Analysis of Gas Liquids by GPA 2186

Application Note

Energy & Chemical

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Abstract

This application note discusses the analysis of heavier hydrocarbons that are removed from natural gas and are known as natural gas liquids (NGLs).

Introduction

Natural gas is a naturally occurring hydrocarbon gas mixture consisting primarily of methane, but can include varying amounts of other higher alkanes and even a lesser percentage of carbon dioxide, nitrogen, and hydrogen sulfide. In addition, the natural gas may contain a significant amount of ethane, propane, butane, pentane, and other heavier hydrocarbons that must be removed prior to the methane being sold for commercial use.

Shale gas is natural gas that is trapped within shale formations, which are fine-grained sedimentary rocks that can be rich sources of petroleum and natural gas. Over the past decade, the combination of horizontal drilling and hydraulic fracturing has allowed access to large volumes of shale gas that were previously uneconomical to produce. One of the fractions that is separated is natural gas liquids known as y-grade, which is typically transferred by pipeline to a centralized storage facility to await fractionation at a later time. The Mid-America lab analyzes these natural gas liquids from the pipeline and issues the certificates of analysis that are used to determine the market value of the product.

Agilent Technologies

Table 1 lists the compounds that are found in y-grade. The heavier fraction typically extends to about C14 although the quantities tail off significantly for the higher molecular weights and may not be detected in the analysis.

Table 1. Composition of Demethanized Natural Gas Liquids Y-Grade

Hydrocarbon	Boiling point	Formula
Ethane	–89°C, –128.2°F	C_2H_6
Propane	–42 °C, –43 °F	C_3H_8
Isobutane	–9 °C, 8–16 °F	C_4H_{10}
Butane	–1 °C, 30–34 °F	C_4H_{10}
Pentane	36 °C, 97 °F	C_5H_{12}
Hexane	68–69 °C, 155–156 °F	C_6H_{14}
Other heavier	> 70 °C, > 157 °F	

These natural gas liquids are the fraction that are analyzed using GPA 2186. The point of the extended analysis is to better characterize the y-grade fraction to determine the maximum market value that can be derived from the particular mixture. Y-grade is not traded as a product but is fractionated into five pure products that are widely traded each day. The products are ethane, propane, *n*-butane, isobutane, and the heavier fraction known as natural gasoline. Each of the component fractions has different physical characteristics, different end-use markets, and most importantly, different factors that make prices rise and fall. Thus, the value of the y-grade is determined by the quantities and characteristics of these five products that can be produced from the particular batch. The more thorough characterization provided by the GPA 2186 extended analysis resolves problems due to shrinkage when NGLs are comingled by basing the analysis on mass rather than volume, which eliminates the need for batching products down the pipeline.

Method

The Gas Processors Association (GPA) publishes several standard methods for the analysis of natural gas and natural gas liquids, as shown in Table 2. In addition, it publishes GPA 2145, which is a table of physical constants for hydrocarbons and other compounds of interest to the natural gas industry. These constants are used in the calculations for the various analytical methods to convert the chromatographic results to the units required by the customer. The separation processes are similar for the methods but vary in the range of compounds measured; the choice of method often depends on the method specified in contracts.

The GPA 2186-02 method used by this application can be performed on two separate gas chromatographs but is more typically done on a single chromatograph with two channels. The method uses both a packed column and a capillary column for the separations and then combines the two analyses into a single report by using the pentane peaks to calculate a bridge factor between the two chromatograms.

Table 2. GPA Standards for the Analysis of Natural Gas or Natural Gas Liquids

GPA standard	Application
2165-95	Analysis of Natural Gas Liquid Mixtures by Gas Chromatography
2177-03	Analysis of Natural Gas Mixtures Containing Nitrogen and Carbon Dioxide by Gas Chromatography
2186-02	Method for the Extended Analysis of Hydrocarbon Liquid Mixtures Containing Nitrogen and Carbon Dioxide by Temperature Programmed Gas Chromatography
2261-00	Analysis for Natural Gas and Similar Gaseous Mixtures by Gas Chromatography
2286-95	Tentative Method of Extended Analysis for Natural Gas and Similar Gaseous Mixtures by Temperature Programmed Gas Chromatography

The sample is dual injected simultaneously onto both columns. Nitrogen/carbon dioxide through *n*-pentane are separated isothermally on the packed column and detected with a thermal conductivity detector (TCD), while the C6+ hydrocarbons are separated on the capillary column and detected with a flame ionization detector (FID). The chromatograms are used to calculate the weight percent, mole percent, and liquid volume percent of each component. The *n*-pentane and isopentane peaks from each chromatogram are used to bridge weight percentages to combine results from both chromatograms into a single report. The chromatographic results are then normalized and summed. The customer wants the total of all reported components to sum to exactly 100.00%, so any residual due to rounding in the calculations is either added to or subtracted from the largest component percentage to accomplish this.

Table 3 lists the components and compositional ranges allowed for GPA 2186-02. For the certificate of analysis, the *n*-butane and 2,2 dimethylpropane or neopentane peaks are not resolved and are reported together as *n*-butane as indicated in the table. Also, hexanes and heptanes+ are combined and reported as hexanes+. The concentration ranges in the table are wide enough to cover nearly any y-grade sample.

Table 3. Components and Compositional Ranges Allowed for GPA 2186-02

Components	Concentration range, wt.%
Nitrogen	0.005–5.000
Carbon dioxide	0.005–5.000
Methane	0.001–5.000
Ethane	0.001–95.000
Propane	0.001–100.000
Isobutane	0.001–100.000
n-Butane	0.001–100.000
2,2-Dimethylpropane	
Isopentane	0.001–50.000
n-Pentane	0.001–50.000
Hexanes	0.001–30.000
Heptanes+	0.001

Sample preparation

The method requires that the sample must be collected so that it is statistically representative of the material in the pipeline. GPA 2186 strongly recommends the use of floating piston cylinders such as those shown in Figures 1A and 1B for sampling and transfer to the gas chromatograph. After the sample is obtained at the sampling point on the pipeline, it is taken to the lab and allowed to thermally equilibrate. It is then rotated end-to-end several times to insure that it is well mixed, and connected to the inlet port of one of the injection valves. The valve on the cylinder is slowly opened to allow the sample to flow through the sample loops on both injector valves and into a waste container. After purging for 15–30 seconds, the exit valve to the waste container is closed, which traps sample in the loops on the sampling valves for injection. The analysis is initiated from the software, which actuates both injector valves simultaneously to begin the runs on both the packed and capillary columns.

Figure 1A. Recommended floating piston cylinders.

Instrumentation

This analysis was performed on a dual channel Agilent 7890A Gas Chromatograph equipped with three 4-port valves and a thermostatted auxillary oven. One channel used a TCD while the other used an FID. The chromatography data system and other associated software are critically important for this method. All chromatograms were obtained with the Agilent OpenLab Chromatography Data System with the ChemStation option. In addition, some type of automation is required to prevent errors in calculation or data entry. COREX is a program that works with the OpenLab CDS and Microsoft Excel to automatically transfer data, perform calculations, and generate reports, and was used in this analysis to perform these functions.

- Gas Chromatograph – Agilent 7890A
- Dual Channel: TDC, FID
- Valves:
  - 2 Injection
  - 1 Backflush
- OpenLab Chromatography Data System
  - COREX Macro Calculator and Report Generator
  - Microsoft Excel

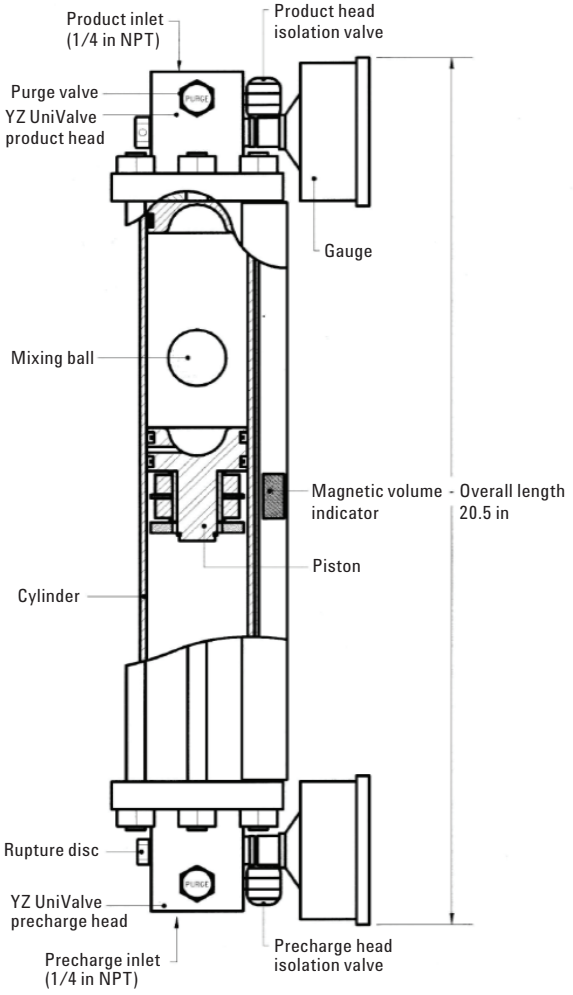


Figure 1B. Floating piston sample analysis.

Procedure

GPA 2186 requires a gas chromatograph equipped with three valves – two for injection and one for backflush. As illustrated in Figure 2, the two valves to the left are purged and filled with sample for injection. The valves are rotated to simultaneously inject sample onto both the packed and capillary columns to start the analysis. After the pentanes elute from the packed columns at about 14 minutes, the third valve on the top right is rotated to reverse flow to flush the heavy C6+ fraction back through the column to the detector where it appears as a broad unresolved peak between about 16 to 27 minutes.

The method uses a packed column with TCD to quantitate ethane through pentane and a capillary column to separate the components and quantitate the C6+ fraction. The method does not specify the type of column but allows the analyst to select any that satisfactorily accomplishes the separations. A dimethylpolysiloxane liquid phase is suggested for the capillary column and silicon DC 200/500 for the packed column. These columns are general purpose nonpolar columns widely used for hydrocarbons, so it is expected that a number of other nonpolar columns will work equally well.

The packed column is held isothermally at 120 °C during the entire run while the oven for the capillary column separation is programmed as indicated in Table 4. The temperature profile can be adjusted as needed to obtain good separation but this has proved satisfactory for our lab. Most of the analysis parameters for GPA 2186 are suggested rather than mandated so that the analyst has the discretion to select values to optimize the chromatography.

Table 4. Experimental Conditions for GPA 2186-02

Oven program		
35 °C for 12 minutes Ramp at 2 °C/min to 70 °C for 0.1 minutes Ramp at 15 °C/min to 200 °C for 6.733 minutes		
Inlets		
Front (Purged Packed)	Back (Split/Splitless)	
	Mode	Split
	Temperature	250 °C
	Split ratio	25:1
Columns		
Packed	Silicone DC 200/500	
Capillary	Agilent CP-Sil 5CB 60 m × 250 µm, 1 µm	
Detectors		
TCD		
Temperature	150 °C	
Reference flow	45.0 mL/min	
Mode	Constant makeup flow	
FID		
Temperature	250 °C	
Hydrogen flow	35.0 mL/min	
Air flow	350.0 mL/min	
Mode	Constant Column Makeup Flow	
Aux oven temperature	120 °C	

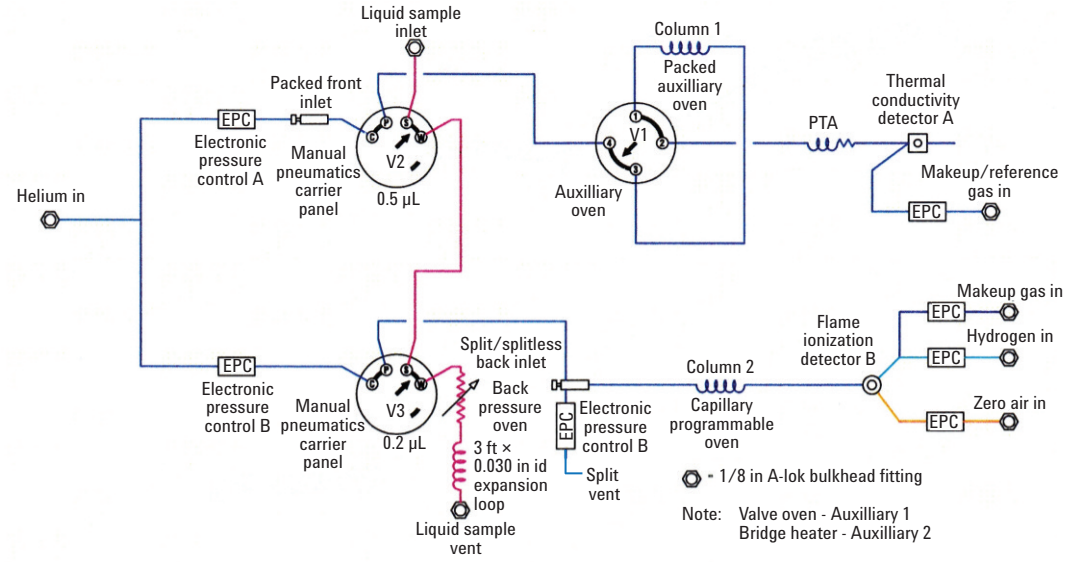


Figure 2. Valve diagram.

Calibration standards are made gravimetrically by a commercial provider. The certificate of analysis shown in Figure 3 is used to calibrate the components that are reported to customers on the standard report, and the certificate shown in Figure 4 is used in calibration of the components in the C6+ fraction. The current standard mixture contains only 62 compounds rather than all 157 that could be detected by the method. This means that some response factors have to be estimated based upon similarities with one of the compounds in the calibration mixture. Calibration could be done based upon the standard mole %, weight %, or LV %. We have found that the wt % works best, and is used routinely for the calibration. Also, the iso- and *n*-pentane are added since the combined quantities are later used to bridge between the two chromatograms obtained by the method.

ACCURATE GAS PRODUCTS, L.L.C.

OFFICE (337) 269-1217
FAX (337) 269-1978

CERTIFICATE OF ANALYSIS

ENTERPRISE / MID AMERICA PIPELINE
P.O. BOX 309
ATTN: GARY WOOD
SKELLYTOWN, TX 79080

DATE: 7/23/13
INVOICE NO: 4715
PO NUMBER: CREDIT CARD
QC NUMBER: 072313-1
SHIP VIA: FED EX

CYL. NO	COMPONENT	ACTUAL MOLE %	ACTUAL WEIGHT %	ACTUAL LV %
17348	NITROGEN	0.055%	0.037%	0.021%
	METHANE	0.800%	0.306%	0.477%
	CARBON DIOXIDE	0.252%	0.264%	0.151%
	ETHANE	45.828%	32.819%	43.112%
	PROPANE	30.981%	32.537%	30.024%
	ISOBUTANE	4.039%	5.591%	4.649%
	N-BUTANE	10.999%	15.226%	12.198%
	NEOPENTANE	0.050%	0.086%	0.067%
	ISOPENTANE	1.999%	3.435%	2.572%
	N-PENTANE	2.498%	4.293%	3.185%
	HEXANES+AGPSIII	2.499%	5.406%	3.544%

1100 HELIUM BACK PRESSURE
2-YEAR SHELF LIFE

ERICH HOFMEISTER-ANALYST

CHRIS SHADLE-QC MANAGER

THE ABOVE CERTIFIED STANDARD WAS MANUFACTURED USING BALANCES TESTED AND ADJUSTED FOR ACCURACY, PRECISION AND SENSITIVITY WITH WEIGHTS TRACEABLE TO THE NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY. THE CALIBRATION PROCEDURE FOLLOWED IS OUTLINED IN PRS REVISION 1 ACCORDING TO MLD STD 5-662A, NIST TEST NUMBER 822/278785-10. TESTED 5/13. THIS STANDARD IS CERTIFIED IN MOLE% TO BE WITHIN +/-2% OF THE NUMBER REPORTED RELATIVE TO THE COMPONENT.

P.O. BOX 65 BROUSSARD LA 70518-0065
116 BOARD ROAD LAFAYETTE, LA 70508

Figure 3. Certificate of analysis for the standard report.

AGPSIII Hexanes Plus Analysis

components in order

QC#012913-3				Mole % of Total Blend	WT% of Total Blend	LV % of Total Blend
				2.499	5.406	3.544

COMPONENTS	MOLE %	WT%	LV%			
Methane	0	0	0			
Ethane	0	0	0			
Propane	0	0	0			
Isobutane	0	0	0			
N-Butane	0	0	0			
2-2-Dimethylpropane (Neopentane)	0	0	0			
Isopentane	0	0	0			
N-Pentane	0	0	0			
2-2-Dimethylbutane (Neohexane)	0.530	0.503	0.549	0.013	**0.0272**	0.019
Cyclopentane	1.800	1.390	1.322	0.045	**0.0751**	0.047
2-3-Dimethylbutane	2.163	2.052	2.197	0.054	**0.1109**	0.078
2-Methylpentane	14.311	13.578	14.719	0.358	**0.7340**	0.522
3-Methylpentane	9.116	8.649	9.221	0.228	**0.4676**	0.327
N-Hexane	19.153	18.169	19.529	0.479	**0.9822**	0.692
2-2-Dimethylpentane	0.102	0.113	0.119	0.003	**0.0061**	0.004
Methylcyclopentane	9.064	8.399	7.950	0.227	**0.4540**	0.282
2-4-Dimethylpentane	0.146	0.161	0.170	0.004	**0.0087**	0.006
2-2-3-Trimethylbutane	0.018	0.020	0.021	0.000	**0.0011**	0.001
Benzene	4.015	3.453	2.784	0.100	**0.1867**	0.099
3-3-Dimethylpentane	0.050	0.055	0.056	0.001	**0.0030**	0.002
Cyclohexane	8.030	7.440	6.773	0.201	**0.4022**	0.240
2-Methylhexane	0.360	0.397	0.414	0.009	**0.0215**	0.015
2-3-Dimethylpentane	0.155	0.171	0.174	0.004	**0.0092**	0.006
3-Methylhexane	0.249	0.275	0.284	0.006	**0.0149**	0.010
1-cis-3-Dimethylcyclopentane	0.009	0.010	0.010	0.000	**0.0005**	0.000
3-Ethylpentane	0.082	0.090	0.091	0.002	**0.0049**	0.003
1-trans-2-Dimethylcyclopentane	0.009	0.010	0.009	0.000	**0.0005**	0.000
2-2-4-Trimethylpentane	0.480	0.604	0.619	0.012	**0.0327**	0.022
N-Heptane	12.442	13.726	14.235	0.311	**0.7420**	0.504
Methylcyclohexane	6.047	6.537	6.025	0.151	**0.3534**	0.214
Ethylcyclopentane	0.013	0.014	0.013	0.000	**0.0008**	0.000
2-5-Dimethylhexane	0.086	0.108	0.110	0.002	**0.0058**	0.004
2-4-Dimethylhexane	0.085	0.107	0.108	0.002	**0.0058**	0.004
Toluene	3.317	3.365	2.753	0.083	**0.1819**	0.098
2-Methylheptane	0.160	0.201	0.204	0.004	**0.0109**	0.007
4-Methylheptane	0.119	0.150	0.151	0.003	**0.0081**	0.005
3-Methylheptane	0.158	0.199	0.200	0.004	**0.0108**	0.007
Cis-1-3-Dimethylcyclohexane	0.203	0.251	0.224	0.005	**0.0136**	0.008
trans-1-2-Dimethylcyclohexane	0.040	0.049	0.045	0.001	**0.0026**	0.002
N-Octane	2.405	3.025	3.056	0.060	**0.1635**	0.108
Trans-1-3-Dimethylcyclohexane	0.202	0.250	0.226	0.005	**0.0135**	0.008
cis-1-2-Dimethylcyclohexane	0.203	0.251	0.232	0.005	**0.0136**	0.008
Ethylcyclohexane	0.325	0.402	0.362	0.008	**0.0217**	0.013
Ethylbenzene	0.258	0.302	0.247	0.006	**0.0163**	0.009

Figure 4. Certificate of analysis for calibration of the C6+ fraction.

Results and Discussion

Figure 5 shows examples of the chromatograms obtained for the calibration mixtures. The major components are baseline resolved on the packed column/TDC chromatogram and are easily quantitated. When sections of the capillary column/FID chromatogram are expanded, the components from the calibration mixture are also baseline resolved. When an actual sample is run, some of the compounds missing from the calibration mixture appear as shoulder peaks with other compounds and may be quantitated together. This is not a serious problem since the properties of the two compounds are typically very similar and the quantities are very low. Overall, the chromatographic separation for this method is very good.

As mentioned previously, the calibration mixture has only 62 compounds while the method measures 157 compounds. This means that over half of the compounds will have to be assigned a response factor based upon a different compound that is present in the calibration mixture. The ability to select multiple response factors is important for use within the chromatogram to appropriately match the grouped compounds that are not in the calibration mixture. In addition, it is necessary to be able to correctly identify retention times of compounds that are not in the calibration mix. This is accomplished by placing the 157 compounds in the correct elution order in the calibration table and guessing the retention times of compounds eluting between the known compounds from the calibration mixture.

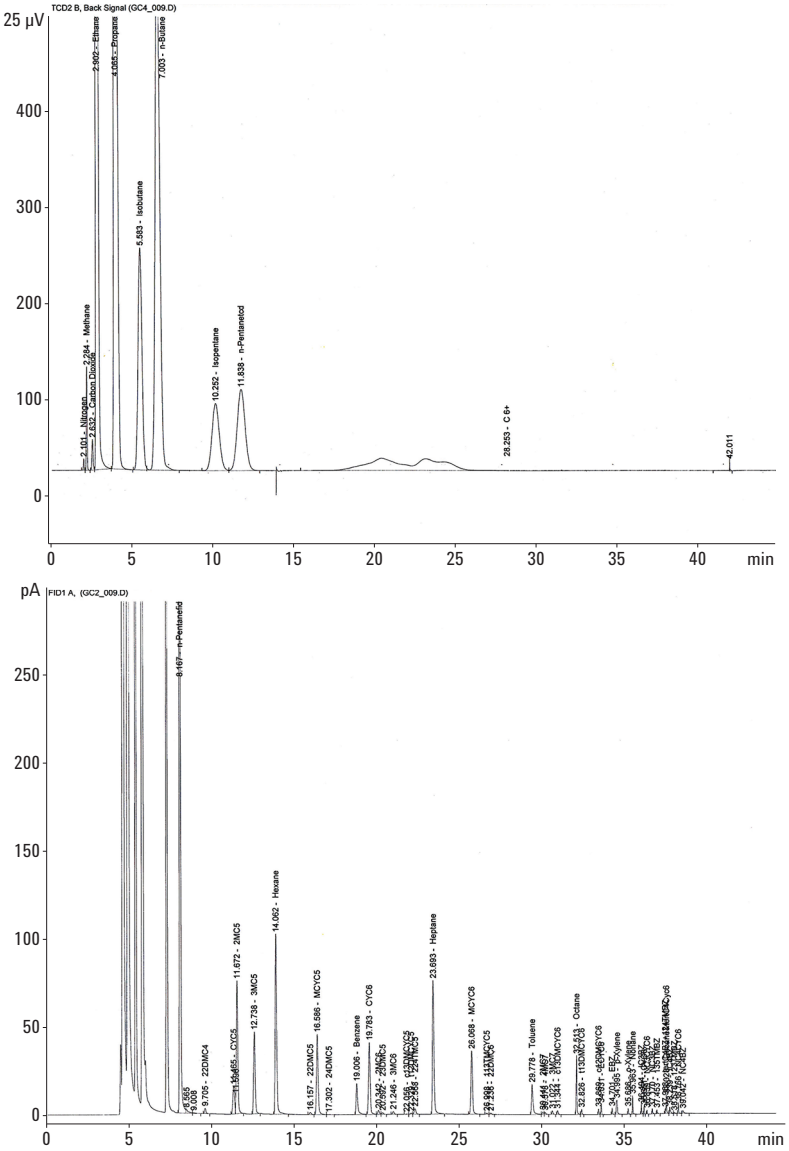


Figure 5. Calibration chromatograms.

High y-grade is a wet gas containing increased amounts of the C6+ fraction. It usually contains most of the 157 compounds that are measured by GPA 2186 so it can be used to correct retention times for compounds that were not in the calibration mixture. Figure 6 shows numerous compounds in the region beyond 25 minutes. This region can be expanded so that most of the compounds can be detected. Since the elution order of the compounds is known from the method, peaks falling between the known calibration mixture peaks can usually be identified as a particular compound and the retention time for that compound can be corrected in the calibration table. Occasionally, a compound may be present in quantities too low for detection so that one has to guess at the identity of one or two peaks. This is not a serious problem since these compounds will always be very minor constituents of the product and any minor error resulting from an incorrect guess will not be significant in the final calculations.

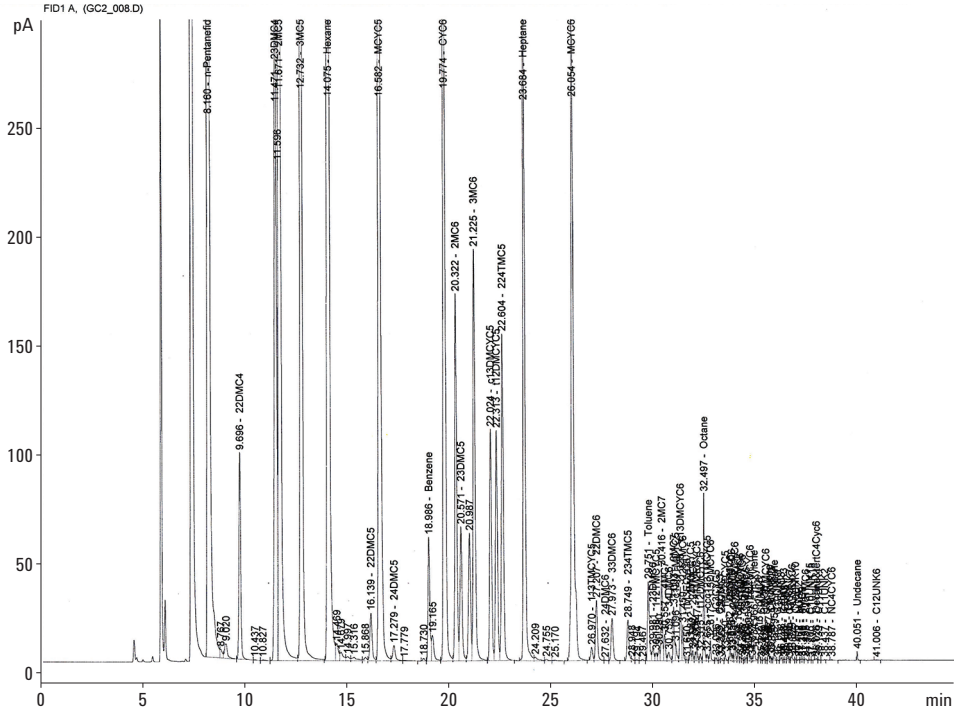


Figure 6. Chromatogram of high y-grade.

Data analysis for GPA2186 is very intensive and relatively complex. First, the data from the two chromatograms obtained for each sample must be combined into a single report and normalized so that the assay sums to 100%. This is done by using the pentane peaks in each chromatograph to bridge the data between the two. At the Mid-America Labs, the bridge factor is calculated by dividing the pentane areas from the packed column by the pentane areas from the capillary column and applying this factor to all peak areas for compounds measured in the C6+ fraction. Some labs may do the inverse by dividing the pentane capillary area by the pentane packed column area to calculate the bridge factor, since it would then have to be applied only to the smaller number of peaks in the packed column chromatogram. Both calculations are equivalent and are allowed by the method and should give the same result. These calculations can be summarized as follows:

- The two analyses are mathematically combined into a single report by the common bridge weight percents of iso- and *n*-pentane
    - Determine area counts for each compound in the calibration standard on both the packed and capillary columns.
    - Divide component area counts by pentane area counts for each of the respective columns (similar to using pentanes as internal standard)

      RF_n = (wt % C_{nstd}/area count C_{nstd}) × (area count C_{5std}/wt. % C_{5std})
- Determine:

  Bridge factor = (Area counts C_5 packed)/(Area counts C_5 capillary)
- Packed column area counts for samples remain unchanged
- Capillary column area counts adjustment for samples:

  Area count for all C_{6+} fraction compounds = Area count × Bridge factor
- Calculate:

  Wt. % C_n = RF_n (Adjusted area count C_n)/Σ(Adjusted area counts for all C_n)

In addition to the weight % calculation, the method requires reporting in units of mole % and liquid volume %.

The method also allows calculation of several other physical properties from the chromatograms such as:

- Weight fraction, liquid volume fraction, molecular weight, and relative density from mol fraction analysis
- Liquid density (lb/gal)
- API gravity
- Cu. ft. vapor/gallon
- Relative density of vapor
- Vapor pressure, BTU/cu. ft., BTU/gal
- BTU/lb
- 26–70 Gasoline content

These calculations are performed using the chromatography data in conjunction with known physical constants. So each sample analysis could generate hundreds of complex calculations requiring hundreds of physical constants. The time required and risk of error make manual calculation impractical, so all calculations are typically done by an automated procedure. The software used in this analysis is COREX, which is a Chemstation extension software developed by Agilent. It provides a convenient graphical user interface that allows the analysis to be performed with just a few mouse clicks. Data from the two sample chromatographs are automatically merged and transferred to Microsoft Excel where calculations are performed and reports are generated. Custom reports are automatically generated without the analyst being involved in the intensive calculations required to obtain the desired output. This complexity is also hidden from the customer since it does not appear in the printed certificates of analysis.

Figure 7 shows an example of how COREX appears on the data station. The calibration chromatograms are displayed on the top and the calibration table on the bottom. This makes it easy to enter retention times, standard mix concentrations, and other data directly into the table. The table is prepopulated with all of the compounds for the method in the correct elution order. Associated response factors can also be assigned in the table by pairing each compound that was not present in the calibration mixture with a similar compound that was present in the mixture and giving both the same response factor.

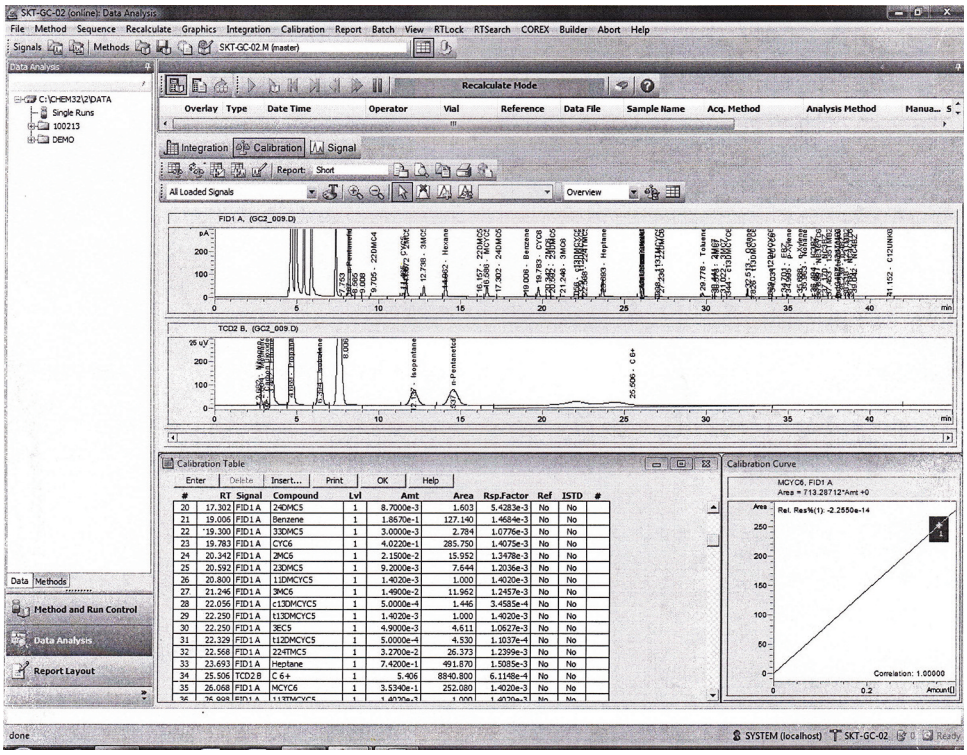


Figure 7. COREX calibration screen.

The calculations for GPA 2186 rely on a number of physical constants for each compound to generate a report. All of these constants are built into the COREX program and are automatically transferred into the Excel spreadsheet to automate the calculations. Table 5 provides a list of some of the physical constants used by the program.

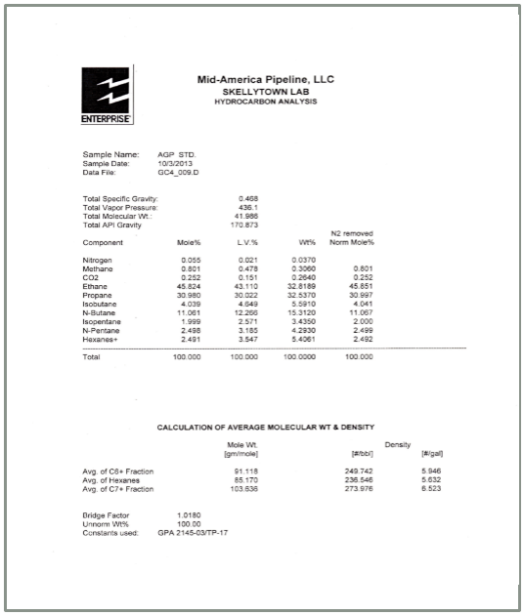
Calculations are done behind the scenes, invisible to the analyst, and do not appear on customer reports.

Table 5. Physical Constants Applied in COREX Spreadsheet

Components	MW	SG liq	RVP	lb/gal	lb/bbl
O_2	31.9988	1.14118		9.5236	399.991
N_2	28.0134	0.80687	–346	6.7271	282.538
C1	16.043	0.30000	5000.000	2.5000	105.000
CO_2	44.010	0.81716		6.8129	286.142
NC2	30.070	0.35628	800.000	2.9704	124.757
NC3	44.096	0.50719	188.620	4.2285	177.597
IC4	58.122	0.56283	72.644	4.6925	197.085
NC4	58.122	0.58420	51.567	4.8706	204.565
IC5	72.149	0.62514	20.474	5.2120	218.904
NC5 (TCD)	72.149	0.63071	15.576	5.2584	220.853
22DMC3	72.149	0.59606	36.720	4.9744	208.925
22DMC4	86.177	0.65421	9.728	5.4543	229.081
CYC5	70.134	0.75040	9.781	6.2562	262.760
23DMC4	86.177	0.66652	7.2980	5.5569	233.390
2MC5	86.177	0.65845	6.665	5.4896	230.563
3MC5	86.177	0.66952	5.963	5.5819	234.440
NC6	86.175	0.66406	4.9610	5.5364	232.529
22DMC5	100.204	0.67876	3.431	5.6590	237.678
MCYC5	84.161	0.75405	4.414	6.2867	264.041
24DMC5	100.204	0.67781	3.234	5.6510	237.342
223TMC4	100.204	0.69480	3.317	5.7927	243.293
BENZENE	78.114	0.88517	3.160	7.3799	309.956
33DMC5	100.204	0.69761	2.724	5.8161	244.276
CYC6	84.161	0.78401	3.207	6.5365	274.533
2MC6	100.204	0.68375	2.227	5.7006	239.425
23DMC5	100.204	0.69993	2.307	5.8354	245.087
11DMCYC5	98.188	0.75923	2.514	6.3298	265.852
3MC6	100.204	0.69217	2.089	5.7708	242.374
T13DMCYC5	98.188	0.75355	2.249	6.2825	263.865
C13DMCYC5	98.188	0.75064	2.167	6.2582	262.844
3EC5	100.204	0.70339	1.9660	5.8643	246.301
T12DMCYC5	98.188	0.75648	2.150	6.3069	264.890
224TMC5	114.231	0.69740	1.6740	5.8088	243.970
Heptane	100.202	0.68823	1.6190	5.7379	240.992
MCYC6	98.188	0.77442	1.576	6.4565	271.173
113TMCYC5	112.215	0.75334	1.364	6.2807	263.789
22DMC6	114.231	0.70019	1.1940	5.8376	245.179

Figure 8 is an example of a typical y-grade sample chromatogram with all of the peaks properly identified.

Figure 9 shows a standard report that lists the products and quantities that can be fractionated from the y-grade. It was generated automatically by the COREX macro in combination with Microsoft Excel. This is the preferred format, but it can easily be changed in Excel or by selecting a different report template. Some customers want a more complete listing of all compounds present in the y-grade, so we are able to select the report on the analysis of the hexanes+ fraction. COREX combines data from the CDS with known physical constants for each compound to generate reports such as this. Other information could be added if desired by constructing a different report template.



Mid-America Pipeline, LLC
SKELLYTOWN LAB
HYDROCARBON ANALYSIS

Sample Name: AGP STD
Sample Date: 10/3/2013
Data File: GC4_009.D

Total Specific Gravity:	0.468
Total Vapor Pressure:	436.1
Total Molecular Wt.:	41.986
Total API Gravity	170.873

Component	Mole%	L.V.%	Wt%	N2 removed Norm Mole%
Nitrogen	0.055	0.021	0.0370	
Methane	0.801	0.478	0.3060	0.801
CO2	0.252	0.151	0.2640	0.252
Ethane	45.824	43.110	32.8189	45.851
Propane	30.980	30.022	32.5370	30.997
Isobutane	4.039	4.649	5.5910	4.041
N-Butane	11.061	12.266	15.3120	11.067
Isopentane	1.999	2.571	3.4350	2.000
N-Pentane	2.498	3.185	4.2930	2.499
Hexanes+	2.491	3.547	5.4061	2.492
Total	100.000	100.000	100.0000	100.000

CALCULATION OF AVERAGE MOLECULAR WT & DENSITY

	Mole Wt. [gm/mole]	Density [lb/bbl]	[lb/gal]
Avg. of C6+ Fraction	91.118	249.742	5.946
Avg. of Hexanes	85.170	236.546	5.632
Avg. of C7+ Fraction	103.636	273.976	6.523

Bridge Factor	1.0180
Unnorm Wt%	100.00
Constants used:	GPA 2145-03/TP-17

Figure 9. Standard COREX report.

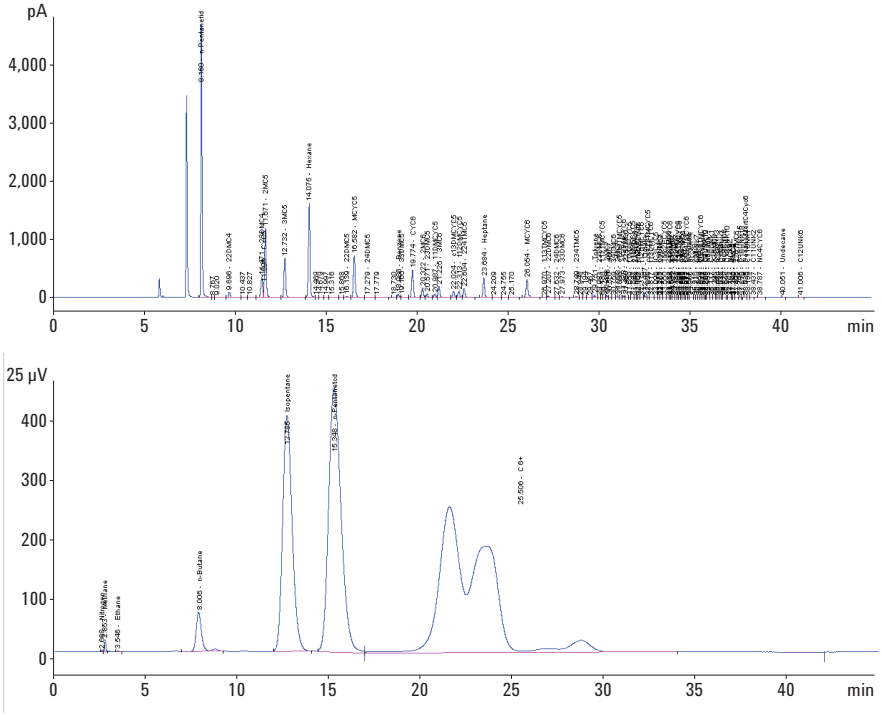


Figure 8. Example of a typical y-grade sample chromatogram.

Conclusion

Although GPA 2186 is a relatively complex method, it provides a detailed characterization of NGLs to insure that natural gas companies obtain fair value for their products. However, the improved characterization of the mixture comes at a price. The calibration procedure is very complicated and sometimes requires a day or more to complete. Part of the problem is that the calibration mixture contains only 62 compounds while the method analyzes for 157. A more complete calibration mixture would help in removing the uncertainty, especially in identification of compounds and setting retention times. High y-grade samples used to fill in retention times for compounds missing from the calibration mixture may not have all of the compounds present in sufficient quantity to accurately identify. Luckily, these compounds are always very minor constituents so small errors in identification and quantitation do not significantly affect the result or value of the product.

Once the initial calibration is completed, it is stable over a long period of time. Therefore, it does not have to be repeated too often. Periodic checks are used to confirm that the calibration remains valid. Automation provided by the COREX Chemstation extension program is essential for running this method in a production environment. By automatically performing all calculations and generating finished reports, the complexity of the method is removed so that the analyst simply loads the sample and starts the run. This allows fast turnaround of samples, eliminates calculation errors, and simplifies training requirements.

For More Information

These data represent typical results. For more information on our products and services, visit our Web site at www.agilent.com/chem.

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