**Documentation on the SPECIATE5.0 Wyoming county-specific oil & gas related Speciation Profiles.**

**INTRODUCTION**

At the 7/14/2016 call of the National Oil and Gas Committee (collaboration with EPA, States, Regional organizations) Madeleine Strum of EPA’s Emissions Inventory and Analysis Group presented the SPECIATE Work group’s efforts to add Region-specific oil and gas speciation profiles to the SPECIATE database. Organizers noted that if states had data that could be used for speciation they should send it to EPA (Madeleine Strum).

In an effort to improve the calculation of emissions from oil and gas production sites in Wyoming, the Wyoming Department of Environmental Quality – Air Quality Division (WDEQ-AQD) has collected numerous extended hydrocarbon analyses from around the state.  Per the National Oil and Gas Committee’s call, these data were made available to EPA to help inform VOC speciation.  On 7/15/ 2016, Brett Davis, WYDEQ, emailed Madeleine Strum EPA/Emissions Inventory and Analysis Group a Microsoft Access databases containing nearly 2,000 gas, condensate, oil, produced water, and tank vapor extended hydrocarbon analyses for the purpose of adding speciation profiles to SPECIATE.

The WDEQ database and additional information provided by Brett Davis on grouping of the samples resulted in the development of 25 county-composite speciation profiles for total organic gas emissions. Profile types included: 1) raw gas at gas wells, 2) raw gas at oil wells, 3) condensate tanks and 4) oil tanks. Not all profile types were available for each county. Each profile and the number of analyses composited are shown in the below table.

| **Profile** | **PROFILE NAME** | **NOTES** |
| --- | --- | --- |
| 95476 | Oil and Gas Production - Composite Profile – Raw Gas, Gas Well, Campbell County, Wyoming | Median of 18 gas analysis samples from gas wells in Campbell County. |
| 95477 | Oil and Gas Production - Composite Profile – Raw Gas, Oil Well, Campbell County, Wyoming | Median of 78 gas analysis samples from oil wells in Campbell County. |
| 95478 | Oil and Gas Production - Composite Profile – Condensate Tank, Campbell County, Wyoming | One tank vapor gas analysis sample from condensate tank in Campbell County. |
| 95479 | Oil and Gas Production - Composite Profile – Oil Tank, Campbell County, Wyoming | Median of two tank vapor gas analysis samples from oil wells in Campbell County. |
| 95480 | Oil and Gas Production - Composite Profile – Raw Gas, Gas Well, Carbon County, Wyoming | Median of 16 gas analysis samples from gas wells in Carbon County. |
| 95481 | Oil and Gas Production - Composite Profile – Raw Gas, Gas Well, Converse County, Wyoming | Median of 5 gas analysis samples from gas wells in Converse County. |
| 95482 | Oil and Gas Production - Composite Profile – Raw Gas, Oil Well, Converse County, Wyoming | Median of 51 gas analysis samples from oil wells in Converse County. |
| 95483 | Oil and Gas Production - Composite Profile – Condensate Tank, Converse County, Wyoming | Median of 2 tank vapor gas analysis samples from condensate tanks in Converse County. |
| 95484 | Oil and Gas Production - Composite Profile – Raw Gas, Oil Well, Crook County, Wyoming | Median of 7 gas analysis samples from oil wells in Crook County. |
| 95485 | Oil and Gas Production - Composite Profile – Raw Gas, Gas Well, Fremont County, Wyoming | Median of 34 gas analysis samples from gas wells in Fremont County. |
| 95486 | Oil and Gas Production - Composite Profile – Raw Gas, Oil Well, Fremont County, Wyoming | One gas analysis sample from oil wells in Fremont County. Sample ID: 1425 |
| 95487 | Oil and Gas Production - Composite Profile – Raw Gas, Gas Well, Hot Springs County, Wyoming | One gas analysis sample from gas wells in Hot Springs County. |
| 95488 | Oil and Gas Production - Composite Profile – Raw Gas, Oil Well, Johnson County, Wyoming | Median of 11 gas analysis samples from oil wells in Johnson County. |
| 95489 | Oil and Gas Production - Composite Profile – Raw Gas, Oil Well, Laramie County, Wyoming | Median of 36 gas analysis samples from oil wells in Laramie County. |
| 95490 | Oil and Gas Production - Composite Profile – Raw Gas, Gas Well, Lincoln County, Wyoming | Median of 45 gas analysis samples from gas wells in Lincoln County. |
| 95491 | Oil and Gas Production - Composite Profile – Raw Gas, Oil Well, Lincoln County, Wyoming | Median of 4 gas analysis samples from oil wells in Lincoln County. |
| 95492 | Oil and Gas Production - Composite Profile – Raw Gas, Oil Well, Niobrara County, Wyoming | Median of 7 gas analysis samples from oil wells in Niobrara County. |
| 95493 | Oil and Gas Production - Composite Profile – Raw Gas, Gas Well, Sublette County, Wyoming | Median of 180 gas analysis samples from gas wells in Sublette County. |
| 95494 | Oil and Gas Production - Composite Profile – Raw Gas, Oil Well, Sublette County, Wyoming | Median of 2 gas analysis samples from oil wells in Sublette County. |
| 95495 | Oil and Gas Production - Composite Profile – Raw Gas, Gas Well, Sweetwater County, Wyoming | Median of 119 gas analysis samples from gas wells in Sweetwater County. |
| 95496 | Oil and Gas Production - Composite Profile – Condensate Tank, Sweetwater County, Wyoming | Median of 2 tank vapor gas analysis samples from condensate tanks in Sweetwater County. |
| 95497 | Oil and Gas Production - Composite Profile – Raw Gas, Oil Well, Sweetwater County, Wyoming | Median of 2 gas analysis samples from oil wells in Sweetwater County. |
| 95498 | Oil and Gas Production - Composite Profile – Raw Gas, Gas Well, Uinta County, Wyoming | Median of 7 gas analysis samples from gas wells in Uinta County |
| 95499 | Oil and Gas Production - Composite Profile – Raw Gas, Oil Well, Weston County, Wyoming | One gas analysis sample from oil well in Weston County. |
| 95500 | Oil and Gas Production - Composite Profile – Raw Gas, Oil Well, Natrona County Wyoming | One gas analysis sample from oil well in Weston County. |

**DATABASE**

On July 15, 2016, Brett Davis emailed a zip file containing the Microsoft Access database “LiquiGasAnalyses(Copy).accdb”.  This is the database that contains roughly 1,600 gas, condensate, oil, produced water, and tank vapor extended hydrocarbon analyses that have been collected from permitting efforts and from requesting data from Wyoming operators.

The main purpose of WYDEQ’s database is to store pressurized samples of gas and liquids from production site separators.  These samples are then utilized in the steady state process simulation software ProMax to simulate tank flashing, standing/breathing, working, and truck loading emissions. Additionally the gas analyses are used to calculate emissions from pneumatics, venting, and fugitives.  It is assumed that the emissions from these sources have the same composition as the production gas.

Most of the hydrocarbon analyses come from either New Source Review permitting or the Wyoming Department of Environmental Quality – Air Quality Division’s (WDEQ-AQD) effort to collect extended hydrocarbon analyses from oil and gas well site operators so that field and formation specific tank flashing emission factors could be developed.  A few analyses have been provided to the WDEQ-AQD’s Emissions Inventory Group during various oil and gas emissions inventory data collections.  A few more analyses were gathered from the Wyoming Oil and Gas Conservation Commission (WOGCC).

With regards to the database all of the properties (i.e. Temperature, Pressure, mol %, etc.) of a given extended hydrocarbon analysis are stored in the “tbl\_Property” table.  Each property is related to a sample.  Information (i.e. analysis date, sampled company, analysis company, etc.) about each sample is stored in the “tbl\_Sample” table.  Each sample is related to a source (i.e. producing well, tank battery, etc.).  “Tbl\_Source” contains information about each source.  Most sources are only described by an API number.  The “tbl\_Well” table contains information about each well (i.e. API number, producing field, producing formation, location, etc).  The three reference tables, tbl\_RefUnit, tbl\_RefSampleType, and tbl\_RefProp, contain useful descriptions of units (i.e. mol%, °F, etc.), sample types (i.e. gas analysis, tank vapor analysis, etc.), and property descriptions (i.e. API gravity, Gas Compressibility Factor, etc.).

Below are the sample analysis types contained in the database.

| **tbl\_RefSampleType** | **Source** |
| --- | --- |
| **SampleTypeName** |  |
| GasAnlys | These are pressurized samples collected from the separator at well sites, well pads, and tank batteries. |
| CondAnlys |
| OilAnlys |
| WaterAnlys |
| UnknownAnlys | This “sample type” is available in the database in the event it is needed to store some abnormal data, but it hasn’t been utilized because of its lack of usefulness. |
| TnkVapors | These are ambient samples of tank vapors. |
| H2OTnkVprs |
| FlrGs | These are pressurized samples of gas from a well site or well pad’s flare inlet.  (i.e. gas that is about to be combusted) This gas mainly includes tank emissions (flashing, standing/breathing, and working emissions) but could possibly include gas byproducts from other equipment such as dehydration units and pneumatics. |
| ProdTest | This sample type contains well production test data that is useful for gathering well head pressures and production rates. |

The database contains:

629 GasAnlys samples,

896 CondAnlys samples,

0 OilAnlys samples,

1 WaterAnlys sample,

0 UnknownAnlys samples,

7 TnkVapors samples,

0 H20TnkVprs samples,

6 FlrGas samples,

and 45 ProdTest samples.

The table below provides the properties in the database. SPECIATE Species ID and Molecular weights were assigned by EPA’s SPECIATE contractor (Abt Associates).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| RefPropID | PropName | Species ID | PropDesc |  |  |
| 1 | SmplT |  | Sample Temperature | |  |
| 2 | SmplP |  | Sample Pressure | |  |
| 3 | FlwTbP |  | Flow Tube Pressure | |  |
| 4 | CsngP |  | Casing Pressure | |  |
| 5 | AvgMW |  | Average Molecular Weight | | |
| 6 | GrossHV |  | Gross Heating Value | |  |
| 7 | SatHV |  | Saturated Heating Value | | |
| 8 | NetHV |  | Net Heating Value | |  |
| 9 | SG |  | Specific Gravity | | Molecular Wt |
| 10 | C1 | 529 | Methane |  | 16.04246 |
| 11 | C2 | 438 | Ethane |  | 30.06904 |
| 12 | C3 | 671 | Propane |  | 44.09562 |
| 13 | iC4 | 491 | IsoButane |  | 58.1222 |
| 14 | nC4 | 592 | Normal Butane |  | 58.1222 |
| 15 | iC5 | 508 | IsoPentane |  | 72.14878 |
| 16 | nC5 | 605 | Normal Pentane |  | 72.14878 |
| 17 | cyC5 | 390 | CycloPentane |  | 70.1329 |
| 18 | nC6 | 601 | Normal Hexane |  | 86.17536 |
| 19 | C6 | 2127 | Hexanes |  | 86.17536 |
| 20 | cyC6 | 385 | CycloHexane |  | 84.15948 |
| 21 | 1cyC6 | 550 | MethylCycloHexane |  | 98.18606 |
| 22 | C7 | 2126 | Heptanes |  | 100.20194 |
| 23 | C8 | 2130 | Octanes |  | 114.22852 |
| 24 | C9 | 2128 | Nonanes |  | 128.2551 |
| 25 | C10 | 500 | Decanes |  | 142.28168 |
| 26 | Bnz | 302 | Benzene |  | 78.11184 |
| 27 | Tol | 717 | Toluene |  | 92.13842 |
| 28 | EBnz | 449 | EthylBenzene |  | 106.165 |
| 29 | Xyl | 507 | Xylenes (mixture or m, o, & p) |  | 106.165 |
| 30 | 224C5 | 118 | 2,2,4-TrimethylPentane |  | 114.22852 |
| 40 | neoC5 | 127 | Neopentane |  | 72.14878 |
| 31 | N2 |  | Nitrogen |  |  |
| 32 | CO2 |  | Carbon Dioxide | |  |
| 33 | O2 |  | Oxygen |  |  |
| 34 | H2S |  | Hydrogen Sulfide | |  |
| 35 | H2O |  | Water |  |  |
| 36 | GasComp(z) | | Gas Compressibility Factor | | |
| 37 | RVP |  | Reid Vapor Pressure | |  |
| 38 | APIgrav |  | American Petroleum Institute gravity | | |
| 39 | TVP |  | True Vaport Pressure | | |
| 41 | He |  | Helium |  |  |
| 42 | H2 |  | Hydrogen |  |  |
| 43 | GasFlow |  | Gas Flow Rate | |  |
| 44 | GWR |  | Gas to Water Ratio | |  |
| 45 | OilProd |  | Oil Production Rate | |  |
| 46 | WaterProd | | Water Production Rate | | |

Test Method:  The analyses are a mixture of many data gathering efforts the test methods can vary.  Pressurized gas samples are usually obtained using GPA2166.  Pressurized liquid samples are usually obtained using GPA2174.  Gas samples are usually tested using GPA2261 and GPA2286.  Liquids are usually tested using GPA2177 and GPA2186.

**USE OF THE DATABASE FOR PROFILE DEVELOPMENT**

The sample types used for developing the speciation profiles were the GasAnlys samples and TnkVapors samples.

1. The condensate analyses are liquid samples.  They are taken from well site separators and are under pressure so that the flashing emissions from the liquid can be modeled using software like ProMax, Aspen+, or E&P Tanks.
2. The flare gas analyses are gas samples.  However, these samples are from flare inlets so it is hard to determine whether the gas is from one source (i.e. just tank emissions) or multiple sources (i.e. a combination of emissions from tanks, dehydration units, pneumatics, truck loading, etc.)
3. The tank vapor analyses are taken from hydrocarbon liquid tanks.  Whether these liquids are considered “condensate” or “oil” would depend on your definition of these terms.

The “GasAnlys” are gas analyses samples are directly related to emissions from pneumatics, venting, and fugitives.  The TnkVapors and H2OTnkVprs samples are directly related to emissions from tanks.  All other emissions are only related to these samples through calculations.

**Source Classification Codes (SCC):**

The WDEQ-AQD uses the following SCC codes to submit oil and gas emissions to EPA:

|  |  |  |
| --- | --- | --- |
| **SCCs** | | |
| **Source** | **Oil** | **Gas** |
| Engines | 2310011600 | 2310021700 |
| Heaters | 2310011100 | 2310021100 |
| Tanks | 2310011020 | 2310021010 |
| Dehydration | 2310021400 | 2310021400 |
| Pneumatic Pumps | 2310111401 | 2310021310 |
| Pneumatic Controllers | 2310010300 | 2310021300 |
| Fugitives | 2310011500 | 2310021509 |
| Venting & Blowdowns | 2310021603 | 2310021603 |
| Drill Rig Engines | 2310000220 | 2310000220 |
| Completion/Fracing Engines | 2310000660 | 2310000660 |
| Workover Engines | 2310000230 | 2310000230 |
| Well Completions | 2310111700 | 2310021500 |
| Truck Loading | 2310011201 | 2310021030 |

Emissions from pneumatic devices and blowdowns are calculated using mass balance equations and composite gas analyses (which were generated from the set of extended hydrocarbon analyses).  Thus, the gas analyses directly represent the speciation of VOCs for the 2310111401, 2310021310, 2310010300, 2310021300, 2310021603, and 2310021603 SCC codes.

Fugitives are calculated using composite gas, light oil, heavy oil, and water analyses and component leak factors.  Thus, the analyses are used in the computation of fugitives but do not directly represent the VOC speciation.

The tank vapor analyses would directly represent the speciation of VOCS from the 2310011020 and 2310021010 SCC codes.

Because it is difficult to determine which sources (i.e. tanks, dehydration units, truck loading, well blowdowns, etc.) contribute to the flare gas extended hydrocarbon analyses, the WDEQ-AQD has not been able to associate these analyses with emissions to submit to EPA or a specific set of SCC codes.

The gas analyses could possibly be used to represent the speciation of VOCs from well completion blowdowns (SCCs 2310111700 and 2310021500).  However, the WDEQ-AQD does not use these analyses to calculate emissions from well completion blowdowns but rather requests that operators provide their own well completion emissions values.  The operator submitted values are then submitted to the EPA by the WDEQ-AQD.

**DATA MANIPULATIONS**

Ying Hsu, Contractor for the SPECIATE database organized the data and computed mass fractions in terms of SPECIATE species for each of the individual samples and computed Wyoming-wide profiles.

WDEQ did not think Wyoming-wide profiles would be appropriate. This is because WDEQ-AQD has observed significant differences in the hydrocarbon speciation of gas and liquid samples from different parts of the state.  These differences are partly due to the fact that some wells produce predominately oil (i.e. oil wells) and others predominately gas (i.e. gas wells) however the WDEQ-AQD has observed that the producing field and formation of a well also has a significant effect on hydrocarbon speciation.  For example, the gas analysis of a gas well in the “Echo Springs” field may have 60 mol% methane while the gas analysis of a gas well in the “Pinedale” field may have 90 mol% methane.  This knowledge is what drove the WDEQ-AQD to group wells in the state of Wyoming into “emission factor groups” by the characteristics of their producing fields and formations.

As a result, Brett Davis provided county-specific data groupings and added the Wyoming Oil and Gas Conservation Commission’s (WOGCC) classification of the well from which each sample was taken (i.e. oil well, gas well, water injection well, etc.).  The WDEQ-AQD uses these WOGCC well classifications to determine which SCC code to use when reporting a given well’s emissions to EPA.

From these groupings, EPA re-computed the composites, resulting in the 25 profiles shown on pages 1-2 of this document.