

Worldwide Pollution Control Association

WPCA-Duke Energy
FF/HAPS Seminar
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*Applications and Evaluation of PPS Media
in Baghouses*

Robert Snyder - B&W Technology

Outline

PPS types and configuration

Performance

Emission

Pressure Drop

Baglife

Most typical Types of PPS Bags

PPS – either self supported or scrim supported

PPS+ – enhanced via P84 or micro denier

PPSm– membrane

Overview:

Focus on Coal Fired Boiler Applications:

Factors that affect filter media interact:

*Temperature – low – normal - upsets

(Example plant winter low load 235F to
summer full load 335F)

Overview:

Factors that affect filter media interact:

- *Corrosiveness – acids, alkalis, solvents, oxidizing agents
Example (SO₃ and H₂O - acid attack, bromine iodine, ozone - oxidizing)

- *Hydrolysis – humidity (Polyesters – typical rating Fair resistance to moist heat)

- *Dimensional Stability – stretch & shrinkage
(Acrylics are sensitive to shrinkage)

Overview:

Factors that affect filter media interact:

The Babcock & Wilcox Company Fabric Comparison Chart					
Fiber	Abrasion Resistance	Acid Resistance	Alkalies Resistance	Maximum Operating Temperature F	Relative Cost
Polypropylene	Excellent	Excellent	Excellent	165 200	\$
Homopolymer Acrylic	Good	Good	Fair - Good	280	\$\$
Copolymer Acrylic	Fair	Good	Fair	250	\$\$
Polyester	Excellent	Fair	Fair-Good	275	\$
Aramid	Excellent	Fair	Good	380	\$\$\$\$
PTFE	Fair	Excellent	Excellent	500	\$\$\$\$\$\$\$
Fiberglass	Fair	Good - Excellent	Fair-Good	500	\$\$\$
PPS	Excellent	Excellent	Good	375	\$\$\$\$\$
P84	Excellent	Good - Excellent	Fair	400	\$\$\$\$\$
Nomex	Good	Poor	Excellent	400	\$\$\$\$\$

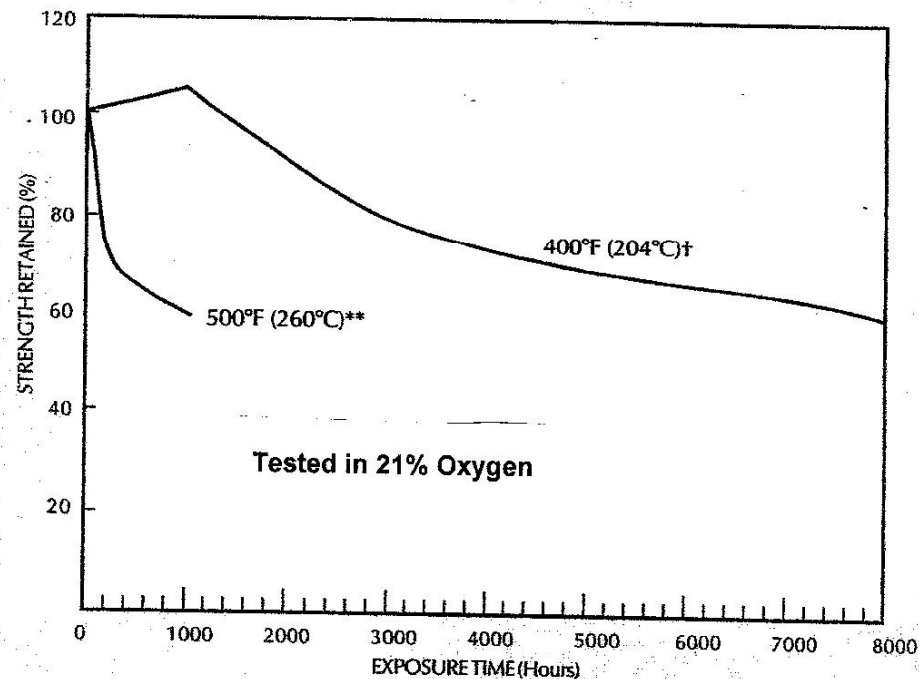
Old Ryton Charts

Figure 1 – Strength Retention of Ryton® Fiber after Exposure in Air at High Temperatures*

Ryton has outstanding strength retention upon exposure to heat.

Ryton retains 60% of its original strength after exposure to 500°F (260°C) for 1000 hours.

It retains 90% strength after exposure to 400°F (204°C) air for 2000 hours — 70% after 5000 hours and almost 60% after 8000 hours.

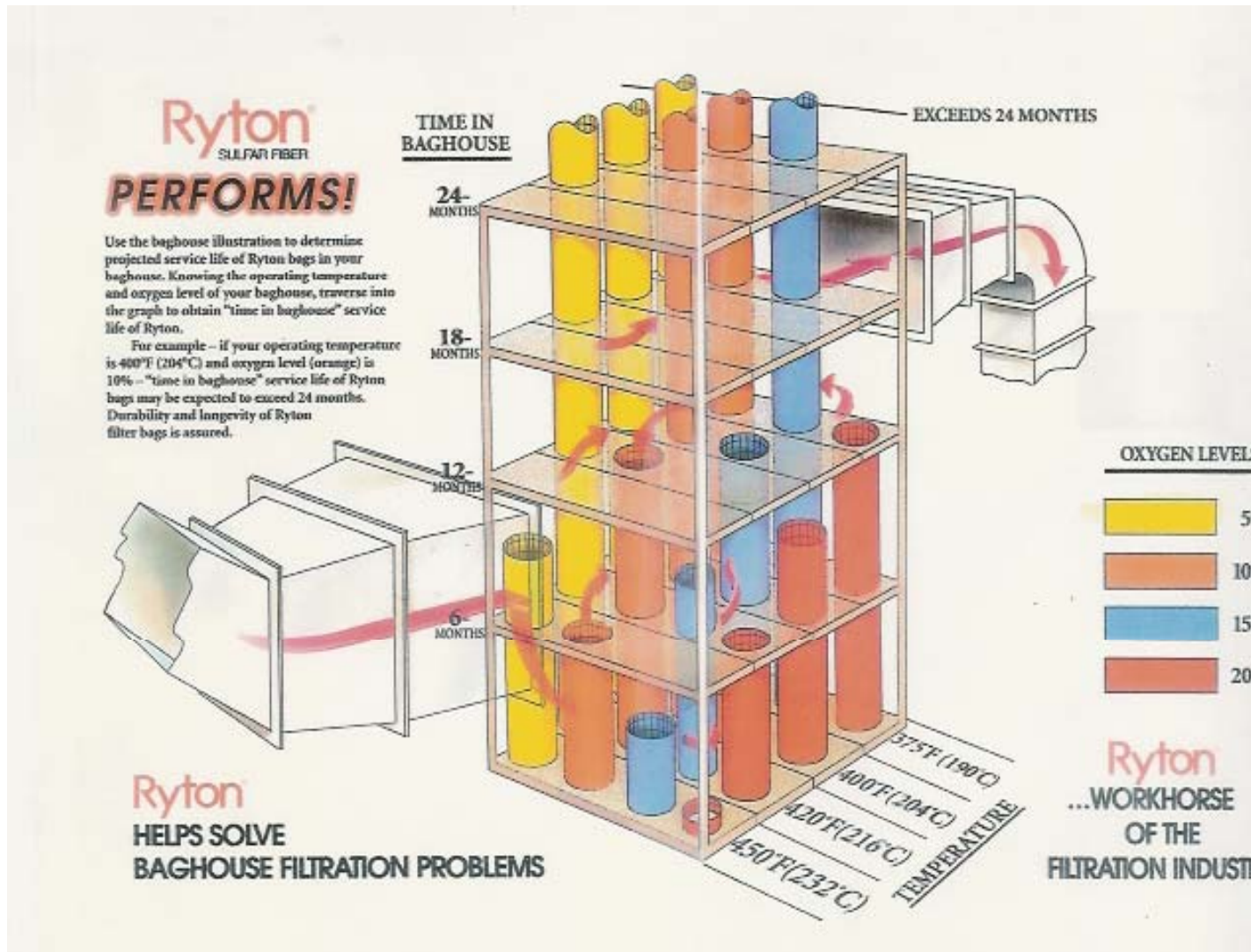


* ASTM D-461

** Based on laboratory tests

† Based on lab and field data

Old Ryton Chart



Performance Issues

Emissions

Emissions

Collection efficiency for pulse-jet filters (felted fabrics) was investigated by Leith and Ellenbecker

$$N_o = N_{st} + N_{se}$$

where: N_o = total outlet flux from filter, kg/m²s;

N_{st} = flux fraction due to straight-through dust, kg/m²s;

N_{se} = flux fraction due to seepage, kg/m²s.

Straight-through penetration is dust passing through the filter without being collected. Seepage was dust collected by any mechanism but released at a later time during filtration.

$$N_o = N_{se} = k W^2 V / t$$

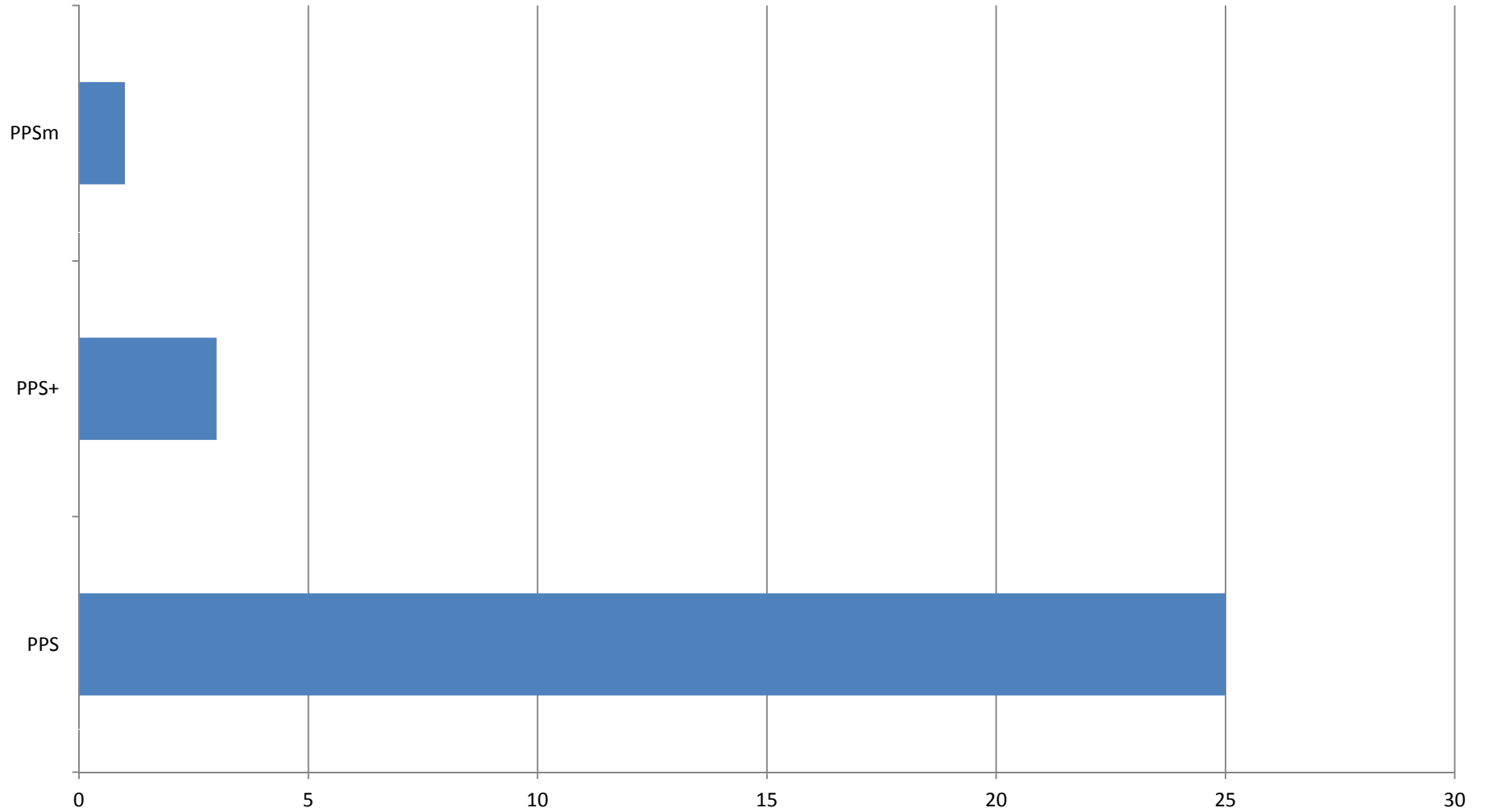
where: t = time between cleaning pulses, s;

V = superficial filtration velocity, m/s;

W = mass of dust per unit area on the filter, kg/m²;

k = a constant depending on fabric elasticity & dust release properties, (ms)/kg.

Relative Emissions Lab Tests

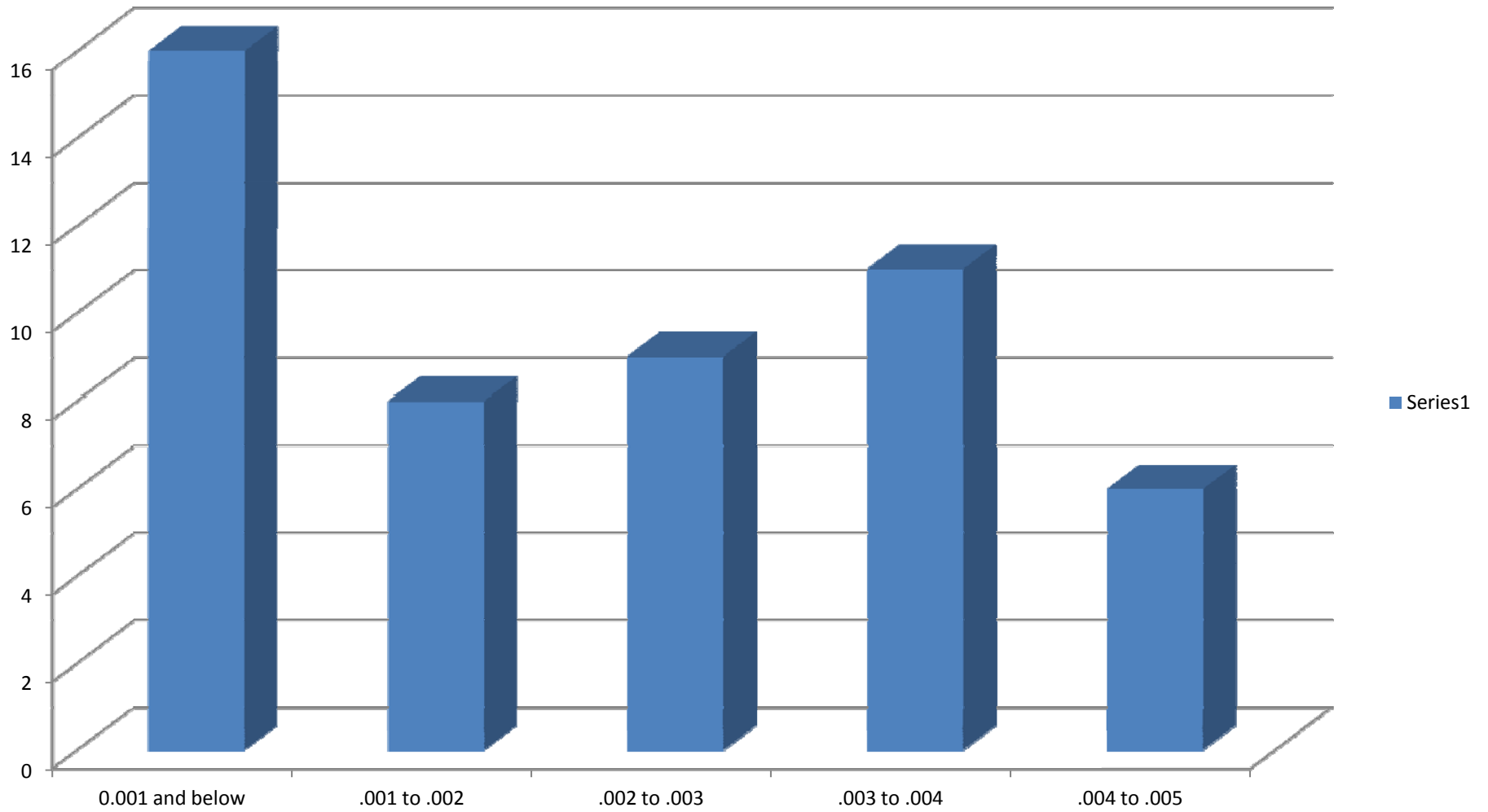


Emissions - Seepage

PPS – theory and lab testing has good correlation between cleaning frequency and emission.

PPS+ and PPSm – theory and lab testing does not have good correlation between cleaning frequency and emission.

Emissions – ICR data – top 50 of 95 tested lb/mbtu



Emissions

Some of the plants in the ICR table were generally below optimal level - lack of maintenance

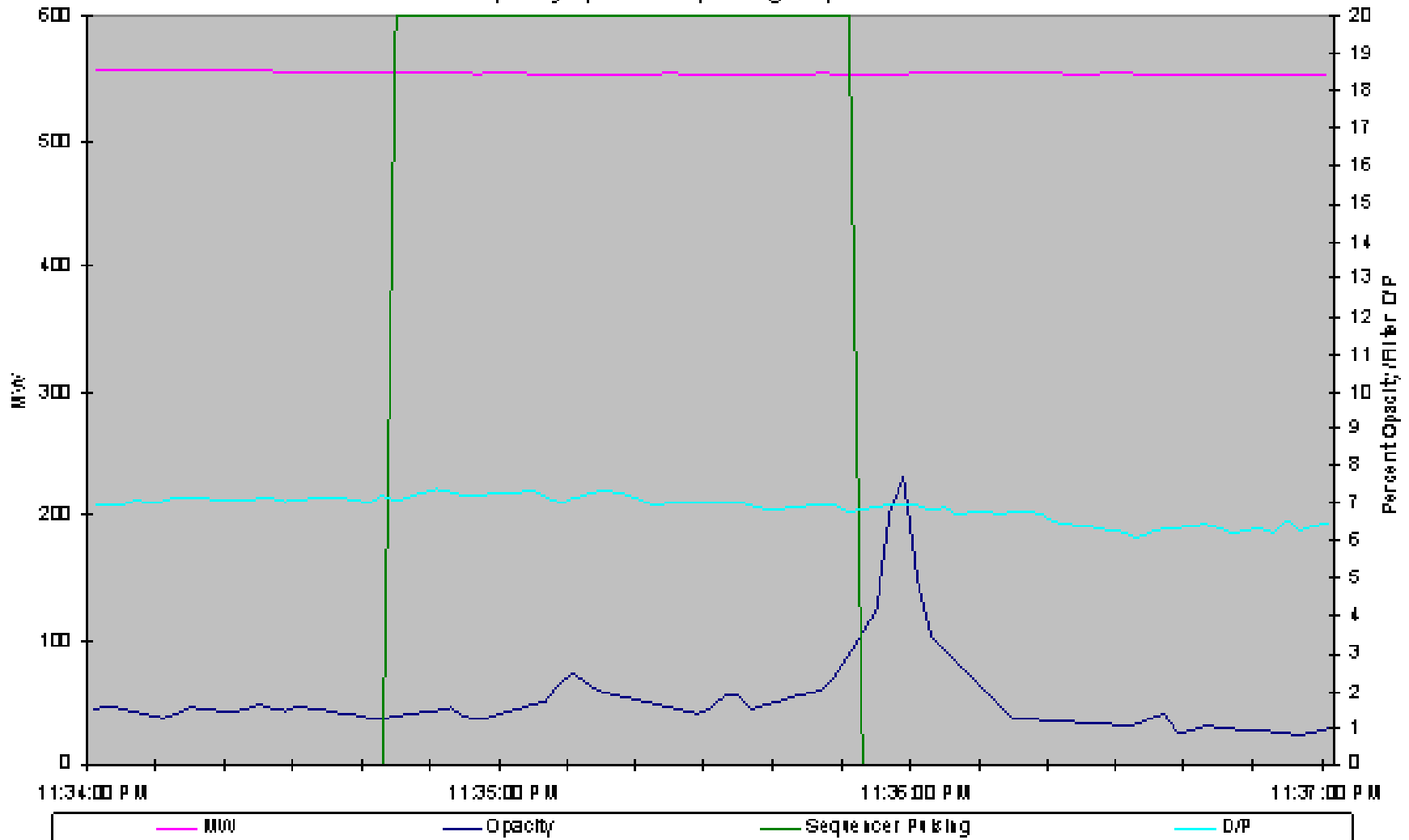
Historically – emissions many times go down as bags age.

Tips for Emission Control

- 1 – fix casing-tubesheet leaks
- 2** – have good quality program when installing bags.
- 3 – monitor emissions on a daily basis (check analog opacity signal) – PJFF
- 4 – fix leaks when they occur – don't hold off.

Emission – Bag Leak

Opacity spike after pulsing sequence



Emissions – some observations

Particle size

Lab versus actual

Locating leaks

Performance Issues

Pressure Drop

General Equation Fabric Filter Pressure Drop

The model is based upon “Fabric Filter - Baghouse I - Theory, Design and Selection” by J.D. McKenna and J.H. Turner

The general equation is:

$$\Delta P = SeV + KCV^2t + ML$$

ΔP = pressure drop, in. w.c. units

V = velocity of gas entering bag surface, ft/min

Se = residual drag, in. w.c./(ft/min)

K = specific cake coefficient, ([in. w.c.] * ft) / (lb * min)

C = dust concentration times, lb/ft³

t = time, minutes ML (*mechanical loss*)

Breakdown of Pressure Loss

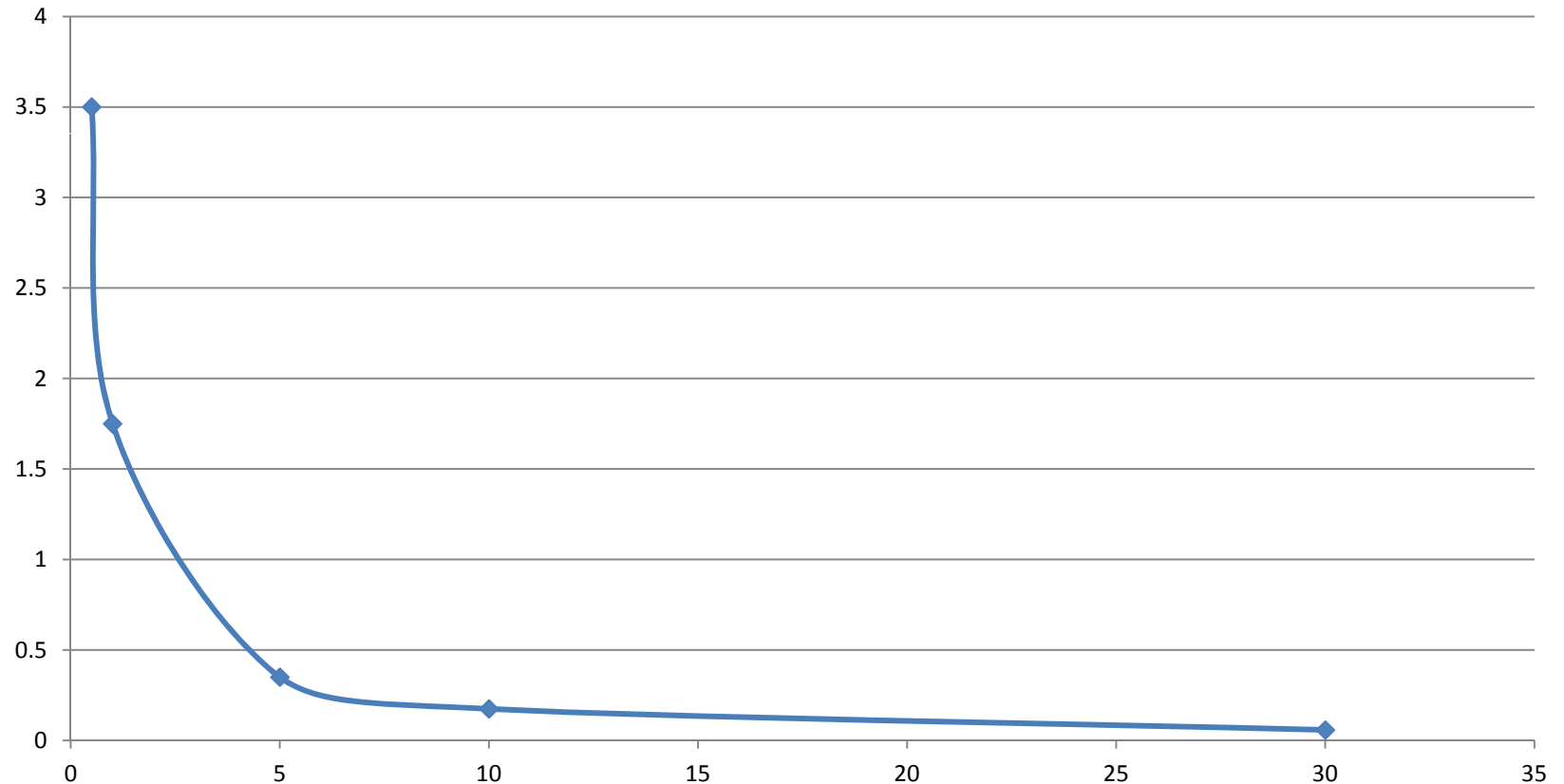
PJFF overall dp = 6 inwc

Mechanical Loss – (manifolds, dampers, entrance and exit) = 2 inwc (typical value)

Residual drag – loss across the bag (permeability of new PPS 30 fpm @ .5 inwc (A/C of 3.5 fpm) dp = 0.06 inwc.

Cake dp = 6inwc – 2 inwc - .06 inwc = 3.94 inwc

Bag Permeability (horizontal) versus dp (vertical) @ A/C 3.5 fpm



Pressure Drop

Loss in permeability over time

Common to nearly all units

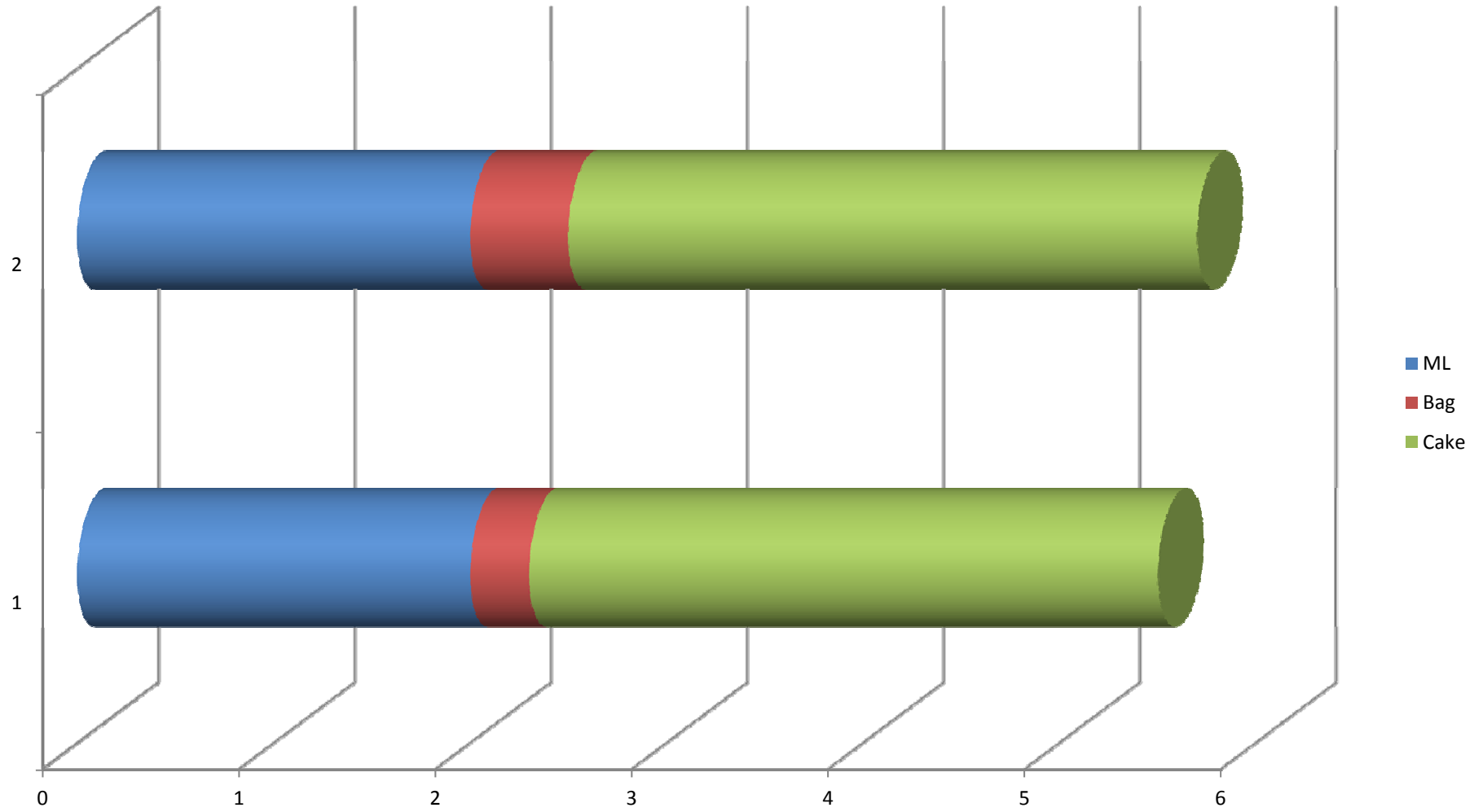
Extreme - 11 months (6inwc -15inwc)

Typical (PJ 3inwc (4yrs))

Event related

Upsets – boiler tube leaks

Pressure drop changes

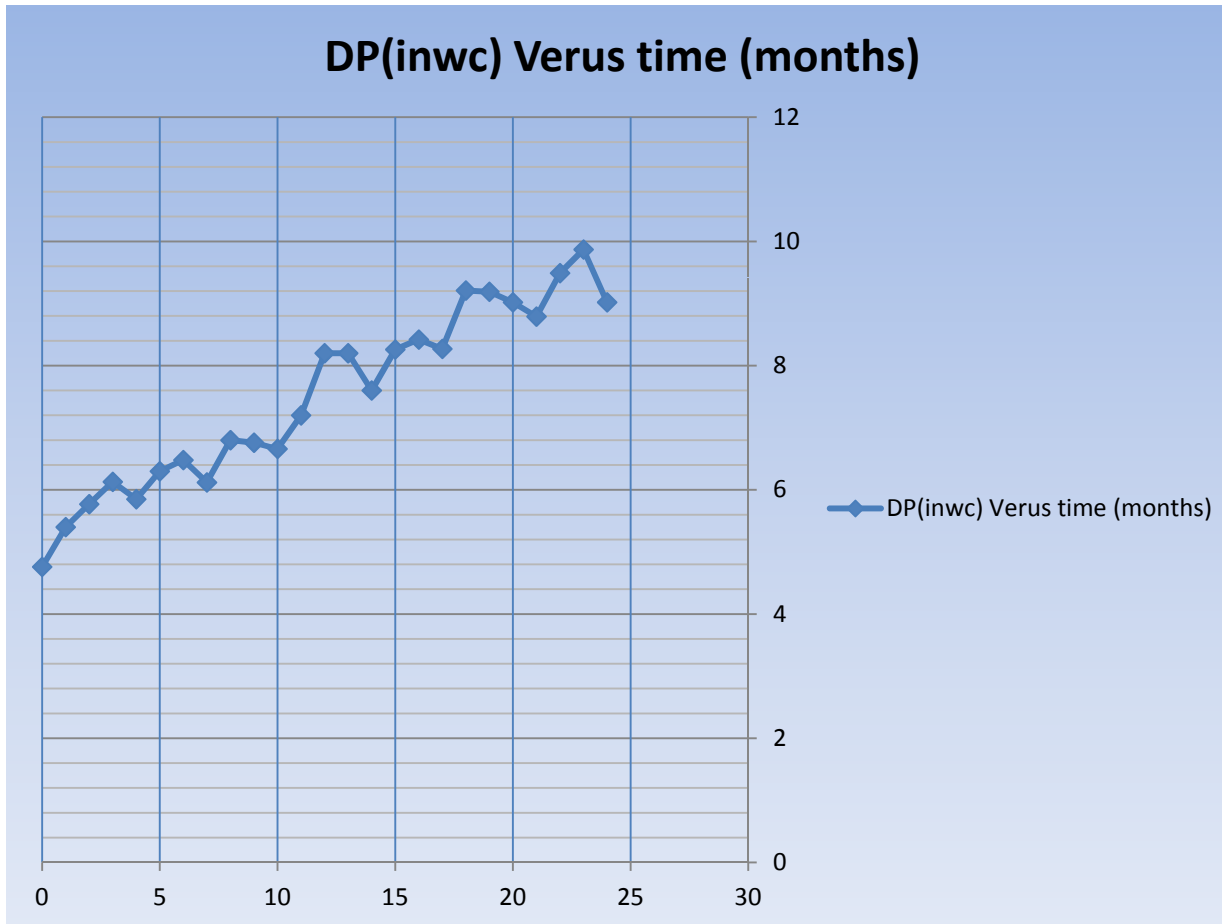


Case Studies

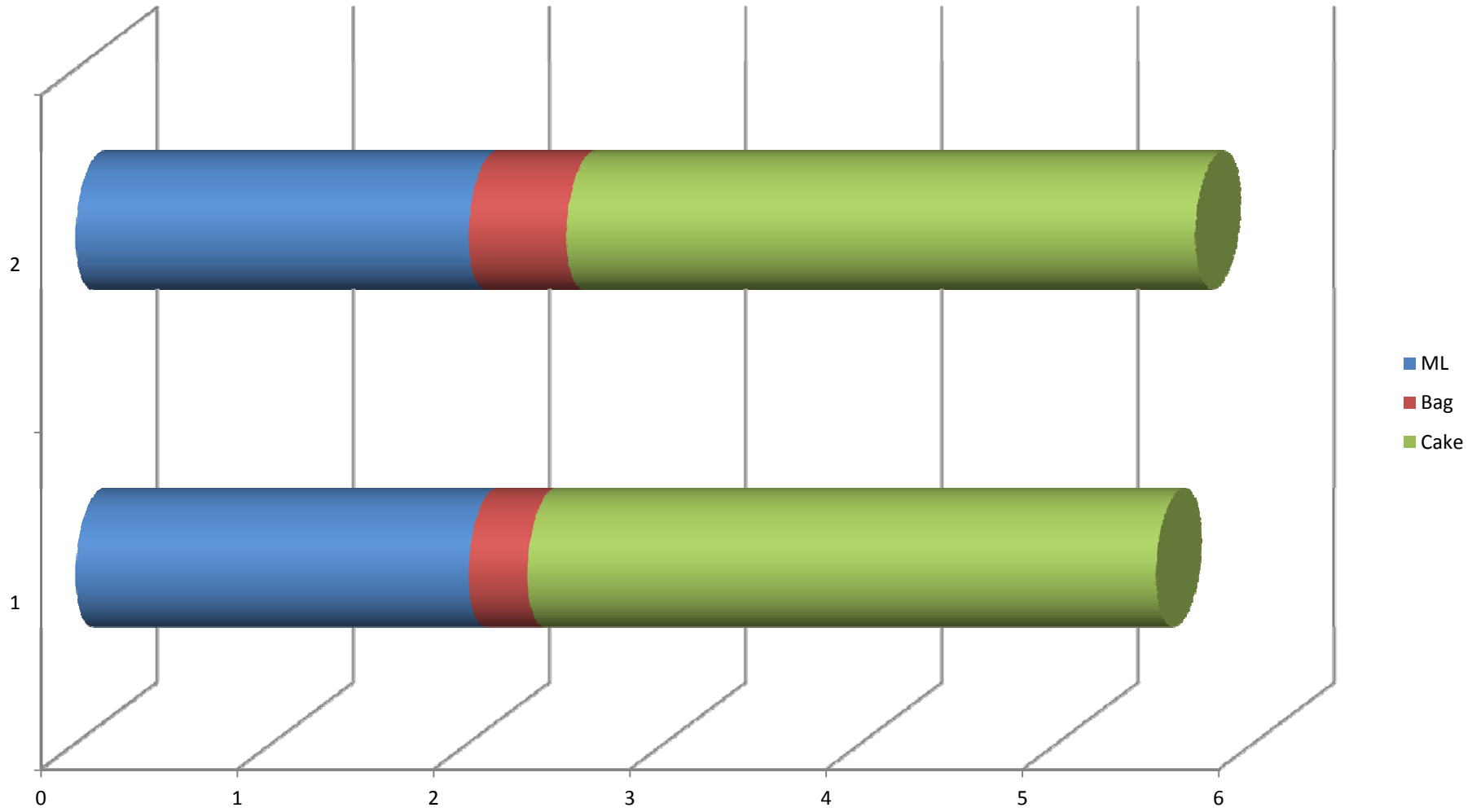
Pressure Loss Example 1

Baghouse Dp Hourly Values					
Date/Time	Baghouse Dp Inches Water	Daily Averages Inches Water	Baghouse Inlet Gas Temp Deg F	Daily Averages Deg F	Gross MW GMW
1/1/2009	4.89		272.99		39.46
1/1/2009 1:00	9.34		304.06		59.40
1/1/2009 2:00	9.37		311.34		59.67
1/1/2009 3:00	9.04		309.63		59.60
1/1/2009 4:00	9.14		308.39		59.60
1/1/2009 5:00	9.39		309.49		59.65
1/1/2009 6:00	9.20		309.52		59.46
1/1/2009 7:00	8.87		308.07		59.60
1/1/2009 8:00	8.48		307.20		59.76
1/1/2009 9:00	8.25		305.06		59.43
1/1/2009 10:00	8.35		306.35		59.86
1/1/2009 11:00	8.72		306.56		59.37
1/1/2009 12:00	8.78		307.84		59.82
1/1/2009 13:00	8.85		307.38		59.97
1/1/2009 14:00	8.81		306.16		59.97
1/1/2009 15:00	8.67		306.71		59.97
1/1/2009 16:00	8.79		308.64		59.97

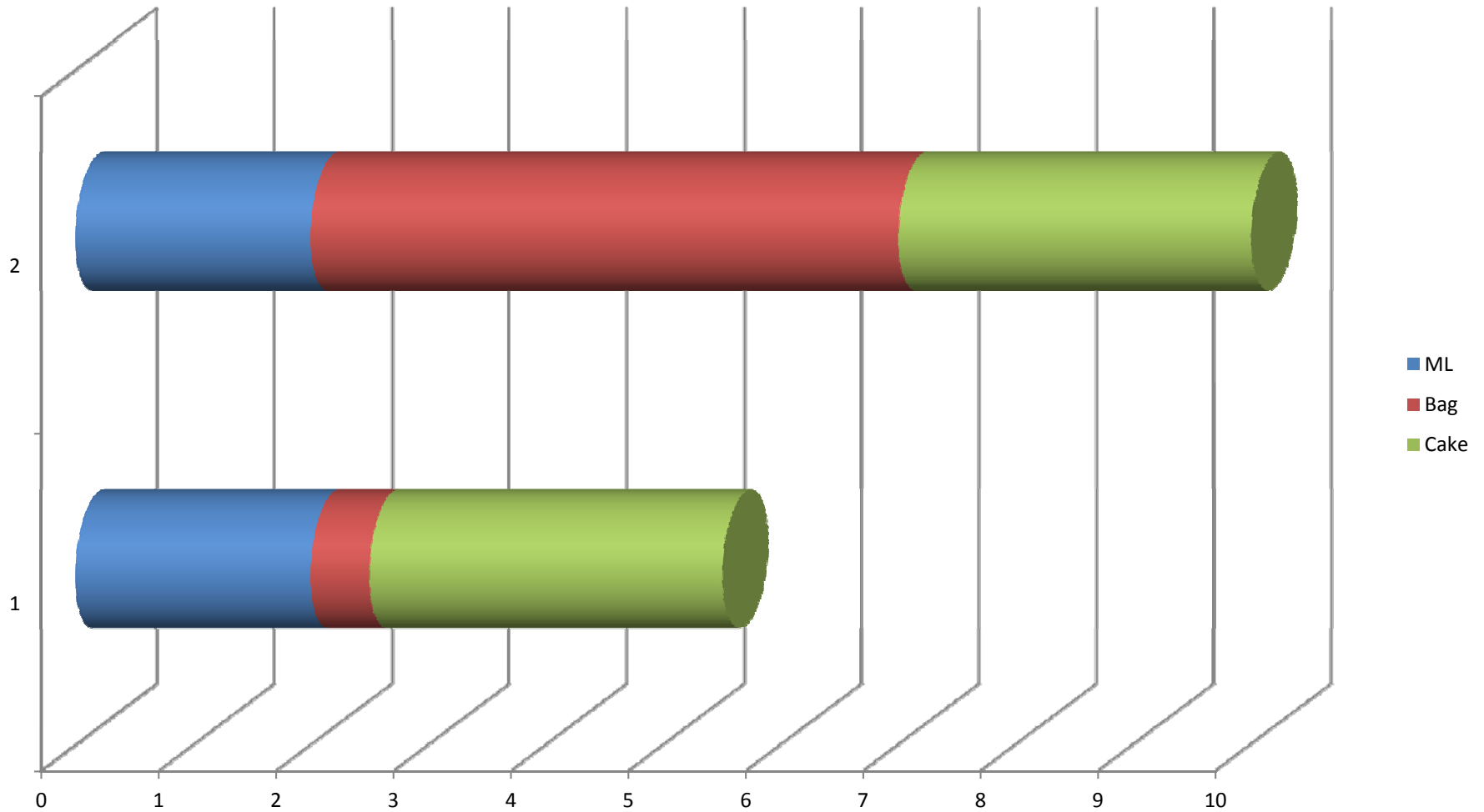
Pressure loss Example 1



Example 1 T=1,2



Example 1 T=1,24



Example 1

Findings:

Unit operates with dp control – off-line cleaning

Based upon rate of dp increase after one or two months –likely cleaned at maximum speed.

No obvious event related dp loss.

Pressure Loss Example 2

Data available (unit PC fired with SDA and FF):

Mw **

Gas Flow **

Gas Temp **

Compartments open **

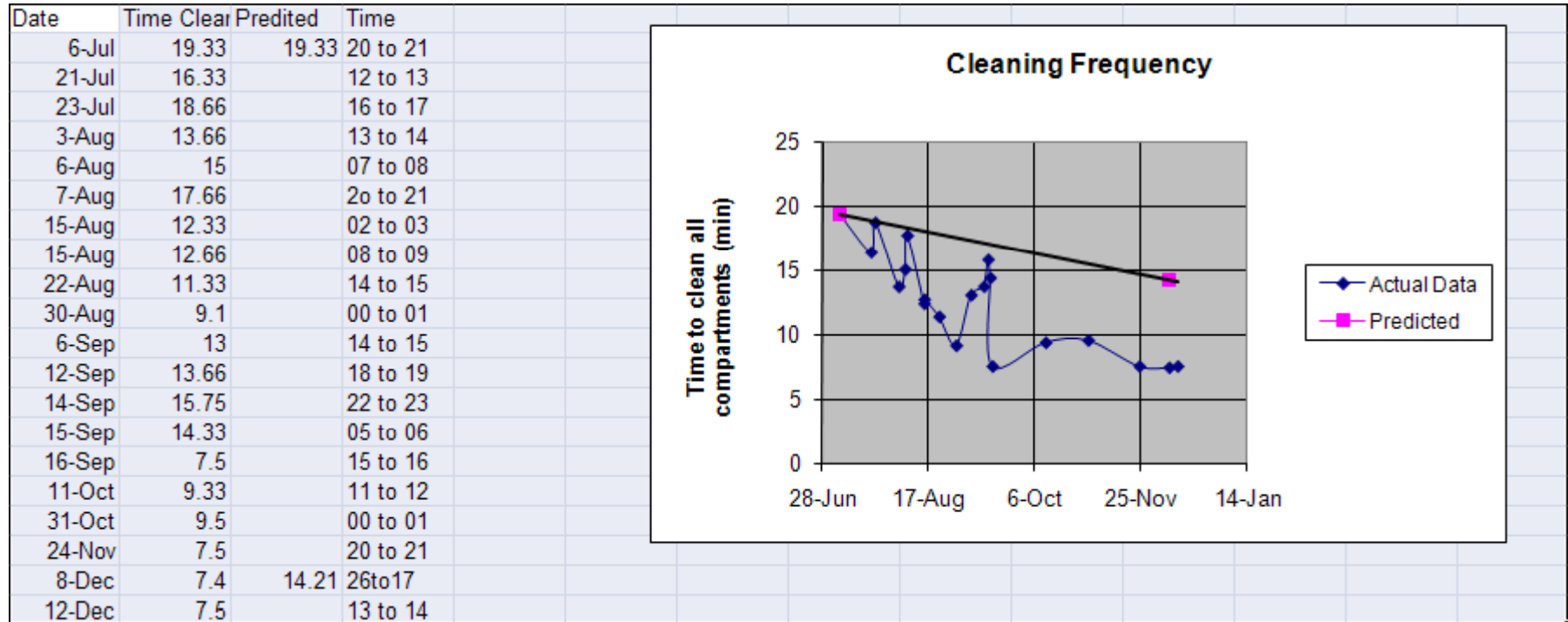
Dp **

Cleaning Speed

Time

** held constant and not shown on chart

Pressure Loss Example 2



Example 2

Conclusions:

Event during July caused fast cleaning frequency which was recoverable.

A second event in September caused a fast cleaning frequency which was not recoverable.

Example 3

Normal dp setting was 5.5 inwc.

After 3 months of service dp 5.5 inwc cleaning 45 minutes. At 10 minute cleaning speed dp was xx inwc.

After 12 months of service dp 5.5 inwc cleaning yy minutes. At 10 minutes cleaning speed dp was zz inwc.

Example 3

What is annual rate of change in dp,

Method 1 - (zz-xx)

Method 2 – using pressure loss equations determine the change in SE. ($Se \cdot V = dp$). Most difficult to determine without good background data.

Example 3

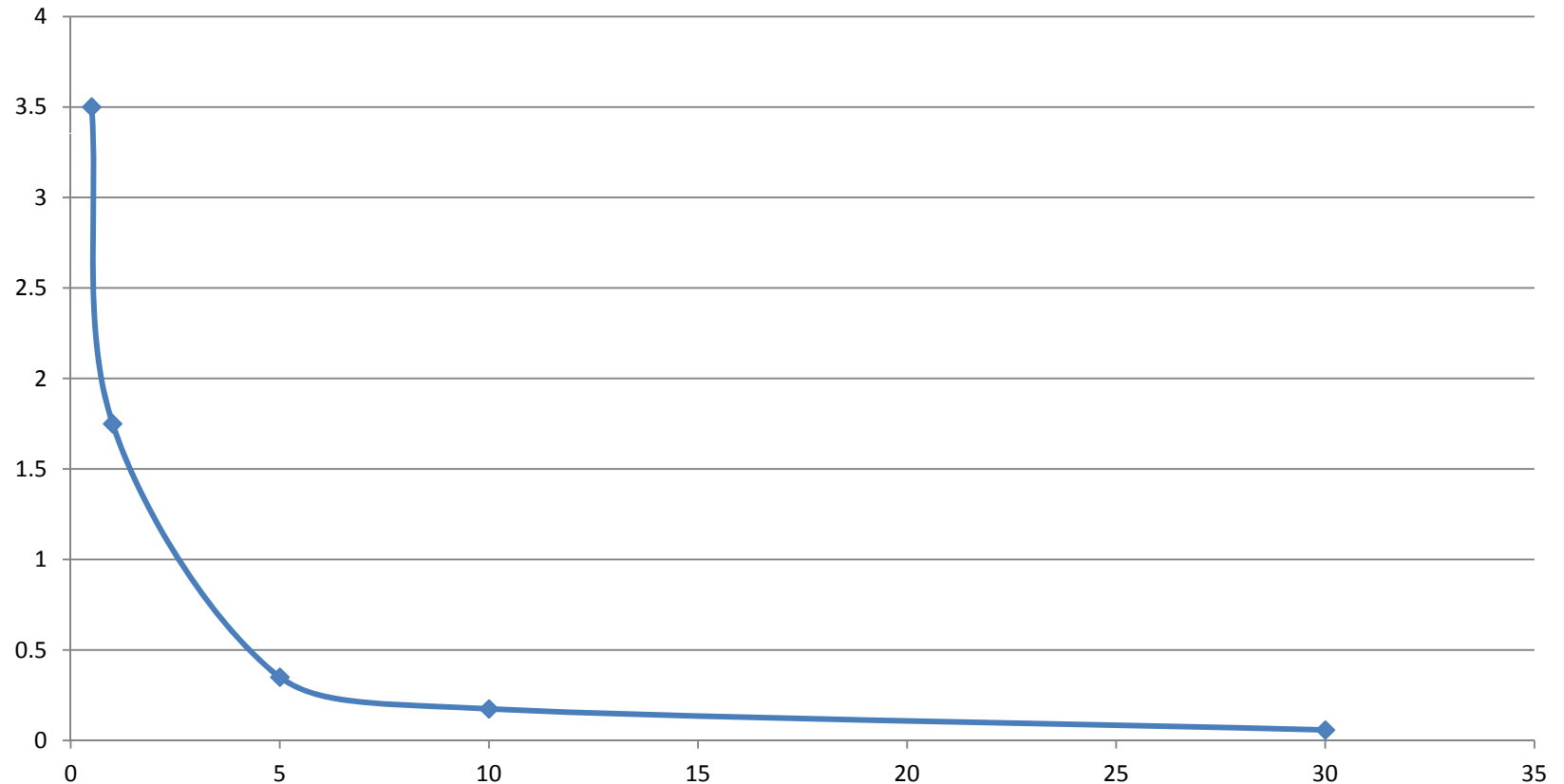
ZZ = 3.58 inwc and XX = 3.74 inwc

Correcting for time 9 months to 1 year.

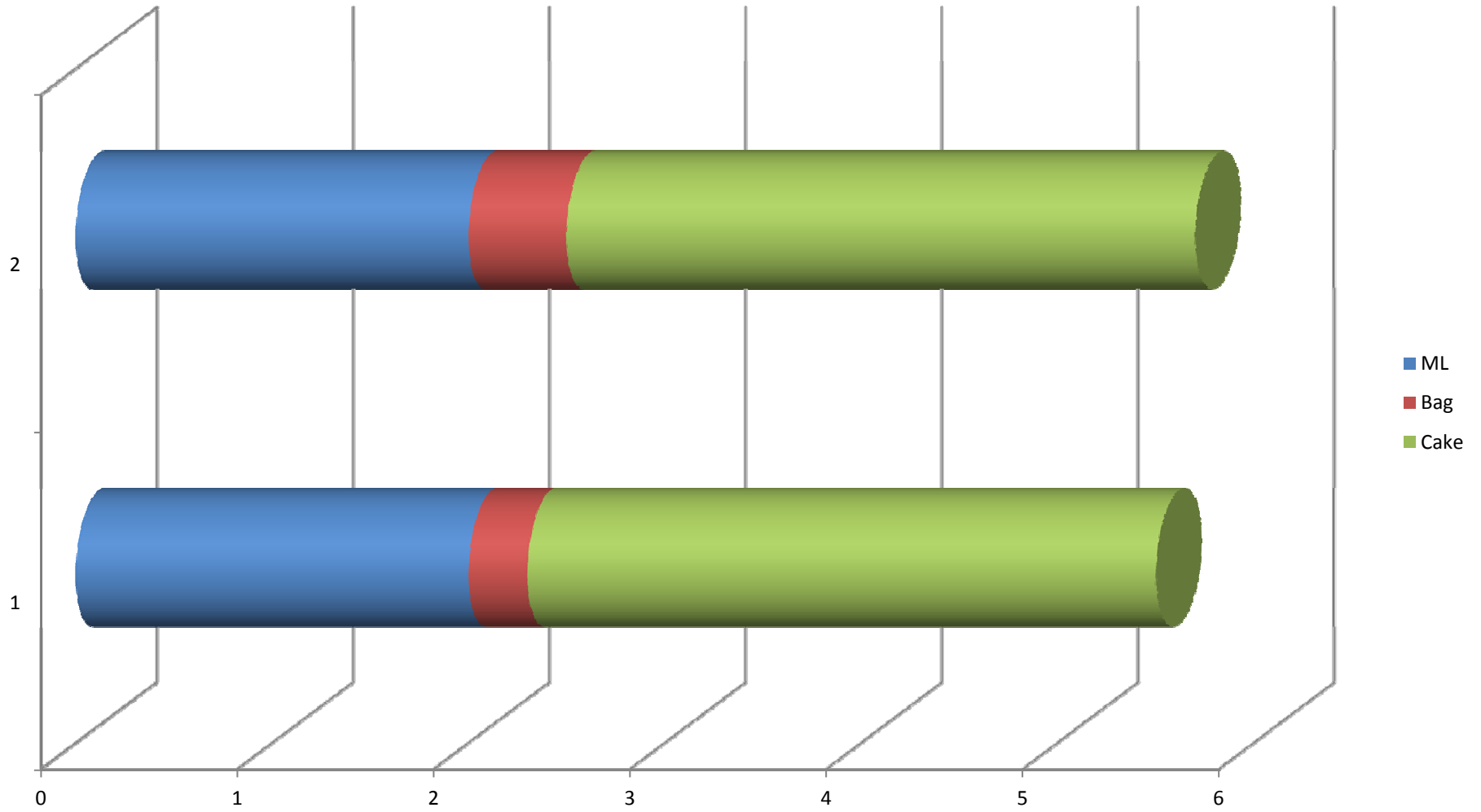
Rate of dp change is $(3.74-3.58)/9m * 12m/yr$
 $= 0.21 \text{ inwc/yr}$

Change in permeability = ?

Bag Permeability (horizontal) versus dp (vertical) @ A/C 3.5 fpm



Example 3



Testing of Permeability

Lab method – examination of air flow through a 6 inch diameter sample at 0.5 inwc.

Field Method – examination of air flow through the bag.

Tubesheet Flow Distribution Study

During unit outage field permeability was examined over a compartment. Grid 5x5 = 25 points.

Results –

Maximum value < 1.28 mean

Minimum value > .71 mean

STD Deviation < 13%

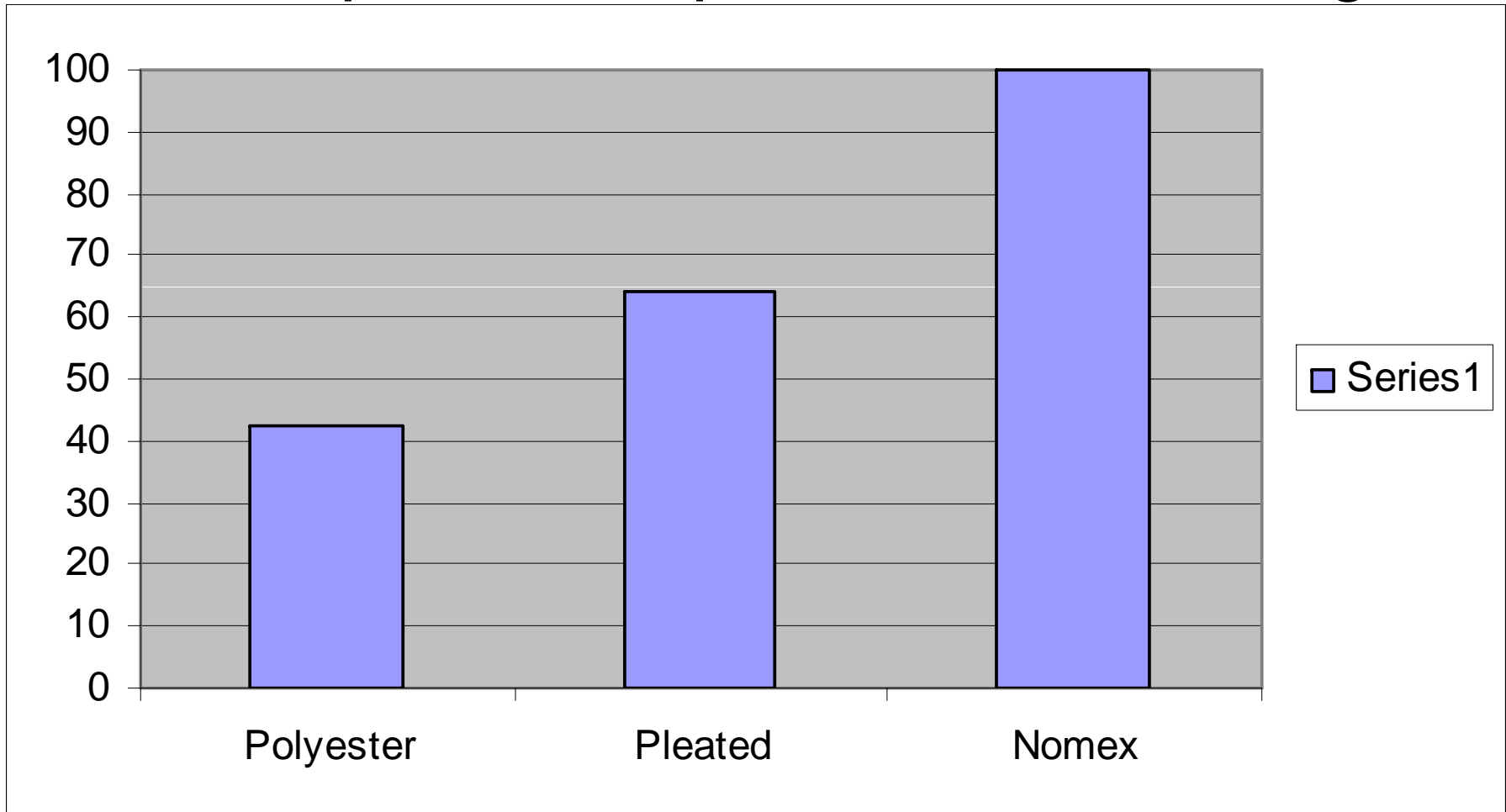
Pressure Drop Evaluation

First Choice – look at operating data

Second Choice – field permeability data – most useful in evaluating various materials over time.

Third choice - lab testing

Example of comparative field testing



Bag life versus Performance Issues

Emissions

Pressure drop

Maintenance Cost

Baglife - Emissions

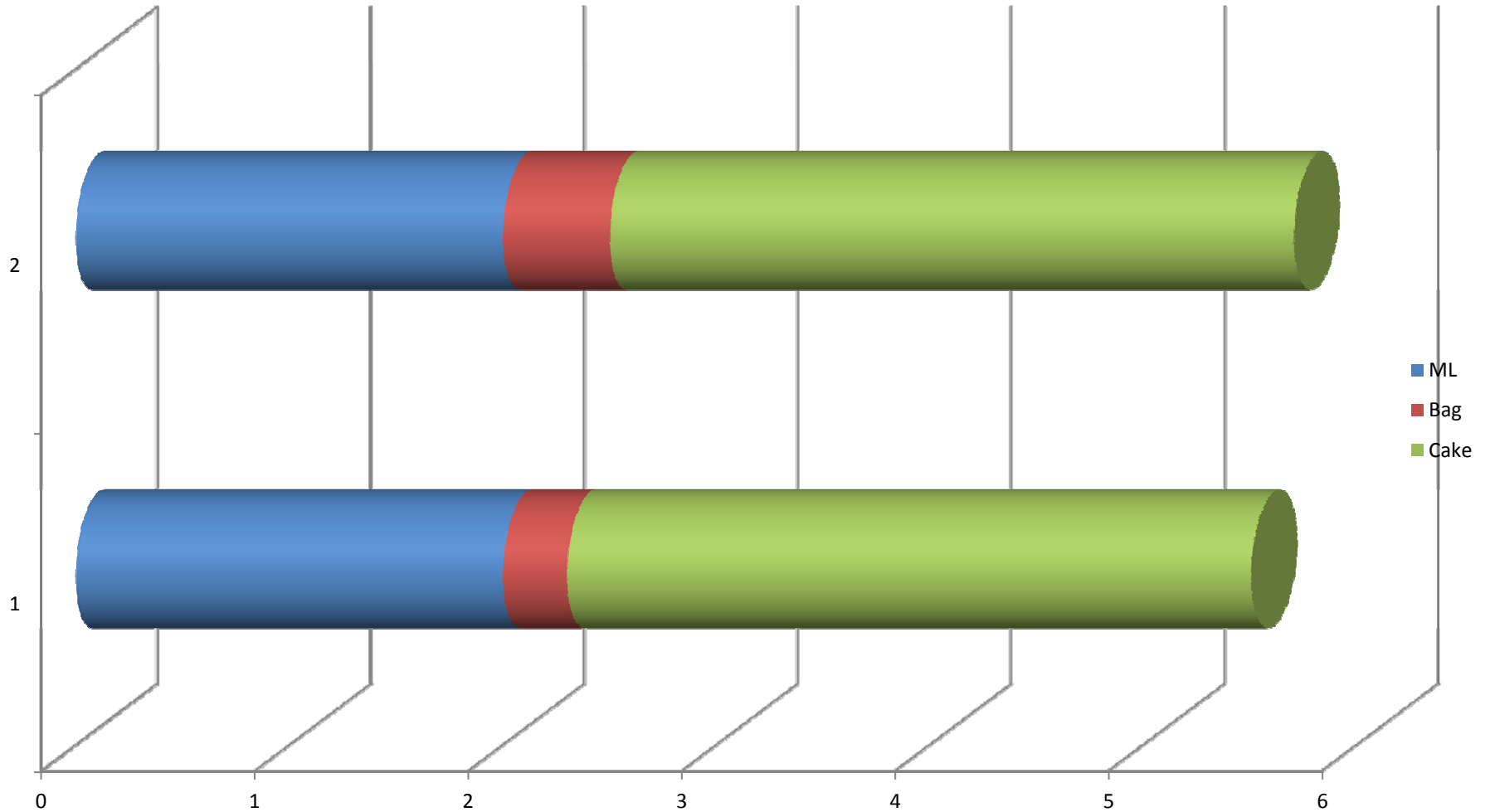
PPS PPS+ PPSm ? seepage

Condensable fraction ? Dp and cleaning rate

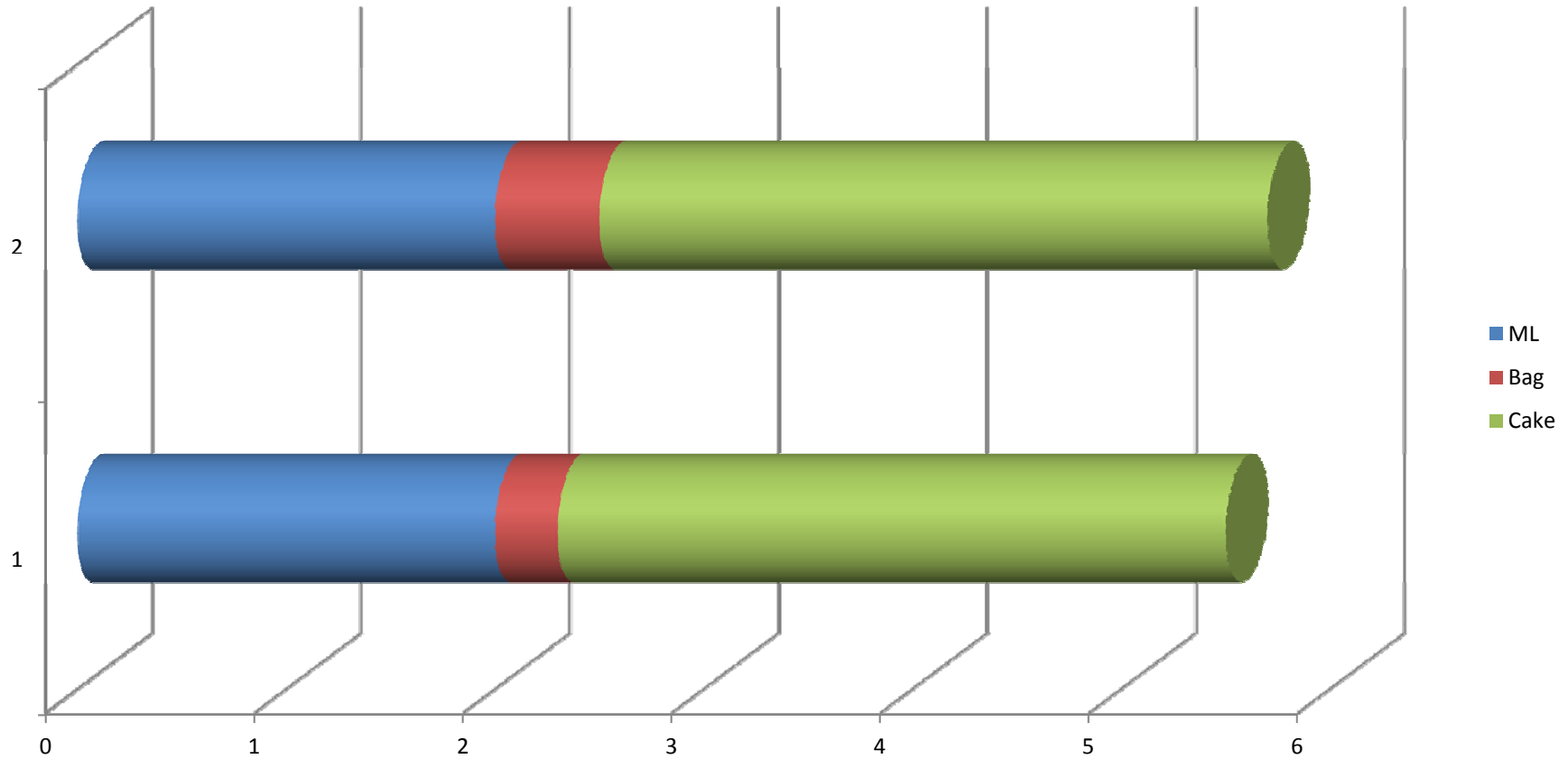
Mercury – PAC rate ?

Sorbent use ? (typical SDA 20% SO₂ capture across the PJFF)

Baglife Emissions option A dp maintained



Baglife Emissions option B dp increased



Operating Costs

Dp – loss of power for sale, higher fuel costs, higher sorbent costs

See previous 2 slides

Emission evaluation

Opacity – monitor over time

PM – monitor annual testing

Lab testing

Permeability – usually done as received, after vacuuming, compared to new, (top middle bottom)

Weight –

Strength – mullen burst, tensile, elongation, flex testing, (can show little to no loss or extensive loss)

Microscopic examination – looking for penetration

Lab testing

Visual examination – abrasion, cuts, stitching

Emission testing - ????? –value

Report – findings

Case 1 - Low sulfur coal fired units without SO₂ capture

PPS –operation <350F PJFF (life 2-5 years) –
sensitive to temperature (winter – summer)

Case 2 – Babcock & Wilcox Power Generation Group Low Sulfur coal fired units with Dry FGD or CDS

PPS typical 3 years

PPS+ 3 to 6 years

PPSm ~ 5 years

Case 3 – High Sulfur coal fired units with FF followed by Wet FGD or CDS.

With or Without ESP precollector

Filter media options (when to use/experience) –

PTFE (3 years+)

Membranes (3 years+) 22oz Fiberglass with membrane.

Case 3 – High Sulfur coal fired units with FF followed by Wet FGD or CDS.

With or Without ESP precollector

Filter media

PPS, PPS+ and PPSm – coupled with SO₃ mitigation (Lime injection)

Summary

Selection of PPS type – test/evaluate all three

Rely on historical operation data for bag permeability

Consider annual PM tests for maintenance prediction

Conduct annual strength tests



Questions?

Thank you.

