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Air Filtration Study For The Optimum Performance of Gas Turbines

by

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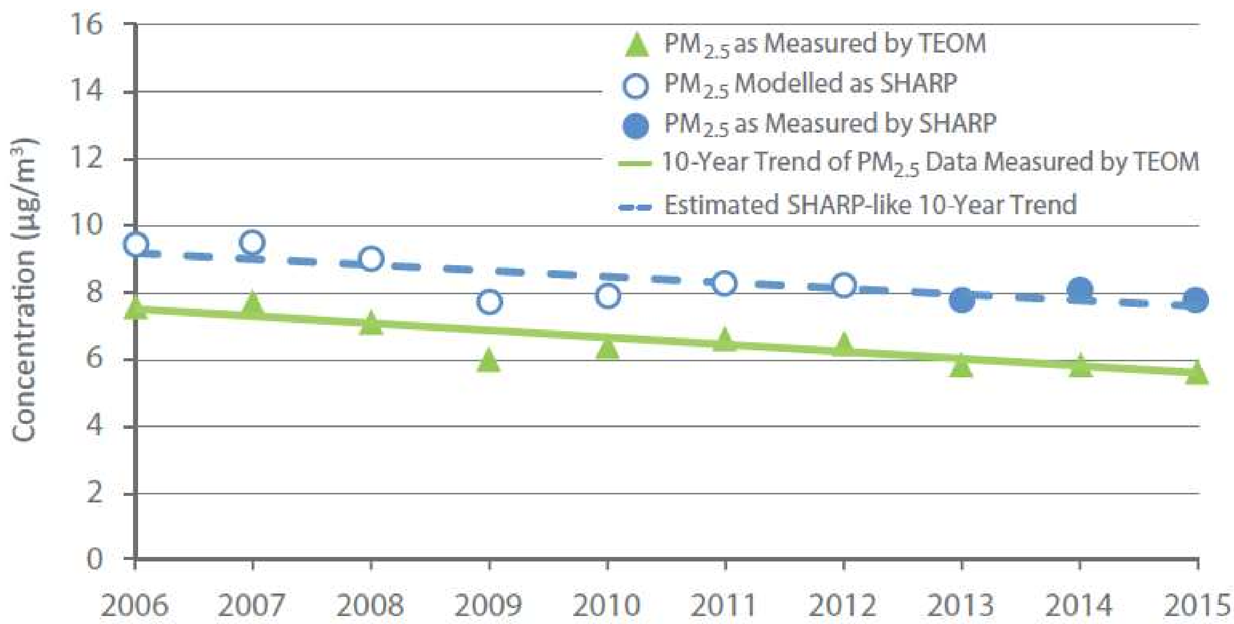
Topics

- Introduction
- Testing and Results
- Comparison M6 vs F9
- Cost - Benefit Analysis
- Process Improvement
- Conclusion and Questions

Introduction

- Objective
- Southwestern On.
- Corridor – 257 km
- Power – 435 MW
- No. of Air Filters – 4000
- Air Filters – Brands, Types
- Centrifugal Units – 23
- Recips – 14

PM2.5 Air Quality – Ontario



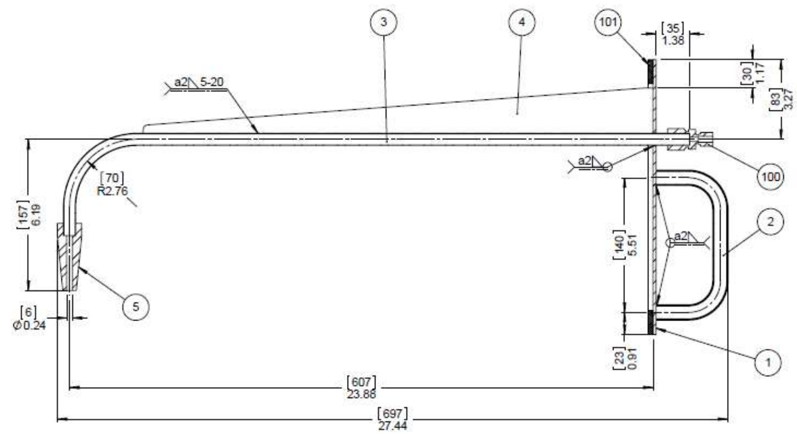
* Air Quality in Ontario 2015 Report, Ministry of the Environment and Climate Change

Scope of Analysis

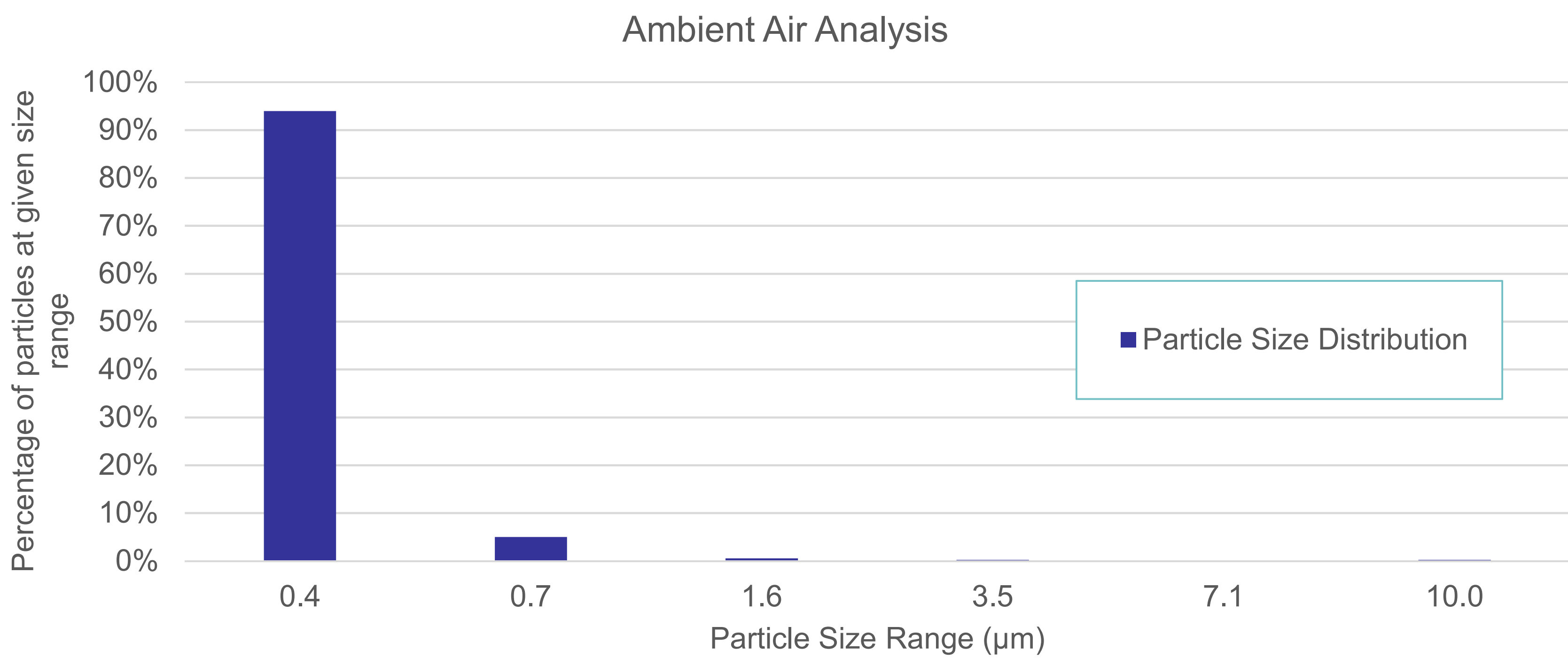
2x side by side RB211 gas turbines

Replace inlet filters, measure impact

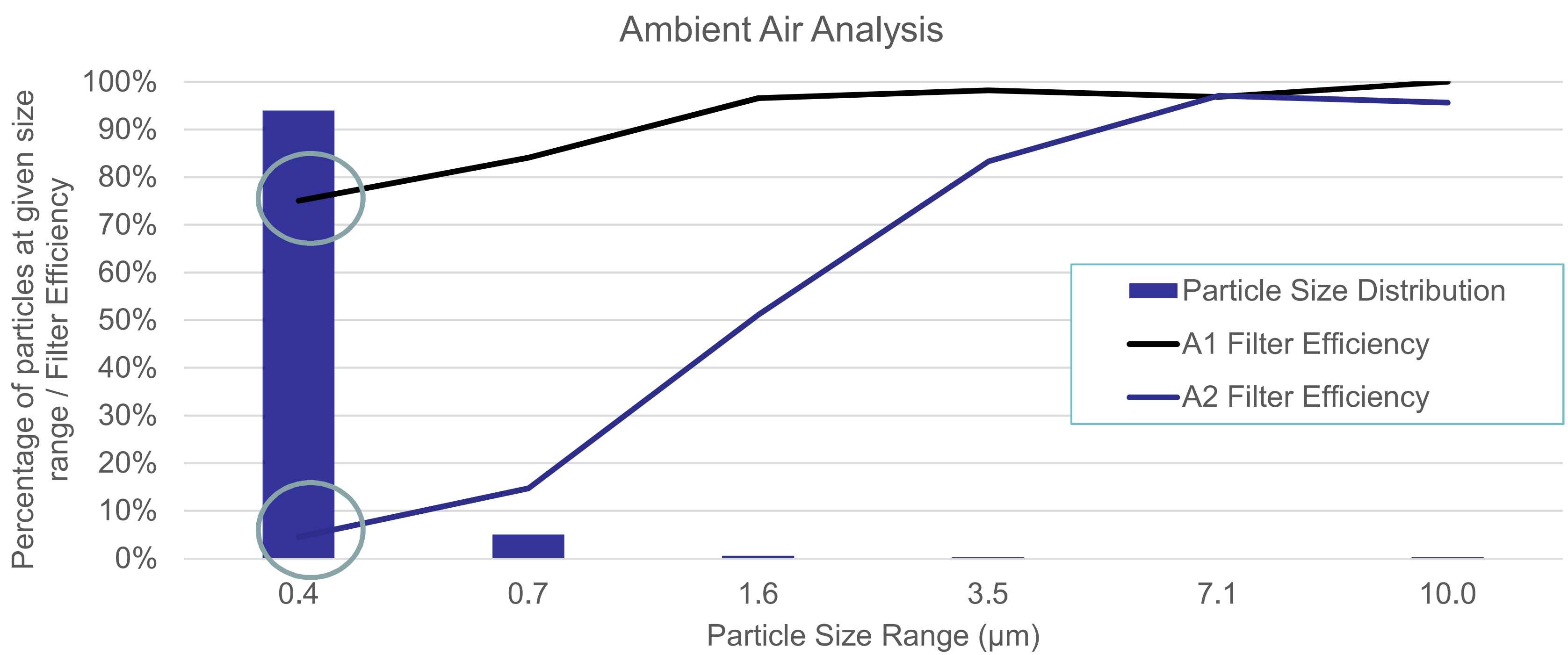
On-Site Measurement Devices



Air Quality at Site



Air Inlet Filter Efficiency



Filter Efficiency Recap

Classification of air filters [1]					
Group	**Class**	**Final pressure drop (test) Pa**	**Average arrestance (A_m) of synthetic dust %**	**Average efficiency (E_m) for 0.4 µm particles %**	**Minimum efficiency [2] for 0.4 µm particles %**
Coarse	G1	250	$50 \leq A_m < 65$	–	–
	G2	250	$65 \leq A_m < 80$	–	–
	G3	250	$80 \leq A_m < 90$	–	–
	G4	250	$90 \leq A_m$	–	–
Medium	M5	450	–	$40 \leq E_m < 60$	–
	M6	450	–	$60 \leq E_m < 80$	–
Fine	F7	450	–	$80 \leq E_m < 90$	35
	F8	450	–	$90 \leq E_m < 95$	55
	F9	450	–	$95 \leq E_m$	70

Water Wash Analysis

Engine	Soak Wash Date	Runtime Between Washes (hours)	TSS (mg/L)	TSS per 1,000 firing hours (mg/L)
A1	07-Mar-14	1,300	230	177
A1	29-Jan-15	1,853	220	119
A2	18-Dec-13	1,000	360	360
A2	19-Mar-14	976	360	369

A1 Average:	148 mg/L per 1,000 fired hours
A2 Average:	364 mg/L per 1,000 fired hours

Cost- Benefit Analysis

- Fuel
- Filters
- Pressure Drop
- Soak washes

- Data (Power and fuel) for various speeds for both normal and post wash (7 days) operations
- Heat rates at corrected speeds for both operations (normal – I ; Post wash –II)
- Performance for A1 and A2 units
- Weighted average degradation
- Fuel saving

$$\text{Heat Rate} = \frac{Fuel\ input\ \ (KW)}{Energy\ output\ (KW)}$$

$$\text{Perf} = \frac{Degrad.Perf\ - Clean\ Perf}{Clean\ Perf}$$

$$\text{Perf} = \frac{Heat\ rate\ \ I - Hea\ \ rate\ II}{Heat\ rate\ II}$$

A1= -0.3 % ; A2= -2.2%

Fuel savings = Fuel Consumption (m^3/hr) x Fuel cost (cad/m^3) x Run time (hrs) x Degradation improvement (%)

- Data for temperatures and pressures before and after
- Eff at corrected speeds for before and after soak wash

$$Compr\ Eff = \left(\frac{Temp\ \ Inlet}{Temp\ \ Outlet - Temp\ \ Inlet}\right) \times \left(\frac{Pressure\ \ Outlet}{Pressure\ Inlet}\right)^{\frac{0.4}{1.4}} - 1$$

- Calculated performance for both A1 and A2 units

$$\text{Perf} = \frac{Degrad.Perf - Clea\ \ \ Perf}{Clean\ Perf}$$

$$\text{Perf} = \frac{Post\ Wash\ Eff - Avg\ Eff}{Post\ \ Wash\ Eff}$$

- Weighted avg degradation

A1= 0.2 % ; A2= 1.2%

Soak washes

- Fixed intervals of 1000 hours

- Typical soak wash costs - $ 2000 to $ 5000 depending upon the size of the unit.

- Reduction in number of soak washes as much as half over typical 20,000 hour filter lifetime based on the test results (TSS)

Overall Cost Analysis

Item	Description	Cost Impact (CAD) – per 20,000 hours
Heat Rate Improvement	Improvement of 1.9% of fuel budget	-$320,000
Pressure Drop Penalty	Cost of 0.03" wg additional pressure drop	+$2,400
Reduced Maintenance Demands	Savings from 10 fewer soak washes	-$50,000
Excess Filter Cost	Additional filter costs for upgrade	+$12,500
Total:		**-$355,100**

Process Improvement

- Check the environment (reports or field testing)
- Operating conditions (fixed speed or varying speed)
- Select filters that fit the operating conditions and environment
- Bring consistency in terms of types and brands of filters
- Shift towards predictive maintenance
  - Air compressor efficiency
  - Heat rate
  - CDP
  - Thermal efficiency
  - Testing of soak wash samples

Conclusion
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