Reinhold Environmental Ltd.

2009 APC Round Table & Expo Presentation

July 12-14, 2009, in The Woodlands, TX

On-line Inspections

- ESP Voltage Controls
  - Where a control should operate
  - How to review ESP operating data
  - Evaluating a troubled control
  - Locating the problem
  - Getting ready for the outage
- Rappers
  - Monthly rapper checks
  - Evaluating a troubled control
- Fly Ash Removal System

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ESP Voltage Controls

- An automatic voltage control (AVC) serves to maintain the voltage level at the optimum value, even when the dust characteristics and concentration exhibit dynamic behavior.
  - This is achieved by varying the duration that current is applied to the T/R set.

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Where a control should operate

- TR set rating
- Artificial limit (manually or energy management)
- Spark limited
- SCR limited (full conduction of the SCRs)

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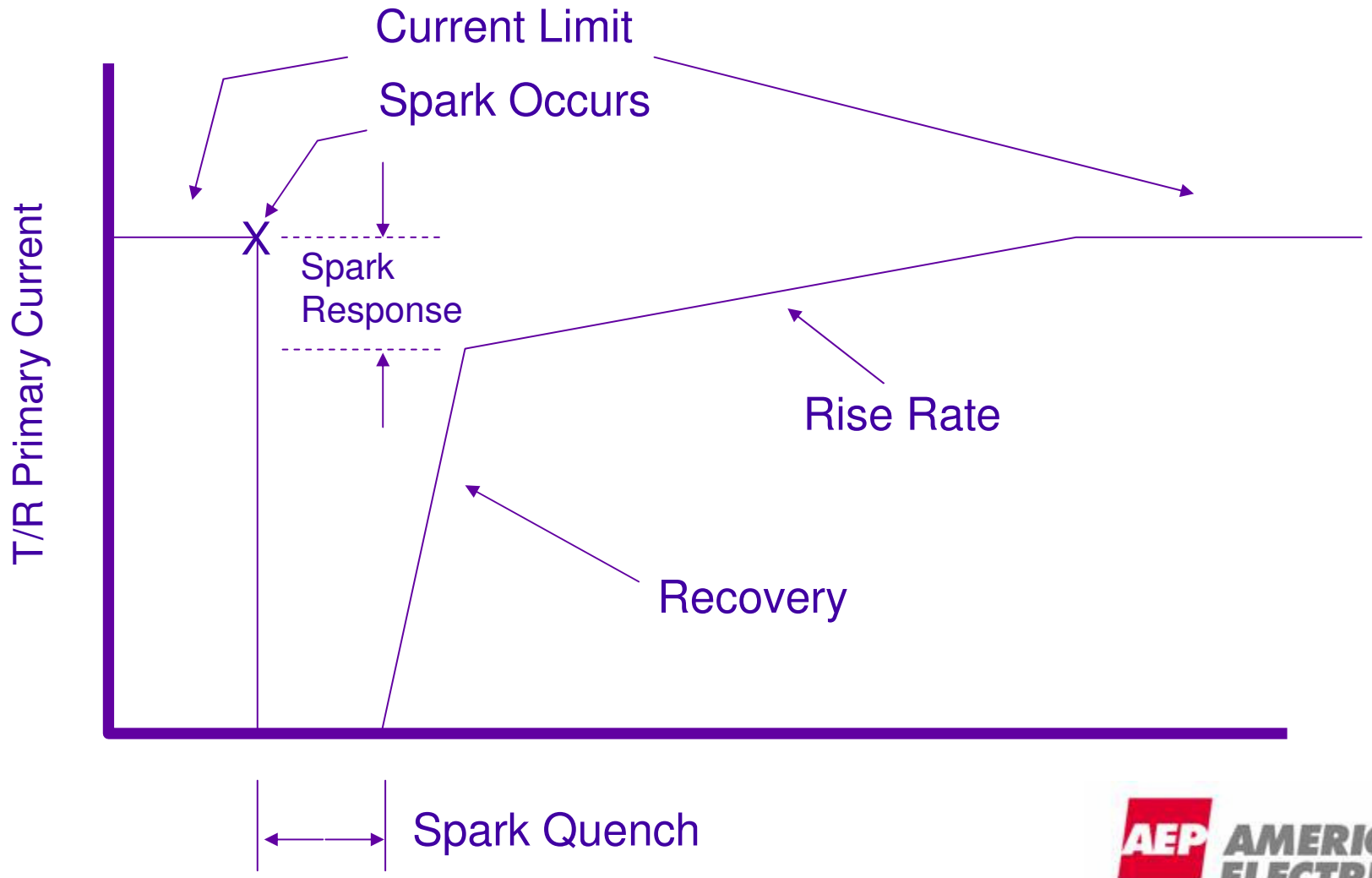
Control Operation



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Terms for Secondary Current

The terms used for a spark cycle are:

Steady state - operation prior to the spark (shown here as current limit)

Spark - a short circuit in side the ESP which disturbed the gases between the wire and plate.

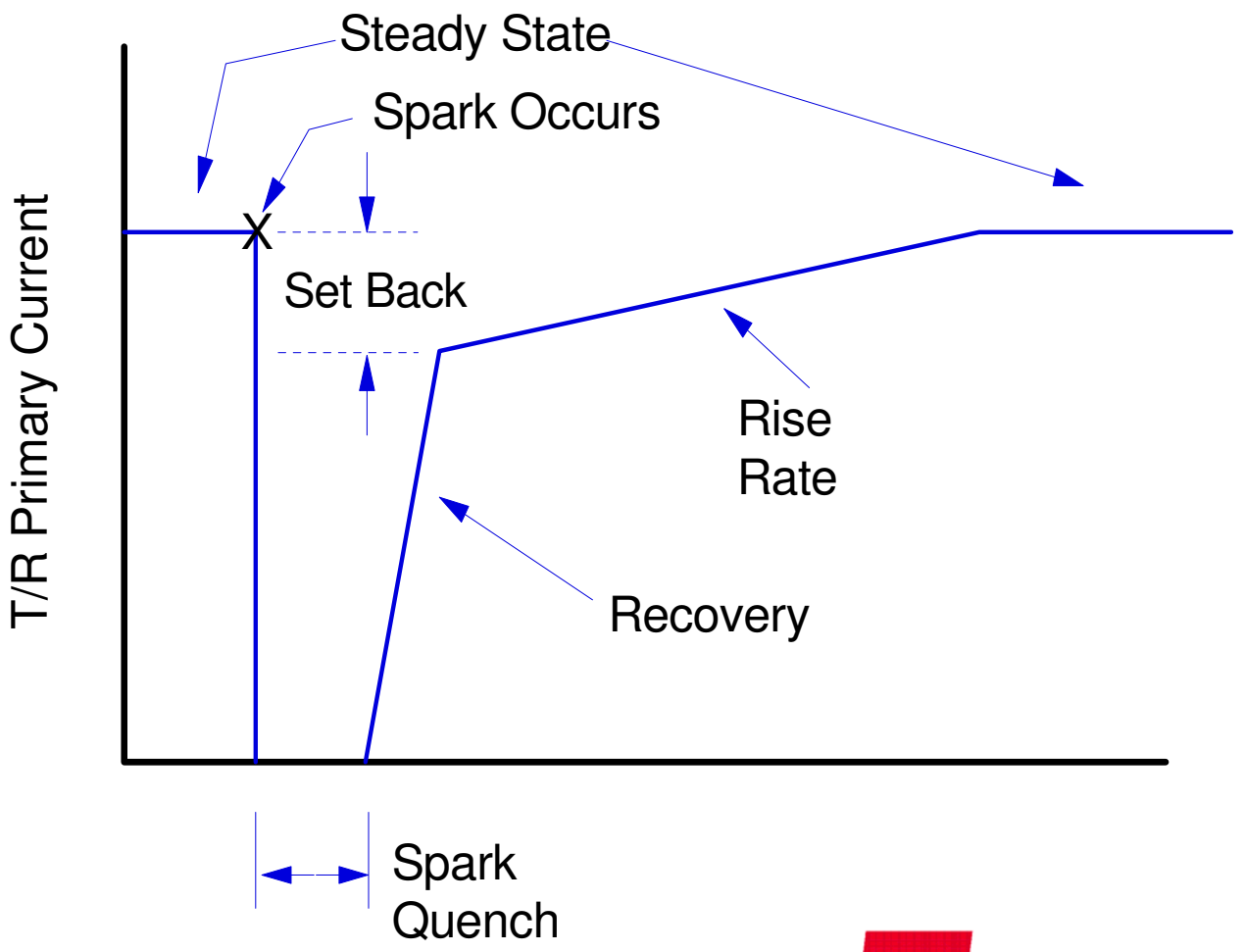
Quench - a period of off time which allows the disturbed gas to be dissipated. (Typically 2 cycles)

Recovery - a series of half cycles where the ESP returns quickly to near prespark conditions. (Typically 4 half cycles)

Set Back / Spark Response - the differential between steady state and recovery operating level. (Typically 3 to 10%)

Slow Ramp / Rise Rate - the period of time it take the control to return to prespark level. The angle is based on **set back** and **spark rate**. Spark rate should never be greater than 60 sparks/minute (typically 10-30 spm for inlet sets and 1-10 spm for outlet sets)

Fast Ramp - a feature on some new controls where the control ramps quickly to induce a spark if one has not occurred based on the preset spark rate. This allows for quicker recovery after an upset inside the ESP.



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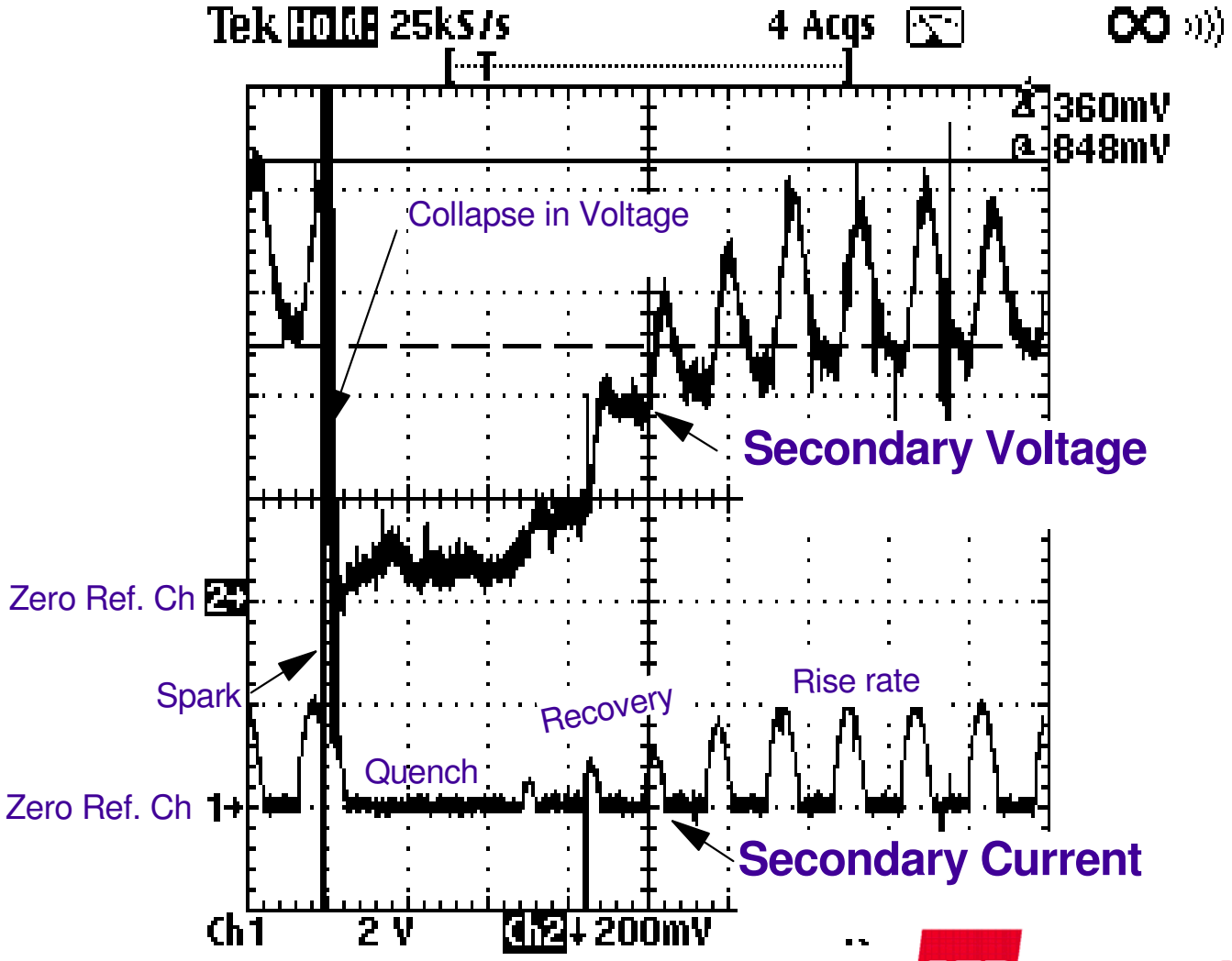
Typical Spark Response

The waveform is a typical trace of a spark response for both secondary voltage (top - shown inverted) and secondary current (bottom). Note the collapse of secondary voltage when the spark occurred. The control quenched and then quickly recovered to a level below the spark point.



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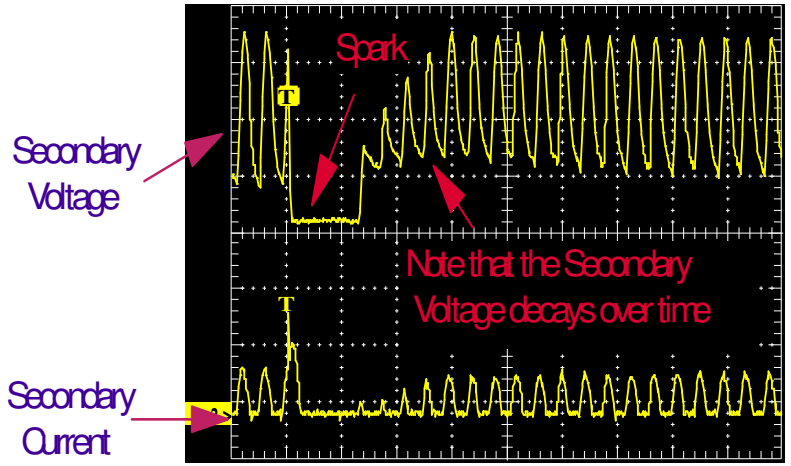
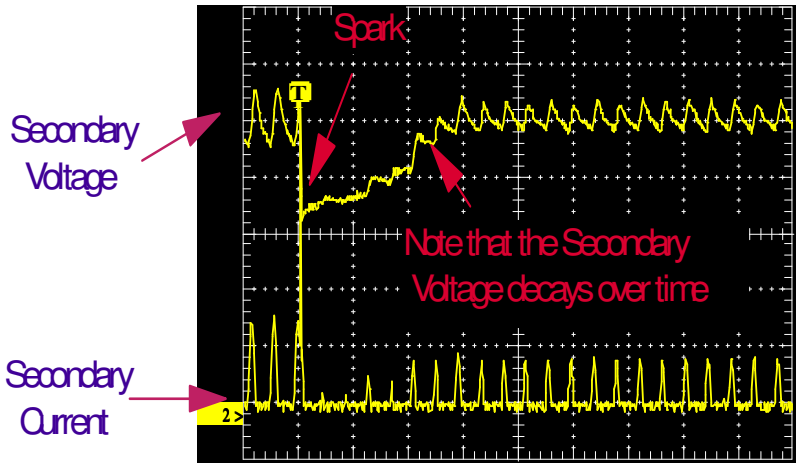
Scope Traces of Back Corona

The two scope traces shown here also have signs of back corona. The upper trace has the classic decay in the trough of the KV signal indicating back corona. However it has a second symptom which is a spread between the peaks and troughs as time progresses. Both of the symptoms of back corona noted here at easily noted.

The lower scope trace is a little more difficult to observe the back corona symptoms. If one only looks at the post spark portion of the waveform, it is difficult to note the back corona. However if the steady state condition before the spark is evaluated, it can be seen that the spread between the peak and troughs have increased over time as well as the decay in the toughs. Both are signs that this bus section is in the early stages of back





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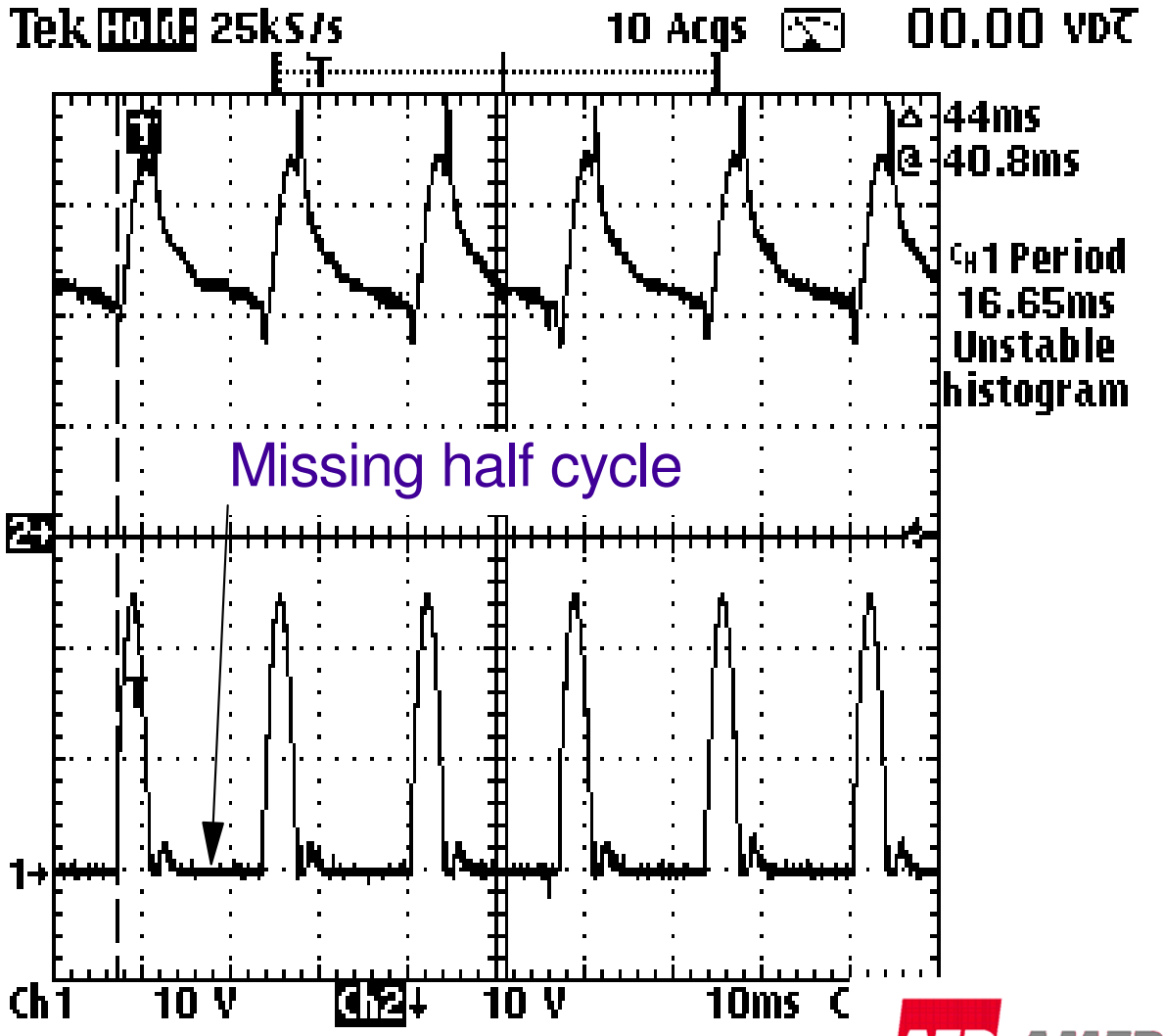
Secondary Signals w/only 1 SCR firing

The waveform is a trace of the secondary voltage and current. The significance of this trace is that the period of the half cycles is 16.67 mS. The period should be 8.33 mS. Since the secondary voltage signal corresponds to the current signal, one of the SCRs is not firing.



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Evaluating a troubled control

- All voltage - no current (open)
- No voltage - but current (short)
- Voltage and current come in together
- Periodic short
- Both current meters peg immediately
- No voltage - no current

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All voltage - no current

- Open T/R
- Open secondary
- Open primary (if no Secondary voltage)

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No voltage - but current

- Short in bus section
- Shorted T/R set secondary

Voltage and current come in together

- Ash Ground

Periodic short

- Broken Wire
- Swinging wire frame

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Both current meters peg immediately

- Shorted SCR
- Shorted T/R

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No voltage - no current (Control Problem)

- Bad Firing module
- Open fuse
- Main breaker open

Procedure for Isolating the Cause of a Grounded Console

A TR set console indicating a ground (all current and little or no voltage) can be result of problems other than conditions internal to the ESP. To isolate the cause of the ground, the following procedure should be followed.

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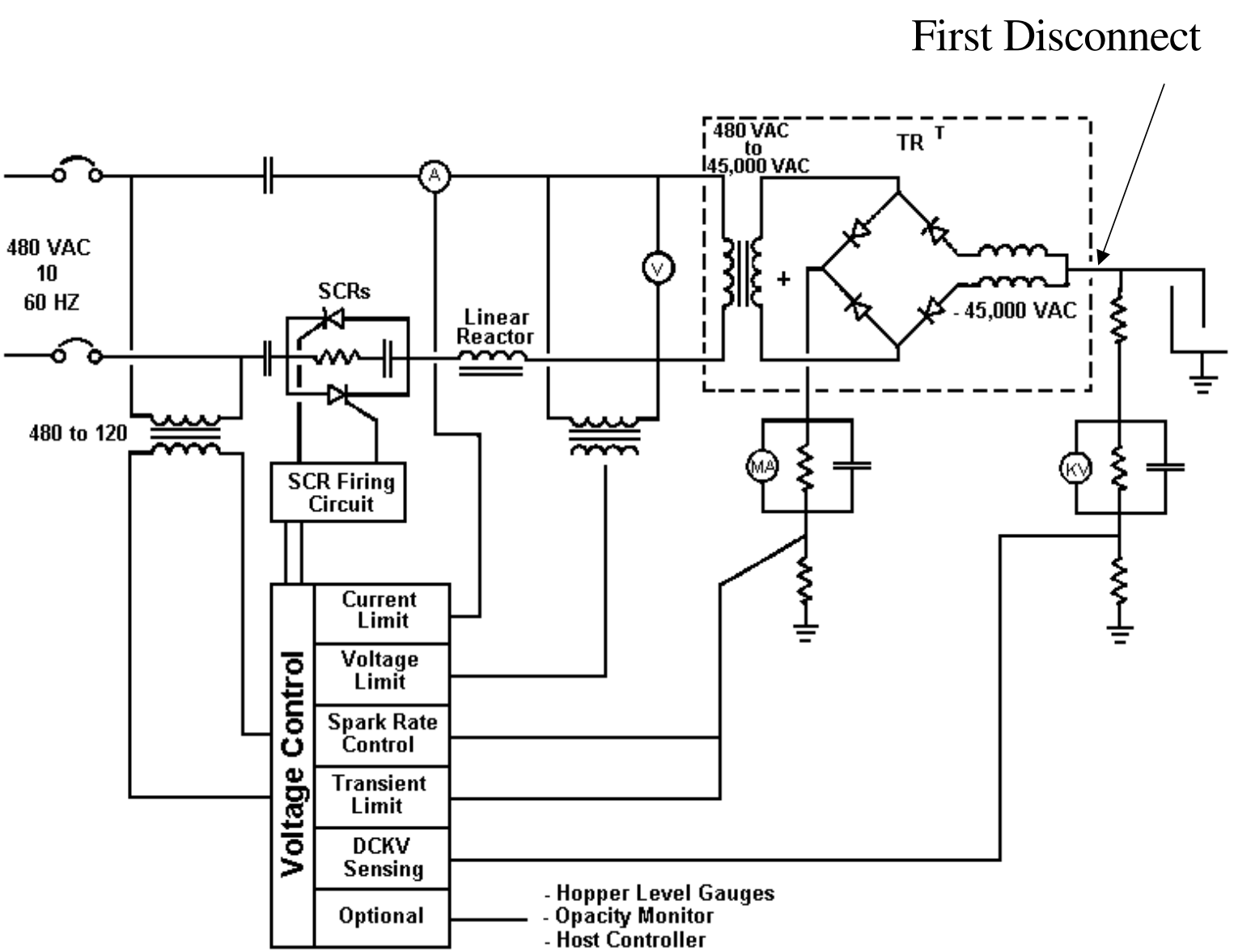
Step One



Disconnect the lead from the high voltage bushing of the TR set. This will open the secondary side of the TR set. In the case of TR set with internal ground switches this can be accomplished by placing the switch in the ground position with a master key. The ground switch open the TR set and ground the bus section lead inside the tank. See below sketch.

Power the control (only for a few second) to establish the electrical readings.

If the AC voltmeter begins to rise (but don't let it exceed 300V) with no current, then the problem is down stream of the where you disconnected.

If the current meters rise first, proceed to step two.

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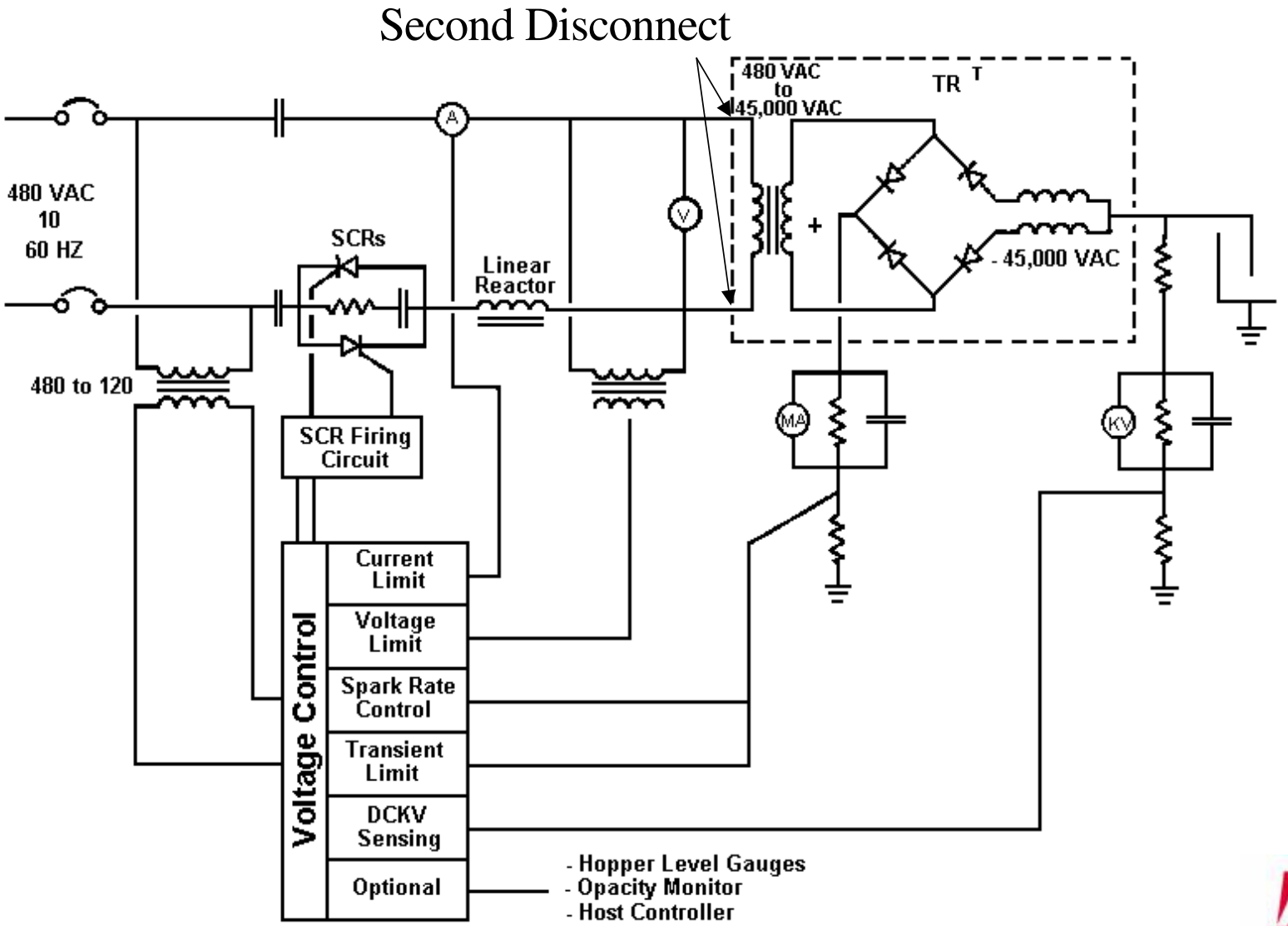
Step Two



Disconnect the two 480 or 600V leads in the low voltage terminal housing on the TR set. This will open the lead going to the TR set, thus taking the TR set out of the picture. See sketch below.

Power the control (only for a few second) to establish the electrical readings.

If the AC voltmeter begins to rise (but don't let it exceed 300V) with no current, then the problem is in the TR set. The fluid should be sampled. If clear then the problem inside the set should be located.

If the current meters rise first, proceed to step three.

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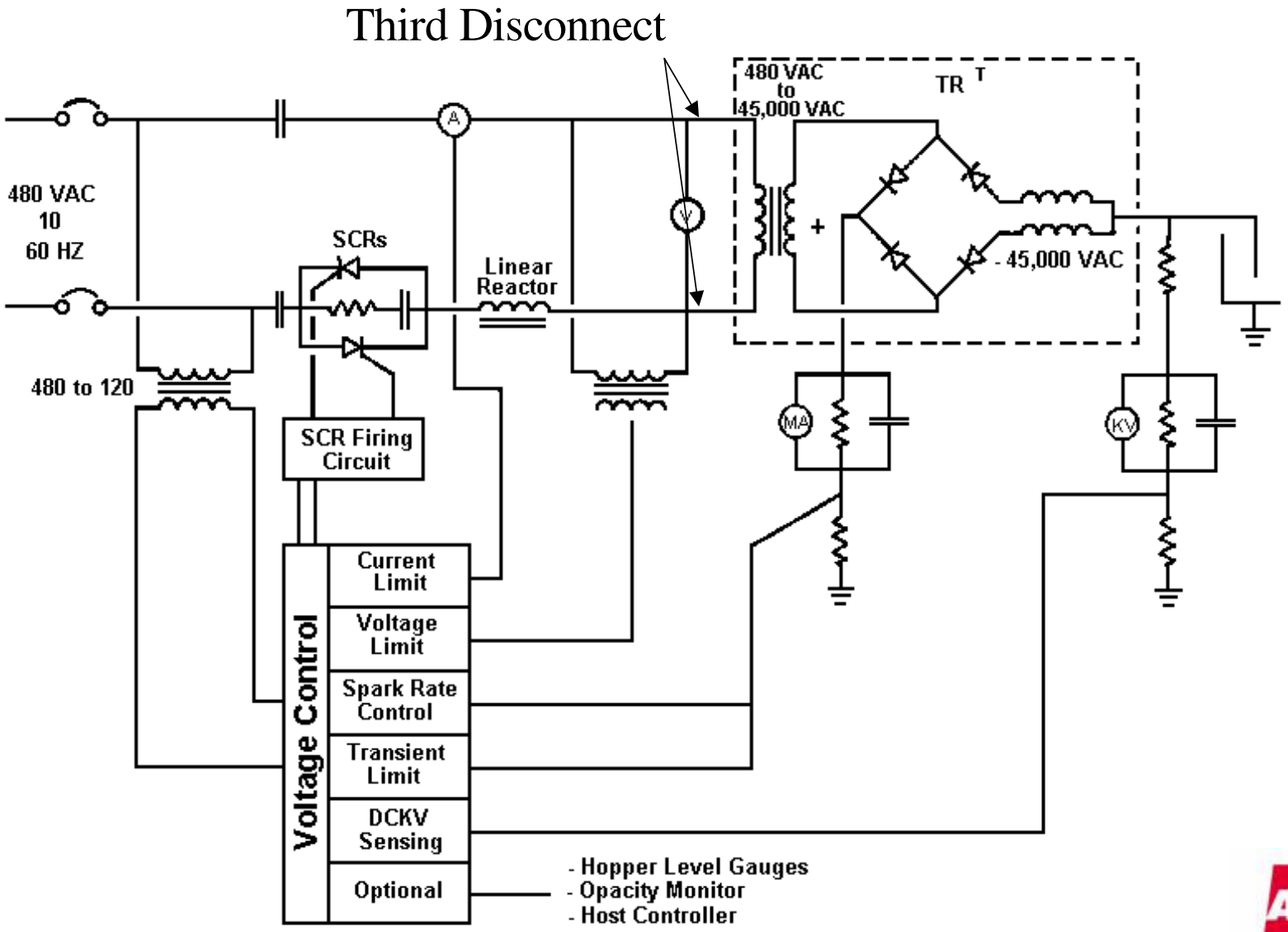
Step Three



Disconnect the two 480 or 600V leads in the TR set control console down stream of the linear reactor (CLR). This will take the TR set feed cables out of the picture. See sketch below.

Power the control (only for a few second) to establish the electrical readings.

If the AC voltmeter begins to rise (but don't let it exceed 300V) with no current, then the problem is in cables feeding the TR set.

If the current meters rise first, proceed to step four.

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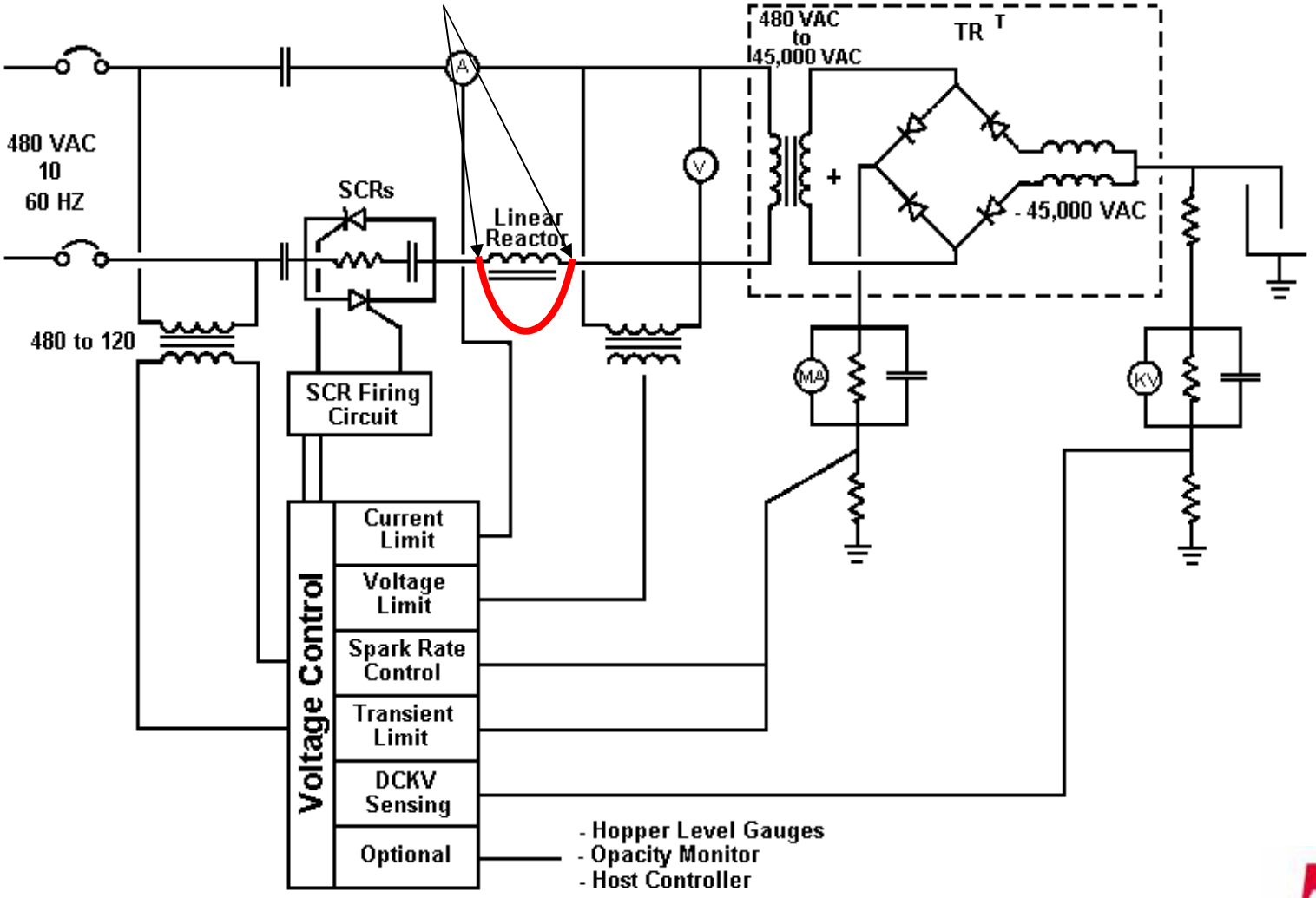
Step Four

Fourth Disconnect & Jumper



Disconnect the two 480 or 600V leads in the TR set control console up stream of the CLR. Connect the cable the its down stream partner or install a jumper if the two cable will not mate. This will take the CLR out of the picture. See sketch below .

Power the control (only for a few second) to establish the electrical readings.

If the AC voltmeter begins to rise (but don't let it exceed 300V) with no current, then the problem is in CLR.

If the current meters rise first, only the SCRs are left.

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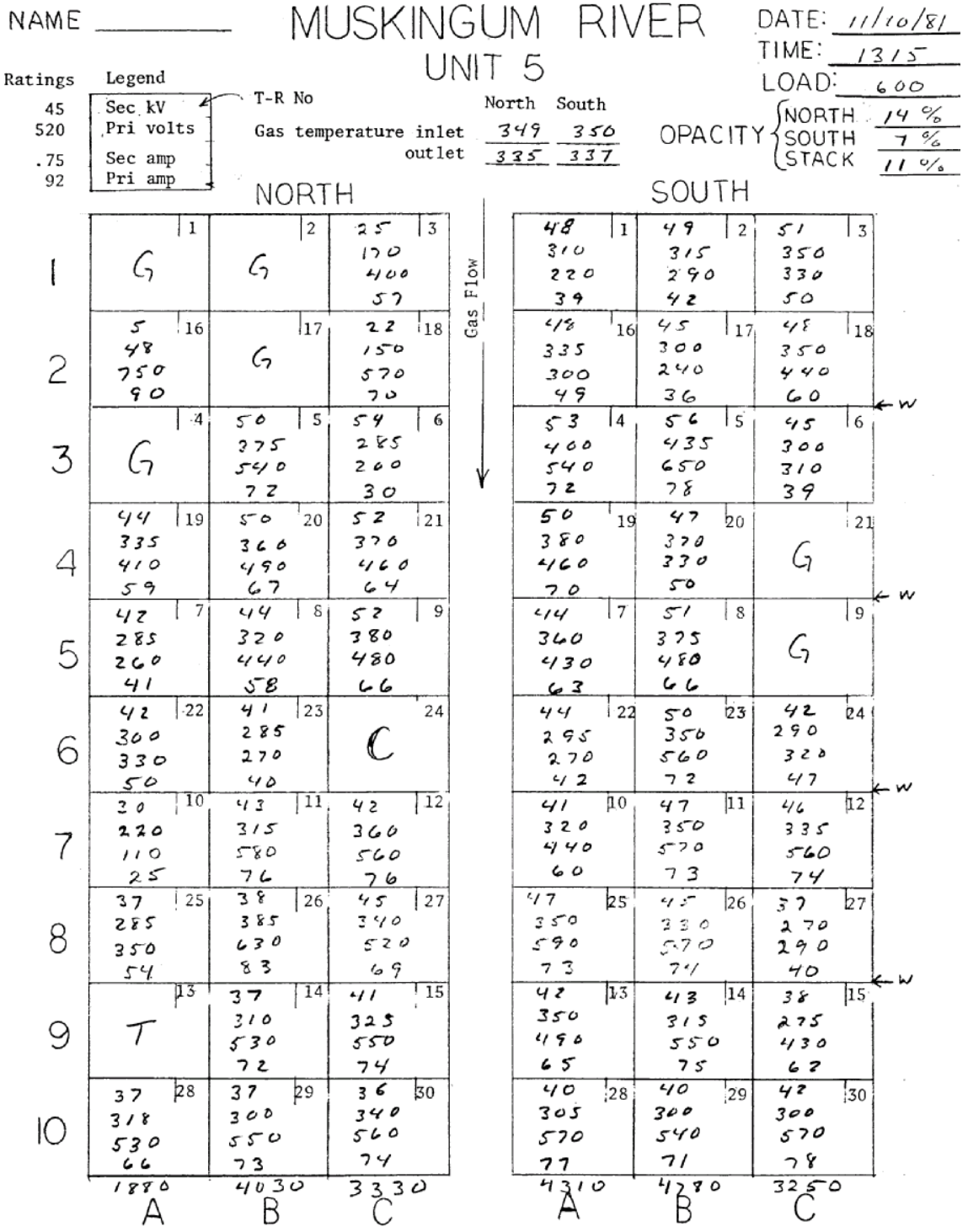
Locating the Problem

Evaluating Console Data

G - Ground
H - High hopper
T - TR Defective
C - Control Console
NR - Down Not Required
O - Other



Who, What, When, Where, How

Basic Questions to Ask the Plant When Suspected Problems Occur with Air Pollution Control Equipment

I. Background Information
- A. Where are you calling? (Plant and Unit)
- B. Why are you calling?
- C. Whom did you reach?
- D. What is their position?
- E. When did you call?

II. Generic Operating Information
- A. Load
- B. Curtailments
  1. Magnitude
  2. Start and end times
  3. Reason
- C. Opacity
- D. Total milliamps
- E. Averager KV
- F. Number of grounds/defective T/R sets
  1. Reason console(s) are O/S (control problem, defective T/R set, dead ground or close clearance)
  2. Locations (if several are O/S)
  3. Date consoles was removed from service
  4. Date grounds or close clearances were last cleared
- G. Exit gas temps.
  1. Economizer/air heater inlet
  2. Air heater exit
  3. ESP outlet
  4. Stack
- H. Coal
  1. Flow
  2. #/MKBTU
     a. Ash
     b. SO_2
     c. Moisture
  I. Outside Air Temp.

III. Systems
- A. Opacity
  1. Visual reading
  2. Monitor
     a. Local reading
     b. Remote reading
     c. Calibration
        i. Date of last calibration
        ii. Type of calibration (in-place or bench)
- B. Rappers
  1. Is ESP being power-off rapped
  2. Plate rappers
     a. Cycle time
     b. # of rappers O/S
     c. Location of O/S rappers
  3. Wire rappers
     a. Cycle time
     b. # of rappers O/S
     c. Location of O/S rappers
- C. Ash removal
  1. # of high hopper
  2. Branch line vacuums
     a. No-load
     b. Full load
  3. Bag filter differentials (if appl.)
- D. Purge air system
  1. # of fans I/S
  2. Air heaters I/S
- E. SO_3 injection system
  1. System leaks
  2. SO_2 Flow Stage temp.
  3. When was system place I/S after start-up
  4. Lance temps.
- F. Steam generator
  1. Feedwater flow
  2. Heater strings O/S
  3. # of pulverizers
     a. # I/S and location
     b. Any w/fineness problems
  4. % excess air
  5. # air heaters I/S
  6. Water loss/make-up rate (tube leak indication)
  7. Slagging indicators
     a. Attemperator flow
     b. Superheater profile
  8. Loading cycle of past several days
- G. Start-up
  1. ESP energization
     a. When
     b. How many fields?
  2. F. D. fan rolled
     a. When?
     b. Which fan?
  3. Oil fire
     a. Established when
     b. Which lighters?
  4. Coal fire
     a. Established when
     b. Which lighters?
  5. Opacity thru start-up
  6. Any unusual events

NOTE: REFER TO DRAWINGS WHEN EVER POSSIBLE!!!

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Trouble Shooting Guide
ESP OPERATION/CONTROL

Symptom	Probable Cause	Remedy
No primary voltage No primary current No precipitator current Vent fan on Alarm energized	Overload condition Misadjustment of current limit control Overdrive of SCR's	Check overload relay settings Check wiring components Check adjustment of current limit control setting Check signal from firing circuit module
No primary voltage No primary current No precipitator current Vent fan off Alarm energized	Relay panel fuse blown Circuit breaker tripped Loss of supply power	Replace reset circuit breaker Check supply to control unit
Control unit trips out on overcurrent when sparking occurs at high currents.	Circuit breaker defective or incorrectly sized Overload circuit incorrectly set Short circuit condition in primary	Check circuit breaker Reset overload circuit Check primary power wiring
High primary current No precipitator current	Transformer or rectifier short	Check transformer and rectifiers
No primary voltage No primary current No precipitator current Vent fan on Alarm no energized	SCR and/or diode failure No firing pulse from firing circuit and/or amplifier	Replace Check signal from firing circuit and/or amplifier
Same as above, even after replacing components or subpanels, changing wires, or repair	SCR's being fired out on phase	Reverse input wires
Low primary voltage High secondary current	High resisting short in secondary circuit or precipitator	Check precipitator for: Interior dust buildup, full hoppers, broken wires Foreign material on H.V. frame or wires Broken insulators
No primary voltage High primary & secondary current	Ground on secondary circuit on precipitator	Check wiring and components in H.V. circuit and pipe and guard Check precipitator for: Broken wires, ground switch left on, ground jumper left on

Trouble Shooting Guide
ESP OPERATION/CONTROL (con't)

Symptom	Probable Cause	Remedy
Primary current and secondary current normal, primary voltmeter drops from normal to zero and remains for a second then jumps back to normal, repeating this sequence rhythmically	Broken wire Swinging frame Tracking cracked insulator	Remove broken wire Check for broken anti-sway bushings Replace insulator
Abnormally low precipitator current and primary voltage with no sparking	Misadjustment of current and/or voltage limit controls Misadjustment of firing circuit control	Check settings of current and voltage limit controls. Turn to maximum (clockwise) and check setting of current and voltage limit controls.
Spark meter reads high -- off scale Low primary voltage and current No spark rate indication	Continuous conduction of spark counting circuit Spark counter counting 60 cycles peak AVC Failure	Deenergize, allow integrating capacitor to discharge, and reenergize. Readjust Replace
Spark meter reads high; primary voltage and current very unstable	Misadjustment of control circuit Loss of limiting control	Readjust Replace
Neither spark rate, current, nor voltage at maximum	Misadjustment of control circuit AVC failure Failure of signal circuits	Readjust setting Replace AVC Check signal circuits
No spark rate indication; voltmeter and ammeter unstable, indicating sparking.	Failure of spark meter Failure of integrating capacitor Spark counter sensitivity too low	Replace spark meter Replace capacitor Readjust
No response to current limit adjustment; however, does respond to other adjustments.	Controlling on spark rate or voltage limit AVC failure Current signal defective	None needed if unit is operating at maximum spark rate or voltage adjustment Reset voltage or spark rate if neither is at maximum Replace AVC Check signal circuit
No response to voltage limit adjustment; however, does respond to current adjustment	Controlling on current limit or spark rate Voltage signal defective AVC failure	None needed if unit is operating at maximum current or spark rate. Reset current and spark rate adjustment if neither is at maximum. Check voltage signal circuit Replace AVC
No response to spark rate adjustment; however, does respond to other adjustment	Controlling on voltage or current AVC failure	None needed if unit is operating at maximum voltage or current. Reset voltage and current adjustment if neither is at maximum. Replace AVC
Precipitator current low with respect to primary current. Low or no voltage across ground return resistors.	Surge arrestors shorted H.V. rectifiers failed H.V. transformer failed Ground or partial ground in the ground return circuit	Reset or replace surge arrestors Replace H.V. rectifiers Replace H.V. transformer Repair ground return circuit

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Getting Ready for the Outage

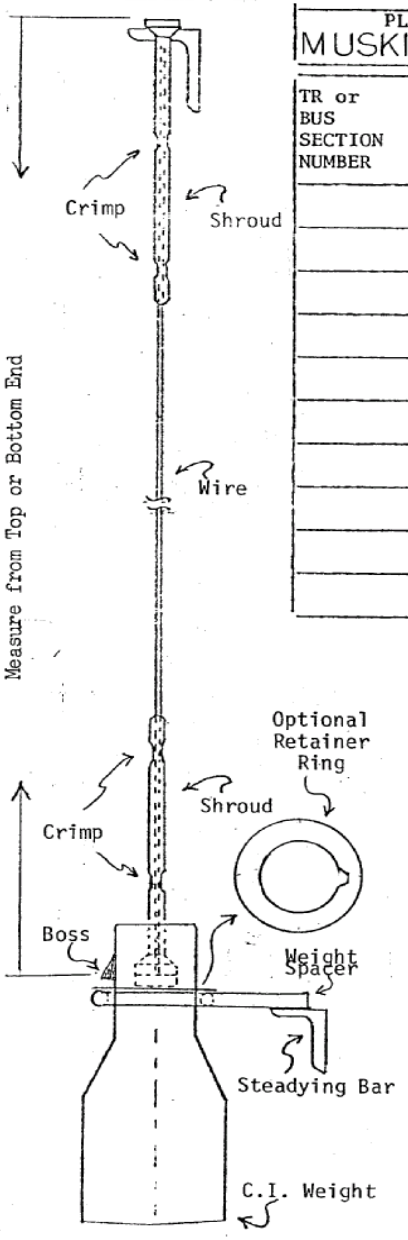
Corona Electrode Failure Report

CORONA ELECTRODE FAILURE REPORT FORM

(CIRCLE ONE) "NORTH" "SOUTH" 1/88 Rev.

PLANT - UNIT NO.	DATE:	DATA BY:
MUSKINGUM RIVER 5	/ /	

TR or BUS SECTION NUMBER	SYMPTOM		CAUSE OF GROUND	DESCRIPTION OF GROUND	GRID LOCATION		FAILURE LOCATION (see * below)
	DATE FOUND	TYPE			WIRE LETTER	LANE NO.	



SYMPTOM TYPES	
	A. Dead Ground - zero voltage, some current, no sparking.
	B. Intermittent Ground - large fluctuations of voltage and current, sparking.
	C. Low Power Operation - Steady state low voltage, sparking.

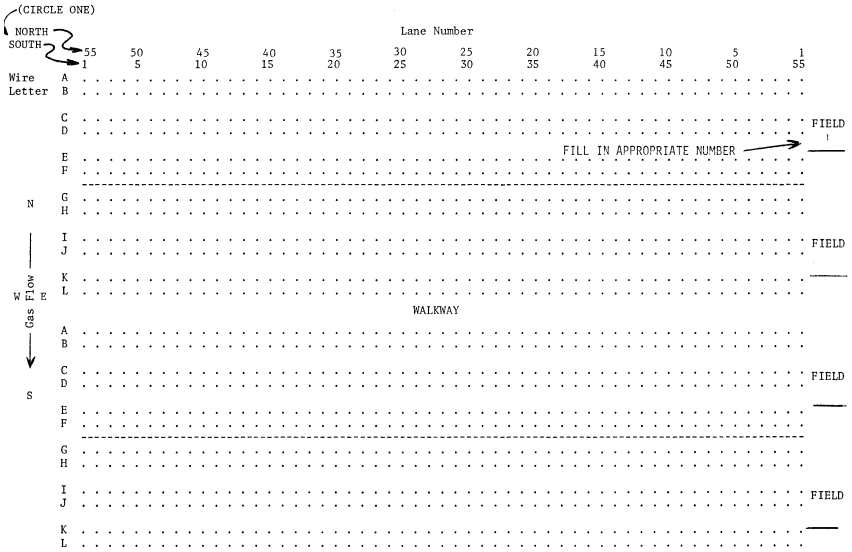
CAUSE OF GROUND	DESCRIPTION OF GROUND
A. Failed corona electrode (wire) touching ground	a1. Penciled break, wire surface away from break smooth (spark erosion). a2. Flat cross-sectional break, wire away from break smooth (mech. fatigue). a3. Reduced and/or pitted cross section, wire surface away from break rough (corrosion). a4. Shroud worn through support angle. a5. Wire pulled out of top shroud. a6. Wire pulled out of bottom shroud. a7. Wire from another bus section.
B. Close clearance or contact between high voltage system and ground	b1. Shifted collecting plate(s) b2. Weight out of guide. b3. Untensioned wire-weight missing. b4. Kinked wire. b5. Bowed collecting plates. b6. Shifted high voltage system.
C. Ash bridge between high voltage system and ground	c1. High hopper flyash level. c2. Clinker between wire and plate. c3. Clinker between shroud and plate. c4. Contaminated or failed bushing or insulator.

*Reference break to closest shroud as shown in Figure. Indicate with a "T" (top) or "B" (bottom) from which shroud measurement was taken, i.e., 15" B.

CORONA ELECTRODE LOCATION CHART

MUSKINGUM RIVER 5

ONE BUS WIDE



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Rappers

- Monthly rapper checks
- Evaluating a troubled control

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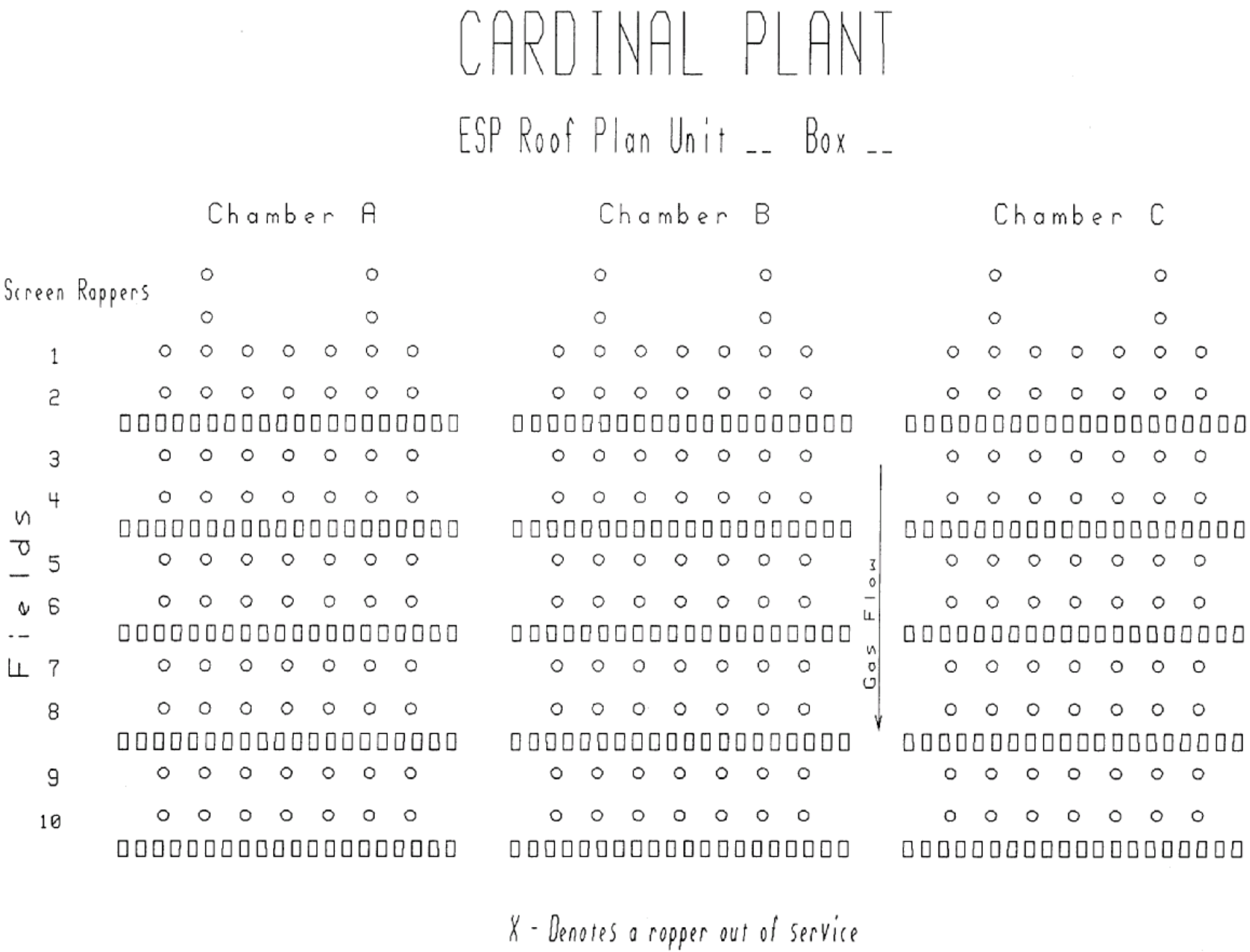
Monthly Rapper Check



Trouble Shooting Guide
RAPPER CONTROLS

Symptom	Probable Cause	Remedy
Circuit breaker trips	Short circuit or component failure in control circuit or power transformer.	Check wiring and component
Fuses blown, indicator light not flashing	Control circuit failure, rapper coil failure, distributor switch firing two coils at once.	Replace defective component, replace coil, repair or realign distributor switch
Indicator light not flashing, no fuse failure	Control circuit not operating effectively, no rotation of distributor switch	Repair or replace component, check motor and drive train
No manual intensity control	Failed potentiometer, faulty intensity control module Vibrators and controls	Replace potentiometer, replace intensity control module
Vibrator inoperative	Vibrator coil open circuited, vibrator improperly adjusted	Replace coil, adjust vibrator
Abnormal ammeter reading	Vibrator improperly adjusted, vibrator coil short circuited	Adjust vibrator, replace coil
Line breaker trips	Short circuit in control wiring	Check circuit

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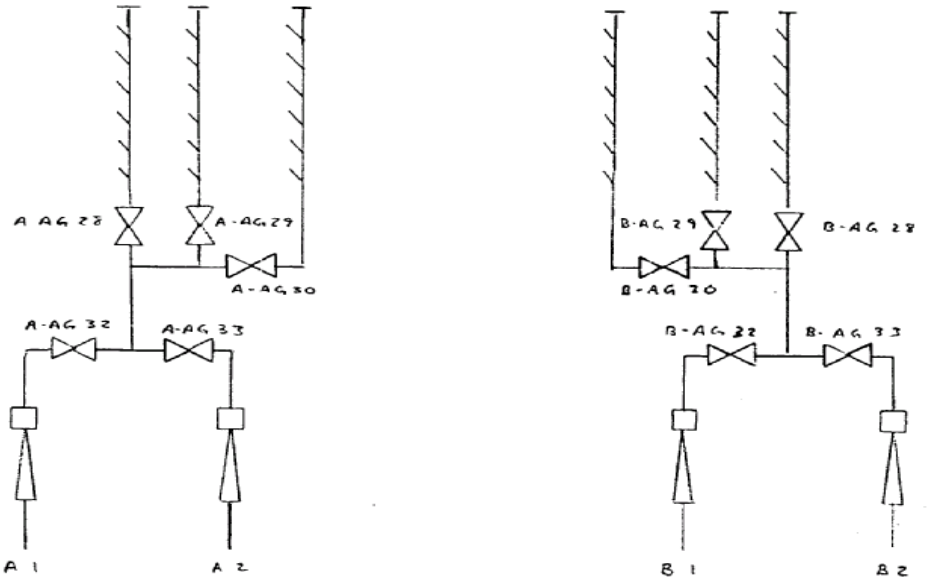
Fly Ash System

CARDINAL PLANT
UNIT _____
FLY ASH SYSTEM CHECK SHEET

DATE: _____ DATA BY _____



PROCEDURE STARTS WITH ALL AG GATES CLOSED. THIS WILL ESTABLISH THE CAPABILITY OF THE HYDROVEYOR.

BOX A	SYSTEM 1/2	A1 OR A2
SET - UP	LOCAL	REMOTE
ALL AG GATES CLOSED		
OPEN AG 32 OR 33 DEPENDING ON SYS 1/2		
OPEN AG 28 PLUG END OF LINE		
CLOSE AG 28 OPEN AG 29 PLUG END OF LINE		
CLOSE AG 29 OPEN AG 30 PLUG END OF LINE		
RETURN SYSTEM TO NORMAL OPERATION		

COMMENTS:

BOX B	SYSTEM 1/2	B1 OR B2
SET - UP	LOCAL	REMOTE
ALL AG GATES CLOSED		
OPEN AG 32 OR 33 DEPENDING ON SYS 1/2		
OPEN AG 28 PLUG END OF LINE		
CLOSE AG 28 OPEN AG 29 PLUG END OF LINE		
CLOSE AG 29 OPEN AG 30 PLUG END OF LINE		
RETURN SYSTEM TO NORMAL OPERATION		

COMMENTS:

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