Confidential

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Stack Emission Test Report

Monitoring objective: Sampling of Airflow

Monitoring deviations/ special requirements: None

Trial Ref	**20.002.4**
Client	Connollys Red Mills,
Address	Grange Lower,Goresbridge,Co Kilkenny .R95EKH4
Contact Name	John Rea
Date of test	21/02/2020
Dryer Name	Flaker 1 ,A2-5
Powder Name	Animal Feed

Contents:

ISO 17025 INAB ACCREDITED TESTING DETAILED IN SCOPE REG NO.323T

Authorised by Eoin.Murphy
Technical Manager

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Software ver 8.342 March 2019

Airflow

1.Executive Summary

Trial Reference:	20.002.4
Client:	Connollys Red Mills,
Address:	Grange Lower,Goresbridge,Co Kilkenny .R95EKH4
Date of test:	21/02/2020
IPPC Licence no:	P1069-01
Emmission Limit:	50 mg/m³

Airflow of stack A2-5

on dryer Flaker 1 ,A2-5

The air flowrate was measured as 9,415 m³/hr of moist air at 16 °C or 8,633 Nm³/hr of dry air under standard conditions, equivalent to 8,774 m³/hr under standard conditions on a wet basis (Note 2)

Notes:
1. Standard conditions are 0°C and 1013 mbar barometric pressure. The figures expressed as ± mg/m³ are expanded uncertainty values (confidence level 95%).
We do not claim uncertainty values for results that are less than the limit of detection.
2. IPPC 4.2.1 expresses emissions under standard conditions on a wet basis for non-combustion gases. See comment at end of Explanatory Note.
3. This report refers only to the items identified herein.

Airflow

2. Method for monitoring Airflow to atmosphere

A series of velocity head readings are taken using a Pitot tube at intervals across the stack, from which the individual velocities at those points are calculated, The Pitot assembly for velocity measurement is mounted on the lance that is normally used for sampling air for particulates, together with a built-in thermocouple. A handheld datalogger reads the stack temperature (from the thermocouple), ambient temperature and barometric pressure. An Airflow type 5 manometer is used to take readings from the Pitot tube. Velocity measurement normally takes place along 2 sampling lines at right angles, according to EN 13284. The report gives total airflow on a wet and dry basis. The calculations are outlined in the Explanatory Note.

Plant Conditions

Trial Reference	20.002.4
Dryer:	Flaker 1 ,A2-5
Duct	A2-5
Powder:	Animal Feed
Start time	11:05:00
End time	11:32:00
Production Rate:	3 tonnes/h
Feed Solid level:	86%
Product moisture:	14%
Inlet temperature:	15℃
Outlet Temperature	16.6℃

Sampled By: Donal Rawle
Experimental officer

Team Leader: eoin.murphy
Research officer

Comment on plant conditions

Normal Conditions
Noise abatement in duct

Airflow

Field Measurements

Stack: A2-5

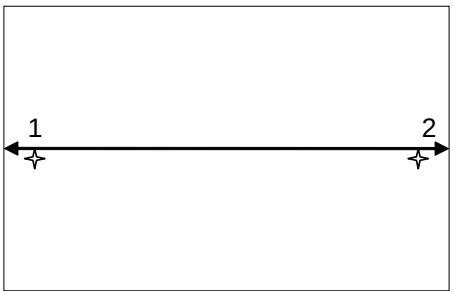
Airflow Determination

Rectangular 2 ***Sampling lines***

Depth 0.69 ***m***

Sampling side length

0.525 ***m***



Per sample line

Pitot Readings
(see table below)

Pitot No.	Readings (N/m²)	Edge Distance (m)	Sample Point	Sample line	Temperature
1	29	0.172	☑	1	16.4
2	18	0.517	☑	1	16.4
3	75	0.172	☑	2	16.6
4	69	0.517	☑	2	16.4

Field Measurements

Stack Temperature:	16.4 *°C*
Static Pressure (relative):	-14 *Pa*
Barometric Pressure (outside stack):	1001.0 *mbar*
Barometric Pressure (in stack):	1000.86 *mbar*

Dimensions (m	0.525 *X* 0.690
Area (m²)	0.3623
Velocity (m/s)	7.2
Air Moisture (g/kg)	10

Air Flow

Mass flow 11,268 *kg/h;* 9,415 *m³/h moist air (Note 3)* 8,633 *Nm³/h dry air*

8,774 *m³/h moist air under standard conditions, Note 4*

Note 1: Stack temperature is an average of temperatures across sampling plane

Note 2: Flowrate was determined by subdivision of cross section area into anular rings in the case of a circular duct and rectangles in the case of a rectangular duct. The summation area accounted for was 0.3623 m^2

Note 3: At stack conditions, density 1.1968 kg/m^3

Note 4: Moist air volume under standard conditions as per 4.2.1 of IPPC for non-combustible gases.

Note 5: No wall effect factor applied.

Note 6: Velocity and flow are determined from the sample points

Sampling

Max/Min Ratio of pitot readings	Ratio < 9:1 OK		
Isokinetic ratio	0.0 %		
Leak Test < 2%	☑		
Ambient temperature	17 °C	*Weight of water collected in moisture trap*	g

Comment on Sampling:

Angle of flow normal (<15°)

6. Explanatory note on Stack Emission Report for Total Particulate

1. The *average air velocity* **v** is calculated as follows:
A cross-sectional area $\mathbf{a_i}$ is associated with each point, where a Pitot reading is taken and where air is sampled for particulate. The velocity $\mathbf{v_i}$ in each segment is calculated as a function of the Pitot pressure and the temperature. The flow $\mathbf{a_i}$ through each segment (associated with each point of measurement) is calculated as:

$$\mathbf{q_i = a_i.v_i} \qquad [m^3/s]$$

The total flow of moist air, $\mathbf{Q = \sum q_i}$ $[m^3/s]$

and the average velocity, $\mathbf{v = Q/A}$, [m/s]

where **A** is the cross-sectional area of the stack, e.g. $\mathbf{A} = \pi (D/2)^2$ for a circular stack.

2. Air density for moist air is determined from first principles as a function of temperature, pressure and water vapour content. The relationship between volumetric flow of moist air in duct, $\mathbf{Q_h}$ $[m^3/h]$, mass-flow of moist air in duct, $\mathbf{m_h}$ [kg/h], and flowrate of dry air in duct under reference conditions, $\mathbf{Q_{nh}}$ $[Nm^3/h]$, is:

a. Flowrate per hour (m^3/h): $\mathbf{Q_h} = 3600\ \mathbf{Q}$, where Q is in (m^3/s)

b. Mass flowrate (kg/h): $\mathbf{m_h} = \mathbf{Q_h}\rho$, where ρ = the density of air at the actual temperature, pressure and moisture in the stack.

c. To convert from volumetric flow of moist air to moist air under standard pressure and temperature:

$$Q_{mh} = Q_h \times \frac{P_s}{1013} \times \frac{273}{273 + T_s}$$

d. Convert from volumetric flow of moist air to dry air under standard conditions:

$$Q_{nh} = Q_h \frac{(100 - B_{ws})}{100} \times \frac{P_s}{1013} \times \frac{273}{273 + T_s}$$

where $\mathbf{B_{ws}}$= air moisture in % v/v (= Air Moisture in g/kg x 0.151). Air Moisture in g/kg is determined from the weight of moisture absorbed by the desiccant [g] and the volume of sampled air recorded by the gasmeter and converted to mass [kg], as follows

Mass of dry air at reference conditions, $M_{ad0} = \frac{V_m \times 273}{T_m + 273} \times \frac{P_m}{1013} \times \rho_0$ [kg]

where P_m = barometric pressure at gasmeter [mbar].

Humidity ratio, $x = \frac{w_w}{M_{ad0}}$ [g/kg of dry air]

where w_w = weight of water absorbed by desiccant.

3. A gasmeter is used to measure the sampled air volume. Measured concentration of particulate is:

c = w x 1000/V_{mo} [mg/Nm^3]**,** where **w** is total weight [g] of dried sample (including washings) and **V_{mo}** is the cumulative flow of sampled air measured by the gasmeter, corrected for temperature and pressure.

The total loss **L** [kg/h] is calculated as **c** times the estimated flowrate of dry air in the stack at standard conditions (0°C and 1013 mbar), divided by 10^6 for unit conversion (mg to kg).

4. *Isokinetic ratio* is calculated as **100 x V_{mo}/V_{no} %**, where **V_{no}** is the target cumulative flow of dry air at the sampling nozzle during sampling, calculated from the Pitot readings **P** as **0.84**$\sqrt{(2P/\rho)}$ for an S-type Pitot tube, and corrected for moisture removal, stack temperature and pressure to standard conditions. The isokinetic ratio should be between 95 and 115% for total particulate.

***5.* Summary of notation:**

A Cross-sectional area of the stack (= $\pi(D/2)^2$ for a circular stack of diameter D).
a Sampling nozzle cross sectional area
a_i Cross-sectional area is associated with each point.
B_{ws} Water vapour content on a volumetric basis, i.e. volume of water vapour / volume of moist air.
c Gravimetric dust concentration [mg/Nm^3]
ELV Emission limit value
GasmeterCF. Gasmeter calibration factor
L Total loss [kg/h] i.e. estimated mass of powder being lost in stack
m_h Total mass flowrate of air in stack [kg/h] = $Q_h \rho$
P Pitot tube reading, Pa
P_s Barometric pressure in stack, mbar. **P_m** = barometric pressure at gasmeter
Q Total airflow in stack = $\sum$ **q_i** , m^3/s
Q_h Total air flow per hour [m^3/h] = 3600 **Q**
q_i Flow associated with each point = **a_i v_i**
Q_{mh} Total air flow expressed as moist air corrected for standard pressure and temperature [m^3/h]
Q_{nh} Total air flow expressed as normal cubic metres (dry air) per hour [Nm^3/h] = **m_h/ρ_o**
t Sampling duration
T_m Gasmeter temperature (°C) ; **T_s** Stack temperature, °C
v Average air velocity = **Q/A**
v_i Velocity at any point (function of the Pitot pressure and the temperature).
v_s Mean velocity at the sampling points
V_m Volume of air measured by gasmeter (m^3),
V_{mo} Cumulative flow of sampled air measured by the gasmeter, corrected for temperature and pressure (Nm^3).
V_{no} Target cumulative flow of dry air at the sampling nozzle during sampling, calculated from the Pitot readings and corrected for moisture removal, stack temperature and pressure to standard conditions (Nm^3).
w Sample weight; **w_w** weight of water absorbed by desiccant
x Humidity ratio (g/kg of dry air)
ρ Density of air at the actual temperature
ρ_o Density of dry air = 1.2928 kg/m^3 at standard conditions (0°C, 1013 mbar)