Delhi Section

Setting the Standard for Automation

FERTILIZER MEET 2017
16TH DECEMBER 2017

& Training

s & Exhibits

The International Society of
Automation Delhi Section

rum

Online Process Mass Spectrometer for Ammonia Process Control

Extrel CMS USA

Quadrupole Mass Spectrometry (QMS)

Founded in 1964

- Over 1300 Research Systems
- Over 1500 Laboratory Systems
- Over 1000 Industrial Process Systems

3 Nobel Prize Recipients

- Dudley R. Herschbach & Yuan T. Lee jointly received Nobel prize for Chemistry in 1985

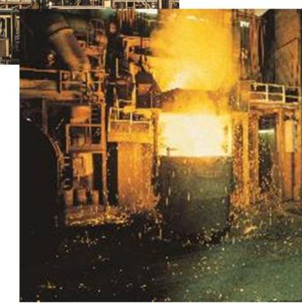
- "for their contributions concerning dynamics of chemical elementary processes"

- Mario Molina received the Nobel Prize for Chemistry in 1995.

- "for his role in elucidating the threat to the Earth's ozone layer of chlorofluorocarbon gases"

ndustrial Applications

- Environmental
  - Ambient Air Monitoring
  - Flare Monitoring
  - VOC is Cooling Water and Waste Water
- Chemical
  - Ammonia Process Control
  - Methanol Process Control
  - Propane Dehydrogenator
- Petrochemicals
  - Ethylene Cracker Effluent
  - Ethylene Oxide Reactor
  - PE/PP Reactor
- Gas Production and Purity
  - Hydrogen Production
  - CO, CO_2, N_2, Ar, …
- BTU And Sulfur
  - Natural Gas Analysis
  - Synthesis Gas
  - Fuel Gas
- Metals Production
  - Converter/BOP
  - VOD
  - Electric Arc Furnace
  - Blast Furnace
  - Gas Blending
- Food and Pharmaceutical
  - Fermentation
  - Dryers
  - Gas Mixtures
  - Solvent Recovery
- Evolved Gases
  - Thermal Decomposition
  - Degradation Temperatures
  - Reaction Monitoring
  - Monitor Solvents and Moisture
- Alternative Fuels
  - Corn to Ethanol
  - Gasification or Coal and Biomass
  - Fuel Cells

Mass Spectrometry

Speed of Analysis

- 0.4 sec/constituent
- 10-20 sec/stream
- Advanced Process Control (APC)

Selectivity

- Mass/Charge Ratio (M/Z)

Multiple Stream

- 1-46 Process Streams
- Different Composition

- Dynamic Range
  - Linear Form ppb to 100%
- Accuracy
  - Equal to Calibration Standards
- Precision
  - Better than Primary Method
  - 0.0025 on 1% Ar
- Maintenance
  - Reduced Maintenance
  - Better Than 98% Uptime

Main use of Ammonia is for Fertilizers

Fertilizers (~78%)

- Anhydrous ammonia
- Urea
- Ammonium nitrates
- Ammonium phosphates
- Other Nitrogen compounds

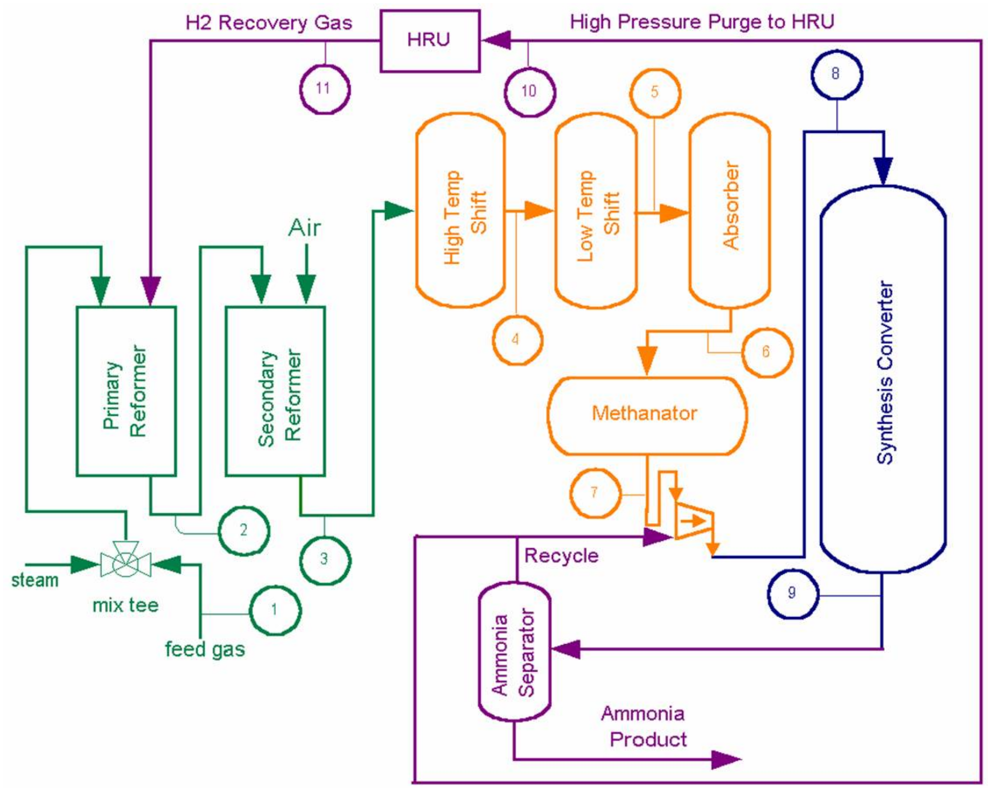
Plastics

Synthetic Fibers and Resins

Explosives

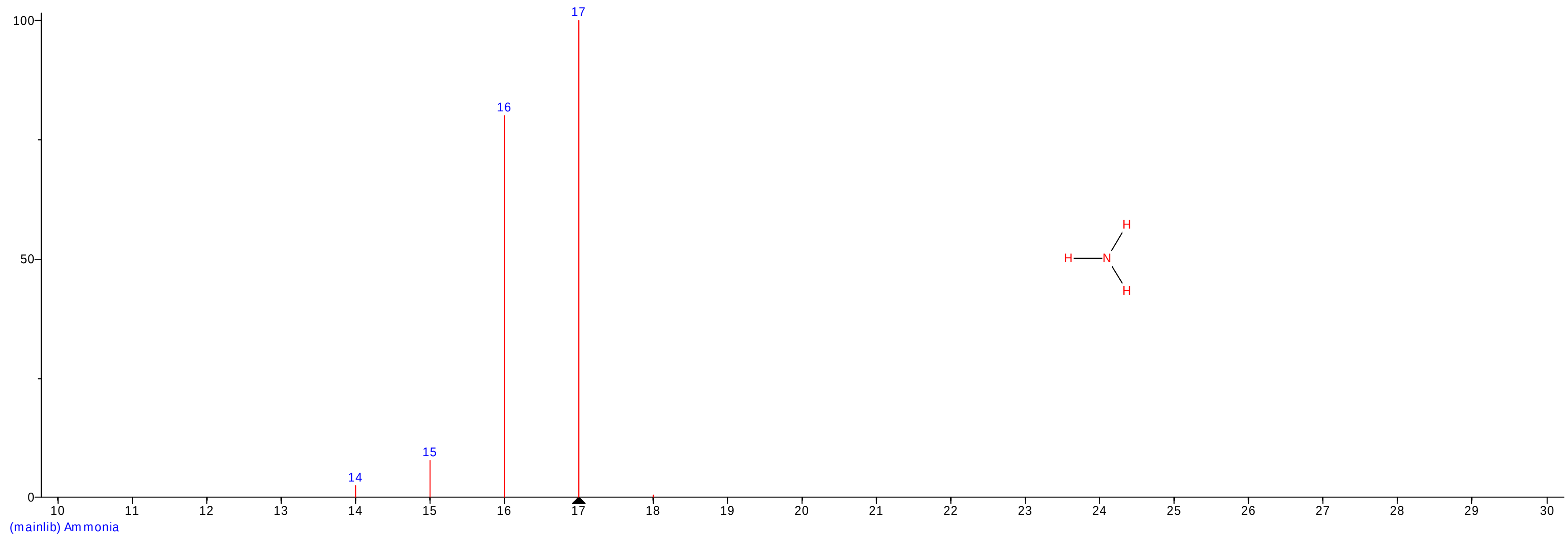
Ammonia Process

Ammonia is made in a multistage process based on steam methane reforming of a natural gas feed



Some plants are designed to use alternative feed stocks such as petroleum feedstock

How Does a Mass Spectrometer Work?



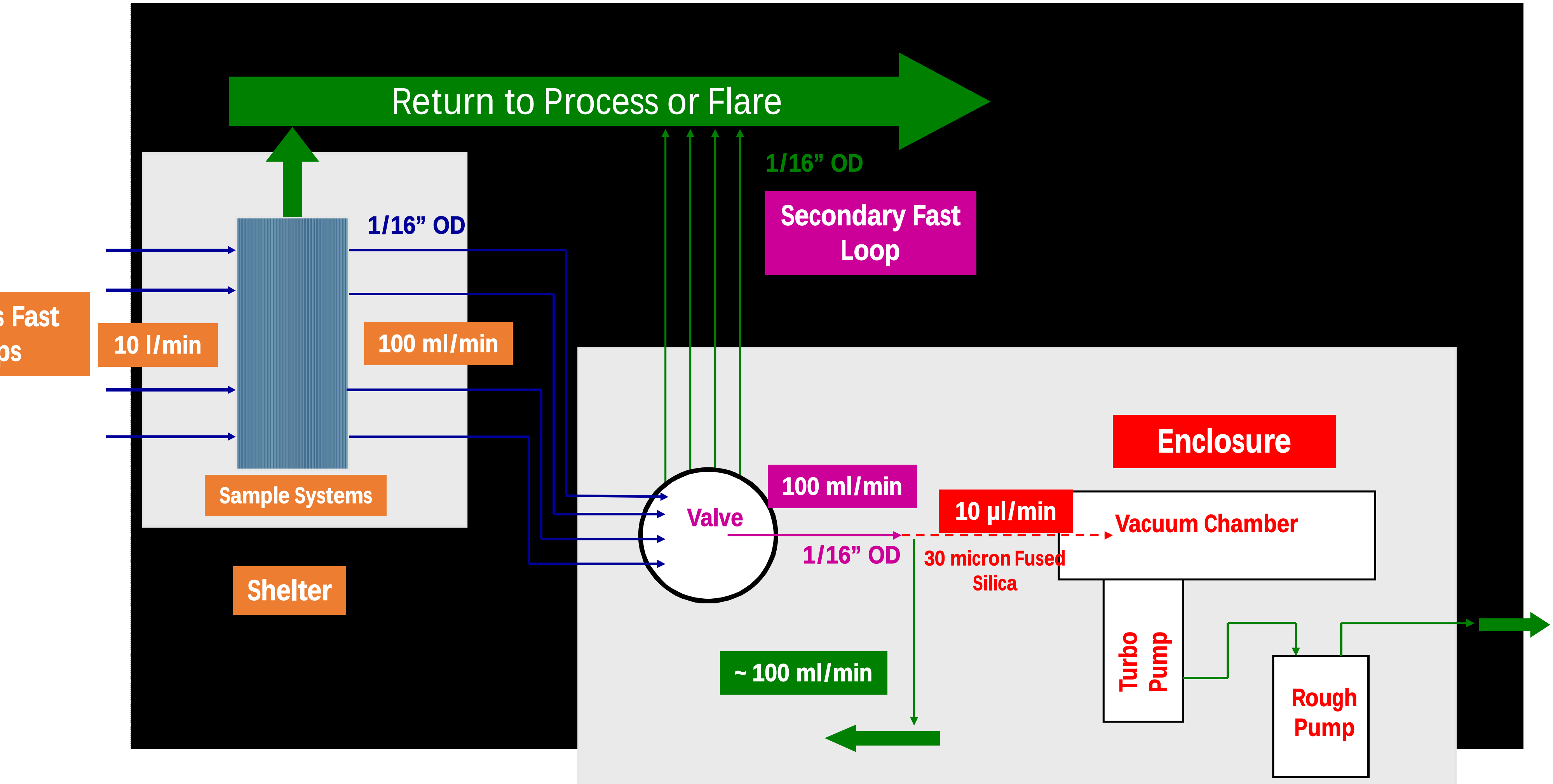
- Constant flow of gas enters the analyzers
- Sample gas is ionized and scanned electronically
  - Each scan produces a set of peaks specific to the composition of the ionized gas
  - All gas samples can be analyzed with a mass spectrometer

Sampling Requirements

Requirements are the same for any Gas Analyzer

- Vapor Phase
  - non-condensing
- Particulates
  - 5 micron filter
- Pressure Range
  - 20PSI to 0.1PSI (1034 to 5 torr)
- Flow
  - 100 cc/min
- Temperature
  - Max. 250C

Typical Sample Flow for Rotary Valve



Components of a Mass Spectrometer

Inlet

- Stream Selection
- Sample Introduction
- Membrane Pre-Concentration

Ionizer

- Electron Impact (EI) Ionization

Mass Filter

- Quadrupole

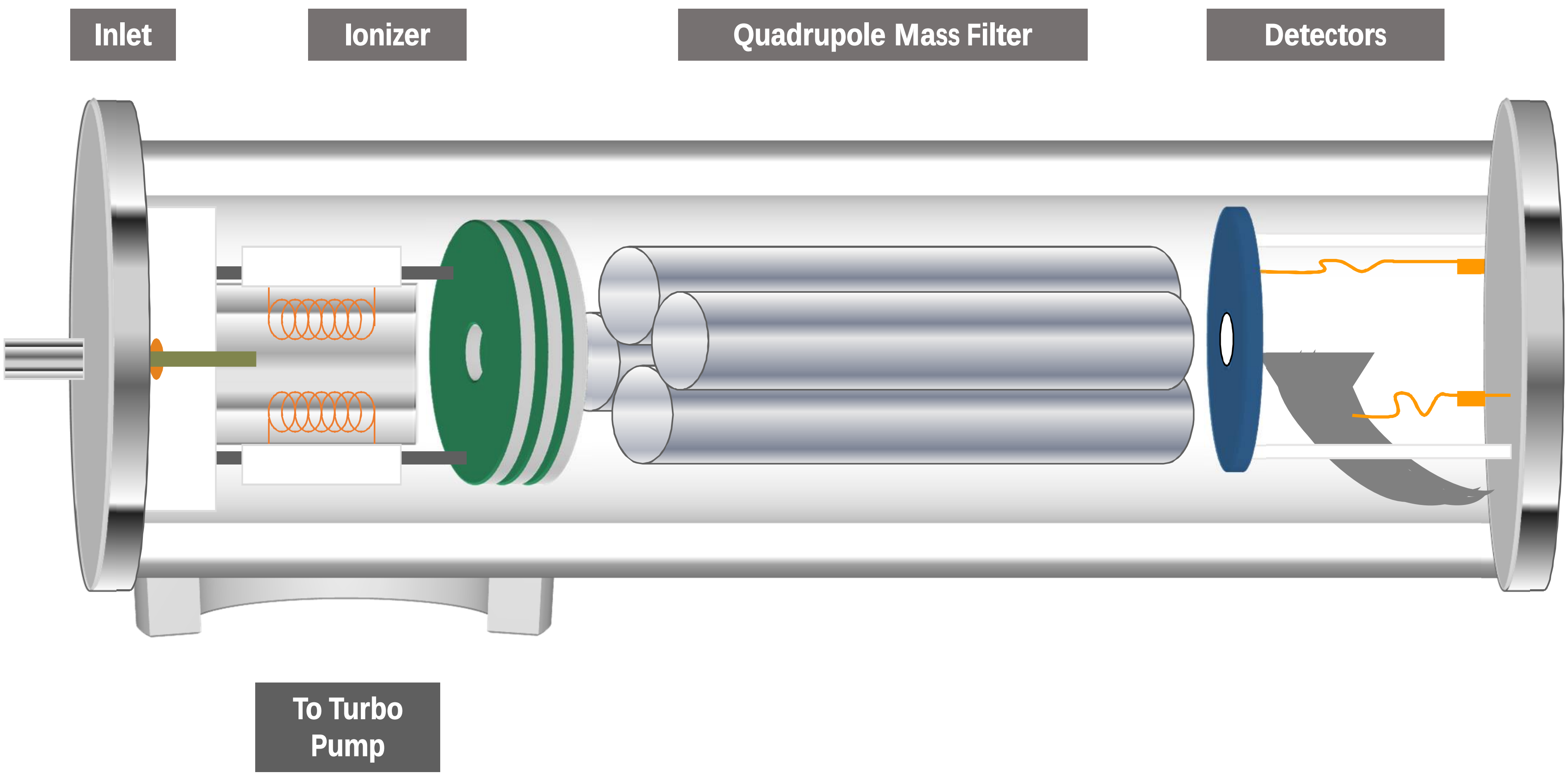
Detector

- Faraday and Electron Multiplier

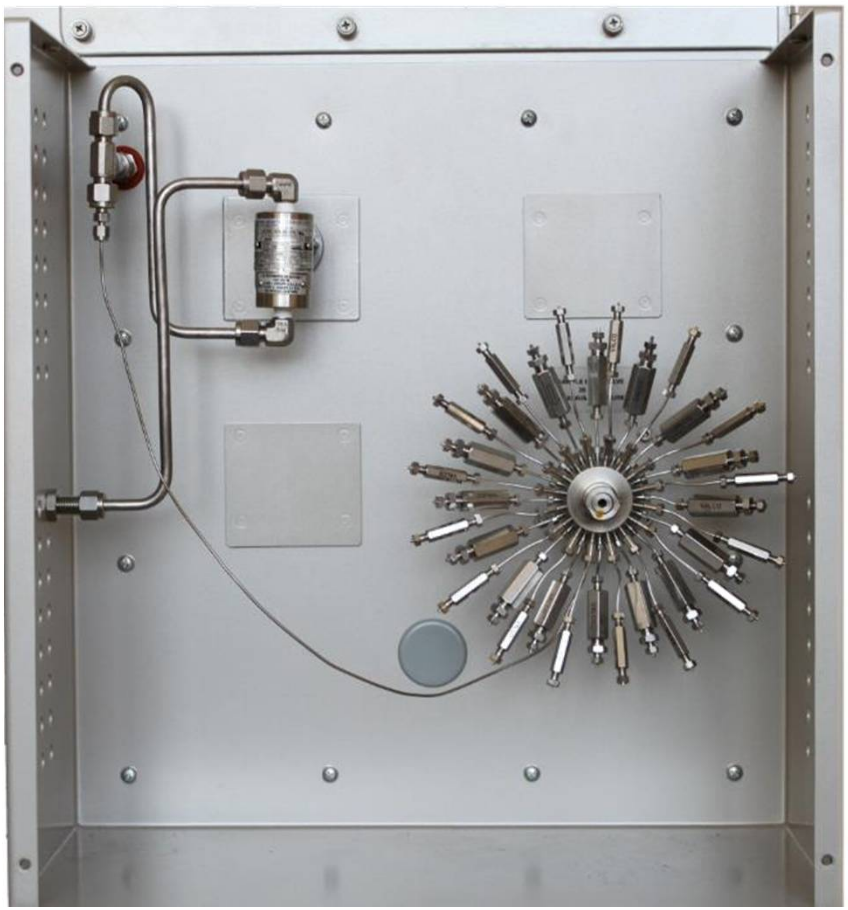
Data System

- Signal Acquisition, Processing and Display

ıtaway" of Mass Spectrometer Vacuum Chamb

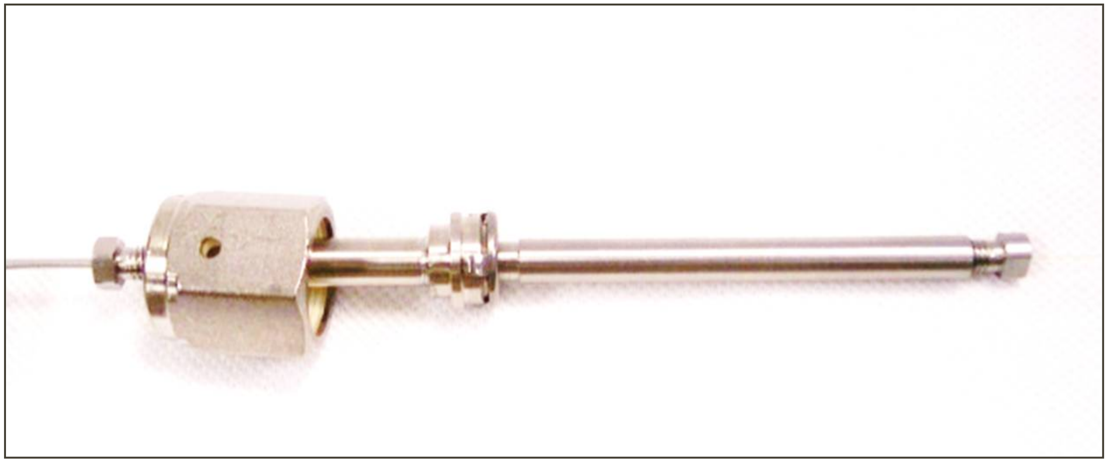


Sample Selector - 16 Port Inlet



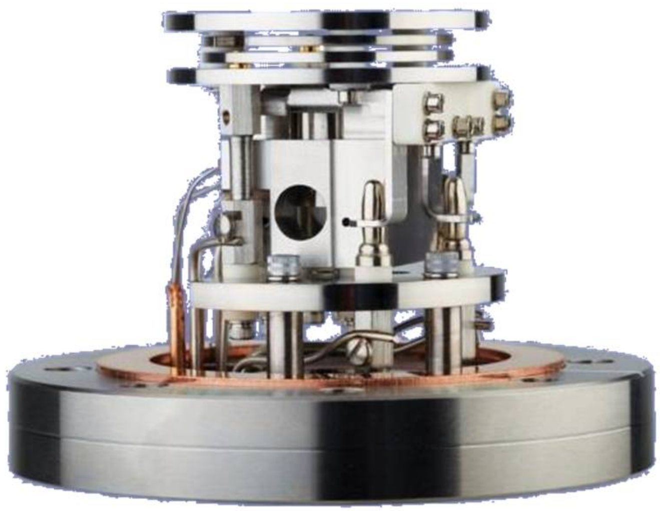
- 31 Port Valve
  - 2- 16 Port Valves in Series
  - 1/16" Lines
  - Each Port is a fast-loop with a separate outlet
  - 1 common feed to analyzer
- Configuration
  - Sample Gases
  - Calibration gases (plugged)
  - Validation gases (plugged)

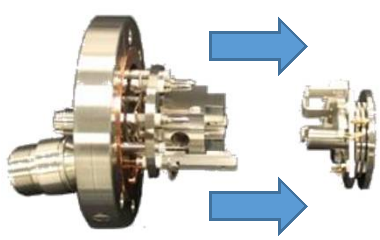
Fused Silica Capillary Inlet



- Reduces the pressure and flow to manageable levels for the vacuum system
  - Flow ~ 10 µl per min
- Easy replacement with innovative design

Disposable Ion Source and Dual Filament

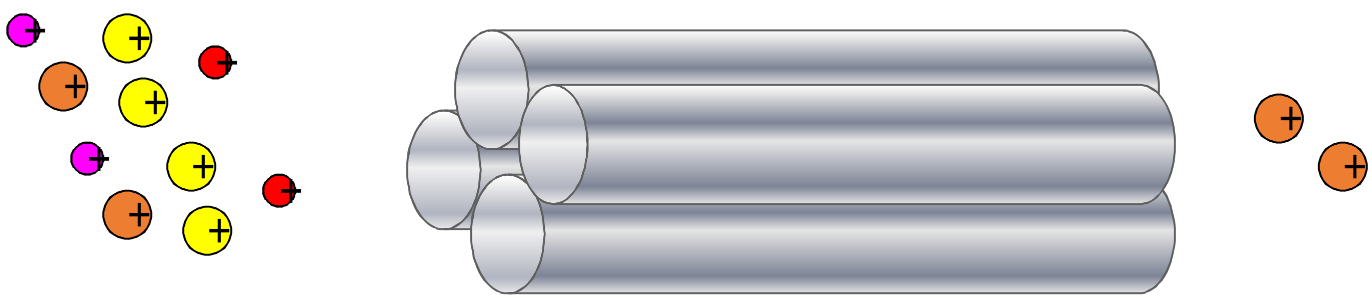




- Electron Impact (IE) Ionization
- One active and one spare filament
- Small ion volume for efficient ionization
- 3 lenses for focusing ions into mass filter
- Redesigned disposable ionizer eliminates cleaning and reduces downtime

Quadrupole Mass Filter

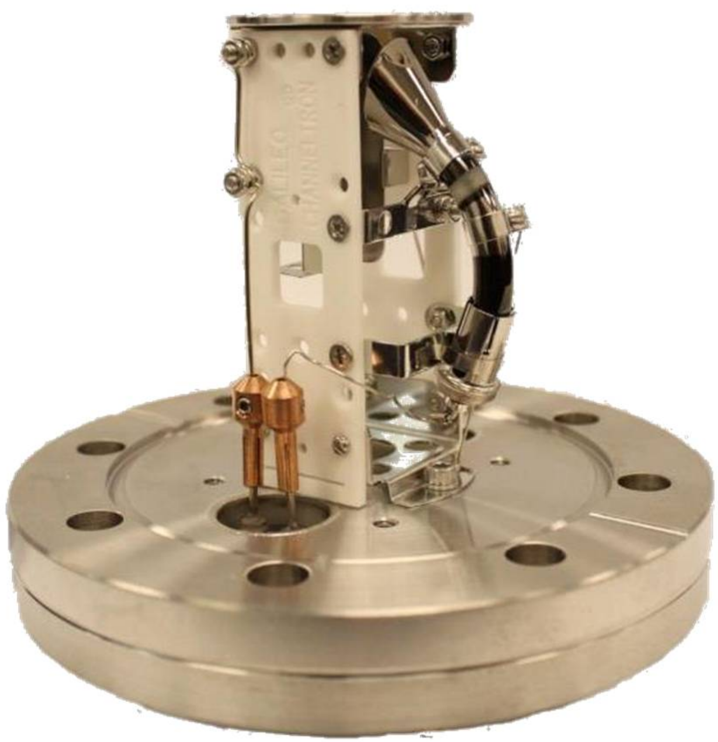
19mm
Quadrupole



Ions of many masses

Ions of selected masses

Dual Faraday and Electron Multiplier Detector

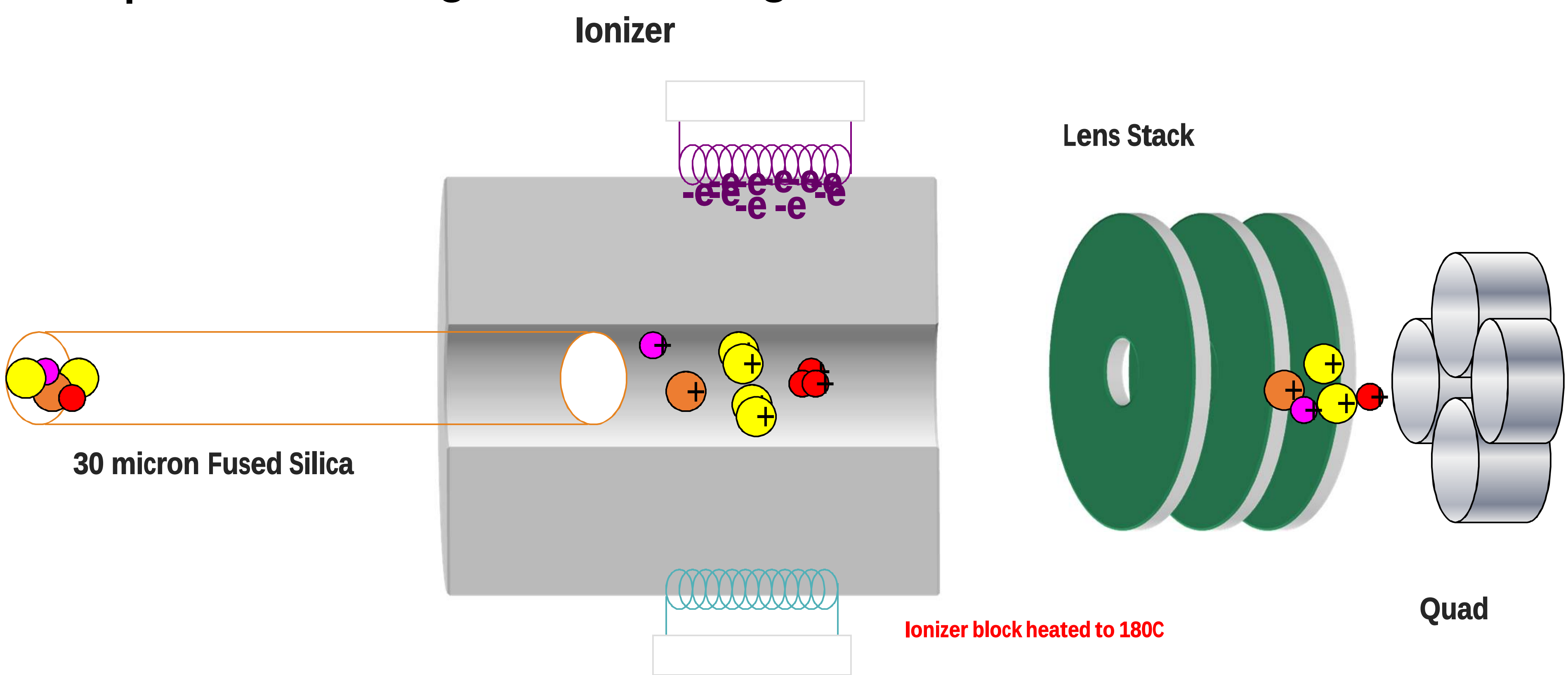


- Faraday Detector
  - 10 parts per million
- Dual Faraday/Electron Multiplier Detector (shown)
  - 10 parts per billion
- Smart Detector will automatically switch between detectors to optimize analysis

The capillary leaks a small amount of sample into the ionizer ...

A current is applied to the (positive) filament to heat it up and emit electrons

Positive charged ions are attracted towards the lens stack where there is a negative voltage ...

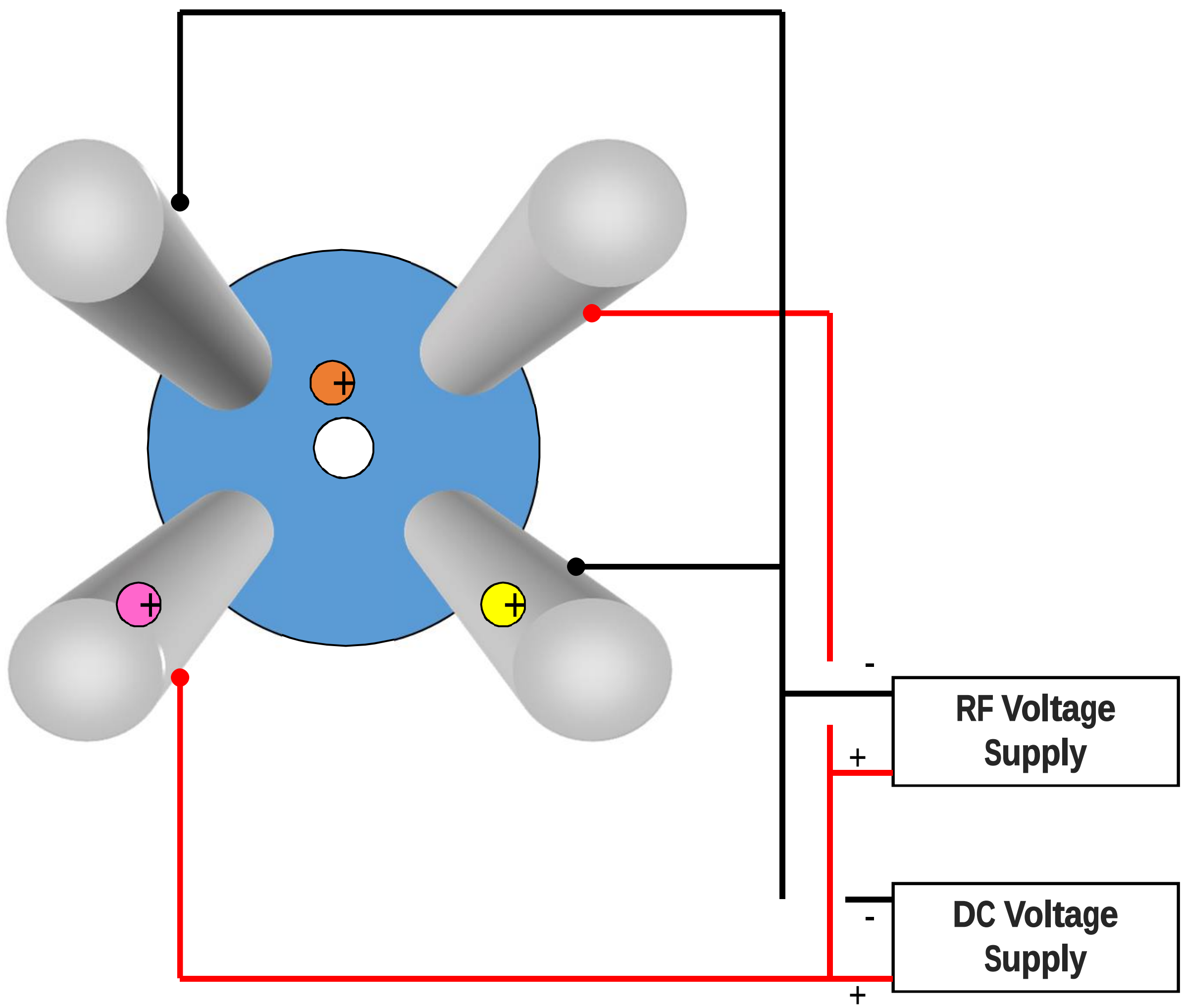


where it is bombarded by electrons to make positively charged ions

the ions are pulled out of the ionizer and propelled into the quadrupole mass filter.

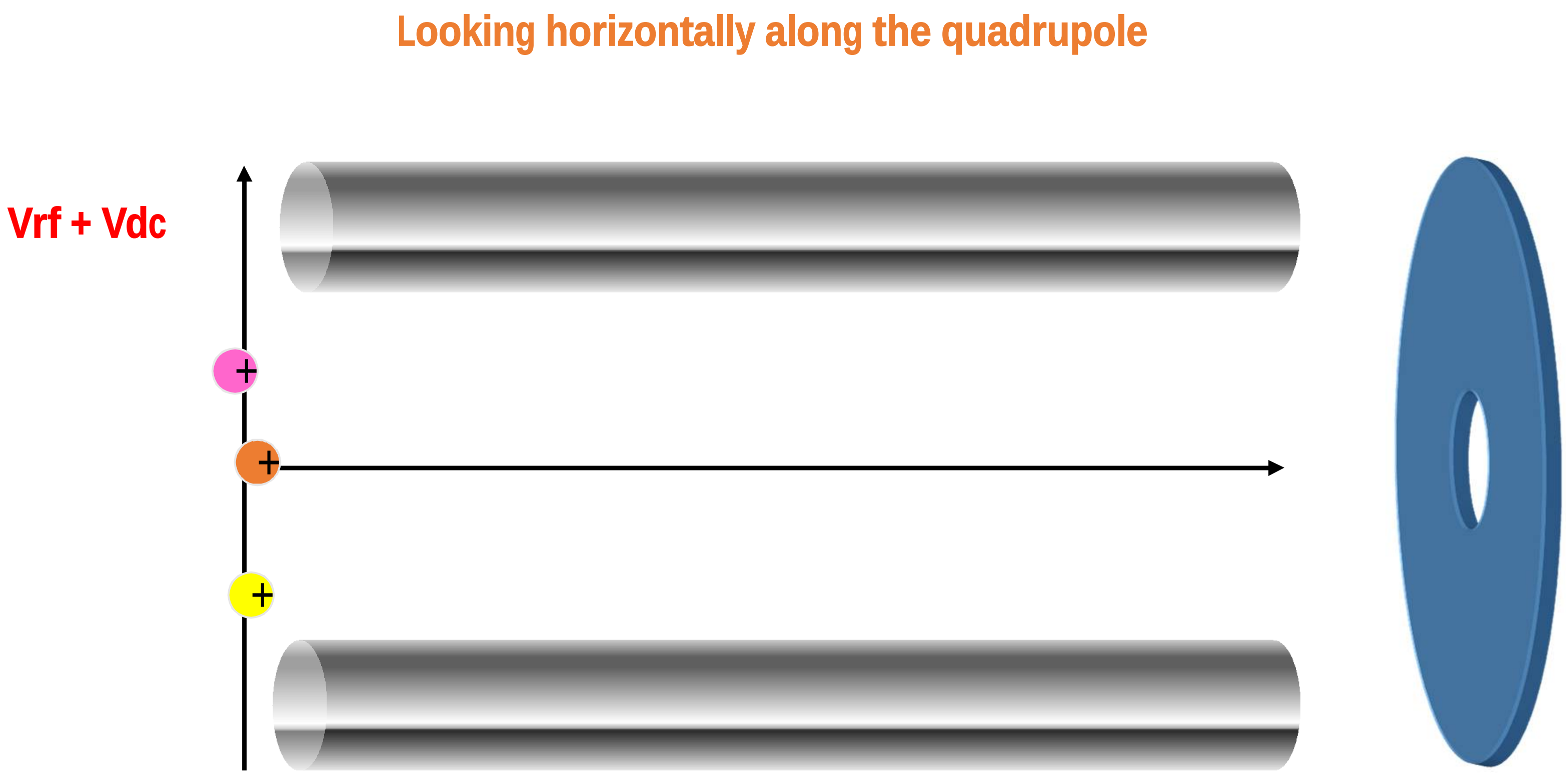
How does a mass filter work?

Looking straight down the quad

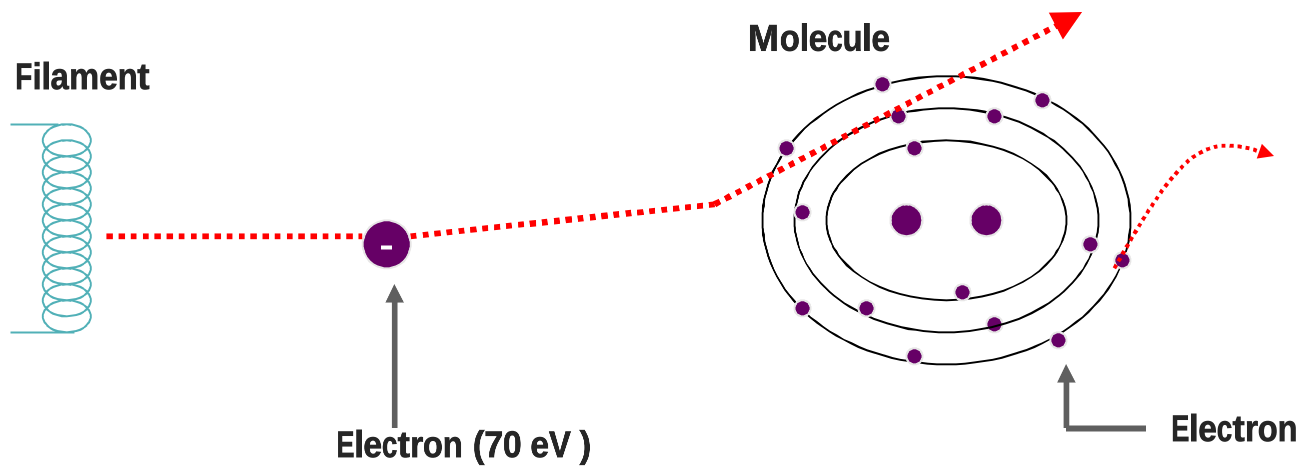


- RF and DC voltage is appl
  opposite rods
- Only ions of the right ma
  make it all the way down
  quad
- Other masses are unstab
  will strike the quad and b
  neutralized and pumped

How does a mass filter work?



Mechanism of Electron Impact Ionization



$M + e \longrightarrow M^{+} + 2e$		Single Ionization
$M + e \longrightarrow M^{++} + 3e$		Double Ionization
$M + e \longrightarrow M_1^{+} + R^{\bullet} + 2e$		Fragmentation

Fragmentation of Methane

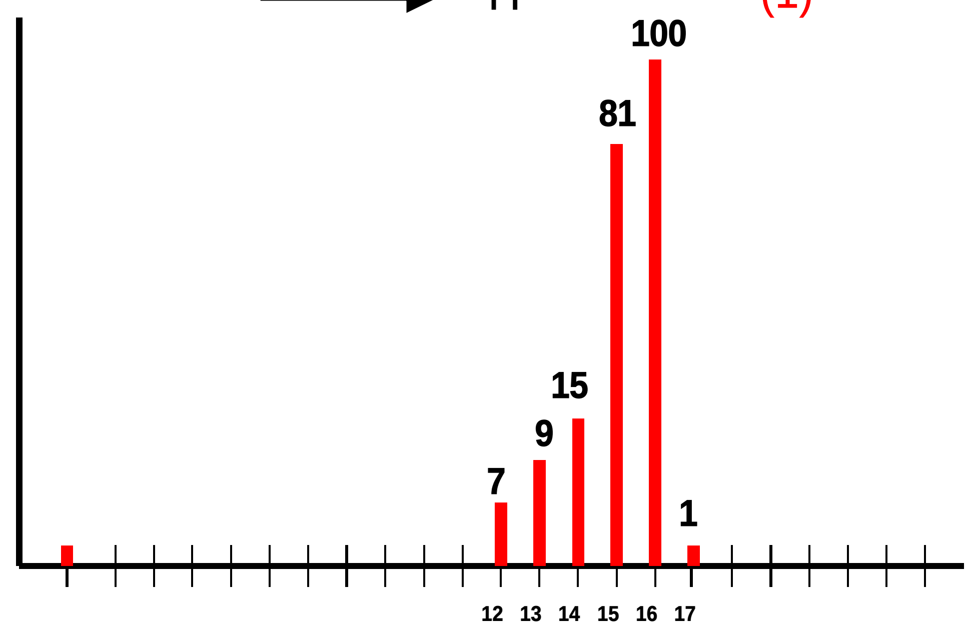
(16) CH_4^+ → $CH_3^+ + H$ (15)

→ CH_2^+ (14)

→ CH^+ (13)

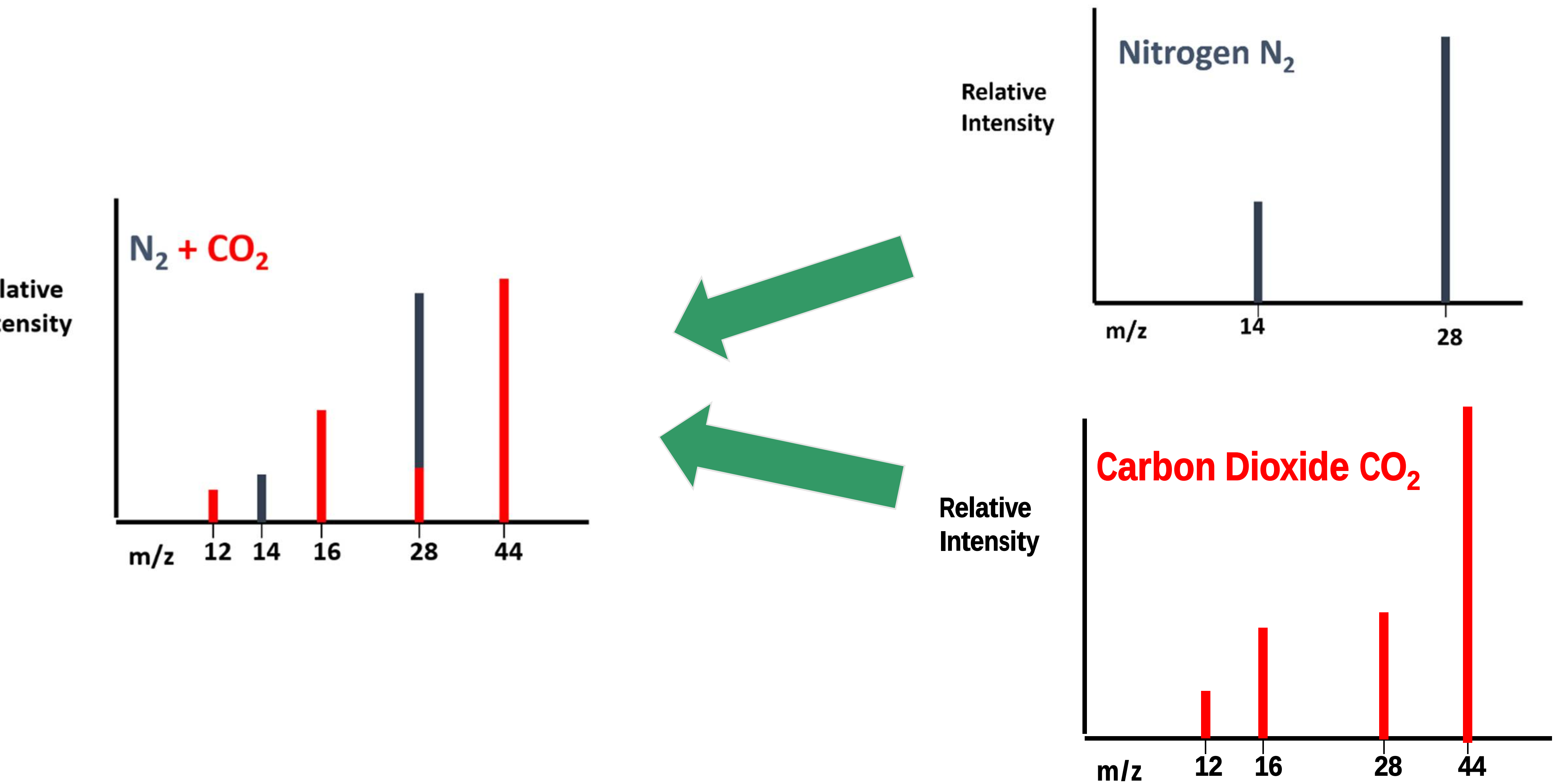
→ C^+ (12)

→ H^+ (1)



- Single Ionization occurs when electron impact (EI) causes CH_4 to lose an electron, becoming CH_4^+
  - Largest peak at mass 16
- Fragmentation occurs whe a bond breaks during ionization, CH_3^+ is produce when CH_4 loses a H
  - Mass 15 peak
- Less frequently, additional fragmentation generates CH_2^+,CH^+ and C^+ and H^+

Fragmentation and Gas Mixtures



Simplified Fragmentation Matrix

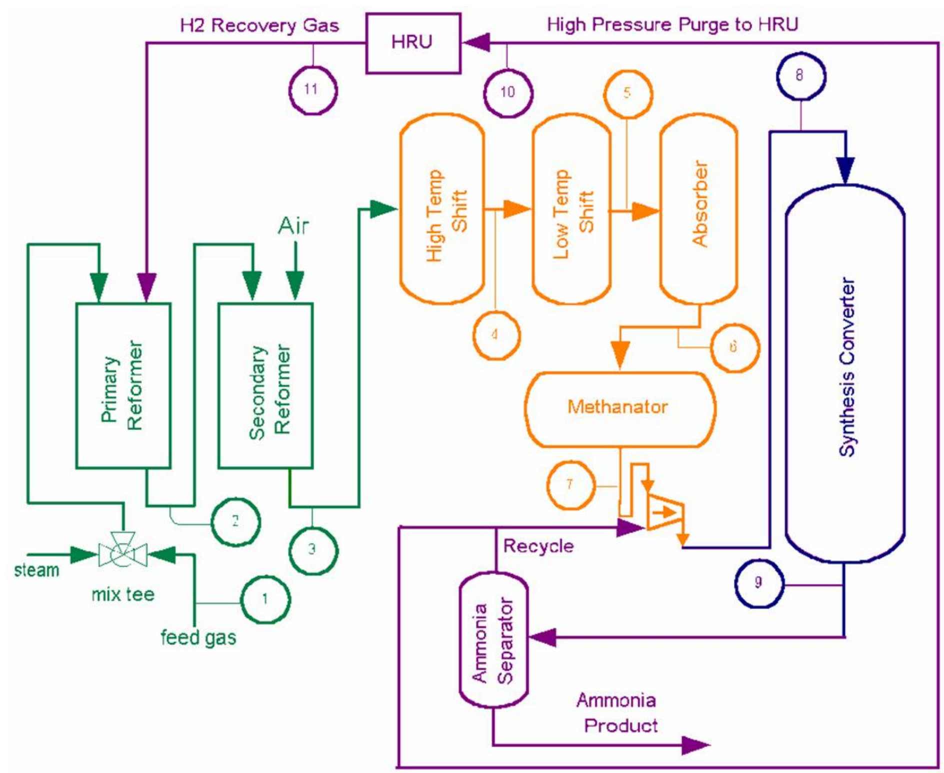
Each component's actual fragmentation pattern is measured using a binary gas mixture.

m/z	28	44

Ammonia Application Information

Analysis of streams to increase efficiency, reduce waste and extend equipment life

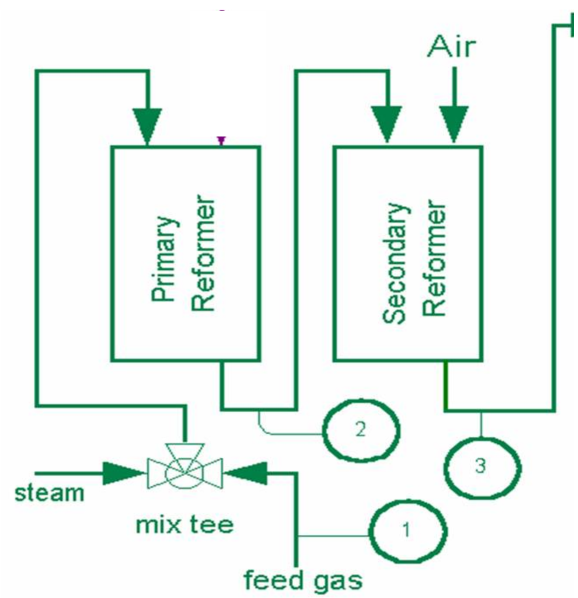
1. Feed Gas
2. Primary Reformer
3. Secondary Reformer
4. High Temperature Shift
5. Low Temperature Shift
6. Absorber Outlet
7. Methanator Outlet
8. Converter Inlet
9. Converter Outlet
10. Purge Gas
11. H_2 Recovery Gas



First Stage: Hydrogen from Feedstock

(3) Air is added at the secondary reformer to convert the remainder of the feedstock.

$H_2 + AIR \longrightarrow 3H_2 + N_2 + (CO_2 + CO$

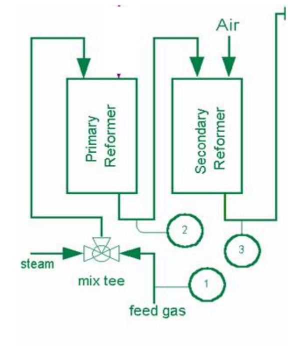


eam is added at the Primary Reformer.

$_4 + H_2O \longrightarrow CO + 3H_2 + (CH_4)$

(1) BTU and H_2S on Feed Gas Stream

(1) Feed Gas Stream: Typical



Component	Concentration
trogen	2.00%
rbon Dioxide	50.00%
ethane	95.00%
hane	3.00%
opane	1.00%
utanes	0.50%
entanes	0.50%
exane	1.00%
ydrogen Sulfide	3ppm

- Steam to Carbon ratio
  - Save energy and fuel by tightly controlling the to within 0.02%BTU values
- Protect the catalyst from being poisoned and deactivated
  - Monitor the feed gas for the presence of hydrogen sulfides

(1) Feed Gas Stream: Results

mponent	Concentration	Sensitivity	Detection Mass	Relative Interference Factor (RIF)	Relative Standard Deviation (F)	Relative Standard Deviation (M)	Standard Deviation ppm
gen	2.00%	1.00000	28	2.0890	0.37%		75
on Dioxide	50.00%	1.86000	44	0.3957	0.37%		1838
ane	95.00%	0.60000	16	<0.01	0.04%		350
ne	3.00%	1.00000	30	0.0493	0.37%		111
ane	1.00%	1.00000	29	1.7160	0.49%		49
nes	0.50%	2.00000	43	1.3800	0.46%		23
anes	0.50%	2.00000	72	<0.01	1.05%		52
ne	1.00%	2.00000	86	<0.01	1.23%		123
ogen Sulfide	3ppm	1.00000	34	<0.01		2.31%	0.07

Reformer Streams: Typical

2. Primary Reformer Stream

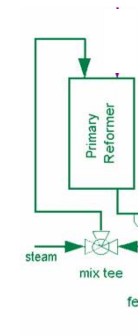
Component	Concentration
Hydrogen	67.00%
Nitrogen	1.50%
Carbon Monoxide	8.00%
Carbon Dioxide	11.50%
Argon	0.10%
Methane	12.00%

3. Secondary Reformer Stream

Component	Concentration
Hydrogen	57.50%
Nitrogen	22.50%
Carbon Monoxide	12.00%
Carbon Dioxide	8.50%
Argon	0.30%
Methane	0.40%

- Methane Slippage
  - Amount of unreacted Methane is an indication of reformer efficiency
  - Wide dynamic range for methane analysis is required
    - > 90% in Feed
    - 10% in Primary Reformer
    - <0.5% in Secondary Reformer
    - Control the methane slippage with +/ 50ppm accuracy
- Accurate H_2 analysis is required in order to control Air injection rate for a 3:1 H_2:N_2 ratio at the exit

Reformer Streams: Results



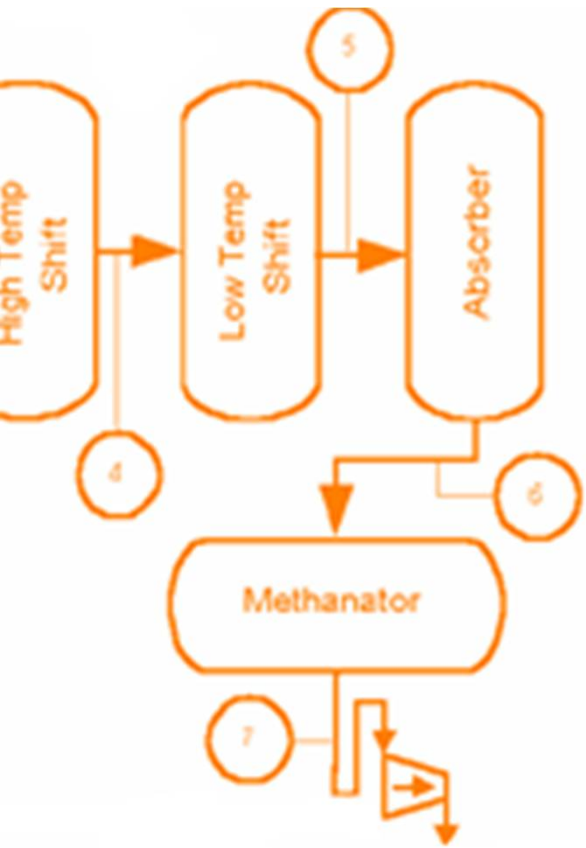
Primary Reformer Stream

Component	Concentration	Sensitivity	Detection Mass	Relative Interference Factor (RIF)	Relative Standard Deviation (F)	Standard Deviation ppm
rogen	67.00%	0.2500	2	<0.01	0.07%	492
ogen	1.50%	1.0000	14	17.59	4.72%	708
bon Monoxide	8.00%	1.0000	28	0.4826	0.13%	103
bon Dioxide	11.50%	1.8600	44	<0.01	0.07%	75
on	0.10%	1.5000	40	<0.01	0.78%	8
hane	12.00%	0.6980	15	<0.01	0.12%	138

Secondary Reformer

Component	Concentration	Sensitivity	Detection Mass	Relative Interference Factor (RIF)	Relative Standard Deviation (F)	Standard Deviation ppm
rogen	57.50%	0.2500	2	<0.01	0.09%	449
ogen	22.50%	1.0000	14	0.1215	0.30%	674
bon Monoxide	12.00%	1.0000	28	2.02	0.15%	181
bon Dioxide	8.50%	1.8600	44	<0.01	0.08%	64
on	0.30%	1.5000	40	<0.01	0.45%	13
hane	0.40%	0.6980	15	0.01989	0.64%	25

econd Stage: Streams are “cleaned up” and he production of H_2 is maximized



(4) High Temperature and (5) Low Temperature shifts remove the CO to increase the production of H_2.

$$CO + H_2O \longrightarrow CO_2 + H_2$$

(6) Absorber removes the CO_2 to levels less than 100ppm.
(7) Methanator converts the remainder of the CO and CO_2, which are poisons, to Methane.

$$CO + 3H_2 \longrightarrow CH_4 + H_2O$$

$$CO_2 + 4H_2 \longrightarrow CH_4 + 2H_2O$$

Temperature Shift: Typical

4. High Temperature Shift

Component	Concentration
Hydrogen	52.70%
Nitrogen	27.27%
Carbon Monoxide	3.60%
Carbon Dioxide	14.53%
Argon	0.35%
Methane	1.55%

5. Low Temperature Shift

Component	Concentration
Hydrogen	54.20%
Nitrogen	26.42%
Carbon Monoxide	0.40%
Carbon Dioxide	17.19%
Argon	0.35%
Methane	1.50%

Analysis of CO, CO_2 and H_2 is desired to calculate the amount of additional steam required to convert CO to CO_2 and H_2

Temperature Shift: Results

4. High Temperature Shift

Component	Concentration	Sensitivity	Detection Mass	Relative Interference Factor (RIF)	Relative Standard Deviation (F)	Standard Deviation ppm
Hydrogen	52.70%	0.2500	2	<0.01	0.08%	436
Nitrogen	27.27%	1.0000	14	0.1399	0.27%	748
Carbon Monoxide	3.60%	1.0000	28	8.401	0.49%	175
Carbon Dioxide	14.53%	1.8600	44	<0.01	0.06%	84
Argon	0.35%	1.5000	40	<0.01	0.41%	14
Methane	1.55%	0.6980	15	<0.01	0.32%	50

5. Low Temperature Shift

Component	Concentration	Sensitivity	Detection Mass	Relative Interference Factor (RIF)	Relative Standard Deviation (F)	Standard Deviation ppm
Hydrogen	54.20%	0.2500	2	<0.01	0.08%	442
Nitrogen	26.42%	1.0000	14	0.1212	0.28%	730
Carbon Monoxide	0.40%	1.0000	28	74.84	4.13%	165
Carbon Dioxide	17.19%	1.8600	44	<0.01	0.05%	91
Argon	0.35%	1.5000	40	<0.01	0.41%	14
Methane	1.50%	0.6980	15	<0.01	0.33%	49

)utlets: Typical

3. Absorber Outlet

Component	Concentration
lydrogen	65.22%
litrogen	31.80%
:arbon Monoxide	0.48%
:arbon Dioxide	0.80%
ırgon	0.41%
lethane	1.81%

7. Methanator Outlet

Component	Concentration
lydrogen	69.80%
litrogen	28.00%
:arbon Monoxide	< 5ppm
:arbon Dioxide	< 5ppm
ırgon	0.30%
lethane	1.70%

The analysis of the oxides, CO and CO2 are important to prevent poisoning of catalysts in converter

utlet: Results

6. Absorber Outlet

Component	Concentration	Sensitivity	Detection Mass	Relative Interference Factor (RIF)	Relative Standard Deviation (F)	Standard Deviation ppm
Hydrogen	65.22%	0.2500	2	<0.01	0.07%	484
Nitrogen	31.80%	1.0000	14	0.1216	0.25%	
Carbon Monoxide	0.48%	1.0000	28	66.29	3.55%	
Carbon Dioxide	0.80%	1.8600	44	<0.01	0.08%	
Argon	0.41%	1.5000	40	<0.01	0.38%	
Methane	1.81%	0.6980	15	<0.01	0.30%	

CO at 5ppm can not be mea
in the presence of N_2

CO_2 will require addition of
Electron Multiplier Detector

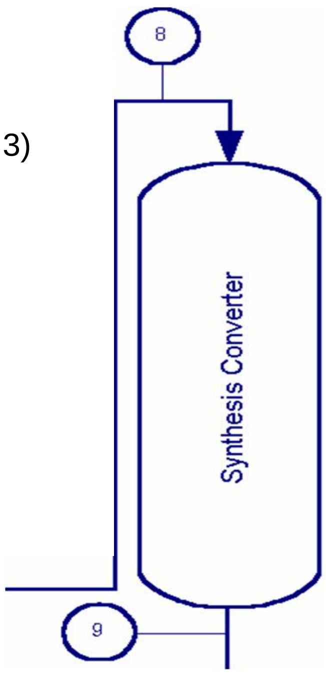
7. Methanator Outlet

Component	Concentration	Sensitivity	Detection Mass	Relative Interference Factor (RIF)	Relative Standard Deviation (F)	Relative Standard Deviation (M)	Stand Deviatio
Hydrogen	69.80%	0.2500	2	<0.01	0.07%		50
Nitrogen	28.00%	1.0000	14	0.1271	0.27%		75
Carbon Monoxide	< 5ppm	1.0000	28	100		423.00%	21
Carbon Dioxide	< 5ppm	1.8600	44	<0.01		1.34%	7
Argon	0.30%	1.5000	40	<0.01	0.45%		1
Methane	1.70%	0.6980	15	<0.01	0.31%		5

Third stage: Converter Produces Ammonia

The (8) Synthesis Converter "converts" the nitrogen and the hydrogen to (9) Ammonia (NH_3)

$$N_2 + 3H_2 \longrightarrow 2NH_3$$



Converter: Typical

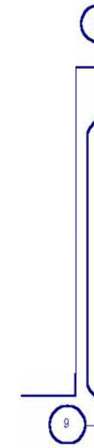
8. Converter Inlet

Component	Concentration
Hydrogen	65.00%
Nitrogen	22.50%
Argon	2.50%
Helium	0.50%
Methane	7.00%
Ammonia	2.00%

9. Converter Outlet

Component	Concentration
Hydrogen	54.00%
Nitrogen	19.50%
Argon	3.50%
Helium	0.50%
Methane	7.50%
Ammonia	15.00%

Efficient production of ammonia through the control of the Feed to Air (H_2:N_2) ratio within +- 0.01%



Converter: Results

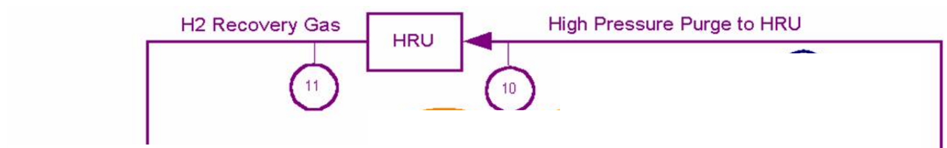
8. Converter Inlet

Component	Concentration	Sensitivity	Detection Mass	Relative Interference Factor (RIF)	Relative Standard Deviation (F)	Standard Deviation ppm
Hydrogen	65.00%	0.2500	2	<0.01	0.07%	484
Nitrogen	22.50%	1.0000	28	<0.01	0.06%	140
Argon	2.50%	1.5000	40	<0.01	0.15%	39
Helium	0.50%	0.0020	4	<0.01	0.95%	47
Methane	7.00%	0.0070	15	0.04156	0.15%	108
Ammonia	2.00%	1.0000	17	0.02443	0.21%	43

9. Converter Outlet

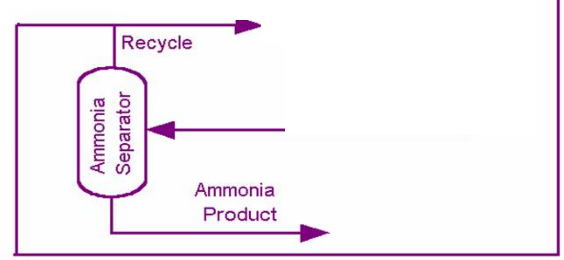
Component	Concentration	Sensitivity	Detection Mass	Relative Interference Factor (RIF)	Relative Standard Deviation (F)	Standard Deviation ppm
Hydrogen	54.00%	0.2500	2	<0.01	0.08%	441
Nitrogen	19.50%	1.0000	28	<0.01	0.07%	132
Argon	3.50%	1.5000	40	<0.01	0.13%	46
Helium	0.50%	0.0020	4	<0.01	0.95%	47
Methane	7.50%	0.0070	15	0.2839	0.17%	124
Ammonia	15.00%	1.0000	17	<0.01	0.08%	116

Final Stage: Collects Ammonia Product, Recycles Inert Gases and Hydrogen Recovery



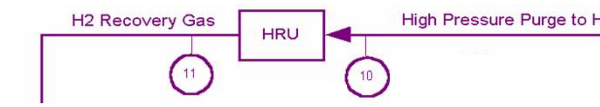
(10) High Pressure Purge to recovered
(11) Hydrogen is sent to the Primary reformer.

H_2, N_2, and inert gases are then sent back to the converter.



The ammonia Produc stream is separated f other gases.

Hydrogen Recovery: Typical



10. Purge Gas

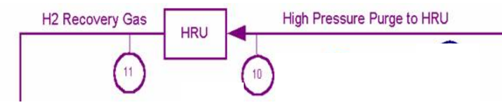
Component	Concentration
Hydrogen	62.00%
Nitrogen	22.50%
Argon	3.50%
Helium	0.50%
Methane	11.00%
Ammonia	2.00%

11. H_2 Recovery Gas

Component	Concentration
Hydrogen	50.00%
Nitrogen	10.00%
Argon	1.75%
Helium	60.00%
Methane	37.50%

- Much of the converter inlet is made up of recycled gases
- Control of the inert gases helps maintain the control for feed gases

Hydrogen Recovery: Results



10. Purge Gas

Component	Concentration	Sensitivity	Detection Mass	Relative Interference Factor (RIF)	Relative Standard Deviation (F)	Standard Deviation ppm
Hydrogen	62.00%	0.2500	2	<0.01	0.08%	473
Nitrogen	22.50%	1.0000	28	<0.01	0.06%	142
Argon	3.50%	1.5000	40	<0.01	0.13%	46
Helium	0.50%	0.0020	4	<0.01	0.95%	47
Methane	11.00%	0.0070	15	0.02645	0.12%	134
Ammonia	2.00%	1.0000	17	0.03839	0.22%	43

11. H_2 Recovery Gas

omponent	Concentration	Sensitivity	Detection Mass	Relative Interference Factor (RIF)	Relative Standard Deviation (F)	Standard Deviation ppm
ydrogen	50.00%	0.2500	2	0.01047	0.09%	427
itrogen	10.00%	1.0000	28	<0.01	0.09%	95
rgon	1.75%	1.5000	40	<0.01	0.19%	32
elium	60.00%	0.0020	4	<0.01	0.87%	5196
Methane	37.50%	0.0070	15	<0.01	0.07%	244

Customer Feedback

Comment	Estimate
Optimizing Purge Gas Recovery	$100,000 to $120,000/year
Energy saving equal to 0.6 GJ per ton NH3	$1,500 per day
Plants run smoothly and stable	Daily production variations were +/- 25 tons/day, now +/- 1-2 tons/day
H/N ratio	With GC's 3.1+/- 0.1. With MS 3.1 +/- 0.007
Stable steam-to-carbon ratio and H/N ratio	1 million $ per plant in 3 years
Yield and Catalyst	Increased yield over time and increased catalyst life
Startup	It takes only hours to reach set point instead of days

New Ammonia Plants

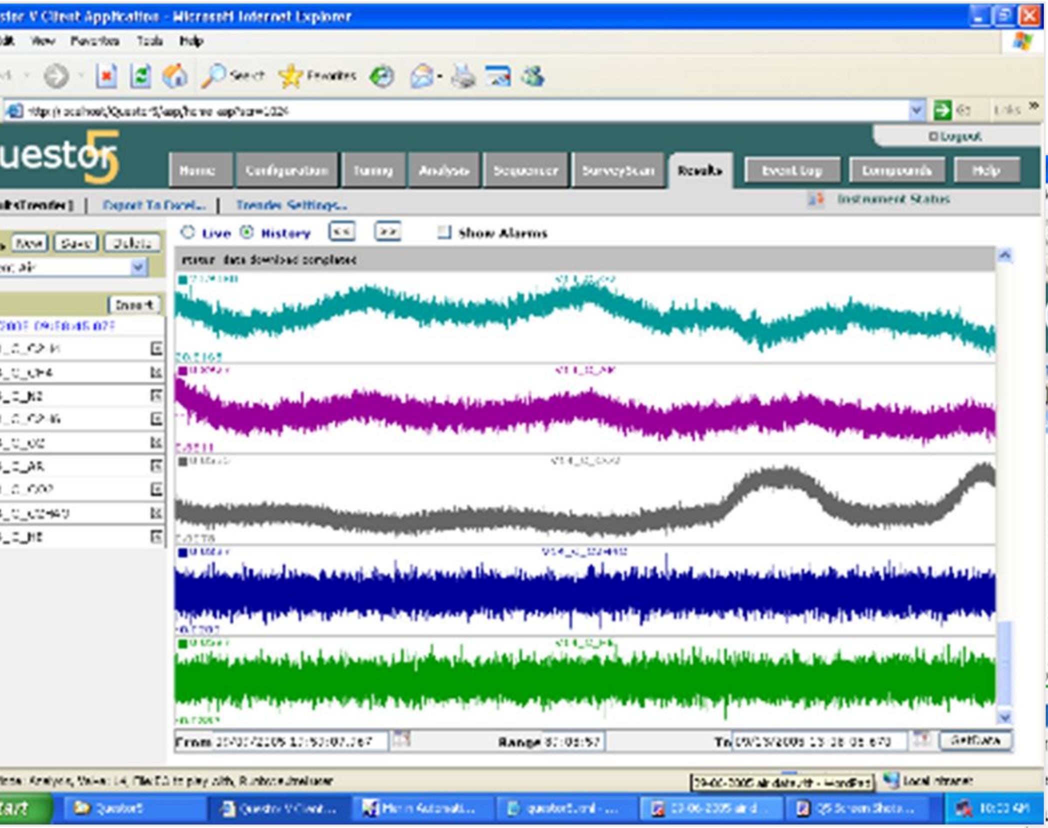
Redundant Mass Spectrometers

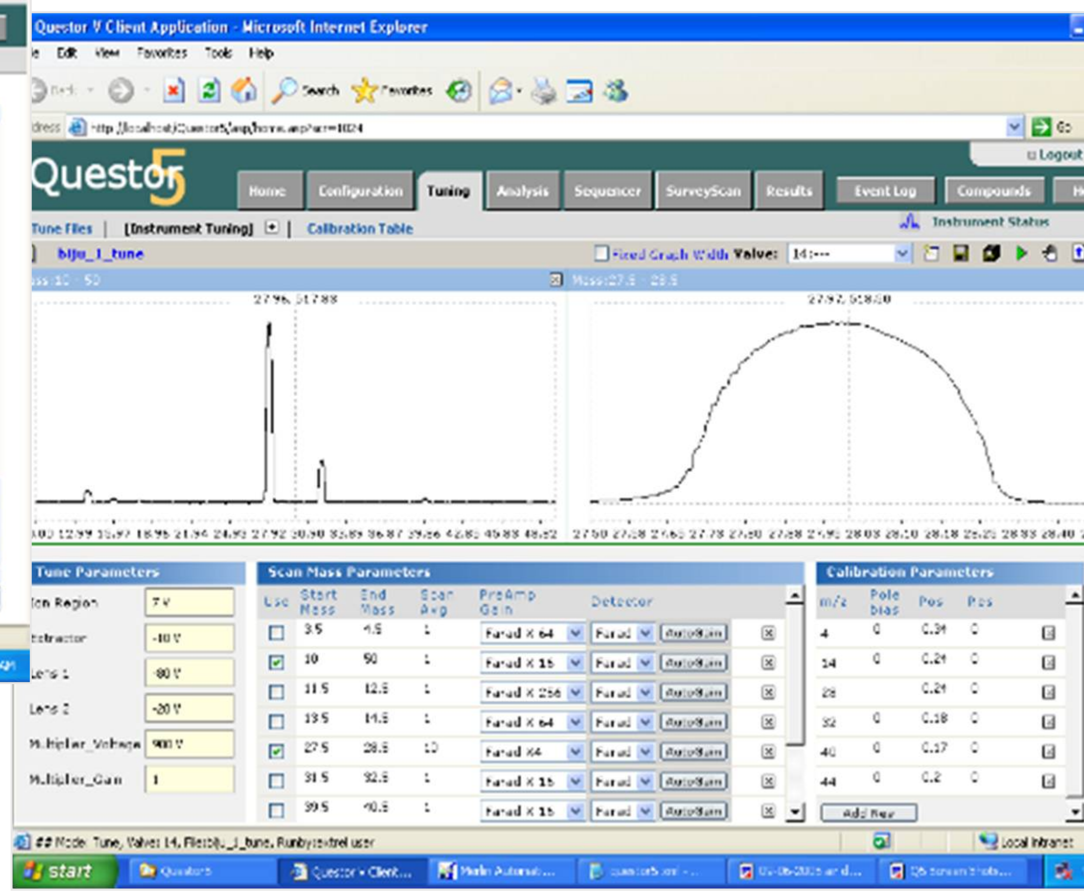
- Provides analysis of half the streams for faster data update
- Eliminates downtime
- Switchover cab be automatic by DCS or Manual

Communication Options

- OPC Server Interface
- Modbus Master & Slave Interface
  - RS422 – 4 Wire
  - RS485 – 2 Wire
  - RS485 – 4 Wire
  - TCP/IP
- DCS Control Option
  - Includes 12 x 4-20 mA Outputs
  - 128 Different Input Coms
  - OPC
  - Modbus TCP/IP
- Fiber Optics Option
- 16 Relay Option
  - Expandable 2 at a Time
- 4-20 mA Output Option
  - Base 8 Outputs
  - Expandable 2 at a Time

Easy to Use Web Page Format





Extrel Mass Spectrometer find installations in majority Ammonia plants around the worl

Installations in Ammonia plants in India include:

- Tata Chemicals Babrala, India – Commissioned in 1997
- Rashtriya Chemicals & Fertilisers, Mumbai– Commissioned in 2001
- Chambal Fertilisers & Chemicals Ltd – Commissioned in 2013
- Zuari Agro Chemicals Ltd., Goa, – Commissioned in 2013
- Indo Gulf Fertilisers – Commissioned in 2014
- IFFCO Kalol – Commissioned in 2017
- Chambal Fertilisers & Chemicals Ltd, Gadepan 3 – Under execution
- Several Global references

WOBBE INDEX ANALYSER

COSA XENTAUR CORP

USA

Cosa9610™

- **Gross Heating Value**:The heating value (Btu) produced by combustion at constant pressure with the following conditions:

  (a) a volume of one cubic foot.

  (b) 60° Fahrenheit.

  (c) reference base pressure.

  (d) with air and gas having the same temperature and pressure.

  (e) recovered heat from the water vapor formed by combustion.

- **Net Heating Value**: The heating value produced under conditions similar to gross heating value conditions excepting the amount of heat potentially recovered from the water vapor produced at combustion. Net heating value is always less than gross heating values. It is sometimes referred to as the inferior heating value

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Relative Density: The ratio of the density a gas to the density of dry air under the same pressure and temperature conditions, (it sometimes referred to as specific gravity).

Wobbe Index: The ratio of the gross heating value of a gas to the square root of the relative density of the gas, ($WI = Hv / \sqrt{RD}$).

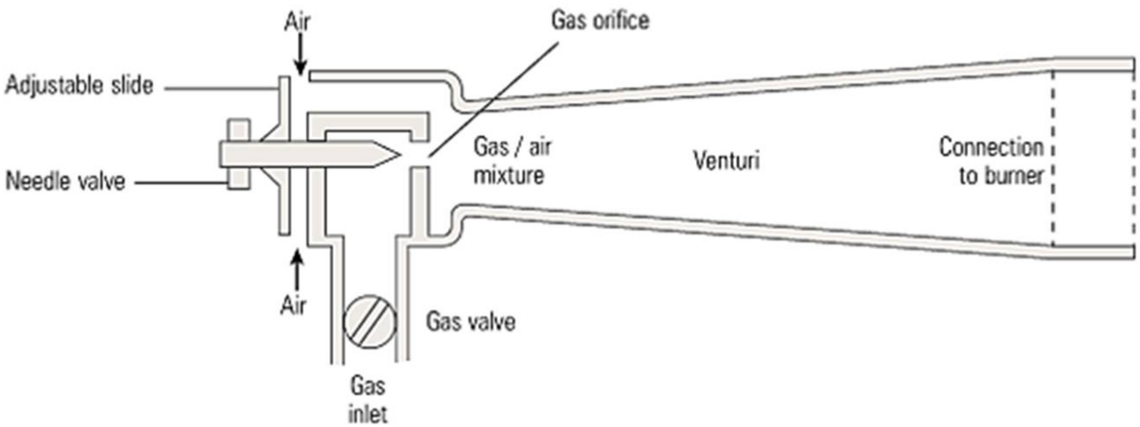
$$\text{Wobbe Index} = \frac{\text{Calorific Value}}{\sqrt{SG}}$$

Wobbe Index of Natural Gas

$$\text{Wobbe Index} = \frac{\text{Calorific Value}}{\sqrt{SG}}$$

$$\text{Wobbe Index} = \frac{1000\ [BTU/cuft]}{\sqrt{0.61}} = \frac{1000}{0.781}$$

Wobbe Index of Natural Gas = **1280**

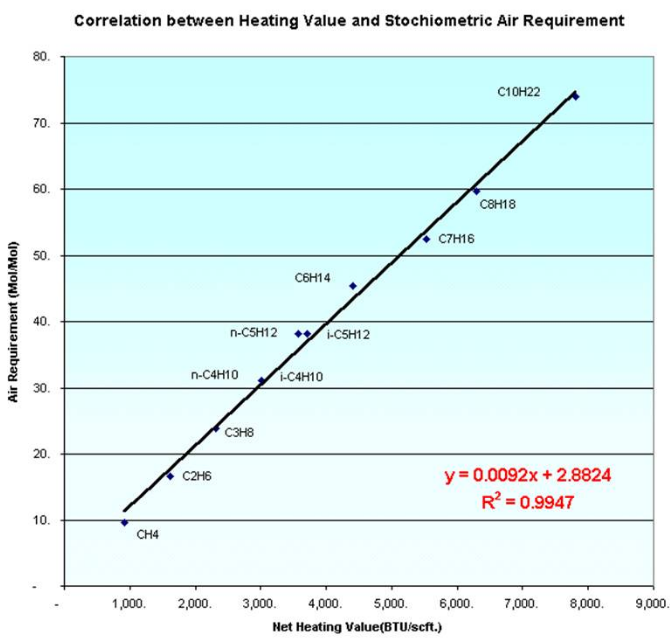


– Wobbe index is a measure of the amount of energy delivered to a burner via an injector (orifice). The energy input is a linear function of Wobbe index.

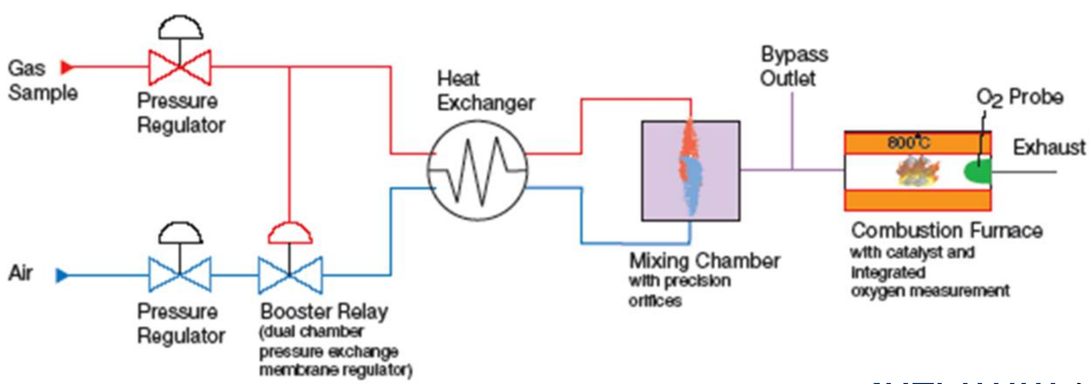
– Two gases differing in composition but having the same Wobbe index will deliver the same amount of energy for any given injector/orifice under the same injector pressure.

– Wobbe is calculated by ratio of the gross or net heating value of a gas by the square root of the relative density of the gas, (WI = Hv √ RD).

(Source ASTM D 1945, American Gas Association Bulletin No. 36, GTI)



- The direct method utilizes principles of Residual Oxygen Measurement.
- When a particular air/gas mixture is combusted a proportional CARI index in created.
- CARI Index correlates to WOBBE from which Btu can be accurately calculated.



rum

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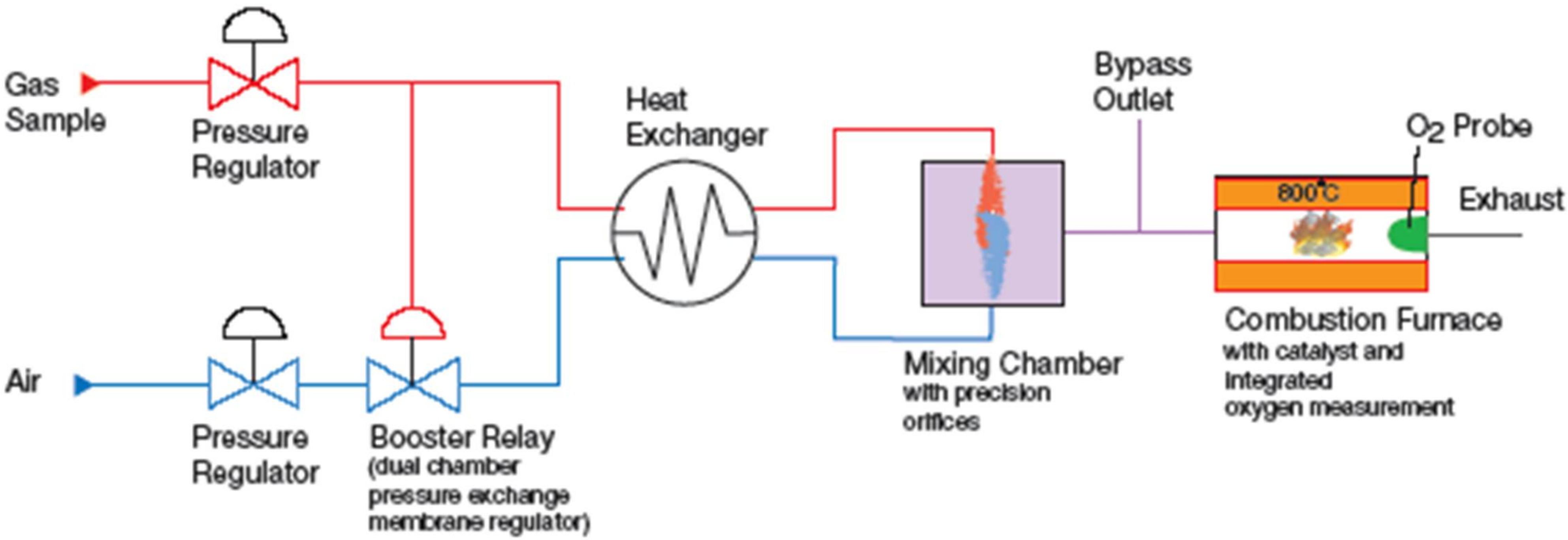
- Based on ***Residual Oxygen Measurement Method***
  - Provides direct measurement of Combustion Air Requirement Index (CARI) of a gas
  - Integrated specific gravity cell for Heating Value calculations
- Fast response time
  - T90 < 5 seconds
  - Ideal for process control applications such as gas blending, fuel air optimization, turbine control and flare stack monitoring and control
- High accuracy
  - 0.4% of reading makes it the tool of choice for turbine control
- Flameless combustion
  - No flame out conditions
  - Ability to analyze low BTU gases without make up gas
- Insensitive to ambient temperature changes
  - Negligible drift over ambient temperature range -40°F to +140°F
- Auto-calibration and validation
- Minimal maintenance
  - Rugged, corrosion resistant design with few moving parts
- User friendly, menu driven software

Cosa9610™


Gas
Sample
Pressure
Regulator
Heat
Exchanger
Bypass
Outlet
O_2 Probe
800°C
Exhaust
Air
Pressure
Regulator
Booster Relay
(dual chamber
pressure exchange
membrane regulator)
Mixing Chamber
with precision
orifices
Combustion Furnace
with catalyst and
integrated
oxygen measurement

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- Combustion air and fuel gas are mixed over critical orifices
- ir flow is constant and the orifice is sized so that always excess air for combustion is added
- uel gas flow through the gas orifice varies with $1/\sqrt{(SG)}$
- he mixture is burnt continuously in a heated furnace
- n this furnace the oxygen content in the flue gas is measured using a reliable ZrO_2 cell
- he oxygen content is proportional with the Wobbe Index!

rum

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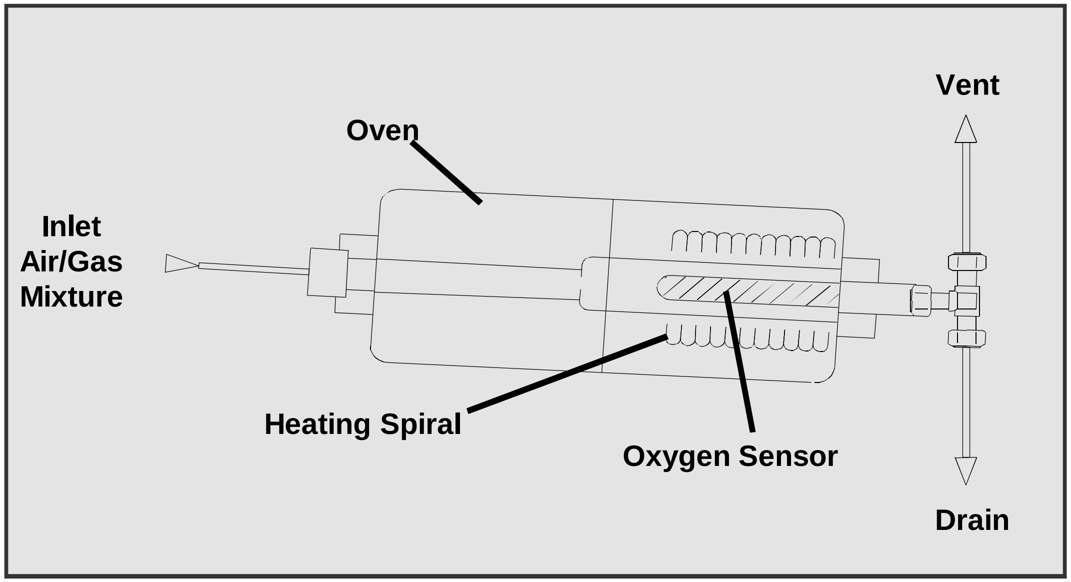
- A Zirconia Oxide cell is used to determine the residual oxygen concentration in the combusted sample



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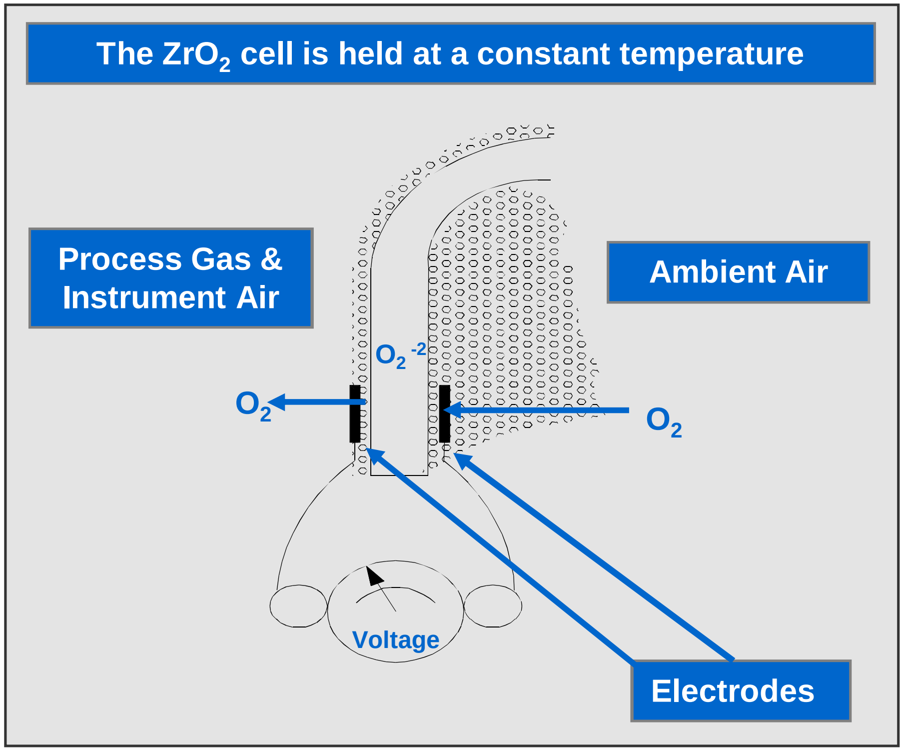
- The zirconium oxide cell is mounted such that one side is in contact with the outside air and the other side with the sample gas
- Porous Platinum electrodes are mounted at both sides of the ceramic channel
- At high temperatures (>600C) O_2 ions become mobile
- O_2 gas molecules take two electrons from one of the Pt electrodes and diffuse through and enter the ceramic (ZRO_2)
- The O2 $^{-2}$ Ions pass through to the other electrode, where they release the two electrons and are converted back into gaseous O_2



- A voltage potential corresponding to the partial pressure is generated as the oxygen moves from one electrode to the other

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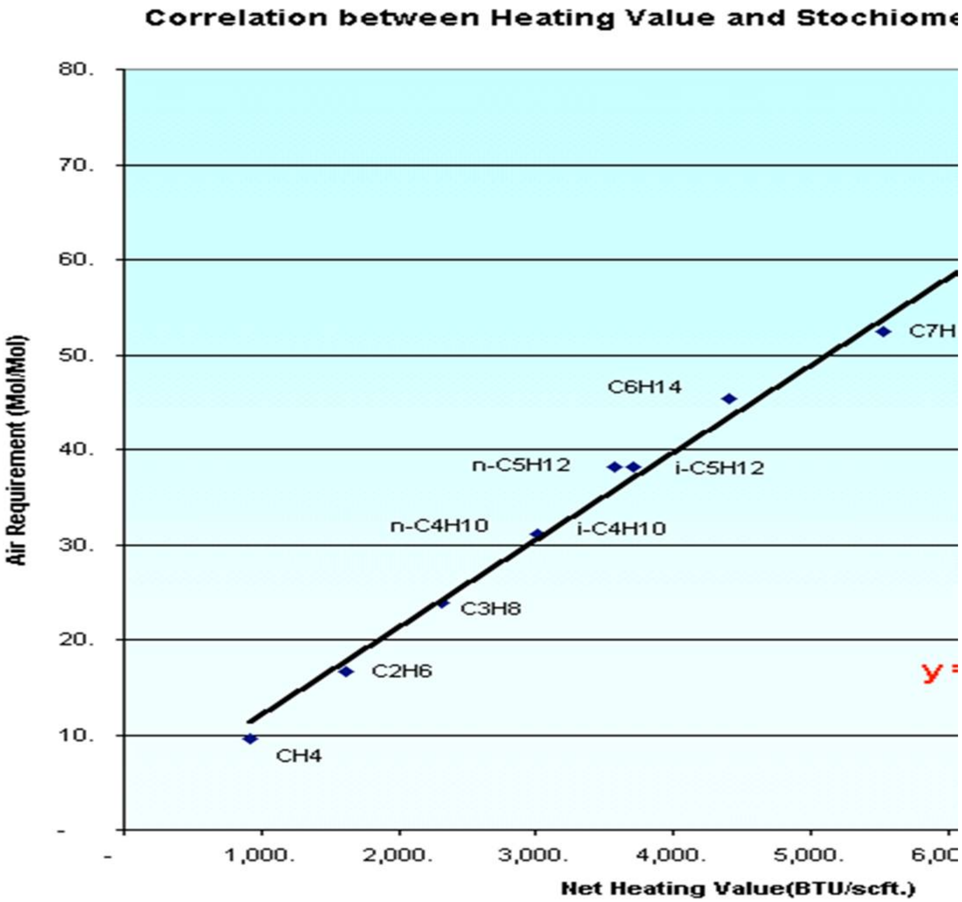
Wobbe Index = Hs / √d
where;
Hs = Gross Calorific Value
d = Relative Density

- CARI is the preferred measurement for fuel/air ratio control applications
- CARI correlates accurately to the Wobbe Index for those applications where the amount of energy to the burner is to be controlled
- Differences between the two measurements can be cancelled out by the use of suitable calibration gases
  - For natural gas, the maximum error due to the Residual Oxygen Measurement Method is less than 0.1% of reading
- An integrated specific gravity cell is used to calculate heating value of the sample gas



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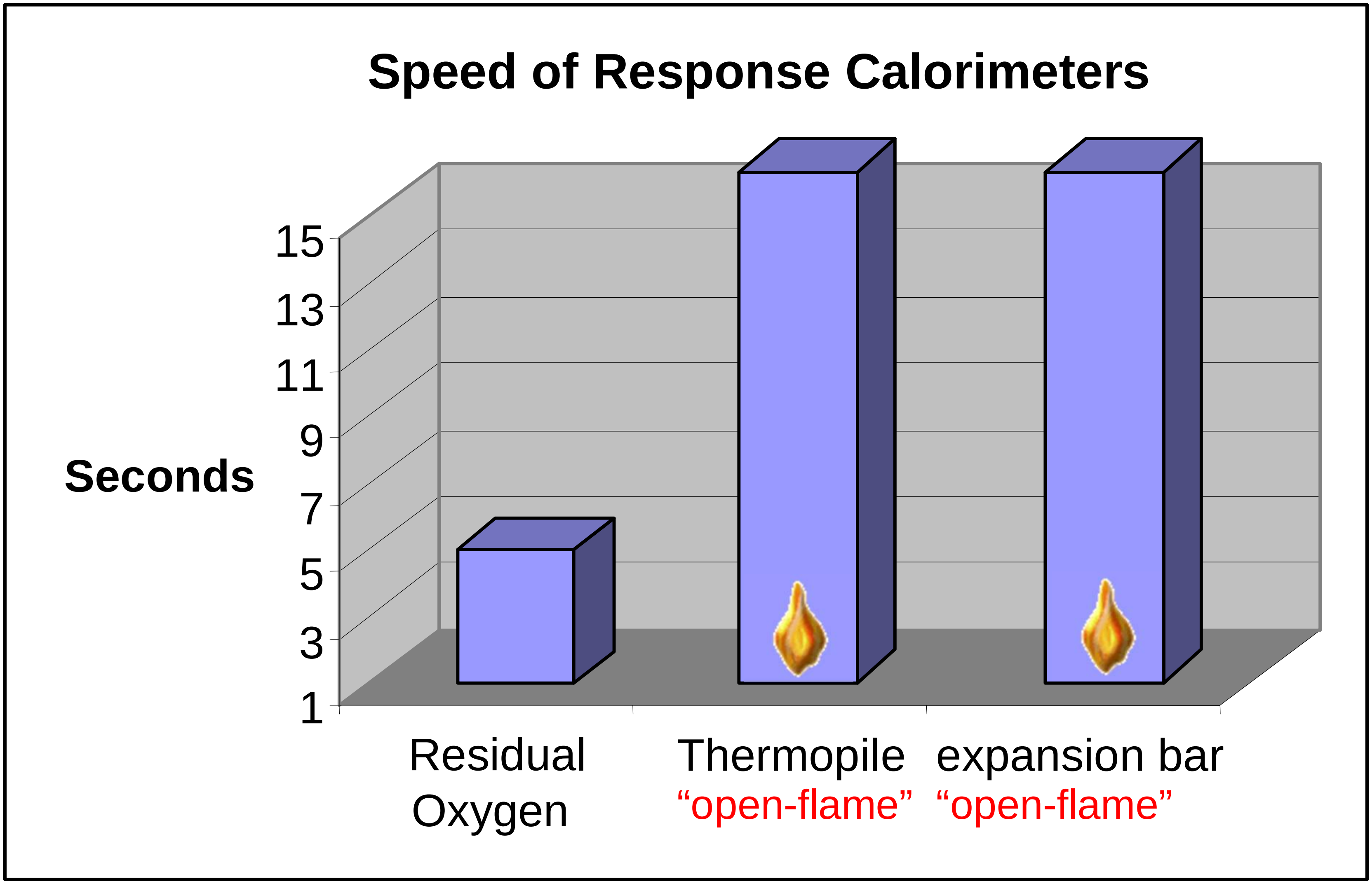
Speed of Response Calorimeters
Seconds
15
13
11
9
7
5
3
1
Residual Oxygen
Thermopile
"open-flame"
expansion bar
"open-flame"

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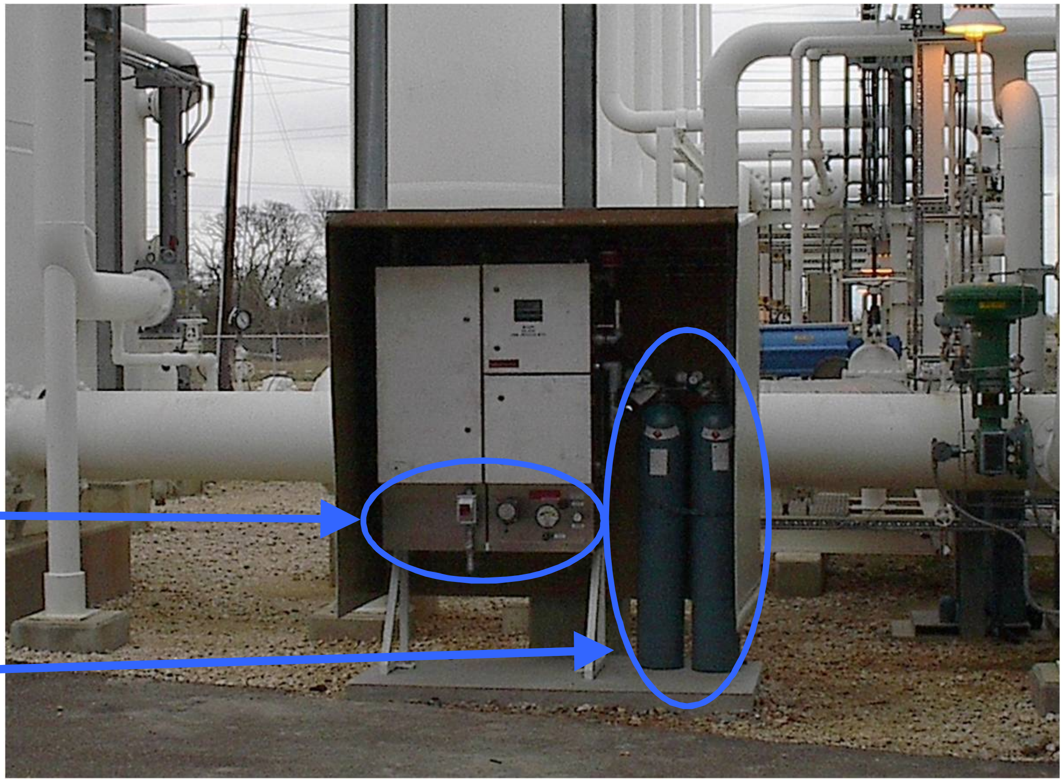
Cosa9610™

SHELTER – customer provides

3-sided



Z-Purge - optional

Class1, Division2, Grp B,C,D

Calibration Gases

Hi & Lo cal gas bottles

Calorimeter: Cosa WIM 9600 & 9610

•Calculates heating Value based on residual oxygen and gas density.

•Fast – Response time < 5 seconds

•Accurate - +/- .4 % of reading for Natural Gas; +/- 2% of reading for refinery gas.

•Wide Range; 0 – 3000 Btu at operating temperatures up to 150 C

Applications:

•Turbine Control

•Flare Stack Control

•Fuel Optimization

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Other products = Moisture measurement / Dew point measurement



1) Standard Transmitters (4-wire)

XDT Series


2) Loop-powered Transmitters (2-wire)

LPDT, HDT

3) Process Analyzers

ESS-SCVP


4) Custom Sample Systems

ESS-xx-xx-xx-….-xx

5) Portable Instrument

XPDM

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Thank you for your attention

Any Questions?