WORLEY NEW ZEALAND

FOR

Ravensdown Fertiliser Co-Operative Ltd.

SSP Air + Emission Study

Revision D Project No: QU911301

4 November 2021

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QU911301-SSP Air Study

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Glossary

Symbol or Abbreviation	Definition or Description
Acidulation	The process where phosphate rock is reacted with a mineral acid to produce a phosphoric acid and gypsum.
BACT	Best Available Control Technology
AZF-GP	Azote Fertilizer Grande Paroisse
DAP	Di-Ammonium Phosphate, $(NH_4)_2HPO_4$
EHS	Environment, Health, and Safety
EPA	Environmental Protection Agency
FSA	Fluosilicic acid
H_3PO_4	Phosphoric acid
H_2SO_4	Sulfuric acid
IBP	International Best Practice
IFC	International Fertilizer Corporation
JESA	JESA Group (A partnership between OCP and Worley)
JT	JESA Technologies
MAP	Mono-Ammonium Phosphate, $NH_4H_2PO_4$
M	Million (M tpy = million tpy)
N	Symbol for nitrogen, an essential crop nutrient
NSPS	New Source Performance Standard
NTU	Number of Transfer Units
OF	Operating Factor
OCP	OCP S.A. or OCP Group is a Global Fertilizer Company
P	Symbol for phosphorus, an essential crop nutrient
P_2O_5	Phosphorus content expressed as phosphorus pentoxide
PFD	Process Flow Diagram
PSD	Particle Size Distribution
ROP	Run of Pile
TIC	Total Installed Cost
tpy (t/y)	Metric tonnes per year
tph (t/h)	Metric tonnes per hour
SSP	Single Super Phosphate, (00:16-20:00 equivalent to 0% N, 16-20% P_2O_5, 0% K_2O)
TSP	Triple Super Phosphate, (00:46:00 equivalent to 0% N, 46% P_2O_5, 0% K_2O)
USD	United States Dollar

Executive Summary

JESA Technologies was engaged to conduct a study to compare Ravensdown's SSP Manufacturing emissions with IBP. The expected performance of the proposed new scrubbers was also to be reviewed against IBP. The study included a site visit by personnel from the Worley in-country office in support of the study. JT has not previously evaluated the operations for this site.

International Best Practice for all stack emissions from SSP plants is defined as follows:

Fluoride <5 mg/Nm^3

Particulate <50 mg/Nm^3

The current consent order indicates that the sum of fluoride discharged from the 2 den stacks and the hygiene stack shall not exceed 1.5 kg/h and the sum shall not exceed a maximum of 1 kg/h in more than 50% of the samples taken in any 12-month period.

The current scrubbing system has three separate stacks. Average results for fluoride are as follows:

Stack	Emission in the 12-month period from October 2019 to October 2020		
	Average Kg/h	Average mgF/Nm^3	Maximum Kg/h
Den #1 Stack	0.02	1.95	0.10
Den # 2 Stack	0.04	3.11	0.14
Hygiene Stack	0.03	0.39	0.25
Combined Stack	0.09	1.03	0.30

Average emissions from each stack are much better than International Best Practice and current consented values.

The existing system consists of two venturis, three void towers and a cyclonic separator in series for each of the den scrubbers and a venturi and cyclonic separator for the hygiene scrubber.

Ravensdown is considering a proposal from Armatec to replace the two existing den scrubbers, which are at end of their life. The proposed new system is a much simpler arrangement. The new den scrubber system is four scrubbers in series and combines the gas flow of the den scrubber with the gas flow of the hygiene scrubber and discharges from a common stack.

Although no design details are provided for either the existing or proposed systems, the existing den scrubbers have more than 10 NTU's based on the measured emissions. The vendor has stated that the new scrubber system has 10 NTU's.

The new system involves less equipment and therefore should have an improved operational benefit. Armatec is proposing to guarantee less than 5 mg/Nm^3 from the stack, which meets International Best Practice. However, it cannot be considered BACT as, based on JT's calculations, it will give higher emissions than the current system.

<table>
<tr><th>Description</th><th colspan="2">Current System[1]</th><th colspan="2">Proposed System[2]</th></tr>
<tr><td>Units</td><td>mg F/m^3</td><td>kg F/h</td><td>mg F/m^3</td><td>kg F/h</td></tr>
<tr><td>Den #1</td><td>1.95</td><td>0.0248</td><td rowspan="2">4.62</td><td rowspan="2">0.1412</td></tr>
<tr><td>Den # 2</td><td>3.11</td><td>0.0411</td></tr>
<tr><td>Hygiene</td><td>0.41</td><td>0.0258</td><td>0.41</td><td>0.0258</td></tr>
<tr><td>Single Stack</td><td>1.01</td><td>0.0918</td><td>1.67</td><td>0.167</td></tr>
</table>

Current stack emissions average 0.092 kg/h versus 0.5 kg/h that is guaranteed, and 0.167 kg/h calculated based on 2.5 NTU's per vessel.

So, while the idea of replacing the Den scrubbers and combining gases in a common system, with a common stack, has merit, the performance of the proposed scrubbing system may be insufficient to meet the requirements of future Consent decree, if that takes into account past scrubber performance.

The current consent order states that particulate emissions from the mills must be no more than 1 kg/h per mill and no more than 2 kg/h in total when two or more mills are operating. The data supplied for mill stack emission data for particulate indicates compliance with the consent order.

Except for the mills, the dust control provisions in the materials handling system are very rudimentary and should be upgraded to include a series of dust extraction points at each transfer point together with associated baghouses equipped with broken bag detectors.

The existing data supplied is insufficient to develop a detailed design for sizing the ventilation and hygiene scrubber system. However, a study completed in 2016 indicated that, although overall and individual ventilation rates are in line with JT norms, there are several noteworthy improvements that could be made. In addition, JT would expect that the system as currently designed is likely susceptible to frequent blockages. If this is confirmed by Ravensdown Operations, a re-design of the system is recommended.

1. Introduction

Ravensdown Fertiliser Co-Operative Ltd. (Ravensdown) is a leading supplier of fertilizers and other agrochemicals in New Zealand. Ravensdown operates a superphosphate manufacturing plant in Napier. The air discharge consent for the superphosphate facility expires in 2022.

Ravensdown engaged Worley New Zealand Limited, who in turn engaged JESA Technologies LLC (JT)

JT will prepare a report describing and assessing the industrial process for the Superphosphate manufacturing Plant at the Ravensdown Napier Works. The report includes:

- Technical credentials of the author and relevant industry experience.
- Description of industrial process with simple flow diagrams and including air emission control technology and key features of industrial process control.
- Key specifications of processes and commentary on scale of the Ravensdown plant vs. global plants.
- Assessment of existing proposed vendor's scrubber technology against international best practice in regard to environmental performance or other applicable standards, and identification of any significant process components that prevent existing technology from being rated as best practice.
- Recommendations for upgrades if applicable.
- A review of the areas where product is exposed to atmosphere (e.g. curing stores and hoods) as it relates to fugitive fluoride emissions. Compare Ravensdown's process and fugitive emissions control are to IBP

Worley provided the local site information and coordination between Ravensdown and JT.

1.1 Purpose of Report

The scope of this study was to review the emissions in the form of fluoride and particulate matter, including pH from the discharge stacks and other fugitive emissions from the Napier Single Superphosphate plant (SSP). Comment on the performance of the Ravensdown plant when compared to current consent limits and International Best Practice and comment on the proposed upgrade to the scrubber system as compared to International Best Practice and the existing scrubber performance.

1.2 International Best Practice

International Best Practice (IBP) is defined as techniques and practices that have been used to establish emission norms that are commonly used for plants constructed around the world. These norms can be considered as a benchmark against which current and proposed emissions can be measured.

1.3 Best Available Control Technology

In the United States of America, Best Available Control Technology (BACT) is a standard used in air pollution in the prevention of deterioration in air quality. New plant permits set emission limits that are achievable using BACT. BACT standards are applicable to all new plants, as well as pre-existing ones whose modifications might increase the level of emission of any pollutant. BACT must be used, regardless of cost, unless it can be demonstrated that it is unfeasible due to substantial and unique local standards.

If a new stationary source is incapable of BACT standards, it is subject to the New Source Standard (NSPS) for a pollutant as determined by the EPA. NSPS's consider cost and energy requirements of the emission reduction processes, which contrasts with BACT standards.

Suffice to say, in the United States at least, the EPA would not sanction modifications to the pollution control system on a pre-existing plant that resulted in an increase of emissions above that which is already being achieved.

2. Author's Technical Credentials

2.1 JESA Technologies

JT is a part of JESA Group. The JESA Group is a 50/50 joint venture between OCP and Worley. In 2019 Worley Parsons purchased Jacobs Engineering's share of JESA Group.

2.1.1 Services

The JT/JESA offices provide the full range of project development services from process development and initial feasibility studies to final start-up, operations and maintenance. The following services are provided:

- Project management, estimating, cost control and planning
- Technical and economic feasibility studies
- Bench and pilot scale test work
- Process engineering and development
- Basic and detailed engineering and design
- Procurement
- Construction and construction management
- Plant start-up and operations/training management
- General consultancy
- Due diligence
- Revamp and plant performance improvement projects

JESA has the capability to organize and manage projects of all sizes from inception through execution to production. Services are tailored to the specific requirements of individual projects and clients and range from minor consulting assignments to complete engineering, procurement, and construction management for major projects.

2.1.2 Phosphate Center of Excellence

JT is a world leader in providing phosphate technology. We license phosphoric acid and granular fertilizer technology as well as offering plant designs for phosphate rock beneficiation.

Since establishment in 1974, the JT office in Lakeland has been responsible for the design and construction of over 130 process facilities for the phosphate fertilizer industry in 29 countries. No other engineering group can offer such extensive experience in the industry.

JESA also has full-service engineering specializing in the detailed design of both mineral processing and chemical plants for the phosphate industry. We have technical expertise in beneficiation, chemical fertilizers, and other areas of work in the phosphate industry.

These overall capabilities have allowed JESA to become one of the foremost experts in the field of phosphate from the mine through to the final granular product.

2.1.3 Granular Fertilizers Experience and Capabilities

In 1974, JT acquired the slurry process technology, experience, and personnel of Dorr-Oliver Incorporated, thereby effectively achieving an unbroken involvement in the industry dating back to the 1930's.

JT plants are installed and operating in countries around the world including:

- Australia
- Bulgaria
- Canada
- China
- England
- France
- India
- Japan
- Morocco
- Nigeria
- Pakistan
- Poland
- Romania
- Saudi Arabia
- Sweden
- Venezuela
- Yugoslavia
- USA

JT designed granulation plants produce over 30 million tonnes per year of granular fertilizer in various forms including DAP, MAP, TSP and NPK grades. Since 2003 in Morocco alone, 11 lines capable of producing over 9 million tonnes per year of fertilizer have been installed.

Four of the lines in Morocco were converted from the AZF-GP process. A further plant in Pakistan was also converted from the AZF-GP process.

Grassroots DAP/MAP plants completed in the last fifteen years include 4 trains of 135 t/h and a further 3 trains of 120 t/h in Morocco, 3 trains of 140t/h in India, and a 135 t/h plant in Australia. These plants are among the largest capacity plants in the world.

Some plants feature high nitrogen products using urea or ammonium nitrate, while others use trace elements as supplementary nutrients. Feedstocks include both high and low-grade phosphate rock and phosphoric acid.

The slurry process came to dominate TSP manufacture in the USA and is displacing ROP processes elsewhere. JT has been responsible for more slurry process triple superphosphate plants using a greater variety of phosphate rock feedstocks than any other process supplier. Over the years, a total of 17 lines operating on 9 different phosphate rocks have been put into operation.

The JT slurry granulation process is very flexible and with minor modifications can be adapted to produce a combination of both TSP, NPK, and APS (Ammonium Phosphate Sulphate) products. Trace elements can also be added to provide supplementary nutrients in the various products.

The JT site in Florida includes pilot plants for phosphoric acid and beneficiation, supported by a world class laboratory. SSP/TSP powder tests are carried out on the bench scale as is the production of many types of granular fertilizer.

2.2 Subject Matter Experts

David Ivell *Granulation Subject Matter Expert*	B.Sc. Honors, MIChemE, C.Eng, Chemical Engineering, 1975, Imperial College, London, UK
	Dave has 45 years of experience in the fertilizer industry. He has extensive knowledge of processes for the production of granular fertilizer (including Superphosphate) and his experience includes both design and start-up work. Dave is the named inventor in a patent accepted in several countries for the production of granular DAP utilizing a pipe reactor. He worked for a fertilizer producer for many years before joining JESA and was part of a process engineering department licensing technology overseas, as well as providing advice to eight plant sites throughout the UK. Production facilities included; phosphoric acid, granular ammonium phosphate, superphosphate (SSP/TSP), NPK based on ammonium nitrate. Since joining JESA, Dave has led many fertilizer projects including design of new facilities as well as the revamp of existing facilities Dave is based in Lakeland, Florida, USA, where he is General Manager of JESA Technologies LLC.
Elton Curran *Senior Phosphate Fertilizer Specialist*	Bachelor of Science, Chemical Engineering, 1983, Auburn University
	Elton has 33 plus years of operations and engineering experience in the fertilizer industry. His experience includes production of phosphate fertilizer such as DAP, MAP, and TSP, Environmental Compliance associated with a phosphate complex, and Engineering Design for many phosphate fertilizer related projects. He holds a Bachelor of Science and Chemical Engineering degree from Auburn University. He joined JESA Technologies in 2011. His responsibilities include working with clients in the field and supervising engineers and designers. He has extensive experience in developing reports, Front End Engineering and Design (FEED) packages. He also has substantial field experience in phosphoric acid and phosphate fertilizer plants. Elton is based in Lakeland, Florida, USA.

3. Methodology

The following approach was used to complete this study:

1. A review of Ravensdown's emission data
2. Benchmarking of other SSP manufacturing plants and their permissible and measured emissions limits
3. Comparison of Ravensdown's operation to International Best Practice and current consent limits
4. Evaluation of the proposed scrubber upgrade project to existing scrubber performance and International Best Practice

3.1 Data and Information Received (Used Local Resource to Obtain Site Information)

1. P&ID's and HMI screen shots
2. Asset list
3. Photos of the plant
4. SOP's for laboratory analytical measurement of fluoride in stack gases
5. Historical emissions data and stack test reports
6. Existing Resource consent
7. Outline description of Armtec proposed replacement scrubber system

3.2 Benchmarking

Most of the world's single superphosphate is produced in China and India. These two countries account for almost 50% of the global production. We know almost nothing about Chinese pollution standards, but the Indian Central Pollution Control Board has relatively lax regulations compared with the World Bank, for example. The Indian regulations are as follows:

- Total Fluoride 20 mg/Nm^3
- Particulates 125 mg/Nm^3

However, it is reported that actual fluoride emissions from one SSP plant was as low as 3.6 mg/Nm^3. Standard practice in these plants is to use four stages of scrubbing which includes venturis followed by separators and to control the pH of the scrubber water in the last stage venturi separator using caustic. All the scrubber water is recovered by recycling to the reaction/den.

The World Bank/IFC prescribes that the limits for pollutants from superphosphate plants should be as follows:

- Gaseous Fluoride 5 mg/Nm^3
- Particulates 50 mg/Nm^3

These standards for SSP plants are considered to be "International Best Practice" and are used in this report to compare Ravensdown's plant performance.

3.3 Evaluation of Potential Scrubber Upgrade

Armatec emission limit in mg F/m^3 is converted to kg F/h and is then compared to the existing plant and the current air permit consent.

Equipment type and quantity is evaluated to predict the expected performance to confirm the suitability of the design.

See section 7 of the report for the results of the comparison.

4. Current Operation

4.1 Description

The existing plant produces various grades of Single Super Phosphate (SSP). The phosphate rock is ground in roller ring mills and the fertilizer is made by reacting phosphate rock powder with sulfuric acid, and the addition of process water from the fume scrubbing system, in a broadfield den followed by direct granulation using water and additives to produce various SSP products.

The plant is organized in four main areas - rock blending, manufacturing, off-gas scrubbing and product storage.

The scrubbing equipment associated with the manufacturing area is reaching the end of life. Ravensdown plans to replace the system and has engaged a local design and build company, Armatec Environmental Limited (Armatec), to carry out the replacement. This is still in the detailed design stage.

4.2 Rock Blending

The rock blending area is for unloading and storage of unground rock. The equipment in the area consists of an unground phosphate rock unloading system, unground rock storage building, unground rock hoppers, belt conveyors, screw conveyors, and fugitive emission control systems.

4.2.1 Unloading and Storage of Unground Rock

The unground phosphate rock is brought in by truck. The trucks are unloaded by gravity flow to a hopper under the truck.

Photo 1 Truck Unloading Hopper

The truck unloading hopper feeds a series of belts leading to the storage buildings, with 8 rooms in the three storage buildings used for storing different rock types. The material in the storage building is handled with a front-end loader.

The front-end loader feeds the phosphate rock to the No. 1 rock intake hopper. The rock intake hopper belt under the hopper conveys the phosphate rock to the rock incline belt, which feeds the rock top belt. The rock top belt has a belt tripper that trips the material off the belt and into one of the five rock silos.

Underneath each rock silo are two belts in series. The first belt is the feeder belt. The feeder belt feeds the rock silo weigh belt. The five rock silo weigh belts feed the rock bottom belt blending various sources of rock together in specific ratios. The rock bottom belt feeds the rock cross rails feed belt. The rock cross rails feed belt feeds the reversing rock screw No. 1. The screw feeds the No. 1 and 2 rock feed hoppers and the No. 2 rock belt. The No. 2 rock belt feeds the rock feed hopper 3 and No. 3 rock belt. The No. 3 rock belt feeds the No. 4 rock belt. The No. 4 rock belt feeds the No. 4 rock feed hopper and the No. 5 rock belt. The No. 5 rock belt feeds the No. 5 rock feed hopper.

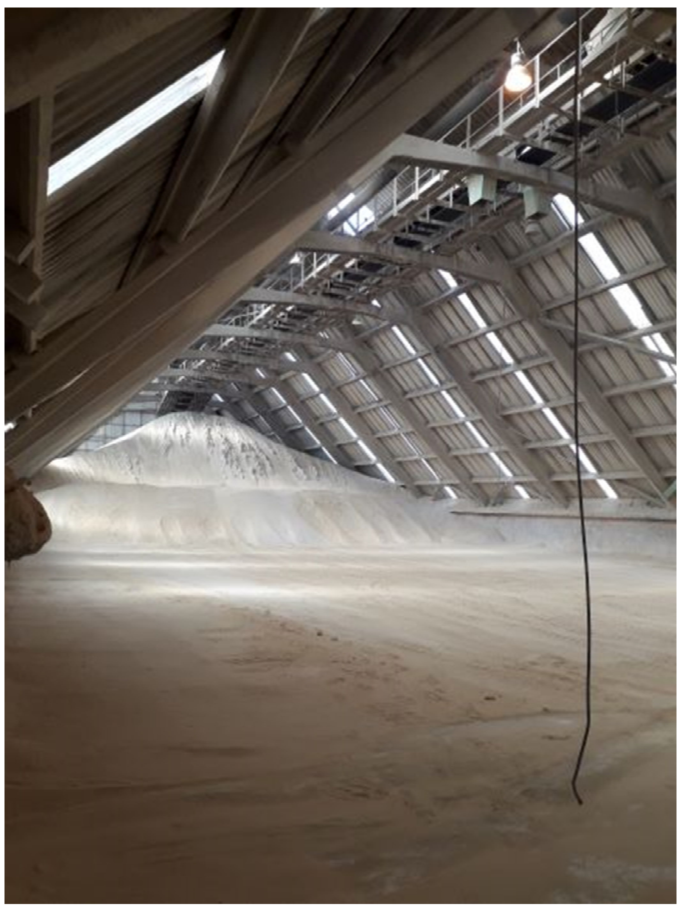


Photo 2 Storage Building

4.2.1.1 Fugitive Emission Controls for Unloading and Storage of Unground Rock

There are various fugitive emission sources and different types of controls for the fugitive emissions from these sources. The fugitive emission controls associated with unloading rock include features such as baffles in the intake hoppers. The truck unloads inside a partially enclosed shed that reduces the effects of wind generated emissions. The belt conveyors are enclosed in galleries that also reduce the amount of dust. The three storage buildings have 8 rooms which are used to store the unground rock. These storage rooms are enclosed with doors on access points to reduce impacts from wind. This storage shed rooms opens onto a corridor containing a hopper. The unground phosphate rock is removed from the storage building and dumped into a hopper using a front-end loader.

Photo 3 Storage Shed Corridor Showing Location of the Rock Intake Hopper

The fugitive emission controls after the rock intake hopper near the storage building are typical for handling particulate matter. The controls consist of negative air pressure areas at transfer points and inside equipment such as unground rock silos. There is a single baghouse and fan with stack discharging to atmosphere in the unground rock unloading and storage area. The negative pressure ventilation system draws air from the following locations: Storage rooms 1 and 2 only, rock incline belt to rock top belt transfer point, 5 rock silos, 5 rock silo weigh feeder belts, 5 rock silo weigh belts.

The extraction unit in the roof above the conveyor that supplies rock to storage shed 1 and 2 is thought to be undersized, hence is not extracting the required volumes of particulate matter when rock is being dropped into the storage sheds. It is thought that the single above-mentioned baghouse would perform better if not overloaded with the storage rooms 1 and 2 extract system. As this system does not meet the performance requirements, it is recommended that a new system or method for managing particulate emissions in the storage rooms is investigated. Ravensdown are currently looking to install doors on their storage rooms. The storage rooms are separated by walls which do not seal to the roof, which will allow air (and particulate matter) to be displaced between each of the storage rooms when rock is being dropped into one of the storage rooms, hence containing the particulate matter within the storage sheds.

On top of the storage shed roof are louvered filter panels. These are a known source of particulate emissions when the rock is being dropped into a storage shed.

4.2.2 Mills

The mills area consists of air-swept roller mills, fans, cyclones, belt conveyors, screw conveyors, and fugitive emission control systems.

4.2.2.1 Milling of Phosphate Rock

There are 4 mills operating at the facility, each mill has the same basic design. The mill No. 1 has been decommissioned and removed from service. The mill is a roller mill. A screw from the rock feed hopper feeds unground phosphate rock to the mill. Air is forced through the mill to a cyclone using a centrifugal fan. The air from the cyclone is circulated back to the suction of the fan. There is an airlock at the bottom of the cyclone that allows dust to transfer to the powder bunker via a series of screws. A negative pressure is induced on the mill by drawing air through a fabric filter type bag house.

4.2.2.2 Fugitive Emission Controls for Mill Units

Each mill has the same fugitive emission control system. The fugitive emission controls are typical for handling particulate matter. The controls consist of withdrawing air from the mill to create a negative air pressure inside the equipment associated with the mill. There is one cloth filter baghouse and fan with stack discharging to atmosphere for each mill. There is a broken bag detector instrument at the inlet to the fan as required by condition 52 of consent. Ravensdown has recently installed a different technology to try to improve the ability to detect bag failures in mill 4 baghouse. The remaining mills are currently undergoing the same upgrade.

Photo 4 Cloth Filter Baghouse

4.2.3 Powder Bunker

The powder bunker area consists of the ground rock bunker, named the powder bunker, and a powder silo, belt conveyors, screw conveyors, and elevators.

4.2.3.1 Powder Bunker System

The powder bunker area has two ground rock storage areas. The powder bunker and the powder silo. The bunker is fed by the mills with a series of screws. The powder silo feed system is fed from the same series of screws. The powder silo feeds the No. 1 bin feeder screw. The No. 1 bin feeder screw feeds the No. 4 powder screw. The powder bunker also feeds the No. 4 powder screw. The No. 4 powder screw feeds the powder bunker elevator. The bunker elevator feeds the No. 5 powder screw. The No. 5 powder screw feeds the precision screw. The precision screw feeds the No. 1 EMC belt weigher. The No. 1 EMC belt weigher feeds the No. 1 EMC screw. The No. 1 EMC screw feeds the No. 1 den mixer.

4.2.3.2 Fugitive Emission Controls for Powder Bunker System

There are various sources of fugitive emissions in the powder bunker silo. The controls mainly consist of enclosed equipment such as screws, bins, bunker, silos and elevators and a belt weigher.

4.3 Manufacturing

The manufacturing area consists of one operational den with mixer, cutters, belt conveyors, mowers, granulator, screen, and three scrubbing systems.

Photo 5 Mixer on Top of Den

4.3.1.1 Reaction Area (No. 1 Den)

The ground phosphate rock is mixed with sulfuric acid and blowdown water from fluoride scrubber 1 and 2 in No. 1 den mixer feeding the No. 1 den. At the discharge of the den is a cutter. The chute below the cutter feeds the No. 2 den incline belt. The SSP leaving the den on the incline belt is mixed with SSP from the overs belt and additives from the No. 2 additives re-feed belt. The No. 2 den incline belt feeds the No. 2 granulation cross belt. The No. 2 granulation cross belt feeds the No. 2 drum feed belt. The No. 1 mower is part of the No. 2 drum feed belt as well. The mower resizes material before the granulation drum.

Photo 6 Mower

4.3.1.2 Granulation and Screens

The No. 2 drum feed belt feeds the No. 2 granulation drum.

Photo 7 No. 2 Granulation Drum

The No. 2 granulation drum feeds the No. 2 granulation screen belt. The No. 2 granulation screen belt feeds the No. 1 granulation screen. Material passing over (overs) from the No. 1 granulation screen, feeds the overs belt. Material passing through the No.1 granulation screen, feeds the No. 2 granule belt. The No. 2 granule belt feeds the final product belt. The final product belt feeds the No. 1 store incline belt assembly. The environment inside the equipment is dusty and the chemical reaction of mixing phosphate rock and sulfuric acid produces fluoride gases. The equipment in the SSP plant is operated with a ventilation system to control fugitive emissions that would otherwise escape from the equipment.

4.4 Scrubbing System

There are three scrubbing systems, each with its own stack discharge to atmosphere in the manufacturing area. The performance of scrubbing system exceeds the performance standards of IBP. The volume of air extracted from the equipment appears to be in line with IBP.

4.4.1 Process Description of the Scrubbing System

The scrubber system consists of fluoride scrubber 1, fluoride scrubber 2, and a hygiene scrubber. The original plant design included two operating dens. Den 1 and 2 have been removed from the manufacturing building and replaced with a new larger den. The ventilation ductwork of the den was then routed to each fluoride scrubber. The gases from the den are withdrawn from near the inlet to the den and from near the outlet of the den. The ventilation ductwork of den 1 is split into two and routed to fluoride scrubber 1 and 2. Fluoride scrubber 1 and 2 operate in parallel and have the same equipment configuration. The hygiene scrubber draws air from the material handling system and from the enclosure installed to enclose the den.

The scrubbing system currently operating is the original scrubbing system. The scrubbers are at the end of their service life and require replacement. Ravensdown would like to simplify the design by having one stack for the manufacturing plant.

4.4.2 Fluoride Scrubber 1

Fluoride scrubber 1 flow sheet is shown in Section 4.5. The scrubber system consists of two venturi scrubbers in series followed by three void towers, also in series. Each Venturi scrubber and void tower has its own basin and circulating pump. A circulating pump sprays water in the inlet of each venturi or spray tower. The scrubber is followed by a cyclonic separator, fan and stack.

The gas flow is as follows:

The gas from the den flows to ET11 venturi, ET13 venturi, ET15 void tower, ET16 void tower, ET17 void tower, ET18 cyclonic separator, EF10 Scrubber Fan No. 2, ET19 stack and to atmosphere.

The circulating water flow is as follows:

The circulating water flow for ET11 Venturi is pumped by EP12 pump from ET12 basin. Water from E121 venturi drains to ET12 basin.

The circulating water flow for ET13 Venturi is pumped by EP13 pump from ET14 basin. Water from ET13 venturi drains to ET14 basin.

The circulating water flow for ET15 void tower is pumped by EP14 pump from the basin under ET15 void tower. Water from ET15 void tower drains to the basin under ET15 void tower.

The circulating water flow for ET16 void tower is pumped by EP16 pump from the basin under ET16 void tower. Water from ET16 void tower drains to the basin under ET16 void tower.

The circulating water flow for ET17 void tower is pumped by EP15 pump from the basin under ET17 void tower. Water from ET17 void tower drains to the basin under ET17 void tower.

The makeup water and blowdown water flow are counter current to the gas flow and is as follows:

The water from ET18 cyclonic separator drains to the basin under ET17. The makeup water for the basin under ET17 is from the hygiene scrubber blown down. The sump under ET17 overflows to the sump under ET16. The sump under ET16 overflows to the sump under ET15. A level transmitter LT EI12 sends a signal to a variable speed drive controlling the speed of EP17 pump. EP17 pump pumps water to ET14 basin. Water from ET14 basin is pumped to ET12 basin.

4.4.3 Fluoride Scrubber 2

Fluoride scrubber 2 consists of the same equipment configuration as scrubber 1. The gases flow through fluoride scrubber 2 in the same way as fluoride scrubber 1. The blowdown from each scrubber is counter-current to the gas stream. The blowdown from the fluoride scrubber 2 is combined with the blowdown from fluoride scrubber 1 and used as makeup water to the den mixer. The makeup water to fluoride scrubber 2 is from the blowdown of the hygiene scrubber.

4.4.4 Caustic Addition System

A small stream of caustic is pumped through an atomizing spray nozzle into the gas flow of the fluoride scrubber 1, fluoride scrubber 2 and the hygiene scrubber. The caustic is pumped into the duct between the droplet separator and inlet of the fan of fluoride scrubber 1 and 2. Caustic is also pumped into the duct after the fan and before the stack of the hygiene scrubber system. EP50 pump supplies caustic to ET19 stack. EP51 pump supplies caustic to ET29 stack. The pH of the water is measured in accordance with the Consent and if the pH is low more caustic is added into the gas stream. The resource consent requires the pH to be maintained above 2.7. The injection of caustic into the gas stream is not typical for IBP.

Fluoride is in the gas stream in three forms. Fluoride is in the gas phase as HF or SiF_4. Fluoride is also present in the liquid phase due to entrained liquid droplets and is in the form of fluoride ion (F^-), or it is in a particulate form such as a compound within SSP. The concentration of liquid and solids in the form of droplets and particulate in the gas stream is relatively low. Therefore, the total fluoride is primarily a function of the fluoride as a gas and the contribution of fluoride from liquid and solids to the total fluoride is not significant.

4.4.5 Hygiene Scrubber

The hygiene scrubber flow sheet is shown in Section 4.6. The scrubber consists of a venturi scrubber, cyclonic separator, fan, and stack.

Photo 8 Hygiene Scrubber

The hygiene scrubber collects fugitive emissions from several points in the manufacturing area. The following areas have vents to collect the fugitive emissions:

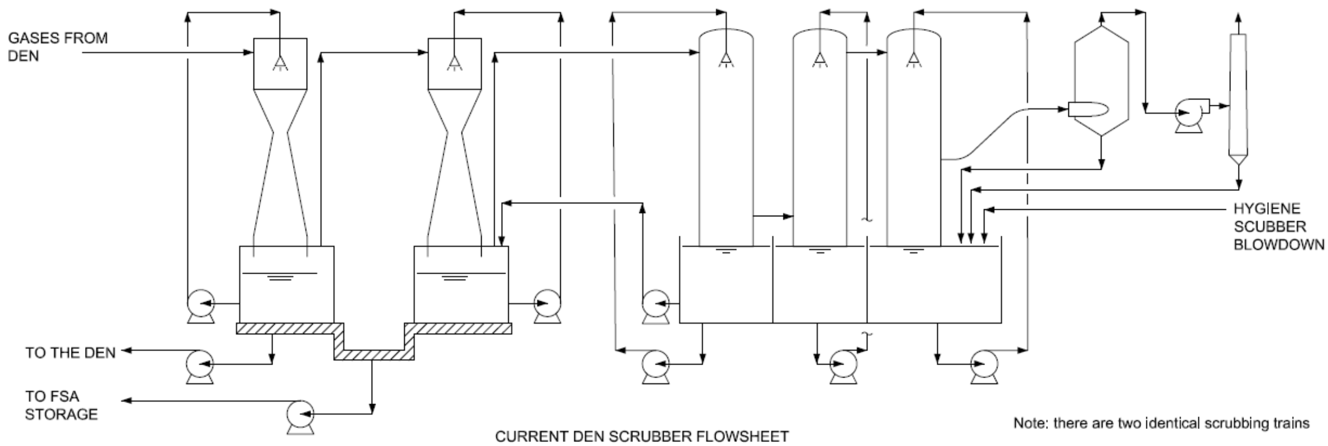
1. The curtains surrounding the mixer and the No. 2 den,
2. No. 1 screen, granulation screen belt covers
3. No. 2 overs belt covers
4. Final product belt
5. No. 1 den belt discharge hood
6. No. 2 den incline belt covers
7. Mower belt cover and granulation cross belt discharge hood
8. Store incline belt covers.

Photo 9 Curtains for the Mixer

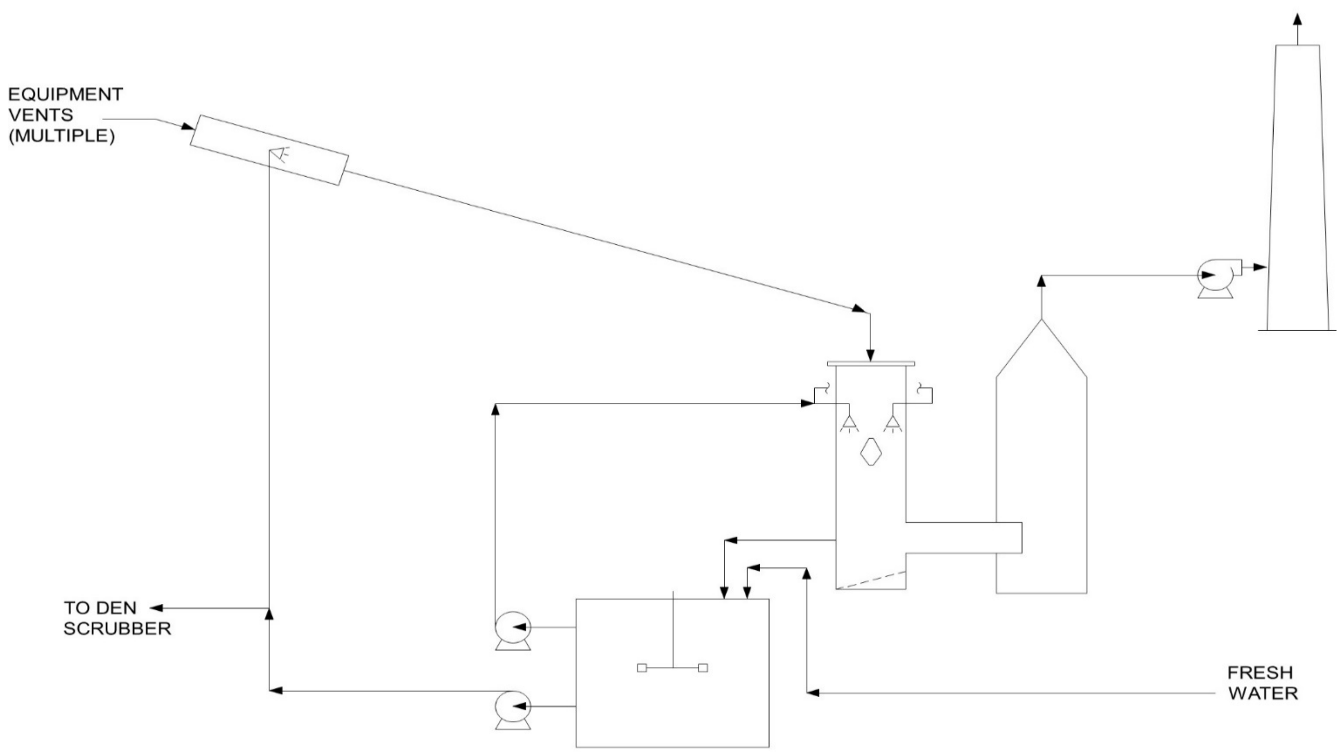
The gas then flows into the venturi of the ET60 scrubber. The scrubber uses two pumps for the circulating water. EP60 pump supplies water to the ductwork leading to the scrubber. EP61 pump supplies water to the inlet of the venturi.

The blowdown from the hygiene scrubber is used as makeup to the fluoride scrubber 1 and 2. The makeup water to the hygiene scrubber is fresh water.

4.5 Current Den Scrubber Flowsheet



4.6 Current Hygiene Scrubber Flowsheet



4.7 Product Storage

The No. 2 granule belt feeds the final product belt. The final product belt feeds the No. 1 store incline belt assembly. The No. 1 store incline belt sends product to multiple bulk stores. The product is removed from the multiple bulk stores by payloader and loaded into trucks for transport offsite. There are no fugitive control systems other than the enclosed building.

4.8 Emissions Testing and Monitoring

4.8.1 Scrubber Emissions

Scrubber emissions are measured, when operating, twice per week using wet chemistry methods. The test must not start until at least one hour of acidulation. The method of fluoride measurement is in accordance with USEPA Method 13B (Total fluoride specific ion electrode). The air flow measurement shall be in accordance with USEPA EPA method 5 (particulate matter). These methodologies are IBP. The frequency of two times per week is significantly higher than IBP which is normally once per year.

4.8.2 Bag House

Emissions are tested for each mill bag houses at least three repeats per quarter. The method of particulate measurement is in accordance with EPA Method 5 or Method 17. Each mill shall not discharge more than 1 kg/h of particulate matter and all mills shall not discharge more than 2 kg/h when two or more mills are operating. The pressure in the mill bag house must be monitored and there must be a broken bag detector on the discharge of the mill bag house.

IBP for particulate concentration from the vent discharge of the baghouse vent is less than 50 mg/Nm^3.

There are no specific requirements in the resource consent for the bag house associated with the rock handling system from truck loadout to storage.

4.9 Summary of Emission Points

There are eight (8) point sources associated with SSP at the facility. The sources include:

1. Rock Blending Baghouse
2. Mill 2 Baghouse
3. Mill 3 Baghouse
4. Mill 4 Baghouse
5. Mill 5 Baghouse
6. Fluoride Scrubber 1
7. Fluoride Scrubber 2
8. Hygiene Scrubber

The requirements for the sources are in the consent order.

The consent has 68 conditions for the facility that also includes a sulfuric acid plant. SSP is produced in the manufacturing plant. The main conditions as it relates to phosphate rock used to produce SSP and SSP are summarized as follows:

1. There shall be no discharge of particulate matter that causes offensive effect beyond the boundary of the site.
2. There shall be no discharge of odour that causes offensive effect beyond the boundary of the site.
3. There shall be no discharge of noxious or dangerous levels of gases, airborne liquid beyond the boundary of the site.
4. There are requirements for storage and handling of phosphate rock outside the storage building.
5. There are requirements for storage of product.
6. There is a requirement that a report must be filed by a qualified person that certifies that all necessary remedial work to the ventilation and extraction system of the manufacturing plant has been undertaken such that fugitive contaminant emissions from the manufacturing plant building have been eliminated.
7. There are requirements to control the pH of the discharge from the manufacturing point sources.
8. There are requirements for the design of the discharges of all point sources.
9. There are requirements for the measurement of fluoride at various onsite and offsite locations.
10. There are requirements for the measurement of particulate matter from non-point sources.
11. There is a requirement for a treatment system to control the acidity of emissions from the manufacturing plant.
12. There is a requirement for the installation of a deluge system for the den.
13. There are requirements for recording meteorological conditions at the site.
14. There are requirements for the measurement of acid deposition.
15. There are requirements for the measurement of fluoride etching.
16. There are requirements for a vegetation monitoring program around the site.
17. There are reporting requirements as it relates to the 68 conditions.

The conditions are designed to address the emissions from phosphate rock storage and grinding, SSP manufacturing and handling equipment, and from SSP product storage. When the manufacturing plant is operating, all the emissions from the equipment must be captured by a scrubber. The conditions in the consent are more stringent than IBP requirements.

The consent requirements target offsite impact from fluoride and particulate. The offsite fluoride emissions are measurable. The source of the fluoride emissions measured offsite is a combination of three types of mechanisms. The mechanisms are:

a. emissions from poorly vented equipment that is not effectively reporting to the scrubbers
b. emissions from product in storage
c. the three manufacturing plant point sources.

Based on the current information provided, the grinding mills and the manufacturing plant are in compliance.

5. Dust Emissions Controls

5.1 Rock Blending

Particulate matter is the main concern in the rock blending area. The fugitive emissions of particulate matter are created when the material is falling through the air. To control the fugitive emissions the rock blending area uses two types of controls to minimize particulate matter.

The first type of control is to enclose the equipment that handles the material. The truck unloading hopper is partially enclosed in a building, open at either end, providing some wind protection. The conveyors are enclosed in galleries and the rock storage area is a partially enclosed shed with 8 storage rooms. The storage rooms have an opening which opens to a corridor which is open at either end.

The second type of control for reducing fugitive particulate emissions is the use of equipment ventilation systems to create a negative pressure in and around the equipment and transfer points. The equipment ventilation is ducted to a bag house. The rock blending area has a bag house that collects fugitive emissions from several conveyor transfer points and from the silos. The extraction system from storage rooms 1 and 2 also supplies this bag house. It does not appear that all conveyor transfer points have ventilation connections. It is recommended that conveyor transfer points missing controls be ventilated to bag houses.

The bag house should also have a particulate detector to monitor the performance of the bag house. In Appendix B is an example of an instrument data sheet for a particulate detector that has been used in similar applications. It is very important that this instrument be installed per the manufacturer recommendation for the proper operation of the instrument.

The rock weigh belt feeding the conveyors that feed the various hoppers that feed the mill originally had a ventilation system that reported to an existing bag house. This system has been disconnected for reasons unknown. A new design for dedusting these items should be implemented to achieve IBP even though these remain enclosed inside the plant building. The bag house should also have a particulate detector to monitor its performance.

Controls such as ventilation to a baghouse would be needed for areas that exhibit visible dust emissions from buildings or create safety risk inside the building where personnel are working to meet IBP.

5.2 Mills

Particulate matter is the main concern for the equipment associated with the mill. The design of the equipment is typical for grinding phosphate rock. All the equipment associated with the mill are fully enclosed and fugitive emissions in the mill equipment are controlled with bag houses. The bag houses for each mill has a broken bag detector. Ravensdown was not satisfied with the original particulate or broken bag detector instrument. This has been replaced by an electrostatic sensor that has proven effective in measuring changes in dust concentration and detecting leaks in bags for mill 4. Ravensdown plans to install the same electrostatic sensor for the three other operating mills.

The compliance requirements for the bag houses are unknown. Data from Ravensdown suggests the dust emissions from the operating mills have a limit of 2 kg/h with an average of 0.041 kg/h for data collected in 2020. The client has indicated that the broken bag detector does not work. A possible replacement technology is shown in Appendix B.

5.3 Powder Bunker

There is a significant number of pieces of equipment associated with conveying dust from the mills to the powder bunker and powder silo. There are no ventilation connections on this equipment. The primary method of fugitive emission control is the use of enclosed equipment. The equipment is located withing a partially enclosed building, open for vehicle access, and while this contains the fugitive dust from these release points within the building, doors remain open, thus allowing some dust to escape the building when there is a draft or wind. Controls such as ventilation to a baghouse with particulate detector would be needed for areas that exhibit visible dust emissions from buildings or create safety risk inside the building where personnel are working to meet IBP.

5.4 Manufacturing Area

Even though particulate matter is not measured at the stack sampling points in the manufacturing area, it is a concern. The design of the equipment is typical for a single super phosphate plant. Particulate emissions are controlled by enclosing the equipment and pulling a vacuum on the equipment to three wet scrubbing systems. There are ventilation hoods associated with each major piece of equipment. There is also a ventilation hood for an area around the den and the mixer, which is enclosed by curtains. The total air flow appears to be appropriate for the quantity of equipment that is ventilated.

A more detailed study completed in 2017 (BECA Report) measured the air flow in each of the ducts and the main duct. The total air flow correlated with the air flow measured in the stack. The individual air flows from each pickup point are adequate by JT standards. There are some noteworthy recommendations in the report such as replacing the covers on the screens and adding dampers to balance the air distribution. However, the design does not follow JT standards as it relates to the orientation/angle of the ductwork, introducing hot air into the ducts to control humidity and maintaining proper air velocities in the ducts.

5.5 Product Storage

Particulate matter is a concern in the product storage area because the material is dry and somewhat friable. The transfer points between conveyors are not ventilated and a potential source of fugitive emissions. There are no fugitive control systems other than the enclosed building. IBP would be to ventilate all transfer points through a dust collector if the fugitive emissions are unacceptable.

6. Fluoride Emission Controls

6.1 Fluoride Emissions

The scrubber performance data shown in Table 1 below is based on stack test data provided by Ravensdown. A substantial amount of data has been provided covering a time period from 2007 to 2020. The maximum allowable fluoride emissions for the three stacks combined is 1.5 kg/h. The table below is based on data from October of 2019 to October 2020. This time period was chosen to correlate with the requirement that the fluoride emissions cannot exceed 1.0 kg/h for 50% of the samples in the last 12 months. See Appendix A for source of data.

Table 1 Scrubber Performance Data

Description	Fluoride Scrubber 1	Fluoride Scrubber 2	Hygiene Scrubber	Combined
Measured Fluoride Emission (kg/h)				
Average	0.0248	0.0411	0.0258	0.0918
Minimum	0.0030	0.0040	0.0010	0.0210
Maximum	0.0950	0.1390	0.2530	0.2950
Standard Deviation as % of Average	75%	75%	173%	61%
Measured Air Flow (m^3/h)				
Average	12,628	15,206	62,651	88,876
Minimum	8,089	10,369	56,226	82,061
Maximum	15,603	18,626	65,598	93,346
Standard Deviation as % of Average	12%	11%	3%	3%
Fluoride Emission (mg F/m^3)				
Average	1.96	3.11	0.39	1.03
Minimum	0.21	0.27	0.02	0.23
Maximum	7.50	10.69	2.15	3.59
Standard Deviation	73%	78%	178%	63%

6.2 Fluoride Emissions Exceedances of the Standard

The data shown in Table 1 shows a significant standard deviation for the fluoride emissions measured in kg/h. Calculated fluoride emissions (mg F/Nm^3) exceeds international best practice for modern SSP plants 16 times in fluoride scrubber 1 and 2. See Appendix A for the table supporting this issue. The hygiene scrubber meets the concentration norm 100% of the time. Note that if all scrubber discharges reported to a single stack, there would be no emissions that exceed IBP.

The number of data exceedances is summarized in Table 2.

Table 2 Data Exceedance

Description	Current System International Best Practice Exceedances[1]	Current System Consent Exceedances[1]
Units	No. of samples greater than 5 mg F/Nm^3	No. of violations of Consent
Den #1 Stack	4	0
Den # 2 Stack	12	0
Hygiene Stack	0	0
Single Stack[2]	0	0

1. Based on analysis of data from October 2019 to October 2020
2. Assuming all three fans discharged to a common stack

The variability of the data combined with proprietary equipment information only available to the original equipment designers and not Ravensdown makes make it difficult to explain the emission numbers and their variability.

Based on international best practice, the data suggests that the emissions from individual stacks are occasionally out of compliance with the 5 mg/Nm^3 standard despite the average meeting international best practice levels. It is also noted that standard deviation of the stack test results is significant. This suggests that the equipment is not always operating as designed or test location or test methods used are not in compliance with testing standards.

There is no data on particulate emissions from the scrubbers. Particulate emissions can be measured using EPA method 5. Use EPA Method 201 to measure PM10 or PM2.5 particulate.

6.3 pH Control of the Scrubber Stack Emissions

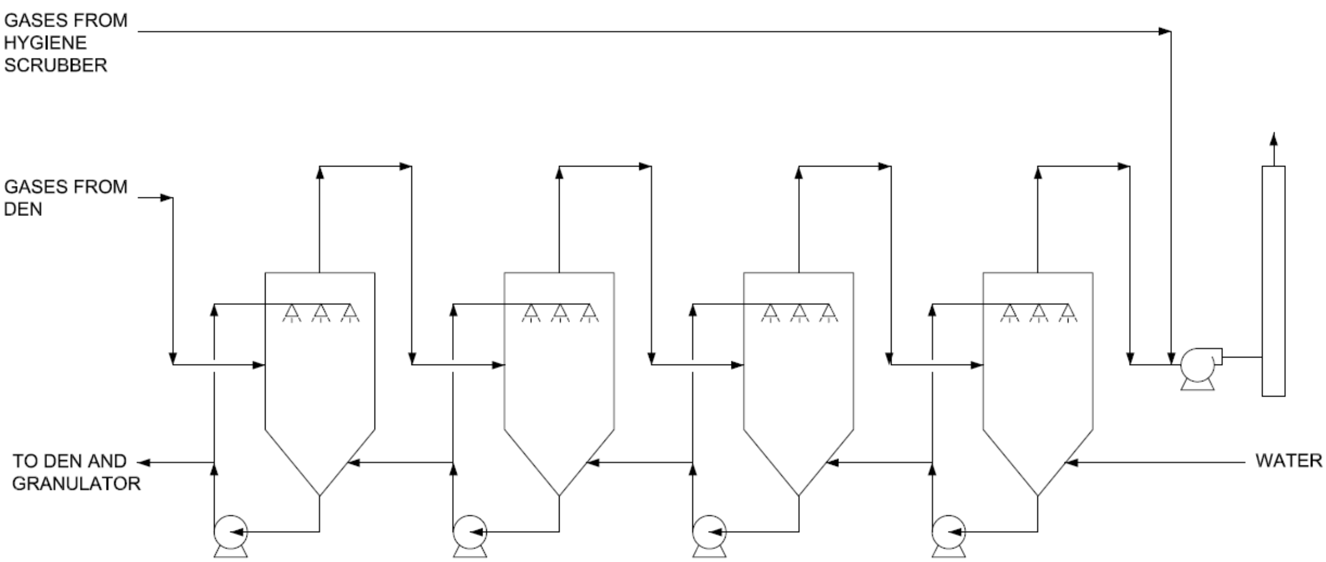
The fluoride scrubber 1, fluoride scrubber 2, and hygiene scrubber use caustic injection to control the pH of the stack condensate per condition 37 of consent document. This requirement ensures that stack pH is not too acidic.

7. Proposed Scrubber Performance

7.1 Description

Ravensdown has selected Armatec to replace the equipment associated with fluoride scrubber 1 & 2. Armatec considers the equipment design proprietary and has expressed concerns that JESA Technologies is a competitor. Armatec has therefore only provided limited information on the design. No details of the new proposed system have been made available other than that the system consists of one scrubber train with four void towers in series, one fan and one stack. The scrubber system will pull gases from the existing den. Water is circulated in each void tower. The blowdown from each void tower is the makeup for the upstream tower. Therefore, the water makeup flow is counter-current to the gas flow. The blowdown from the first tower is utilized in the den and granulator.

7.2 Proposed Scrubber Flowsheet



PROPOSED NEW SCRUBBER SYSTEM

7.3 Proposed System vs. Current Operation

The current system's performance is very efficient. Detailed calculations could not be carried out as equipment design data was not able to be provided but a venturi scrubber is generally designed for at least 3 NTU's. Based on stack loss measurements, the current den scrubbing system has in excess of 10 NTU's in total. Void towers on the other hand can typically only be counted on for up to 1.5 NTU's, although Armatec states that their design provides 2.5 NTU's per vessel.

Calculations were carried out to determine the loss from the new Armatec scrubbing system assuming 2.5 NTU's per vessel. A comparison with the existing operation is provided in the Table 3.

Table 3 Comparison of Existing VS. Proposed Operation

Description	Current System[1]		Proposed System[2]	
Units	mg F/m^3	kg F/h	mg F/m^3	kg F/h
Den #1	1.95	0.0248	4.62	0.1412
Den # 2	3.11	0.0411		
Hygiene	0.41	0.0258	0.41	0.0258
Single Stack	1.01	0.0918	1.67	0.167

1. See Appendix A for source of data for current system

2. Proposed system is based on den scrubber air flow of 30,000 m^3/h flow, a concentration of 30,000 mg F/m^3, 4 stages of scrubbing each with 2.5 NTU, and a 12.5 m^3/h blowdown and current system hygiene stack emissions and a total air flow of 100,000 m^3/h

7.4 Critique of Proposed Design

Critical information required to predict the performance of the proposed design, such as liquid and gas flows in the scrubbers, pressure drop across the various spray towers, and dimensions of the void towers, is not available due to intellectual property concerns.

The proposed design will simplify the operation of the scrubbers by reducing the number of pieces of equipment required to operate the scrubbing system. The reduction in pieces of equipment will result in improved operating factor and may lead to less variability in stack emissions. The vendor indicates the proposed design will emit less than 5 mg F/Nm^3.

This compares to the existing operation where, if all three stacks are combined, the emissions would average 1.01 mg F/m^3. The current stacks when combined emit 0.092 kg/h on average, which is significantly lower than the current allowable emissions. JT calculates that after the Armatec scrubbers are installed, the stack emission will be 0.167 kg/h. This based on 30,000 m^3/h flow from the den with a concentration of 30,000 mg F/m^3, 4 stages of scrubbing each with 2.5 NTU, and a 12.5 m^3/h blowdown. This figure includes emissions from the hygiene scrubber which currently emits on average 0.0258 kg F/h. The effect of caustic is not considered in the calculations. It is understood that Armatec will include caustic addition as a provision of its design so that caustic may be added if RFL so chooses.

Armatec's guarantee is 5 mg/Nm^3 which is in line with IBP. However, it cannot be considered BACT, since the current system emits less fluoride than the new system is guaranteed or expected to do. The council may consider the current scrubbing technology performance when evaluating the scrubber replacement and developing a future consent decree.

8. Recommendations

- As normally required by environmental authorities, the expected performance of the new system should be backed up by calculations provided by the vendor. These calculations should take into account the fluoride vapor pressure in each stage, as the fluosilicic acid increases in concentration from stage to stage. Ravensdown should consider requesting a lower guarantee than has currently been provided since it is so much higher than what is currently achieved.
- Except for the mills, the dust control provisions in the materials handling system are very rudimentary and should be upgraded to include a series of dust extraction points at each transfer point together with associated baghouses equipped with broken bag detectors.
- The existing data supplied is insufficient to develop a detailed design for sizing the ventilation and scrubber system. However, the current system has several design deficiencies which would be expected to cause blockages to frequently occur. If this is confirmed by Ravenadown Operations, a re-design of the system is recommended.

Appendix A. Manufacture and Hygiene Stack Testing Data

APPENDIX A

MANUFACTURE & HYGIENE STACK TESTING DATA

Date	Den #1 (kg/h)	Den #2 (kg/h)	Granulation (kg/h)	Total + Gran (kg/h)	Stack 1 Flowrate m^3/h	Stack 2 Flowrate m^3/h	Gran Flowrate m^3/h	Combined Flowrate m^3/h	Den #1 (mg F /m^3)	Den #2 (mg F /m^3)	Granulation (mg F /m^3)	Combined (mg F /m^3)	#1 stack pH	#2 stack pH	Hygiene Stack pH
Limits				1.5 kg/h											
5/10/19	0.011	0.006	0.004	0.021	10,734	14,208	64,390	89,332	1.02	0.42	0.06	0.24	6.09	5.10	6.18
6/10/19	0.005	0.014	0.003	0.022	9,768	13,461	63,801	87,031	0.51	1.04	0.05	0.25	5.81	4.59	4.26
8/10/19	0.011	0.013			9,350	12,348			1.18	1.05			6.54	4.43	
11/10/19	0.008	0.011			10,219	13,615			0.78	0.81			6.37	4.24	
12/10/19			0.008				64,899				0.12				3.38
13/10/19			0.013				65,078				0.20				3.96
19/10/19	0.009	0.018	0.115	0.142	10,112	12,494	65,598	88,203	0.89	1.44	1.75	1.61	5.34	3.64	4.22
20/10/19	0.003	0.014	0.185	0.202	10,622	13,717	64,246	88,584	0.28	1.02	2.88	2.28	4.26	3.28	4.89
21/10/19	0.017	0.025	0.253	0.295	8,089	12,104	61,868	82,061	2.10	2.07	4.09	3.59	3.82	3.35	5.11
24/10/19			0.030				63,893				0.47				7.36
26/10/19	0.017	0.013			9,306	13,628			1.83	0.95			6.83	4.13	
2/11/19	0.006	0.022	0.105	0.133	10,165	13,427	62,856	86,447	0.59	1.64	1.67	1.54	6.12	3.36	3.89
3/11/19	0.004	0.022	0.166	0.192	9,910	13,006	63,312	86,227	0.40	1.69	2.62	2.23	5.59	3.29	3.64
9/11/19	0.008	0.013	0.030	0.051	10,497	12,351	63,561	86,409	0.76	1.05	0.47	0.59	3.03	3.23	3.24
10/11/19	0.006	0.007	0.018	0.031	10,140	13,571	64,483	88,193	0.59	0.52	0.28	0.35	3.17	3.21	3.35
16/11/19	0.021	0.029	0.009	0.059	10,618	10,628	63,933	85,178	1.98	2.73	0.14	0.69	6.32	6.41	3.49
17/11/19	0.022	0.017	0.008	0.047	10,097	13,743	62,719	86,559	2.18	1.24	0.13	0.54	6.14	5.96	3.24
20/11/19	0.022	0.038	0.013	0.073	12,089	12,064	64,267	88,419	1.82	3.15	0.20	0.83	6.92	6.89	4.06
24/11/19	0.02	0.139	0.011	0.170	12,926	13,621	64,101	90,647	1.55	10.20	0.17	1.88	6.79	3.75	3.59
30/11/19	0.014	0.01	0.069	0.093	10,751	12,600	64,184	87,535	1.30	0.79	1.08	1.06	6.51	5.19	3.47
1/12/19	0.017	0.014	0.046	0.077	10,621	13,005	62,657	86,282	1.60	1.08	0.73	0.89	6.82	4.84	3.88
6/12/19	0.034	0.061			11,754	13,177			2.89	4.63			7.04	6.92	
7/12/19			0.017				64,436				0.26				3.68
8/12/19	0.015	0.057	0.012	0.084	12,487	13,643	63,982	90,112	1.20	4.18	0.19	0.93	6.50	6.05	3.57
10/12/19	0.039	0.066			12,199	13,660			3.20	4.83			7.27	6.76	
11/12/19			0.005				64,640				0.08				8.74
12/12/19	0.026	0.02	0.007	0.053	12,267	14,704	64,711	91,682	2.12	1.36	0.11	0.58	6.55	5.77	5.12
18/01/20	0.027	0.054	0.004	0.085	13,369	13,147	64,691	91,207	2.02	4.11	0.06	0.93	7.09	4.14	4.11
19/01/20	0.017	0.048	0.004	0.069	12,550	14,236	61,549	88,335	1.35	3.37	0.06	0.78	6.63	5.26	4.46
25/01/20	0.015	0.12	0.008	0.143	13,345	12,990	63,410	89,745	1.12	9.24	0.13	1.59	7.12	6.49	4.86
26/01/20		0.113	0.007			12,661	62,216			8.92	0.11		NC #886	3.65	3.94
28/01/20	0.095	0.139	0.013	0.247	12,660	12,998	63,185	88,843	7.50	10.69	0.21	2.78	6.75	3.57	3.7
29/01/20	0.066	0.05			12,207	13,226			5.41	3.78			5.94	6.16	
2/02/20			0.030				63,128				0.48				4.14
8/02/20	0.041	0.038	0.014	0.093	14,067	13,246	63,373	90,685	2.91	2.87	0.22	1.03	6.00	4.30	3.58
9/02/20	0.016	0.046	0.015	0.077	13,374	13,002	63,675	90,051	1.20	3.54	0.24	0.86	4.42	4.06	3.35
12/02/20	0.079	0.016			14,938	12,812			5.29	1.25			7.00	3.99	
14/02/20	0.015	0.036	0.006	0.057	13,699	13,987	63,442	91,129	1.09	2.57	0.09	0.63	4.20	4.12	4.11
15/02/20			0.012				64,088				0.19				3.42
21/02/20	0.028	0.046	0.005	0.079	13,897	13,456	62,580	89,933	2.01	3.42	0.08	0.88	6.20	4.10	4.26
23/02/20	0.035	0.05	0.004	0.089	13,011	14,764	64,198	91,972	2.69	3.39	0.06	0.97	5.04	4.15	4.1

APPENDIX A

MANUFACTURE & HYGIENE STACK TESTING DATA

Date Limits	Den #1 (kg/h)	Den #2 (kg/h)	Granulation (kg/h)	Total + Gran (kg/h) 1.5 kg/h	Stack 1 Flowrate m^3/h	Stack 2 Flowrate m^3/h	Gran Flowrate m^3/h	Combined Flowrate m^3/h	Den #1 (mg F /m^3)	Den #2 (mg F /m^3)	Granulation (mg F /m^3)	Combined (mg F /m^3)	#1 stack pH	#2 stack pH	Hygiene Stack pH
27/02/20	0.014	0.033	0.001	0.048	13,607	14,271	62,844	90,722	1.03	2.31	0.02	0.53	5.58	5.17	3.97
1/03/20	0.024	0.028	0.006	0.058	12,021	13,619	62,605	88,245	2.00	2.06	0.10	0.66	6.08	4.89	4.26
2/03/20	0.026	0.075	0.019	0.120	12,564	12,894	62,582	88,040	2.07	5.82	0.30	1.36	4.58	4.21	3.74
3/03/20	0.048	0.03	0.019	0.097	12,472	12,781	62,301	87,554	3.85	2.35	0.30	1.11	6.69	5.96	4.08
13/03/20	0.013	0.055	0.015	0.083	14,529	14,997	63,250	92,775	0.89	3.67	0.24	0.89	3.64	3.91	3.8
21/03/20	0.032	0.068	0.008	0.108	12,766	12,753	63,462	88,981	2.51	5.33	0.13	1.21	4.42	4.61	3.72
22/03/20	0.017	0.089	0.005	0.111	13,656	12,636	63,559	89,851	1.24	7.04	0.08	1.24	5.95	3.61	4.15
28/03/20	0.06	0.058	0.006	0.124	12,624	12,226	63,747	88,597	4.75	4.74	0.09	1.40	3.94	3.93	3.96
29/03/20	0.054	0.043	0.006	0.103	13,895	12,827	63,980	90,702	3.89	3.35	0.09	1.14	5.05	4.40	4.06
4/04/20	0.03	0.018	0.018	0.066	12,556	13,270	63,194	89,020	2.39	1.36	0.28	0.74	5.48	4.33	3.51
5/04/20	0.024	0.039	0.011	0.074	12,855	12,630	64,047	89,533	1.87	3.09	0.17	0.83	4.29	5.57	3.69
11/04/20	0.014	0.036	0.006	0.056	12,782	12,019	63,826	88,626	1.10	3.00	0.09	0.63	4.30	6.22	4.48
12/04/20	0.018	0.025	0.005	0.048	12,290	12,520	63,285	88,094	1.46	2.00	0.08	0.54	4.06	3.96	3.87
17/04/20	0.014	0.043	0.006	0.063	12,747	12,392	63,226	88,365	1.10	3.47	0.09	0.71	5.32	3.82	3.56
19/04/20	0.021	0.095	0.005	0.121	13,166	10,369	63,039	86,574	1.60	9.16	0.08	1.40	4.74	4.70	3.74
25/04/20	0.048	0.042	0.061	0.151	12,157	11,965	62,866	86,988	3.95	3.51	0.97	1.74	6.36	4.00	3.42
26/04/20	0.03	0.035	0.030	0.095	13,639	13,584	63,908	91,131	2.20	2.58	0.47	1.04	4.94	4.05	3.89
1/05/20	0.058	0.024	0.008	0.090	13,418	14,144	64,038	91,599	4.32	1.70	0.12	0.98	5.94	5.27	3.47
3/05/20	0.025	0.025	0.006	0.056	13,361	13,073	63,479	89,913	1.87	1.91	0.09	0.62	4.16	3.26	3.84
9/05/20	0.019	0.012	0.003	0.034	13,405	13,183	63,973	90,561	1.42	0.91	0.05	0.38	3.90	3.57	3.44
10/05/20	0.013	0.008	0.006	0.027	13,505	13,936	63,569	91,010	0.96	0.57	0.09	0.30	4.06	3.66	3.68
16/05/20	0.042	0.043	0.125	0.210	13,040	13,333	64,493	90,866	3.22	3.23	1.94	2.31	3.70	3.56	3.91
17/05/20	0.012	0.046	0.055	0.113	14,407	13,311	63,178	90,896	0.83	3.46	0.87	1.24	3.94	3.42	3.48
23/05/20	0.011	0.033	0.013	0.057	14,001	12,852	64,278	91,132	0.79	2.57	0.20	0.63	3.74	3.25	3.68
24/05/20	0.01	0.02	0.014	0.044	13,571	13,091	63,662	90,324	0.74	1.53	0.22	0.49	3.80	3.33	3.31
30/05/20	0.034	0.098	0.006	0.138	13,833	14,358	62,917	91,108	2.46	6.83	0.10	1.51	3.70	3.36	3.46
31/05/20	0.047	0.037	0.008	0.092	12,562	13,356	63,317	89,235	3.74	2.77	0.13	1.03	4.78	3.62	4.33
3/06/20	0.012	0.037	0.122	0.171	14,236	13,384			0.84	2.76			3.56	3.36	3.38
29/08/20	0.019	0.042	0.006	0.067	14,040	14,053	60,016	88,109	1.35	2.99	0.10	0.76	4.40	4.30	4.88
30/08/20	0.015	0.004	0.005	0.024	14,721	14,854	59,402	88,977	1.02	0.27	0.08	0.27	4.35	3.97	4.72
5/09/20	0.027	0.033	0.013	0.073	13,323	13,207	57,350	83,879	2.03	2.50	0.23	0.87	4.10	4.56	3.49
6/09/20	0.028	0.027	0.016	0.071	13,000	13,407	57,693	84,099	2.15	2.01	0.28	0.84	3.95	4.58	3.97
7/09/20	0.034				13,179				2.58				3.67		
12/09/20		0.036	0.009			13,794	58,888			2.61	0.15			3.70	4.14
13/09/20	0.017	0.069	0.008	0.094	13,707	13,656	59,461	86,823	1.24	5.05	0.13	1.08	4.11	3.73	3.96
18/09/20	0.08	0.099	0.007	0.186	12,777	13,735	59,054	85,566	6.26	7.21	0.12	2.17	3.51	3.22	3.61
20/09/20	0.043	0.116	0.007	0.166	13,161	13,603	59,195	85,959	3.27	8.53	0.12	1.93	3.60	3.29	3.69
25/09/20	0.024	0.028	0.005	0.057	13,618	13,733	58,877	86,228	1.76	2.04	0.08	0.66	3.76	3.74	4.13
26/09/20	0.028	0.04	0.030	0.098	13,474	13,644	58,817	85,935	2.08	2.93	0.51	1.14	3.76	3.62	3.63
2/10/20	0.007	0.01	0.010	0.027	14,433	18,347	59,290	92,071	0.48	0.55	0.17	0.29	3.72	3.60	3.49
10/10/20	0.009	0.017	0.006	0.032	15,603	18,626	59,117	93,346	0.58	0.91	0.10	0.34	3.38	3.66	3

APPENDIX A

MANUFACTURE & HYGIENE STACK TESTING DATA

Date Limits	Den #1 (kg/h)	Den #2 (kg/h)	Granulation (kg/h)	Total + Gran (kg/h) 1.5 kg/h	Stack 1 Flowrate m^3/h	Stack 2 Flowrate m^3/h	Gran Flowrate m^3/h	Combined Flowrate m^3/h	Den #1 (mg F /m^3)	Den #2 (mg F /m^3)	Granulation (mg F /m^3)	Combined (mg F /m^3)	#1 stack pH	#2 stack pH	Hygiene Stack pH
11/10/20	0.003	0.01	0.008	0.021	14,586	18,277	59,793	92,656	0.21	0.55	0.13	0.23	3.38	3.27	3.51
17/10/20	0.008	0.023	0.007	0.038	14,272	17,979	56,226	88,478	0.56	1.28	0.12	0.43	3.98	3.34	3.96
18/10/20	0.007	0.033	0.004	0.044	14,351	18,382	58,561	91,293	0.49	1.80	0.07	0.48	3.83	3.38	3.61
Average	0.0248	0.0411	0.0258	0.0918	12,628	13,563	62,651	88,876	1.95	3.11	0.39	1.03	5.06	4.30	4.00
Minimum	0.0030	0.0040	0.0010	0.0210	8,089	10,369	56,226	82,061	0.21	0.27	0.02	0.23	3.03	3.21	3.00
Maximum	0.0950	0.1390	0.2530	0.2950	15,603	18,626	65,598	93,346	7.50	10.69	4.09	3.59	7.27	6.92	8.74
Standard Dev.	0.0186	0.0310	0.0446	0.0560	1,540	1,484	2,087	2,295	1.4185	2.4093	0.6891	0.6452	1.26	1.01	0.84
Std. Dev. as % of Avg.	75%	75%	173%	61%	12%	11%	3%	3%	73%	78%	178%	63%	25%	23%	21%

LEGEND
Indicates parameter exceeds International Best Practice

Appendix B. Particulate Emission Detector

APPENDIX B

FilterSense
Particulate Monitoring and Control Solutions

DynaCHARGE™ PM 1 PRO Particulate Monitor

Particulate monitor employing charge induction sensing for continuous measurement, monitoring and detection of particulate in stacks, ducts, or pipes.

Key Features (some optional):

- Fully isolated probe combined with induction sensing for the highest reliability in moist, corrosive and conductive media applications
- Diagnostics to NAMUR 107 for insight and efficiency
- EPA self-testing to ASTM D7392 for EPA MACT, NESHAP, OSHA etc.
- HART communications, data and event logging
- Remote electronics (for safe, easy access) or integral (one-piece)
- Rotatable graphic display and housing
- Easily removable molded electronics module , modular nipple/probe

Technical Data:

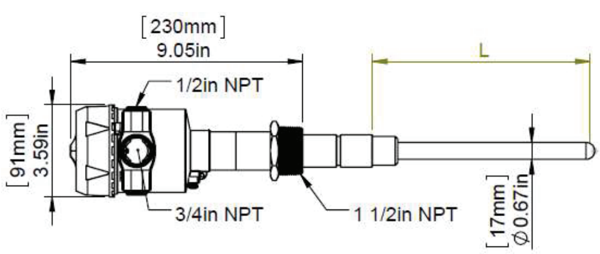
Resolution…..……0.1 pA (Measurement)…0.5 pA (Monitor)…5.0 pA (Detect)
Minimum Detection ……………………..……………………..……...at least 1.0 mg/m^3
Max. Process Pressure ……………………..……………..........…… 1000 psi (69 bar)
Max Process Temperature ……………………………………..…. 1650 °F (898 °C)
Ambient Temperature Range……………..………-40 °F to 158 °F (-40 to 70 °C)
Hazardous Areas……………………………………......….Class I Div. I (Zone 0/20)

PM 1 PRO -T (Transmitter)
Power/Output..loop powered/4-20mA (2-wire)

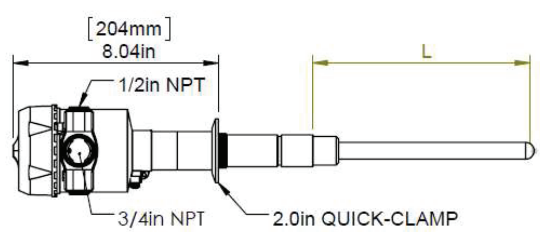
PM 1 PRO -A (Alarm)
Power/Output.................. 24 VDC or 240 VAC/2 SPST 5A @ 240 VAC

Dimensions:

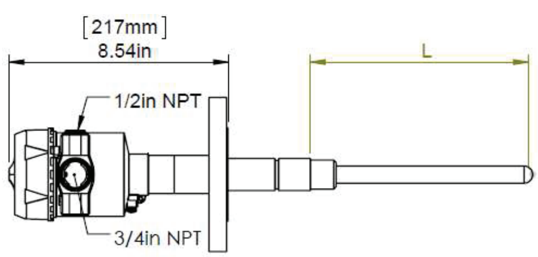
Threaded Version



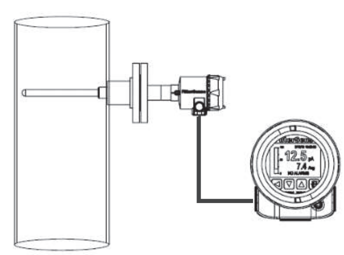
Quick Clamp Version



Flanged Version

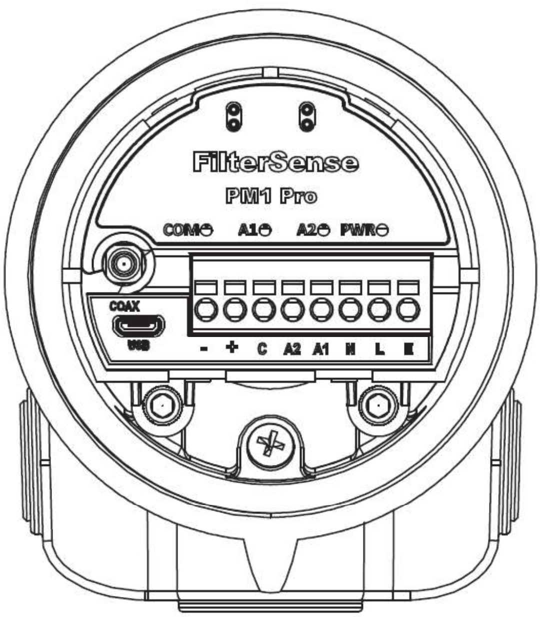


Remote Electronics (2-Piece Configuration)

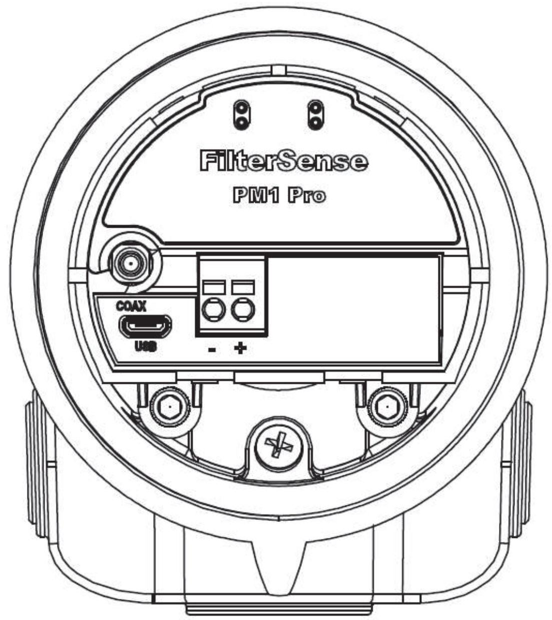


Electrical Interface / Wiring:

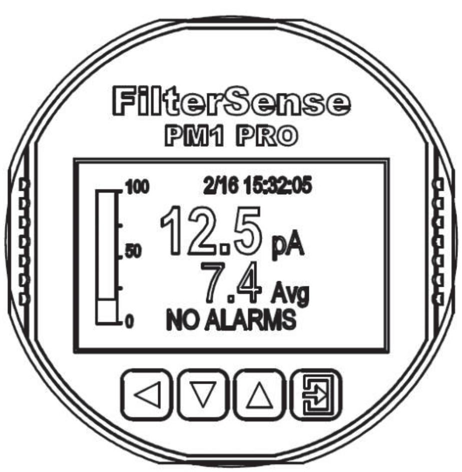
PM 1 PRO-T (Transmitter)



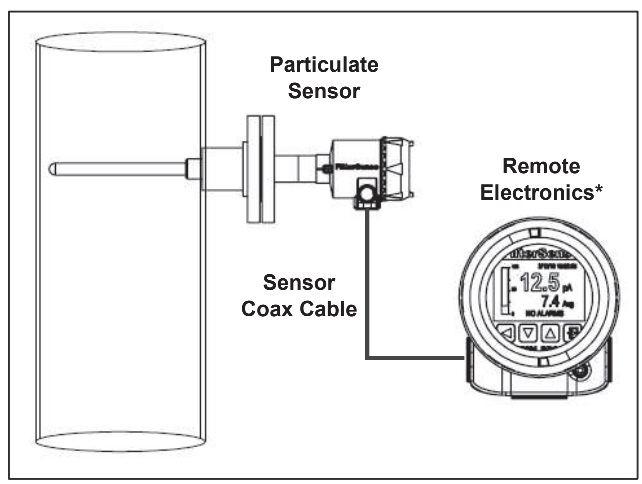
PM 1 PRO-A (Alarm)



Rotatable/Removable Display



Remote Electronics
(2-Piece Configuration)



* Pipe mount or flush mount