

























































Ecobat Solutions  
Permit No : EPR/DB3704FG  
Variation No : EPR/DB3704FG/V006  
Report Ref : P5558 : R001

Installation Name : Recupyl Shredder Exhaust  
Visit Details : Emissions – August 2023  
Survey Dates : 16th August 2023  
Report Issue Date : 18th September 2023

## LABORATORY ANALYSIS RESULTS

Laboratory analysis for Speciated VOC was subcontracted to RPS laboratories, a UKAS Accredited Testing Laboratory, Number 0605.

RPS DO NOT hold UKAS & MCERTS accreditation for this analysis.

As required by the MCERTS Performance Standard for Organisations, the analysis results are shown below.

Laboratory analysis for Acetaldehyde was subcontracted to RPS laboratories, a UKAS Accredited Testing Laboratory, Number 0605.

RPS DO hold UKAS & MCERTS accreditation for this analysis.

As required by the MCERTS Performance Standard for Organisations, the analysis results are shown below.

Ecobat Solutions  
 Permit No : EPR/DB3704FG  
 Variation No : EPR/DB3704FG/V006  
 Report Ref : P5558 : Root

Installation Name : Recupyl Shredder Exhaust  
 Visit Details : Emissions – August 2023  
 Survey Dates : 16th August 2023  
 Report Issue Date : 18th September 2023

## Comments

**Report No.: 23-09288-1**

Customer Reference: 2023 Stack Preferential Rates

Customer Order No: E0862 P5558

RPS Sample Number	Customer Number	Sample Comments
199505	ECL/23/4628	Front: Carbonic acid, ethyl-, methyl ester 836µg  Back VOC <5µg
199506	ECL/23/4629	Front: Carbonic acid, ethyl-, methyl ester 1365µg  Back VOC <5µg
199507	ECL/23/4630	Front: VOC <5µg  Back VOC <5µg

Environmental Compliance Limited

Ecobat Solutions  
 Permit No : EPR/DB3704FG  
 Variation No : EPR/DB3704FG/V006  
 Report Ref : P5558 : R001

Installation Name : Recupyl Shredder Exhaust  
 Visit Details : Emissions – August 2023  
 Survey Dates : 16th August 2023  
 Report Issue Date : 18th September 2023

**Results Summary**

**Report No.: 23-09274-1**

Customer Reference: 2023 Stack Preferential Rates

Customer Order No: E0862 P5558

Customer Sample No	ECL/23/4625	ECL/23/4626	ECL/23/4627
RPS Sample No	199478	199479	199480
Sample Matrix	TUBE	TUBE	TUBE
Sampling Date	16/08/2023	16/08/2023	16/08/2023

Determinand	CAS No	Codes	SOP	RL	Units			
acetaldehyde FRONT	75-07-0	UM	A40	0.1	ug	0.6	0.6	< 0.1
acetaldehyde BACK	75-07-0	UM	A40	0.1	ug	< 0.1	< 0.1	< 0.1

Environmental Compliance Limited

Ecobat Solutions  
Permit No : EPR/DB3704FG  
Variation No : EPR/DB3704FG/V006  
Report Ref : P5558 : R001

Installation Name : Recupyl Shredder Exhaust  
Visit Details : Emissions – August 2023  
Survey Dates : 16th August 2023  
Report Issue Date : 18th September 2023

## UNCERTAINTY CALCULATIONS

Environmental Compliance Limited

Ecobat Solutions  
 Permit No : EPR/DB3704FG  
 Variation No : EPR/DB3704FG/V006  
 Report Ref : P5558 : R001

Installation Name : Recupyl Shredder Exhaust  
 Visit Details : Emissions – August 2023  
 Survey Dates : 16th August 2023  
 Report Issue Date : 18th September 2023

**TVOC Measurement Uncertainty**

Recupyl Shredder Exhaust - TVOC - Measurement Uncertainty - Uncertainty Calculations Table 1

Performance Characteristics	Standard Uncertainty (% of Range)	Distribution	Min Certified Ranges
			TVOC 0 - 15 mgC/m <sup>3</sup>
Lack of fit <sup>(1)</sup>	$u_{lof}$	Rectangular (Divisor = $\sqrt{3}$ )	0.73
Span drift <sup>(2)</sup>	$u_{d,s}$	Rectangular (Divisor = $\sqrt{3}$ )	0.35
Repeatability Standard Deviation (span) <sup>(3)</sup>	$u_r$	Normal (Divisor = 1)	8.87
Losses/ leakage in the sample system <sup>(4)</sup>	$u_{loss}$	Rectangular (Divisor = $\sqrt{3}$ )	3.33
Temperature dependant span drift <sup>(5)</sup>	$u_t$	Rectangular (Divisor = $\sqrt{3}$ )	0.30
Interferents <sup>(1)</sup>	$u_i$	Rectangular (Divisor = $\sqrt{3}$ )	4.39
Uncertainty of Reference Gas <sup>(6)</sup>	$u_{ref}$	Rectangular (Divisor = $\sqrt{3}$ )	2.55
Effect of Voltage Fluctuation <sup>(7)</sup>	$u_v$	Rectangular (Divisor = $\sqrt{3}$ )	1.80
Effect of Oxygen Synergism <sup>(7)</sup>	$u_{syn}$	Rectangular (Divisor = $\sqrt{3}$ )	4.60

Note:

$$\text{when } |(x_{i,max} - x_{i,adj})| = |(x_{i,min} - x_{i,adj})|, \text{ then } u(x_i) = \frac{\Delta x_i}{\sqrt{3}}$$

- Expressed as a percentage of the certified range
- Expressed as maximum drift per 24hr period as percentage of the certified range
- Expressed as a percentage of the certified range
- Expressed as a percentage of the certified range
- Expressed as a percentage of the certified range per one degree centigrade
- Expressed as standard uncertainty in units of measurement i.e. mg/m<sup>3</sup> / %Vol taking account of an additional uncertainty of 2% for gas blending
- Expressed as a percentage of the certified range

Recupyl Shredder Exhaust - TVOC - Measurement Uncertainty - Uncertainty Calculations Table 2

Performance Characteristics	Uncertainty	Value of Standard Uncertainty	* TVOC 0 - 15 mgC/m <sup>3</sup>
Lack of fit	$u_{lof}$	$u(x_i) = \frac{u_{lof} \times R_i}{\sqrt{3}} =$	0.064
Span drift	$u_{d,s}$	$u(x_i) = \frac{u_{d,s} \times R_i}{\sqrt{3}} =$	0.031
Repeatability Standard Deviation (span)	$u_r$	$\sigma = \sqrt{\frac{\sum_{i=1}^n (x_i - \bar{x})^2}{n-1}} =$	1.33
Losses/ leakage in the sample system	$u_{loss}$	$u(x_i) = \frac{u_{loss} \times R_i}{\sqrt{3}} =$	0.29
Temperature dependant span drift	$u_t$	$u(x_i) = \frac{u_t}{100} \times R_i \times \sqrt{\frac{(x_{i,max} - x_{i,adj})^2 + (x_{i,min} - x_{i,adj})(x_{i,max} - x_{i,adj}) + (x_{i,min} - x_{i,adj})^2}{3}}$	0.052
Interferents	$u_i$	$u(x_i) = \frac{u_i \times R_i}{\sqrt{3}} =$	0.38
Uncertainty of Reference Gas	$u_{ref}$	$u(x_i) = \frac{u_{ref}}{\sqrt{3}} =$	1.47
Effect of Voltage Fluctuation	$u_v$	$u(x_i) = \frac{u_v \times R_i}{\sqrt{3}} =$	0.16
Effect of Oxygen Synergism	$u_{syn}$	$u(x_i) = \frac{u_{syn} \times R_i}{\sqrt{3}} =$	0.40
Combined Standard Uncertainty		$u_c = \sqrt{u_{lof}^2 + u_{d,s}^2 + u_r^2 + u_{loss}^2 + u_t^2 + u_i^2 + u_{ref}^2}$	2.09
Expanded measurement uncertainty (at 95% confidence)		$U_{EXP} = 2 \times u_c$	4.18
Applied Span Concentration			147.35
Measured Span Concentration, STP Dry Gas			147.07
Expanded measurement uncertainty as % of Applied Span			3 %

\* Signal 3030 FID

Ecobat Solutions  
 Permit No : EPR/DB3704FG  
 Variation No : EPR/DB3704FG/V006  
 Report Ref : P5558 : R001

Installation Name : Recupyl Shredder Exhaust  
 Visit Details : Emissions – August 2023  
 Survey Dates : 16th August 2023  
 Report Issue Date : 18th September 2023

**TVOC Uncertainty of Measurement Result**

**Recupyl Shredder Exhaust - TVOC - Uncertainty of Measurement Results - Calculations Part 1**

Performance Characteristics	Standard Uncertainty (% of Range)	Distribution	Divisor	Min Certified Range
				TVOC 0 - 15 mgC/m <sup>3</sup>
Lack of fit <sup>(1)</sup>	$u_{lof}$	Rectangular	$\sqrt{3}$	0.73
Span drift <sup>(2)</sup>	$u_{d,s}$			0.35
Losses / leakage in the sample system <sup>(4)</sup>	$u_{loss}$			0.54
Temperature dependant span drift <sup>(5)</sup>	$u_t$			0.30
Interferents <sup>(1)</sup>	$u_i$			4.39
Effect of Voltage Fluctuation <sup>(7)</sup>	$u_v$			1.80
Effect of Oxygen Synergism <sup>(7)</sup>	$u_{syn}$			4.60

**Notes:**

For rectangular distributions,  $u(x_i) = \frac{u \times R_i}{\sqrt{3}}$

For  $u(x_i) = \Delta x_i \sqrt{\frac{(x_{i,max} - x_{i,adj})^2 + (x_{i,min} - x_{i,adj})(x_{i,max} - x_{i,adj}) + (x_{i,min} - x_{i,adj})^2}{3}}$ , when  $|x_{i,max} - x_{i,adj}| = |x_{i,min} - x_{i,adj}|$ , then  $u(x_i) = \frac{\Delta x_i}{\sqrt{3}}$

Where  $u(x_i) = \frac{\sigma}{\sqrt{n}}$  (See note 6 below),  $\sigma = \sqrt{\frac{\sum_{i=1}^n (x_i - \bar{x})^2}{n-1}}$

Performance Characteristics	Uncertainty (Units of final measurement)	Distribution	Divisor	TVOC 0 - 15 mgC/m <sup>3</sup>
Lack of fit	$u_{lof}$	Rectangular	$\sqrt{3}$	0.064
Span drift	$u_{d,s}$			0.031
Temperature dependant span drift	$u_t$			0.039
Interferents	$u_i$			0.38
Effect of Voltage Fluctuation (See Note)	$u_v$			0.16
Effect of Oxygen Synergism (See Note)	$u_{syn}$			0.40

**Recupyl Shredder Exhaust - TVOC - Uncertainty of Measurement Results - Calculations Part 2**

Performance Characteristics	Uncertainty (Units of final measurement)	Date & Time	TVOC 0 - 15 mgC/m <sup>3</sup>
Losses / leakage in the sample system	$u_{loss}$	16/08/23 10:27 - 12:40	1.73
Standard Error of Measured Value	$u_{SE}$	16/08/23 10:27 - 12:40	5.73

**Effect on Uncertainty Caused by Oxygen**

$$u_{Corr_{O_2}} = \frac{20.9\% - O_{2,ref}}{(20.9\% - O_{2,measured})(20.9\% - O_{2,measured})} \times \text{Uncertainty of } O_2 \text{ Meas} = 1.00$$

$$f_{O_2} = \frac{20.9\% - O_{2,ref}}{20.9\% - O_{2,measured}} = 1.0000$$

$$u_{f_{O_2}} = \frac{u_{Corr_{O_2}}}{f_{O_2}} \times 100 = 0.00 \%$$

The effect of oxygen on the overall uncertainties (below) is incorporated using the following equation:-

$$u_{combined} = \sqrt{\sum (u_{f_{O_2}})^2 + (\text{Uncertainty of Measurement of Determinand})^2}$$

Where oxygen or moisture correction is required, uncertainty based on the standard error of the measured peripheral value is converted to units of final measurement using a sensitivity coefficient C.

$$\therefore u(x_i) = C_i u_i \text{ where } C_i = \frac{\partial f}{\partial x_i}$$

**Recupyl Shredder Exhaust - TVOC - Uncertainty of Measurement Results - Calculations Part 3**

Uncertainty	Date & Time	* TVOC 0 - 15 mgC/m <sup>3</sup>
Measured Concentration	16/08/23 10:27 - 12:40	316.91
Expanded Uncertainty as Percentage of Measured Concentration		4 %

**Combined Standard Uncertainty**  $u_c = \sqrt{u_{lof}^2 + u_{d,s}^2 + u_r^2 + u_{loss}^2 + u_t^2 + u_i^2 + u_{ref}^2 + u_v^2 + u_{syn}^2}$

**Expanded uncertainty (at 95% confidence)**  $U_{Exp} = 2 \times u_c$

- Expressed as a percentage of the certified range
- Expressed as a percentage of the certified range as maximum drift per 24hr period
- Expressed as a percentage of the certified range
- Expressed as a percentage of the applied span concentration
- Expressed as a percentage of the certified range per one degree centigrade
- Where the uncertainty of moisture is taken from the manual extract test calculations.
- Expressed as a percentage of the certified range
- Where no uncertainty is presented above, the uncertainty is > 100%

Environmental Compliance Limited

Ecobat Solutions  
 Permit No : EPR/DB3704FG  
 Variation No : EPR/DB3704FG/Voo6  
 Report Ref : P5558 : R001

Installation Name : Recupyl Shredder Exhaust  
 Visit Details : Emissions – August 2023  
 Survey Dates : 16th August 2023  
 Report Issue Date : 18th September 2023

Note:  
 Results based on Charcoal Tubes Only!

Site: Ecobat Solutions, Darlaston  
 Location: Recupyl Shredder , Stack ID:Exhaust Stack

				Standard Uncertainty @ 95%	
Sampled Volume	$V_m$	0.00610	m <sup>3</sup>	$uV_m$	0.0002 m <sup>3</sup>
Meter Correction Factor or ml/count	Yd	0.986	...	...	...
Meter Temperature	$T_m$	293.67	k	$uT_m$	1.5 k
Barometric Pressure	$P_b$	1004.00	mBar	10.0	mBar
Oxygen content	$O_{2,m}$	20.90	%Vol	$uO_{2,m}$	1.25 %Vol
Moisture	$H_2O$	0.00	%Vol	$uH_2O$	%Vol

Tubes		
Determinand	Recovered Mass	Standard Uncertainty
Acetaldehyde	0.60 µg	uM 0.0300 µg

Note: In the following calculations, the sensitivity coefficient (C) is estimated using  $C_i = \frac{\partial f}{\partial x_i}$   
 For each factor, uncertainty is then calculated by  $C_i u_i$  where C is the sensitivity coefficient, u is the standard uncertainty and i is the index identifying the contributing factor e.g. i=  $uV_m$ ,  $uT_m$  etc.

Where results are required at wet conditions, the following correction factor is used to convert the data from the dry gas meter:

$$f_{s,wet} = \frac{100}{(100 - H_2O)} = 1.00$$

Uncertainty in correction factor to STP due to measured barometric pressure uncertainty component (upb), measured temperature of dry gas uncertainty component (uTm) & measured moisture (uH2O) where required

$$f_s = \frac{273}{T_m} \times \frac{P}{101.3} = 0.92$$

	Maximum	Minimum	Sensitivity	ufsp
$uP_b$	0.48	0.47	0.000476	0.00476
$uT_m$	0.93	0.92	0.00314	0.00471
$uH_2O$	...	...	...	...

$$\frac{uf_s}{f_s} = \sqrt{\left(\frac{uP_b}{(P_b/101.3)}\right)^2 + \left(\frac{uT_m}{(T_m/273.15)}\right)^2 + \left(\frac{uH_2O}{(100/(100 - H_2O))}\right)^2} = 0.00598$$

Uncertainty in volume @ STP due to volume correction factor uncertainty component (uVstd) & volume uncertainty component (uVm)

$$V_{std} = V_{measured} \times f_s = 0.00554$$

	Maximum	Minimum	Sensitivity	Standard Uncertainty
Effect of $uP_b$	0.00558	0.00550	0.00601	0.0000360
Effect of $uV_m$	0.00568	0.00540	0.91	0.000138

$$\frac{uV_{std}}{V_{std}} = \sqrt{\left(\frac{uf_s}{f_s}\right)^2 + \left(\frac{uV_m}{V_m}\right)^2} = 0.000130$$

Uncertainty of correction factor to reference conditions (excluding oxygen contribution) & Uncertainty in final measurement @ reference conditions due to uncertainty component arising from leak and/or loss (assumed 2% max) in the sample system (uL)

$$uL = \frac{Conc \times 2}{\sqrt{3}}$$

	Tubes	Condensate
	uL	uL
	mg/Nm <sup>3</sup>	mg/Nm <sup>3</sup>
Acetaldehyde	0.00125	...

$$Conc = \frac{M_{Recovered}}{V_m \times f_s \times f_{O_2}}$$

Uncertainty in final measurement @ Reference Conditions due to uM<sub>Recovered</sub>

Charcoal Tube Results				
	Maximum	Minimum	Sensitivity	Standard Uncertainty
	mg/Nm <sup>3</sup>	mg/Nm <sup>3</sup>		mg/Nm <sup>3</sup>
Acetaldehyde	0.11	0.10	180.51	0.00542
Condensate Results				
	Maximum	Minimum	Sensitivity	Standard Uncertainty
	mg/Nm <sup>3</sup>	mg/Nm <sup>3</sup>		mg/Nm <sup>3</sup>
Acetaldehyde				

Uncertainty in final measurement @ Reference Conditions due to uV<sub>std</sub>

Charcoal Tube Results				
	Maximum	Minimum	Sensitivity	Standard Uncertainty
	mg/Nm <sup>3</sup>	mg/Nm <sup>3</sup>		mg/Nm <sup>3</sup>
Acetaldehyde	0.11	0.11	19.56	0.00255

Combined Uncertainty (excluding Oxygen contribution)

$$u_{combined} = \sqrt{\sum (u_M)^2 + (u_L)^2 + (uV_{std})^2}$$

Charcoal Tubes:	Combined	Expanded	Measured	Percent of
Determinand	Uncertainty	Uncertainty	Concentration	Measured
	mg/Nm <sup>3</sup>	mg/Nm <sup>3</sup>	mg/Nm <sup>3</sup>	Concentration
Acetaldehyde	0.00611	0.0122	0.11	11.29



Environmental Compliance Limited

Ecobat Solutions  
 Permit No : EPR/DB3704FG  
 Variation No : EPR/DB3704FG/V006  
 Report Ref : P5558 : R001

Installation Name : Recupyl Shredder Exhaust  
 Visit Details : Emissions – August 2023  
 Survey Dates : 16th August 2023  
 Report Issue Date : 18th September 2023

Note:  
 Results based on Charcoal Tubes Only!

Site: Ecobat Solutions, Darlaston  
 Location: Recupyl Shredder, Stack ID: Exhaust Stack

			Standard Uncertainty @ 95%	
Sampled Volume	$V_m$	0.00600 m <sup>3</sup>	$uV_m$	0.0002 m <sup>3</sup>
Meter Correction Factor or ml/count	$Y_d$	0.966 ...	...	...
Meter Temperature	$T_m$	294.50 k	$uT_m$	1.5 k
Barometric Pressure	$P_b$	1004.00 mBar		10.0 mBar
Oxygen content	$O_{2,m}$	20.90 %Vol	$uO_{2,m}$	1.25 %Vol
Moisture	$H_2O$	0.00 %Vol	$uH_2O$	%Vol

Tubes			Standard Uncertainty	
Determinand	Recovered Mass			
Acetaldehyde	0.60 µg		uM	0.0300 µg

Note: In the following calculations, the sensitivity coefficient (C) is estimated using:  $C_i = \frac{\partial f}{\partial x_i}$   
 For each factor, uncertainty is then calculated by  $C_i u_i$  where  $C_i$  is the sensitivity coefficient,  $u_i$  is the standard uncertainty and  $i$  is the index identifying the contributing factor e.e.  $i = uV_m, uT_m$  etc.

Where results are required at wet conditions, the following correction factor is used to convert the data from the dry gas meter:

$$f_{s,wd} = \frac{100}{100 - H_2O} = 1.00$$

Uncertainty in correction factor to STP due to measured barometric pressure uncertainty component (upb), measured temperature of dry gas uncertainty component (uTm) & measured moisture (uH2O) where required

$f_s = \frac{273}{T_m} \times \frac{p}{101.3} =$	0.92			
upb	Maximum 0.48	Minimum 0.47	Sensitivity 0.000475	ufstp 0.00475
uTm	0.92	0.91	0.00312	0.00468
uH2O	...	...	...	...
$\frac{uf_s}{f_s} = \sqrt{\left(\frac{uP_b}{(P_b/101.3)}\right)^2 + \left(\frac{uT_m}{(T_m/273.15)}\right)^2 + \left(\frac{uH_2O}{100(100-H_2O)}\right)^2}$	= 0.00594			

Uncertainty in volume @ STP due to volume correction factor uncertainty component (uVstd) & volume uncertainty component (uVm)

$V_{std} = V_{measured} \times f_s =$	0.00544	0.00515		
	Maximum m <sup>3</sup>	Minimum m <sup>3</sup>	Sensitivity	Standard Uncertainty m <sup>3</sup>
Effect of $u_{f_s}$	0.00547	0.00540	0.00592	0.000352
Effect of $u_{V_m}$	0.00557	0.00530	0.91	0.000136
$\frac{uV_{std}}{V_{std}} = \sqrt{\left(\frac{uf_s}{f_s}\right)^2 + \left(\frac{uV_m}{V_m}\right)^2}$	= 0.000127			

Uncertainty of correction factor to reference conditions (excluding oxygen contribution) & Uncertainty in final measurement @ reference conditions due to uncertainty component arising from leak and/or loss (assumed 2% max) in the sample system (uL)

$uL = \frac{Conc \times 2}{\sqrt{3}}$	Tube ul	Condensate ul		
	mg/Nm <sup>3</sup>	mg/Nm <sup>3</sup>		
Acetaldehyde	0.00127	...		
$Conc = \frac{M_{Recoverd}}{V_m \times f_s \times f_{d_1}}$				

Uncertainty in final measurement @ Reference Conditions due to  $uM_{Recoverd}$

Charcoal Tube Results				
	Maximum	Minimum	Sensitivity	Standard Uncertainty
Acetaldehyde	mg/Nm <sup>3</sup>	mg/Nm <sup>3</sup>		mg/Nm <sup>3</sup>
	0.12	0.10	183.88	0.00552
Condensate Results				
Acetaldehyde	mg/Nm <sup>3</sup>	mg/Nm <sup>3</sup>	Sensitivity	Standard Uncertainty mg/Nm <sup>3</sup>

Uncertainty in final measurement @ Reference Conditions due to  $uV_{20}$

Charcoal Tube Results				
	Maximum	Minimum	Sensitivity	Standard Uncertainty
Acetaldehyde	mg/Nm <sup>3</sup>	mg/Nm <sup>3</sup>		mg/Nm <sup>3</sup>
	0.11	0.11	20.30	0.00258

Combined Uncertainty (excluding Oxygen contribution)

$$u_{combined} = \sqrt{\sum (u_{M})^2 + (u_{L})^2 + (u_{V_{20}})^2}$$

Charcoal Tubes:	Combined Uncertainty	Expanded Uncertainty	Measured Concentration	Percent of Measured Concentration
Determinand	mg/Nm <sup>3</sup>	mg/Nm <sup>3</sup>	mg/Nm <sup>3</sup>	
Acetaldehyde	0.00622	0.0124	0.11	11.28

Environmental Compliance Limited

Ecobat Solutions  
 Permit No : EPR/DB3704FG  
 Variation No : EPR/DB3704FG/V006  
 Report Ref : P5558 : R001

Installation Name : Recupyl Shredder Exhaust  
 Visit Details : Emissions – August 2023  
 Survey Dates : 16th August 2023  
 Report Issue Date : 18th September 2023

Note:  
 Results based on Charcoal Tubes Only!

Site: Ecobat Solutions, Darlaston  
 Location: Recupyl Shredder , Stack ID:Exhaust Stack

				Standard Uncertainty @ 95%	
Sampled Volume	V <sub>m</sub>	0.01254	m <sup>3</sup>	uV <sub>m</sub>	0.000 m <sup>3</sup>
Meter Correction Factor or ml/count	Yd	0.5	...	...	...
Meter Temperature	T <sub>m</sub>	294.83	k	uT <sub>m</sub>	1.5 k
Barometric Pressure	P <sub>b</sub>	1004.00	mBar		10.0 mBar
Oxygen content	O <sub>2,m</sub>	20.90	%Vol	uO <sub>2,m</sub>	1.25 %Vol
Moisture	H <sub>2</sub> O	0.00	%Vol	uH <sub>2</sub> O	%Vol

  

Tubes		
Determinand	Recovered Mass	Standard Uncertainty
Carbonic acid, ethyl-, methyl ester	841.00 µg	uM 41.82 µg

Note: In the following calculations, the sensitivity coefficient (C) is estimated using  $C_i = \frac{\partial f}{\partial x_i}$   
 For each factor, uncertainty is then calculated by  $u_i = C_i \times u_{x_i}$  where C is the sensitivity coefficient, u is the standard uncertainty and i is the index identifying the contributing factor e.g. i=uV<sub>m</sub>, uT<sub>m</sub>, etc.

Where results are required at wet conditions, the following correction factor is used to convert the data from the dry gas meter:

$$f_{s,wet} = \frac{100}{(100 - H_2O)} = 1.00$$

Uncertainty in correction factor to STP due to measured barometric pressure uncertainty component (up<sub>b</sub>), measured temperature of dry gas uncertainty component (uT<sub>m</sub>) & measured moisture (uH<sub>2</sub>O)

$$f_s = \frac{273}{T_m} \times \frac{P}{101.3} = 0.92$$

	Maximum	Minimum	Sensitivity	ufstp
up <sub>b</sub>	0.48	0.47	0.000475	0.00475
uT <sub>m</sub>	0.92	0.91	0.00311	0.00467
uH <sub>2</sub> O	...	...	...	...

$$\frac{uf_s}{f_s} = \sqrt{\left(\frac{uP_b}{P_b/101.3}\right)^2 + \left(\frac{uT_m}{T_m/273.15}\right)^2 + \left(\frac{uH_2O}{100/(100-H_2O)}\right)^2} = 0.00592$$

Uncertainty in volume @ STP due to volume correction factor uncertainty component (uVstd) & volume uncertainty component (uVm)

$$V_{std} = V_{measured} \times f_s = 0.00575$$

	Maximum	Minimum	Sensitivity	Standard Uncertainty
	m <sup>3</sup>	m <sup>3</sup>		m <sup>3</sup>
Effect of u <sub>f<sub>s</sub></sub>	0.00579	0.00572	0.00627	0.0000371
Effect of uV <sub>m</sub>	0.00590	0.00561	0.46	0.000144

$$\frac{uV_{std}}{V_{std}} = \sqrt{\left(\frac{uf_s}{f_s}\right)^2 + \left(\frac{uV_m}{V_m}\right)^2} = 0.0000752$$

Uncertainty of correction factor to reference conditions (excluding oxygen contribution) & Uncertainty in final measurement @ reference conditions due to uncertainty component arising from leak and/or loss (assumed 2% max) in the sample system (uL)

$$uL = \frac{Conc \times \frac{2}{100}}{\sqrt{3}}$$

	Tubes uL	Condensate uL
	mg/Nm <sup>3</sup>	mg/Nm <sup>3</sup>
Carbonic acid, ethyl-, methyl ester	1.69	...

$$Conc = \frac{M_{Recovered}}{V_m \times f_s \times f_{O_2}}$$

Uncertainty in final measurement @ Reference Conditions due to uM<sub>Recovered</sub>

Charcoal Tube Results				
	Maximum	Minimum	Sensitivity	Standard Uncertainty
	mg/Nm <sup>3</sup>	mg/Nm <sup>3</sup>		mg/Nm <sup>3</sup>
Carbonic acid, ethyl-, methyl ester	153.44	138.91	173.81	7.27

  

Condensate Results				
	Maximum	Minimum	Sensitivity	Standard Uncertainty
	mg/Nm <sup>3</sup>	mg/Nm <sup>3</sup>		mg/Nm <sup>3</sup>
Carbonic acid, ethyl-, methyl ester				

Uncertainty in final measurement @ Reference Conditions due to uV<sub>STD</sub>

Charcoal Tube Results				
	Maximum	Minimum	Sensitivity	Standard Uncertainty
	mg/Nm <sup>3</sup>	mg/Nm <sup>3</sup>		mg/Nm <sup>3</sup>
Carbonic acid, ethyl-, methyl ester	148.11	144.29	25411.18	1.91

Combined Uncertainty (excluding Oxygen contribution)

$$u_{combined} = \sqrt{(u_M)^2 + (u_L)^2 + (uV_{std})^2}$$

Charcoal Tubes: Determinand	Combined Uncertainty mg/Nm <sup>3</sup>	Expanded Uncertainty mg/Nm <sup>3</sup>	Measured Concentration mg/Nm <sup>3</sup>	Percent of Measured Concentration
Carbonic acid, ethyl-, methyl ester	7.70	15.41	146.18	10.54

Environmental Compliance Limited

Ecobat Solutions  
 Permit No : EPR/DB3704FG  
 Variation No : EPR/DB3704FG/V006  
 Report Ref : P5558 : R001

Installation Name : Recupyl Shredder Exhaust  
 Visit Details : Emissions – August 2023  
 Survey Dates : 16th August 2023  
 Report Issue Date : 18th September 2023

Note:  
 Results based on Charcoal Tubes Only!

Site: Ecobat Solutions, Darlaston  
 Location: Recupyl Shredder , Stack ID:Exhaust Stack

				Standard Uncertainty @ 95%	
Sampled Volume	V <sub>m</sub>	0.01250	m <sup>3</sup>	uV <sub>m</sub>	0.000 m <sup>3</sup>
Meter Correction Factor or ml/count	Y <sub>d</sub>	0.5	...	...	...
Meter Temperature	T <sub>m</sub>	296.17	k	uT <sub>m</sub>	1.5 k
Barometric Pressure	P <sub>b</sub>	1004.00	mBar		10.0 mBar
Oxygen content	O <sub>2,m</sub>	20.90	%Vol	uO <sub>2,m</sub>	1.25 %Vol
Moisture	H <sub>2</sub> O	0.00	%Vol	uH <sub>2</sub> O	%Vol

Tubes		
Determinand	Recovered Mass	Standard Uncertainty
Carbonic acid, ethyl-, methyl ester	1365.00 µg	uM 68.25 µg

Note: In the following calculations, the sensitivity coefficient (C) is estimated using:  $C_i = \frac{\partial f}{\partial x_i}$

For each factor, uncertainty is then calculated by  $u_i$  where C is the sensitivity coefficient, u is the standard uncertainty and i is the index identifying the contributing factor e.g. i=uV<sub>m</sub>, uT<sub>m</sub>, etc.

Where results are required at wet conditions, the following correction factor is used to convert the data from the dry gas meter:

$$f_{s, wet} = \frac{100}{(100 - H_2O)} = 1.00$$

Uncertainty in correction factor to STP due to measured barometric pressure uncertainty component (uP<sub>b</sub>), measured temperature of dry gas uncertainty component (uT<sub>m</sub>) & measured moisture (uH<sub>2</sub>O)

$$f_s = \frac{273}{T_m} \times \frac{P}{101.3} = 0.91$$

	Maximum	Minimum	Sensitivity	ufstp
uP <sub>b</sub>	0.48	0.47	0.000473	0.00473
uT <sub>m</sub>	0.92	0.91	0.00308	0.00463
uH <sub>2</sub> O	...	...	...	...

$$\frac{uf_s}{f_s} = \sqrt{\left(\frac{uP_b}{P_b/101.3}\right)^2 + \left(\frac{uT_m}{T_m/273.15}\right)^2 + \left(\frac{uH_2O}{100/(100-H_2O)}\right)^2} = 0.00585$$

Uncertainty in volume @ STP due to volume correction factor uncertainty component (uV<sub>std</sub>) & volume uncertainty component (uV<sub>m</sub>)

$$V_{std} = V_{measured} \times f_s = 0.00571$$

	Maximum	Minimum	Sensitivity	Standard Uncertainty
Effect of uP <sub>b</sub>	0.00575	0.00568	0.00625	0.0000366
Effect of uV <sub>m</sub>	0.00585	0.00557	0.46	0.000143

$$\frac{uV_{std}}{V_{std}} = \sqrt{\left(\frac{uf_s}{f_s}\right)^2 + \left(\frac{uV_m}{V_m}\right)^2} = 0.0000744$$

Uncertainty of correction factor to reference conditions (excluding oxygen contribution) & Uncertainty in final measurement @ reference conditions due to uncertainty component arising from leak and/or loss (assumed 2% max) in the sample system (uL)

$$uL = \frac{Conc \times 2}{\sqrt{3} \times 100}$$

	Tubes	Condensate
Carbonic acid, ethyl-, methyl ester	mg/Nm <sup>3</sup>	mg/Nm <sup>3</sup>
	2.76	...

$$Conc = \frac{M_{recovered}}{V_m \times f_s \times f_{O_2}}$$

Uncertainty in final measurement @ Reference Conditions due to uM<sub>recovered</sub>

Charcoal Tube Results				
	Maximum	Minimum	Sensitivity	Standard Uncertainty
Carbonic acid, ethyl-, methyl ester	mg/Nm <sup>3</sup>	mg/Nm <sup>3</sup>		mg/Nm <sup>3</sup>
	250.92	227.02	175.07	11.95
Condensate Results				
	Maximum	Minimum	Sensitivity	Standard Uncertainty
Carbonic acid, ethyl-, methyl ester	mg/Nm <sup>3</sup>	mg/Nm <sup>3</sup>		mg/Nm <sup>3</sup>

Uncertainty in final measurement @ Reference Conditions due to uV<sub>std</sub>

Charcoal Tube Results				
	Maximum	Minimum	Sensitivity	Standard Uncertainty
Carbonic acid, ethyl-, methyl ester	mg/Nm <sup>3</sup>	mg/Nm <sup>3</sup>		mg/Nm <sup>3</sup>
	242.13	235.90	41844.52	3.11

Combined Uncertainty (excluding Oxygen contribution)

$$u_{combined} = \sqrt{(u_M)^2 + (u_L)^2 + (uV_{std})^2}$$

Charcoal Tubes:	Combined Uncertainty	Expanded Uncertainty	Measured Concentration	Percent of Measured Concentration
Determinand	mg/Nm <sup>3</sup>	mg/Nm <sup>3</sup>	mg/Nm <sup>3</sup>	
Carbonic acid, ethyl-, methyl ester	12.65	25.30	238.97	10.59

Ecobat Solutions  
 Permit No : EPR/DB3704FG  
 Variation No : EPR/DB3704FG/V006  
 Report Ref : P5558 : R001

Installation Name : Recypyl Shredder Exhaust  
 Visit Details : Emissions – August 2023  
 Survey Dates : 16th August 2023  
 Report Issue Date : 18th September 2023

**Stack Reference Exhaust Stack**

**Measurement Uncertainty Calculations - Velocity at Stack Conditions**

Contribution From	Standard u/c (Pa)	
Pitot Calibration Uncertainty Contribution	0.04	A
Manometer Calibration Uncertainty Contribution	0.037666667	B
Variation in Actual Pitot reading at sample points	0.60	C
<b>Combined u/c (Pa) =</b> SQRT $(A/\sqrt{3})^2 + (B/\sqrt{3})^2 + (C/\sqrt{3})^2$	<b>Combined u/c (Pa)</b> 0.35	
<b>Expanded Uncertainty of Flow Measurements Pa</b>	<b>0.70</b>	
	<b>Standard u/c (K)</b>	
Temperature Calibration (K)	1.46	D
Variation in Actual Temp reading at sample points	0.00	E
<b>Combined u/c of Temp (K)</b> SQRT $((D/\sqrt{3})^2 + (E/\sqrt{3})^2)$	<b>Combined u/c (K)</b> 0.84	
<b>Expanded Uncertainty of Temp Measurements (K)</b>	<b>1.69</b>	
Measured Average Velocity (m/s) at Stack Conds	3.53	
Maximum Average Velocity (m/s) at Stack Conds	3.70	
Standard Uncertainty Velocity at Stack Conditions (%)	4.82	
<b>Expanded Uncertainty Velocity (at Stack Conditions)</b>	<b>9.63 (%)</b>	

**Measurement Uncertainty Calculations - Flowrate at Stack Conditions**

Contribution From	Standard u/c (m <sup>2</sup> )
Area (m <sup>2</sup> )	0.00047
Measured Average Flowrate (m <sup>3</sup> /s) at Stack Conds	0.17
Maximum Average Flowrate (m <sup>3</sup> /s) at Stack Conds	0.18
Standard Uncertainty Flowrate (m <sup>3</sup> /s) at Stack Conditions (%)	5.86
<b>Expanded Uncertainty Flowrate (m<sup>3</sup>/s) at Stack Conditions</b>	<b>11.73 (%)</b>

**Measurement Uncertainty Calculations - Flowrate at STP & Wet Gas**

Contribution From	Standard u/c (%)
Temperature Calibration (K)	0.5
Barometer Calibration	0.5
Measured Average Flowrate (m <sup>3</sup> /s) at STP Wet	0.15
Maximum Average Flowrate (m <sup>3</sup> /s) at STP Wet	0.16
Standard Uncertainty Flowrate (m <sup>3</sup> /s) at STP Wet	6.36
<b>Expanded Uncertainty Flowrate (m<sup>3</sup>/s) at STP Wet</b>	<b>12.72 (%)</b>