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**MEMORANDUM**

To: Alison Eyth and Madeleine Strum, OAQPS, EPA

From: John Grant, Tejas Shah, and Greg Yarwood, Ramboll Environ, Novato, CA

Subject: Piceance Basin Dehydrator Speciation

Ramboll Environ developed a speciation profile for oil and gas dehydrators in the Piceance Basin. The methodology to estimate the Piceance Basin dehydrator speciation profile is described in this memorandum and the resulting composite SPECIATE profile provided. A SPECIATE database standard profile format spreadsheet and detailed profile compilation spreadsheet will also be provided to EPA as separate deliverables.

# Background

All raw natural gas is fully saturated with water vapor when produced from an underground reservoir. Because most of the water vapor must be removed from natural gas before it can be commercially marketed, natural gas is subject to a dehydration process. One of the most common methods for removing water vapor from produced gas is glycol dehydration. Many oil and gas well sites and midstream compression and treating facilities use glycol dehydrators to remove water vapor from the gas stream after three-phase separation to remove liquid water. In the process of removing water vapor, some hydrocarbons in the gas stream are also extracted. The glycol must be regenerated (by heating) at which stage the extracted water and hydrocarbons may be emitted directly to the atmosphere or sent to an emissions control device. Dehydrators are an important volatile organic compound (VOC) emission source in the oil and gas (O&G) sector. Dehydrator outlet gas composition is substantially different from produced gas, which is currently being used to speciate emissions in basins where a dehydrator specific SPECIATE profile is not available.

# Methodology

Dehydrator emission simulation models (e.g. GRI-GlyCalc) are used to estimate emissions from dehydrators in permitting applications. Dehydrator model input/output reports typically include an emission profile by component. The Colorado Department of Public Health (CDPHE) permits dehydrators at facilities with criteria air pollutant emissions less than two tons per year (tpy) or hazardous air pollutant emissions less than 250 pounds per year (lb/yr) in the Piceance Basin. Ramboll Environ queried CDPHE’s calendar year 2014 permit database[[1]](#footnote-1) for dehydrator source classification codes (SCCs; see Table 1) in the Piceance Basin to develop a list of potential facilities from which to gather dehydrator input/output data for developing speciation profiles. 128 facilities with emissions from dehydrator SCCs were found in the Piceance Basin in the CDPHE permit database.

Table 1. Dehydrator Point Source SCCs with descriptions.

|  |  |
| --- | --- |
| **SCC** | **SCC Description** |
| 31000304 | Industrial Processes;Oil and Gas Production;Natural Gas Processing Facilities;Glycol Dehydrators: Ethylene Glycol: General |
| 31000303 | Industrial Processes;Oil and Gas Production;Natural Gas Processing Facilities;Glycol Dehydrators: Phase Separator Vent: Triethylene Glycol |
| 31000302 | Industrial Processes;Oil and Gas Production;Natural Gas Processing Facilities;Glycol Dehydrators: Reboiler Burner Stack: Triethylene Glycol |
| 31000301 | Industrial Processes;Oil and Gas Production;Natural Gas Processing Facilities;Glycol Dehydrators: Reboiler Still Vent: Triethylene Glycol |
| 31000228 | Industrial Processes;Oil and Gas Production;Natural Gas Production;Glycol Dehydrator Reboiler Burner |
| 31000227 | Industrial Processes;Oil and Gas Production;Natural Gas Production;Glycol Dehydrator Reboiler Still Stack |

Per CDPHE staff input, we obtained permit documents with dehydrator model input/output data by searching CDPHE’s online Environmental Records Database[[2]](#footnote-2). Ramboll Environ staff searched the Environmental Records Database for all 128 facilities with dehydrator emissions and identified 37 permit documents which contained dehydrator model input/output. From each of the 37 permit documents, Ramboll Environ compiled the aggregate emissions profile summary into EXCEL spreadsheet format for further analysis; an example of the compiled data for an individual facility is shown in Table 2.

GRI-GlyCalc estimates emissions from regenerator vents and flash tanks separately. However, we only analyzed aggregated profile (i.e. combined regenerator and flash tank emissions) since dehydrator configuration determines whether flash tank emissions are included in the aggregated profile (dehydrators may be configured so as not to emit from the flash tank).

Table 2. Sample metadata and emissions data extracted from a CDPHE permit document.

|  |  |
| --- | --- |
| **Metadata** | |
| **Permit** | 103-0520 |
| **Model Run Date** | 11/23/2011 |
| **Flaring Controls** | No |
| **GRI-GlyCalc Model Component** | **Emissions Data (tons/yr)** |
| Methane | 0.5474 |
| Ethane | 0.2251 |
| Propane | 0.1420 |
| Isobutane | 0.1229 |
| n-Butane | 0.0760 |
| Isopentane | 0.0870 |
| n-Pentane | 0.0449 |
| Cyclopentane | 0.0000 |
| n-Hexane | 0.0609 |
| Cyclohexane | 0.2306 |
| Other Hexanes | 0.1274 |
| Heptanes | 0.3618 |
| Methylcyclohexane | 0.6807 |
| 2,2,4-Trimethylpentane | 0.0123 |
| Benzene | 2.2007 |
| Toluene | 3.6179 |
| Ethylbenzene | 0.0379 |
| Xylenes | 0.6682 |
| C8+ Heavies | 1.5157 |
| **Total Emissions** | **10.7593** |
| **Total Hydrocarbon Emissions** | **10.7593** |
| **Total VOC Emissions** | **9.9868** |
| **Total HAP Emissions** | **6.5979** |
| **Total BTEX Emissions** | **6.5247** |

We compiled all of the aggregate emission profiles from the 37 permit documents into a single data table. In cases where model output for an individual model component indicated emissions less than 0.0001 tpy, emissions were set to 0.00005 tpy. For each emissions profile, each model component’s emissions were divided by the total dehydrator emissions to arrive at a speciation profile by model component. We compiled statistics for all samples and developed a composite profile for samples (1) without flaring control (uncontrolled) and (2) with flaring control (controlled). As shown in Figure 1, there are only marginal, insignificant differences between the flared and unflared profiles. To avoid mixing controlled and uncontrolled profiles, we used only uncontrolled profiles for developing the final composite dehydrator profile. We note that since the two average profiles (controlled and uncontrolled) are so similar, the uncontrolled composite profile can essentially represent both controlled and uncontrolled emissions.

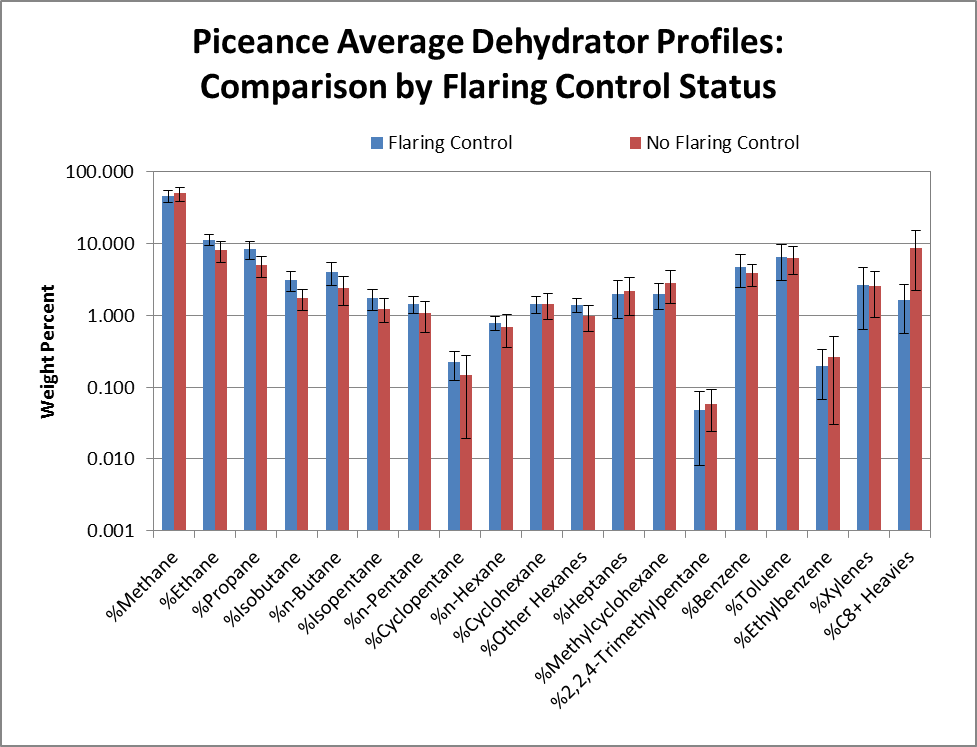


Figure 1. Piceance Basin dehydrator profile by model output component by flaring control status.

The GRI GlyCalc model uses extended gas analysis from the inlet to the absorber tower as input. The “C8+ heavies” compound in the inlet gas stream is calculated by adding weight percent of octanes, nonanes and decanes+. Similarly, we could assign C8+ heavies in the profile to C8 paraffin. We investigated the ratio of C7 alkanes (heptanes) to aromatics (toluene) between the inlet gas stream and dehydrator output emissions to see whether there is an “aromatic enrichment” effect from the dehydration process. We calculated these ratios from four permits’ GRI GlyCalc input/output data. Our analysis results made clear that the “aromatic enrichment” effect was sufficient for output toluene to exceed heptanes in two of four cases. This casts doubt on the assumption that C8+ heavies are all alkanes. As a result, the “C8+ heavies” compound in the final composite profile was unpacked into alkanes and aromatics using the same proportion as C7 alkanes (heptanes) and aromatics (toluene). The final uncontrolled profile is shown in Table 3.

Table 3. Piceance Basin uncontrolled SPECIATE Profile.

|  |  |  |
| --- | --- | --- |
| **Species ID** | **SPECIATE Name** | **Weight (%)** |
| 529 | Methane | 50.2672 |
| 438 | Ethane | 8.1377 |
| 671 | Propane | 5.0788 |
| 491 | Isobutane (or 2-Methylpropane) | 1.7222 |
| 592 | N-butane | 2.4217 |
| 508 | Isopentane (or 2-Methylbutane) | 1.2480 |
| 605 | N-pentane | 1.0639 |
| 390 | Cyclopentane | 0.1465 |
| 601 | N-hexane | 0.6976 |
| 385 | Cyclohexane | 1.4504 |
| 2127 | Isomers of hexane | 0.9792 |
| 2008 | C7 Paraffins | 2.2056 |
| 550 | Methylcyclohexane | 2.8391 |
| 118 | 2,2,4-trimethylpentane | 0.0588 |
| 302 | Benzene | 3.8660 |
| 717 | Toluene | 6.3868 |
| 449 | Ethylbenzene | 0.2654 |
| 522 | M & p-xylene | 2.5311 |
| 2014 | C8 Paraffin | 2.9129 |
| 507 | Isomers of xylene | 5.7209 |

1. CDPHE Air Pollutant Emission Notice (APEN) calendar year 2014 database provided via email to John Grant (Ramboll Environ) by Dale Wells (CDPHE), April 19, 2016. [↑](#footnote-ref-1)
2. <http://environmentalrecords.colorado.gov/HPRMWebDrawer/FormSearch> [↑](#footnote-ref-2)