UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

OFFICE OF
AIR QUALITY PLANNING
AND STANDARDS

Mr. Josh Ravichandran
Consulting Engineer -- Western U.S.
Bryan Research & Engineering, LLC
3131 Briarcrest Drive
Bryan, TX 77807

03/31/2022

Dear Mr. Ravichandran:

This letter is our response to your original request dated September 2, 2020, to Robin Segall of my staff, supplemented by your data package and emails dated March 1, 2021, and April 21, 2021, requesting broad source category-wide approval for use of Bryan Research & Engineering's process simulation software, ProMax® (ProMax) in lieu of the GRI-GLYCalc™ software (GLYCalc) for modeling glycol dehydration unit emissions in demonstrating compliance with 40 CFR 63, Subpart HH, National Emission Standards for Hazardous Air Pollutants from Oil and Gas Production Facilities (Subpart HH). The U.S. Environmental Protection Agency's (EPA) Office of Air Quality Planning and Standards, as the delegated authority, must make the determination on any major alternatives to test methods and other compliance determination procedures required under 40 CFR parts 59, 60, 61, 63, and 65.

Background

In 1995, the EPA's Office of Research and Development along with the Gas Research Institute (GRI) and the American Petroleum Institute (API) conducted a study to assess the GRI-GLYCalc model for possible regulatory use.[1] [2] BTEX (benzene/toluene/ethylbenzene/xylene) and total volatile organic compound (VOC) emissions were measured from ten glycol dehydration unit sites using a total capture condensation (TCC) approach considered by the EPA to be the benchmark test method along with two other approaches. The BTEX and total VOC emissions results from these sites were then compared with emissions values modeled for the same units using the GRI-GLYCalc software and the following process parameter inputs: gas flow rate, gas temperature, gas pressure, glycol circulation rate, dry gas water content, lean glycol water content, gas pump volume, flash tank temperature, flash tank pressure, and reboiler

[1] C.O. Rueter, Reif, D.L., and Myers; D.B. Glycol Dehydrator BTEX and VOC Emissions Testing Results at Two Units in Texas and Louisiana, Volume I, Technical Report; EPA Report Number EPA-600/R-95-046a; March 1995. Note: Sites 1 and 2 in this EPA Report correspond to Sites 9 and 10 in Tables 1 and 2 of this letter and in the EPA Office of Research and Development memo cited below summarizing the data from ten sites tested by GRI, API, and the EPA.

[2] 'Glycol Dehydrator Emissions Test Report and Emissions Estimation Methodology,' Memo from Larry G. Jones, EPA Office of Research and Development to J. David Mobley, EPA Office of Air and Radiation, dated April 13, 1995.

temperature. Tables 1 and 2 summarize the comparative data for BTEX and total VOC, respectively, from this study for the ten units. This work provided the technical basis for including GLYCalc as an option in Subpart HH.

Table 1. BTEX Comparisons (tons/yr)

Emissions Measurement Method				Emissions Calculated using GLYCalc	% Difference, GLYCalc from TCC Benchmark
Site	Total Capture Condensation (TCC)	Pressurized Rich/Lean Glycol	Atmospheric Rich/Lean Glycol		
Site 1	0.34	0.43	0.5	0.4	17.6
Site 2	4.92	5.48	5.39	9.76	98.4
Site 3	89.6	98.6	98.1	85.4	-4.7
Site 4	9.89	9.88	9.87	20.6	108.3
Site 5	29.1	26.8	26.8	45.7	57.0
Site 6	8.56	10.1	8.55	13.5	57.7
Site 7	17.7	20.6	19.3	30.1	70.1
Site 8	2.61	2.71	3	4.25	62.8
Site 9	3.58	3.71	3.79	3.87	8.4
Site 10	22.8	25.9	21.4	22.3	-2.6

Table 2. Total VOC Comparisons (tons/yr)

Emissions Measurement Method				Emissions Calculated using GLYCalc	% Difference, GLYCalc from TCC Benchmark
Site	Total Capture Condensation (TCC)	Pressurized Rich/Lean Glycol	Atmospheric Rich/Lean Glycol		
Site 1	3.48	5.42	2.41	4.68	34.5
Site 2	8.37	8.39	7.87	13.4	60.1
Site 3	166	176	168	203	22.3
Site 4	155	61.1	42.5	183	18.1
Site 5	66.7	46	42.7	81.3	21.9
Site 6	48.2	40.4	24.2	66.1	37.1
Site 7	48.3	57	48.3	65.8	33.5
Site 8	45.6	28.4	26.5	44.9	-1.5
Site 9	19.8	10.7	11.4	21.8	10.1
Site 10	36.9	37.9	30.8	36.1	-2.2

In your request, you note that the GLYCalc model is allowed for a number of emissions assessments and other determinations in Subpart HH. You also note that, in all but one instance under Subpart HH §63.773(d)(3)(i)(H), where ProMax is currently allowed, facilities are allowed to use only the GLYCalc software when choosing the option to model rather than measure emissions and related parameters from their affected glycol dehydration units. Therefore, your clients are seeking use of ProMax more widely under Subpart HH as an alternative to GRI-GLYCalc. More specifically, you are requesting to use ProMax as an alternative to GLYCalc for six specific measurement-related requirements in Subpart HH as summarized below.

1. **§63.772 (b)(2)(i)** – Allows the use of GLYCalc as one of two options for determining compliance with benzene or BTEX emissions limits from glycol dehydration units.

2. **§63.772(d)(2)(iii)** – Allows use of GLYCalc as an alternative to Method 18 (40 CFR 60, Appendix A) or ASTM Method D6420-99 (Reapproved 2004) coupled with flowrate measurements for determining BTEX emissions from glycol dehydration units.

3. **§63.772(e)(3)(iii)(B)(4)** – Allows use of GLYCalc for determining the mass rate of total organic compounds (minus methane and ethane) or total hazardous air pollutants (HAP) at the inlet of the control device for a glycol dehydration unit as an alternative to Method 18 or Method 25A (40 CFR 60, Appendix A) coupled with flowrate measurements.

4. **§§63.772(e)(4)(i) and (e)(5)** – Allows use of GLYCalc to generate a condenser performance curve as an alternative to the condenser design analysis, which includes vent stream composition, constituent concentrations, flowrate, relative humidity, and temperature.

5. **§§63.773(d)(5)(ii)(B) and (C)** – Allows use of GLYCalc to generate a condenser performance curve as an alternative to the condenser design analysis.

6. **§§63.764(d)(2)(ii) and 63.775(c)** – Specifies use of GLYCalc to calculate an alternative glycol circulation rate for use in demonstrating compliance when a triethylene glycol dehydration unit is unable to meet the sales gas specification for moisture when operating at or below the glycol circulation rate determined using the equation in §63.764(d)(2)(i).

You explain that ProMax is a process simulation product developed for the oil and gas industry that is widely used and well known for its ability to predict BTEX and VOC (volatile organic compound) absorption into ethylene glycol solutions and emissions from oil and gas facilities. It includes the capability to estimate emissions of BTEX and VOC from glycol dehydration units, as well as a number of other process parameters, using process operating data. You also explain that ProMax and GLYCalc both employ vapor-liquid equilibrium (VLE) models and mass balance calculations as the basis to predict emissions.

Justification

As justification for your request to use ProMax as an alternative to GLYCalc for six specific measurement-related requirements in Subpart HH, you again point out that Subpart HH (§63.773(d)(3)(i)(H)) already allows the use of ProMax to calculate the inlet composition and flowrate of the glycol still overheads (the inlet emissions) entering a combustion control device, which are defined as E_i. You note that the composition of this waste gas stream is a result of all other unit operations within a dehydration model and can only be accurate if all other parts of the model are also considered to be accurate and, thus, ProMax should be considered for use as an alternative to GLYCalc for the six other applications that you request and were listed above. Additionally, you note that ProMax is commonly used in place of the EPA's TANKS 4.09D programs and that these widely accepted flash calculations used for tank emissions estimates are derived from the same accurate modified equations of state that are used for the glycol dehydration unit process simulations. You further contend that, considering both ProMax and GLYCalc employ VLE models along with balance calculations to predict emissions, ProMax is far more advanced at this point when compared to the latest version of GLYCalc (Version 4.0) as it was last revised in 2000 while ProMax continues to be updated to include the most recent VLE data.

You provided a link to an article posted online in 2011 by John M. Campbell & Co.[3] This article compares predictions from the ProMax model to those from the GLYCalc model for BTEX absorption in triethylene glycol (TEG) solutions (the most commonly used adsorption solution in glycol dehydration units). The predictions are presented for three combinations of circulation rate and temperature, all at 1000 psia (6,895 kPa), with 99.0 weight % lean TEG, and three theoretical trays in the contactor column. Table 3 below summarizes these results, which show relatively consistent agreement between the two models with the exception of benzene at the lower temperature and higher circulation ratio. In all cases, the ProMax results are more conservative than the GLYCalc results as higher BTEX absorption rates would result in higher emission rates.

Table 3. ProMax versus GLYCalc at Various Circulation Rate/Temperature Combinations

Software	Temp, °F	Circulation Ratio, gal TEG/lb H_2O removed	BTEX Absorption, %			
			Benzene	Toluene	Ethylbenzene	O-xylene
GLYCalc	77	5.39	7.8	15.6	19.3	27.7
ProMax	77	5.39	11.7	19.0	22.2	32.9
GLYCalc	95	3.12	7.6	11.6	14.5	20.9
ProMax	95	3.12	8.6	13.5	15.7	23.1
GLYCalc	122	3.67	13.5	19.1	24.3	33.2
ProMax	122	3.67	13.9	21.1	24.5	34.7

In your request, you provide comparative data for ProMax and GLYCalc for Sites 1 and 2 (referred to as Sites 9 and 10 in Tables 1 and 2 above). These two sites were the only ones from the 1995 study, now decades old, where the process parameter inputs for the glycol dehydrator units were actually published.[1] The data you submitted (see Table 4 below) show generally good agreement for both BTEX and total VOC between ProMax, GLYCalc, and the total capture condensation testing approach considered the benchmark method, with the ProMax values being consistently comparable or conservative.

[3] http://www.jmcampbell.com/tip-of-the-month/2011/06/absorption-of-aromatics-compounds-in-teg-dehydration-process/

Table 4. ProMax versus GLYCalc and Total Capture Condensation Method

Site	Pollutant	Method and Results (tons/yr)			% Difference, ProMax from GLYCalc	% Difference, ProMax from TCC Benchmark
		Total Capture Condensation (TCC)	GLYCalc	ProMax		
Site 1 (9)	BTEX	3.58	3.88	4.15	7.0	15.9
Site 2 (10)	BTEX	22.9	22.3	26.8	20.2	17.0
Site 1 (9)	Total VOC	19.8	21.8	21.7	-0.05	9.6
Site 2 (10)	Total VOC	36.9	36.1	39	8.0	5.7

With your data package, you also included comparisons of glycol dehydration unit BTEX, benzene, HAP, and VOC emissions data generated using GLYCalc and ProMax. You explain that the process input data used to run the ProMax and GLYCalc model simulations came from thirteen glycol dehydration units located in West Virginia having a wide range of inlet gas compositions[4] to represent the range of natural gas from various basins across the country, with and without flash tanks, and with and without regenerator controls. Parity plots in units of tons of emissions per year were used to summarize the comparisons for uncontrolled regenerator emission results for BTEX, HAP, and VOC; uncontrolled flash tank emission results for BTEX, HAP, and VOC; and uncontrolled regenerator emission results for benzene. These parity plots are presented as Figures 1, 2, and 3. The agreement for BTEX, benzene, and HAPS are very good and the agreement for VOC is also good, though slightly more variable.

[4] The methane mole fractions ranged from 86% to 98%, the ethane mole fractions from 1.5% to 9%, the VOC mole fractions (or C3+) from 0.08% to 3.7%, and the BTEX concentrations from 0 to 756 ppm. These ranges of concentrations can be found within a single basin and also across different basins.

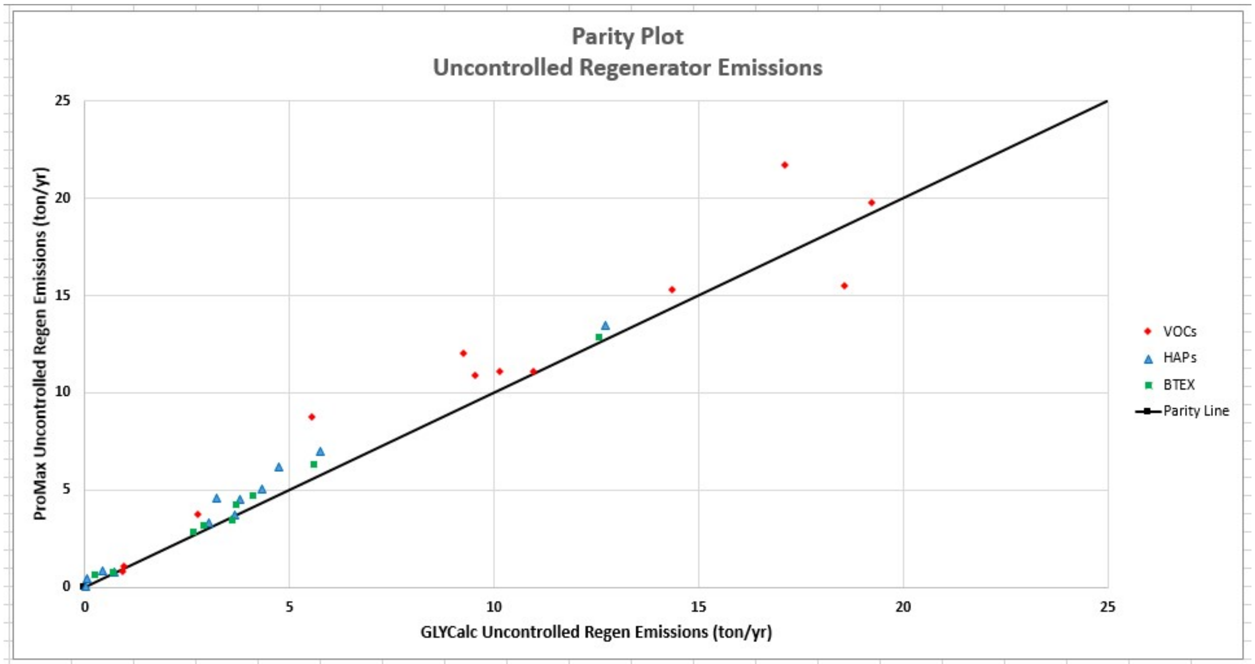

Figure 1. Parity plot for BTEX, HAP, and VOC emissions (tons/yr) from uncontrolled regenerators as determined by ProMax versus GLYCalc.

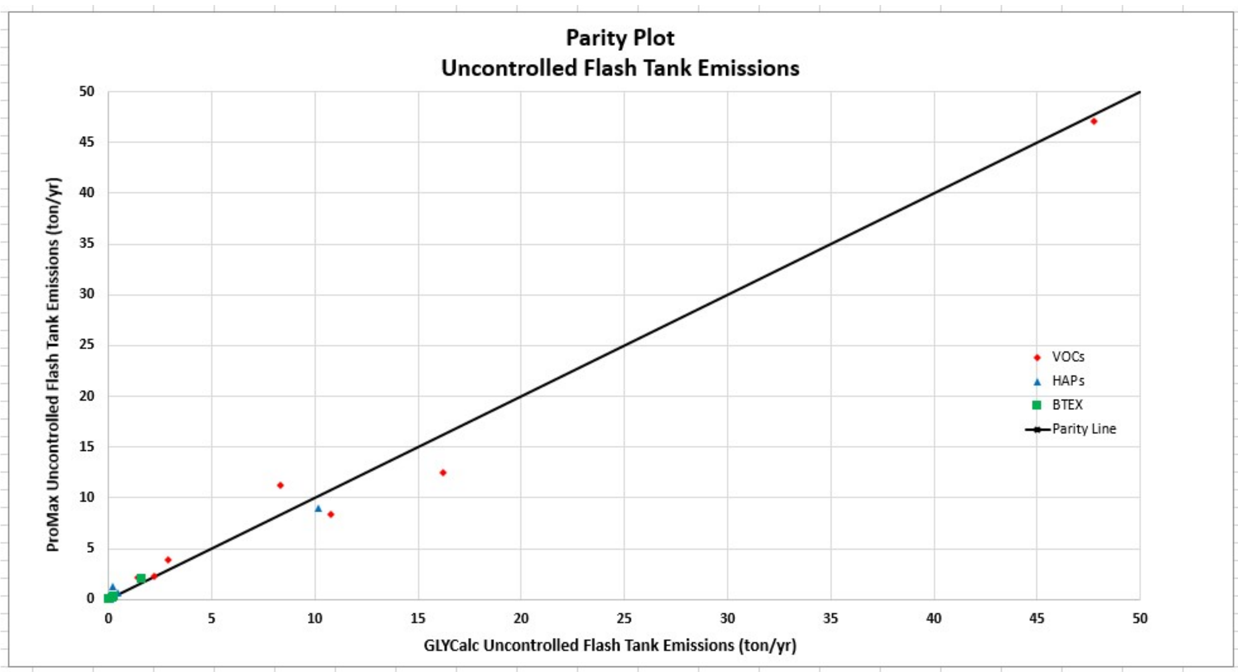

Figure 2. Parity plot for BTEX, HAP, and VOC emissions (tons/yr) from uncontrolled flash tanks as determined by ProMax versus GLYCalc.

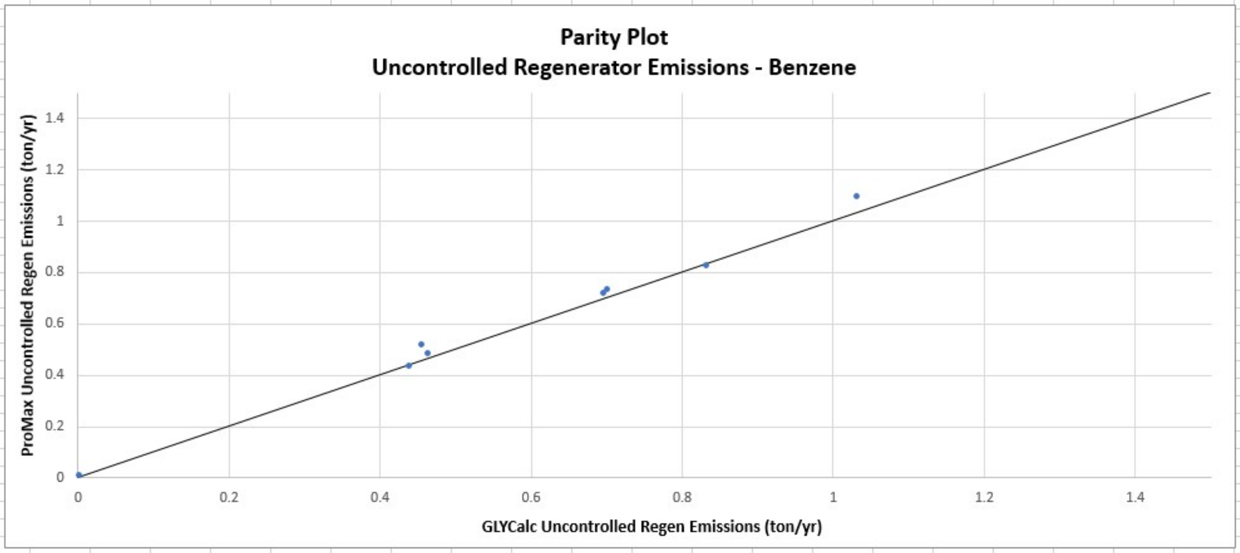

Figure 3. Parity plot for benzene emissions (tons/yr) from uncontrolled regenerators as determined by ProMax versus GLYCalc.

Lastly, you included data/information in your submittal intended to show that the VLE data upon which the ProMax model is based yields outputs that compare well with empirical data published by the Gas Processors Association (GPA).[5] In specific, Figure 4 is a parity plot for BTEX compounds along with methane comparing ProMax calculated mole percent of each compound in the liquid and vapor phases to the empirically measured results from GPA studies. The ProMax calculated and GPA empirical data compare well for both vapor and liquid phases.

[5] GPA Research Report RR-131, The Solubility of Selected Aromatic Hydrocarbons in Triethylene Glycol; H.-J. Ng, C.-J. Chen, and D.B. Robinson; DB Robinson Research Ltd, Alberta; Project 895; December 1991.

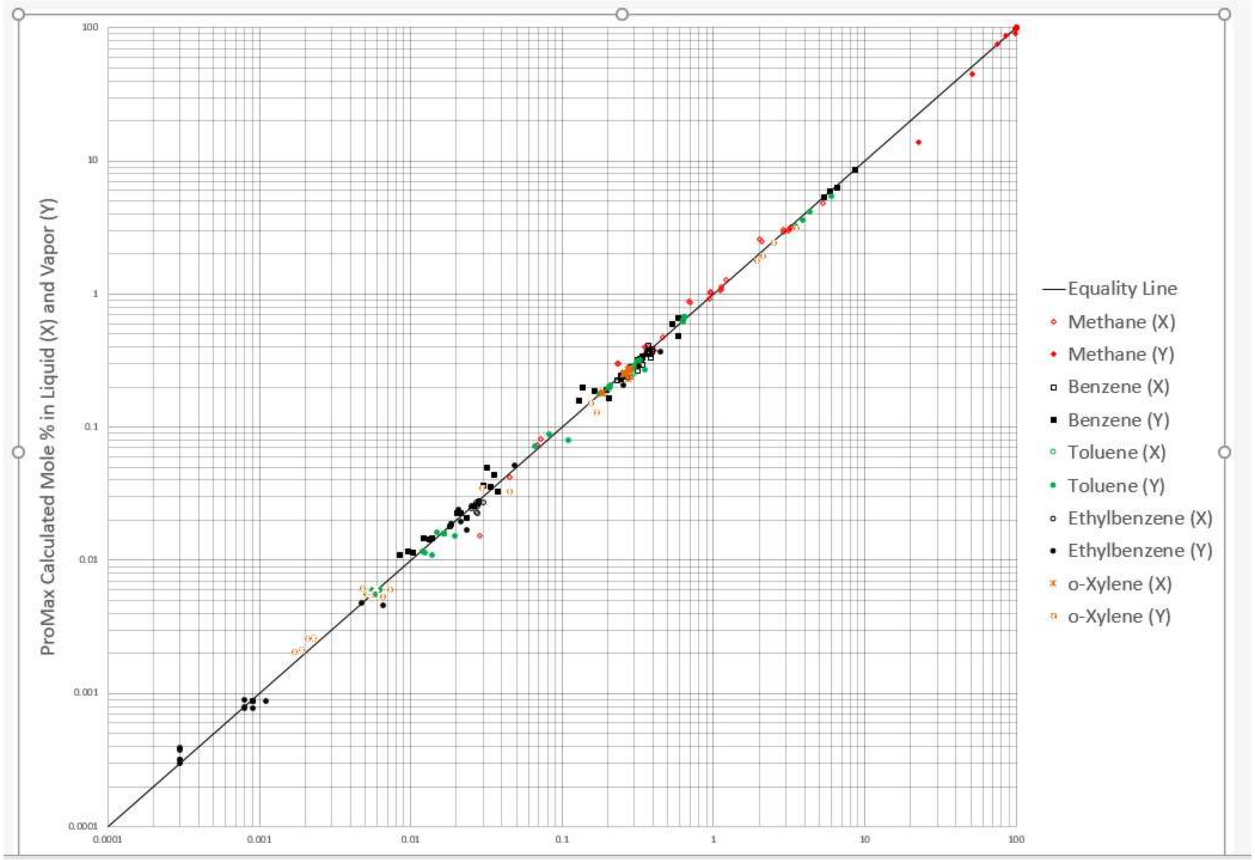

Figure 4. Parity plot for benzene, toluene, ethylbenzene, o-xylene, and methane (mole percent in the liquid and vapor phases) as calculated by ProMax versus empirically measured results from GPA.

<u>Determination</u>

We have reviewed your submittal including the supporting data and Subpart HH in detail. We conclude that the ProMax model results are typically equivalent or more conservative when compared to the results from the GLYCalc model and the total capture condensation method used by the EPA in its research. Therefore, we agree that the ProMax model would be suitable for performing the emissions and related parameter determinations for which the GLYCalc model is already allowed in Subpart HH and, with this letter, approve the use of the ProMax model, Version 5.0 or higher, as an alternative to the GLYCalc model under the following specific sections of 40 CFR 63, Subpart HH subject to the caveats explained below.

- §63.772 (b)(2)(i)
- §63.772(d)(2)(iii)
- §63.772(e)(3)(iii)(B)(4)
- §§63.772(e)(4)(i) and (e)(5)
- §§63.773(d)(5)(ii)(B) and (C)
- §§63.764(d)(2)(ii) and 63.775(c)

Use of the ProMax model, Version 5.0 or higher, as an alternative to the GLYCalc model is subject to the following caveats.

- Inputs to the ProMax, Version 5.0 or above, software shall include the parameters listed below, which must be representative of the actual operating conditions of the glycol dehydration unit:

    - Wet gas flowrate
    - Wet gas composition (dry basis)
    - Wet gas water content (if unknown, can assume a worst-case of 100% saturation)
    - Wet gas (absorber) temperature
    - Wet gas (absorber) pressure
    - Glycol circulation rate (or dry gas water content or glycol circulation ratio)
    - Dry gas water content
    - Lean glycol water content
    - Gas pump volume ratio (when gas injection pump is used)
    - Reboiler temperature
    - Flash tank parameters (when installed)
        - Temperature
        - Pressure
    - Control device parameters (when installed)
        - Combustion device destruction efficiency
        - Condenser temperature and pressure
    - Stripping gas (if used)
        - Type (dry gas, flash gas, nitrogen)
        - Flowrate

- Affected facilities using this alternative (ProMax as an alternative to GLYCalc under Subpart HH) for their affected glycol dehydration units must notify the responsible agency before use of the alternative and notification should include a copy of this letter.

- Facilities must include a copy of this letter with each report presenting results using the ProMax software.

- Once a facility chooses to use ProMax as an alternative to GLYCalc under one or more of the Subpart HH provisions listed above, the facility must continue to use ProMax in meeting the provision(s) until the owner/operator receives approval from this office for use of a new alternative method or the responsible agency for use of any other options in Subpart HH, including returning to the use of GLYCalc (see §63.7(f)(5)).

Because we have approved this alternative method for application to glycol dehydration units under 40 CFR 63 Subpart HH, wherever GLYCalc has been previously allowed as detailed above, we will post this letter as ALT-147 on the EPA website at *https://www.epa.gov/emc/broadly-applicable-approved-alternative-test-methods* for use by other interested parties.

If you have any questions regarding this approval or need further assistance, please contact Robin Segall at (919) 541-0893 or *segall.robin@epa.gov* or Jason DeWees at (919) 541- 9724 or *dewees.jason@epa.gov*.

Sincerely,

STEFFAN JOHNSON Digitally signed by STEFFAN JOHNSON Date: 2022.03.31 10:21:23 -04'00'

Steffan M. Johnson, Group Leader
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