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Plotting, Tracking and Optimizing Electrostatic Precipitator Operation

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PLOTTING, TRACKING AND OPTIMIZING ELECTROSTATIC PRECIPITATOR OPERATION

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ABSTRACT

Many industrial plants are faced with the reality of reduced staffing, which may have resulted in the loss of an on-site electrostatic precipitator expert. This has created a void in which precipitator troubleshooting, operation and optimization may not be fully understood. Problems such as increased emissions, back corona and ineffective rapping (to name a few) may go undiagnosed which may lead to de-rates, upsets or shutdowns.

The PrecipRADAR™ software is a new and unique approach to analyzing precipitator operation and brings the precipitator expert to the site. In this paper some results gathered from the software will be discussed by highlighting some of the issues it can uncover and the options to improve precipitator performance. The intent is to help the end user understand the benefits of this technology.

INTRODUCTION

Precipitator analysis and optimization is performed using many tools such as historical information, real time data, human intelligence, and experience. Numerous factors can affect precipitator performance. Proper data analysis is necessary to allow accurate assessment of current operating conditions and solid recommendations for improvement. However, as process conditions (or other factors) change, the analysis must commence again, creating a continuous circle of human intervention. To enhance performance, intelligent methodology is being introduced to precipitator control systems. The result should reduce the need for most human intervention and keep the precipitator at optimal performance. PrecipRADAR software is one of these intelligent methods, and the topic of this paper.

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Typical Precipitator Analysis

The analysis process begins with a problem, usually increased emissions. This starts a review of the historical trends of precipitator operation and plant process data. Correlations in the data are looked at to determine the root cause of the issue. (See Fig. 1.)

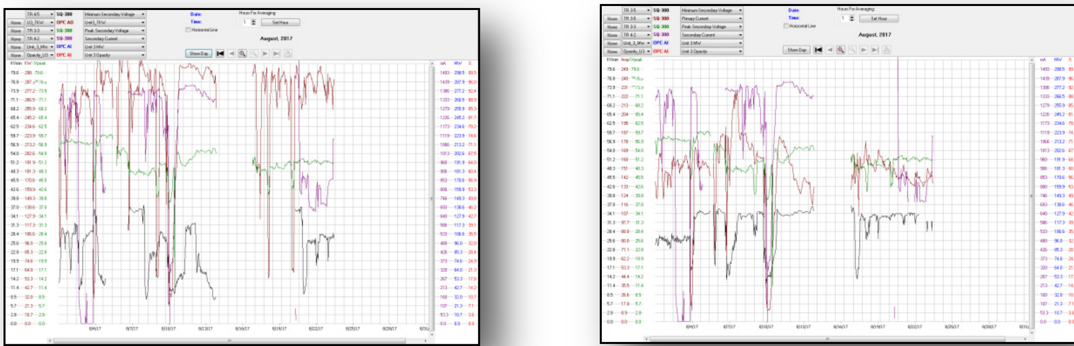
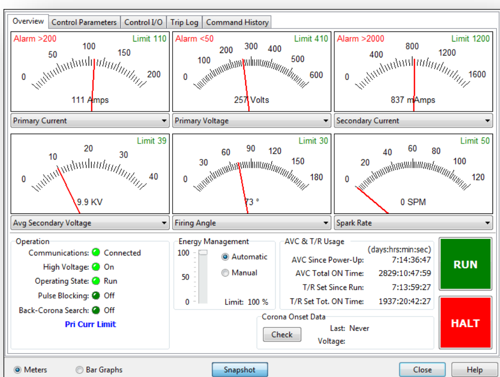


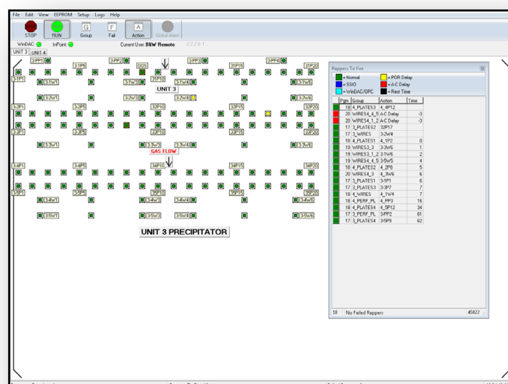
Fig. 1 Precipitator and plant process historical data

Other observations that may be necessary, shown in Fig. 2, include:

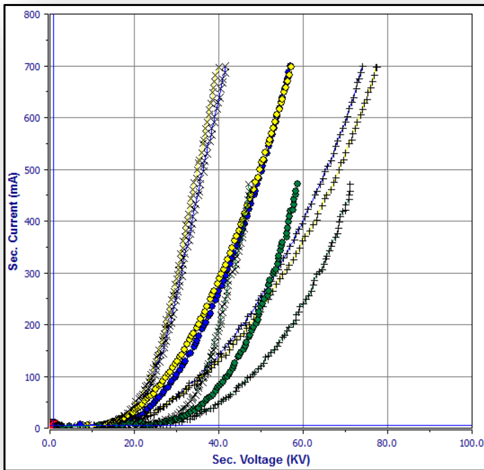
- Setup and operation of each AVC (automatic voltage control)
- Comparisons of VI (voltage-current) curves
- Observation of the electrical waveforms for each precipitator field
- Setup and operation of the rapper control



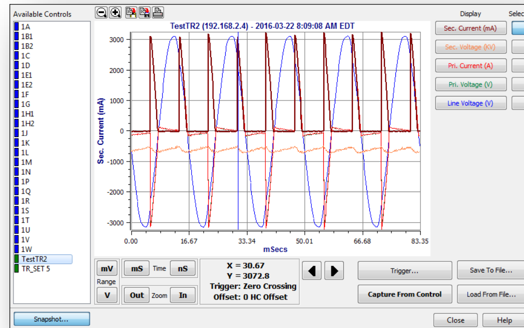
AVC operation



Rapper control operation



VI curve analysis



Electrical waveforms

Fig. 2 Additional precipitator observations

The collection and analysis of the data may take significant time and resources. This can be especially true if the investigator is new to precipitator operation. All the while, the problem may still be occurring. Depending upon the severity of the problem, de-rates, and emission violations may occur. In the worst case scenario, a shutdown may be necessary. This can all add up to significant revenue losses.

Innovative Precipitator Analysis

As described, monitoring, troubleshooting, and optimizing precipitator operation can be a long and tedious process. To reduce the amount of human intervention and provide a faster methodology for precipitator optimization, intelligent algorithms are being placed into precipitator controls systems. The foundation for these intelligent algorithms commences with having a base line.

During good operation, a *snapshot* (VI Curve) of the electrical field is performed. This becomes the baseline and can be used to compare against real-time operation. This comparison provides a *deviation from baseline* result. Depending upon this result, changes can be performed to the precipitator control system automatically in an attempt to get the precipitator field back to baseline operation.

Deviation from Baseline

All electrical circuits can be simplified to three basic characteristics: resistive, capacitive and inductive. A precipitator's predominate electrical characteristics is that of capacitance and resistance. However, these characteristics are not constant, but vary. This variation may be dependent upon many variables, including chemical composition of the dust, temperature, moisture content, and mechanical design and condition.

The difference between air load and process load changes the capacitive and resistive characteristics of the precipitator field. (See Fig. 3.) Through deviation analysis, the extent of change in resistance and/or capacitance of the precipitator field can be determined. These characteristic changes can provide insight to process or field related issues.

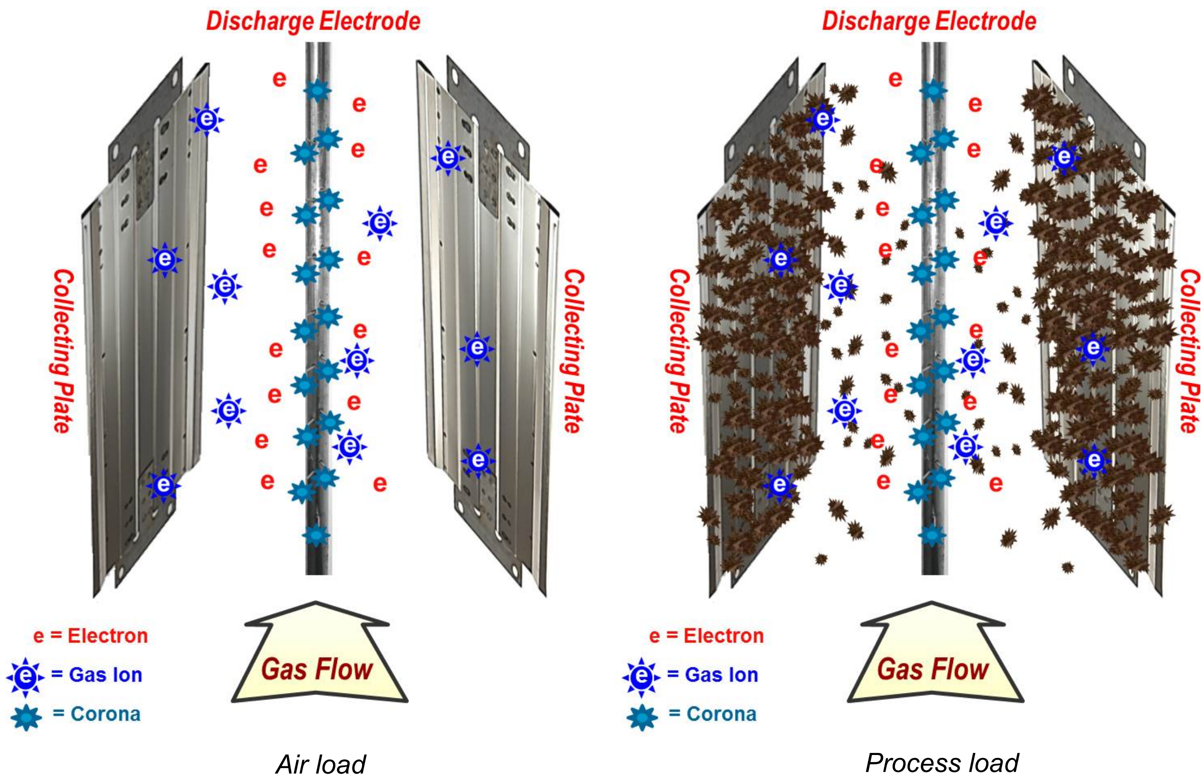


Fig.3 Precipitator air load and process load

PrecipRADAR software

PrecipRADAR software is new methodology to troubleshoot, diagnose and optimize precipitator performance. It accomplishes this through comparing a baseline VI curve to that of real-time operation, and provides a deviation of the data. This change in deviation can provide insight to changes in the electrical characteristics of the precipitator fields. In Fig. 4, the baseline VI curve (in blue) is represented as a red dot in the center of PrecipRADAR screen.

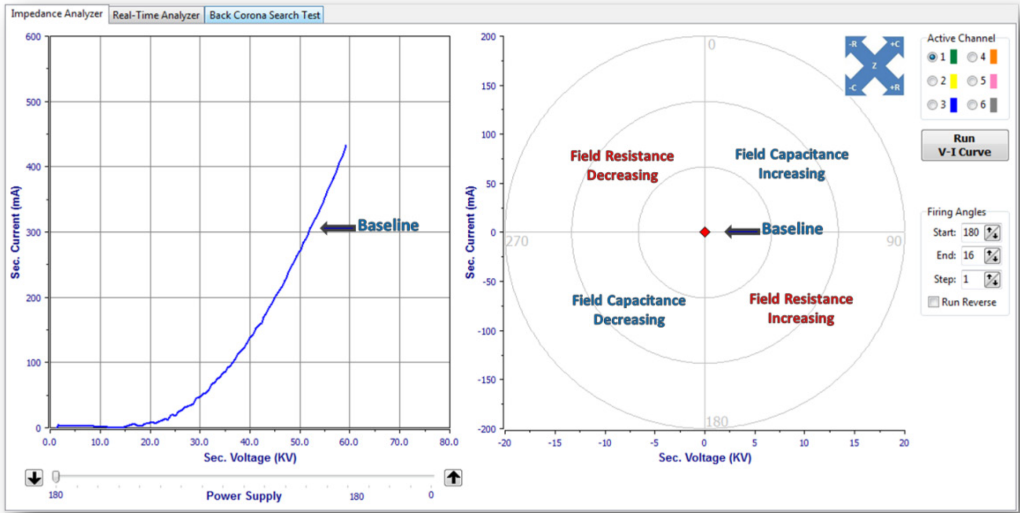


Fig. 4 PrecipRADAR software screen showing baseline

In Fig. 5, when a comparison VI curve (in yellow) is loaded, a deviation is indicated between the two. The PrecipRADAR screen indicates how the yellow curve deviates from the baseline and indicates capacitance has increased but that resistance has a more dominate effect.

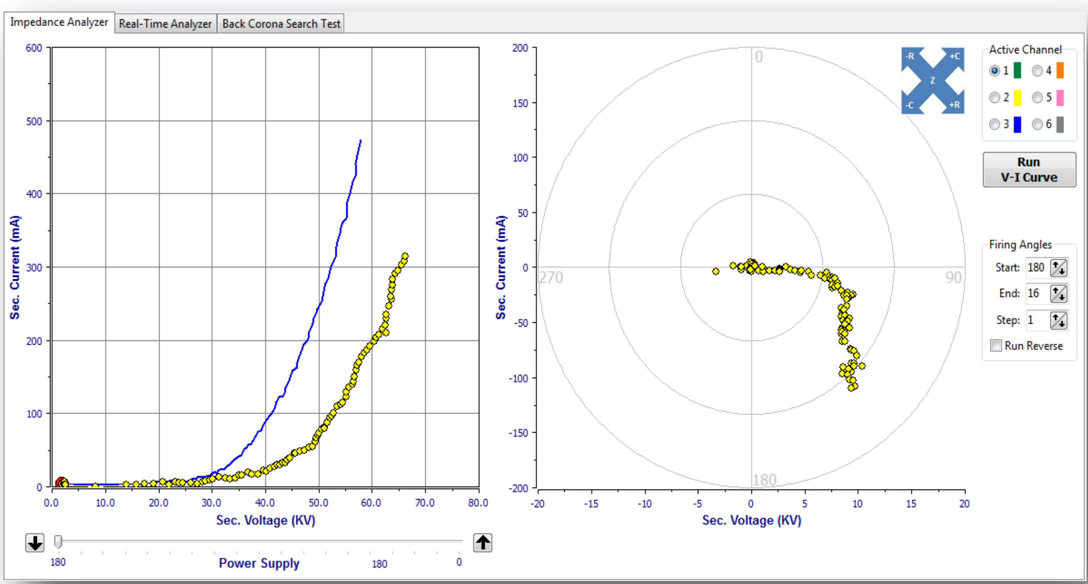


Fig. 5 PrecipRADAR software screen showing deviation

Back Corona

Back corona is a phenomenon typically occurring in precipitators collecting high resistivity dust. This high-resistivity dust accumulates on the collecting plate surface until a point is reached where the collecting plate will start to emit a positive corona. At this point, collection efficiency begins to diminish.

In Fig. 6, a real-time curve is compared to its good operational baseline. When back corona starts, a significant breakdown of the field resistance is indicated in the PrecipRADAR software.

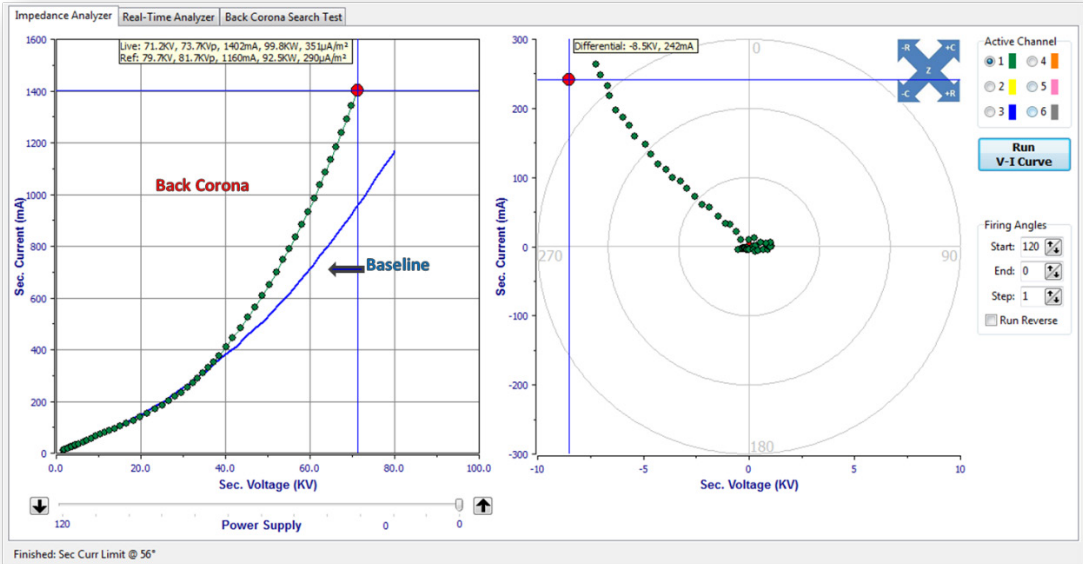


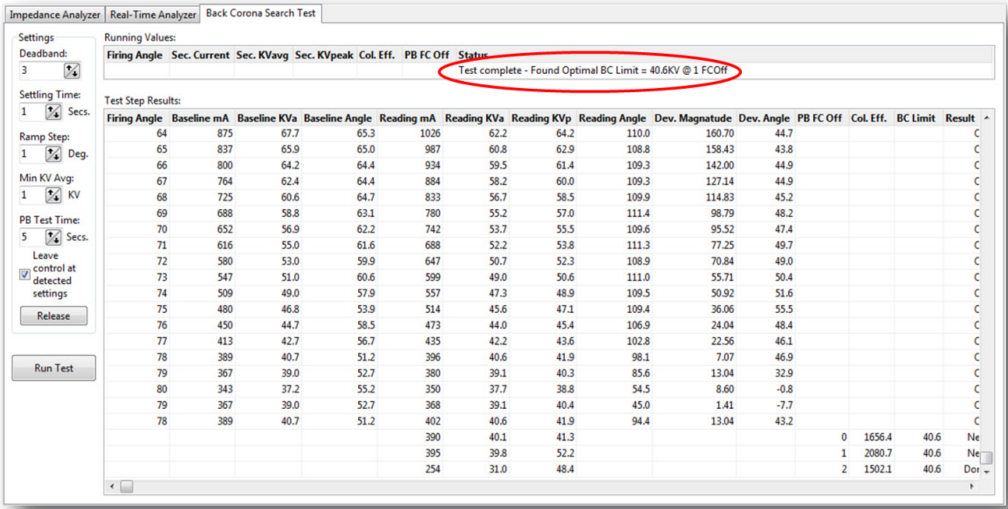
Fig. 6 PrecipRADAR software screen showing back corona

Fig. 6.1 shows the point at which back corona just starts to form and Fig. 6.2 shows back corona in full development.

Fig. 6.1 Back corona commencing

Fig. 6.2 Back corona fully developed

To mitigate the effects of back corona, automation can be added to detect the point at which back corona commences (deviates from baseline). The AVC is then limited to this point and additional optimization may continue through intermittent energization and/or increased rapping. Fig. 6.3 shows a typical setup screen and mitigation routine results.



Firing Angle	Baseline mA	Baseline KVa	Baseline Angle	Reading mA	Reading KVa	Reading KVp	Reading Angle	Dev. Magnatude	Dev. Angle	PB FC Off	Col. Eff.	BC Limit	Result
64	875	67.7	65.3	1026	62.2	64.2	110.0	160.70	44.7				C
65	837	65.9	65.0	987	60.8	62.9	108.8	158.43	43.8				C
66	800	64.2	64.4	934	59.5	61.4	109.3	142.00	44.9				C
67	764	62.4	64.4	884	58.2	60.0	109.3	127.14	44.9				C
68	725	60.6	64.7	833	56.7	58.5	109.9	114.83	45.2				C
69	688	58.8	63.1	780	55.2	57.0	111.4	98.79	48.2				C
70	652	56.9	62.2	742	53.7	55.5	109.6	95.52	47.4				C
71	616	55.0	61.6	688	52.2	53.8	111.3	77.25	49.7				C
72	580	53.0	59.9	647	50.7	52.3	108.9	70.84	49.0				C
73	547	51.0	60.6	599	49.0	50.6	111.0	55.71	50.4				C
74	509	49.0	57.9	557	47.3	48.9	109.5	50.92	51.6				C
75	480	46.8	53.9	514	45.6	47.1	109.4	36.06	55.5				C
76	450	44.7	58.5	473	44.0	45.4	106.9	24.04	48.4				C
77	413	42.7	56.7	435	42.2	43.6	102.8	22.56	46.1				C
78	389	40.7	51.2	396	40.6	41.9	98.1	7.07	46.9				C
79	367	39.0	52.7	380	39.1	40.3	85.6	13.04	32.9				C
80	343	37.2	55.2	350	37.7	38.8	54.5	8.60	-0.8				C
79	367	39.0	52.7	368	39.1	40.4	45.0	1.41	-7.7				C
78	389	40.7	51.2	402	40.6	41.9	94.4	13.04	43.2				C
				390	40.1	41.3				0	1656.4	40.6	Ne
				395	39.8	52.2				1	2080.7	40.6	Ne
				254	31.0	48.4				2	1502.1	40.6	Dor

Fig. 6.3 Back corona routine

Rapping

The PrecipRADAR software can be utilized to detect whether changes in rapping may be necessary. An example of stopping rapping in a precipitator field for 30 minutes is presented in Fig. 7.

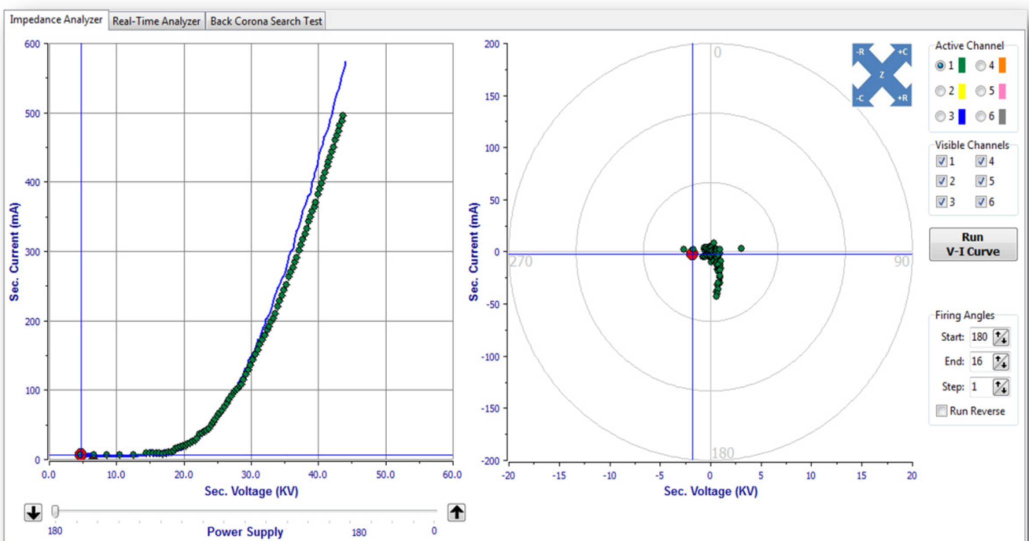


Fig. 7 No rapping

As shown in Fig. 7, additional dust buildup within the precipitator field resulted in a deviation from the baseline. This information could be sent to the rapper control to automatically provide additional rapping to the field in an attempt to return it to baseline operation.

Typically, rapping programs are created from experience based upon how a particular precipitator operates. However, as process conditions change, analysis of whether the rapping program needs changed is rarely performed. Constant automatic analysis of the electrical conditions in precipitator fields should be a significant benefit towards maintaining optimal precipitator performance.

Lime injection testing

Testing was performed at the Duke Energy – Asheville Plant, Unit #2 to provide data on the electrical effects in precipitator fields with and without lime injection.

Fig. 8 displays the layout of the precipitator.

Unit #2

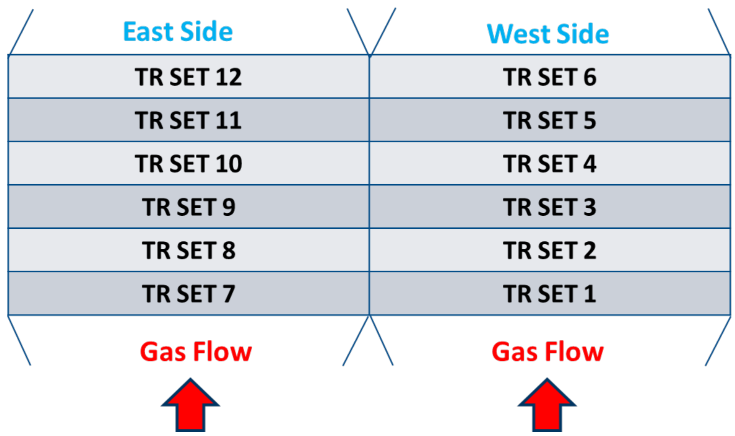


Fig. 8 Precipitator layout

The baseline VI curves were taken at full load with lime injection. Lime injection was then stopped and VI curves taken again. These VI curves were utilized as the comparison to the baseline. The following figures, Fig. 8.1 through Fig. 8.6, show the results.

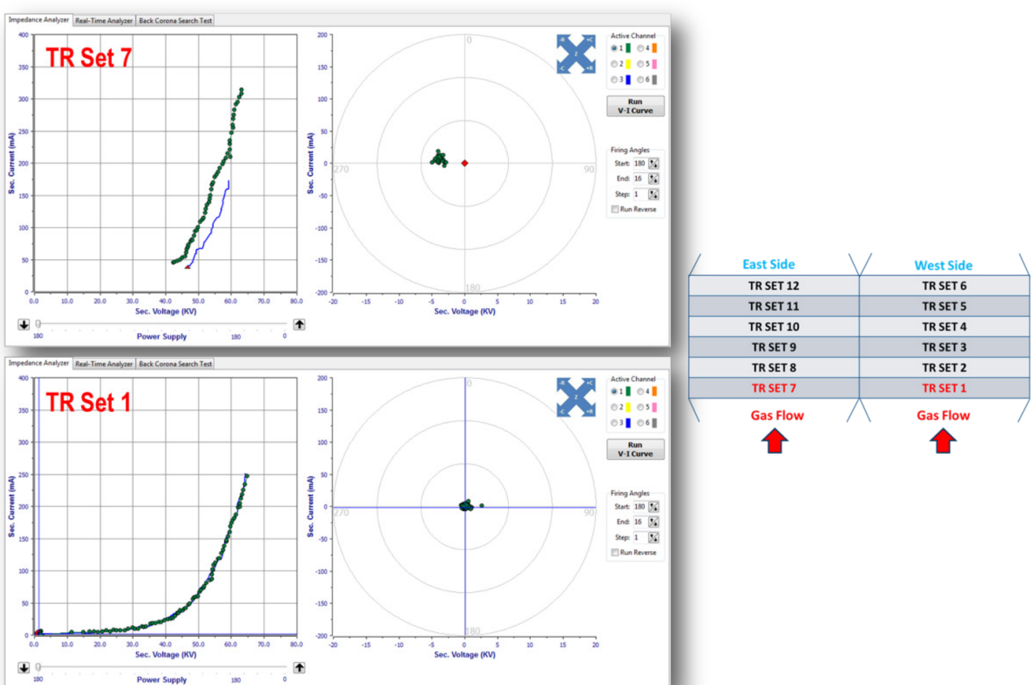


Fig. 8.1

- *Negative resistance change to TR SET 7*
- *Slight change to TR SET 1*

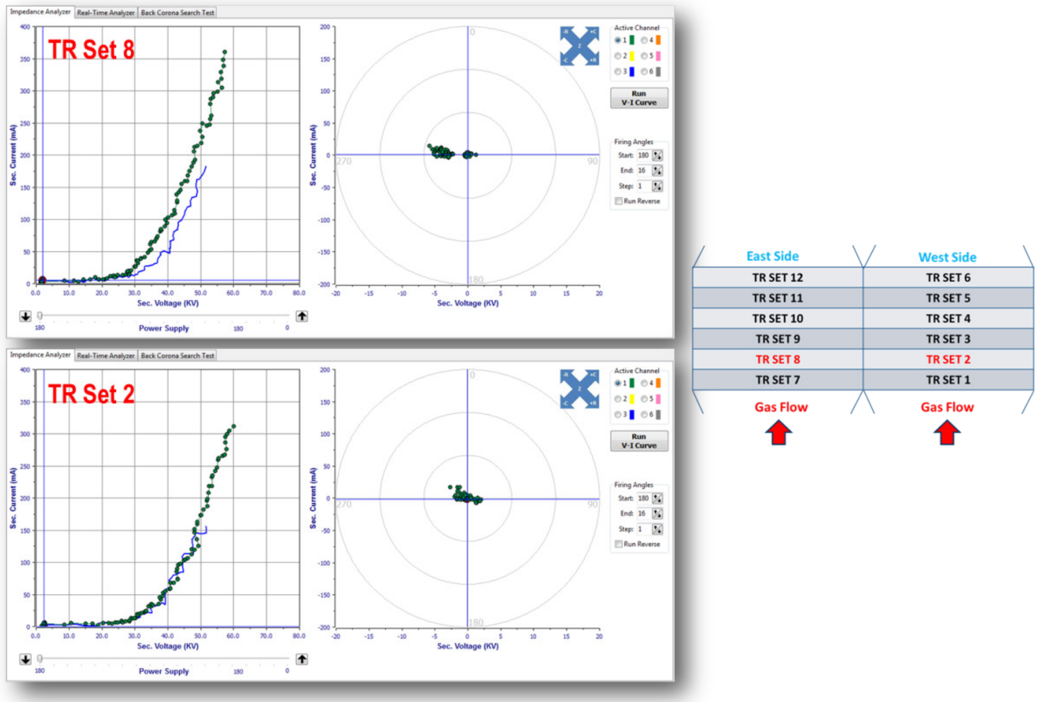


Fig. 8.2

- *Negative resistance change to TR SET 8*
- *Slight change to TR SET 2*

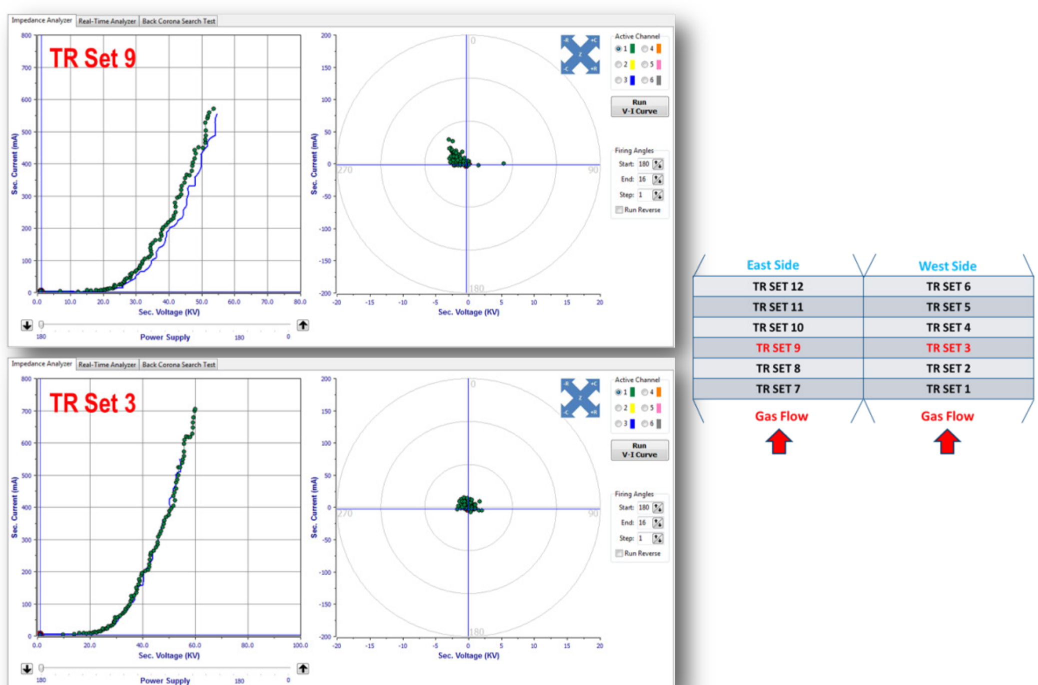


Fig. 8.3

- *Negative resistance change to TR SET 9*
- *Slight change to TR SET 3*

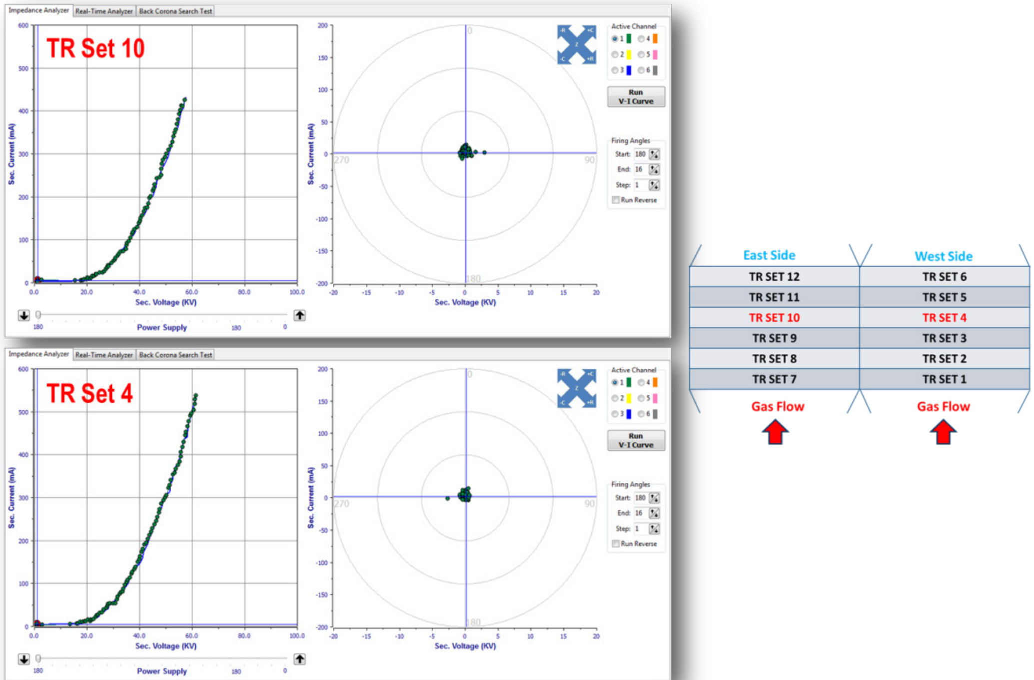


Fig. 8.4

- *Insignificant change to TR SET 10*
- *Insignificant change to TR SET 4*

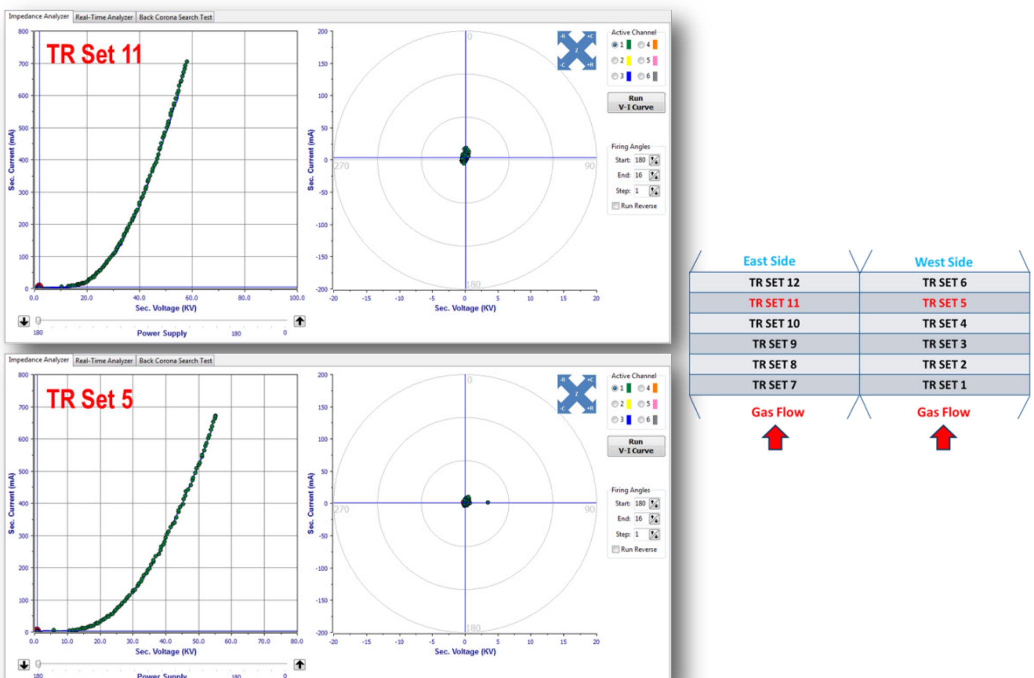


Fig. 8.5

- *Insignificant change to TR SET 11*
- *Insignificant change to TR SET 5*

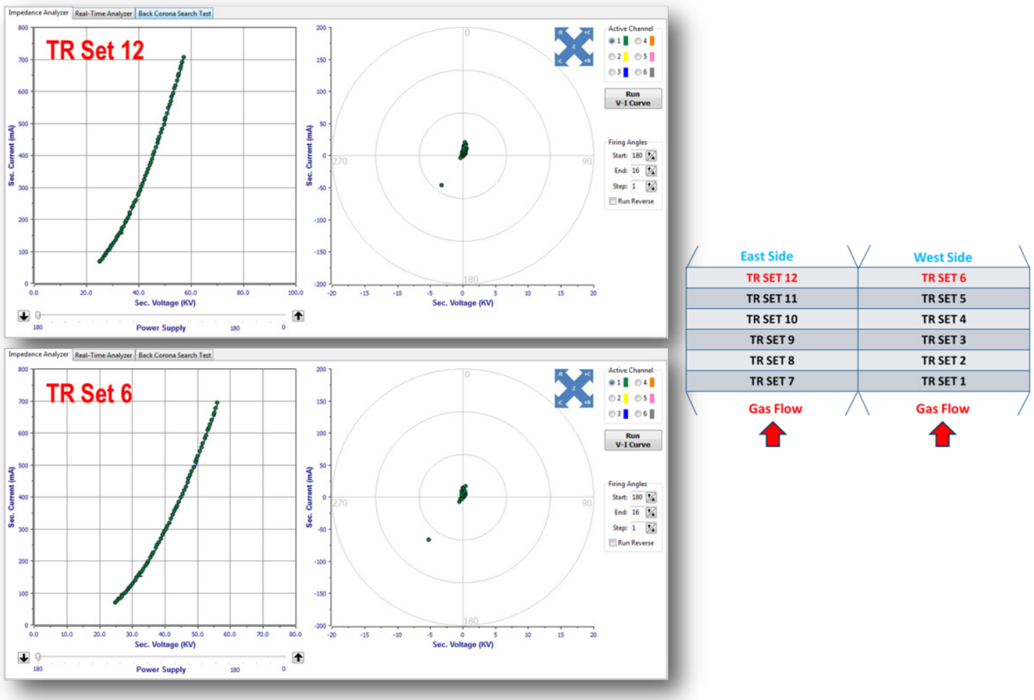


Fig. 8.6

- *Insignificant change to TR SET 12*
- *Insignificant change to TR SET 6*

The results appear to indicate that the lime injection increased the resistance of the fields and that this effect diminished after the third field of the precipitator. Additionally, precipitator fields in the relatively same positions on the East and West sides should operate similarly. However the deviation analysis appears to indicate that this is not the case for the first three fields. This may be related to an over injection of lime on the East side of the precipitator.

SUMMARY AND LOOKING AHEAD

The process for electrostatic precipitator troubleshooting and optimization can be extensive. Through the use of innovative algorithms, this process can be greatly simplified and automated while minimizing the need for constant human intervention to maintain optimum performance.

Ultimately, total intelligent precipitator automation can perform:

- Analysis and reporting of precipitator operation
- Analysis and optimization of the rapper system to increase or decrease rapping, change cycle times due to loss of a field, and reduce emissions spiking
- Back corona detection and mitigation
- Detection of field problems and providing fault scenarios and corrective actions
- Optimal spark rate setting

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