masking compounds possible

Wastewater

Methane produced within sealed sewage digestor

- Composition relatively stable
- Siloxanes common
- Nitrogen levels typically reasonable

Farm

Methane produced within sealed digestor

- Composition relatively stable
- Nitrogen levels typically reasonable

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When to Reject Biomethane

- Low BTU Value (Under 985 BTU)
- Oxygen (over 0.2%)
- H_2S (Over 4 PPM / 1/4 grain/100 scf)
- Total Sulfur (over 1 grain/100 scf)
- Excessive N_2 or CO_2 (Balance of Non-Combustible Gases)
- High H_2O (over 7 lbs/MMscf = 153 ppmv)
- Temperature
- Pressure
- Bacteria
- Mercury
- Pesticides
- Siloxanes
- Ammonia

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H_2-blended Gas Composition & Measurement Differences

Geologic Natural Gas

- On-Line
  1. GC C6+ (N2, CO2, HCs)
  2. H2S
  3. Water (ppmv / dew point)
  4. Total Sulfur (Sx)
  5. HC Dew Point

Hydrogen-Blended Natural Gas

- On-Line
  1. Hydrogen-capable C6+ GC (H2, N2, CO2, HCs)
  2. O2 (GC or stand-alone)
  3. H2S (GC or stand-alone)
  4. Water (ppmv / dew point)
- Measurement Issues to Address
  1. Special GC requirements – typical natural gas GCs using He (or H2) carrier gas cannot 'see' the hydrogen blended into the natural gas
  2. GCs are too slow to accurately control or monitor H2-blending
  3. Systems and operating procedures must address what to do if the %H2 exceeds its maximum limit

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When to Reject Hydrogen Blended Natural Gas

- Low BTU Value (Under 985 BTU)
  - H_2 has about 1/3 BTU/SCF as CH_4
- %H_2 > max limit
- Temperature
- Pressure

Agenda

1. RNG – Renewable Natural Gas

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3. Gas Measurement Technologies

Biomethane Challenges

Compositional Challenges

- 100% CH_4 only has 1010 BTU/SCF
  - It can be difficult for producers to continuously meet a Hv min of >980 BTU/SCF which means <3% $CO_2+N_2+O_2$
- Excess Nitrogen and Oxygen are difficult and costly to remove
  - Primarily a landfill operational challenge
- Several critical contaminants require periodic, off-line lab analysis

Design and Operational Challenges

- Meeting pipeline pressure requirement
- Custody Transfer Gas Quality and Volume measurements, and DAC
- Actions to take with off-spec biomethane
  - Blend with LPG
  - Blend with pipeline gas
    - Dilute biomethane to increase avg. BTU and dilute biomethane contaminants
  - Divert to recycle through biogas upgrading plant
  - Divert all off-spec gas to Flare
  - Shut-in / block all sample flow
  - Detecting geologic gas dilution of biomethane
- On-Site Support / Monitoring
- Maximize uptime of custody transfer equipment

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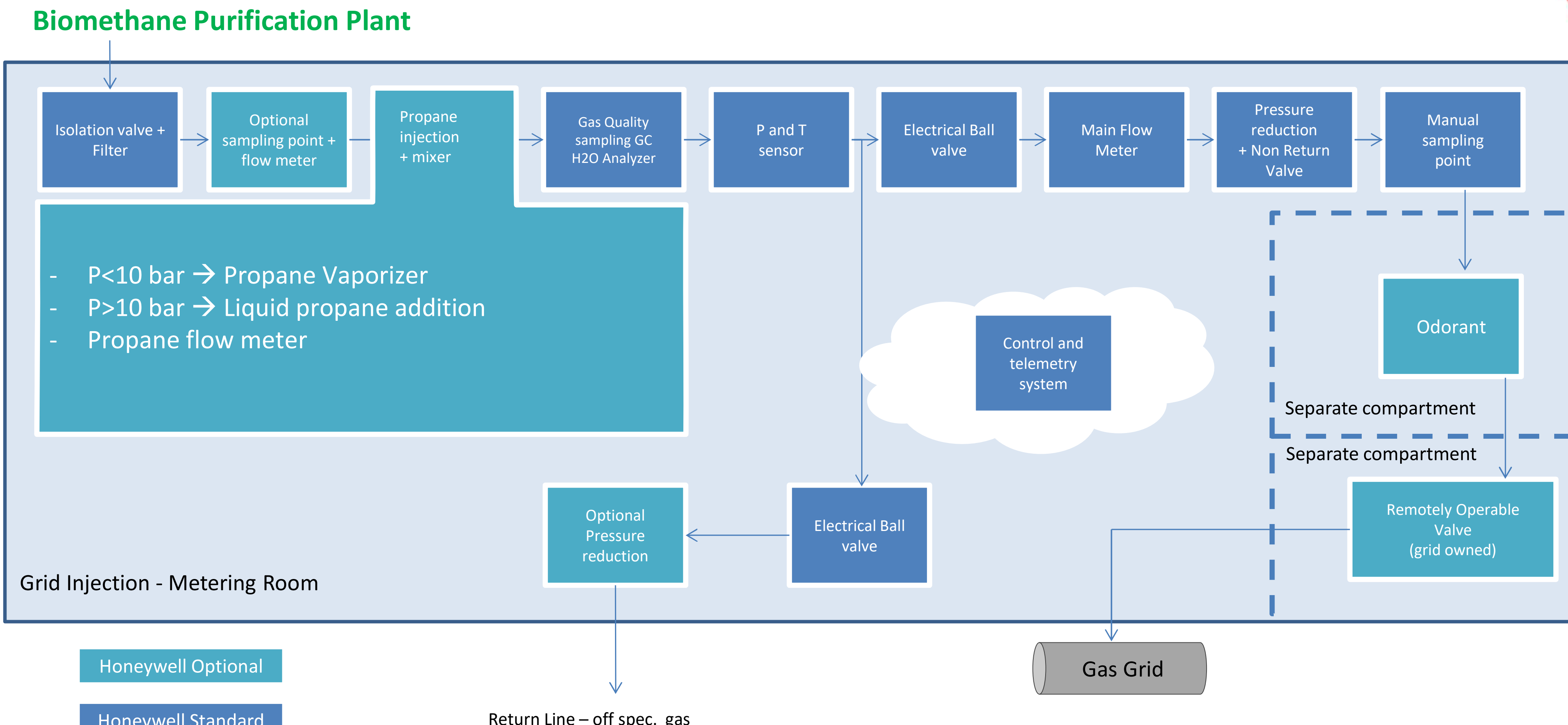
Block Diagram – Typ. Biomethane Grid Injection Solution



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Honeywell Solutions and Products

GAS QUALITY
via EnCAL3000 Gas Chromatograph & GasLab Q2 real time BTU Analyzer

GAS LEAK DEVTECTION
via XNX Transmitter, Sensepoint Sensor and Searchzone Sonik

PRESSURE AND TEMPERATURE

FLOW MEASUREMENT
via RABO Rotary Flowmeter with EC 350 & Q Sonic Ultra Sonic Meter

PRESSURE REGULATION AND SAFETY SHUT OFF (SLAM SHUT)

PLC AND RTU
via ControlEdge PLC & RTU

Biomethane Solutions - Kiosk Design Strategy

Metering, regulation, gas analysis, and control in one multi-room building. Through Honeywell's experience of hundreds of these units we found this design de-risks the solution and proven performance.

Pros:

- Simpler installation
- Equipment is hidden and protected
- Everything protected from weather (↑ uptime)
- Small gas leaks quickly and easily detected by flammable gas detector
- Entire system easily removed for decommissioning or relocation

Cons:

- Potential additional housing costs
- offset by lower engineering costs due to design standardization

Biomethane Solutions - Kiosk Design Strategy

Metering, regulation, gas analysis, and control in one multi-room building. Through Honeywell's experience of hundreds of these units we found this design de-risks the solution and proven performance.

Issues Solved:

- Pressure Regulation and Control
- Custody Transfer Measurements
  - Redundancy options available
- DAC and Gas Control
- Low-BTU
  - LPG blending with Real-time control
  - Blend with pipeline gas to meet Hv and contaminant limits
    - Dual Custody Transfer: Pre- and Post-Blending quality and volume measurements
- Monitoring & Support of all gas quality and flow measurements is also possible via a Support Contract that includes performance a monitoring MIQ sysytem

Biomethane Solutions - Kiosk Design Strategy

Metering, regulation, gas analysis, and control in one multi-room building.

Issues Solved:

- Divert off-spec gas at kiosk
    - Avoids dead ending gas flow at GC probe keeping QA measurements 'live'
    - Permits automatic or remote control of divert valve (shut-in). Minimizes shut-in time / flaring

- Detecting geologic gas dilution of biomethane
    - Concerns over 'cheating' by recycling pipeline gas to sell as valuable biomethane can be alleviated by monitoring the biomethane for C2+ which should not be present.
    - When blending schemes are used, two separate custody transfer measurements may be needed: one on the unblended biomethane for RNG credit and one on the blended pipeline quality gas.

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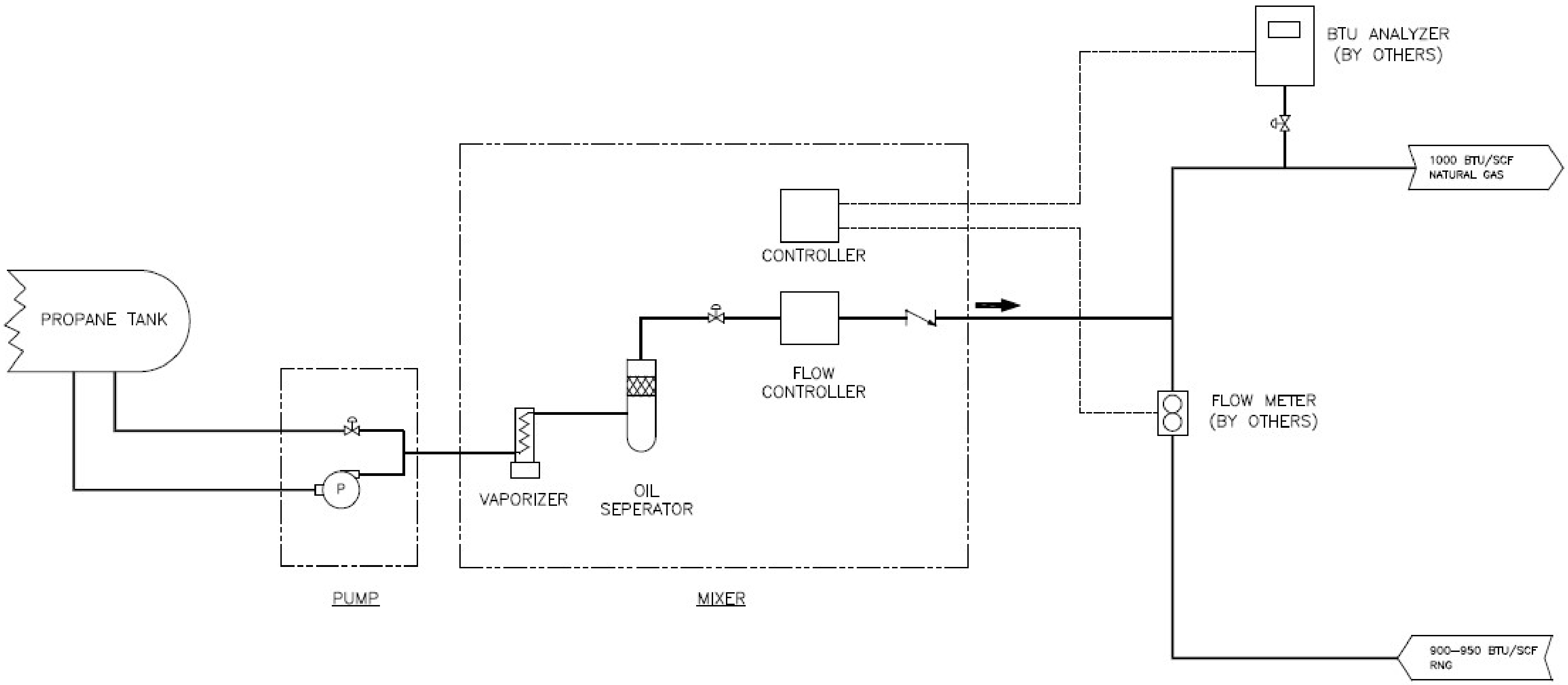
Real-Time Propane Enrichment Control Eliminates Low BTU Issues

Gaslab Q2



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Natural Gas Chromatograph

EnCal 3000

- High Performance
- 1 to 5 Streams
- Carrier gas 24 to 30 months
- C9 / C8 / C6+
- Biomethane
- C9 with H2 (up to 30%)
- C9 with H2S (2.0 to >15 ppmv)
- Hydrocarbon Dew Point
- H2S (1.0 ppmv to >1%)
- Odorant monitoring
- Much more…

ProChain

- Market Performance
- 1 to 5 Streams
- Carrier gas 5 to 7 years
- C6+

Future Applications

- Biomethane
- C6+ with H2

Natural Gas Chromatograph

GasLab Q2

- Real-time natural gas quality measurements
- Calorific Value
- Density
- Wobbe
- Compressibility
- Methane Number (MN)

- Every 1 second (3,600/hr)

- Requiring:
  - A binary CO_2 in CH_4 Cal. gas that may last 5 years
  - Ideal for: gas blending, feed-forward combustion optimization (industrial, compressor engines, power turbines), GC replacement or on-line validation, process monitoring

Measurement IQ

- Station Monitoring Software System
- Quickly identify potential problems, prioritize & monetize the problem, guide field techs

- **24/7 Condition Based Monitoring**
- **One page overview of all meas. assets**
- **Monetary priority of activities**
- **Recommendations on actions**

- Monitors flow meters, GCs, pressure and temperature transmitters, more
- Abilities added yearly

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Hydrogen Challenges – Gas Blending

Compositional Challenges

- Hydrogen has only about 1/3 the BTU of Methane. Hence adding hydrogen to pipeline natural gas lowers the BTU/SCF

Design and Operational Challenges

- Meeting pipeline pressure requirement
- Custody Transfer Gas Quality and Volume measurements, and DAC
- Actions to take with off-spec gas blends
  - Dilute the mix with more pipeline gas
    - If %H2 exceeds its allowed maximum, post-blend flooding with pipeline gas will quickly drop the %H2 below the max until the blending system meets spec.
  - Divert all off-spec gas to a Flare
  - Shut-in / block all hydrogen blending
- On-Site Support / Monitoring
- Maximize uptime of custody transfer equipment

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Hydrogen Challenges – Hydrogen De-Blending

Compositional Challenges

- Hydrogen blended into natural gas pipeline flows may have more value as a separate, pure fuel in a gas distribution region. A means to strip H2 from the natural gas an validate its gas volume and purity are needed.

- Regional gas distribution areas may impose a lower %H2 limit than the gas pipeline itself. Deblending some of the hydrogen from the pipeline gas may be required before custody transfer.

Design and Operational Challenges

- Meeting pipeline pressure requirement
- Custody Transfer Gas Quality and Volume measurements, and DAC
- Actions to take with off-spec gas blends
  - Dilute the mix with more pipeline gas
    - If %H2 exceeds its allowed maximum, post-blend flooding with pipeline gas will quickly drop the %H2 below the max until the blending system meets spec.
  - Divert all off-spec gas to a Flare
  - Shut-in / block all hydrogen blending
- On-Site Support / Monitoring
- Maximize uptime of custody transfer equipment

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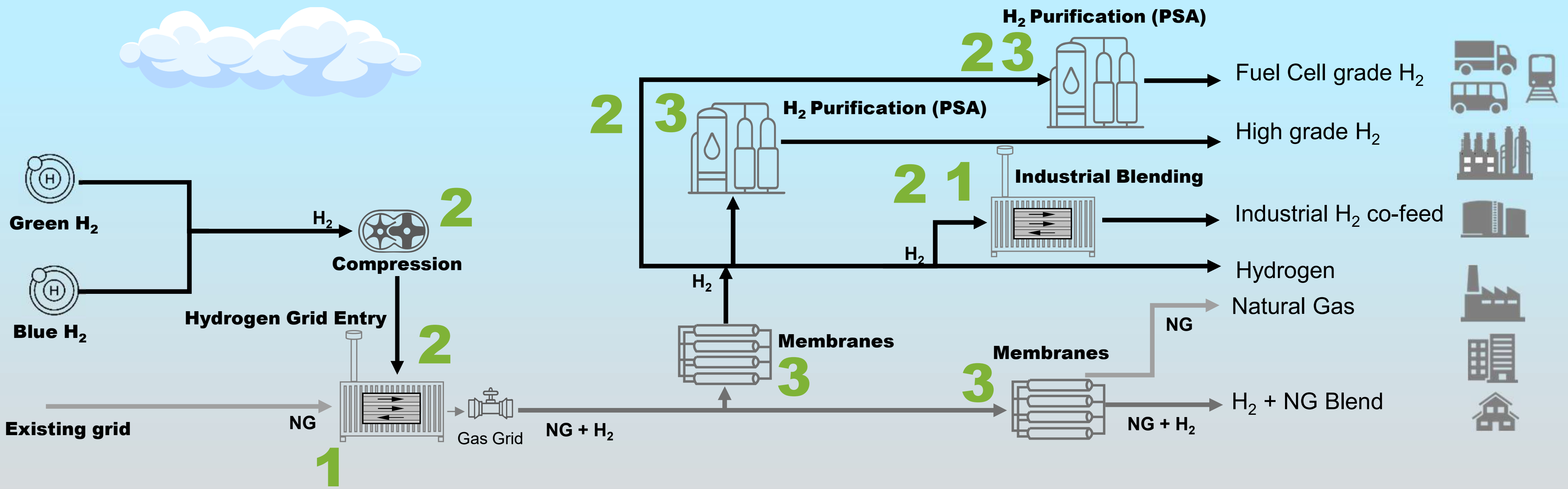
NATURAL GAS GRID | A BRIDGE TO A H_2 ECONOMY



1 **Hydrogen Blending**
Grid Entry Units and Industrial Blending solutions for H_2 co-feed into industry required.

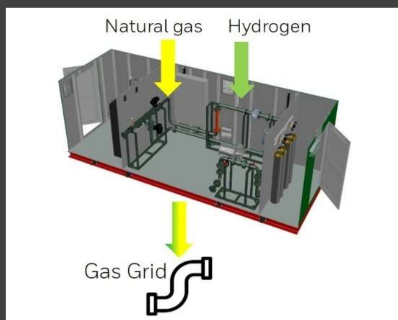
2 **Control and measurement**
End-to-end, integrated controls covering production, compression, blending, distribution and deblending will be required

3 **Deblending Solutions**
Wide range of end consumers require a portfolio of deblending solutions to address all needs

4 **Analytics and Centralized Reporting**
Required to manage complex ecosystem and provide consolidated oversight

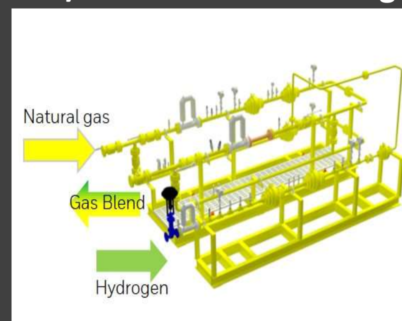
HYDROGEN SOLUTIONS

Hydrogen Grid Injection



Compact hydrogen injection system for green or blue hydrogen entry to natural gas grids.

H2 / Natural Gas Blending



Blending skid for hydrogen blending in natural gas fuel supplies to industrial processes.

Hydrogen De-Blending

Hydrogen De-blending solutions from Honeywell-UOP at point of sales utilizing decades of experience. Over 1100 unites installed worldwide.

Remote Monitoring
Autonomous Operation

SCADA Integration
Data Analytics

Safety and Emission
Compliance Monitoring

Lifecycle services
24/7 Expert on Call

GRID ENTRY UNIT'S & HYDROGEN BLENDING

Grid Injection Unit

NATURAL GAS → GRID INJECTION UNIT

BIO METHANE OR HYDROGEN → GRID INJECTION UNIT

GRID INJECTION UNIT → GAS GRID → NG / H_2

GAS GRID

Industrial Blending

NATURAL GAS → INDUSTRIAL BLENDING

HYDROGEN → INDUSTRIAL BLENDING

INDUSTRIAL BLENDING → NG / H_2 → GAS BLEND TO INDUSTRIAL PROCESS

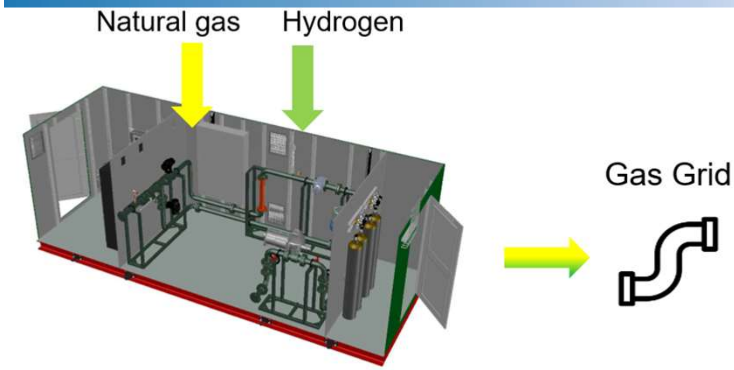
GAS BLEND TO INDUSTRIAL PROCESS

- Flow metering Natural Gas flow
- Flow metering Hydrogen stream
- Pressure control
- Blending control systems
- Gas Quality Control (Gas Chromatograph)
- RTU/Control system

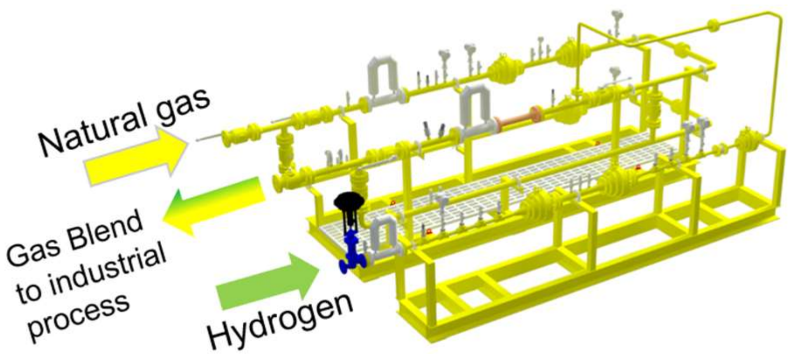
HONEYWELL BLENDING SOLUTIONS

for H_2 / Natural gas integration

Grid entry unit



Industrial blending skids



Both grid operator and end user needs must be addressed

End-to-end success

By addressing needs at origin and destination

- Integrated flow metering and pressure control
- Blending and gas quality control (GC)
- Remote Terminal Unit (RTU) and Control systems
- Connected capability
- Integrated odorization

H_2

- Tailor made to integrate into industrial systems
- Rapid response to process changes
- Gas Quality Control using GC or GasLab Q2

Note that at time of publishing some of the system depicted herein were undergoing development

HYDROGEN GAS TRAIN - GVU

1st Hydrogen Gas Train

Customer:
Anglo Belgian Corporation
Diesel and Fuel-Flexible Engines

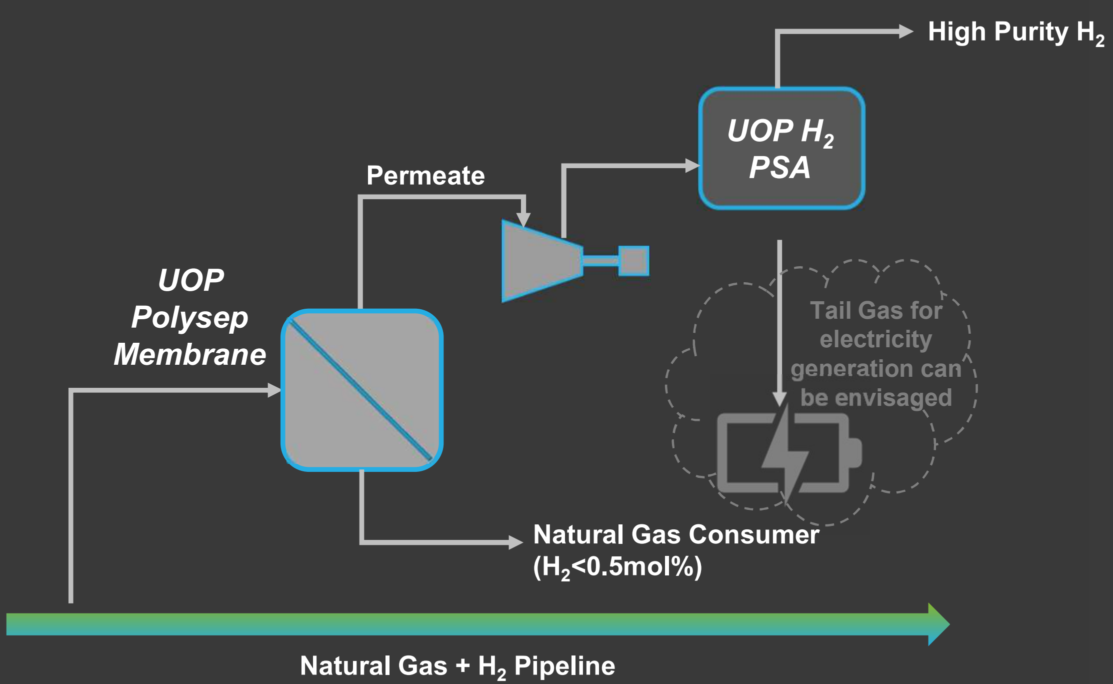
Application:
Hydrogen powered engine for a dredge ship

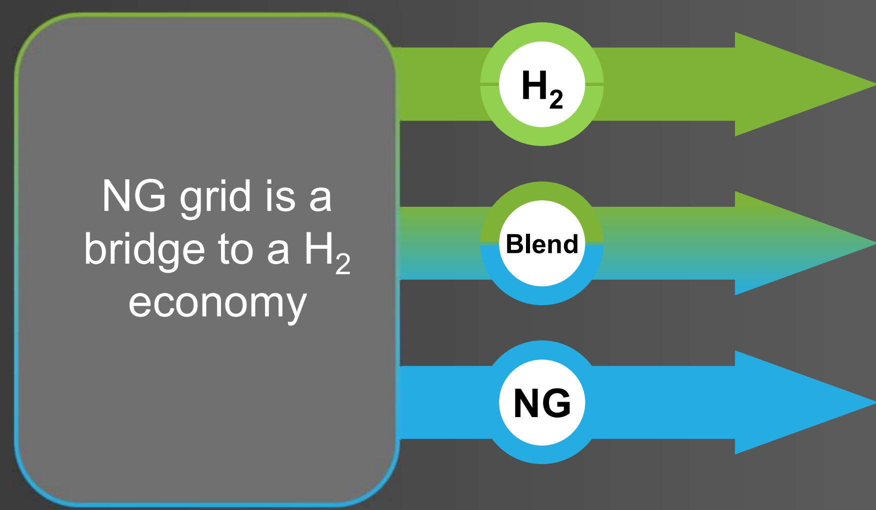
ANGLO BELGIAN CORPORATION
We power your future

16DZD BEHYDRO

- Up to 2,670 kWm
- 85% hydrogen - 15% diesel
- Natural aspirated low pressure gas feeding
- SMART mechanical

DEBLENDING SOLUTIONS
TO ADDRESS END CONSUMER NEEDS





AGENDA

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Why Use Chromatography To Analyze Natural Gas?

Measurement technologies have limitations

When attempting to measure a component within a mixture, the measurement technology must be capable of avoiding, or eliminating, cross-interference from all other compounds present in the mixture.

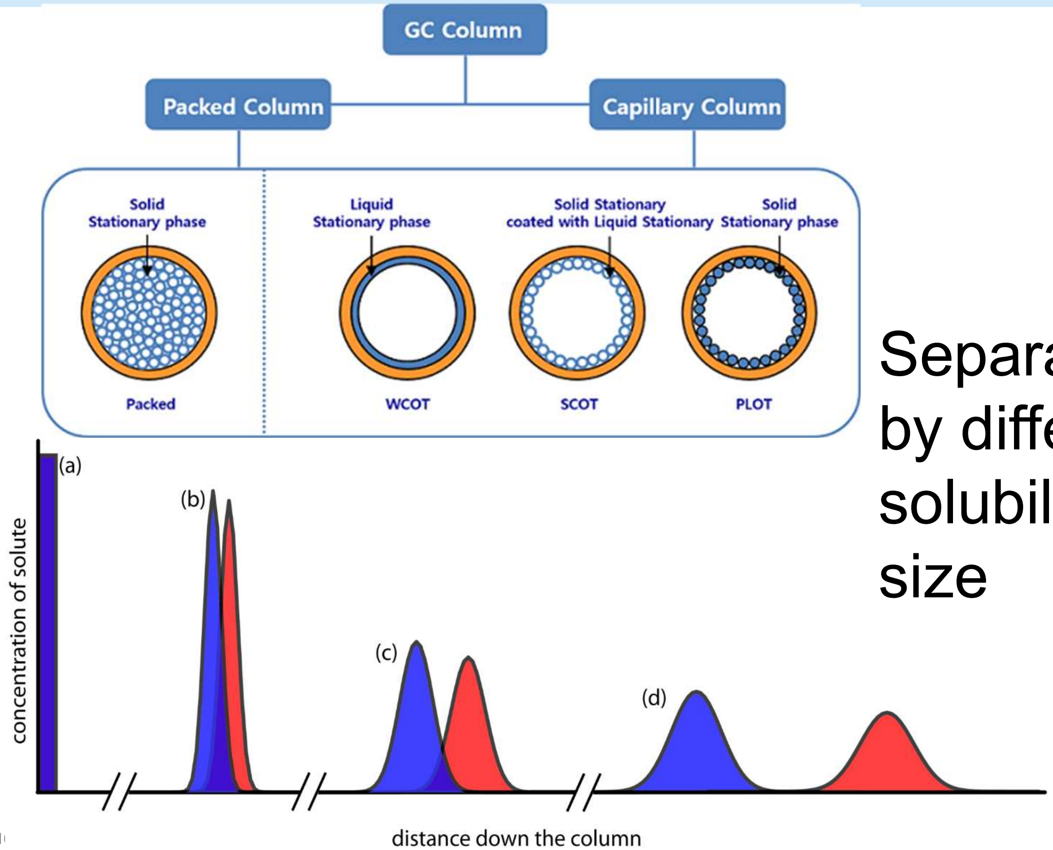
- Interference Free: Measured property is a function of only one unknown
- Cross-interference: Measured property is a function of multiple unknowns

If the cross-interference cannot be eliminated, the measurement cannot be performed.

Chromotography eliminates cross-interference by separating a mixture into individual components prior to measurement.

What is Gas Chromatography?

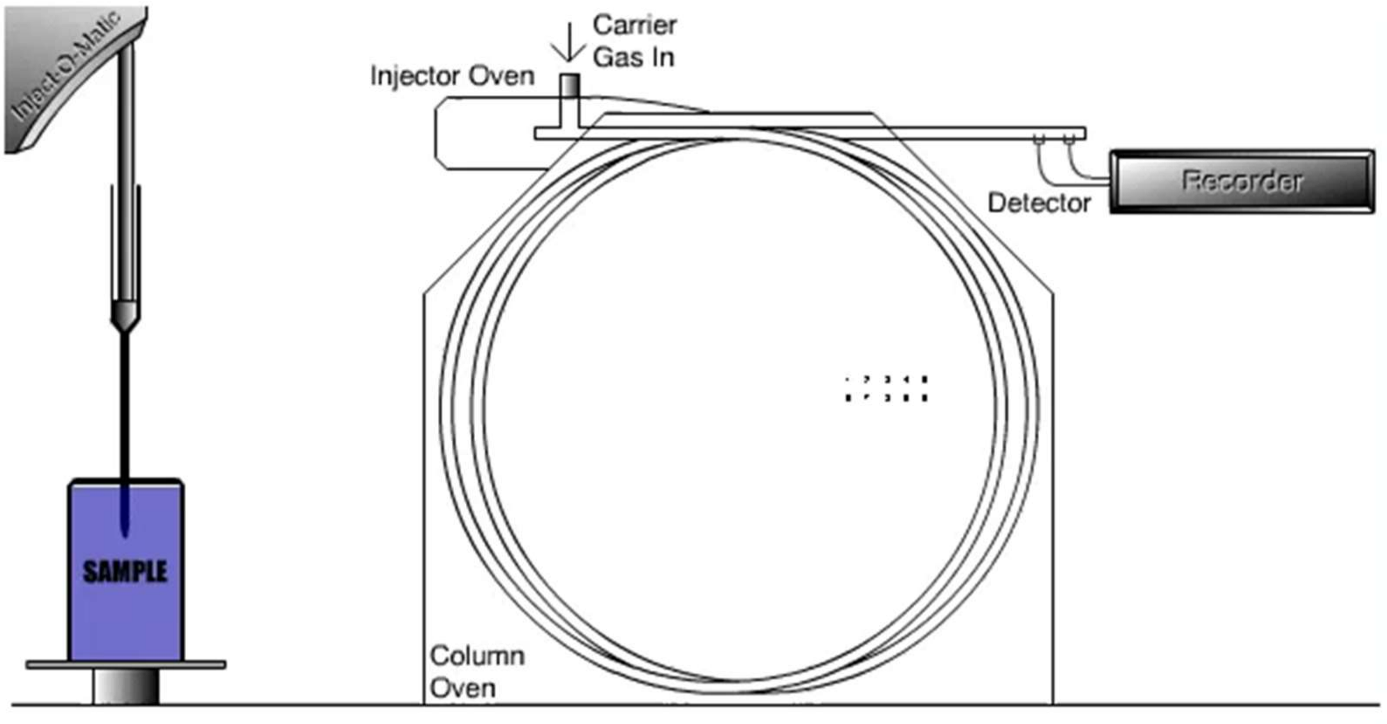
The separation of a gas-phase mixture by passing it through a medium in which the components of the mixture move at different speeds. Measurement cycles typically take 3 to 5 minutes depending upon application and hardware.



Separation is caused by differences in solubility / affinity / size

Chromatography

Carrier gas, a highly purified gas that is typically helium, flows continuously to push the mixture through the column. It is the baseline (background) against which the components are detected and measured.



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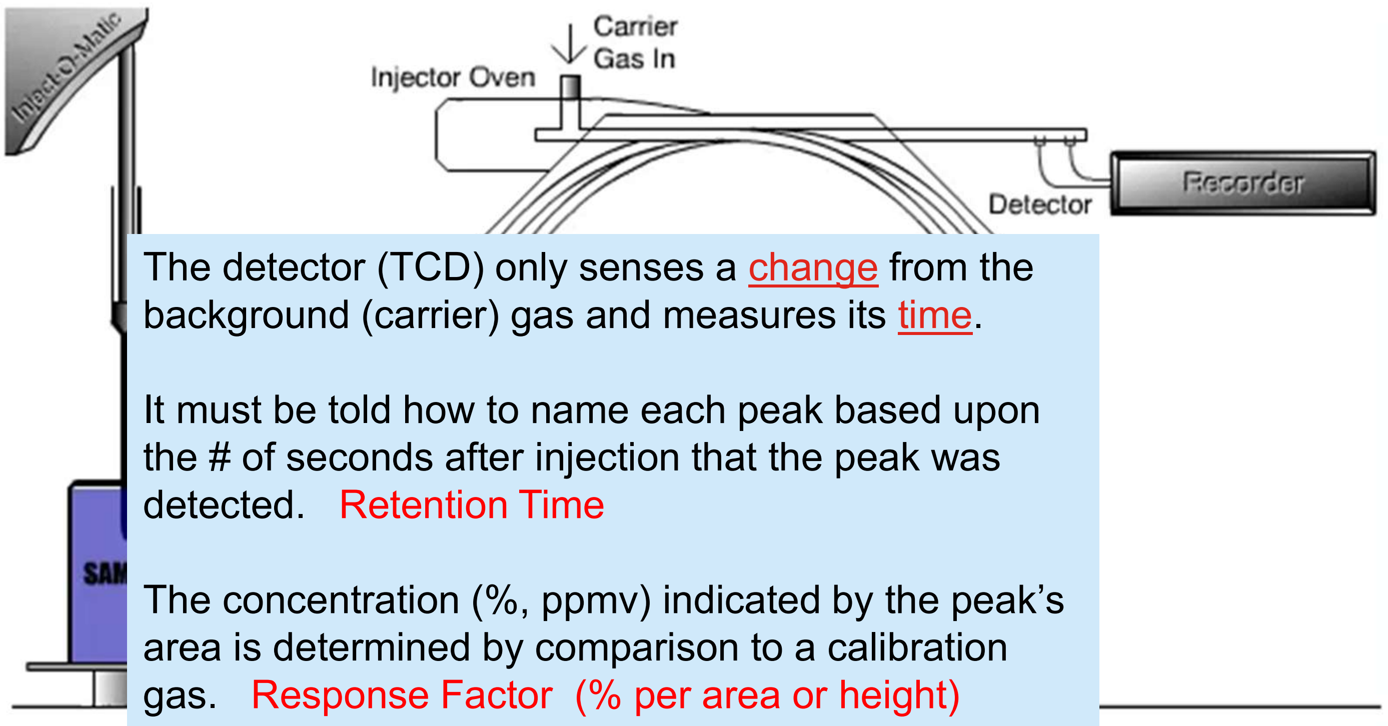
Chromatography

PLAY



The detector (TCD) only senses a change from the background (carrier) gas and measures its time.

It must be told how to name each peak based upon the # of seconds after injection that the peak was detected. Retention Time

The concentration (%, ppmv) indicated by the peak's area is determined by comparison to a calibration gas. Response Factor (% per area or height)

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Measurement: Peak Size to Concentration

First, Retention Time is used to ID the name of the unknown peak detected.

Second, the peak's Area is multiplied by the matched RF resulting in an **Un-Normalized Concentration**

AREA X RF = ESTD Conc.
4.98 E-05 * 82041.2891 = 4.087266

SAMPLE		ENERGY		ENVIRONMENT	
Sampling Time	6-5-2007 15:29	Calc.Method	ISO 6976	Sampling Analog #1	0
Run Number	96	Compressibilit	0.99723	Sampling Analog #2	0
Run Type	Analysis	Molar Mass	18.10497	Cabinet Temperature	30
Calibration Level	1	Molar Mass Ra	0.62512	Ambient Pressure	102
Stream #	6	Rel.Density	0.62648	Digital in #1	0
Alarm Status	OK	Abs.Density	0.80999	Digital in #2	0
Verification Check	Approved	Hs	11.13001	Digital in #3	0
Sum ESTD	99.9862	Hi	10.05231		
Sum Estimates	0	Wobbe Sup.	14.06181	SITE INFO	
Sum Areas	1814323.512	Wobbe Inf.	12.70023	Customer ID	
Total Peaks	14			Instrument Name	EnCal 3000
Is Startup Run	False			Serial Number	60700252
Unknown Peaks	0			Tag Number	
Current Stream #	6			Cylinder 1 Tag	

#	Channel	Peakname	ESTD Conc.	Norm. Conc.	Retention [s]	Area	Height	Meth-Index	Group#	R.F.
1	1	Nitrogen	4.087266	4.087828	7.28	82041.2891	6645368.985	1	0	4.98E-05
2	1	Methane	88.78094	88.793155	9.21	1510619.131	69542492.18	2	0	5.88E-05
3	1	CO2	1.499977	1.500183	23.31	36240.7487	843331.2575	3	0	4.14E-05
4	1	Ethane	3.990364	3.990913	37.99	104858.4328	1585079.97	4	0	3.81E-05
5	2	Propane	0.998948	0.999086	11.96	45007.5005	6938540.25	5	0	2.22E-05
6	2	i-Butane	0.199951	0.199978	13.81	10401.7423	1435779.266	6	0	1.92E-05
7	2	n-Butane	0.20143	0.201458	15.23	10879.8099	1440925.815	7	0	1.85E-05
8	2	neo-Pentane	0.04946	0.049467	15.95	2607.186	310067.1352	8	0	1.90E-05
9	2	i-Pentane	0.04986	0.049867	19.9	2965.2094	291440.0808	9	0	1.68E-05
10	2	n-Pentane	0.049767	0.049774	22.09	3053.5154	301205.135	10	0	1.63E-05
11	2	n-Hexane	0.049822	0.049829	36.67	3427.6981	222991.1834	11	0	1.45E-05
12	2	n-Heptane	0.019723	0.019726	67.52	1507.6185	61164.7044	12	0	1.31E-05
13	2	n-Octane	0.006703	0.006704	132.41	544.1777	13205.7243	13	0	1.23E-05
14	2	n-Nonane	0.002032	0.002032	268.57	169.4533	2205.8017	14	0	1.20E-05

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Chromatography Limitations in RNG and Blending

Biomethane

- Typical natural gas GCs are unable to separate O_2 from N_2
- A 4+ minute cycle time is not suited to controlling or monitoring a gas blending process which can have rapid changes

Hydrogen Blended Natural Gas

- Hydrogen is not measurable by typical natural gas GCs which use He carrier
  - Unable to 'see' the hydrogen, the GC assumes the traditional C6+ analysis represents 100% of the mixture leading to serious mis-measurement
- Special GCs can use argon or nitrogen carrier gas for the H_2 measurement
- The cycle time of GCs is not suited to controlling gas blending processes

EnCal 3000 for Biomethane

#1 GAS CHROMATOGRAPH

- C1…C6+
- N_2
- CO_2

#1, #2, #3 EnCal 3000 Biomethane
3 to 5 minute cycle time

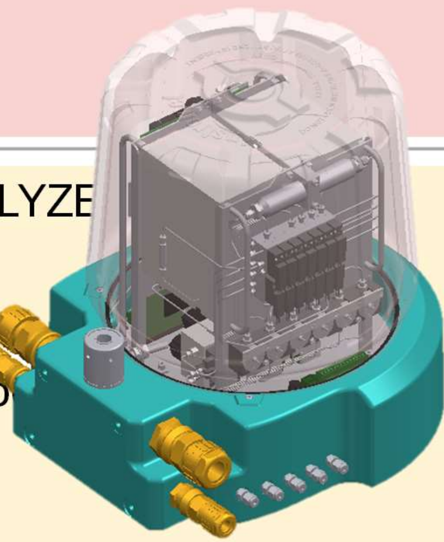
Measures:
$C_1…C_4$, N_2, O_2, CO_2, $*H_2S$, *COS, $*H_2$
*optional

#4 MOISTURE ANALYZER

- Tunable Diode Laser
- Quartz Crystal Microbalance
- Metal- or Ceramic-oxide probe

#2 H_2S ANALYZE

- Paper Tape
- Tunable Dio
- UV



#3 OXYGEN ANALYZER

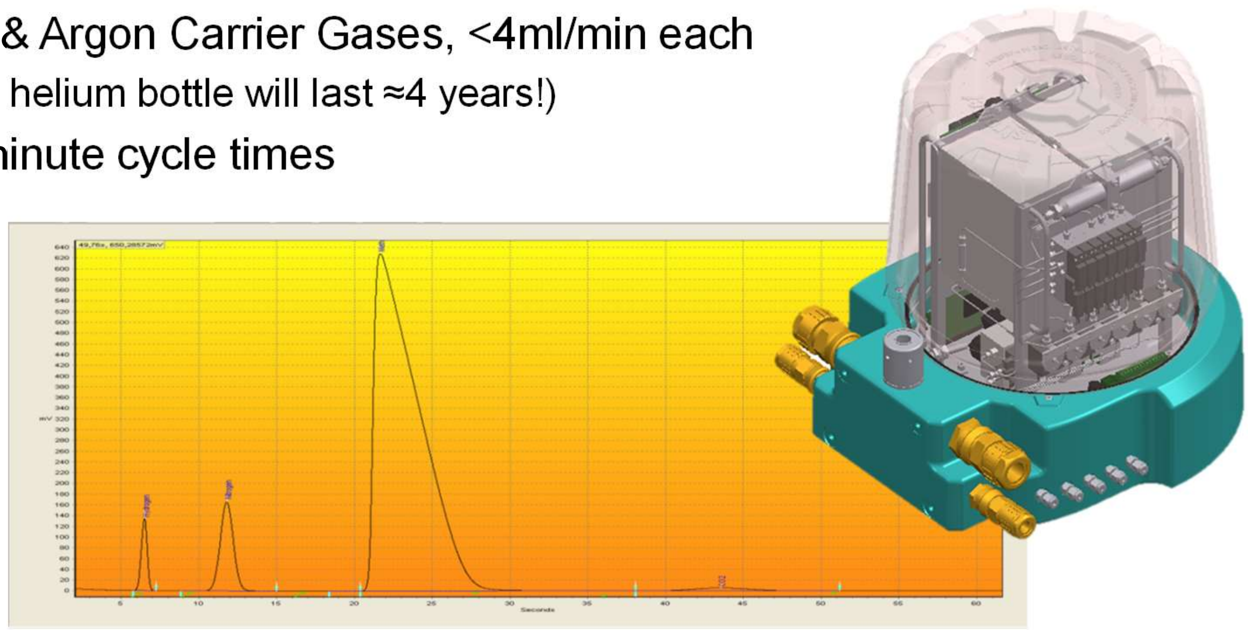
- Quenched Fluorescence
- Quench Luminescence
- Electrochemical sensors

Column1 : O_2, N_2, $*H_2$ ← Carrier gas He or Ar (*optional)

Column 2: CH_4, CO_2, C2, C3, i- n-C4, $*H_2S$, COS ← Carrier gas He

EnCal 3000 for Hydrogen-Natural Gas Blends
Accurate analysis of natural gas containing Hydrogen

- Accurate measurement of natural gas containing 0-30% hydrogen and for hydrogen purity
- Available in C6+, C8, or C9
- Helium & Argon Carrier Gases, <4ml/min each
  - (the helium bottle will last ≈4 years!)
- 3 to 5 minute cycle times



Gaslab Q2 - Engineered for Process Control and Optimization

Ideal for Feed-Forward Control and 'Live' Gas Quality Monitoring

Speed Of Response: T90<6 seconds

Update Frequency: 1/second

Continuous, Non-Cyclic Measurements

Monitor CO_2 Separation membranes
Control LPG injection systems
Control Gas blending systems

CHROMATOGRAPHY VS. GASLAB TECHNOLOGY

Chromatography

Provides Measurements:

- C1…C6+ Composition
- Calorific Value
- Density
- Wobbe
- Z - Compressibility

- Every 240 - 300 seconds

Requiring:

- C6+ Calibration Gas bottle every year
- Carrier Gas Bottles w/ changeover system

Gaslab

Provides Measurements:

- C1…C8 Composition
- Calorific Value
- Density
- Wobbe
- Z - Compressibility
- Methane Number (MN)
- **Every 1 second**

Requiring:

- CO_2/CH_4 Cal. gas that may last 5 years

Lack of carrier and costly calibration gas can save >$9,000 over 5 years

THE PURPOSE OF GASLAB TECHNOLOGY

Provide a better solution for natural gas process monitoring and blending control than Calorimeters and Chromatographs.

Flame/Combustion Calorimeters provide a very fast response speed. However, they **are costly to buy, costly to run, and need lots of maintenance.** Many only provide an estimate of Wobbe and excess fuel unless equipped with a costly densitometer that is needed to measure density to permit a calculation of calorific value.

Chromatographs are precise but blind >99% of the time. They only provide a 3 to 5 minute old ‘photograph’ of the injected gas sample’s quality.

This data rate and lag time are often insufficient for use in process monitoring and control applications such as LPG upgrading.

DECARBONIZATION THROUGH SAFE AND RELIABLE Biomethane GRID INJECTION

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Honeywell Process Measurement & Control

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Honeywell
THE FUTURE IS WHAT WE MAKE IT

Honeywell