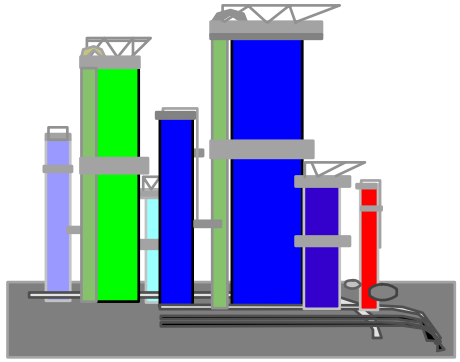
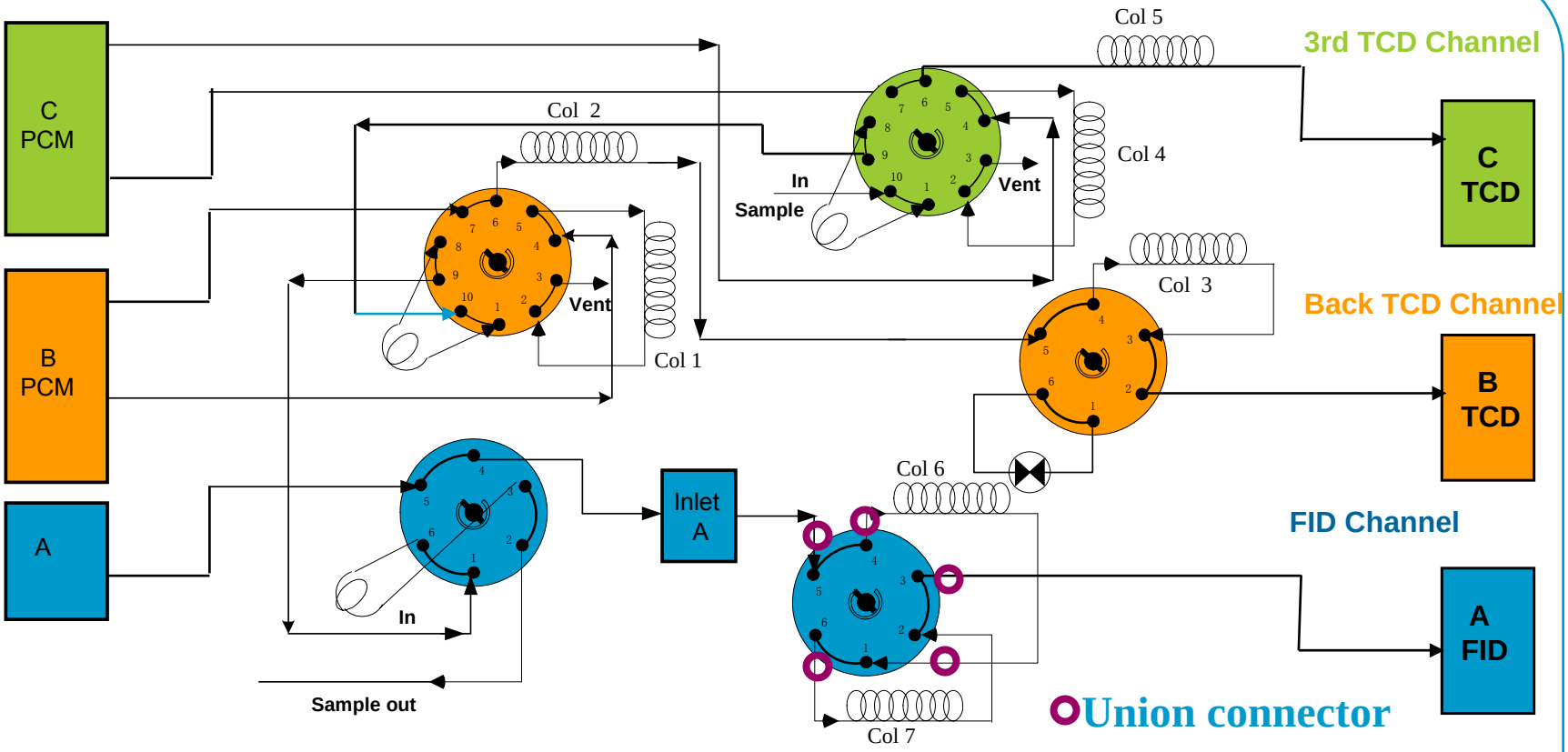
Parallel GC for Fast Refinery Gas Analysis



Background information

- Refinery gas is a collection of various gas streams produced in refinery processes
- Refinery gas composition is very complex, so determining individual components of each gas stream is a challenge
- Analysis of refinery gas is essential for process and product quality control
- Sample complexity requires increased separation power
- Labs must increase their efficiency or productivity
- The Agilent 7890A GC supports a third parallel detector (TCD) for simultaneous detection across three channels, which provides a complete analysis of refinery gas in 6 minutes

Fast RGA Configuration



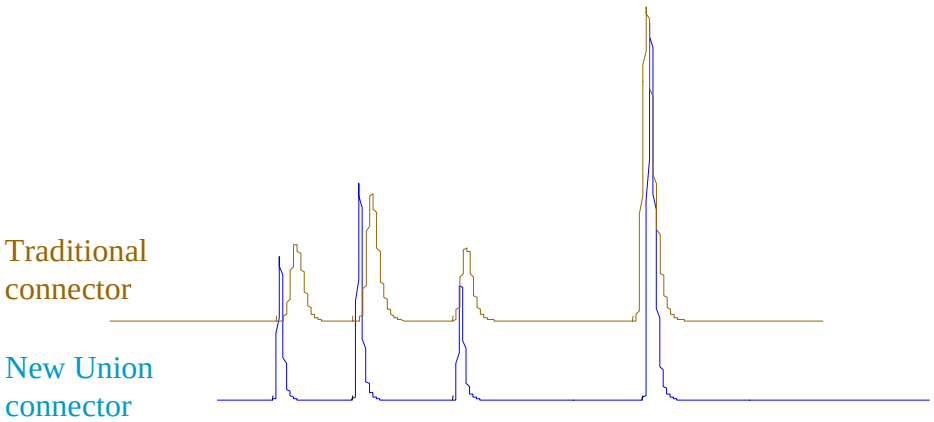
Column 1 HayeSep Q 80/100, 0.5m
Column 2 HayeSep Q 80/100, 6ft
Column 3 Molsieve 5A 60/80, 6ft
Column 4 HayeSep Q 80/100, 3ft

Column 5 Molsieve 5A 60/80, 8ft
Column 6 DB-1, 2m x 0.32mm x 5um
Column 7 HP-AL/S, 25m x 0.32mm x 8um

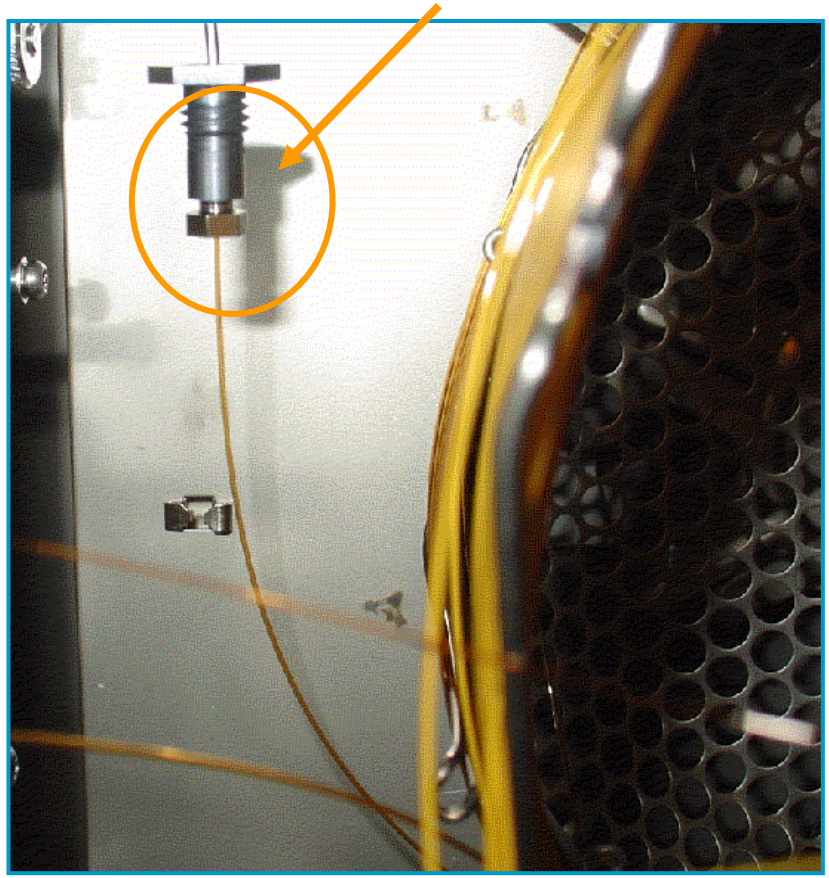
Seven Columns in GC Oven

Five valves, seven columns, and still a lot of room for people to work within the oven.

Enhance Gas Analysis with Union Connector



Column Union Connector



… Peak shape enhancement

Fast analysis GC conditions

Oven program: 60 ºC (1min), 20 ºC/min, 100 ºC, 30C/min 190C

Split temperature: 150 ºC, Valve box: 120 ºC

FID for Hydrocarbons

Columns:
(1) DB-1, 2 m x 0.32 mm x 5 um
(2) HP-AL/S 25 m x 0.32 mm x 8 um

Carrier Gas: He @ 3.3 mL/min, constant flow mode (12.7 psi at 60 ºC)

Split Ratio: 1:60

Loop: 25 uL

Back TCD for Permanent Gases

Columns:
(1) HayeSep Q 80/100, 0.5m
(2) HayeSep Q, 80/100, 6ft
(3) Molsieve 5A, 60/80, 6ft

Carrier Gas: He @ 25 mL/min (36 psi at 60 ºC), constant flow mode

Pre-column Flow: 22 mL/min at 60 ºC (7 psi), constant pressure mode

Loop: 500 uL

2nd TCD for Hydrogen

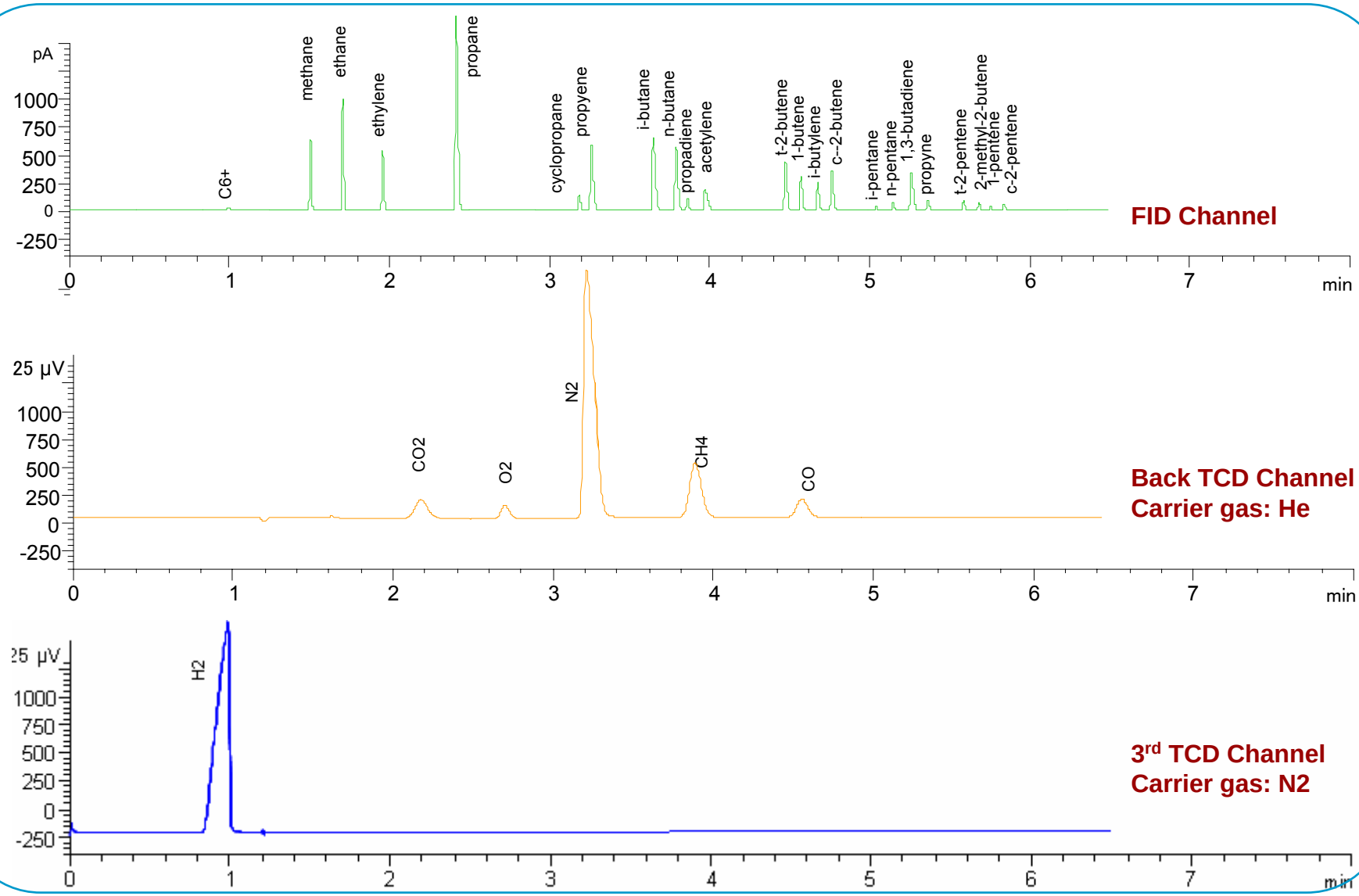
Columns:
(1)HayeSep Q 80/100, 3ft
(2)Molsieve 5A, 60/80, 8ft

Carrier Gas: N2 24 mL/min, (26 psi at 60 ºC), constant flow mode

Pre-column Flow: 24 mL/min at 60 ºC (7 psi), constant pressure mode

Loop: 500 uL

Application and Result- RGA standards



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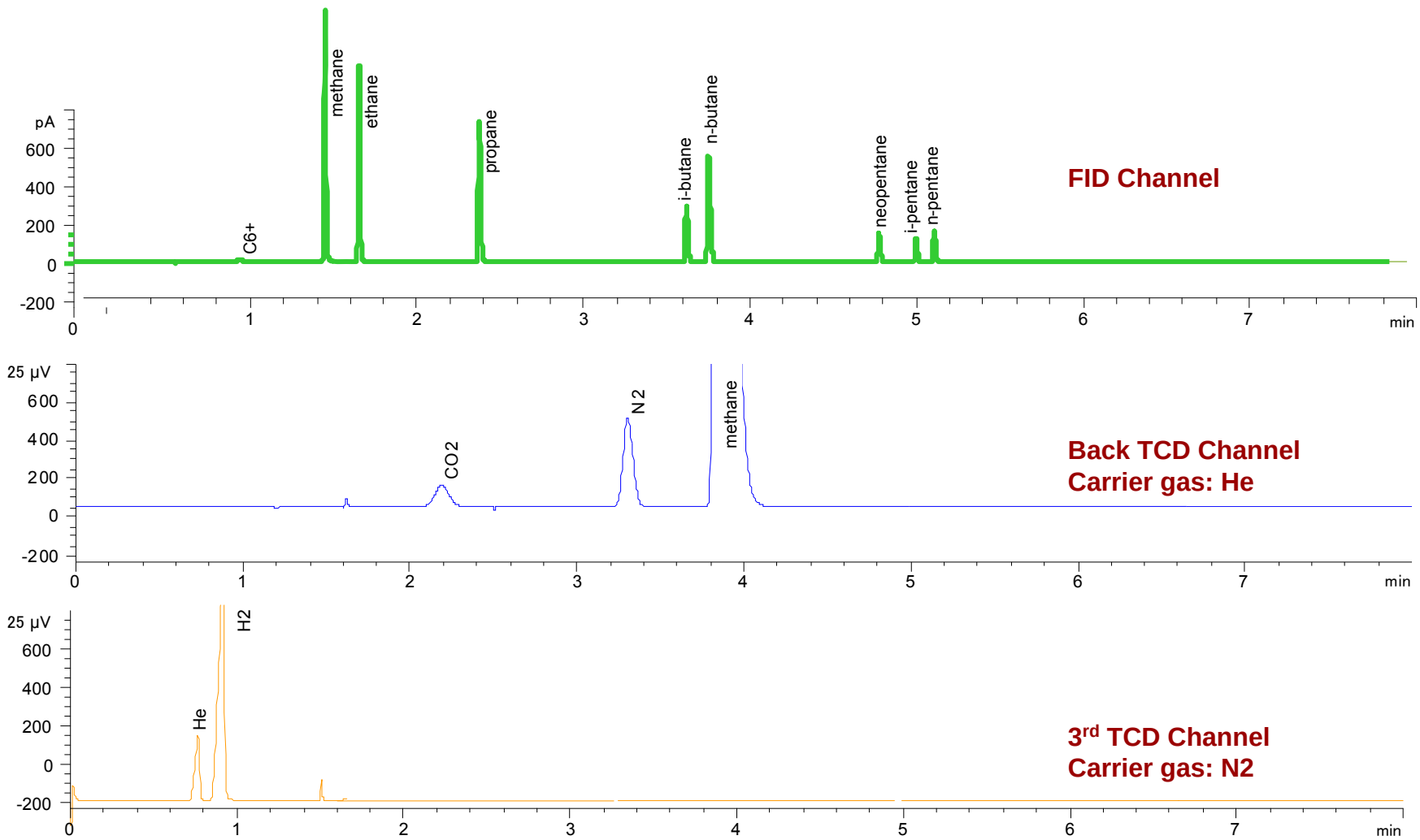
Application and Result- NGA standards



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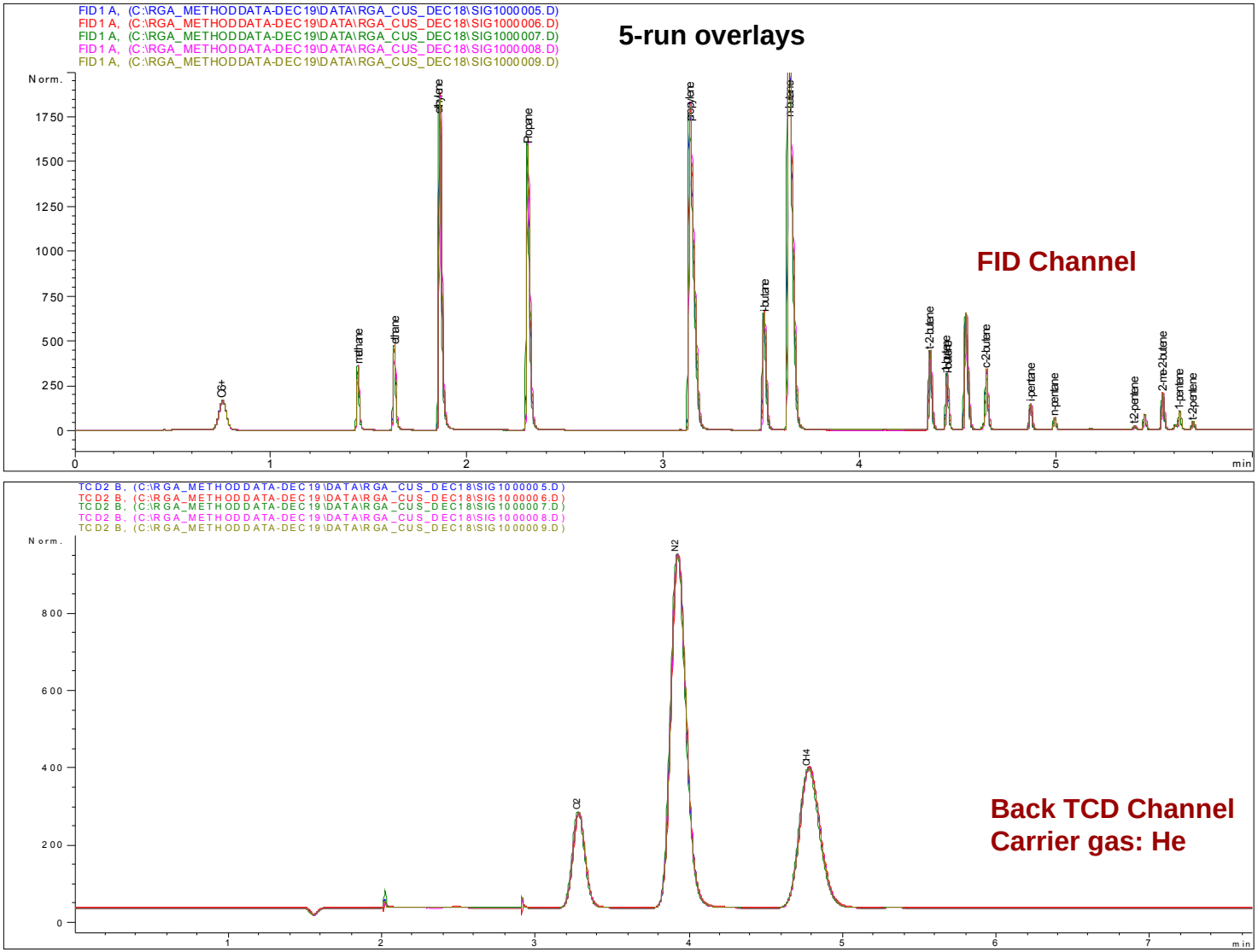
Application and Result- Customer's sample



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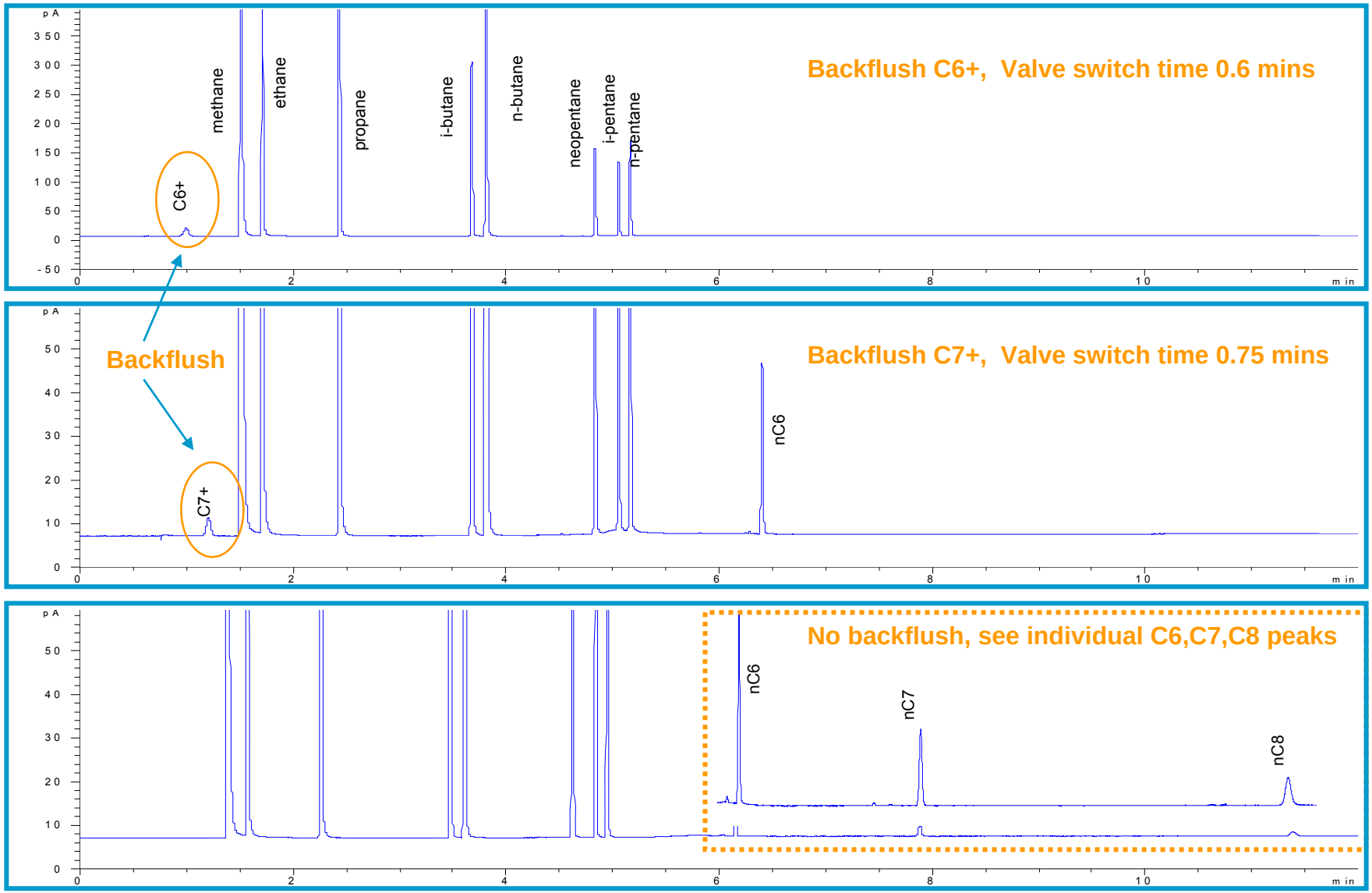
Flexibility for Hydrocarbon Analysis



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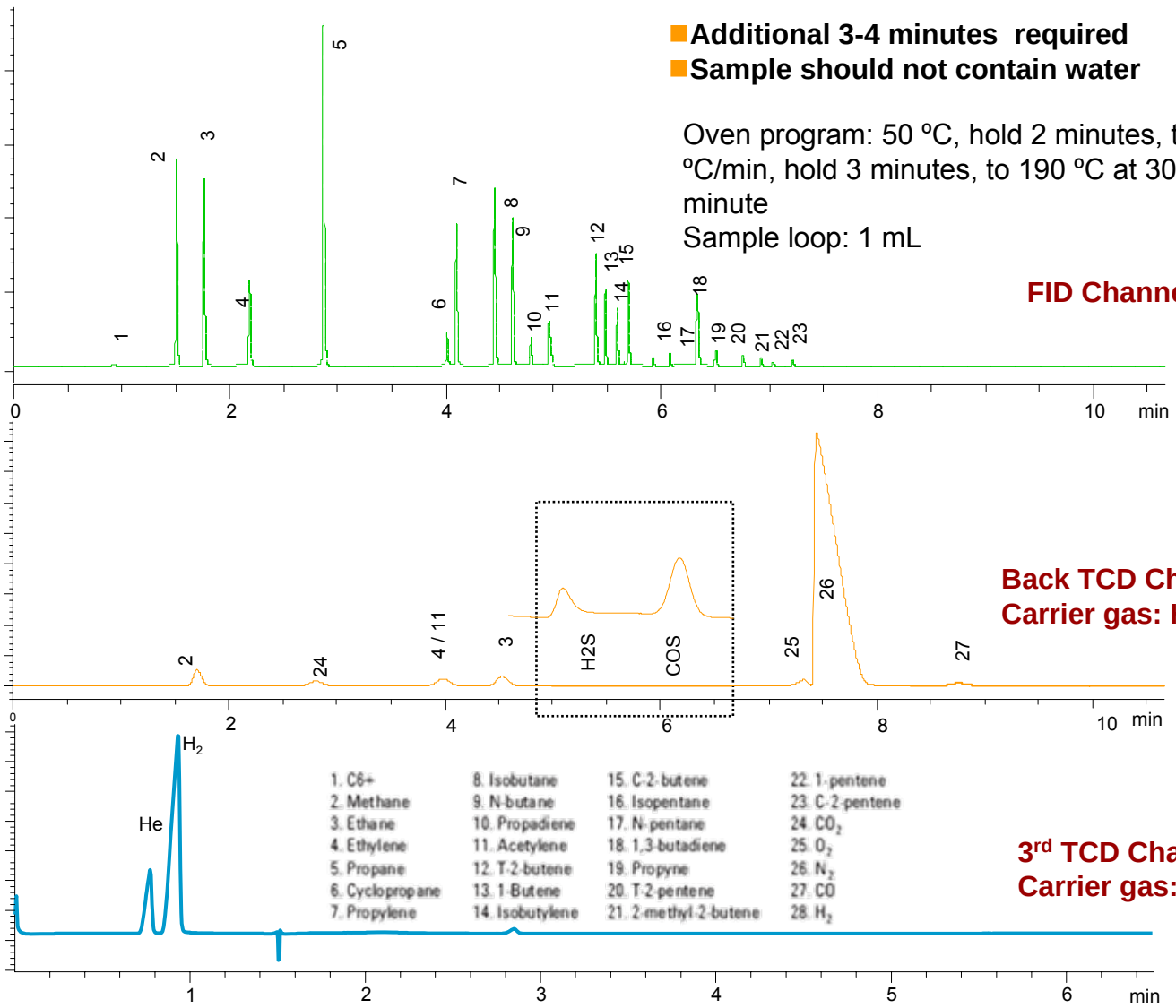
H2S and COS Analysis

- **Additional 3-4 minutes required**
- **Sample should not contain water**

Oven program: 50 ºC, hold 2 minutes, to 150 ºC at 30 ºC/min, hold 3 minutes, to 190 ºC at 30 ºC/min, hold 1 minute
Sample loop: 1 mL



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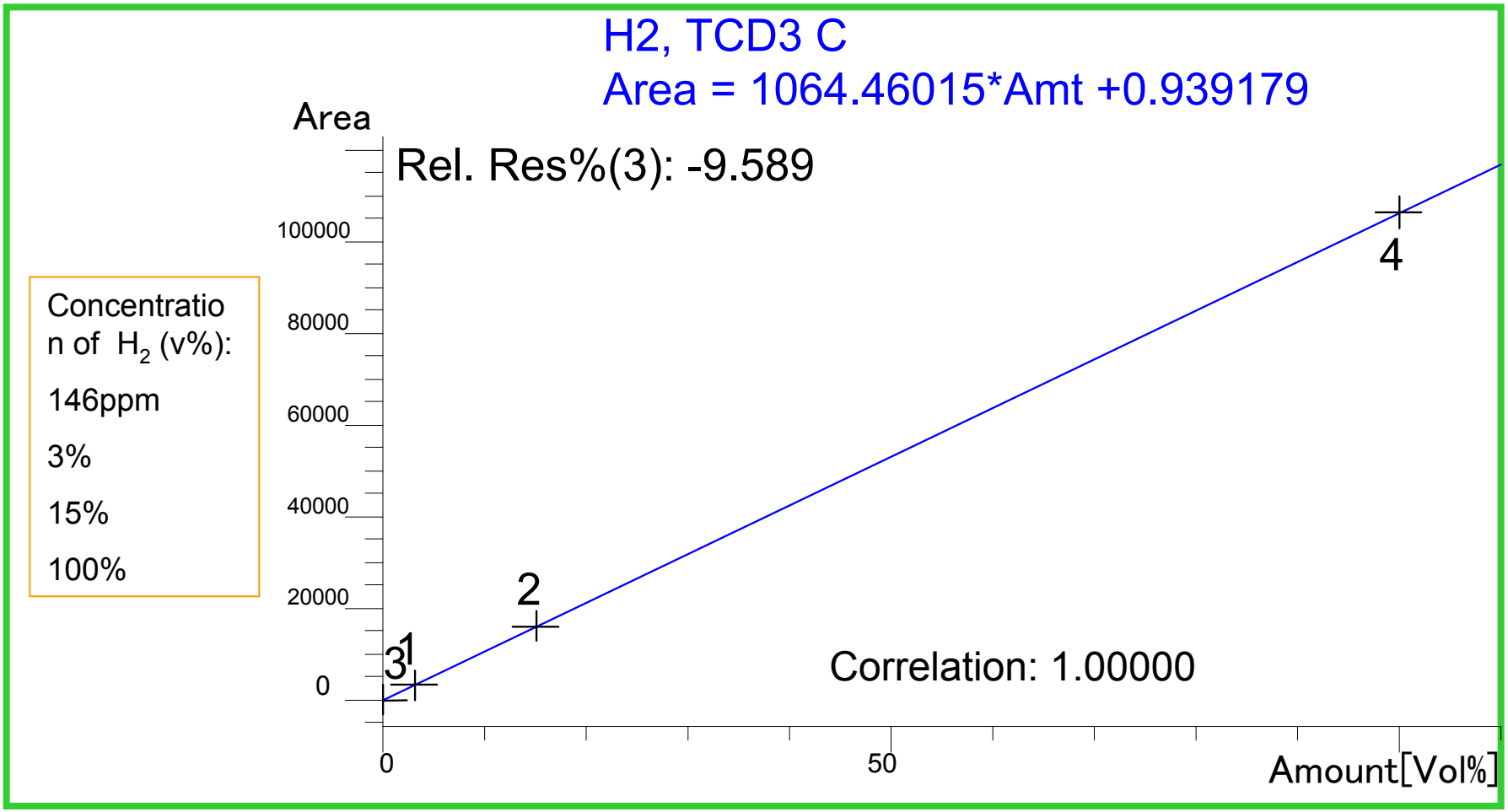
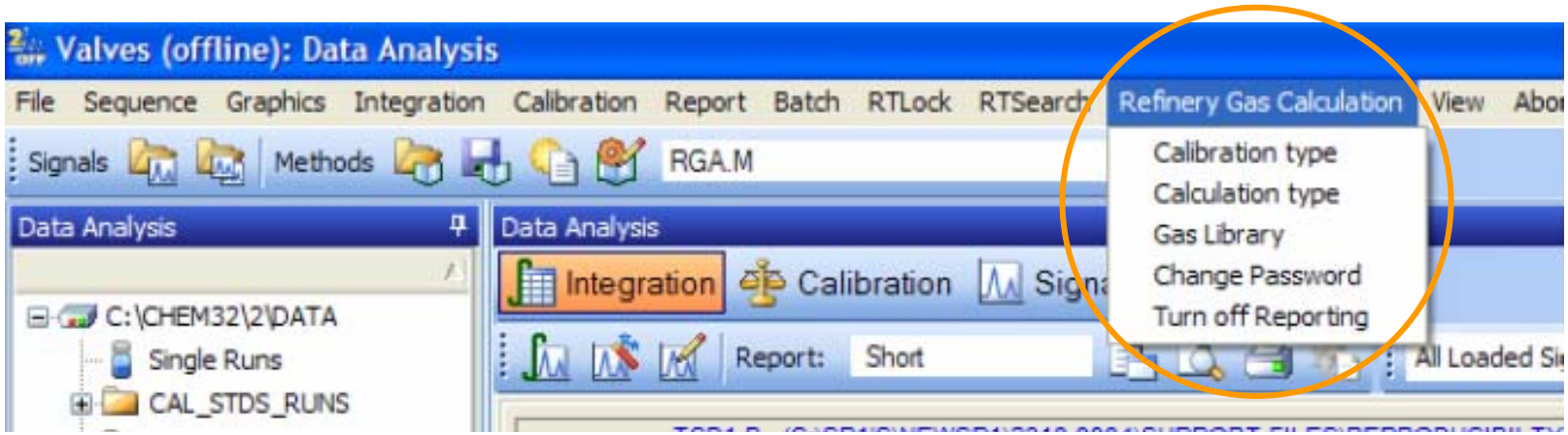
H_2 calibration (4-point)



Excellent Repeatability for Both RT and Area

Compounds	RT		n=6		Area	n=6
	Average	Std. Dev.	RSD%	Average	Std. Dev.	RSD%
C6+	0.99648	0.00031	0.03	59.01	1.10	1.86
methane	1.50780	0.00046	0.03	490.02	1.45	0.30
ethane	1.70788	0.00052	0.03	807.40	2.35	0.29
ethylene	1.95732	0.00071	0.04	472.31	1.31	0.28
propane	2.41706	0.00075	0.03	1950.35	5.96	0.31
cyclopropane	3.18506	0.00075	0.02	145.62	0.45	0.31
propyene	3.26195	0.00072	0.02	732.90	2.01	0.27
i-butane	3.64883	0.00055	0.02	885.04	3.15	0.36
n-butane	3.79161	0.00070	0.02	682.13	2.59	0.38
propadiene	3.86098	0.00095	0.02	109.08	0.65	0.60
acetylene	3.96990	0.00120	0.03	348.17	2.39	0.69
t-2-butene	4.47301	0.00106	0.02	507.88	2.59	0.51
1-butene	4.57118	0.00110	0.02	332.39	2.03	0.61
i-butylene	4.67529	0.00121	0.03	260.95	1.95	0.75
c-2-butene	4.76367	0.00112	0.02	403.80	3.47	0.86
i-pentane	5.03923	0.00090	0.02	45.03	0.05	0.11
n-pentane	5.14583	0.00099	0.02	69.23	0.40	0.58
1,3-butadiene	5.25906	0.00122	0.02	485.49	3.66	0.75
propyne	5.36385	0.00155	0.03	101.08	0.41	0.40
t-2-pentene	5.58664	0.00121	0.02	82.85	0.66	0.79
2-methyl-2-butene	5.68220	0.00117	0.02	62.54	0.61	0.98
1-pentene	5.75553	0.00126	0.02	39.57	0.38	0.96
c-2-pentene	5.83970	0.00131	0.02	59.08	0.50	0.85
CO2	2.18561	0.00221	0.10	2040.33	2.37	0.12
O2	2.72634	0.00060	0.02	930.68	6.53	0.70
N2	3.25170	0.00044	0.01	22500.18	68.87	0.31
CO	4.61692	0.00083	0.02	903.09	2.77	0.31
H2	0.9869	0.00099	0.10	16097.38	106.53	0.66

Reporting



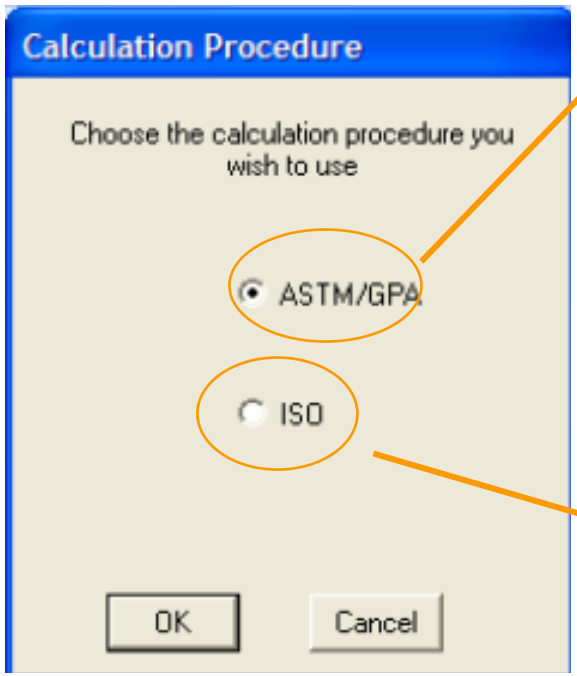
The Macro program will give a report in:

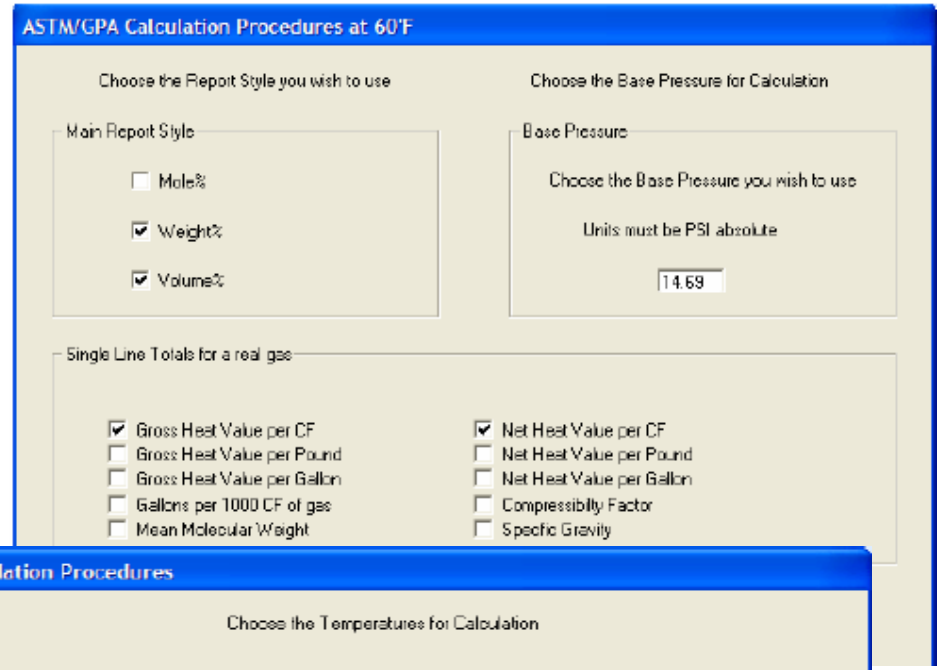
- Mole%, Weight% or Volume%, or any combination of the three
- Heat values for the gas analyzed and other standard calculations
- Calculations are made using ASTM, GPA or ISO formulas

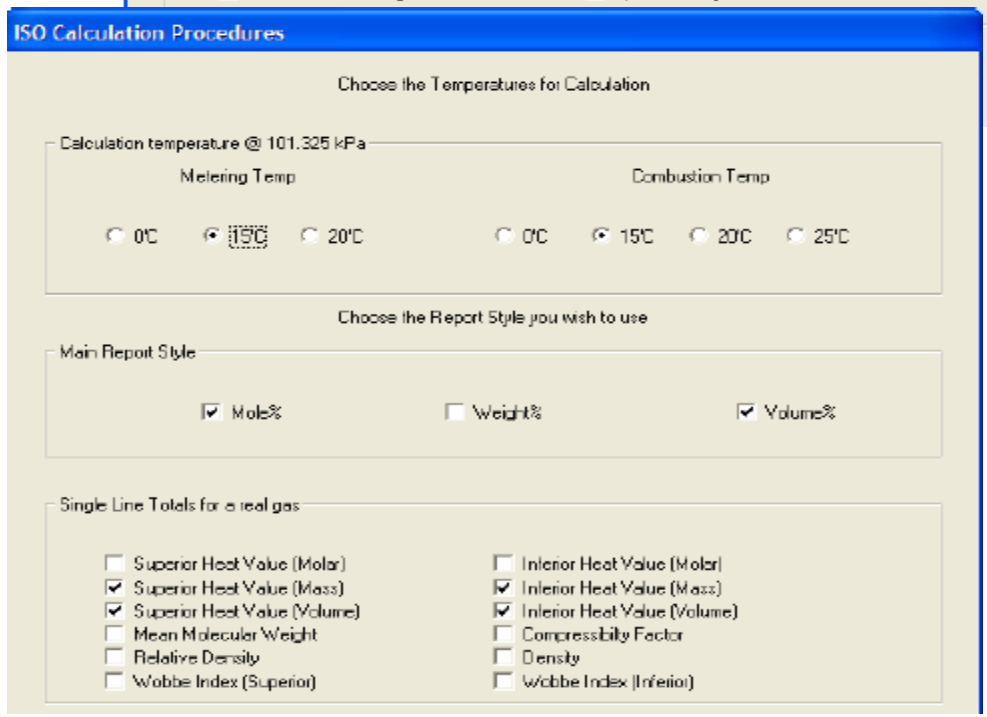
A library contains all physical constants for the most common compounds found in refinery gas

Reporting

Reports can be calculated using formulas given in the ASTM/GPA or ISO standards







Reporting

- The reports use some of the features of the ChemStation report layout screen, which allows you to customize the reports by adding or removing text
- The main body of the report where the compounds are listed will always give the compound name, RT, area, and then Mole%, Weight% and Volume%, depending on what you have chosen.

Example of an ASTM/GPA report-Main report

Compound	RT	Area	Mole%	Wt%	Vol%
C6+	0.675	224.3	0.41	1.22	0.38
Hydrogen	0.986	16189.3	15.81	1.11	15.94
Methane	1.508	493.7	6.36	3.55	6.39
Ethane	1.710	812.6	5.39	5.65	5.39
Ethylene	1.962	474.8	3.18	3.11	3.18
Carbon Dioxide	2.186	2041.2	3.16	4.85	3.17
propane	2.422	1960.2	8.54	13.11	8.45
Oxygen	2.726	1006.5	2.30	2.56	2.31
cyclopropane	3.192	144.9	0.53	0.77	0.52
Nitrogen	3.249	22697.7	28.68	27.99	28.89
propylene	3.269	734.1	3.22	4.73	3.20
i-butane	3.655	887.1	2.87	5.82	2.81
n-butane	3.797	678.8	2.23	4.51	2.17
propadiene	3.868	111.1	0.97	1.35	0.96
methane	3.948	2811.5	6.35	3.55	6.39
acetylene	3.978	343.6	1.82	1.65	1.82
trans-2-butene	4.480	501.1	1.63	3.18	1.58
1-butene	4.578	328.9	1.05	2.06	1.03
Carbon Monoxide	4.616	911.8	1.59	1.56	1.61
2-methylpropene	4.683	258.0	0.85	1.67	0.83
cis-2-butene	4.771	395.3	1.29	2.52	1.26
i-pentane	5.045	44.5	0.10	0.26	0.10
n-pentane	5.151	57.6	0.13	0.32	0.12
1,3-butadiene	5.266	476.0	1.54	2.90	1.51

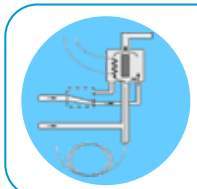
Real Gas Values Dry

Gross Heat Value per CF 1073.97 BTU
Net Heat Value per CF 989.17 BTU
Mean Molecular Weight 28.70
Specific Gravity 0.9949

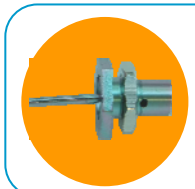
Agilent New fast RGA Highlights

One 7890A GC configured with three parallel channels with simultaneous detection provides a comprehensive, fast, and high-resolution analysis of refinery gas with one injection in six minutes

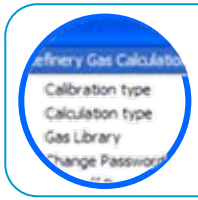
Use of optimized columns allows faster hydrocarbon and permanent gas analysis with the same oven temperature program



A third TCD can be used for improving hydrogen detection and linearity by using nitrogen as a carrier



New, easy-to-use tubing connectors based on Capillary Flow Technology are used to connect valves and capillary columns to improve chromatographic performance including peak shape



Macro program provides automated gas properties calculation, extensive reporting options

Advantages of the Agilent RGA solution

- **Consistent results / highest precision / highest efficiency**

− The FID's wide dynamic response range improves the analysis of samples containing high- and low-concentration components

− The Agilent TCD uses a single filament flow switching design that eliminates the need for a reference column, improving stability, and the small dead volume improves sensitivity

− 0.001 psi EPC GC for consistent valve switch timing setup

− New union connecter based on Capillary Flow Technology is used for the connection of capillary columns to valves, enhancing the peak shape

− Valve in separate heated zone to ensure no compromising or cold spots

− 3rd TCD can be operated simultaneously with the other two detectors, giving three parallel channels for gas analysis

- **Proven solutions backed by world-class experts**

– Our experts have invested a combined total of over 200 membership years in ASTM- the world's most trusted source for standards development

– Our 40 years of trusted industry partnership experience helping make labs around the world more productive