Worldwide Pollution Control Association

FirstEnergy ESP Seminar

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WPCA

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Effects of Temperature on ESP Performance

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Temperature affects ESP performance in three ways

It changes the volume flow through the ESP.

It changes the resistivity of the ash.

It changes the adhesion and cohesion properties of the ash.

Deutsch-Anderson equation for the collection efficiency of an ESP

$$p = \exp(-v_k * A/V)$$

where

p = fractional penetration of precipitator collection efficiency

A = total collecting area

V = flue gas flow rate

v_k = the ‘effective migration velocity’ of the particles

A/V = Specific Collection Area (SCA)

[collection efficiency of ESP = 100*(1 - p)]

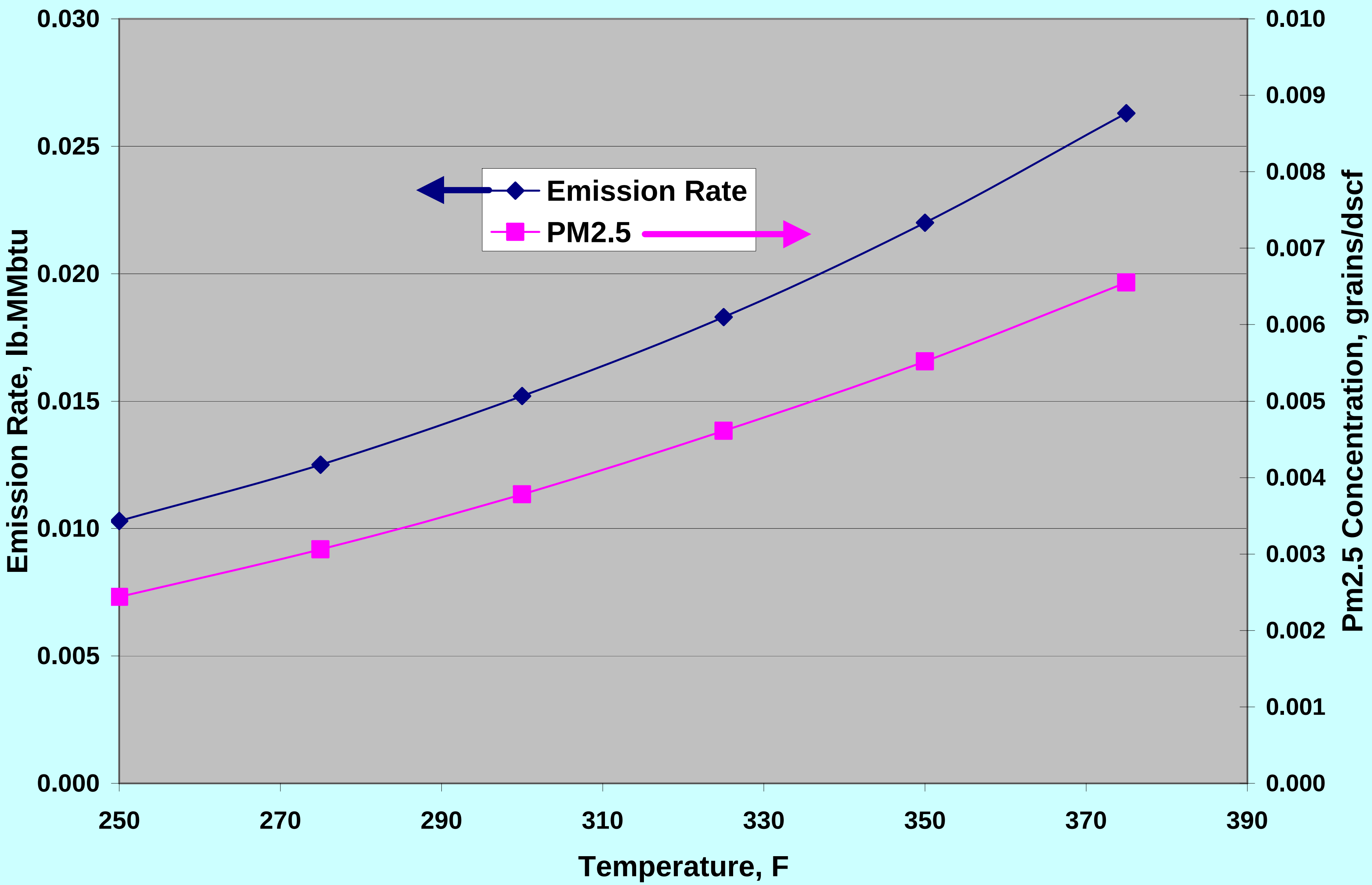
Examples to follow are based on an ESP with four sections of uniform length.

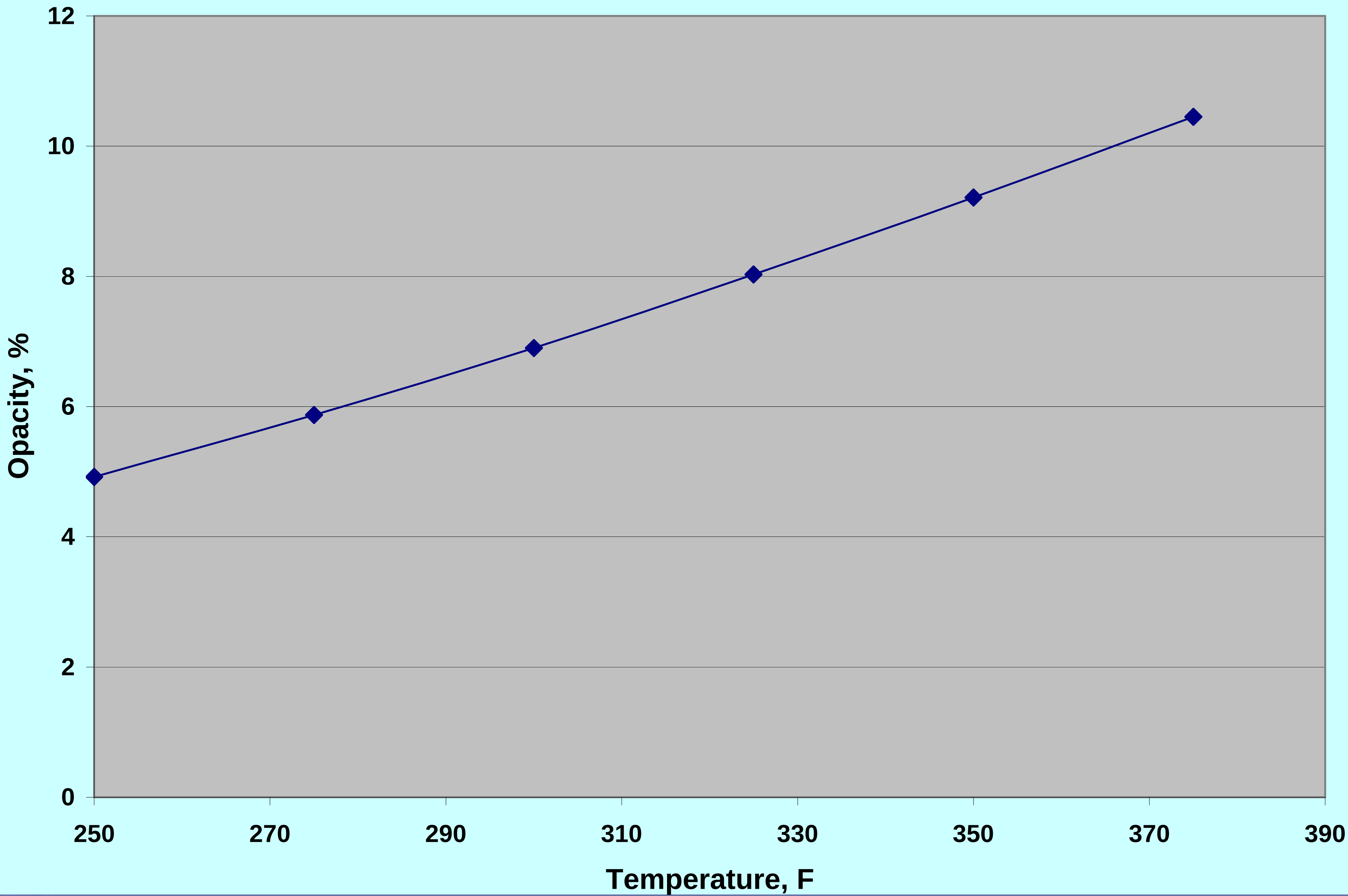
The SRI ESP model was used to estimate performance over a temperature range of 250 F to 375 F with constant mass flow of gas and inlet particulate matter.

The SCA was 288 sq.ft./kacfm at 300 F

Opacities were calculated based on a stack diameter of 30 feet.

First: Vary only volume flow using a fixed ash resistivity of $1X10^{10}$ ohm-cm.


0.030
0.025
0.020
0.015
0.010
0.005
0.000
Emission Rate, lb.MMbtu
0.010
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0.000
Pm2.5 Concentration, grains/dscf
Emission Rate
PM2.5
250
270
290
310
330
350
370
390
Temperature, F



Opacity, %
Temperature, F
0
2
4
6
8
10
12
250
270
290
310
330
350
370
390

Electrical Effects

In dust layer:

Electric Field = (current density) x (resistivity)

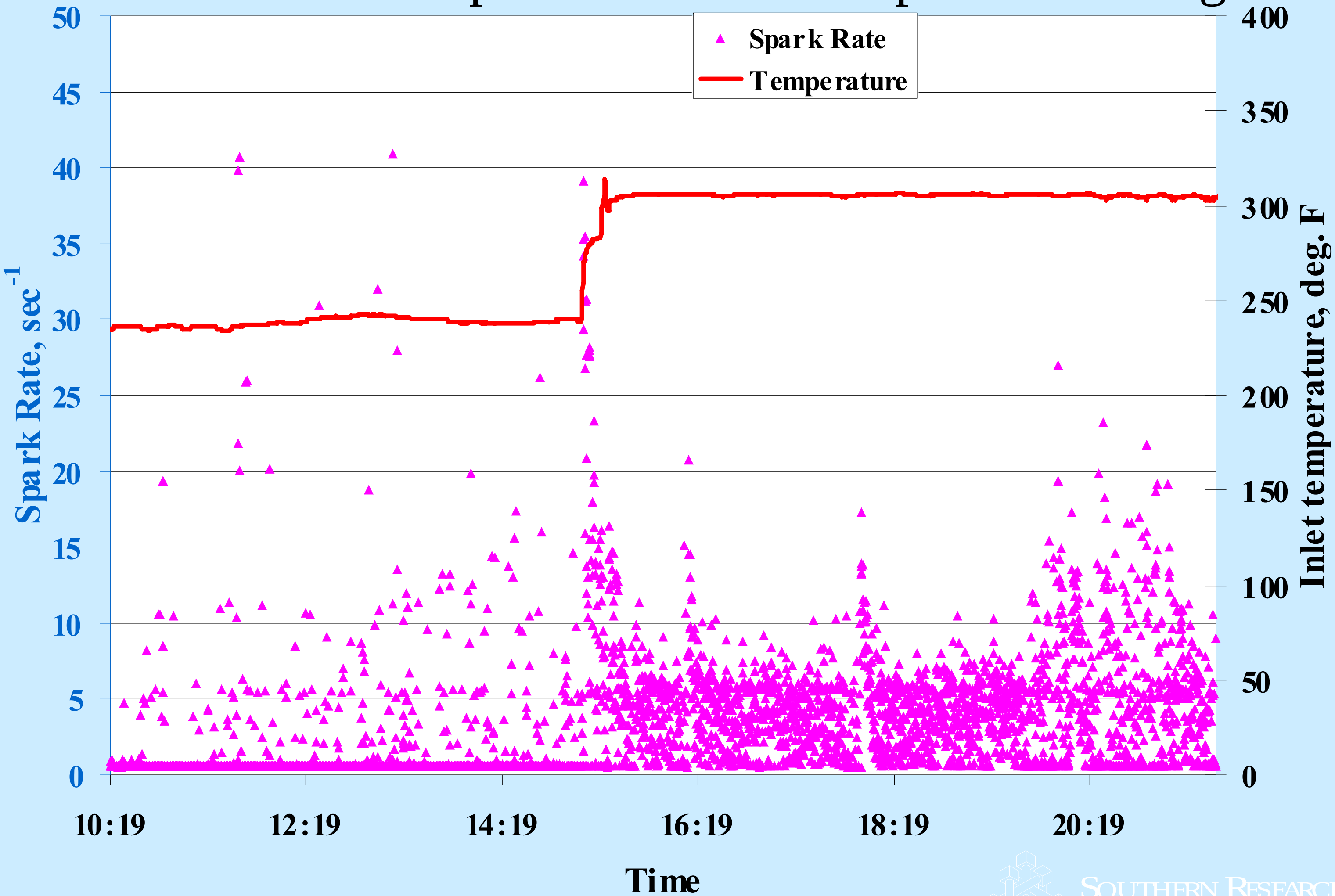
If Electric Field > Breakdown field strength, then corona initiation occurs in dust layer.

Breakdown for

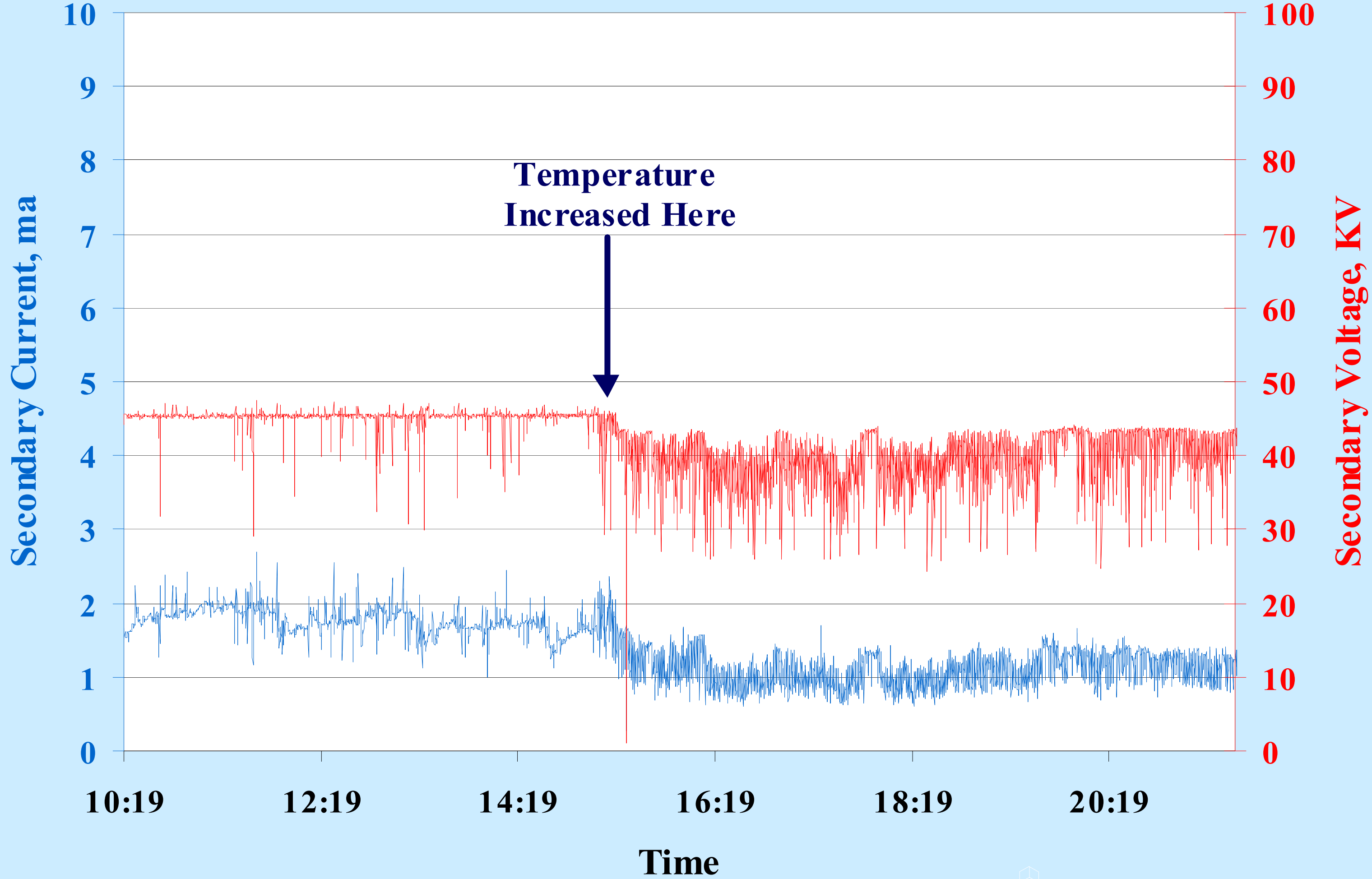
moderately high resistivities => sparkover ($\rho \sim 10^{11}$ **ohm-cm)**

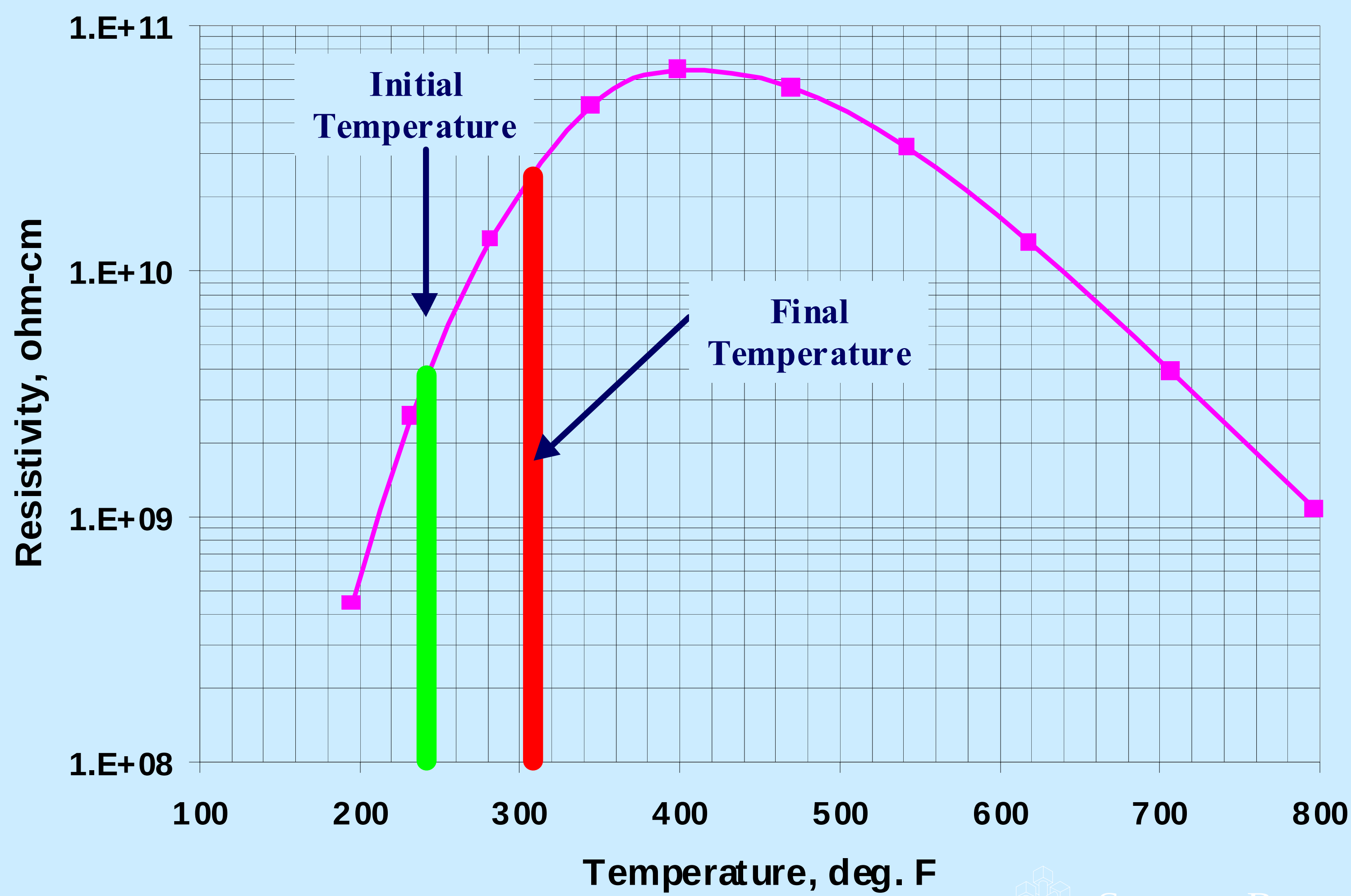
very high resistivities => back corona ($\rho \sim 10^{12}$ **ohm-cm)**

Field data from a pilot ESP with temperature change



Field data from a pilot ESP with temperature change




1.E+11
1.E+10
1.E+09
1.E+08
Initial Temperature
Final Temperature
100
200
300
400
500
600
700
800
Temperature, deg. F
Resistivity, ohm-cm
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Next: Allow resistivity and gas volume
to vary with temperature

Calculations were done for two ashes.

1. A hard-to-condition ash from a low sulfur, Eastern bituminous coal

2. An easy to condition Eastern bituminous coal

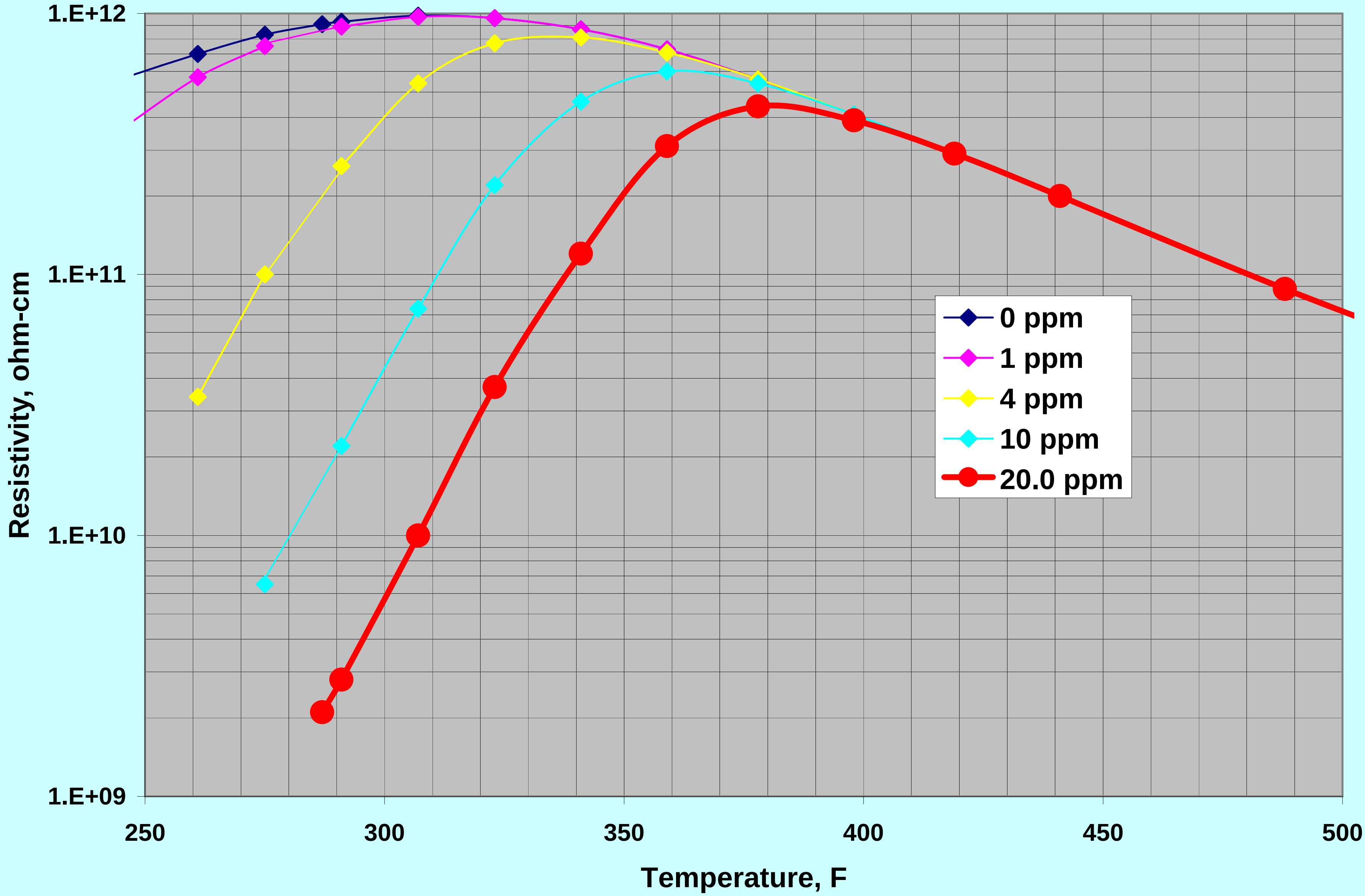
Again, the examples to follow are based on an ESP with four sections of uniform length.

The SRI ESP model was used to estimate performance over a temperature range of 250 F to 375 F with constant mass flow of gas and inlet particulate matter.

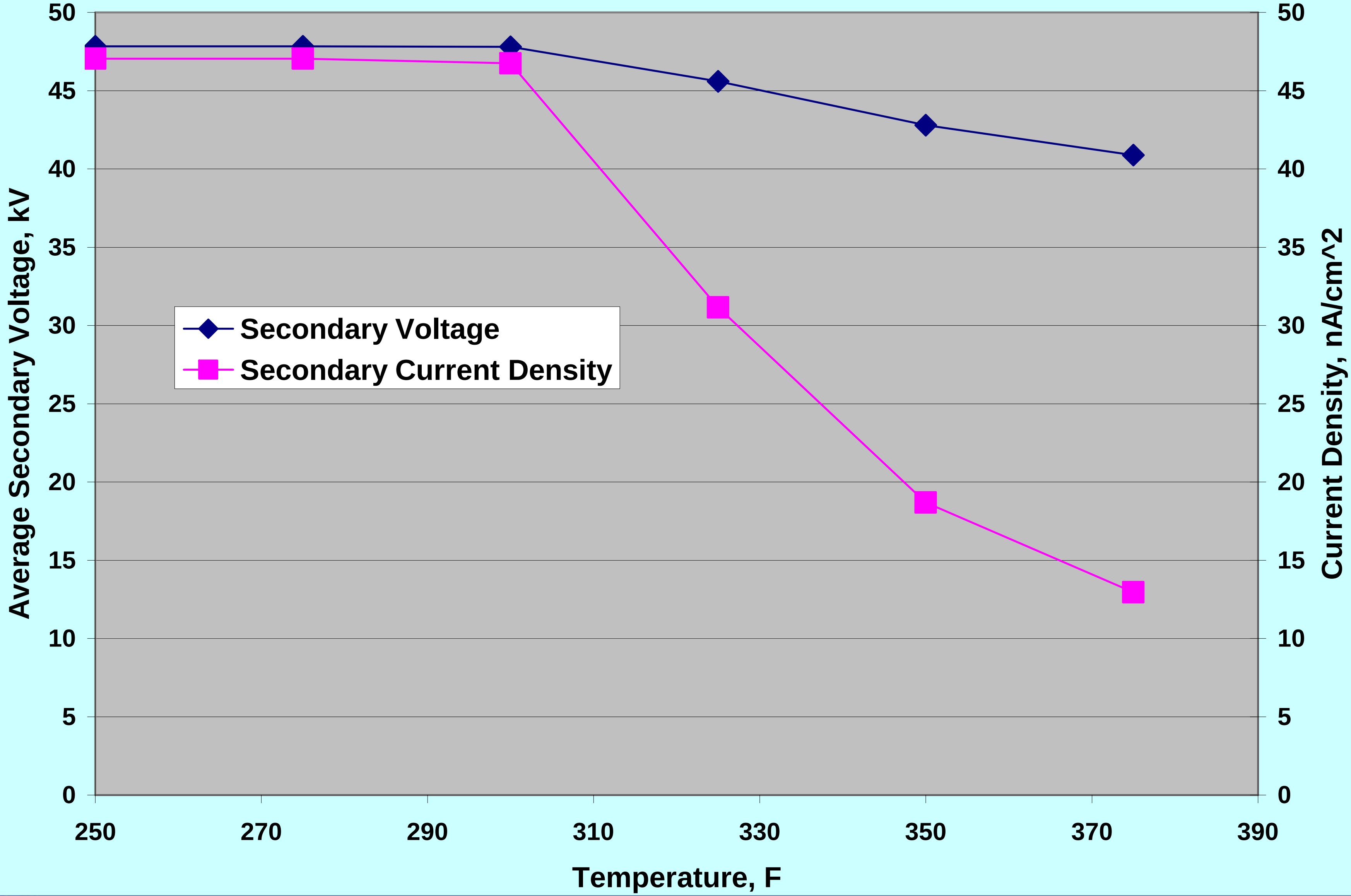
The SCA was 288 sq.ft./kacfm at 300 F

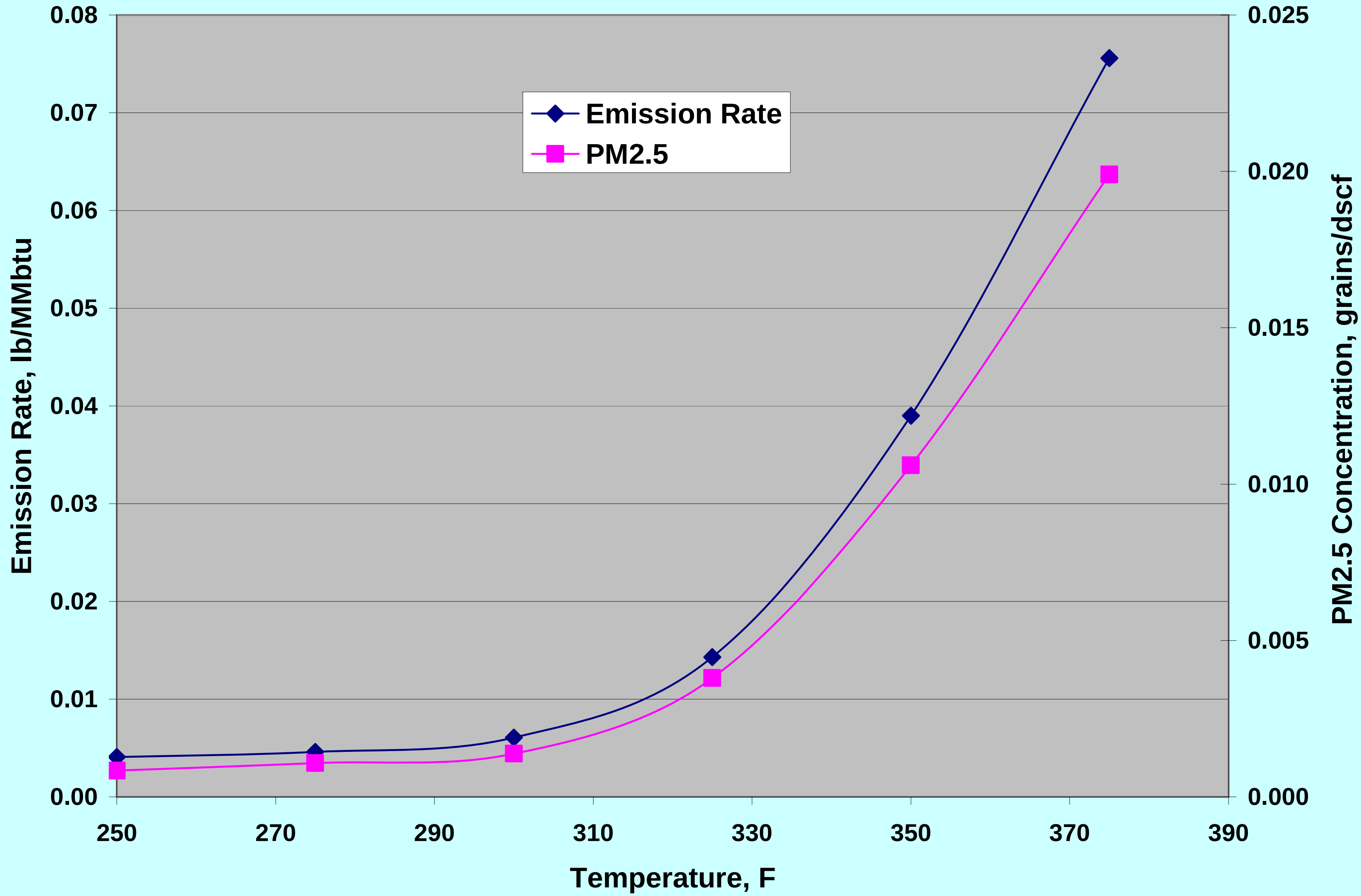
Opacities were calculated based on a stack diameter of 30 feet.

Hard to Condition Ash

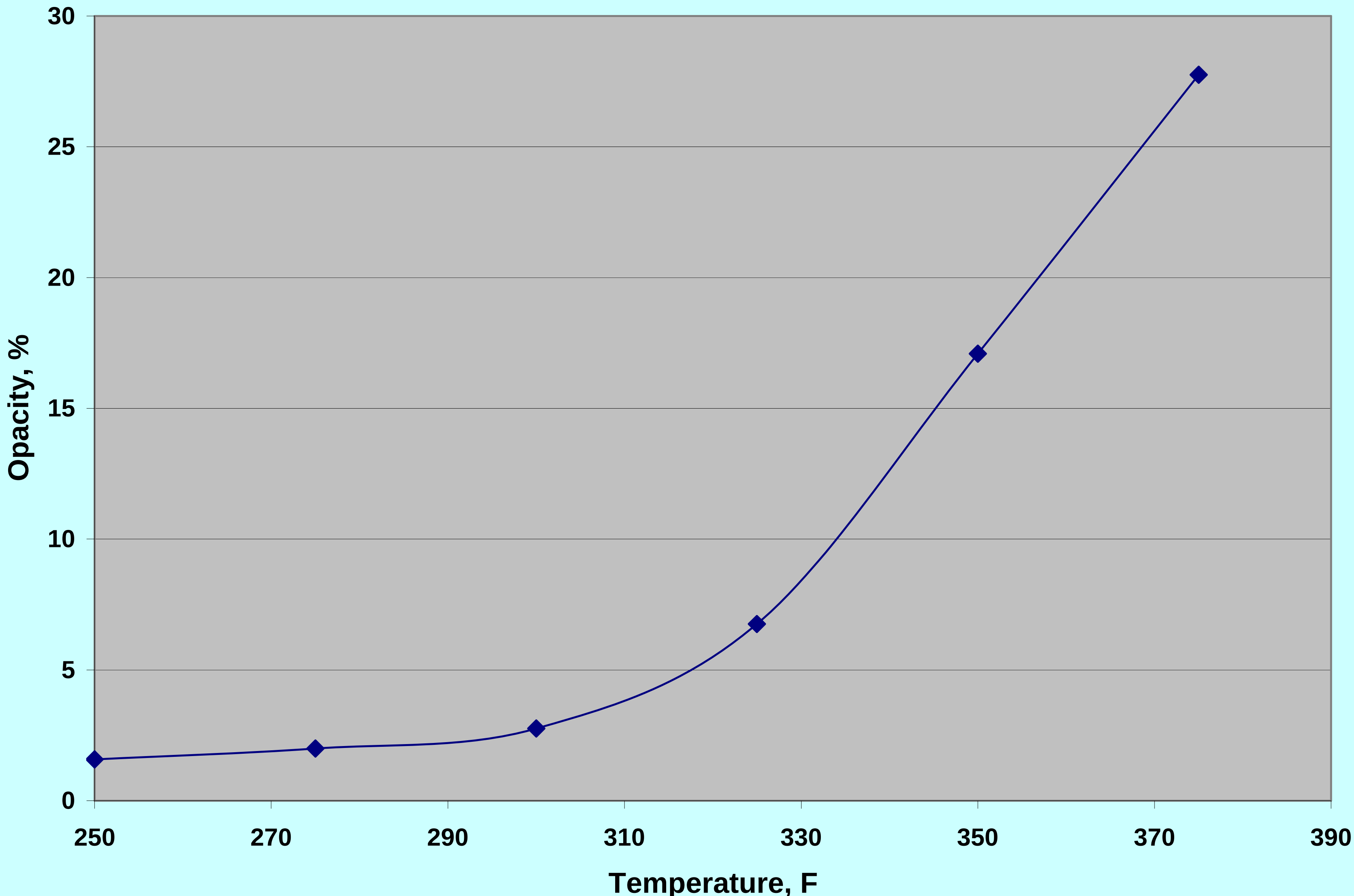


1.E+12
1.E+11
1.E+10
1.E+09
250
300
350
400
450
500
Resistivity, ohm-cm
Temperature, F
0 ppm
1 ppm
4 ppm
10 ppm
20.0 ppm


Secondary Voltage
Secondary Current Density
Average Secondary Voltage, kV
Current Density, nA/cm^2
Temperature, F
0
5
10
15
20
25
30
35
40
45
50
250
270
290
310
330
350
370
390

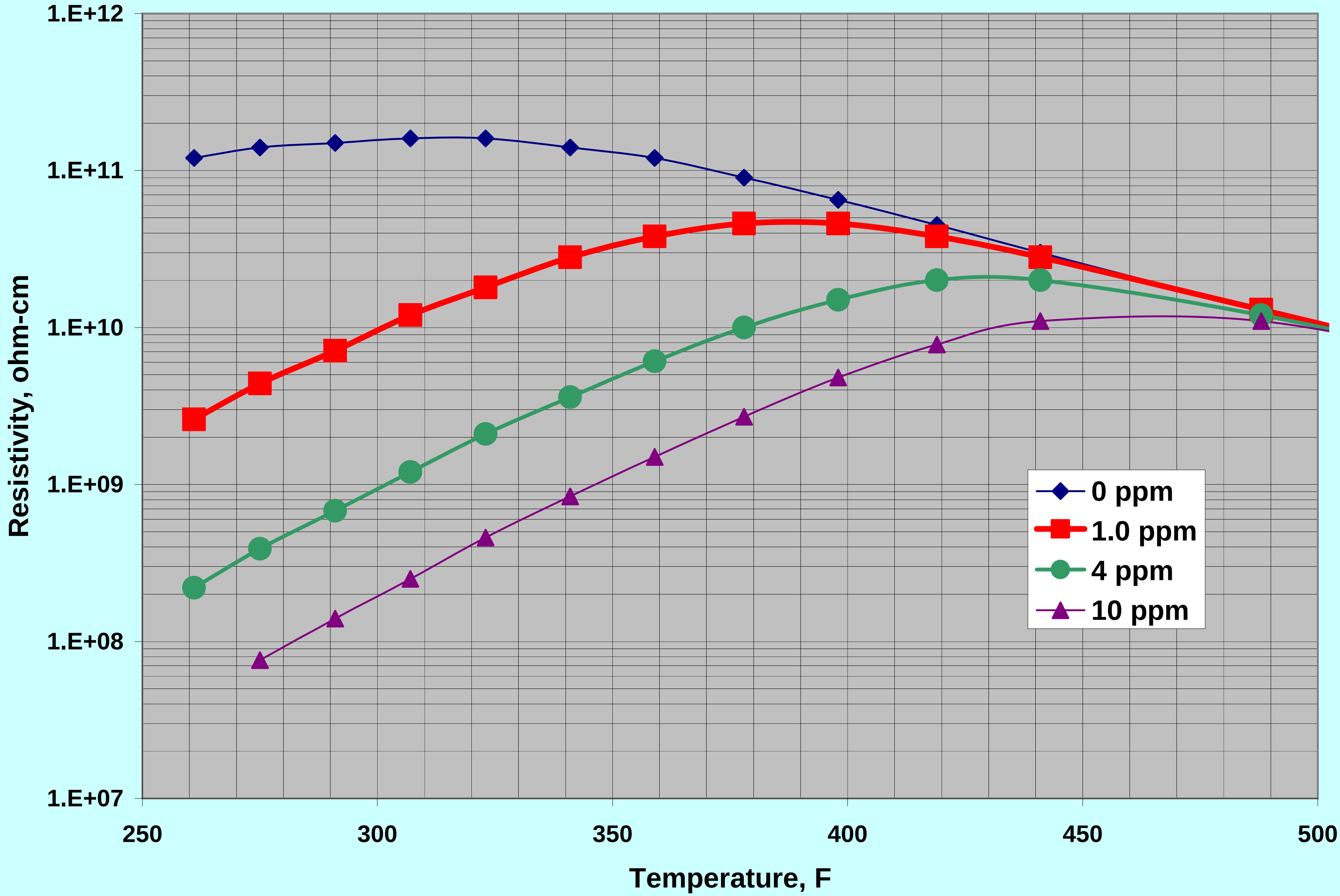


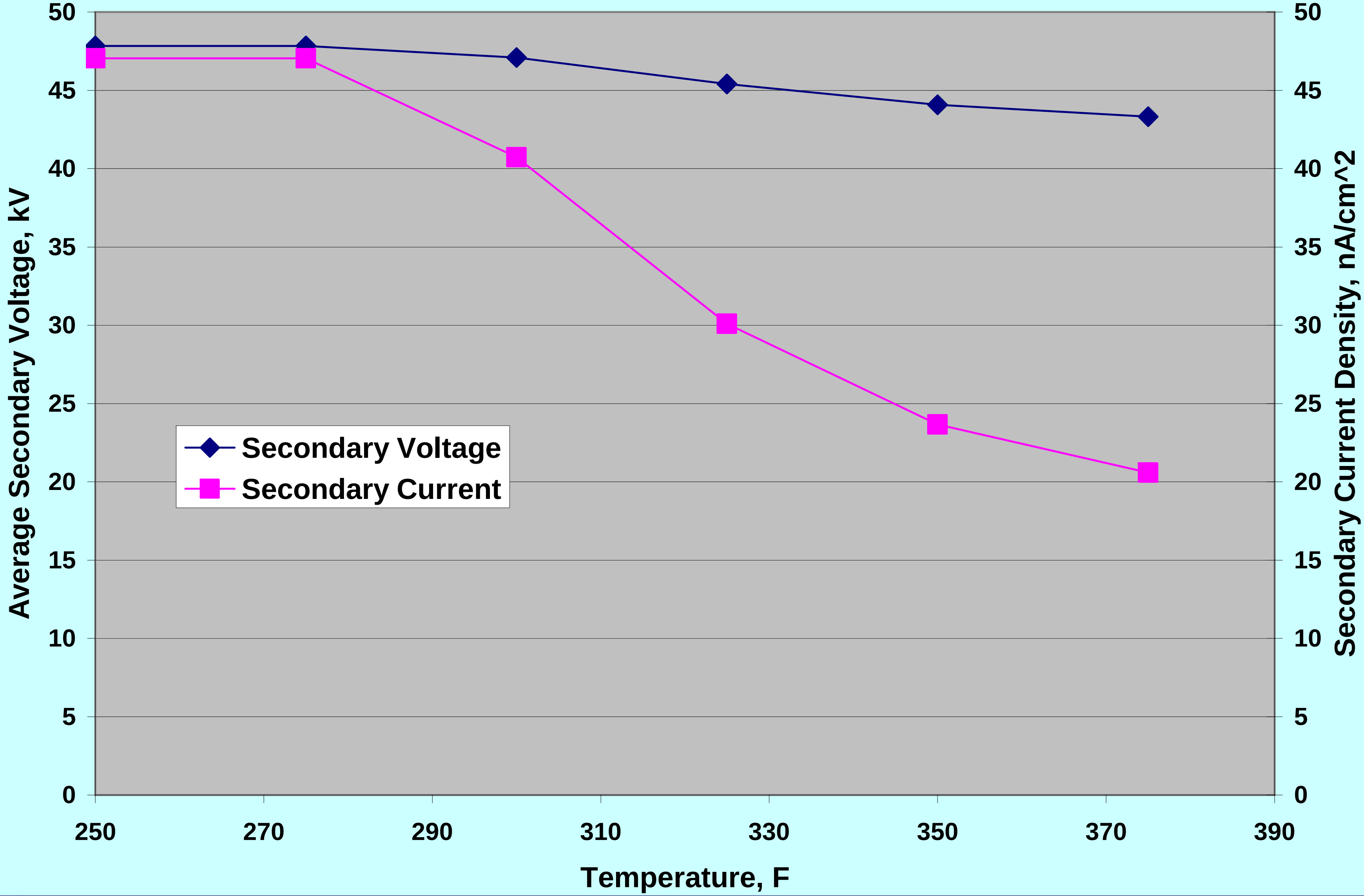
Emission Rate
PM2.5
Emission Rate, lb/MMbtu
PM2.5 Concentration, grains/dscf
Temperature, F
0.00
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.000
0.005
0.010
0.015
0.020
0.025
250
270
290
310
330
350
370
390

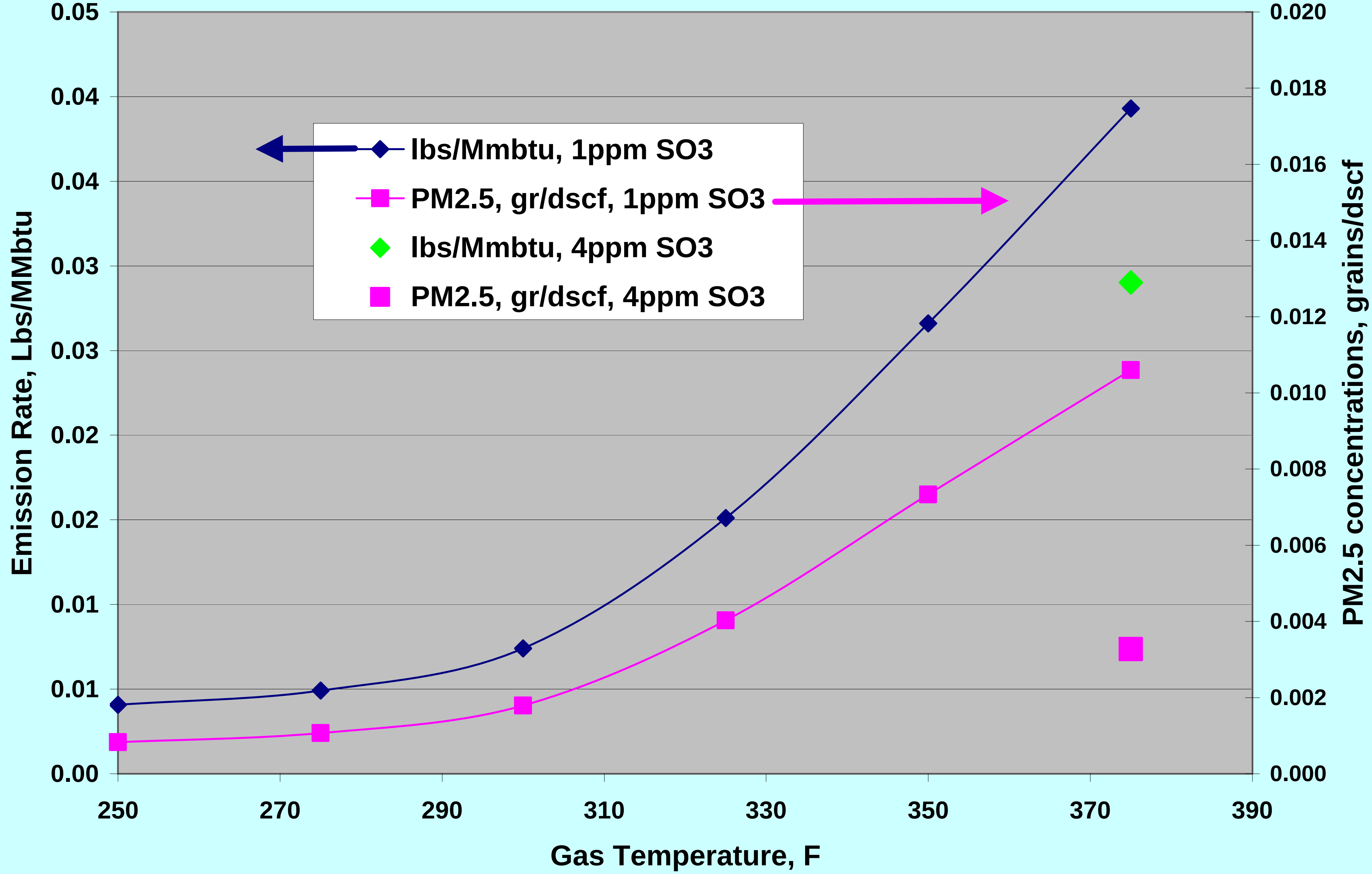


30
25
20
15
10
5
0
Opacity, %
250
270
290
310
330
350
370
390
Temperature, F

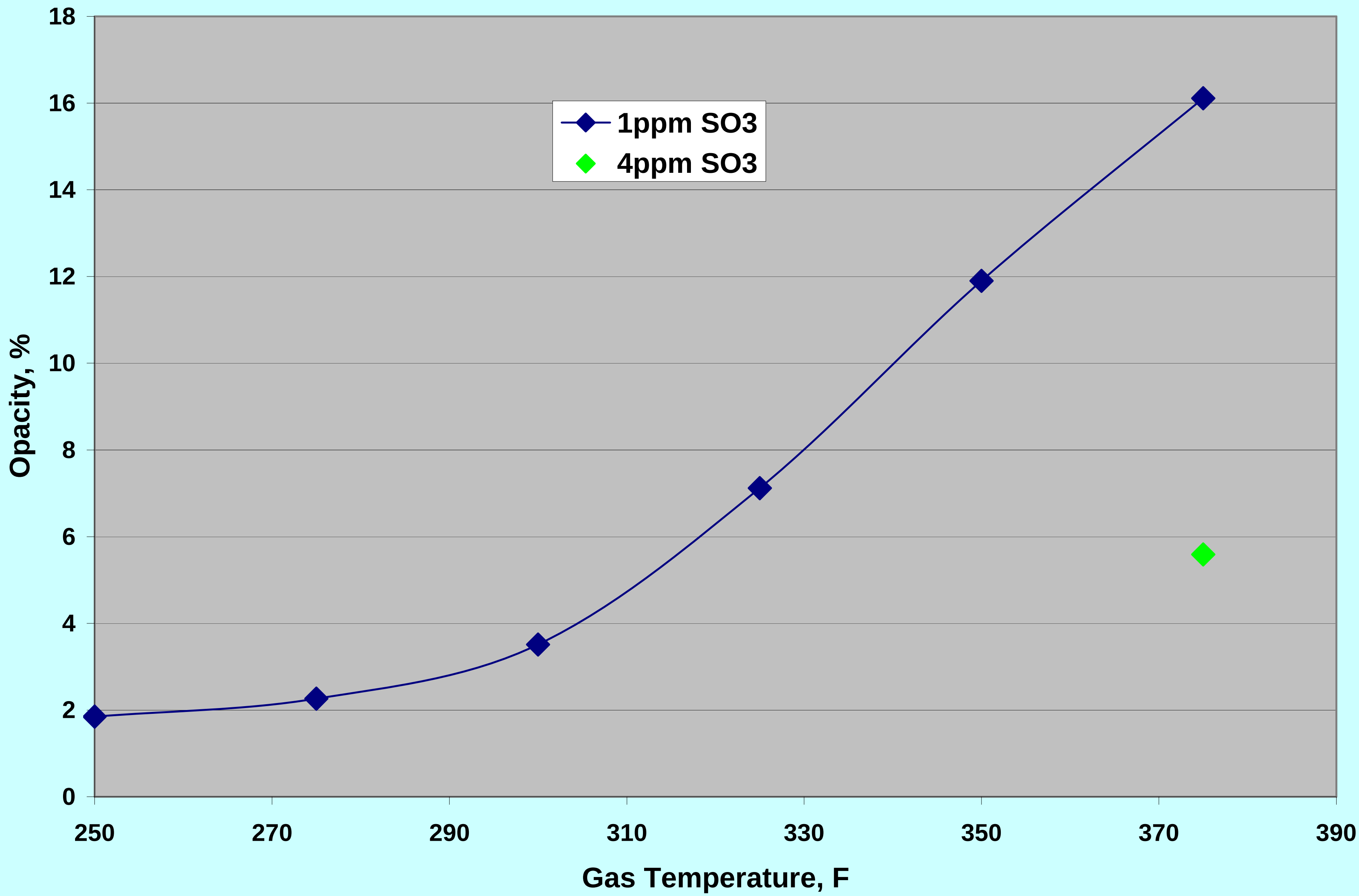
Easy to Condition Ash


1.E+12
1.E+11
1.E+10
1.E+09
1.E+08
1.E+07
250
300
350
400
450
500
Resistivity, ohm-cm
Temperature, F
0 ppm
1.0 ppm
4 ppm
10 ppm


Average Secondary Voltage, kV
Secondary Current Density, nA/cm^2
Temperature, F
Secondary Voltage
Secondary Current
0
5
10
15
20
25
30
35
40
45
50
250
270
290
310
330
350
370
390



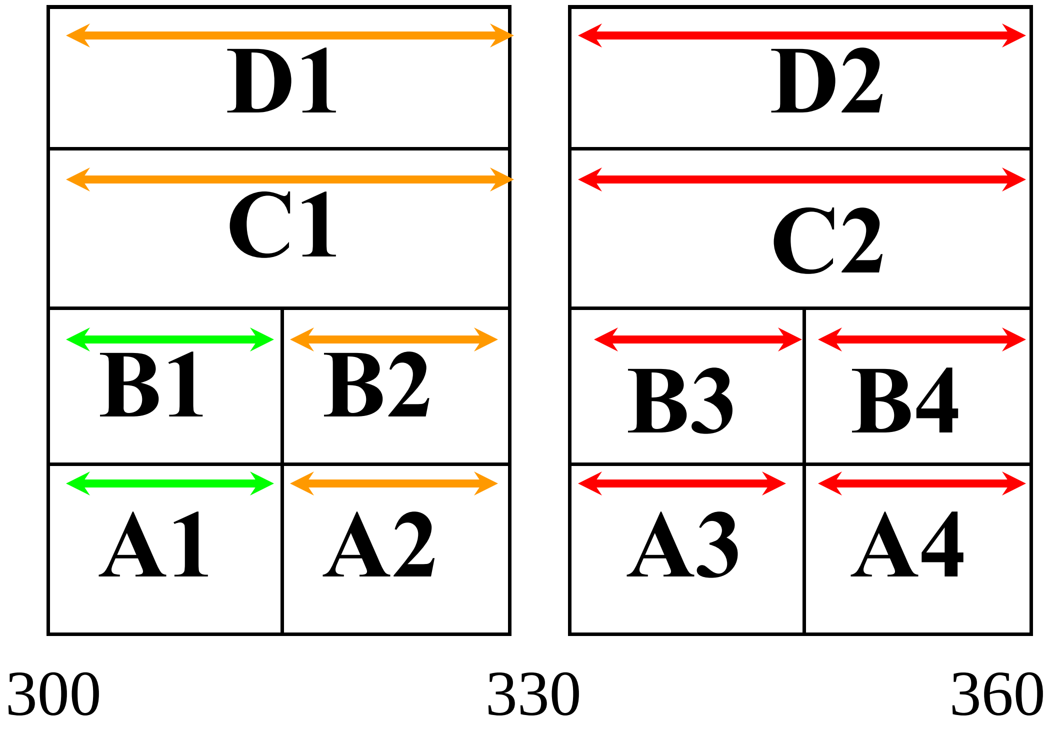
0.05
0.04
0.04
0.03
0.03
0.02
0.02
0.01
0.01
0.00
Emission Rate, Lbs/MMbtu
0.020
0.018
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
PM2.5 concentrations, grains/dscf
250
270
290
310
330
350
370
390
Gas Temperature, F
lbs/Mmbtu, 1ppm SO3
PM2.5, gr/dscf, 1ppm SO3
lbs/Mmbtu, 4ppm SO3
PM2.5, gr/dscf, 4ppm SO3



Opacity, %
18
16
14
12
10
8
6
4
2
0
250
270
290
310
330
350
370
390
Gas Temperature, F
1ppm SO3
4ppm SO3

Effect of temperature spreads across ESPs following rotary air heaters.

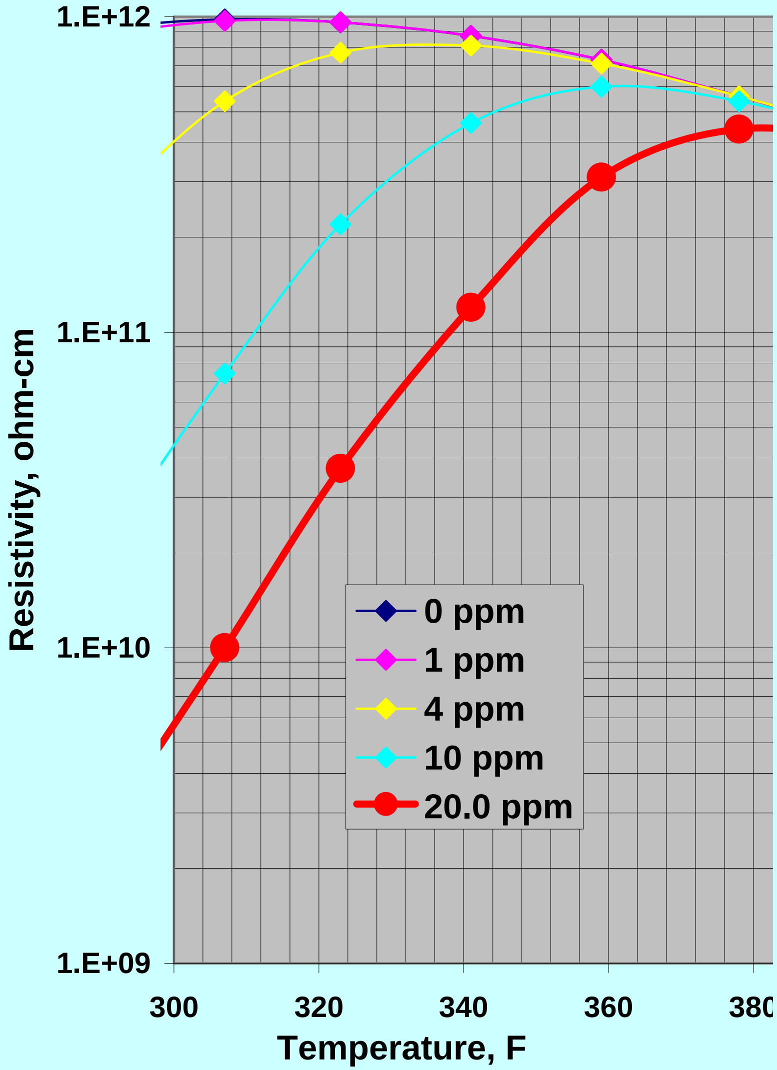
Typical temperature spread is around 60 to 100 F



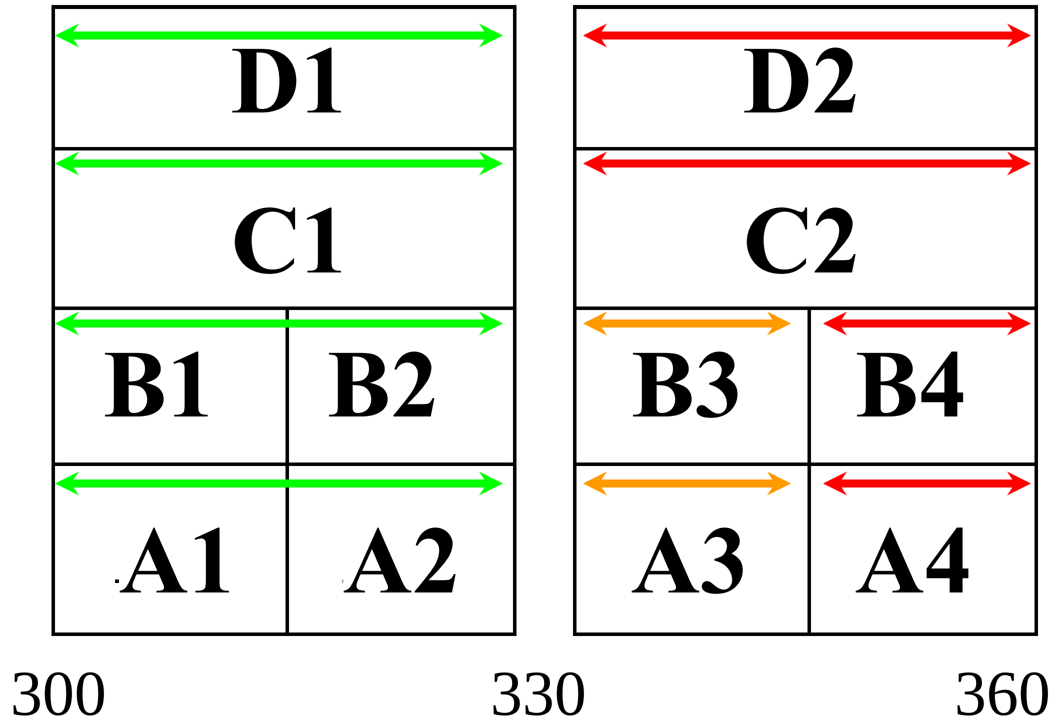
Green Arrow = Good Performance

Orange Arrow = Impaired Performance

Red Arrow = Very Poor Performance



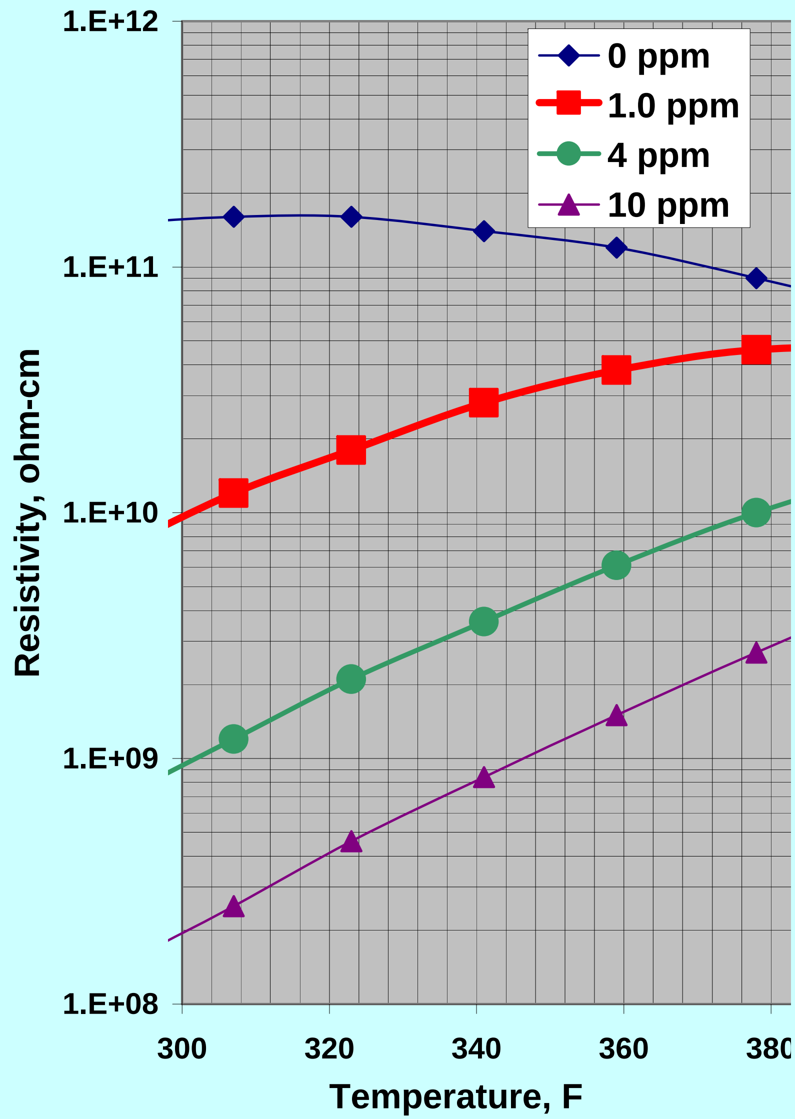
Hard to Condition Ash



Green Arrow = Good Performance

Orange Arrow = Impaired Performance

Red Arrow = Poor Performance



Easy to Condition Ash

Effects of Ash Adhesion and Cohesion

Higher temperatures tend to result in lower adhesion and cohesion.

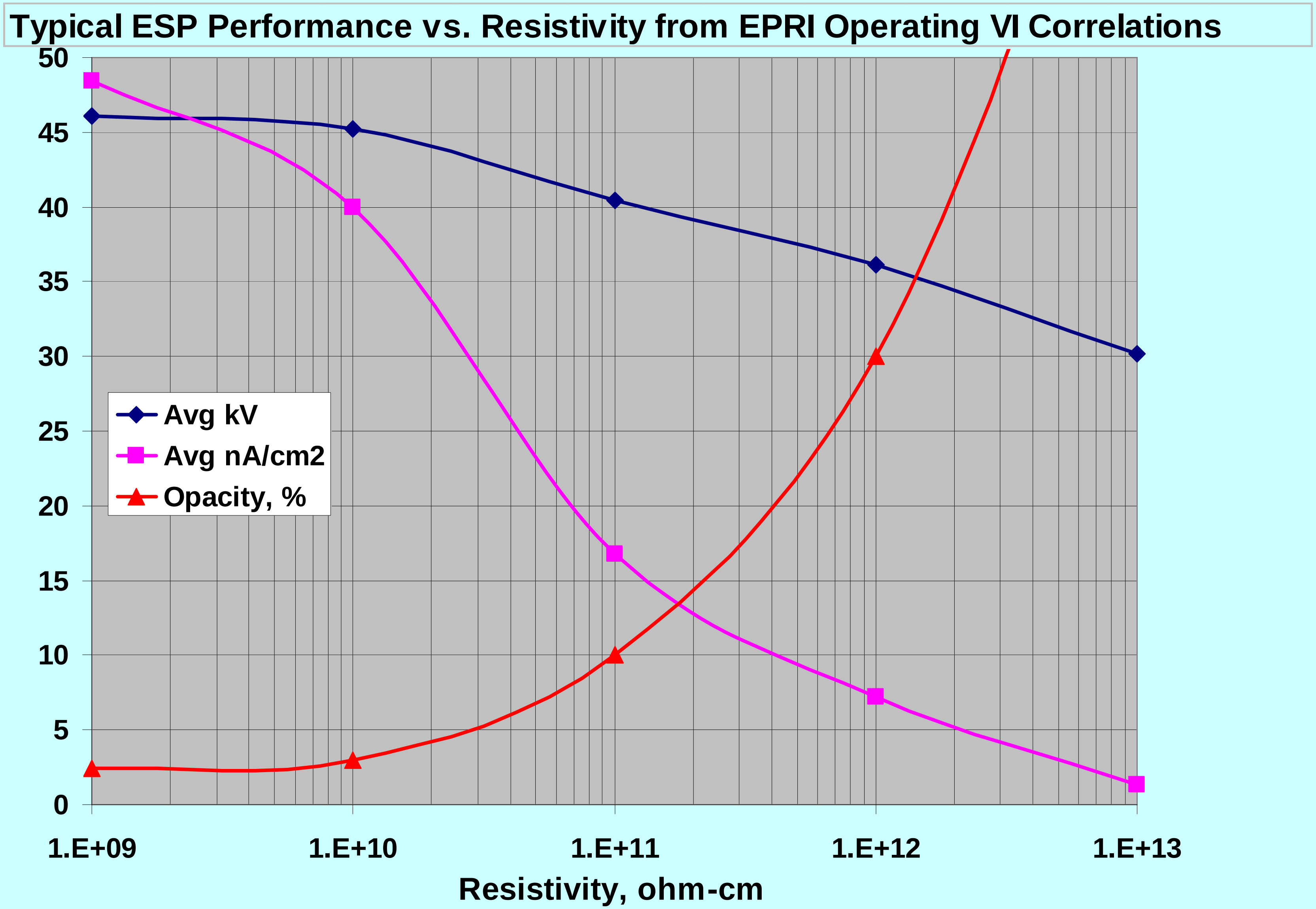
Only limited quantitative data is available.

Data was collected during a multi-plant study of rapping losses.

Sites used included four units with cold-side precipitators and two with hot-side precipitators.

Example of the effect of ash adhesion and cohesion

	Using Coldside Rapping Model	Using Hotside Rapping Model	
Inlet	3.17	3.17	Grains/dscf
Outlet	0.0073	0.0305	Grains/dscf
Emission Rate	0.013	0.056	lb/Mmbtu
Outlet $PM_{2.5}$	0.0034	0.0102	Grains/dscf
Outlet PM_{10}	0.0067	0.0268	Grains/dscf
Opacity	5.75	16.26	%



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Questions??