Worldwide Pollution Control Association

FirstEnergy ESP Seminar

November 27th – 28th, 2007

Visit our website at www.wpca.info

Advanced Electrostatic Precipitator Diagnostics

GE Energy

John A. Knapik

imagination at work

Does This ESP Have A Problem?

*****AVERAGE VALUES*****

Unit	Amps	Volts	MA	KV	S/M
#3-1A1	26	285	150	43.0	29
#3-2A1	52	313	333	42.4	10
#3-3A1	76	275	450	39.5	14
#3-4A1	73	245	404	35.7	14
#3-5A1	68	320	501	41.1	22
#3-6A1	83	274	622	35.8	11
#3-7A1	64	193	350	26.8	20
#3-8A1	198	346	1400	37.7	5
#3-1A2	***	***	****	****	***
#3-2A2	27	253	149	38.5	18
#3-3A2	41	249	211	38.6	17
#3-4A2	41	204	193	30.9	14
#3-5A2	41	274	235	39.8	29
#3-6A2	67	278	470	34.1	12
#3-7A2	77	237	492	30.6	15
#3-8A2	164	336	1124	39.6	8
#3-1B1	***	***	****	****	***
#3-2B1	41	226	252	31.4	17
#3-3B1	105	303	700	33.3	13
#3-4B1	130	309	836	36.9	14
#3-5B1	28	282	157	42.4	28
#3-6B1	33	228	175	36.7	18
#3-7B1	71	312	419	35.8	17
#3-8B1	65	232	347	34.8	14
#3-1B2	56	285	375	36.0	29
#3-2B2	63	226	436	30.1	15
#3-3B2	116	292	757	34.7	20
#3-4B2	179	343	1299	39.8	14
#3-5B2	20	227	104	34.7	29
#3-6B2	46	266	287	35.9	17
#3-7B2	90	317	572	38.0	18
#3-8B2	102	285	622	34.1	14

GE
Proprietary

How Can One Easily Tell?

*****AVERAGE VALUES*****

Unit	Amps	Volts	MA	KV	S/M
#3-1A1	26	285	150	43.0	29
#3-2A1	52	313	333	42.4	10
#3-3A1	76	275	450	39.5	14
#3-4A1	73	245	404	35.7	14
#3-5A1	68	320	501	41.1	22
#3-6A1	83	274	622	35.8	11
#3-7A1	64	193	350	26.8	20
#3-8A1	198	346	1400	37.7	5
#3-1A2	***	***	****	****	***
#3-2A2	27	253	149	38.5	18
#3-3A2	41	249	211	38.6	17
#3-4A2	41	204	193	30.9	14
#3-5A2	41	274	235	39.8	29
#3-6A2	67	278	470	34.1	12
#3-7A2	77	237	492	30.6	15
#3-8A2	164	336	1124	39.6	8
#3-1B1	***	***	****	****	***
#3-2B1	41	226	252	31.4	17
#3-3B1	105	303	700	33.3	13
#3-4B1	130	309	836	36.9	14
#3-5B1	28	282	167	42.4	28
#3-6B1	33	228	175	36.7	18
#3-7B1	71	312	419	35.8	17
#3-8B1	65	232	347	34.8	14
#3-1B2	56	285	375	36.0	29
#3-2B2	63	226	436	30.1	15
#3-3B2	116	292	757	34.7	20
#3-4B2	179	343	1299	39.8	14
#3-5B2	20	227	104	34.7	29
#3-6B2	46	266	287	35.9	17
#3-7B2	90	317	572	38.0	18
#3-8B2	102	285	622	34.1	14

This Leads Us to...

A Step by Step Analysis for Diagnosing a Misbehaving ESP

That data was for an ESP that had:

(2) Boxes, American Style ESP

(4) Fields

(4) T-R Sets Per Field

(16) T-R Sets Per Box

(2) Lungstrom Air Heaters

Burning High Sulfur Coal

First Step:

imagination at work

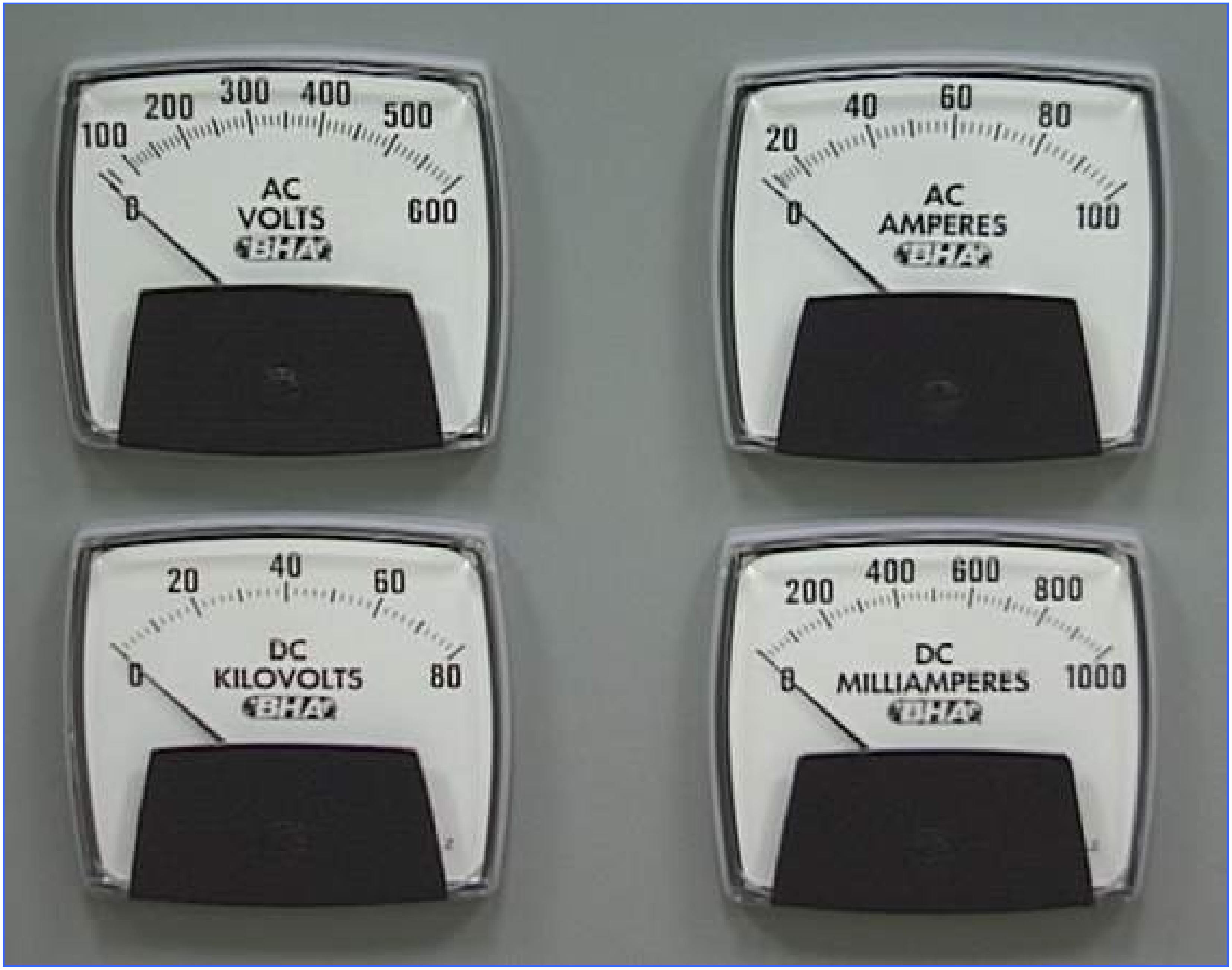
Put T-R Sets in an ESP Plan View

4B2	*4B1*	*8B2*	*8B1*	*T/R SETS*	*4A2*	*4A1*	*8A2*	*8A1*
3B2	*3B1*	*7B2*	*7B1*		*3A2*	*3A1*	*7A2*	*7A1*
2B2	*2B1*	*6B2*	*6B1*		*2A2*	*2A1*	*6A2*	*6A1*
1B2	*1B1*	*5B2*	*5B1*		*1A2*	*1A1*	*5A2*	*5A1*

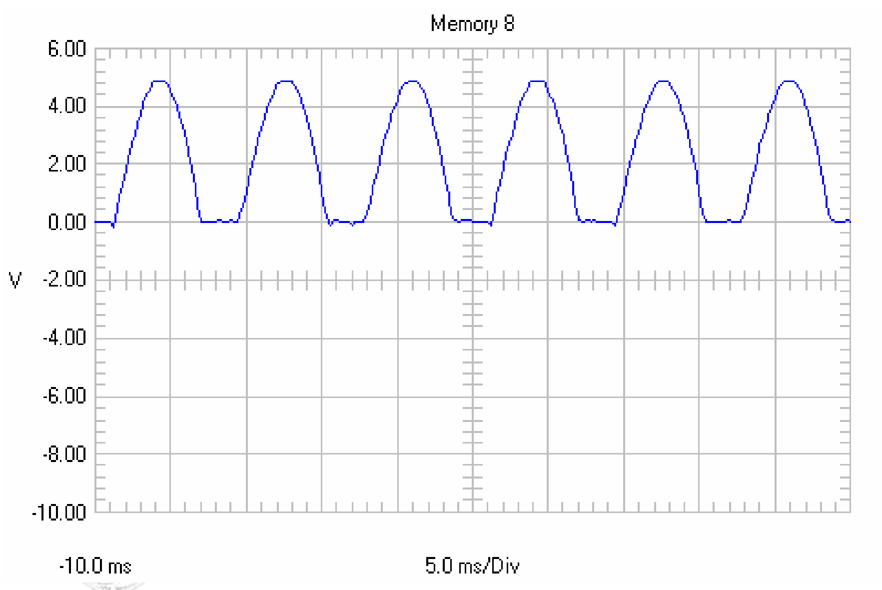
Next show your meter readings.

But what AVC meters should you use?

Gas Flow

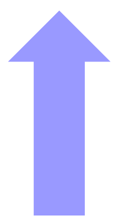

100
200
300
400
500
0
600
AC
VOLTS
BHA
20
40
60
80
0
100
AC
AMPERES
BHA
20
40
60
0
80
DC
KILOVOLTS
BHA
200
400
600
800
0
1000
DC
MILLIAMPERES
BHA

What Is the Best AVC Meter to Use to Evaluate an ESP Field?



Put Data in an ESP View

4B2	4B1	8B2	8B1	T/R SETS	4A2	4A1	8A2	8A1
3B2	3B1	7B2	7B1		3A2	3A1	7A2	7A1
2B2	2B1	6B2	6B1		2A2	2A1	6A2	6A1
1B2	1B1	5B2	5B1		1A2	1A1	5A2	5A1
1299	836	622	347	MILLIAMP	193	404	1124	1400
757	700	572	419		211	450	492	350
436	252	287	175		149	333	470	622
375	OFF	104	157		OFF	150	235	501



Gas Flow

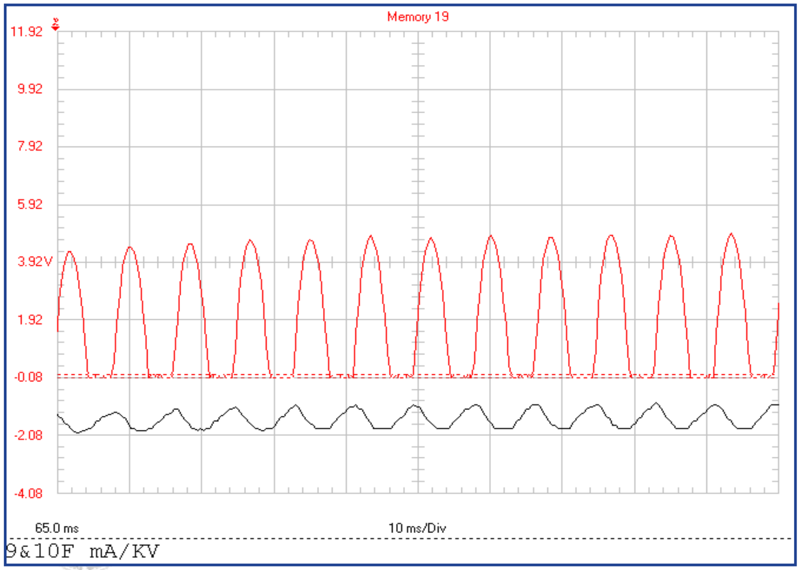
Which Meter Next?

Put Data in an ESP View

4B2	4B1	8B2	8B1	T/R SETS	4A2	4A1	8A2	8A1
3B2	3B1	7B2	7B1		3A2	3A1	7A2	7A1
2B2	2B1	6B2	6B1		2A2	2A1	6A2	6A1
1B2	1B1	5B2	5B1		1A2	1A1	5A2	5A1
1299	836	622	347	MILLIAMP	193	404	1124	1400
757	700	572	419		211	450	492	350
436	252	287	175		149	333	470	622
375	OFF	104	157		OFF	150	235	501
14	15	15	14	SPM	14	11	6	1
18	13	18	17		12	11	16	20
22	18	14	17		14	11	15	11
30	OFF	30	27		OFF	28	27	25

Gas Flow

What About the KV Meter?



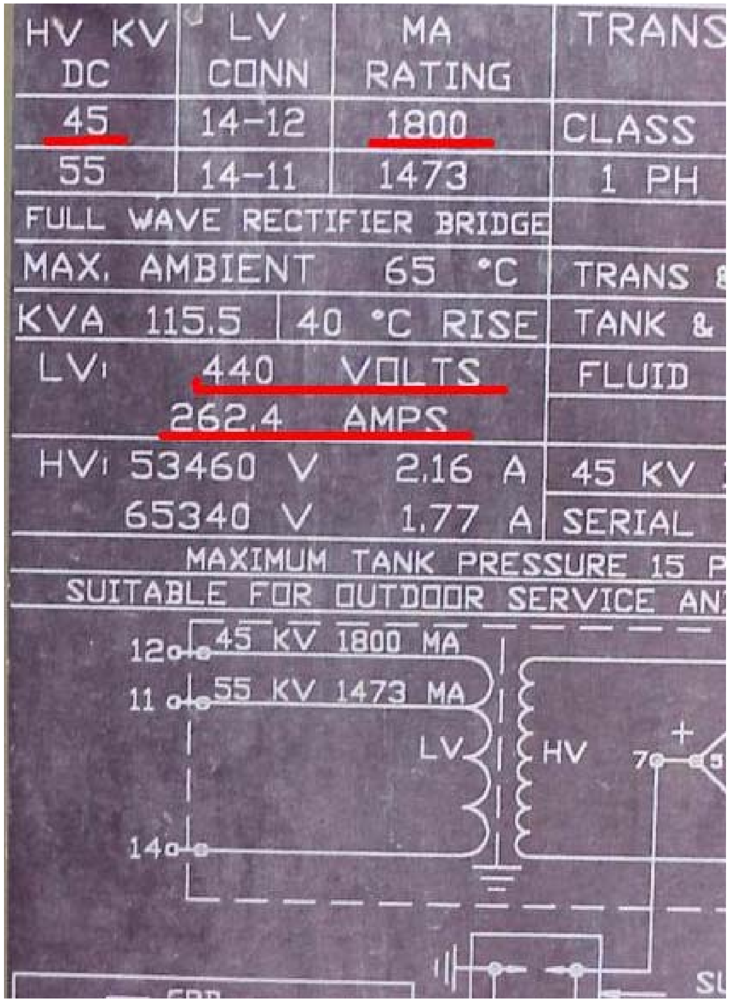
Step 2

If a T/R set is not sparking, then its AVC should be pushing that T/R set to one of its pre-set limits (volts, amps, KV, or ma)

Again, know the ratings of the T/R sets on the ESP being reviewed.

imagination at work

Walk up to the roof of the ESP and look at the nameplate on the T/R set



One T/R Running with “No” Sparking

1600	1600	1600	1600	T/R SIZE	1600	1600	1600	1600
1400	1400	1400	1400		1400	1400	1400	1400
1250	1250	1250	1250		1250	1250	1250	1250
950	950	950	950		950	950	950	950
1299	836	622	347	MILLIAMP	193	404	1124	1400
757	700	572	419		211	450	492	350
436	252	287	175		149	333	470	622
375	OFF	104	157		OFF	150	235	501
14	15	15	14	SPM	14	11	6	1
18	13	18	17		12	11	16	20
22	18	14	17		14	11	15	11
30	OFF	30	27		OFF	28	27	25

Is it at a limit?

Check to see if T/R is at limit. The mA values on the previous page were average values. Looking closer we find

VALUES	AMPS	VOLTS	mA	KV	SPM
T-R RATING	214	480	1600	45	
ACTUAL	215	365	1517	39.7	1
AVERAGE	198	246	1400	37.7	5

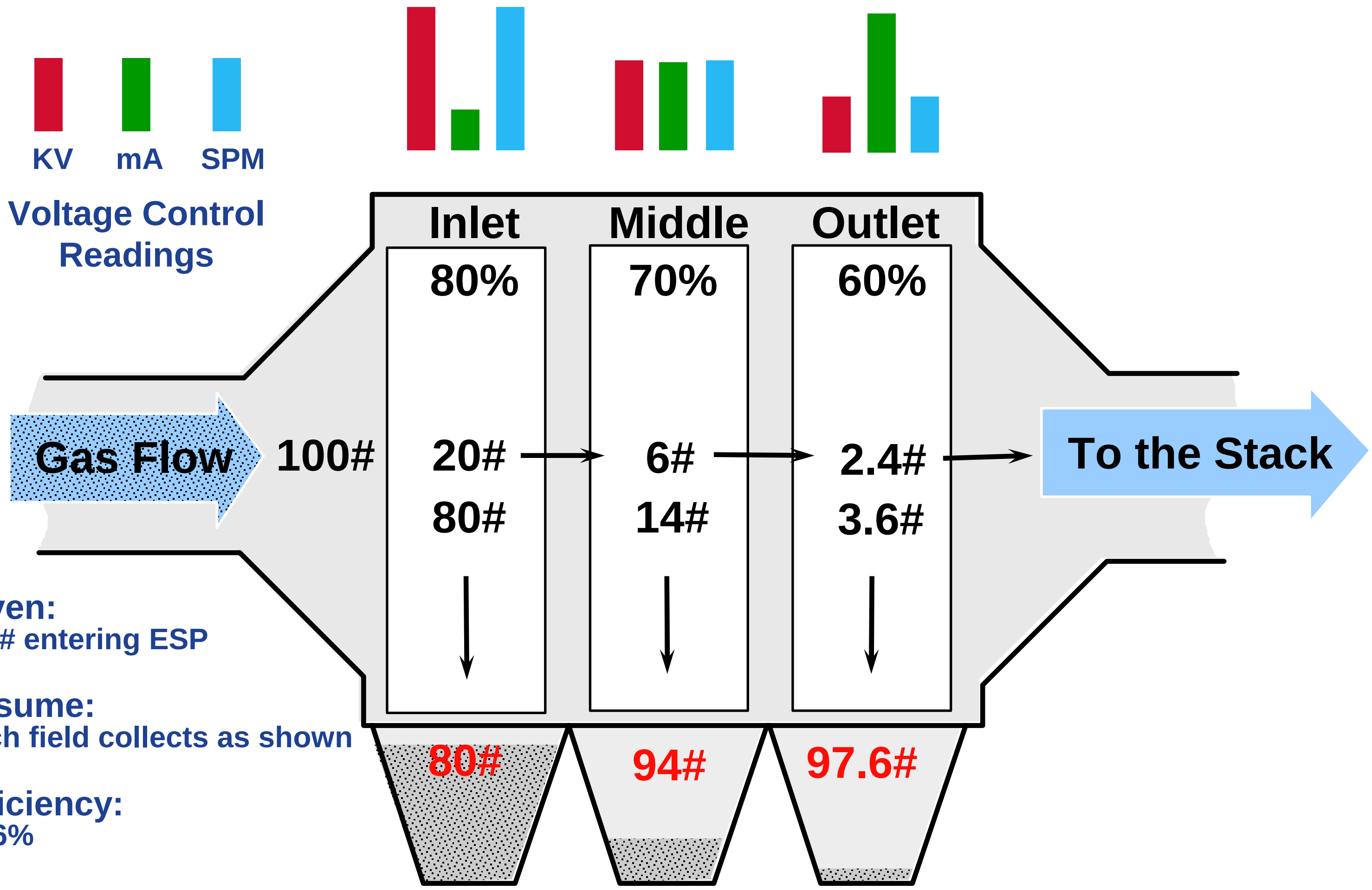
VALUES	AMPS	VOLTS	mA	KV	SPM
T-R RATING	214	480	1600	45	
ACTUAL	215	365	1517	39.7	1
AVERAGE	198	246	1400	37.7	5

Yes, the T/R is primary amp limited

Step 3

3. Each succeeding field of a precipitator should have the same or higher precipitator current (mA), better said as current density, than the preceding field.

Incremental Collection Efficiency and Secondary Operating Conditions



Given:
100# entering ESP

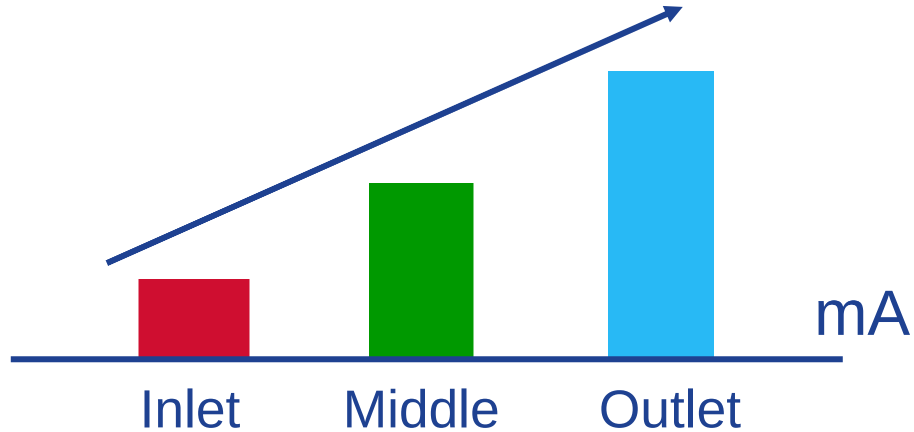
Assume:
Each field collects as shown

Efficiency:
97.6%

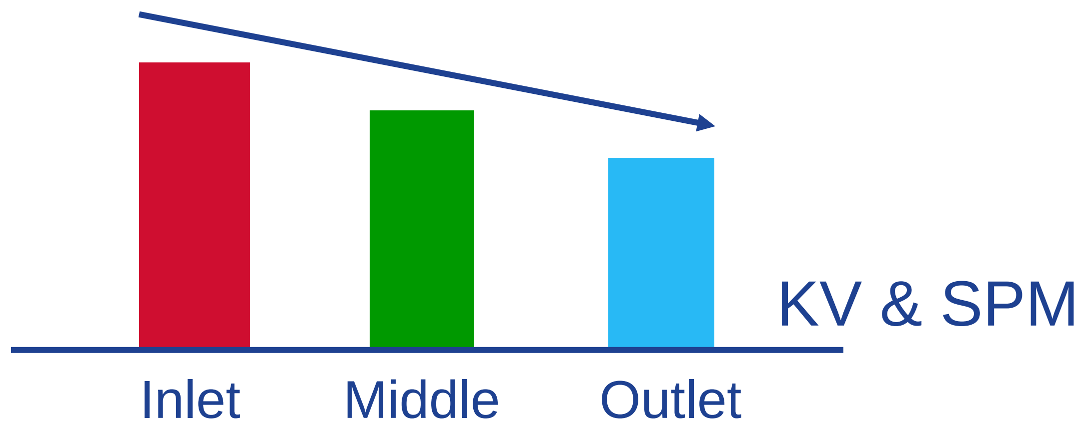
Values shown are to represent relationship only...not necessarily actual conditions

Space Charge Effects on Meters

Always look for this trend...



Decreasing KV and SPM from inlet to outlet is not quite as evident

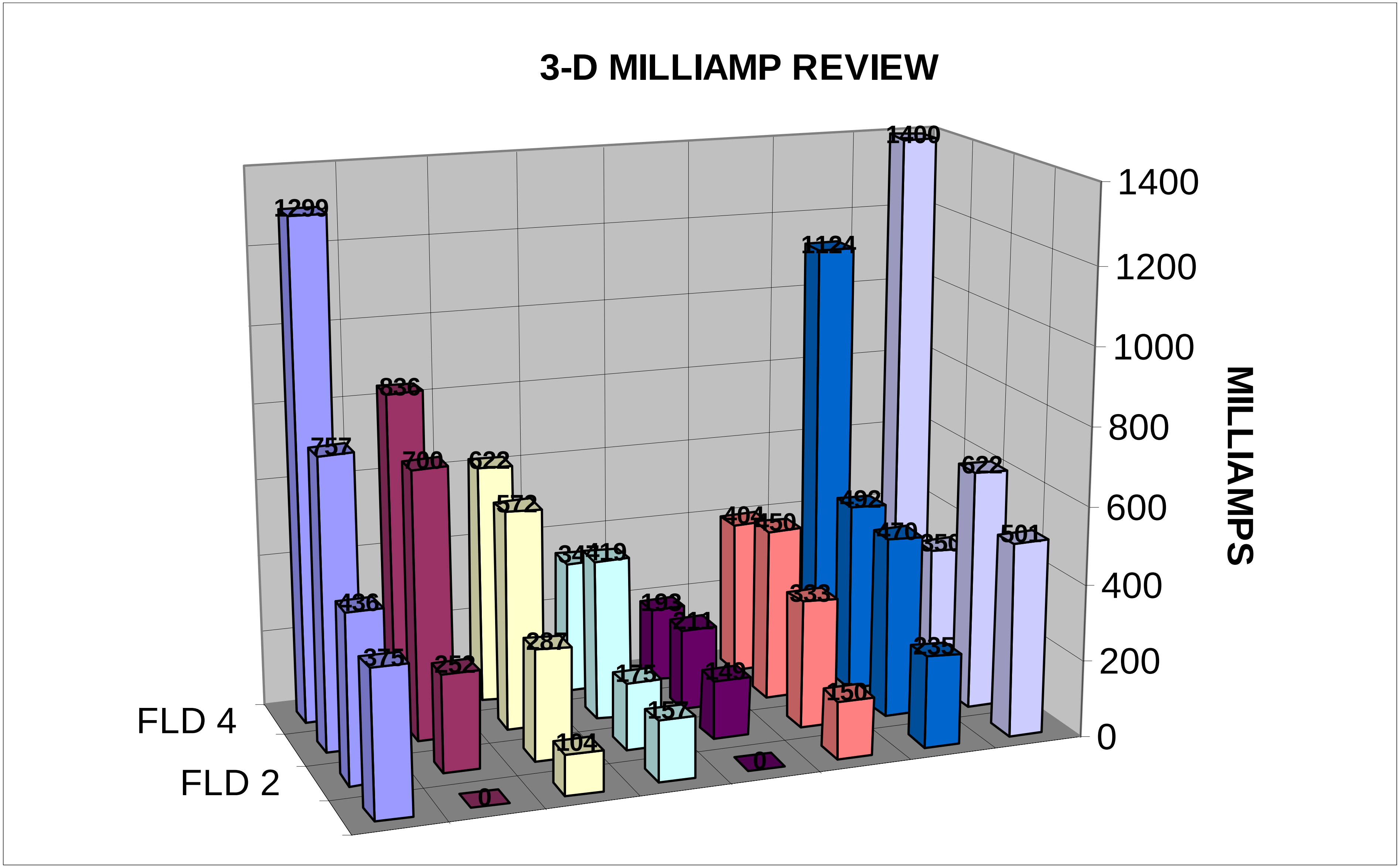


Applying Step 3, we get:

Gas Flow

1299	836	622	347	MILLIAMP	193	404	1124	1400
757	700	572	419		211	450	492	350
436	252	287	175		149	333	470	622
375	OFF	104	157		OFF	150	235	501

At first glance, probably not enough "bad" sets to cause the high opacity


3-D MILLIAMP REVIEW
MILLIAMPS
1400
1200
1000
800
600
400
200
0
FLD 4
FLD 2
1299
757
436
375
836
700
252
0
622
572
287
104
419
175
157
193
211
149
0
404
450
333
150
1124
492
470
235
1400
622
501

Step 4

4. If the dust is not highly resistive, then outlet fields usually run at full current and little or no sparking.

But These Outlet Fields Are Sparking. Should This Happen With High Sulfur Coal?

1600	1600	1600	1600	T/R SIZE	1600	1600	1600	1600
1400	1400	1400	1400		1400	1400	1400	1400
1250	1250	1250	1250		1250	1250	1250	1250
950	950	950	950		950	950	950	950
1299	836	622	347	MILLIAMP	193	404	1124	1400
757	700	572	419		211	450	492	350
436	252	287	175		149	333	470	622
375	OFF	104	157		OFF	150	235	501
14	15	15	14	SPM	14	11	6	1
18	13	18	17		12	11	16	20
22	18	14	17		14	11	15	11
30	OFF	30	27		OFF	28	27	25

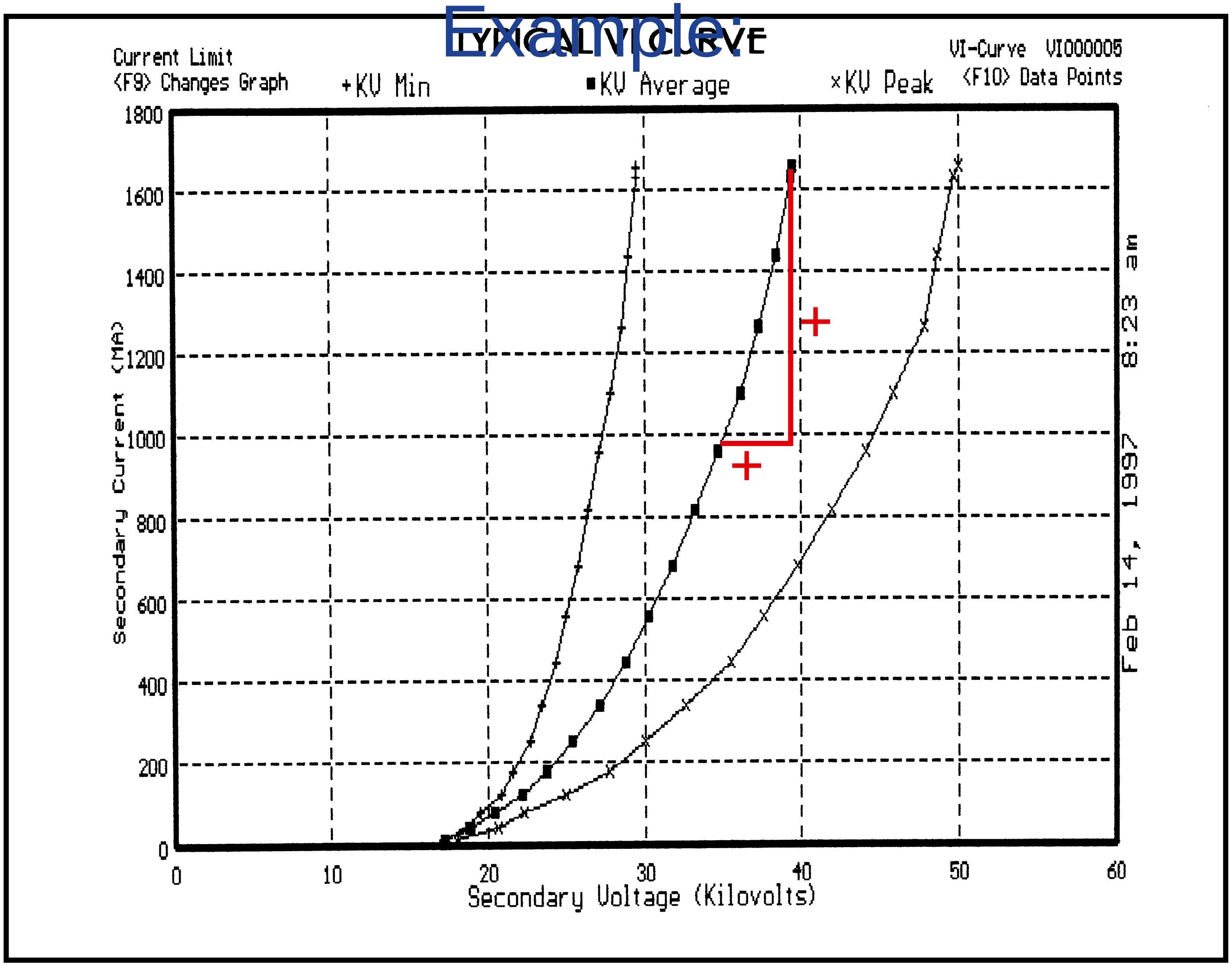
Maybe the dust is resistive?
This one is tricky!

Wouldn't Hurt to Run a Couple of <u>Quick</u> V-I Curves

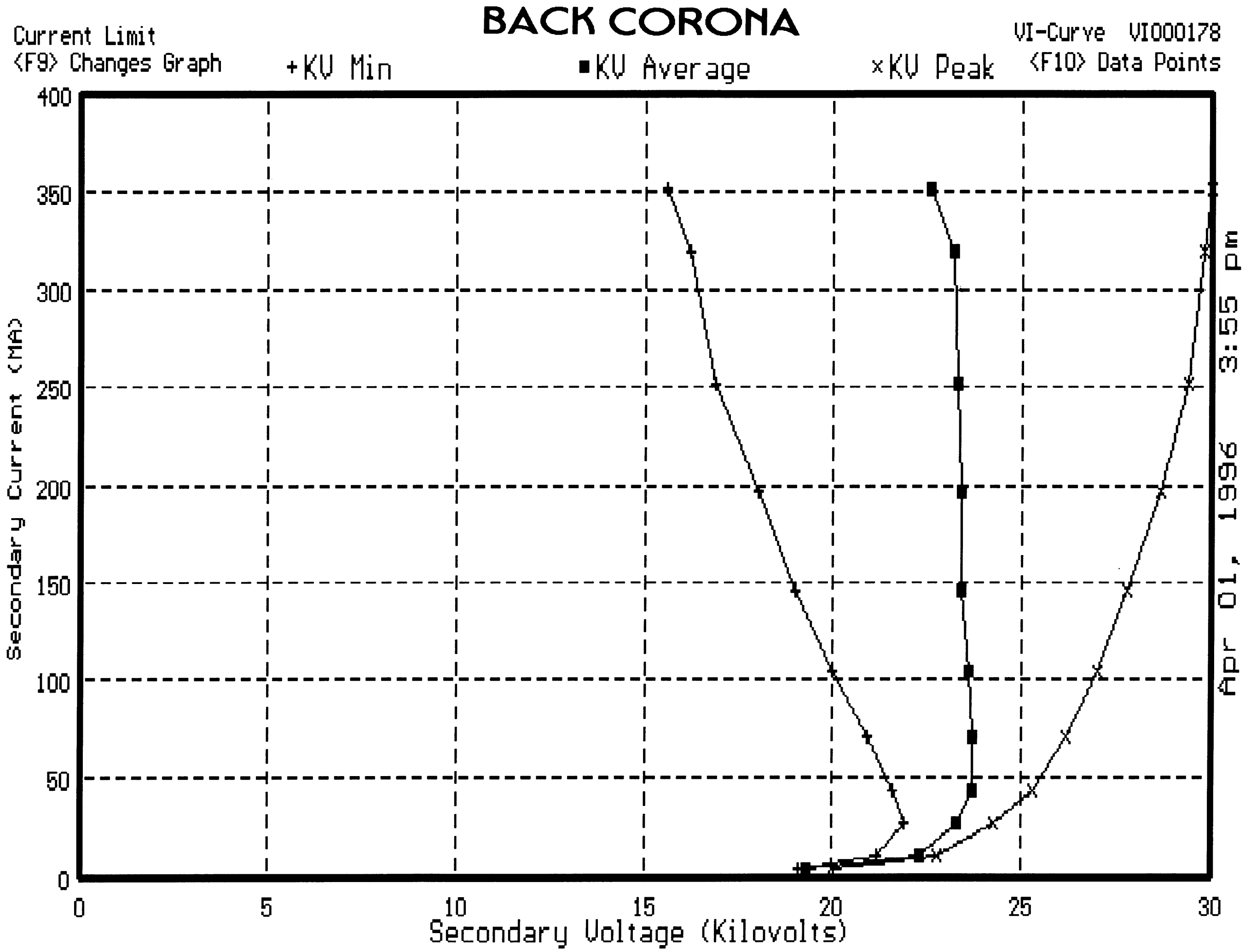
imagination at work

If the Dust is Conductive, then the Curve should Slope to the Right.

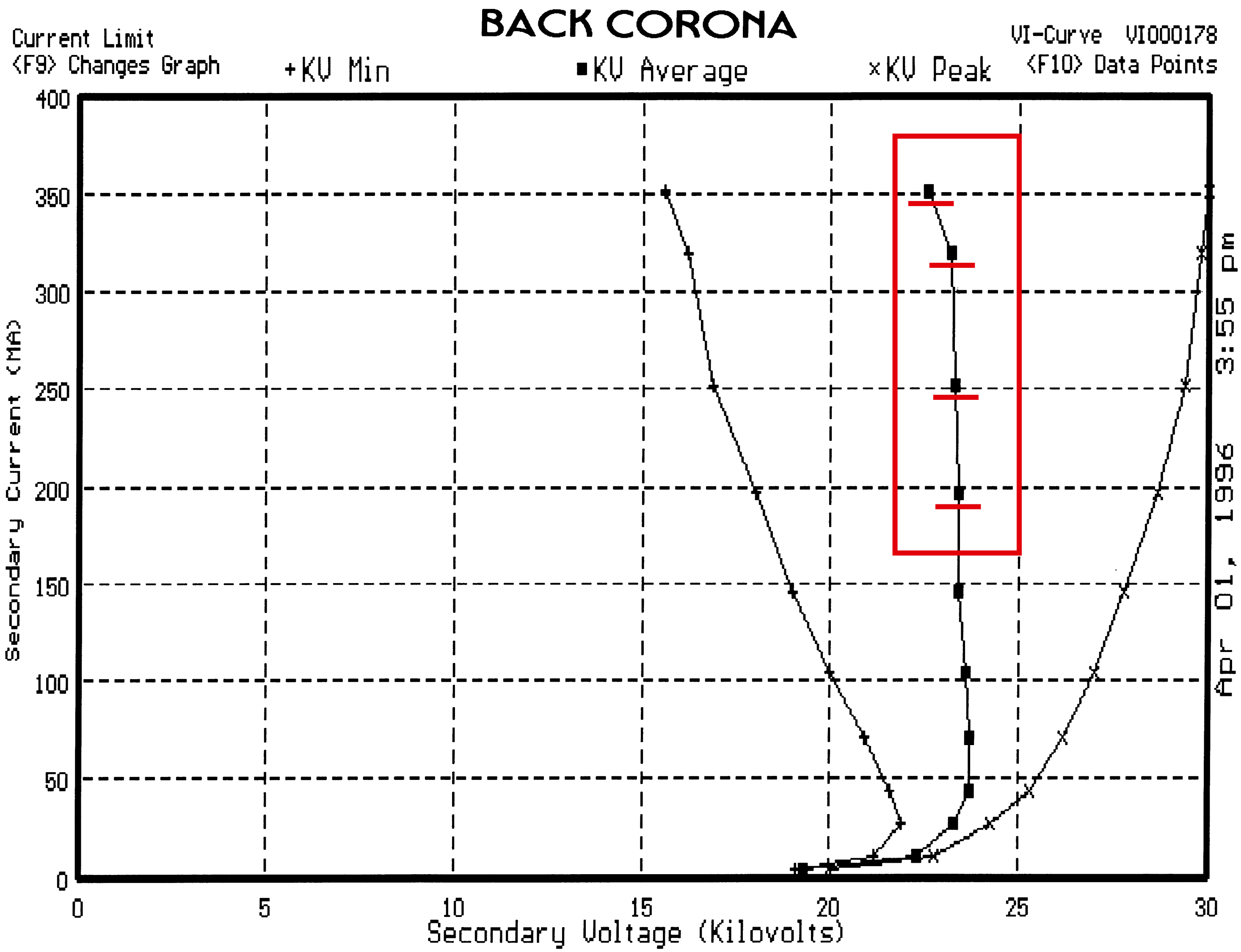
Example:



If the Dust is Resistive, then the Curve will be Vertical or Slope to the Left. Example:



Running a “Quick VI Curve would Yield:



Unfortunately, No V-i Curves Were Run at the Time for This ESP. So, Let's See What Else Might Be Helpful.

Step 5

5. Current densities are the best tool to check for dust resistivity and to compare successive fields' current (mA) values.

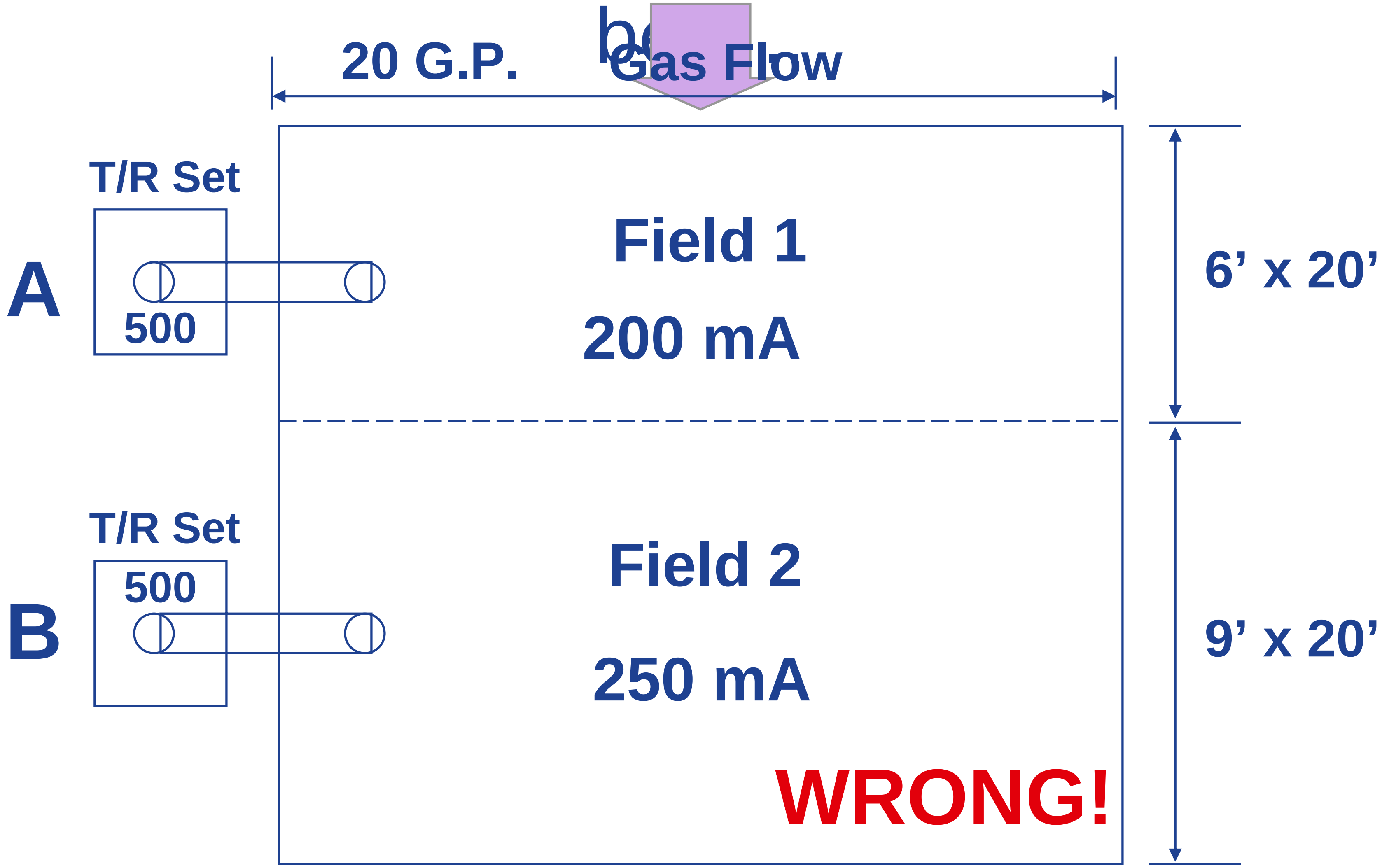
Current Density

imagination at work

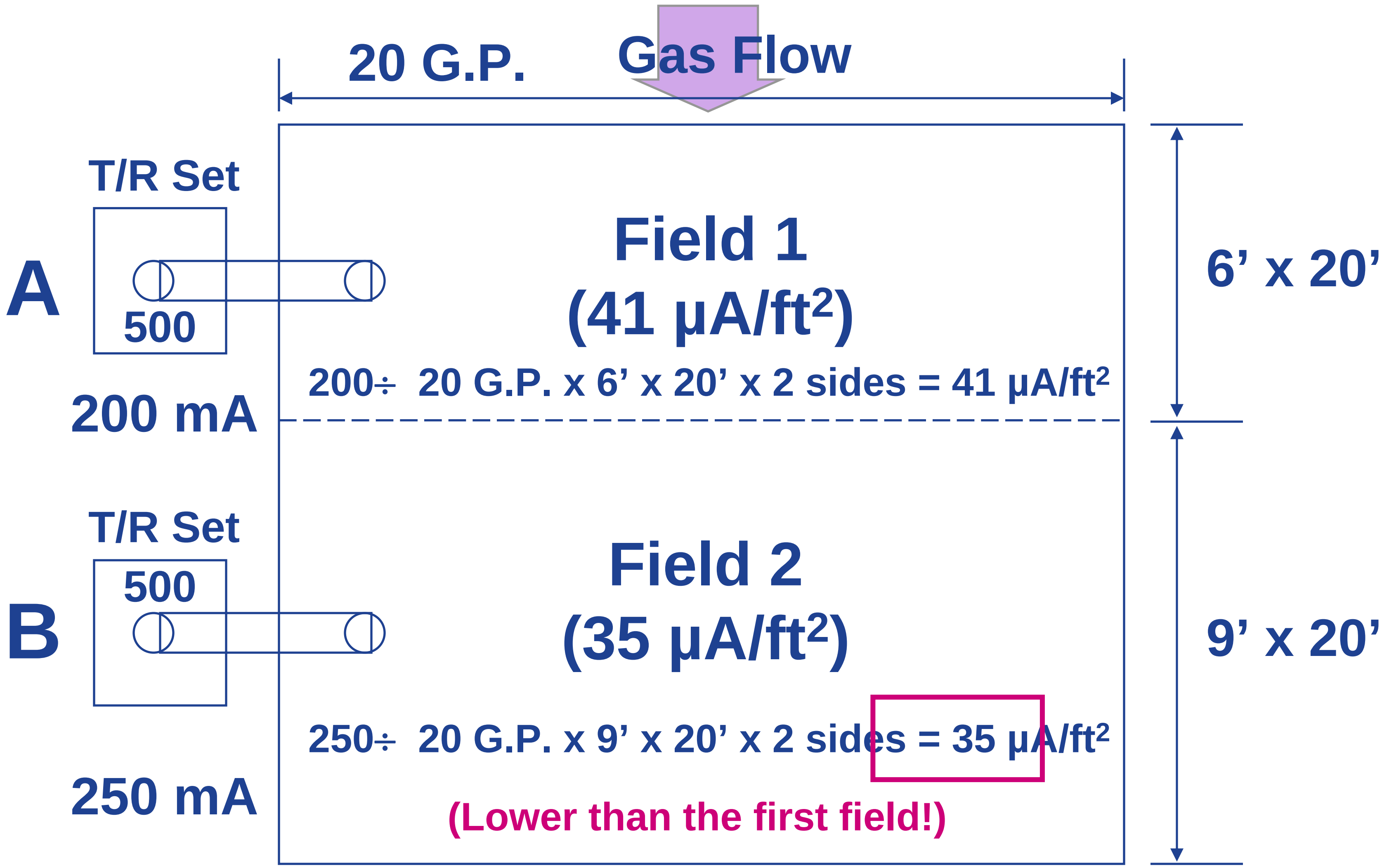
Current Density

1. Enables A true comparison of ESP current for T/R sets not energizing the same square feet of collecting plates.
2. Generally accepted values for low and high resistivity dust, can aid in troubleshooting.

Based on what we learned in Step 3, this ESP is OK. However, that would be



Current Density



I. Current Densities **(for conductive dust)**

In general, typical range of values for current density for a four field

American ESP

Field Number	Current Density ($\mu A/ft^2$)
1	15 - 25
2	25 - 40
3	40 - 60
4	60 - 80

I. Current Densities **(for conductive dust)**

In general, typical range of values for current density for a four field **European ESP** where T-R sets may not be sized to provide more than 40μA/ft^2

Field Number	**Current Density (μA/ft^2)**
1	10 - 20
2	20 - 30
3	30 - 40
4	30 - 40

II. Current Densities **(for high resistivity dust)**

Typical values of current density for high resistivity but no Back Corona.

Field Number	Current Density ($\mu A/ft^2$)
1	7 - 25
2	7 - 25
3	7 - 25
4	7 - 25

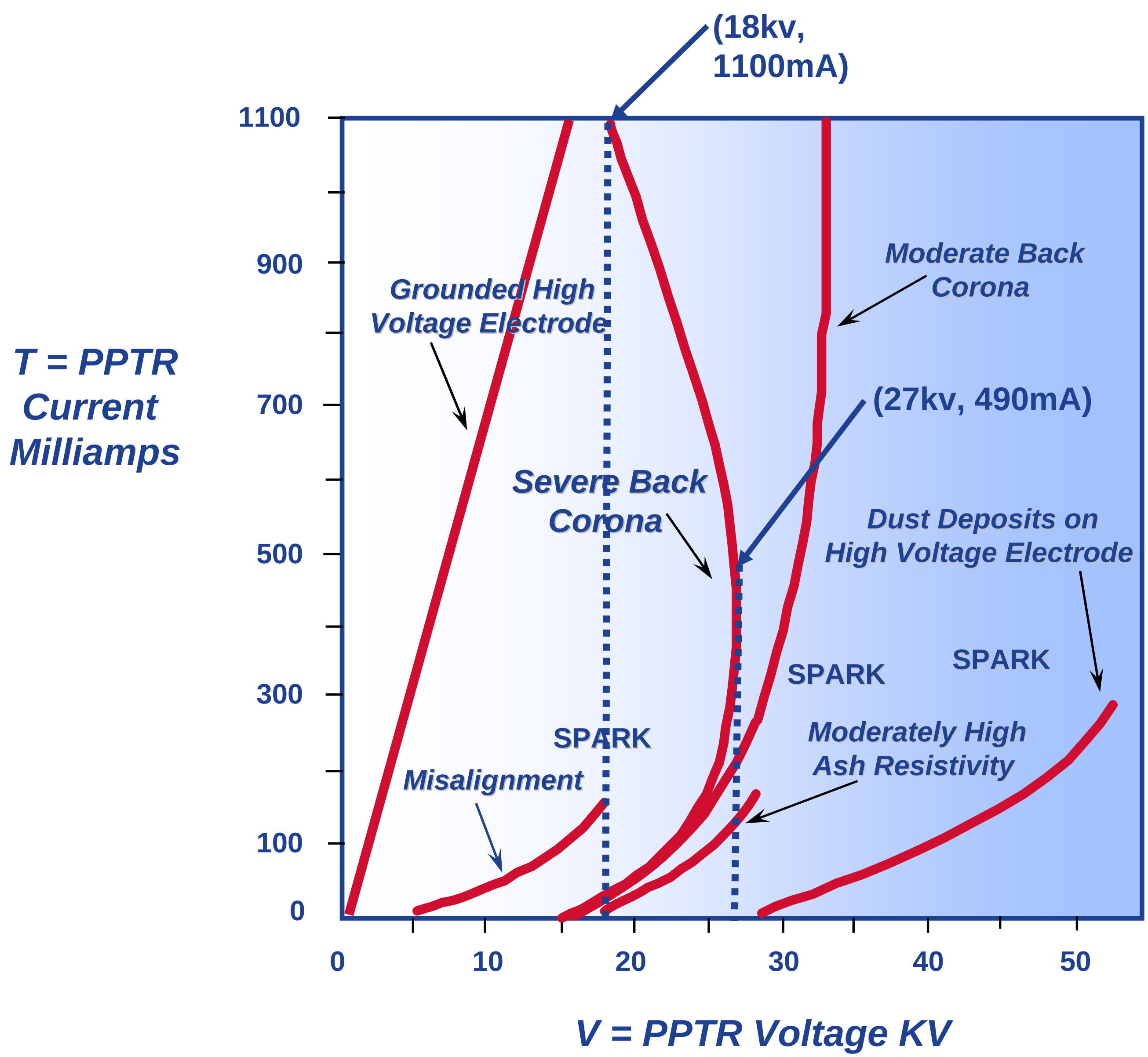
(Accompanied by sparking in all fields)

III. Current Densities **(an example of high resistivity in fields 2 and 3 and stable back corona in the 4th field)**

Field Number	Current Density ($\mu A/ft^2$)
1	21
2	20
3	19
4	72

Don't be fooled by useless current!

Back Corona – Non Useful Current!



Converting to Densities we get:

1299	836	622	347	MILLIAMP	193	404	1124	1400
757	700	572	419		211	450	492	350
436	252	287	175		149	333	470	622
375	OFF	104	157		OFF	150	235	501
109	70	52	29	DENSITY	16	34	95	118
64	59	48	35		18	38	41	29
37	21	24	15		13	28	40	52
32	OFF	9	13		OFF	13	20	42

Evaluating Densities We Get:

1299	836	622	347	MILLIAMP	193	404	1124	1400
757	700	572	419		211	450	492	350
436	252	287	175		149	333	470	622
375	OFF	104	157		OFF	150	235	501
109	70	52	29	60 - 80	16	34	95	118
64	59	48	35	40 - 60	18	38	41	29
37	21	24	15	25 - 40	13	28	40	52
32	OFF	9	13	15 - 25	OFF	13	20	42

There appears to be a pattern here. Why?

Step3 vs. Step 5 Comparison

1299	836	622	347	MILLIAMP	193	404	1124	1400
757	700	572	419		211	450	492	350
436	252	287	175		149	333	470	622
375	OFF	104	157		OFF	150	235	501

Step 3

Notice how many more "substandard" fields are identified by applying Step 5

109	70	52	29	60 - 80	16	34	95	118
64	59	48	35	40 - 60	18	38	41	29
37	21	24	15	25 - 40	13	28	40	52
32	OFF	9	13	15 -25	OFF	13	20	42

Step 5

GE Proprietary

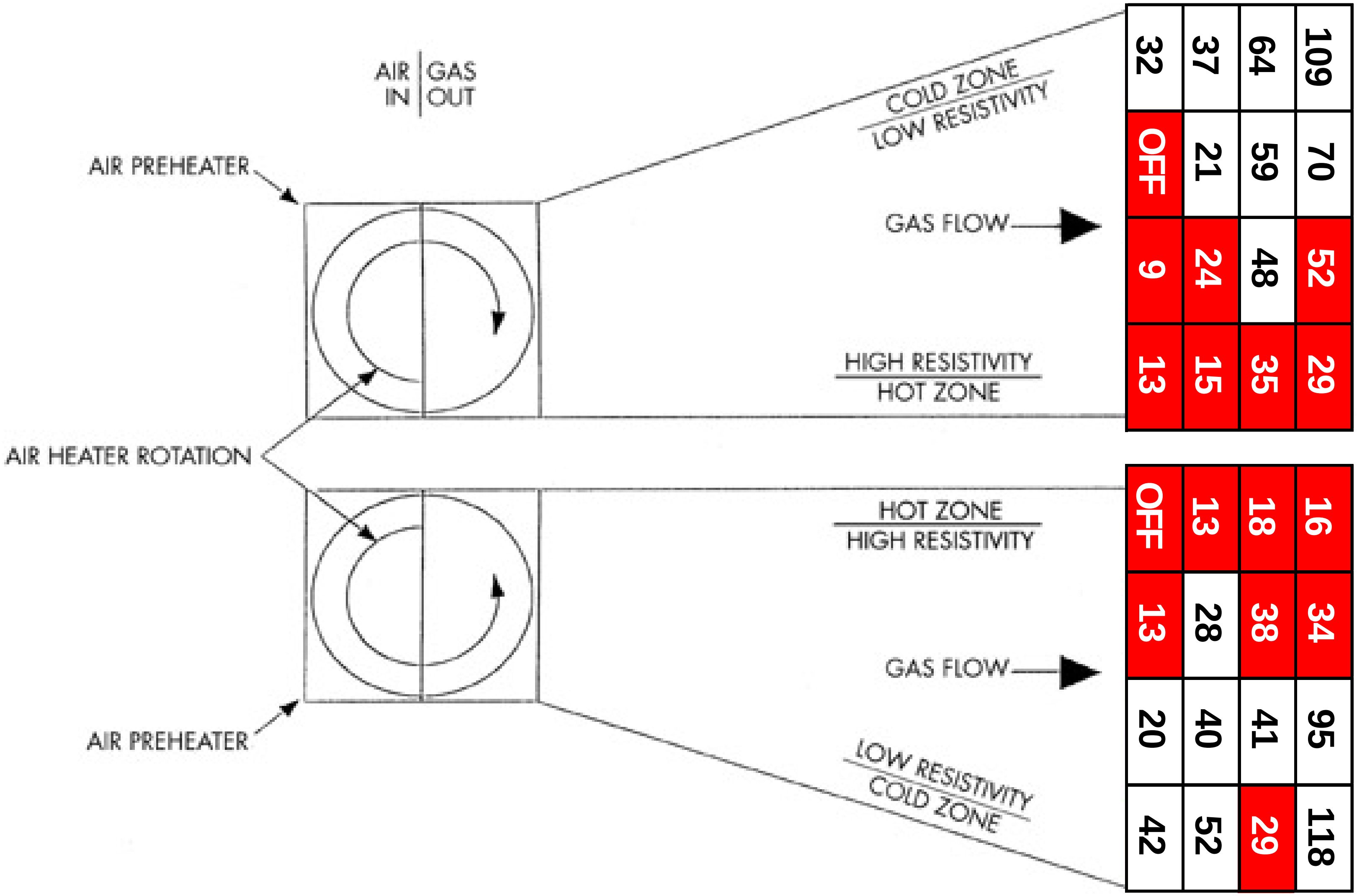
Get the point?

Looking at things again:

1299	836	622	347	MILLIAMP	193	404	1124	1400
757	700	572	419		211	450	492	350
436	252	287	175		149	333	470	622
375	OFF	104	157		OFF	150	235	501
109	70	52	29	60 - 80	16	34	95	118
64	59	48	35	40 - 60	18	38	41	29
37	21	24	15	25 - 40	13	28	40	52
32	OFF	9	13	15 -25	OFF	13	20	42

There appears to be a pattern here. Why?

Graphic Visualization



Densities also explain why there was sparking in outlet fields on the conductive side

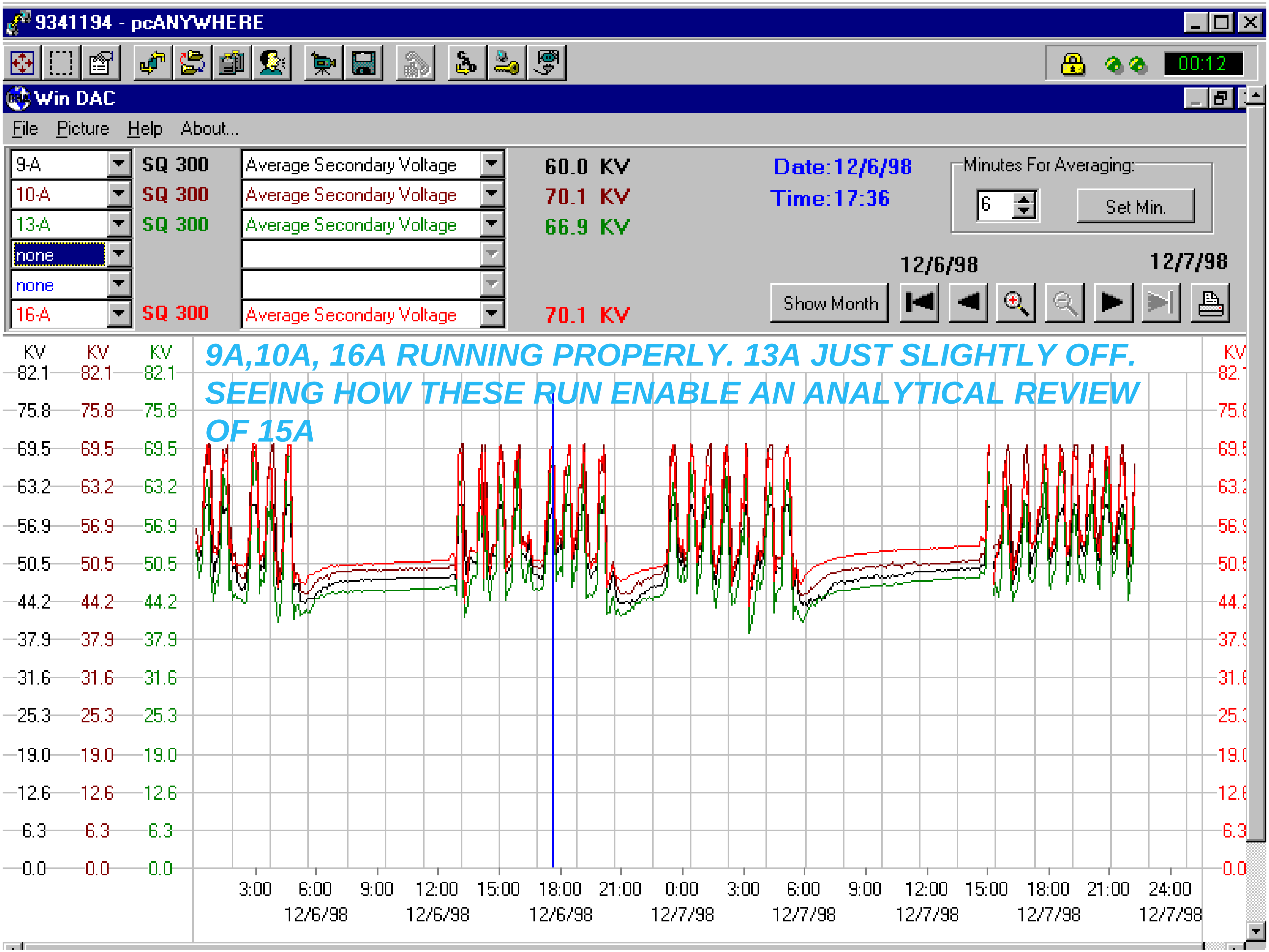
109	70	52	29	60 - 80	16	34	95	118
64	59	48	35	40 - 60	18	38	41	29
37	21	24	15	25 - 40	13	28	40	52
32	OFF	9	13	15 -25	OFF	13	20	42
14	15	15	14	SPM	14	11	6	1
18	13	18	17		12	11	16	20
22	18	14	17		14	11	15	11
30	OFF	30	27		OFF	28	27	25

The T/R sets are oversized. They provide more current

than required. Their quantity had been doubled.

Step 6

6. T/R sets in the same relative field position should run at the same power levels, both voltage (kV) and current (mA)


9341194 - pcANYWHERE
00:12
Win DAC
File Picture Help About...
9-A SQ 300 Average Secondary Voltage 60.0 KV
10-A SQ 300 Average Secondary Voltage 70.1 KV
13-A SQ 300 Average Secondary Voltage 66.9 KV
none
none
16-A SQ 300 Average Secondary Voltage 70.1 KV
Date:12/6/98
Time:17:36
Minutes For Averaging:
6
Set Min.
12/6/98
12/7/98
Show Month
9A,10A, 16A RUNNING PROPERLY. 13A JUST SLIGHTLY OFF. SEEING HOW THESE RUN ENABLE AN ANALYTICAL REVIEW OF 15A
KV KV KV
82.1 75.8 69.5 63.2 56.9 50.5 44.2 37.9 31.6 25.3 19.0 12.6 6.3 0.0
3:00 6:00 9:00 12:00 15:00 18:00 21:00 0:00 3:00 6:00 9:00 12:00 15:00 18:00 21:00 24:00
12/6/98 12/6/98 12/6/98 12/7/98 12/7/98 12/7/98 12/7/98 12/7/98

Applying Step 6 we get:

1299	836	622	347	MILLIAMP	193	404	1124	1400
757	700	572	419		211	450	492	350
436	252	287	175		149	333	470	622
375	OFF	104	157		OFF	150	235	501

Step 6 can achieve the same results as a density review and is simpler, but not as precise.

With just numbers, we were nowhere.

Time = Thu 1998/03/05 2:11pm

Page 1 of 3

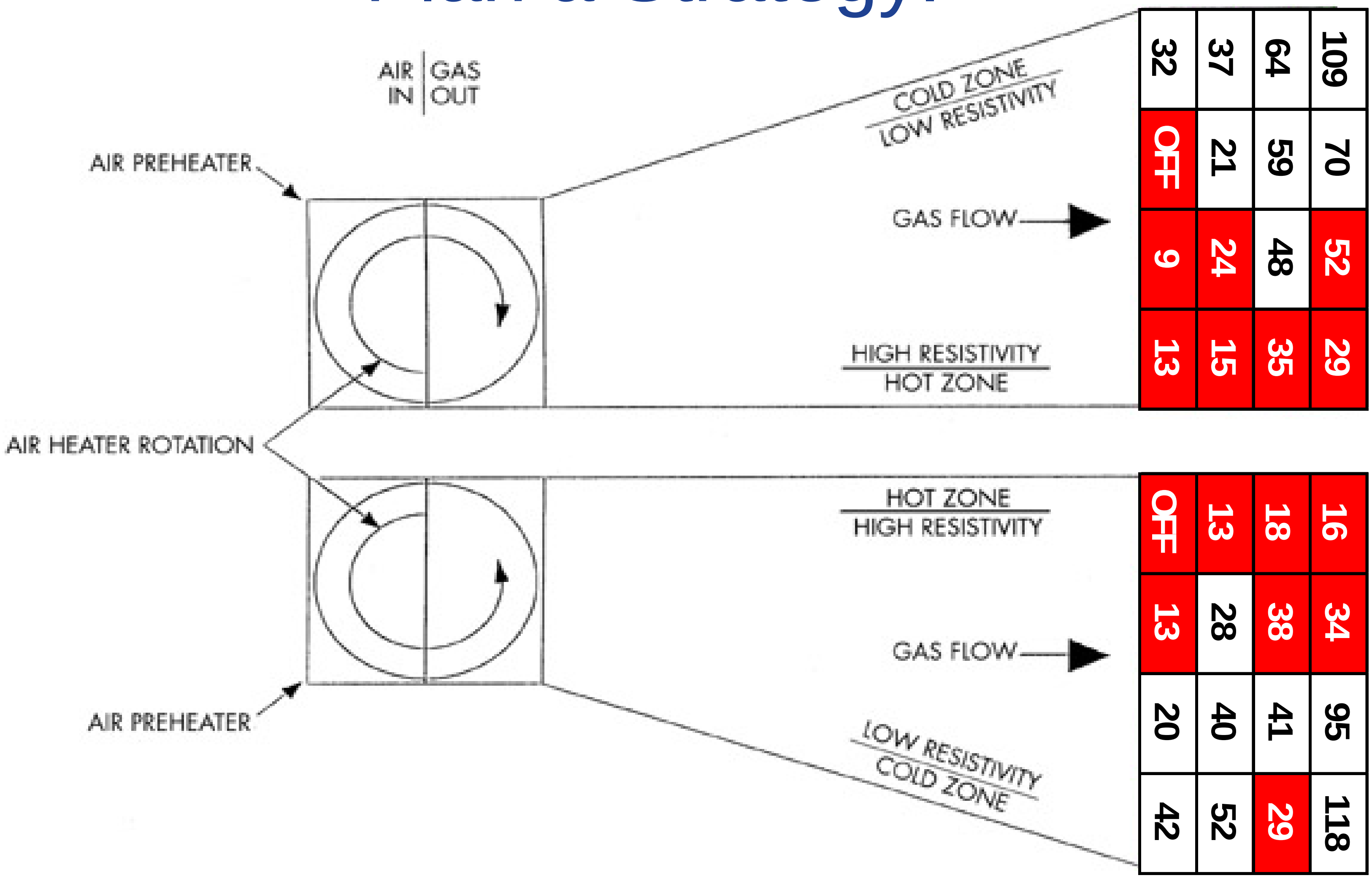
PrecipTech, Inc.
Power Guard Management System
DAC Version 2.9014
SQ-300 AVC

*******Supplemental Printout*******

*****CURRENT VALUES*****

Unit	Amps	Volts	MA	KV	S/M	Status
#3-1A1	22	254	126	39.2	28	Running
#3-2A1	58	346	379	45.0	11	Running
#3-3A1	60	248	324	37.5	11	Running
#3-4A1	76	252	415	36.1	11	Running
#3-5A1	83	357	652	44.5	25	Running
#3-6A1	115	334	909	41.4	11	Running
#3-7A1	59	185	312	25.9	20	Running
#3-8A1	215	365	1517	39.7	1	Running
#3-1A2	***	***	****	****	***	No Response
#3-2A2	16	194	71	33.2	14	Running
#3-3A2	35	236	166	38.1	12	Running
#3-4A2	37	207	173	31.9	14	Running
#3-5A2	39	265	217	39.6	27	Running
#3-6A2	60	263	375	33.3	15	Running
#3-7A2	55	210	308	26.6	16	Running
#3-8A2	144	312	924	38.1	6	Running
#3-1B1	***	***	****	****	***	No Response
#3-2B1	36	217	213	30.6	18	Running
#3-3B1	165	399	1229	42.2	13	Running
#3-4B1	84	206	782	30.4	15	Running
#3-5B1	26	266	150	39.7	27	Running
#3-6B1	23	200	102	35.3	17	Running
#3-7B1	115	377	758	41.3	17	Running
#3-8B1	76	249	415	36.0	14	Running
#3-1B2	55	276	355	35.1	30	Running
#3-2B2	49	207	296	28.1	22	Running
#3-3B2	112	291	719	34.8	18	Running
#3-4B2	192	373	1339	41.6	14	Running
#3-5B2	12	173	55	29.7	30	Running
#3-6B2	97	373	687	44.7	14	Running
#3-7B2	111	345	743	38.1	18	Running
#3-8B2	79	251	438	31.2	15	Running

Now After Applying 6 Steps, We Can Plan a Strategy.



Questions?

Thank you.

imagination at work