CALCULATION OF AIR EMISSIONS FROM AN ACETYLENE PLANT

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Amendments to 84/08

Section	Change
	Editorial to align style with IHC associations
	Addition of reference documents
3	Definition added
4.3	Revision and clarification of table to match spreadsheet calculation

NOTE Technical changes from the previous edition are underlined

1 Introduction

This publication describes a standard method of calculating air emissions from an acetylene plant. The user can input their own information specific to their plant and obtain an estimate of the air emissions, which can be used for permit applications. This publication has an excel spreadsheet tool that can be used to calculate the emissions.

2 Scope and purpose

2.1 Scope

This publication provides a standard calculation method for air emissions from acetylene plants. More details of best practices and other environmental impacts can be found in EIGA Doc 109, *Environmental Impacts of Acetylene Plants* and EIGA Doc 226, *Best Available Techniques for Acetylene Production* [1, 2].[1]

3 Definitions

For the purpose of this publication, the following definitions apply.

3.1 Publication terminology

3.1.1 Shall

Indicates that the procedure is mandatory. It is used wherever the criterion for conformance to specific recommendations allows no deviation.

3.1.2 Should

Indicates that a procedure is recommended.

3.1.3 May

Indicates that the procedure is optional.

3.1.4 Will

Is used only to indicate the future, not a degree of requirement.

3.1.5 Can

Indicates a possibility or ability.

4 Air Emissions of an Acetylene Plant

4.1 Chemical Reaction

Acetylene is produced by reaction between calcium carbide and water:

$$CaC_2 + 2\,H_2O \rightarrow C_2H_2 + Ca(OH)_2$$

4.2 Sources of Emissions

Acetylene is considered a volatile organic compound (VOC) with a low ozone creation potential [3].

[1] References are shown by bracketed numbers and are listed in order of appearance in the reference section.

Acetylene plants are designed to minimise emissions to avoid flammable atmospheres and to maximise production efficiency (see EIGA Doc 123, *Code of Practice - Acetylene* [4]).

Typical emission sources of an acetylene plant are:

- generators;
- lime pits;
- gas holders;
- purification units;
- compressors;
- filling stations; and
- cylinder maintenance.

The main sources for which a calculation is needed are the generator and the lime pits. The other possible sources are estimates of the emissions from cylinder maintenance and compressors as fugitive emissions.

The calculation for lime pits requires both theoretical background and various technical data for each single plant. For smaller quantities from other sources, it is recommended to determine the emissions by approximate calculation, as their share is less than 5% of the total amount.

The amount of gas which is emitted depends on various parameters of the production process. Table 1 explains how to calculate and to estimate gaseous emissions release during normal operation. The table ensures that different figures for each plant will be considered.

Typical emissions from the lime pit are shown as in Figure 1. Emissions from lime pit can vary depending on temperature, see Figure 2.

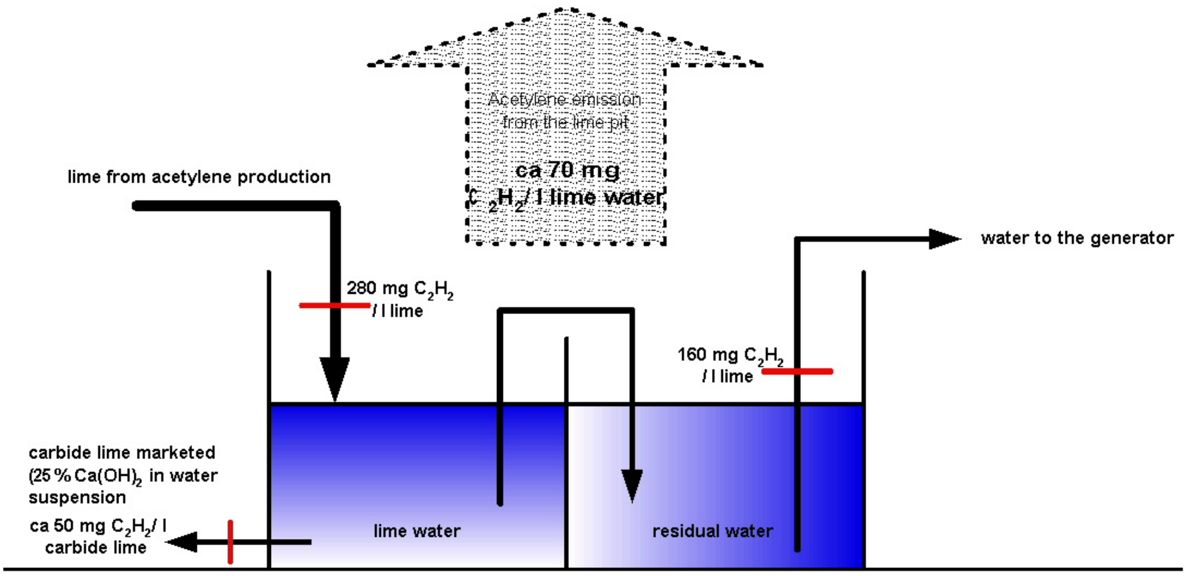

Figure 1 – Typical acetylene emissions from a lime pit, based on a specific plant example

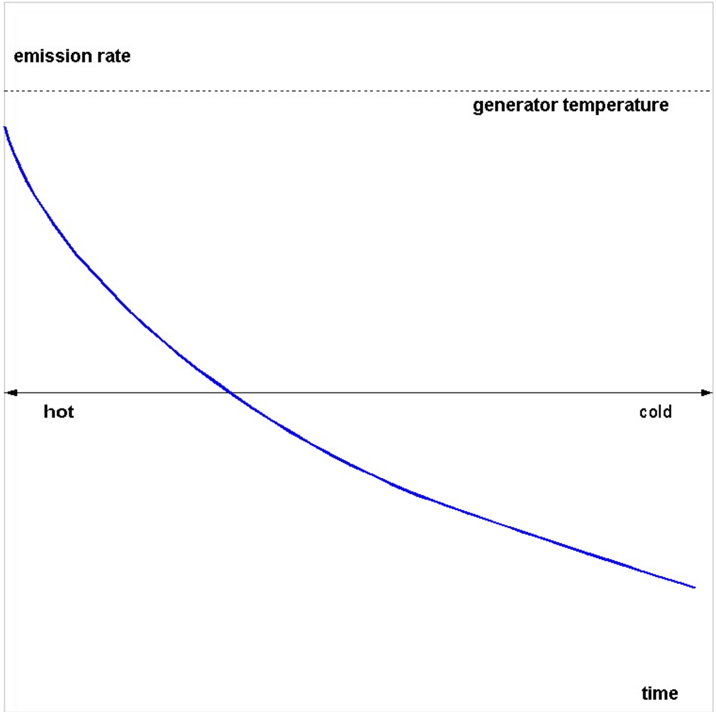

Figure 2 – Emission rate vs temperature of lime over time

NOTE It should be clearly stated that the following calculations are based on practical experience.

4.3 Calculation of air emissions of low pressure closed generator

Table 1 – Calculation of air emissions from acetylene plants

Data	Units	Value	Remarks	Formula
1. General Data Acetylene Production				
1.1 Operating days per year, ***D***	(d)	**250**	Figures given are an example	
1.2 Operating hours per day, ***h***	(h/d)	**24**		
1.3 Carbide consumption, ***C***	(T/y)	**2520**		
1.4 Acetylene generator pressure, ***P***	(mm H_2O)	**750**		
1.5 Filling amount per charge, ***W***	(T)	**1.7**		
Charging volume, V_{CaC2}	(m³)	0.73	Density of carbide, ρ_{CaC2} = 2.33kg/m³	***W*** / ρ_{CaC2}
Charges per year, ***N***	(/y)	1483		***C*** / ***W***
1.6 Volume of water per CaC_2, V_{H2O}	(m³/T)	**10**		
1.7 Water volume in the circle of acetylene generation, ***Q***	(m³/y)	25200		***D*** x ***V***
	(m³/h)	4.20		***Q*** / (***D*** x ***h***)
2. Impurities in raw acetylene				
2.1 Phosphine (PH_3), X_{PH3}	(ppm)	**300**[1)]	1ppm = 1 ml / m³	
	(mg/kg)	419	PH_3 density, ρ_{PH3} = 1.53 kg/m³ C_2H_2 density, ρ_{C2H2} = 1.095 kg/m³ 1ppm PH_3 = 1.53mg PH_3/1.095kg C_2H_2	300 x ρ_{PH3} / ρ_{C2H2}
2.2 Ammonia (NH_3), X_{NH3}	(ppm)	**620**[1)]	NH_3 density, ρ_{NH3} = 0.7715 kg/m³	
	(mg/kg)	436	1ppm NH_3 = 0.7715mg NH_3/1.095kg C_2H_2	620 x ρ_{NH3} / ρ_{C2H2}
2.3 Hydrogen sulphide (H_2S), X_{H2S}	(ppm)	**10**[1)]	H_2S density, ρ_{H2S} = 1.539 kg/m³	
	(mg/kg)	14.05	1ppm H_2S = 1.539mg H_2S/1.095kg C_2H_2	10 x ρ_{H2S} / ρ_{C2H2}
2.4 Arsine (AsH_3)	(ppm)	-	Ignoring amount	
	(mg/kg)	-		
3. Carbide dust emission (cyclone) Carbide dust emission is not relevant for a closed generator				
4. Acetylene production				
4.1 Average production rate, ***R***		**0.355**	kg C_2H_2 per kg CaC_2	
4.2 Yield, ***Y***	%	87.4	***$CaC_2+2H_2O \Rightarrow C_2H_2+Ca(OH)_2$*** Theoretically, 64kg CaC_2 produces 26kg C_2H_2 and 74kg $Ca(OH)_2$	***R*** / (26/64)
4.1 Acetylene, ***A***	(T/y)	895		***C*** x ***R***
4.2 Lime @ 25%, ***L***	(T/y)	10185	Lime may be used for different applications in different concentrations	***C*** x ***Y*** x (74/64) / 25%
	(T/mon)	849	This calculation uses 25% $Ca(OH)_2$ water suspension	***L*** / 12

Data	Units	Value	Remarks	Formula
5. Emissions				
5.1 Charging generator with C_2H_2[2) 3)]				
5.1.1 Acetylene, C_2H_2, $\boldsymbol{E_1}$	(kg/y)	1273		$\boldsymbol{V} \times \boldsymbol{N} \times \boldsymbol{P} \times \rho_{CaC2}$
5.1.2 Phosphine, PH_3, $\boldsymbol{E_2}$	(kg/y)	0.534		$\boldsymbol{E_1} \times \boldsymbol{X_{PH3}}$
5.1.3 Ammonia, NH_3, $\boldsymbol{E_3}$	(kg/y)	0.556		$\boldsymbol{E_1} \times \boldsymbol{X_{NH3}}$
5.1.4 Hydrogen sulphide, H_2S, $\boldsymbol{E_4}$	(kg/y)	0.018		$\boldsymbol{E_1} \times \boldsymbol{X_{H2S}}$
5.2 Emission from lime pit				
C_2H_2 concentration, $\boldsymbol{L_{C2H2}}$	**70**	(mg/l)	The concentrations should be determined for each single plant to consider for example, different sizes of the lime pits, specific water consumption for acetylene generation, lime temperature	
PH_3 concentration, $\boldsymbol{L_{PH3}}$	**0.029**	(mg/l)		
NH_3 concentration, $\boldsymbol{L_{NH3}}$	**0.03**	(mg/l)		
H_2S concentration, $\boldsymbol{L_{H2S}}$	**0.001**	(mg/l)		
5.2.1 Acetylene, C_2H_2, $\boldsymbol{E_5}$	(kg/y)	1764		$\boldsymbol{Q} \times \boldsymbol{L_{C2H2}}$
5.2.2 Phosphine, PH_3, $\boldsymbol{E_6}$	(kg/y)	0.73		$\boldsymbol{Q} \times \boldsymbol{L_{PH3}}$
5.2.3 Ammonia, NH_3, $\boldsymbol{E_7}$	(kg/y)	0.76		$\boldsymbol{Q} \times \boldsymbol{L_{NH3}}$
5.2.4 Hydrogen sulphide, $\boldsymbol{E_8}$	(kg/y)	0.03		$\boldsymbol{Q} \times \boldsymbol{L_{H2S}}$
5.3 Emissions from gas holder			Estimate 1% of lime pit emissions	
5.3.1 Acetylene, C_2H_2, $\boldsymbol{E_9}$	(kg/y)	17.64		$\boldsymbol{0.01} \times \boldsymbol{E_5}$
5.3.2 Phosphine, PH_3, $\boldsymbol{E_{10}}$	(mg/y)	7308		$\boldsymbol{0.01} \times \boldsymbol{E_6}$
5.3.3 Ammonia, NH_3, $\boldsymbol{E_{11}}$	(mg/y)	7560		$\boldsymbol{0.01} \times \boldsymbol{E_7}$
5.3.4 Hydrogen sulphide, $\boldsymbol{E_{12}}$	(mg/y)	252		$\boldsymbol{0.01} \times \boldsymbol{E_8}$
5.4 Emissions from relief system			Estimate 1% of lime pit emissions	
5.3.1 Acetylene, C_2H_2, $\boldsymbol{E_{13}}$	(kg/y)	17.64		$\boldsymbol{0.01} \times \boldsymbol{E_5}$
5.3.2 Phosphine, PH_3, $\boldsymbol{E_{14}}$	(mg/y)	7308		$\boldsymbol{0.01} \times \boldsymbol{E_6}$
5.3.3 Ammonia, NH_3, $\boldsymbol{E_{15}}$	(mg/y)	7560		$\boldsymbol{0.01} \times \boldsymbol{E_7}$
5.3.4 Hydrogen sulphide, $\boldsymbol{E_{16}}$	(mg/y)	252		$\boldsymbol{0.01} \times \boldsymbol{E_8}$
5.5 Emission from compressors / drying system / filling system, $\boldsymbol{E_{17}}$	(kg/y)	895	Estimate 0.1% of acetylene production, or 1% in case of old or poorly maintained compressors	$\boldsymbol{A} \times 0.001$
5.6 Emissions from cylinder testing				
5.6.1 Acetylene, C_2H_2, $\boldsymbol{E_{18}}$	(kg/y)	8946	Estimation 1% of acetylene production	$\boldsymbol{A} \times 0.01$
5.6.2 Acetone[4)]				
Acetone consumption, ***S***	(kg/T)	**40**	kg acetone per tonne acetylene, typical consumption estimate	
Acetone, C_3H_6O, $\boldsymbol{E_{19}}$	(kg/y)	118	Vapour density, $\rho_{C3H6Ov} = 0.0026$ Liquid density, $\rho_{C3H6Ol} = 0.79$	$\boldsymbol{A} \times \boldsymbol{S} \times (\rho_{C3H6Ov} / \rho_{C3H6Ol})$
6. Sum of emissions				
6.3.1 Acetylene, C_2H_2, $\boldsymbol{E_{20}}$	(kg/y)	12913		$\boldsymbol{E_1} + \boldsymbol{E_5} + \boldsymbol{E_9} + \boldsymbol{E_{13}} + \boldsymbol{E_{17}} + \boldsymbol{E_{18}}$
6.3.2 Phosphine, PH_3, $\boldsymbol{E_{21}}$	(kg/y)	1.28		$\boldsymbol{E_2} + \boldsymbol{E_6} + \boldsymbol{E_{10}} + \boldsymbol{E_{14}}$
6.3.3 Ammonia, NH_3, $\boldsymbol{E_{22}}$	(kg/y)	1.33		$\boldsymbol{E_3} + \boldsymbol{E_7} + \boldsymbol{E_{11}} + \boldsymbol{E_{15}}$
6.3.4 Hydrogen sulphide, $\boldsymbol{E_{23}}$	(kg/y)	0.04		$\boldsymbol{E_4} + \boldsymbol{E_8} + \boldsymbol{E_{12}} + \boldsymbol{E_{16}}$

NOTE Figures in **Bold** are inputs and shall be taken from the technical specification.

1) concentration in ppm is determined by analysis, concentrations should be analysed before a new calculation is made.

2) There are no direct emissions into the atmosphere during charging a closed generator system, because acetylene from the generator escapes into the closed carbide vessel, which will be subsequently released to the atmosphere.

3) This calculation does not consider an inert atmosphere in the carbide vessel, which may not be replaced during charging carbide into the generator. If you want to do, multiply the results by 0.5-0.8.

4) If acetone is filled with a gas displacement device, these emissions can be neglected.

4.4 Excel Spreadsheet to calculate Air Emissions

EIGA Doc 84.01, *Spreadsheet for Calculation of Air Emissions from an Acetylene Plant*, accompanying this publication is an Excel spreadsheet where the user can input the information described in Table 1 [5]. The spreadsheet performs the calculations according to the formulae described in Table 1.

5 References

[1] EIGA Doc 109, *Environmental Impacts of Acetylene Plants*, www.eiga.eu.

[2] EIGA Doc 226, *Best Available Techniques for Acetylene Production*, www.eiga.eu.

[3] *Photochemical ozone creation potentials for a large number of reactive hydrocarbons under European conditions*, R.G. Derwent, M.E. Jenkin, S.M. Saunders, Atmospheric Environment Volume 30 Issue 2, www.sciencedirect.com.

[4] EIGA Doc 123, *Code of Practice - Acetylene,* www.eiga.eu.

[5] EIGA Doc 84.01, *Spreadsheet for Calculation of Air Emissions from an Acetylene Plant*, www.eiga.eu.