GAS PORTFOLIO 2016

GE imagination at work

Product Portfolio

Electrochemical

oxy.IQ

Galvanic Fuel Cell oxygen sensor for ppm or $\%O_2$ in gases

Delta F

Non-depleting electrochemical oxygen sensors for ppm O_2 in gases.

ThermoParamagnetic

XMO2

$\%O_2$ in gases Transmitter w/optional displays with relatively constant background gas

Zirconium Oxide

CGA351

Clean Gas Oxygen Analyzer for analytical applications

Thermal Conductivity

XMTC

%Gas Analyzer in other gases based on measuring differences in thermal conductivity (Typically H_2 analysis)

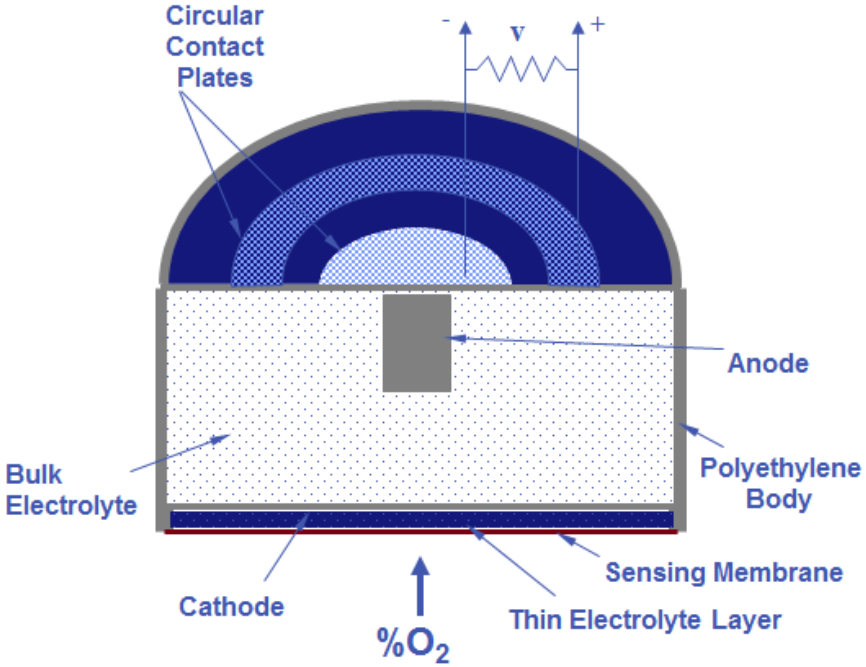
imagination at work

Fuel Cell O2

oxy.IQ

The Biggest Small Thing in Oxygen Analysis

Measuring Oxygen: Fuel Cell O2 Sensor



Cathode:

$O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$

Anode:

$2Pb \rightarrow 2\ Pb^{+2} + 4e^-$

Overall:

$2Pb + O_2 \rightarrow 2PbO$

Current output is proportional to O2 concentration

GE imagination at work

Simple Installation

oxy.IQ has same process and electrical connections

- 1/8 NPT
- 2 wire loop powered 4 to 20 mA

oxy.IQ New O2 Transmitter

Key Features

- ✓ Display & Keypad
- ✓ Small size, half size of O2X1
- ✓ User Interface
  - ✓ Multiple user selectable output ranges
    - ✓ 0 to 10, 20, 50, 100, 200, 500, 1000, 2000, 5000 ppm
    - ✓ 0 to 1, 2, 5, 10, 25, 50, 100% O2
  - ✓ Sensor diagnostics
    - ✓ Sensor lifetime feature
    - ✓ Sensor raw signal
  - ✓ Error indication choice
    - ✓ High low, specific mA output value, NAMUR format
  - ✓ Low reading / possible sensor failure alarm
- ✓ Temperature compensation algorithm
- ✓ Sensor noise reduction
- ✓ Tropicalized
- ✓ Intrinsically Safe (IS) option for hazardous area locations

oxy.IQ New O2 Transmitter

Specifications

Accuracy

±2% of range at the calibration point for the 0 to 10 ppm range (OX-1 or OX-2 only)

±1% of range at calibration point all other ranges

Repeatability

±2% of Range for the 0 to 10 ppm range (OX-1, 2 only)

±1% of range

Resolution

±0.1% of range

Linearity

±2% of range (OX-1, 2, 3, 5)

±5% of range (OX-4)

O2 Sensor Operating Temperature

32°F to 113°F (0°C to 45°C)

oxy.IQ New O2 Transmitter

Specifications

Atmospheric Pressure Effect

±0.13% of reading per mmHg (directly proportional to absolute pressure). During calibration, pressure and flow must be kept constant.

Recommended Sample Pressure

Vent to atmosphere

Sample Flow Rate

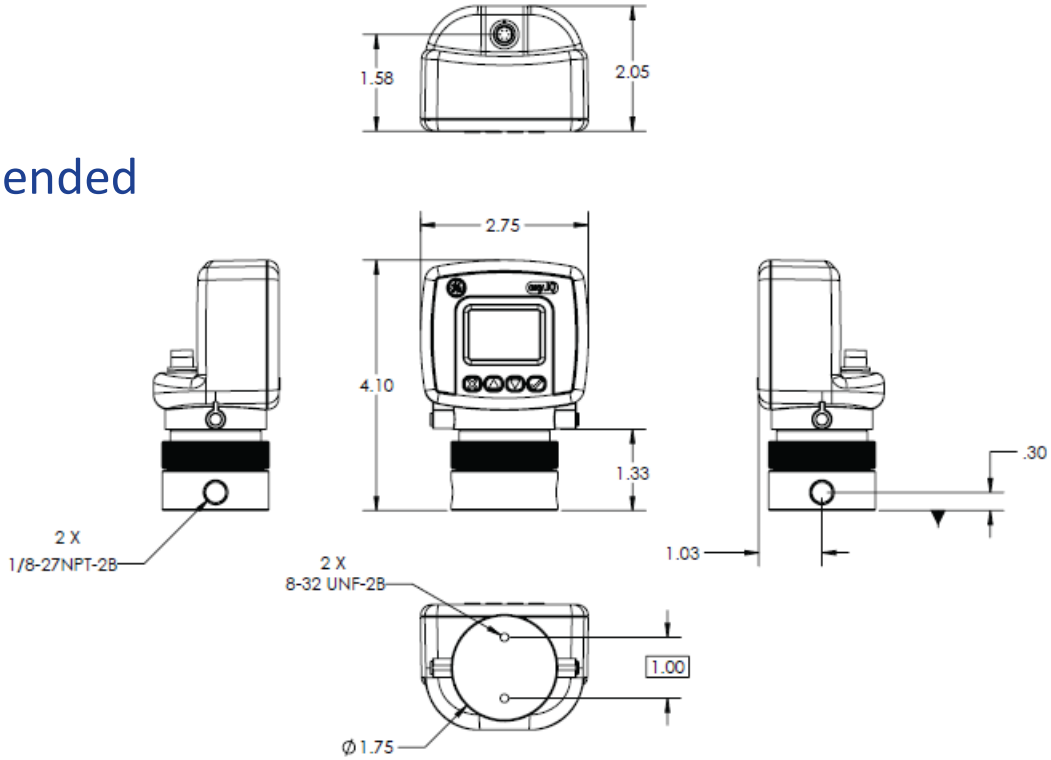
1.0 SCFH (500 cc/min) recommended

Dimensions

4.10 in x 2.75 in x 2.05 in

Weight

1.35 lb (612 grams)



oxy.IQ New O2 Transmitter

Specifications

- Electrical Classification/Certification
  - Certifications received in March 2015
  - Intrinsically Safe
    - USA/Canada
      - IS for Class I, Div 1, Groups ABCD, T4 AEx ia IIC T4
    - ATEX and IECEx
      - Ex ia IIC Ga T4 Tamb -20 to 60°C
- European Compliance
  - Complies with EMC Directive 2004/108/EC

oxy.IQ Ex Flameproof Option – ATEX & IECEx Certified

ISSeP
Institut scientifique de service public

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Tél : +32(0)4.229.83.11
Fax : +32(0)4.252.46.65

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rue de la Plâtinerie
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Tél : +32(0)65.61.08.11
Fax : +32(0)65.61.08.09

e-mail : direction@issep.be
site web : http://www.issep.be

(1) EC TYPE EXAMINATION CERTIFICATE

(2) **Equipment or protective system intended for use in potentially explosive atmospheres Directive 94/9/EC**

(3) EC type examination certificate number: **ISSeP10ATEX011**

(4) Equipment : Equipped flameproof housings
Types GUB * S/W - *

(5) Applicant : Officina Meccanica e Apparecchiature Antideflagranti

(6) Address: Via Vico Veneto 32
20090 Fizzonasco di P.ve Emanuele (MI)
Italie

(7) This equipment or protective system and any acceptable variation thereto is specified in the schedule to this certificate and the documents therein referred to.

(8) ISSeP, notified body n° 492 in accordance with article 9 of the Council Directive 94/9/EC of 23 March 1994, certifies that this equipment or protective system has been found to comply with the Essential Health and Safety Requirements relating to the design and construction of equipment and protective systems intended for use in potentially explosive atmospheres given in annex II to the Directive.

The examination and test results are recorded in confidential report no 08027

(9) Compliance with the Essential Health and Safety Requirements has been assured by compliance with:
EN 60079-0:2009 (IEC 60079-0:2007) EN 60079-1:2007 (IEC 60079-1:2007)
EN 60079-11:2007 (IEC 60079-11:2006) EN 60079-31:2009 (IEC 60079-31:2008)

(10) If the symbol "X" is placed after the certificate number, it indicates that the equipment or protective system is subject to special conditions for safe use specified in the schedule to this certificate

IEC IECEx

IECEx Certificate of Conformity

INTERNATIONAL ELECTROTECHNICAL COMMISSION
IEC Certification Scheme for Explosive Atmospheres
for rules and details of the IECEx Scheme visit www.iecex.com

Certificate No.: IECEx INE 11.0018X issue No.:0 Certificate history:

Status: Current

Date of Issue: **2013-01-16** Page 1 of 3

Applicant: **OFFICINE MECCANICHE MAM**
Via Vico Veneto, 32
I - 20090 Fizzonasco di Peve Emanuele (MI)
Italy

Electrical Apparatus: **Enclosures type GUB.....**
Optional accessory:

Type of Protection: **d, d [ia], tb, tb [ia]**

Marking: Ex d IIC T6, T5 or T4 Gb, Ex tb IIIC T85°C, T100°C or T135°C,
Ex d [ia Ga] IIC T6 Gb, Ex tb [ia Da] IIIC T85°C Db IP66

Approved for issue on behalf of the IECEx Certification Body: Thierry HOUEIX

Position: Ex Certification Officer

oxy.IQ Sensor Selection Guide – Acid Gas Compatibility

Gas	OX-1 and OX-5, ppm Cont.	OX-2, ppm Cont.	OX-3, %		OX-4%	
			Cont.	Int. (1)	Cont.	Int.
H_2S	<5 ppm	<10 ppm	0.0005%	0.01%	0.001%	0.1%
SO_3	<10 ppm	<10 ppm	0.01%	0.1%	0.01%	0.1%
SO_2	<10 ppm	(3)	0.01%	0.1%	(3)	(3)
HCl	<1000 ppm	(3)	0.1%	1.0%	(3)	(3)
HCN	<1000 ppm	(3)	0.1%	1.0%	(3)	(3)
CO_2	<1000 ppm	(3)	0.1%	20%	(3)	(3)
NO_2	(2)	(2)	(2)	(2)	(2)	(2)
CL_2	(2)	(2)	(2)	(2)	(2)	(2)

Cont. = Continuous, Int. = Intermittent

(1) Recommended maximum exposure 30 minutes followed by flushing with ambient air for equal period

(2) Minimal effect on sensor performance, but produces signal interference of 1:2 ratio, ppm levels only. For example, 100 ppm NO_2 looks like 200 ppm O_2

(3) Minimal effect on sensor performance

oxy.IQ Applications – Glove Boxes

Glove boxes are used to create a protective atmosphere for the materials under process. Typically Oxygen and Moisture are controlled at trace levels

- Oxygen measurement is usually at trace ppm levels, therefore electrochemical O2 sensor is required

oxy.IQ is the low cost solution – ideal for OEM Glove box manufacturer

Low initial costs in line with range ability, accuracy, response time and maintenance expectations

Fig 1: Glove box with purification for product protection. Work under positive pressure with controlled atmosphere 1 ppm [O2] and [H2O] Manipulation of products sensitive to moisture and/or oxygen

Fig 2: Remote purification system used in combination with glove box systems for product protection. Controls e.g. Oxygen and Moisture concentrations

oxy.IQ Applications - Natural Gas in North America

HygroPro and oxy.IQ

oxy.IQ replaces O2X1

oxy.IQ Applications - Natural Gas in Europe

- EASEE-gas: European Association for the Streamlining of Energy Exchange
- Organization has defined Common Business Practices (CBP) and recommends specifications for Minimum Gas Quality at cross border points in Europe, and describes parameters, ranges, and implementation plan. The spec for Oxygen in NG is (0.01 %)
- EASEE has specified oxy.IQ as the preferred sensor for the measurement of Oxygen at cross border stations and other locations.
- Eff Oct 2010, the CBP is applicable for all organization in the NG supply chain: producer, distributor and network operators

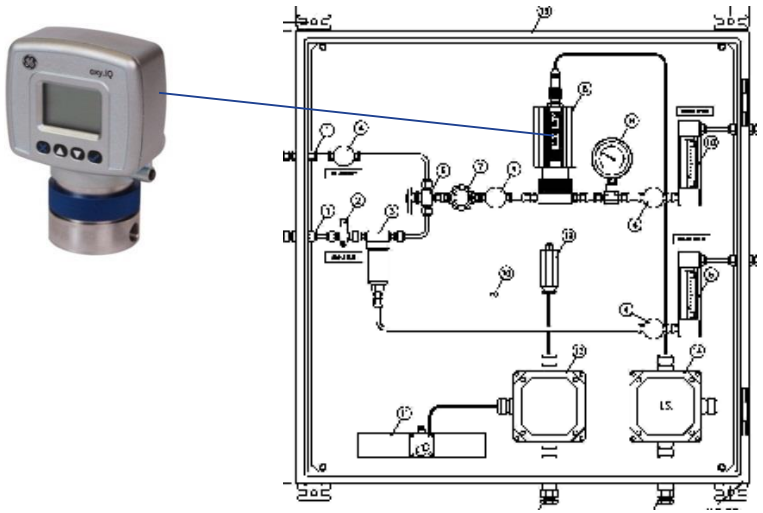


Fig 1: typical sample system for the application of NG quality measurement. oxy.IQ replaces O2X1
Components required:
1: oxy.IQ Oxygen Transmitter
2: Cable
3: Zener Barrier (located in safe area) MTL7706
4: Sample System

Fig 2: selection of member organization of the EASEE:

oxy.IQ Applications – Air Separation Skids

N_2 Generation

- Oxygen measurement is trace so paramagnetic analyzer is not suitable.
- Usually want least expensive oxygen measurement device which is typically depleting electrochemical

oxy.IQ low cost solution – ideal for OEM Nitrogen generator manufacturer

Low initial costs in line with range ability, accuracy, response time and maintenance expectations

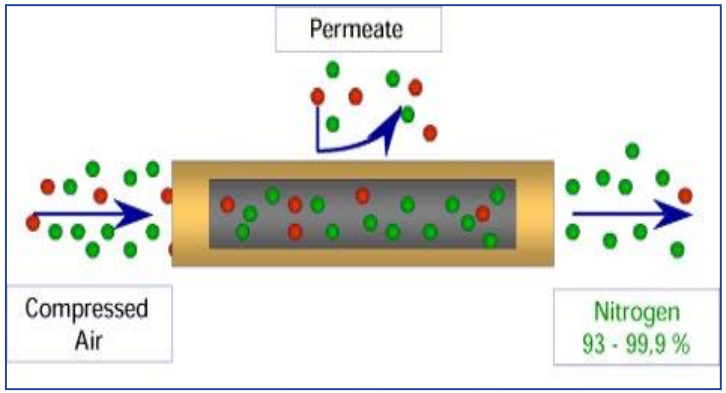


Fig 1: Compressed Air feed Oil-free Membrane allows other gases to permeate out of supply air
Result is purified N_2 stream

Fig2: N_2 membrane generator at GE Sensing China Service Center in Shanghai Nov. 2006

H_2 Generation

- Several processes used for H_2 production including catalytic reforming of methanol, Natural Gas, LPG or NH3 in combination with PSA purifying
- Oxygen measurement is trace so paramagnetic analyzer is not suitable
- Usually want least expensive oxygen measurement device which is typically depleting electrochemical

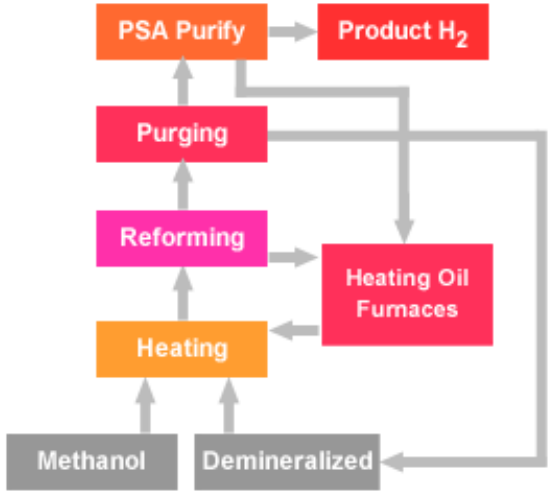


Fig 1: methanol and demineralized H2O, through heater into reactor, reforming in catalytic reactor forming CO2 and H2

Fig 2: Steam reactor unit used for H2 production

Petrochemical/Refinery

Hydrocarbon Gases

- Flare Gas
- Process Gases
  - Ethane
  - Propane
  - Butane
- Vapor Recovery

Paramagnetic O2

XMO2 Thermomagnetic O2 Sensor Overview

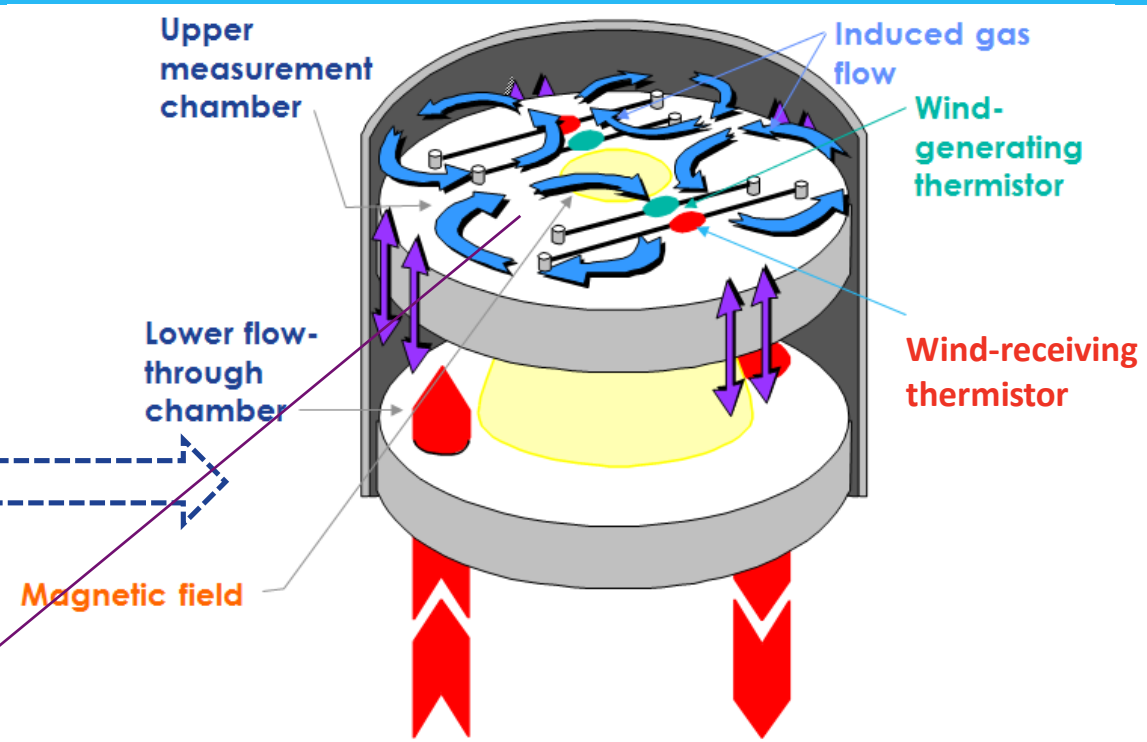
XMO2

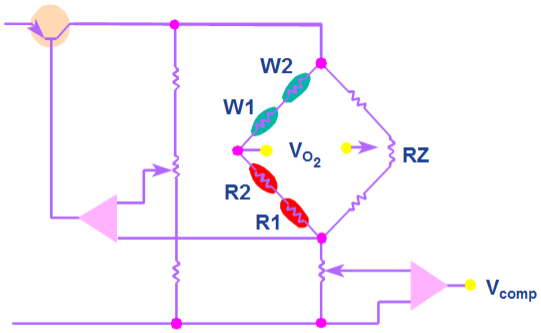
TMO2D

XDP

Sample Systems

XMO2 Thermomagnetic O2 Sensor





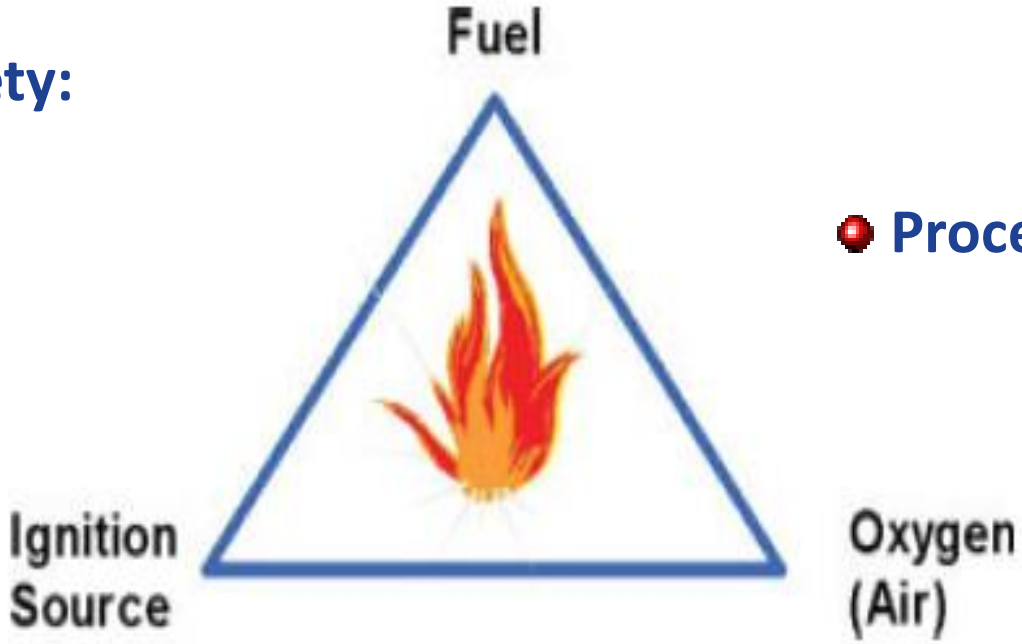
W1, W2 = WIND GENERATING THERMISTORS
R1, R2 = WIND RECEIVING THERMISTORS

Inerting Gas Application

Why monitor oxygen?

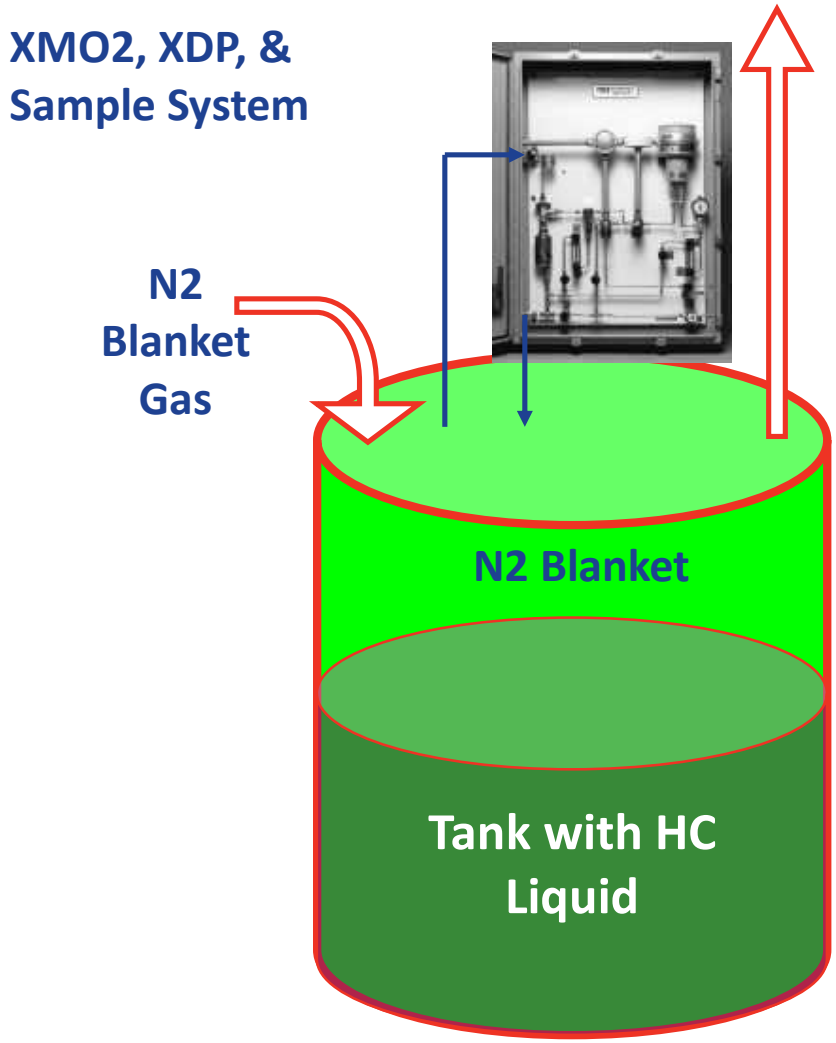
Why?
Why?
Why?
Why?

- **Safety:**



- **Process Control:**

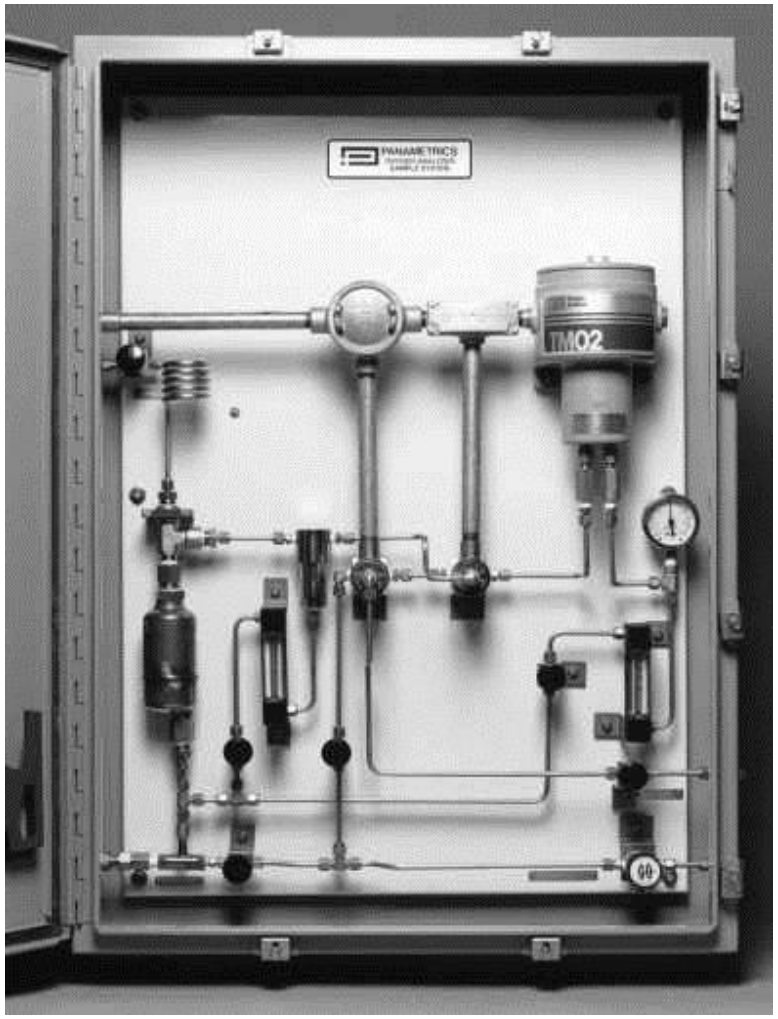
Inerting Gas Application



XDP Display / Power Supply can be mounted locally or remotely

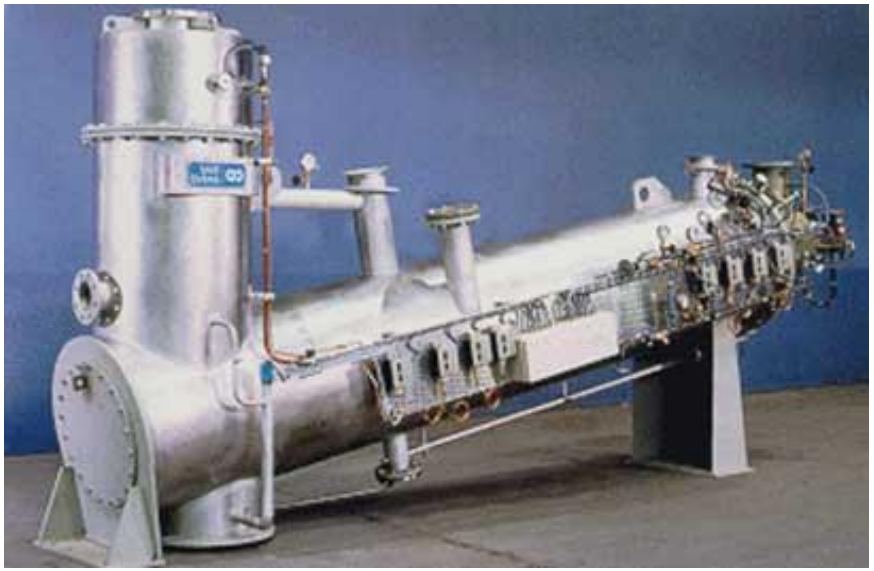
Inerting Gas Application

Sample System for Inerting Application
with Auto-calibration

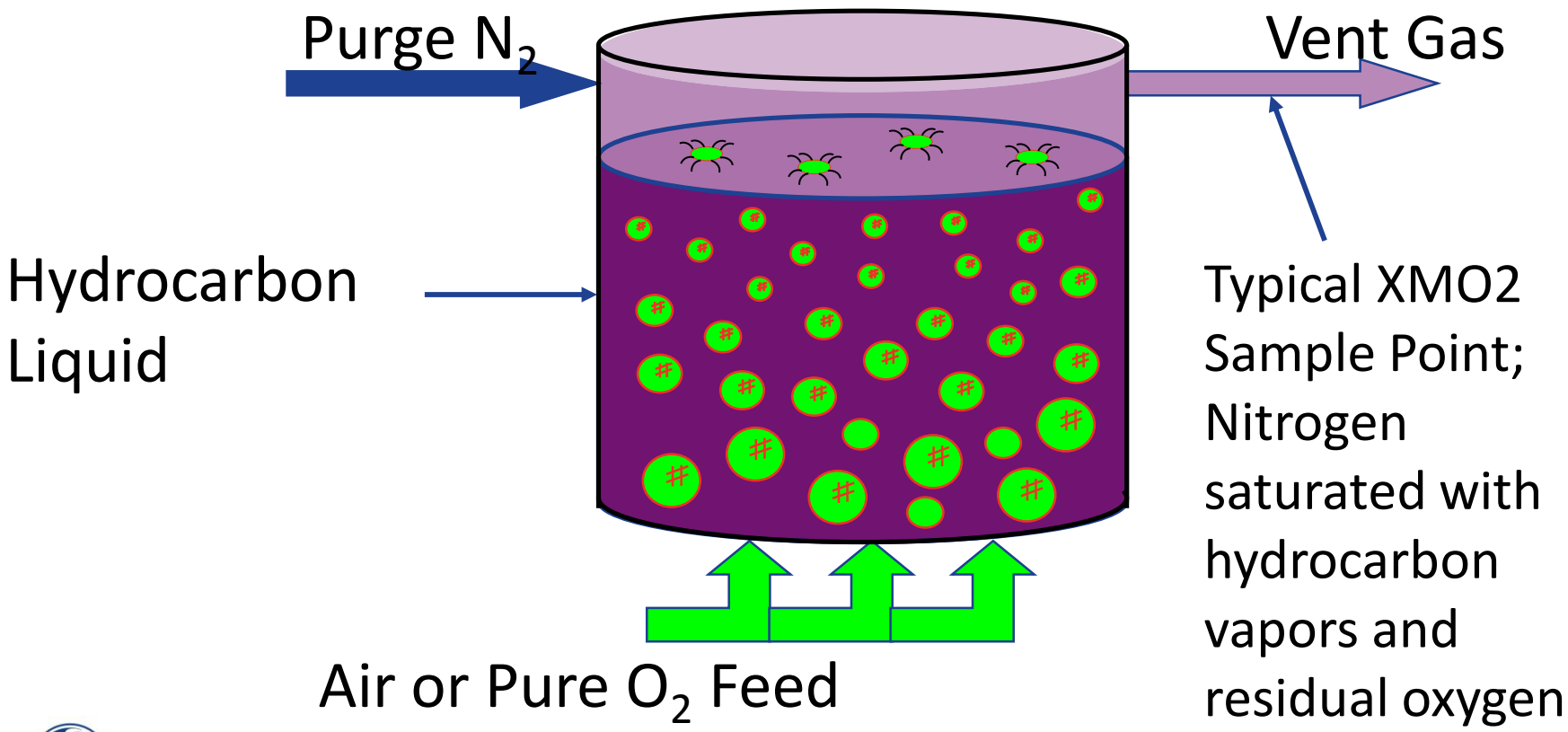


Inerting Gas Application

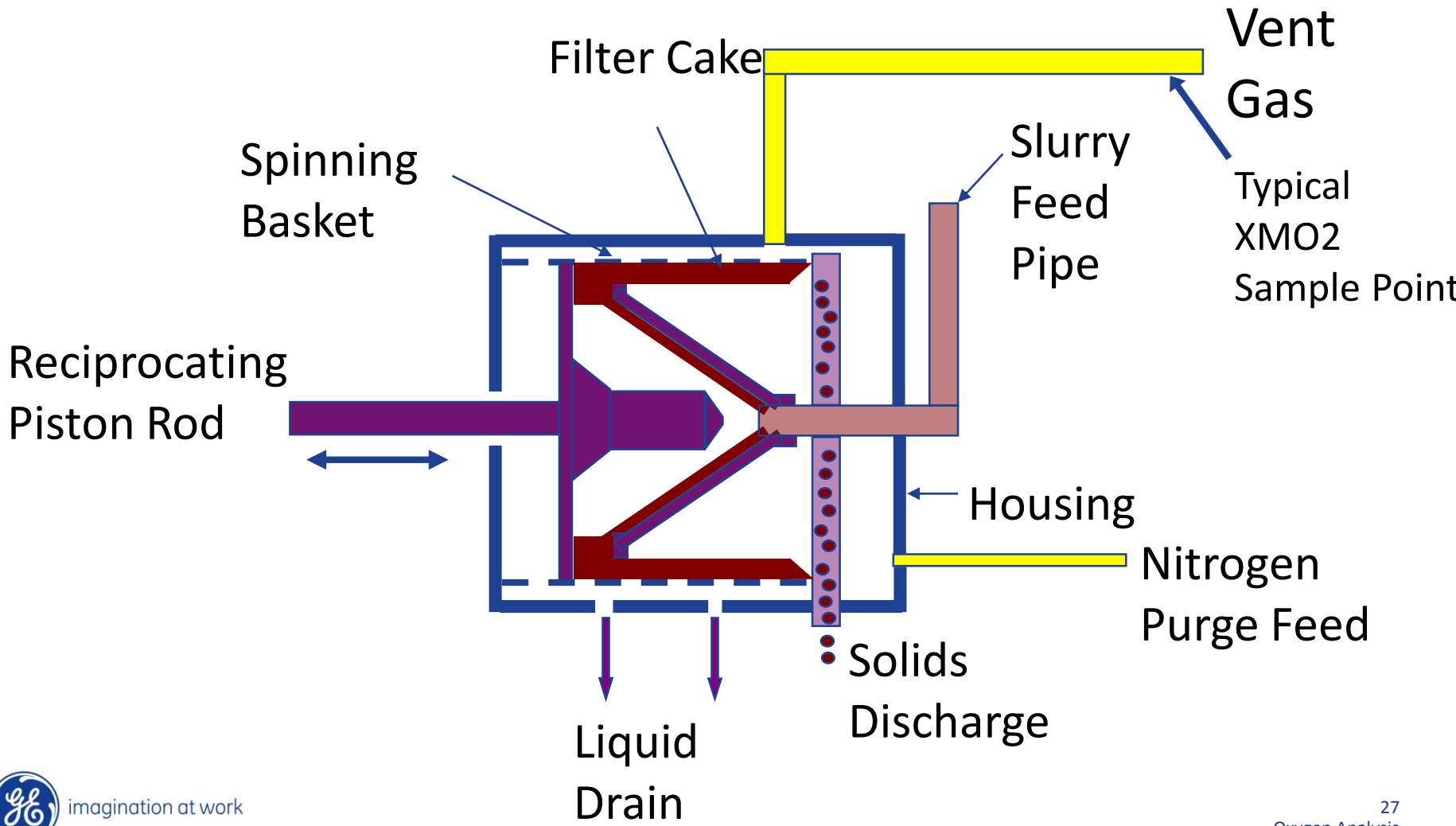
More than 400 XMO2 sailing the seven seas



Oxidation Reactor Application

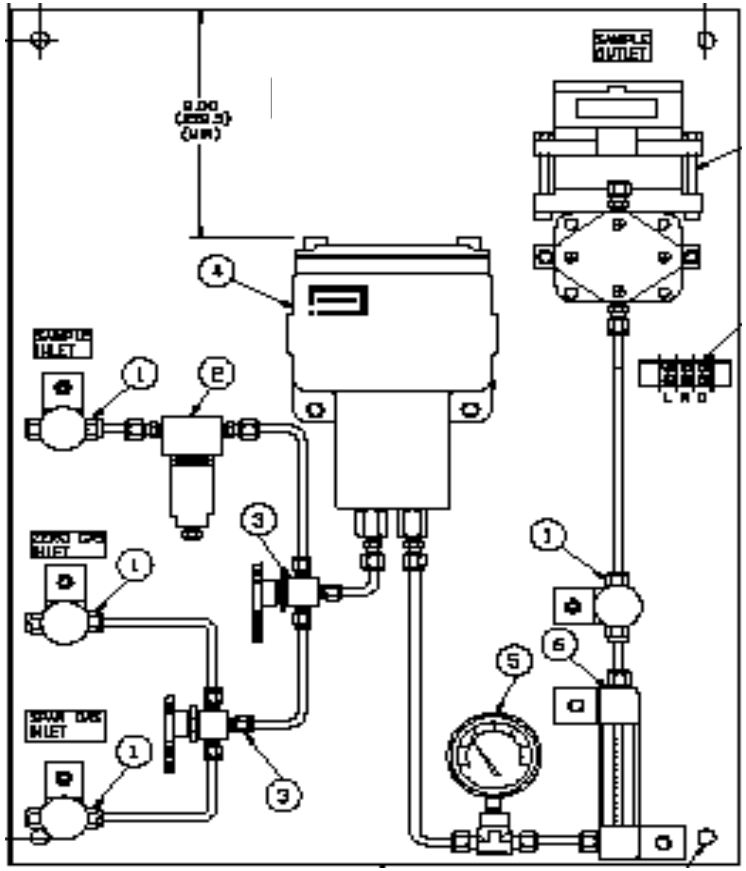


Centrifuge Application



Furnace Application

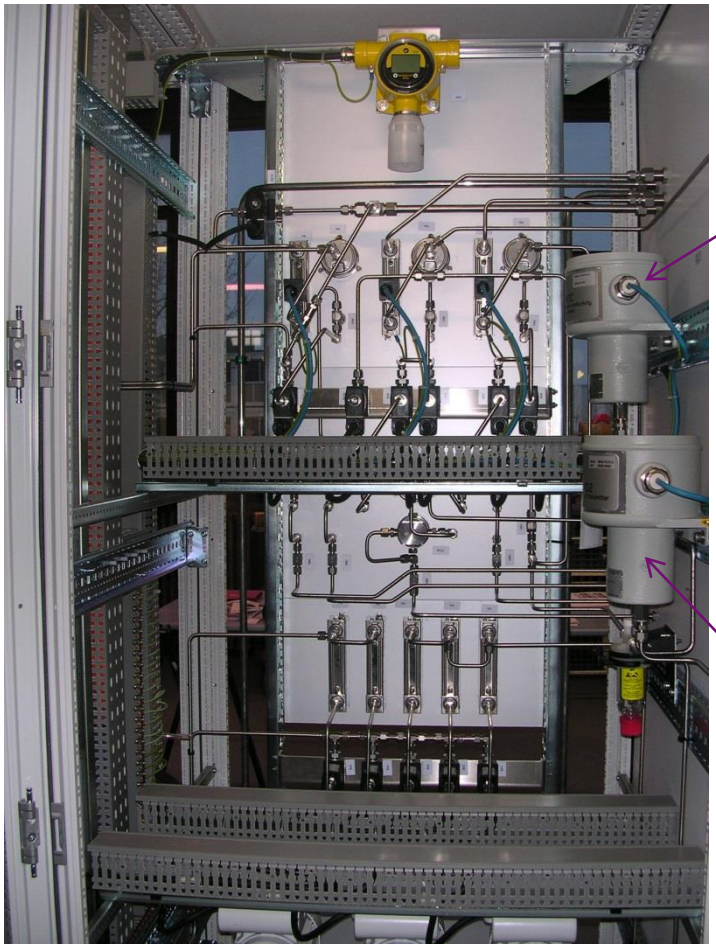
Bell Furnace



Sample system – Filtration and Pump required

XMO2 Thermomagnetic O2 Sensor Applications

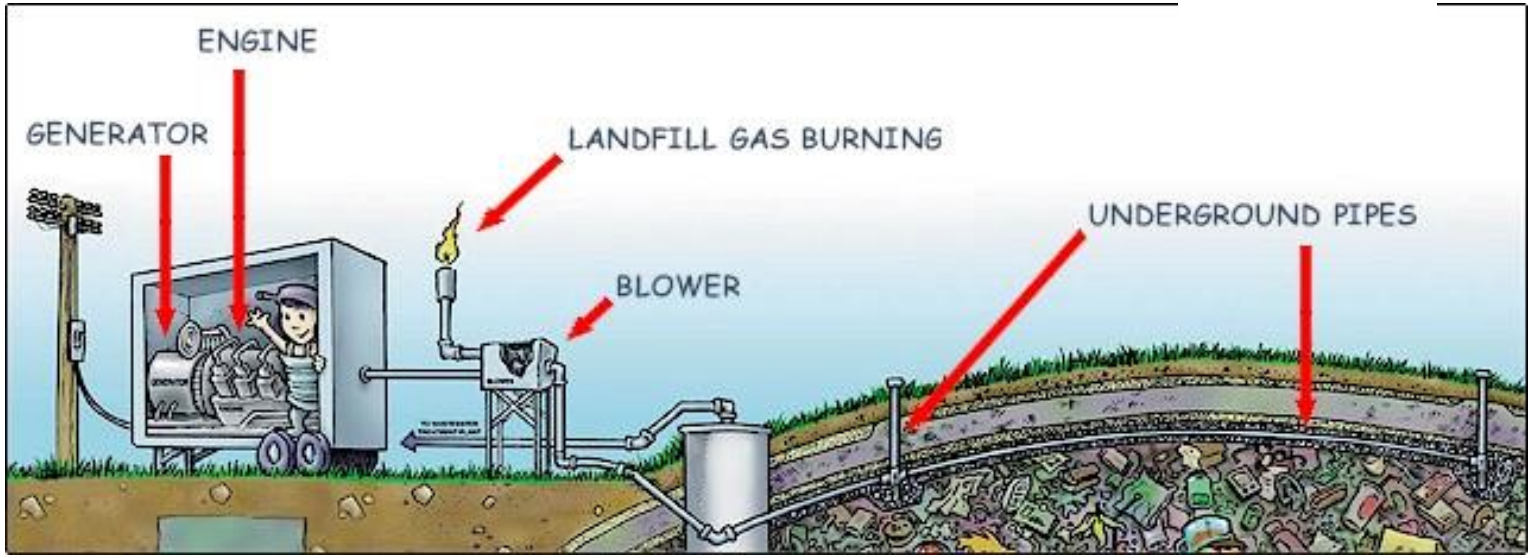
Furnace Application – 3 Measurands



XMTC

XMO2

Biogas Applications



Landfill Gas

Ken Pugh calibrating an XMO2 and XMTC at the Frederick County Landfill in Maryland, USA

Wastewater Digester Application

Waste Water Treatment Plant –
Aerobic Digesters

Our Valued Customers

Chemical

3M

MOMENTIVE performance materials

MONSANTO

DSM

IFF International Flavors & Fragrances Inc.

sabic

Rhodia

L'ORÉAL

Ciba

sasol reaching new frontiers

bp

Nestlé

BASF The Chemical Company

MARATHON

Pharmaceutical

MERCK

BAYER Bayer

AVEVA Drug Delivery Systems

NOVARTIS

gsk GlaxoSmithKline

Our Valued Customers

Heat Treating

JW Aluminum

DREVER International

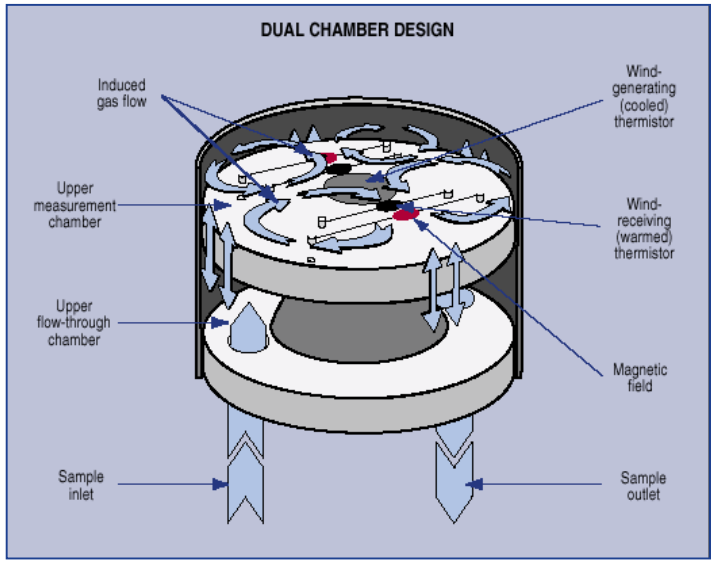
CHARTER STEEL

ArcelorMittal

AK Steel

USS

The XMO2 Advantage



XMO2 Oxygen Transmitter

- Thermoparamagnetic sensor
- No moving parts
- Ultra stable thermistors
- Dual chamber design
- Stainless steel or Hastelloy wetted materials

No Moving Parts → **Longer time in-between calibrations / Less touch time by the customer**

Dual chamber design → **Less transmitter down time**

Hazardous Area Rating → **Smaller package, no external barriers – lower cost**

imagination at work

Delta F O2 cell

DF Electrochemical sensors & analyzers

DF Electrochemical sensors & analyzers

Specifications

- Range: PPM & % range cells available (up to max 25%)
- Output: moisture.IQ outputs (Digital & analog 0/4-20mA)
- Accuracy: +/- 1% of full scale (+/-5% of full scale for ranges <2.5ppm)
- Response Time: Instantaneously to O2 change
- Stability: 0.4% of span per month
- Intrinsically safe for hazardous area use

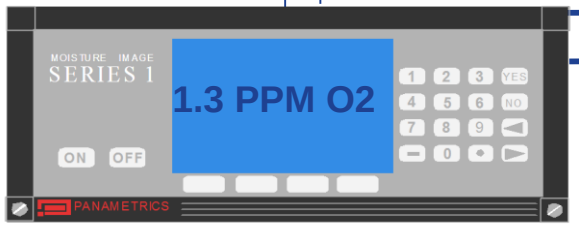
Technical Benefits

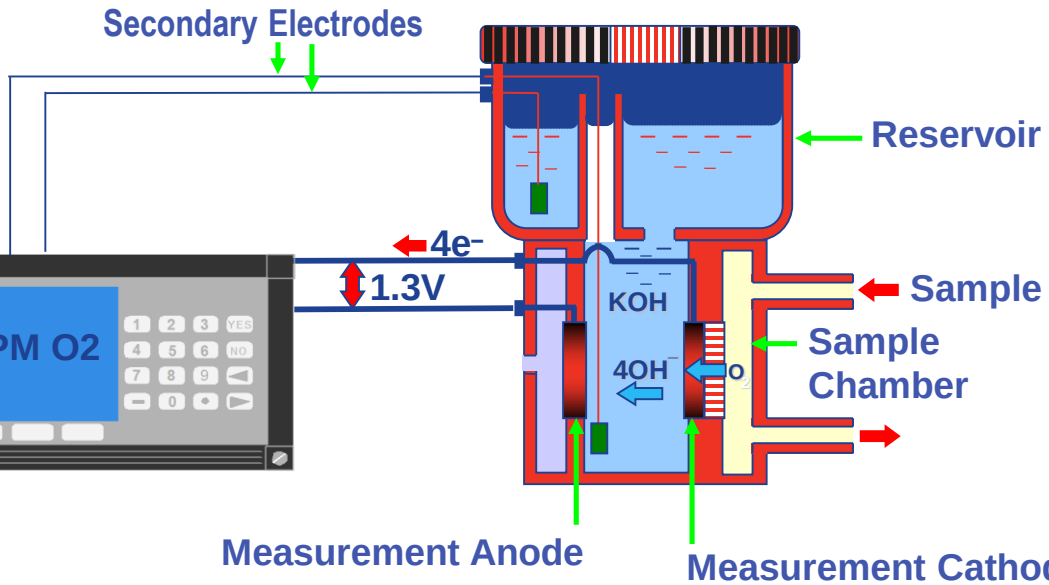
- Ultra stable, drift free
- Long lifetime
- Fast response and fast recovery after transient oxygen shock.

Applications

- Gas purity monitoring
- Petrochemical feed gases

DF Electrochemical sensors & analyzers





•When oxygen is present in the sample, a current is produced in the measurement circuit which is proportional to the oxygen concentration. Unlike the galvanic cell, the measurement reaction is driven by an applied voltage across the measurement electrodes supplied from the instrument electronics.

Zirconia O2 Analyzer

CGA351 Zirconium Oxide O_2 Analyzer

Specifications

- Range: Field Programmable between 0.1 ppm to 100% O2, typical range 0 to 10ppm O2
- Output: 0/4 to 20 mA
- Dual Alarm contacts, fail safe
- Accuracy: +/- 0.2ppm from 0 to 10ppm or +/- 2% of reading
- Response Time: less than 2 sec for 90% step change
- Stability: less than 3% of reading per year

CGA351 Zirconium Oxide O_2 Analyzer

Technical Strengths

- Fastest Responding Oxygen Sensor
- Provides Oxygen Measurement over the widest range
- Maintenance free

Applications

- Air Separation Plants – Gas Purity Measurement
- Cylinder Filling

Thermal Conductivity Gas Analyzer

XMTC Thermal Conductivity Gas Analysis

- XMTC
  - Thermal Conductivity Principle of Operation
  - RS232 & IDM
  - Improved linearity
  - Fast response
  - Temperature Compensation for reduced temperature effect based on heater duty cycle

XMTC Thermal Conductivity Gas Analysis

- Binary gas analyzer: measures one gas in another gas or gas mixture based on difference in TC or thermal conductivity of the two gases
- Hydrogen, Hydrogen, Hydrogen
  - furnace gases, steel galvanizing
  - petrochemical gases
  - electricity generators, hydrogen purity
  - chlorine gas
- Used by itself as stand alone transmitter or with optional displays TMO2D or XDP

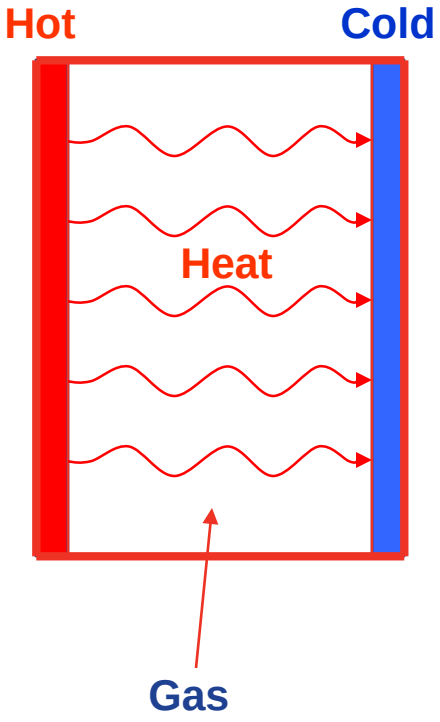
Definitions

Thermal Conductivity

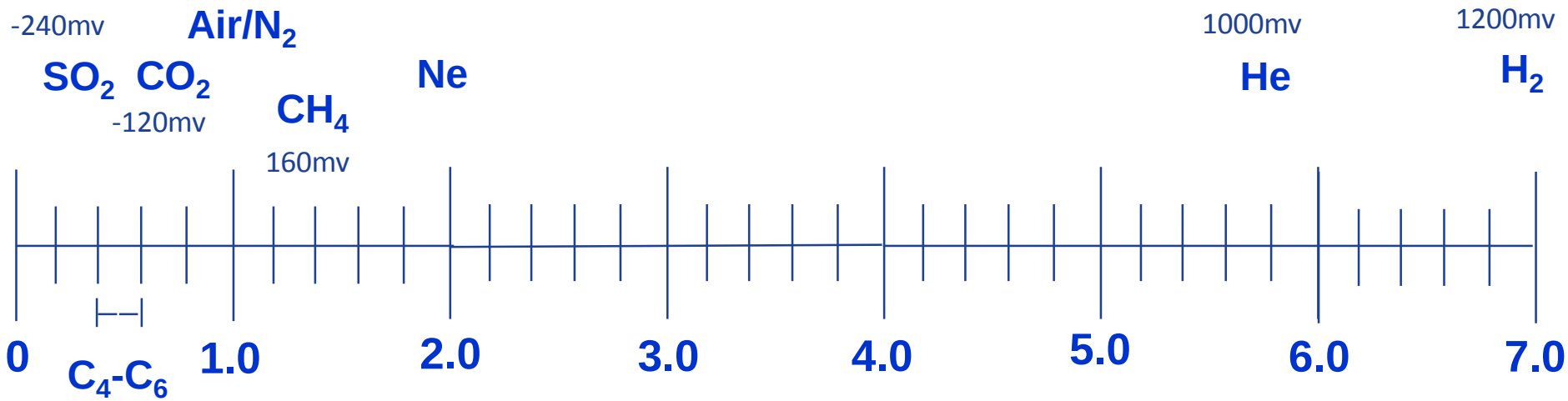
- The quantity of heat that will flow through a material in a certain amount of time, over a specific distance, per degree of temperature gradient

Typical Units

- W / (m x K)
- Cal / (cm x sec x K)



Relative Thermal Conductivity of Common Gases

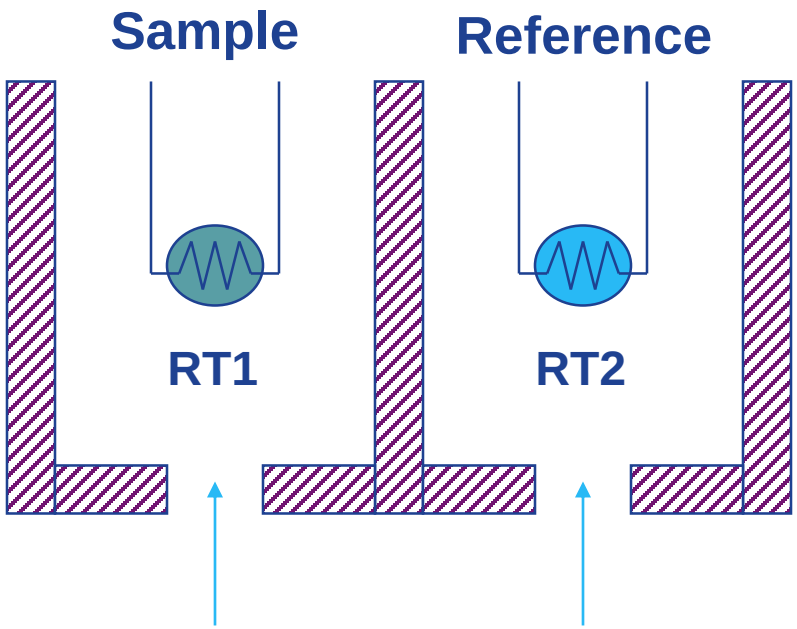


Lowest Measurable Ranges with N_2 Background

- 0 to 2% H_2 in N2
- 0 to 2% He in N2
- 0 to 20% CO_2 in Air
- 0 to 20% CH4 in N2
- 0 to 10% CH4 in CO2
- 0 to 5% SO2 in Air

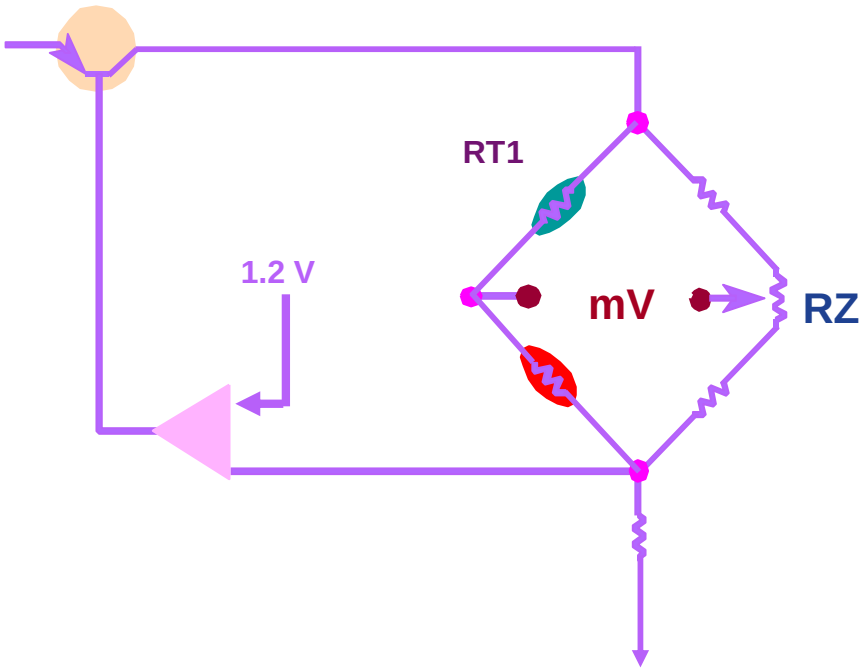
TC Sensor

- Sample and Reference Gases Come in Contact With Constant Current Thermistors (~150°C)
- Heat Is Transferred From 150°C Thermistor to 55°C Cell Wall at a Rate Proportional to the Thermal Conductivity of the Gas Mixture
- RT1 and RT2 Reach Different Equilibrium Temperatures; Therefore, They Have Different Resistances
- RT1 and RT2 Are Two Legs of a Wheatstone Bridge Circuit
- Linear Relationship Between Bridge Voltage and Gas Composition



Wheatstone Bridge

- The resistance difference between RT1 and RT2 yields a mV signal across the inside of the Wheatstone Bridge.



XMTC Thermal Conductivity Gas Analysis

- Wetted Parts: 316SS (Optional Hastelloy), FEP Coated Aluminum (CPVC), glass
- Dimensions
  - NEMA 4X: 242 mm (H) x 145 mm (D)
  - NEMA 7: 266 mm (H) x 145 mm (D)
- Weight: 9.5 lb (4.3 kg)
- Connections
  - Electrical: 3/4 inch NPTF
  - Process: 1/4 inch NPTF
- Certifications
  - Explosion-proof: Class I, Division 1, Groups A,B,C&D FM File No. J.I.2Z4A8.AE (3615) CSA LR44204-15
  - Flameproof: ATEX II 2 GD EEx d IIC T6 or T5 ISSeP02ATEX022
  - Complies with EMC Directive 2004/108/EC and PED 97/23/EC

XMTC Thermal Conductivity Gas Analysis - Applications

Furnace Gases

Metal and Steel Manufacturers use heat treating furnaces to achieve certain characteristics in different materials

- –Hardness
- –Strength
- –Ductility
- –Surface Finish

Continuous Annealing Line

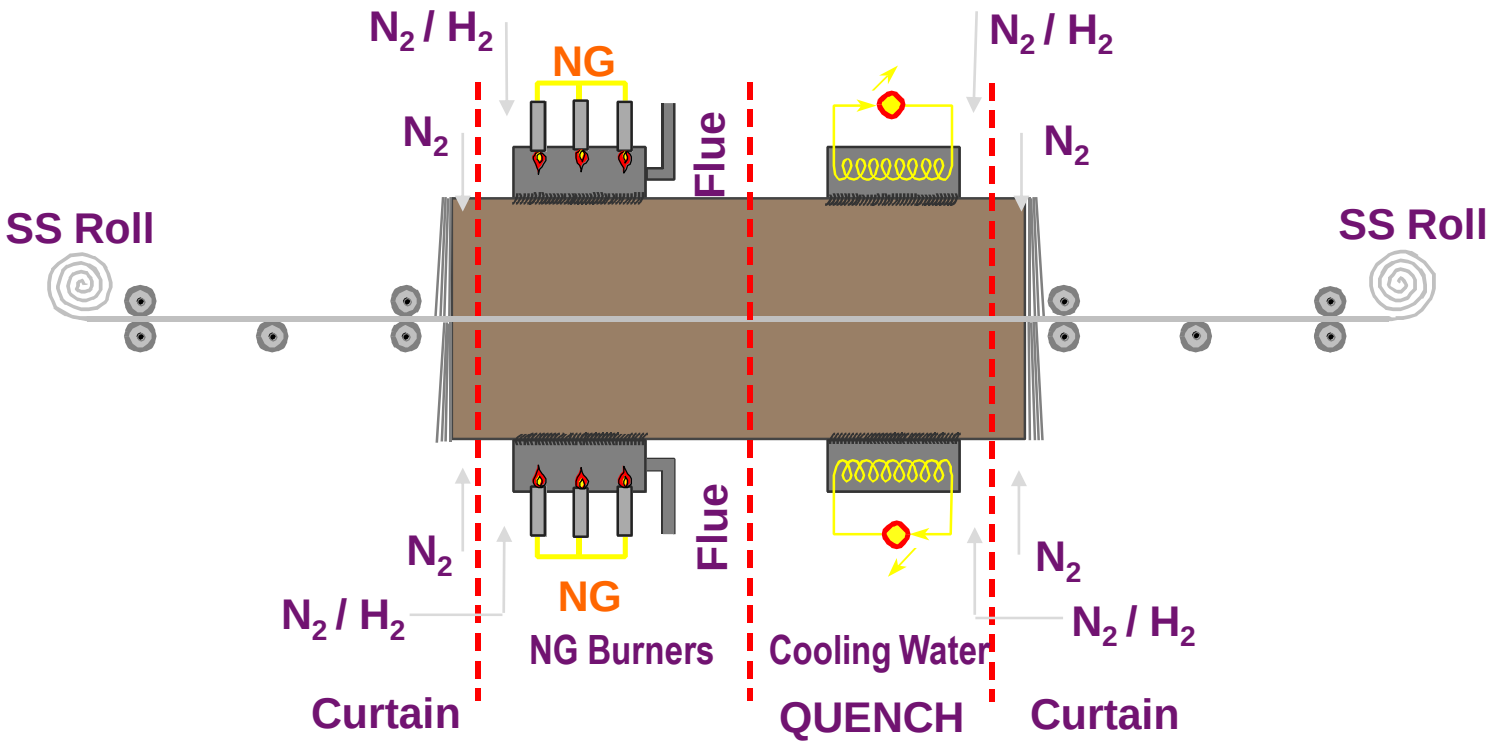
O2, H2 and Moisture Control System (Five Steins / GE)

Furnace Gases

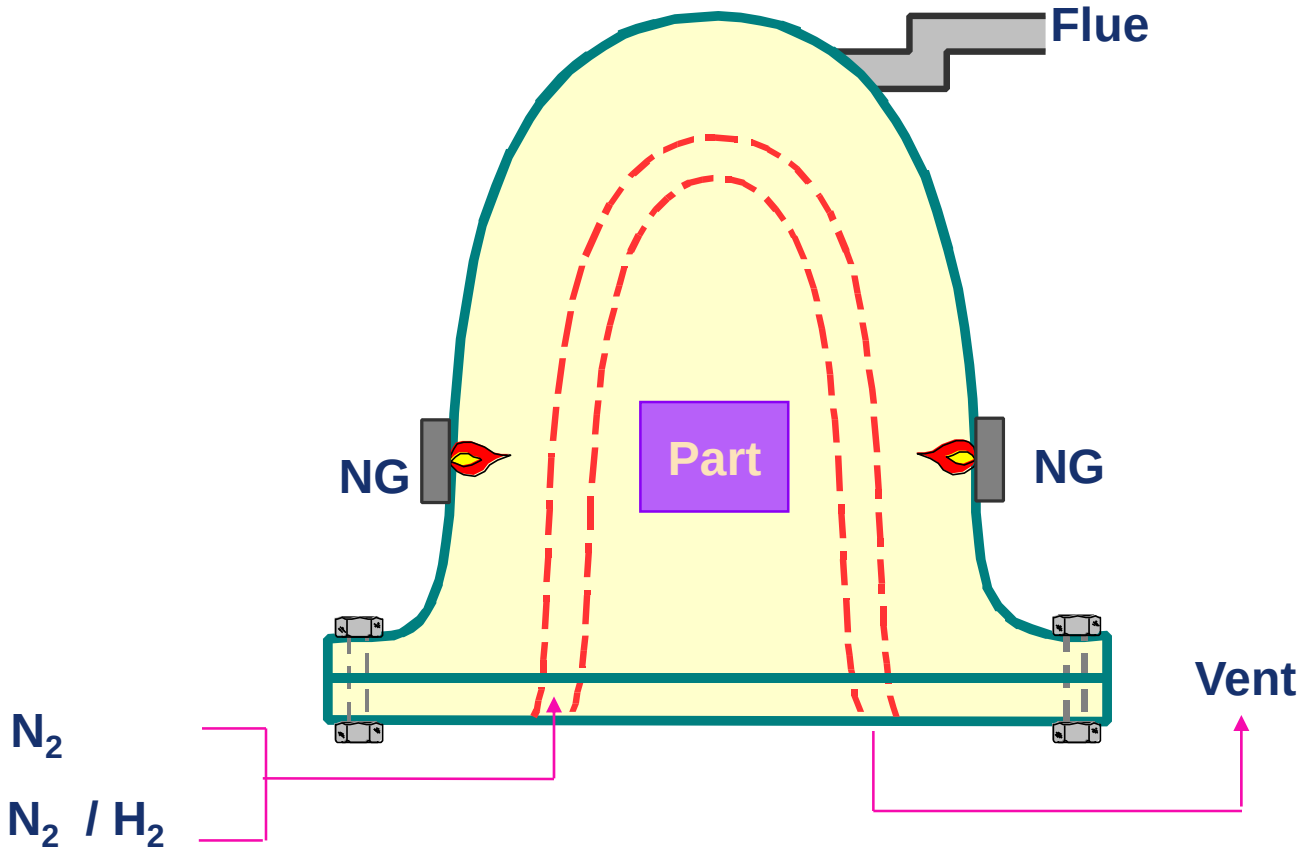
- Why is Hydrogen used in furnace gases?
  - To assist in heat transfer to the metals so that they can heat and cool at different rates
  - Hydrogen will react with any oxygen to form water to reduce the possibilities of corrosion caused by oxidation

Bell Furnace

Typical continuous feed furnace:



Typical Bell Type Furnace:

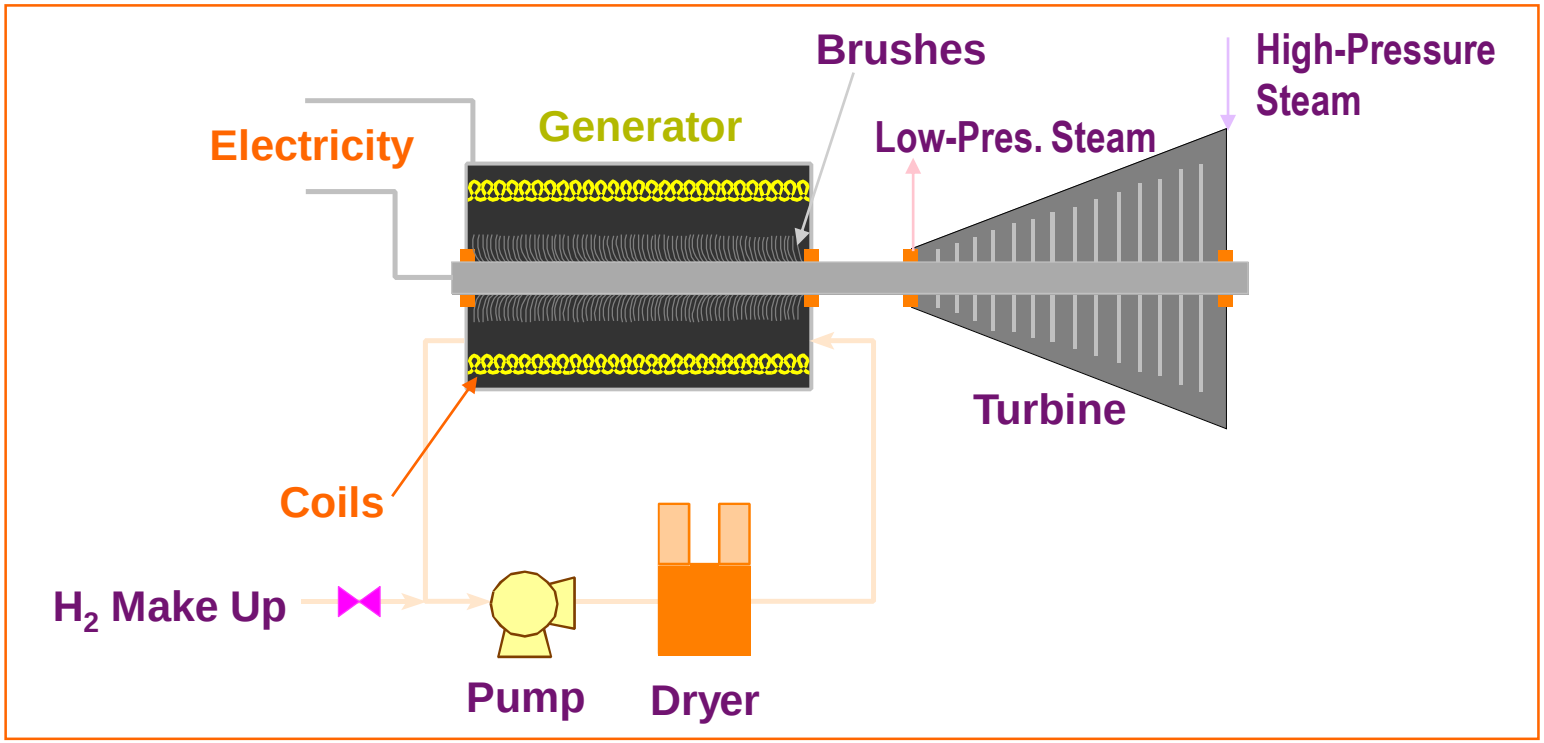


Hydrogen Cooled Generators

Generators use hydrogen for two reasons:

1. Hydrogen, because of its extremely high thermal conductivity, is used to draw the heat away from the generator and keep it cool.
2. Hydrogen has a very low viscosity and, therefore, reduces the amount of wind resistance on the spinning main shaft.

Hydrogen Cooled Generators

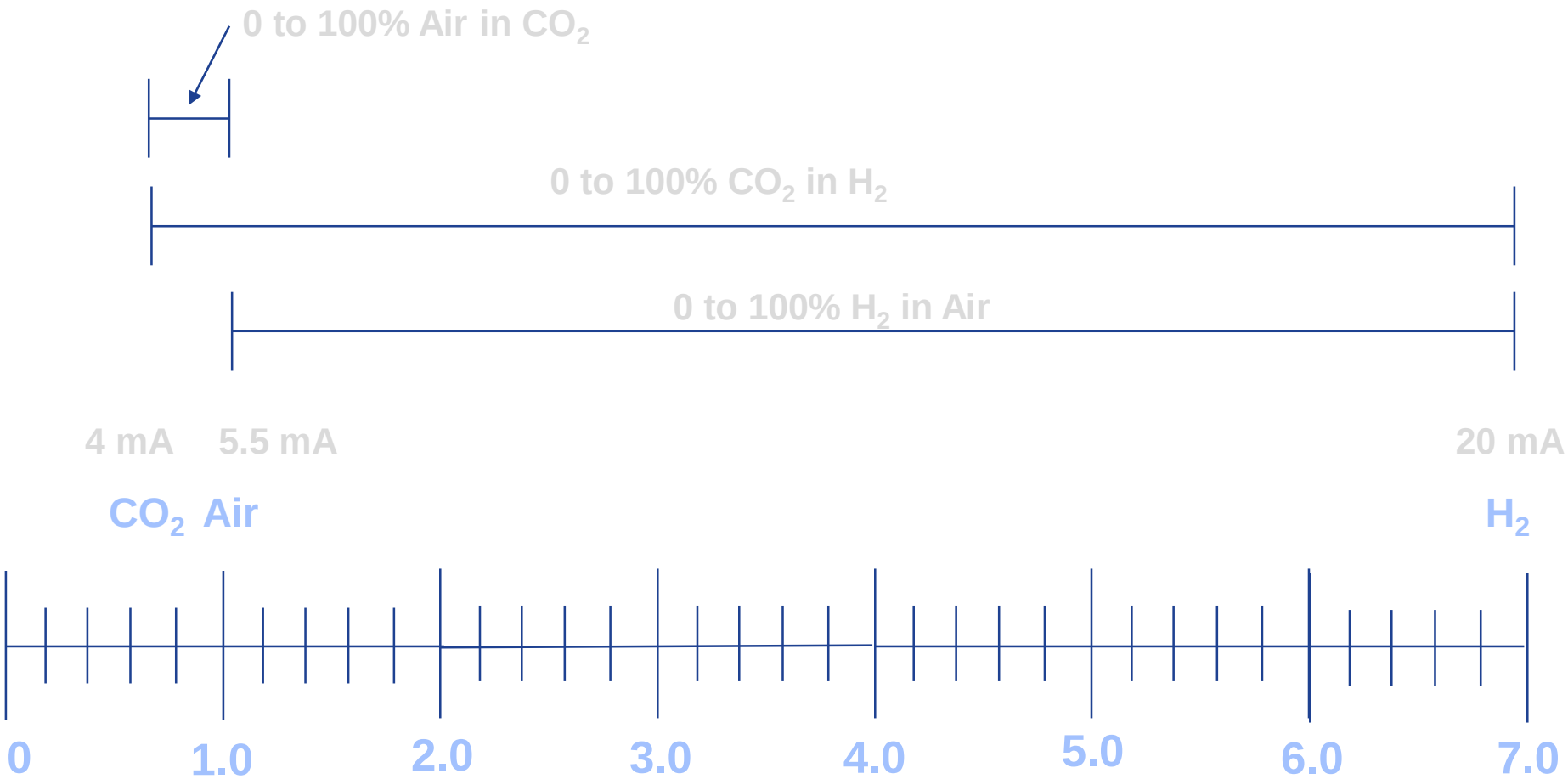


Three Range Application

- Shut-Down and Start-Up Mixtures

Curve 1:	Hydrogen in Air
Curve 2:	Carbon Dioxide in Hydrogen
Curve 3:	Air in Carbon Dioxide

Hydrogen Cooled Generators



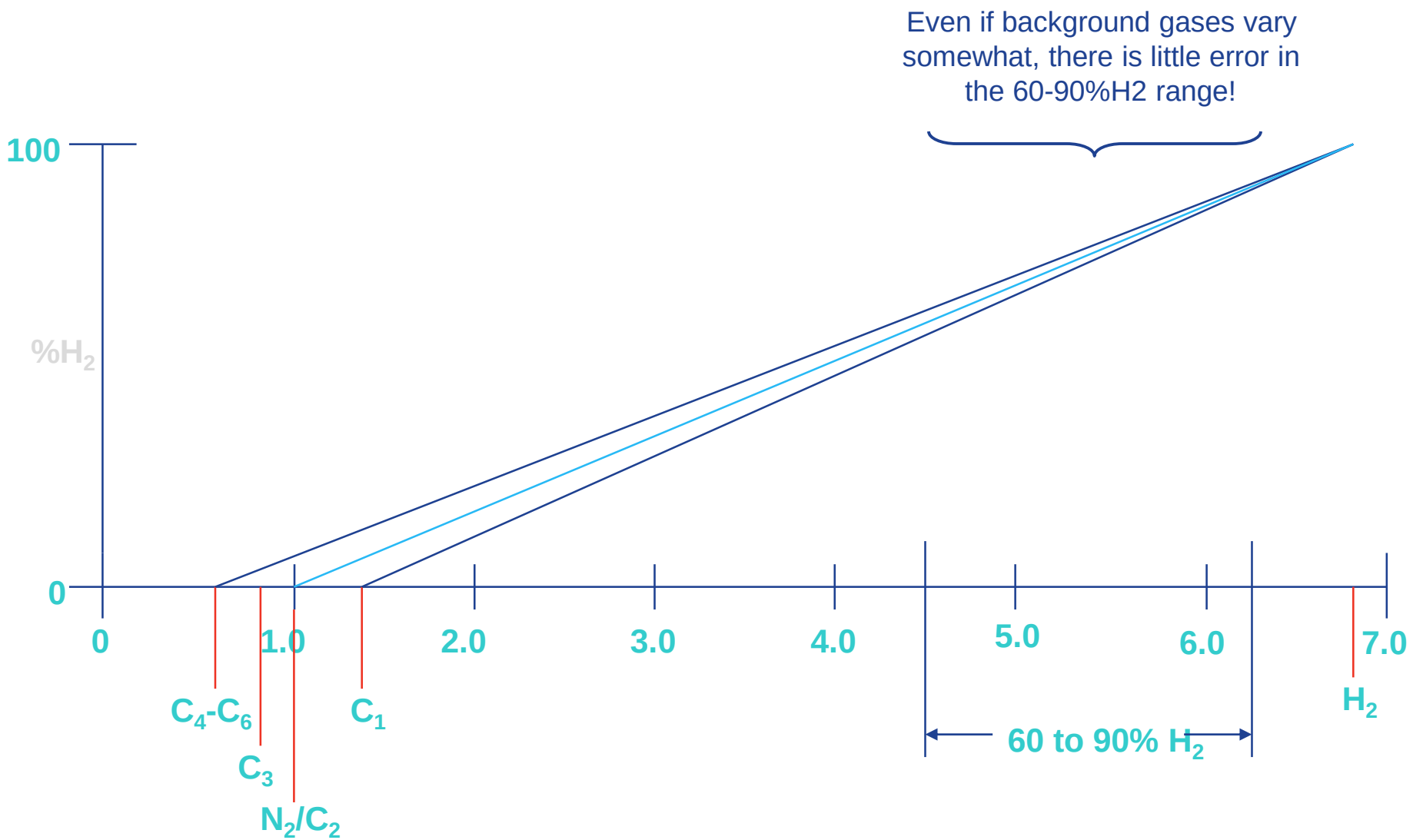
How does the XDP fit into this application?

- Each of the previous mixtures is a binary gas
- Each of the gases in the binary mixture has a different thermal conductivity
- Program XDP with Three Different Calibration Curves Depending upon Operating Situation
- Certified for
  - FM/CSA Cl. 1, Div. 1, Gr. B, C, D
  - Flameproof: KEMA 01ATEX2128, Atex E II 2 GD Eex d IIC T6

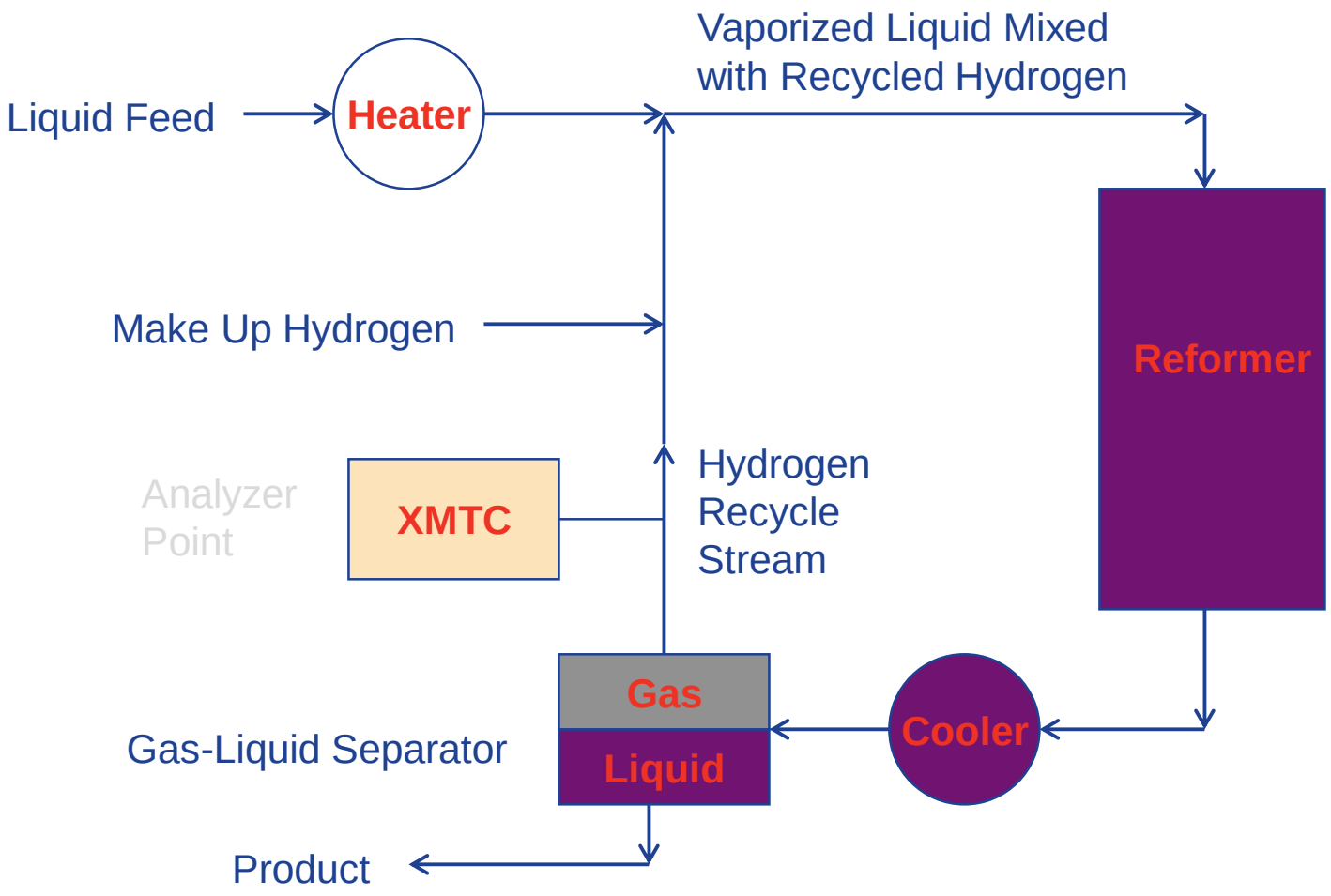
Hydrogen Recycle Gas

- Petrochemical Plant Application
  - Measurement of Hydrogen in a pseudo-binary gas mixture. Other gases present besides Hydrogen are light to heavy end hydrocarbons (C1 to C6 typically).

Hydrogen Recycle Gas



Hydrogen Recycle Gas



Biogas

- Landfill Application
  - –Measurement of either methane or carbon dioxide that is reclaimed from a covered landfill

Biogas