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Use of Gasket Parameters as a Reasonable Alternative to the Average Emission Factor Method for Estimating Fugitive Emissions from Flanged Connectors

Standards
Certification
Education & Training
Publishing
Conferences & Exhibits

Presenter

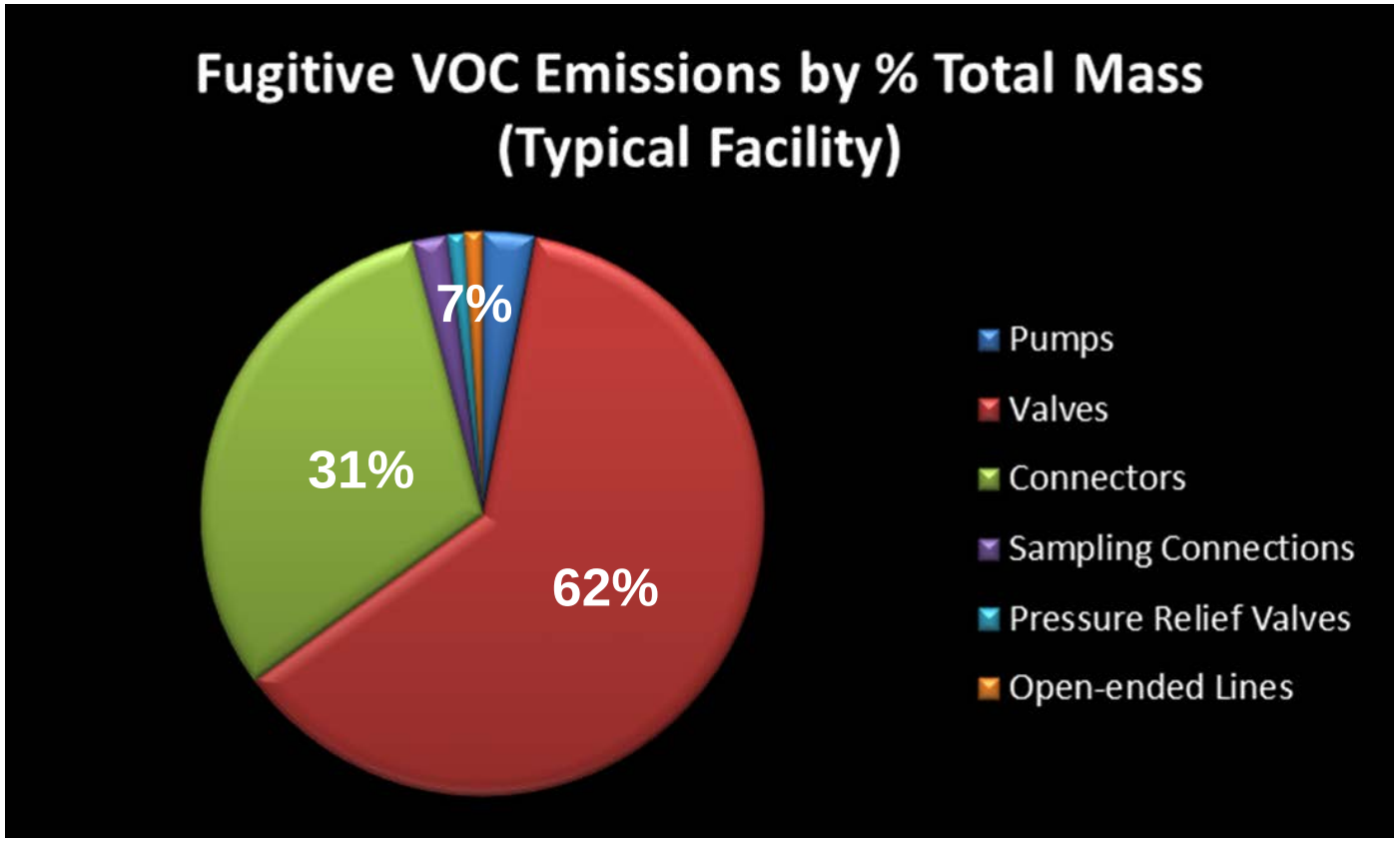
Dale Rice has over 25 years of engineering and consulting experience in the environmental field, and is currently an environmental engineer with VSP Technologies. He is responsible for coordinating and supporting efforts to assist customers in meeting their environmental requirements with the products and technologies that VSP supplies. Mr. Rice has key focus areas: fugitive emissions associated with gasket leakage, corporate sustainability, and environmental compliance regulations. He holds a B.A. in Chemistry from Hope College and a M.S. in Environmental Engineering from Syracuse University. Mr. Rice is a registered Professional Engineer and resides with his wife, Susan in greater Wilmington, North Carolina.

Significance of Fugitive Emissions

Air Emissions as Reported for the Toxic Release Inventory
(All industries, HAPs, U.S. , 2012)

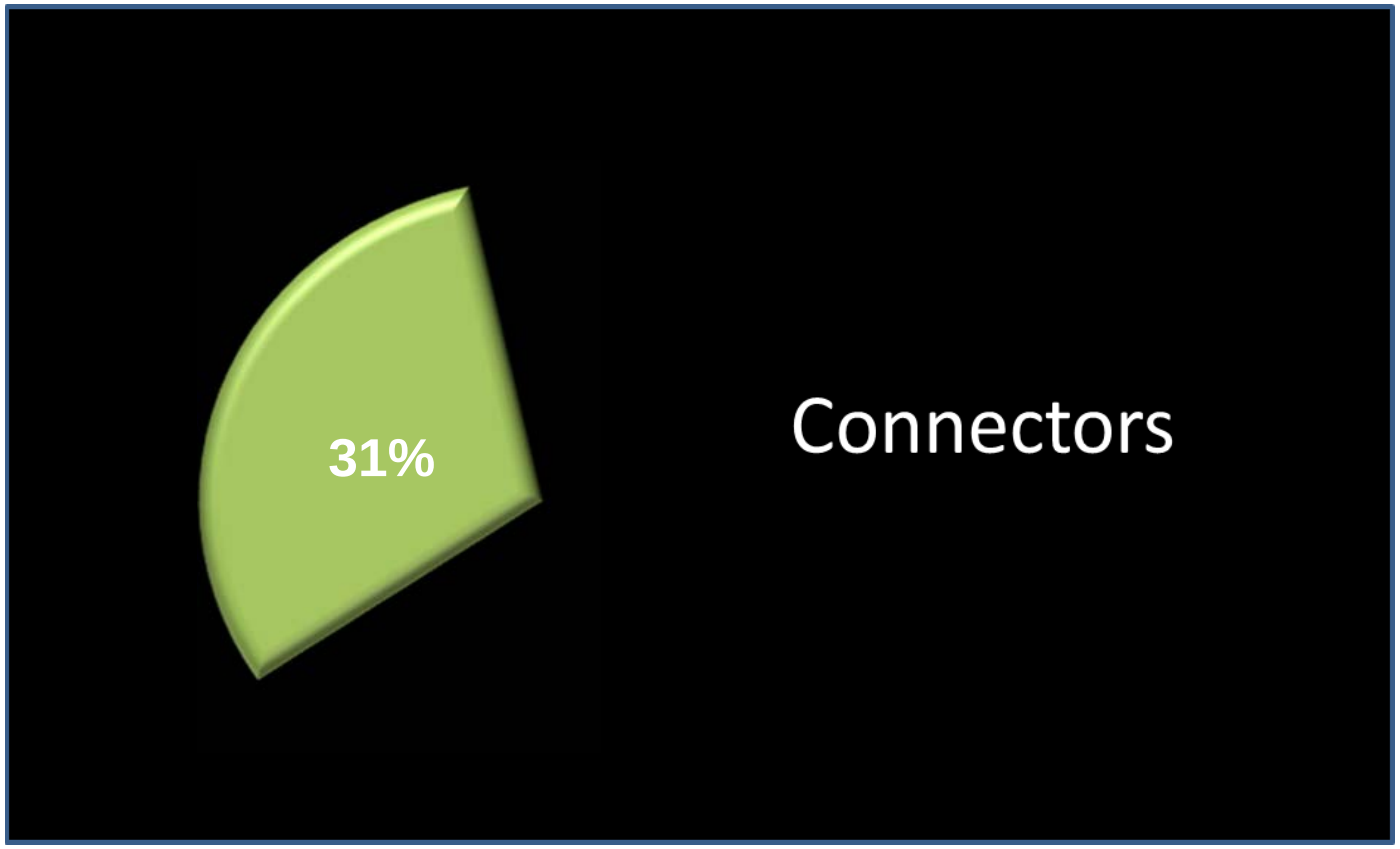
Air Emissions Source	Annual Amount (Pounds)	Percent
Point Source	345,301,389	78%
Fugitive	97,598,445	22%

Sources of Fugitive Emissions at a Chemical Plant

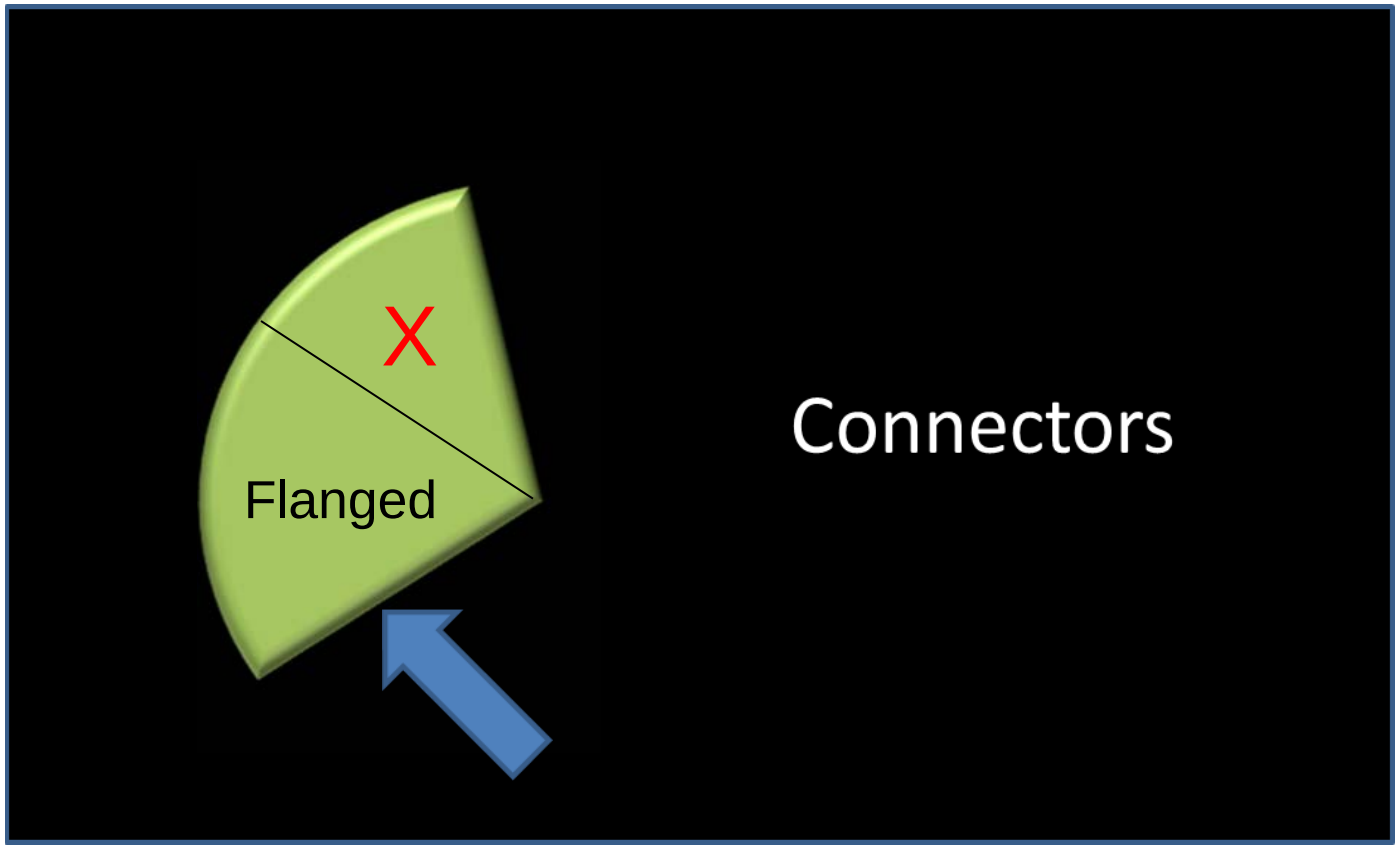


Source: “Leak Detection and Repair – A Best Practices Guide”, USEPA

Our Focus Today: Connectors



Specifically: Bolted Flanged Connectors



Why Only Bolted Flanged Connectors?

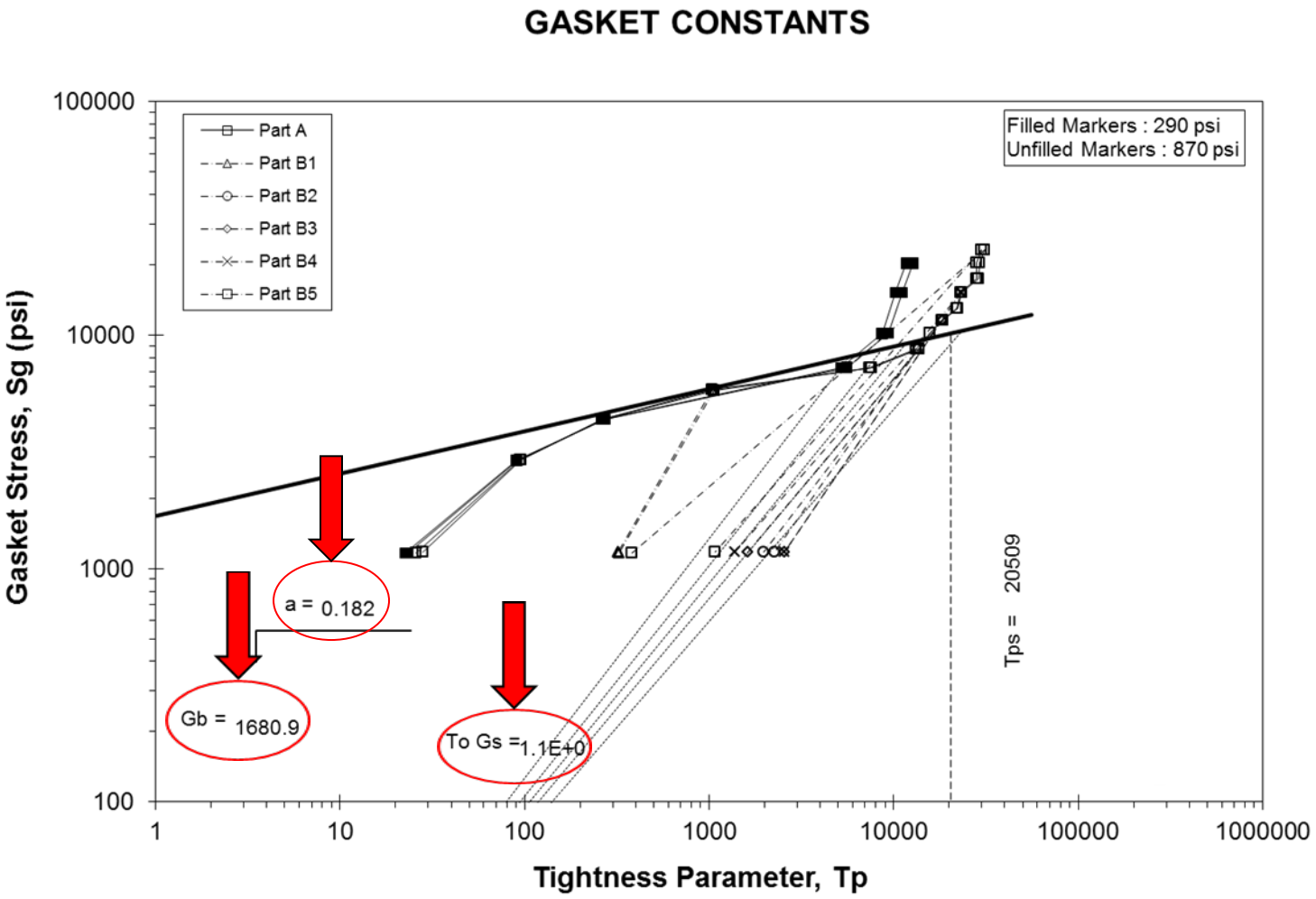
BFCs Use Gaskets

Test Coefficients Available for Many Gaskets

Gasket Coefficients Can Be Used to Predict Emission Rates

Predicted Emission Rates Can Be Used (Potentially) for Some Environmental Reporting

Room Temperature Test (ROTT)



PVRC Empirical Method

Empirical tools used to estimate the leakage rate[1]:

$$T_p = (S_g/G_b)^{(1/a)} \leq T_{pmax} \quad \text{(unitless)}$$

$$S_f = r\,(\eta\, S_g - P\,(A_i/A_c)) \quad \text{(psi)}$$

$$k_f = \log(\eta\, S_g/G_s) / \log T_p \quad \text{(unitless)}$$

$$T_f = (S_f/G_s)^{(1/k_f)} < T_{pmax} \quad \text{(unitless)}$$

$$L_r = [(P/14.7)(1/T_f)]^2 / 150 \quad \text{(mg / sec /mm)}$$

$$L_{tot} = L_r\, d\, (3600)(25.4)(1x10^{-6}) \quad \text{(kg/hr)}$$

[1] Rice, Dale and Waterland, Jerry, "Environmental Considerations for Gasket Selection and the Development of an Emissions Calculator for Gasket Materials", PVP2014-28024, Proceedings of the ASME 2014 Pressure Vessels & Piping Conference, July 20-24, 2014, Anaheim, CA (To Be Published.)

Fugitive Emissions Calculator

The "FEC" requires the following data:

- Number and NPS of connectors
- Operational pressure
- Annual hours of operation
- Percent of chemical in process stream(s)
- Published emission factor(s)
- ROTT data for selected gasket materials

PVRC Empirical Method

The FEC calculated leakage rate has a built-in conservative factor:

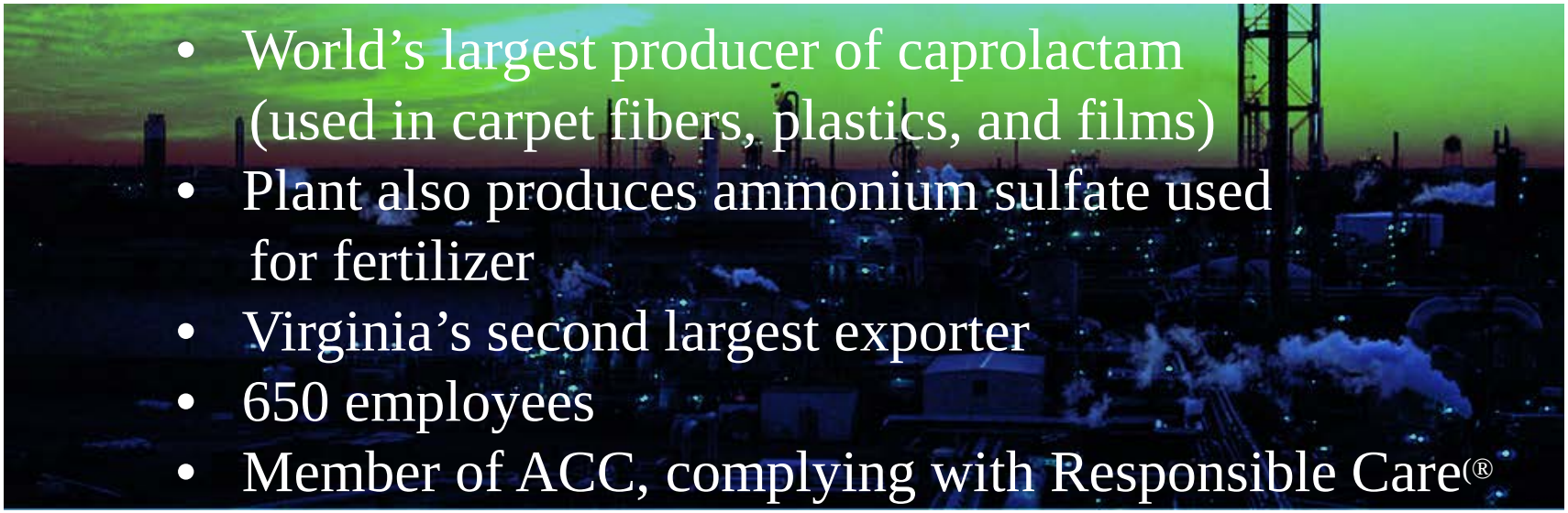
ROTT data are based on the leakage rates for helium. Therefore, the FEC leakage rate for all other fluids (except hydrogen) is actually lower than calculated.

PVRC Empirical Method

The FEC is based on the premise that the user has an identified Gasket-Use Process Management Program at the site (or process unit level), which which will ensure that all procedures for proper connector installation and maintenance are in place.

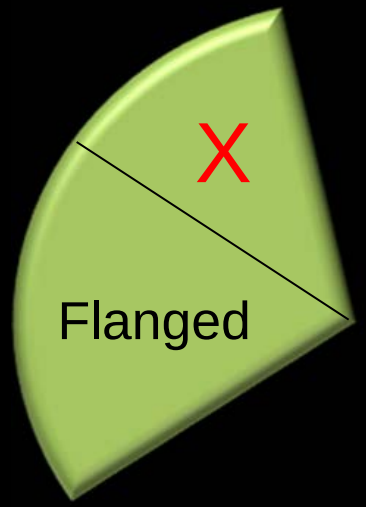
Confidential Test Facility

Confidential Test Facility



- World's largest producer of caprolactam (used in carpet fibers, plastics, and films)
- Plant also produces ammonium sulfate used for fertilizer
- Virginia's second largest exporter
- 650 employees
- Member of ACC, complying with Responsible Care®

Confidential Test Facility



Test Process Area (Toluene):

Total Connectors: 744
Flanged: 413 (56%)

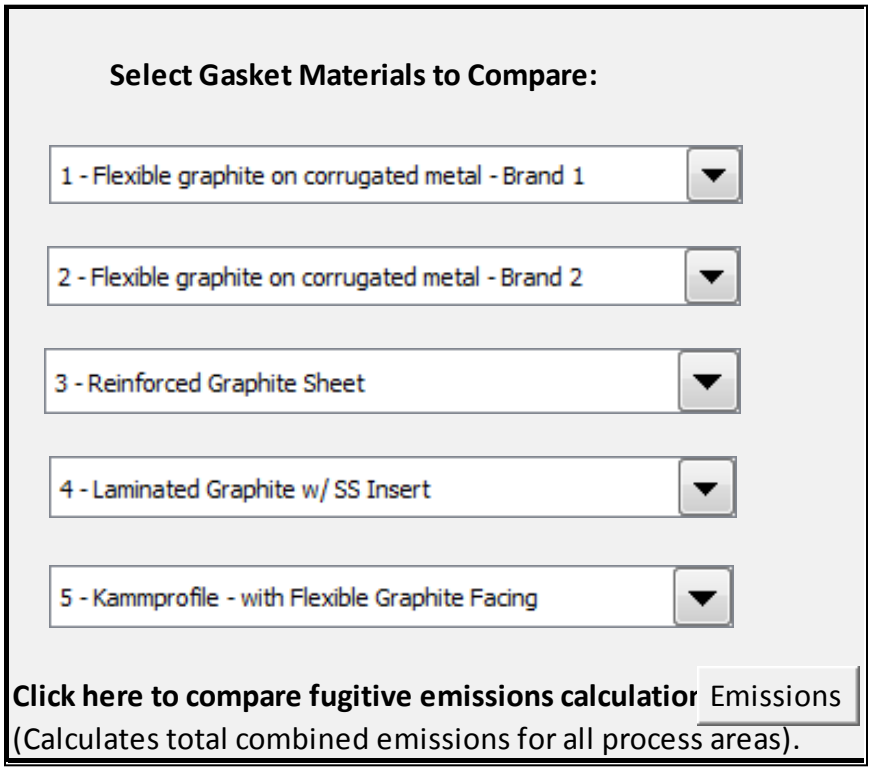
Fugitive Emissions Calculator

Inputs:

Name of Facility:		
Facility Contact:	Jan Kountz	
Chemical Name:	Toluene	
Data Year:	2013	
Name of Process 1	Area X Toluene	
No. Connectors	(Enter Any Integer)	400
% Annual Hrs Operated	(Enter 1 - 100)	100
% Process Stream	(Enter 1 - 100)	100
Emission Factor Used	(Number in lbs/hr/connect.)	0.00004
Operational Pressure	(Number in psi)	50
Name of Process 2	Area X Recycled Toluene	
No. Connectors	(Enter Any Integer)	13
% Annual Hrs Operated	(Enter 1 - 100)	100
% Process Stream	(Enter 1 - 100)	85
Emission Factor Used	(Number in lbs/hr/connect.)	0.00004
Operational Pressure	(Number in psi)	50

Fugitive Emissions Calculator

Inputs:



Fugitive Emissions Calculator

Outputs:

Each process area is calculated separately.

Facility Name:						
Chemical:	Toluene					
Data Year:	2013					
	Published Emissions Factor (PEF) Calculations					
Process Area(s):	Connector Count	Assumed Annual Hrs. of Operation	Assumed Operating Pressure (psig)	Chemical Percent of Process Stream	Chemical Emissions Amt (lbs/yr)	Avg Emissions / Connector (lbs/yr)
Area X Toluene	400	8760	50	100%	140.16	0.350
Area X Recycle Toluene	13	8760	50	85%	3.87	0.298
	0	0	0	0%	0	
	0	0	0	0%	0	
Totals	413				144.03	

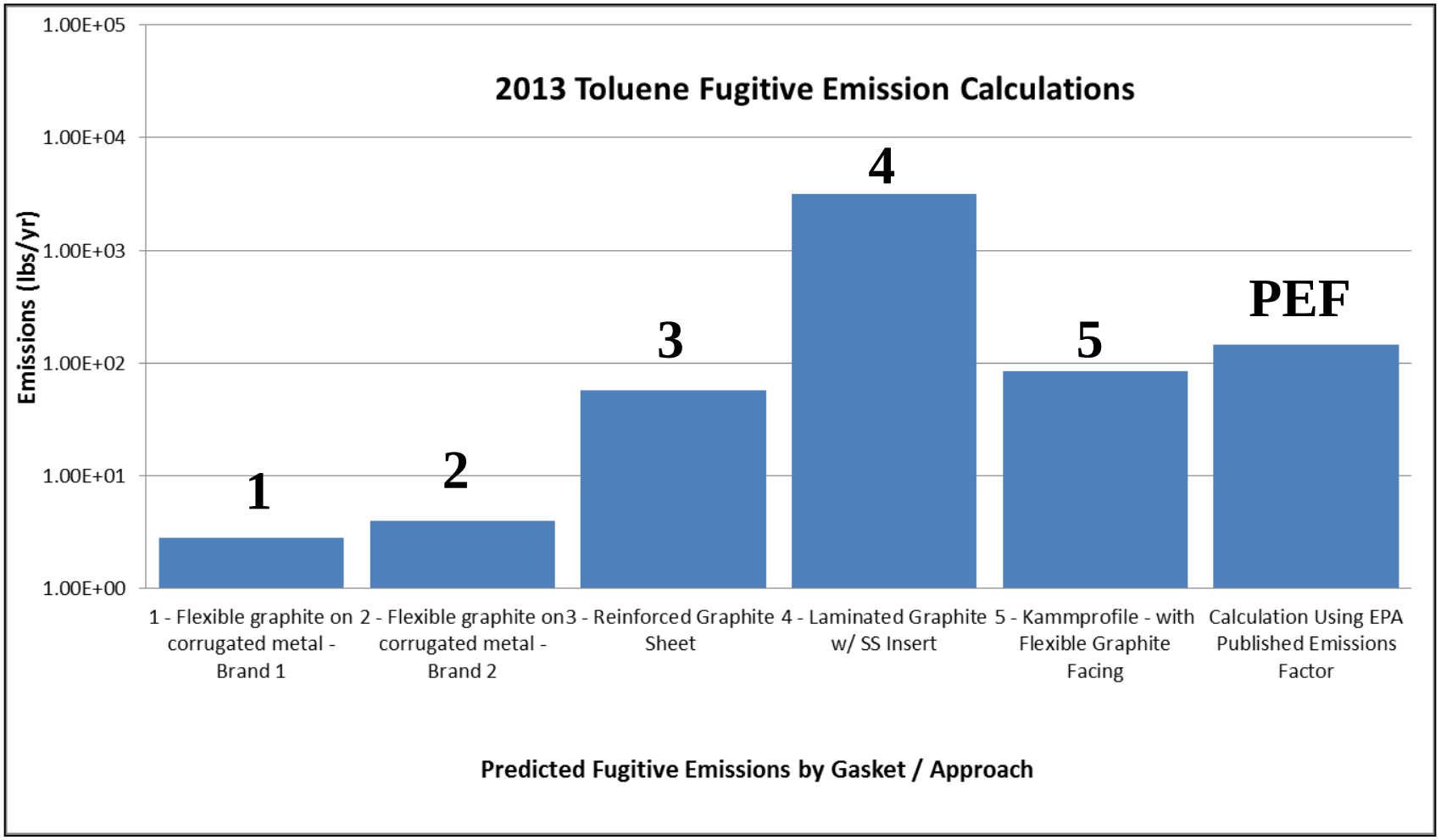
Fugitive Emissions Calculator

Outputs:

Calculated Total Emissions for All Gasketed Connectors (Compared to PEF)	Total Emissions (lbs/yr)
1 - Flexible graphite on corrugated metal - Brand 1	2.8
2 - Flexible graphite on corrugated metal - Brand 2	3.9
3 - Reinforced Graphite Sheet	57
4 - Laminated Graphite w/ SS Insert	3192
5 - Kammprofile - with Flexible Graphite Facing	84
Calculation Using Published Emission Factor	144.0

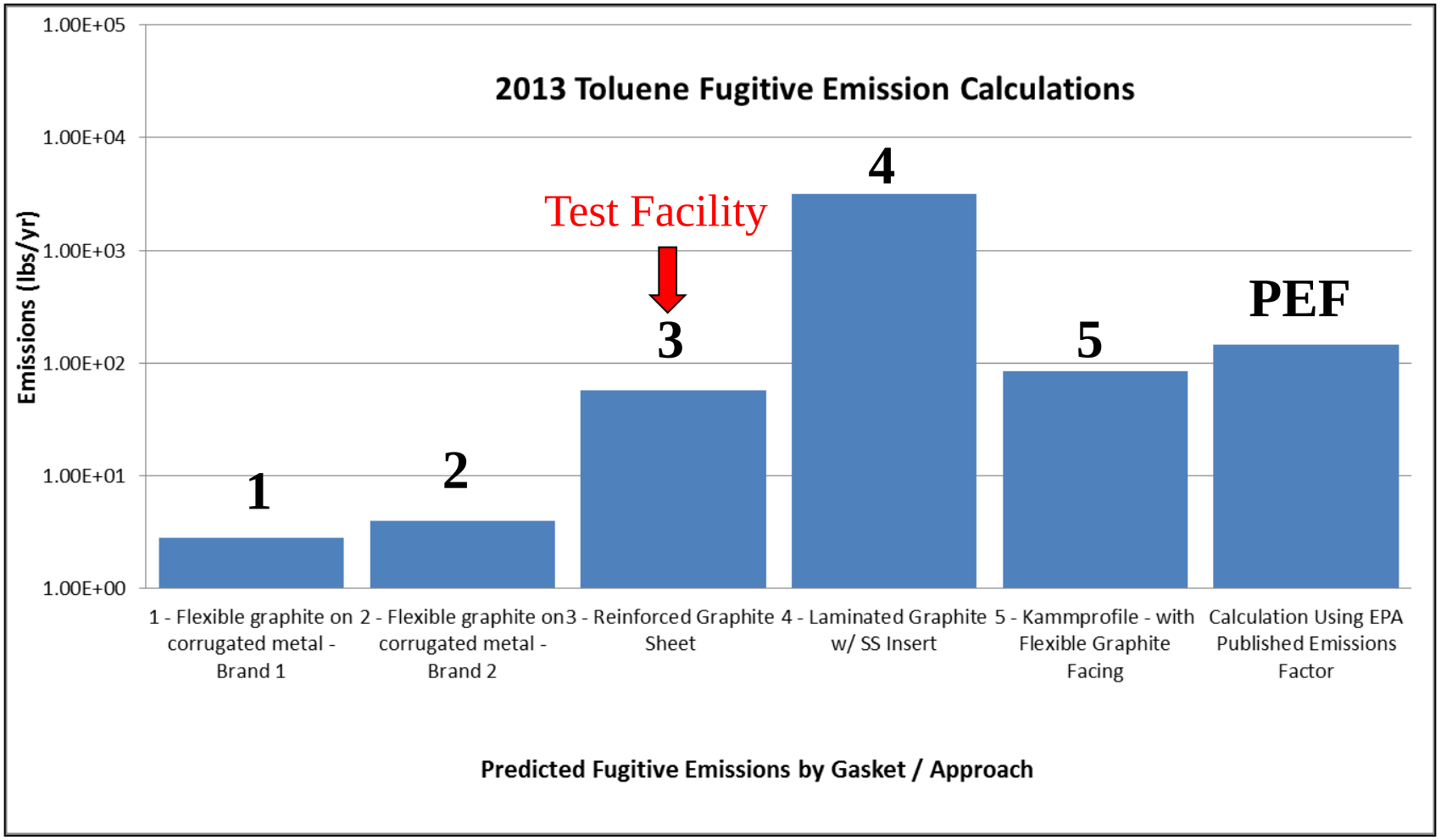
Fugitive Emissions Calculator

Outputs:



Fugitive Emissions Calculator

Outputs:



Fugitive Emissions Calculator

Test Facility:

Estimated 2013 Toluene Fugitive Emissions

Published Emission Factor Approach: 260 Pounds
Using Partial* FEC Approach: 169 Pounds

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91 Pound / Yr Reduction!

* 413 flanged connectors using FEC and 331 non-flanged using PEF

Fugitive Emissions Calculator

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2. Assume “once size fits all” – each NPS uses the same emission rate!

Comparing FEC with PEF Estimates

NPS		Published Emission Factor Approach (lbs toluene/yr)	Fugitive Emissions Calculator (lbs toluene/yr)
	1 in OD	0.35	0.009
	24 in OD	0.35	10.1

Fugitive Emissions Calculator

So why is there a major difference between the two approaches?

Published emission factors:

1. Are based on averaged monitoring results at a number of different facilities.
2. Assume “once size fits all” – each NPS uses the same emission rate!
3. Do not distinguish between gasket materials being used.

Fugitive Emissions Calculator

However, FEC results are a function of:

1. Operating pressure
2. Connector diameter
3. Gasket material used
4. In-service gasket mechanical stability

Conclusions

1. The FEC offers a reasonable alternative to the traditional published emissions factor approach. The FEC accounts for several important factors that are not included with the emission factor approach.

2. The published emission factor method results are often overly conservative.

3. To be fully credible, the FEC method should be backed by a defined gasket-use process management program at the site or process unit level, to ensure consistent input/design conditions.

Questions?

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