RECENT DEVELOPMENTS IN IMPROVING RELIABILITY AND AVAILABILITY OF REMP AIR SAMPLING SYSTEMS

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REMP AIR SAMPLING SYSTEM TECHNOLOGY

- Historically – Analog Systems
  Requires significant human intervention

- Post 1990's – Introduction of automated systems with digital electronics
  Provides significant automation
  - — Automatic volume totalization
  - — Accurate measurement of elapsed sample time
  - — Auto shut off capability
  - — Digital display
  - — Normalization of flow rates and volumes to an internationally recognized reference standard

TYPICAL REMP SYSTEM HARDWARE CHARACTERISTICS

Analog:

- 1/4 or 1/3 H.P. Carbon Vane Pump
- Rotameter
- Elapsed time meter (optional accessory)

Digital:

- 1/4 or 1/3 H.P. Carbon Vane Pump
- Microprocessor-controlled electronic module
- Multiple sensors
- RS232 Communications port

IMPACTS UNIQUE TO DIGITAL UNITS

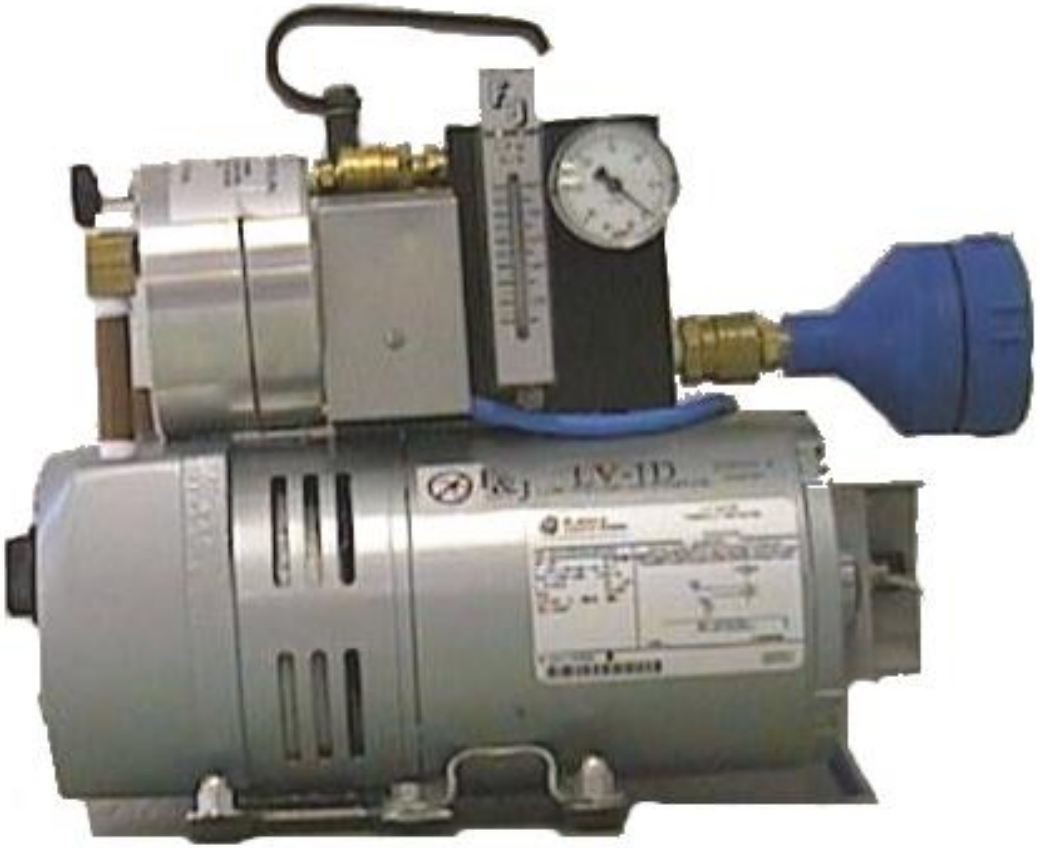
- Low Voltage or Brown Out Conditions
  — Power line voltages at remote locations can drop to less than 90 VAC

- Power line surges (transients)
  — Brief over voltages or disturbances on a power waveform

BASE LINE TESTING FOR LOW VOLTAGE TOLERANCE

- Use standard analog REMP air sampler for baseline data
- Lower the input voltage to the air sampler in steps until air sampler ceases to operate
- Observe flow rate as the input voltage is reduced

TYPICAL ANALOG REMP STYLE AIR SAMPLER



ANALOG AIR SAMPLER LOW VOLTAGE TOLERANCE TEST

Table I

Variac Output Voltage	Pre-Operational Inlet Voltage	Instantaneous Start Up Voltage	Stable Steady State Voltage
124.6	124.6	117.9	122.5
120.0	120.0	114.7	118.2
115.0	115.0	109.1	113.5
110.2	110.2	103.6	108/.1
105.7	105.0	100.7	102.8
100.0	100.0	94.3	98.8
95.1	95.1	87.8	93.3
90.0	90.0	81.9	88.2
85.3	85.3	77.0	82.5
80.4	80.4	72.2	78.3
75.0	75.0	68.1	72.6
70.1	70.1	62.7	67.0
65.3*	65.3	—	—

* Air Sampler would not operate

RESULTS OF LOW VOLTAGE TESTING ANALOG AIR SAMPLER

- Large inrush current upon startup
- ~40 – 42 amps for ~100 milliseconds
- Voltage shut off value - ~70VAC

DIGITAL REMP AIR SAMPLER TESTING

- The same procedure was utilized with original design of F&J digital low volume air sampler.

LOW VOLTAGE IMPACTS ON AN F&J DIGITAL AIR SAMPLER (ORIGINAL DESIGN) TABLE II

Variac Output Voltage	Pre-Operational Inlet Voltage	Instantaneous Start Up Voltage	Stable Steady State Voltage
124.3	124.3	117.9	122.4
120.0	120.0	113.2	118.3
115.0	115.0	107.1	113.1
110.1	110.1	103.4	107.6
105.0 [a]	105.0	99.9	—
100.0 [b]	100.0	—	—

Display turns off below 75 VAC
(a)Vacuum pump cycles on and off
(b)Vacuum pump does not start

RESULTS OF LOW VOLTAGE TESTING DIGITAL AIR SAMPLER (ORIGINAL DESIGN)

- The voltage at which air sampler ceased operating was ~105 VAC.
- Elapsed sample time and accumulated sample volume was saved in memory.
- Upon return of power, the elapsed time and accumulated sample volume commenced with the saved values.

OTHER FIELD OBSERVATIONS

Issue:

Multiple voltage transients in a short period of time resulted in a failure of the microprocessor to restart the pump motor.

Solution:

Software modification was made to the firmware to overcome the problem of multiple short term low voltage transients.

SOLUTIONS TO DEFICIENCY IN PERFORMANCE

Solution to Low Voltage (Brownout) Issues

- Redesign of the system electronics to enable operation of the digital air sampler to the same low voltage value as the analog air sampler.

- Implement wide voltage range electronic components in the design.

LOW VOLTAGE IMPACTS ON AN F&J DIGITAL AIR SAMPLER (NEW ELECTRONIC DESIGN)

Variac Output Voltage	Pre-Operational Inlet Voltage	Instantaneous Start Up Voltage	Stable Steady State on Voltage
124.4	124.0	117.0	122.4
120.0	120.0	117.7	118.2
115.3	115.4	108.0	114.4
109.8	109.7	101.0	107.7
100.2	100.2	91.1	97.4
95.2	95.2	86.0	93.3
90.0	90.0	81.1	88.3
85.0	85.0	77.0	83.0
80.4	80.4	71.5	78.3
75.2	75.2	69.0	73.3
70.3	70.3	62.0	67.9
* 65.0	65.0	57.0	—
23.0 [a]	—	—	—
34.0 [b]	—	—	—

* Pump cycles on and off
(a)Loss of digital display
(b)Return of digital display

RESULTS OF LOW VOLTAGE TESTING DIGITAL AIR SAMPLER (NEW ELECTRONIC DESIGN)

- The digital air sampler with the new wide voltage range electronic design operated down to ~70 VAC as did the analog air sampler.

- Elapsed time and accumulated sample volume data were saved in memory.

- Upon return of power, the saved parameters commenced with the saved values.

Surge Protection Basics

And SPD Utilization with
REMP Air Samplers

Sources of Electrical Surges

- Lightning
  - environmental causations
- Power system switching (switching surges)
  - system or component causations

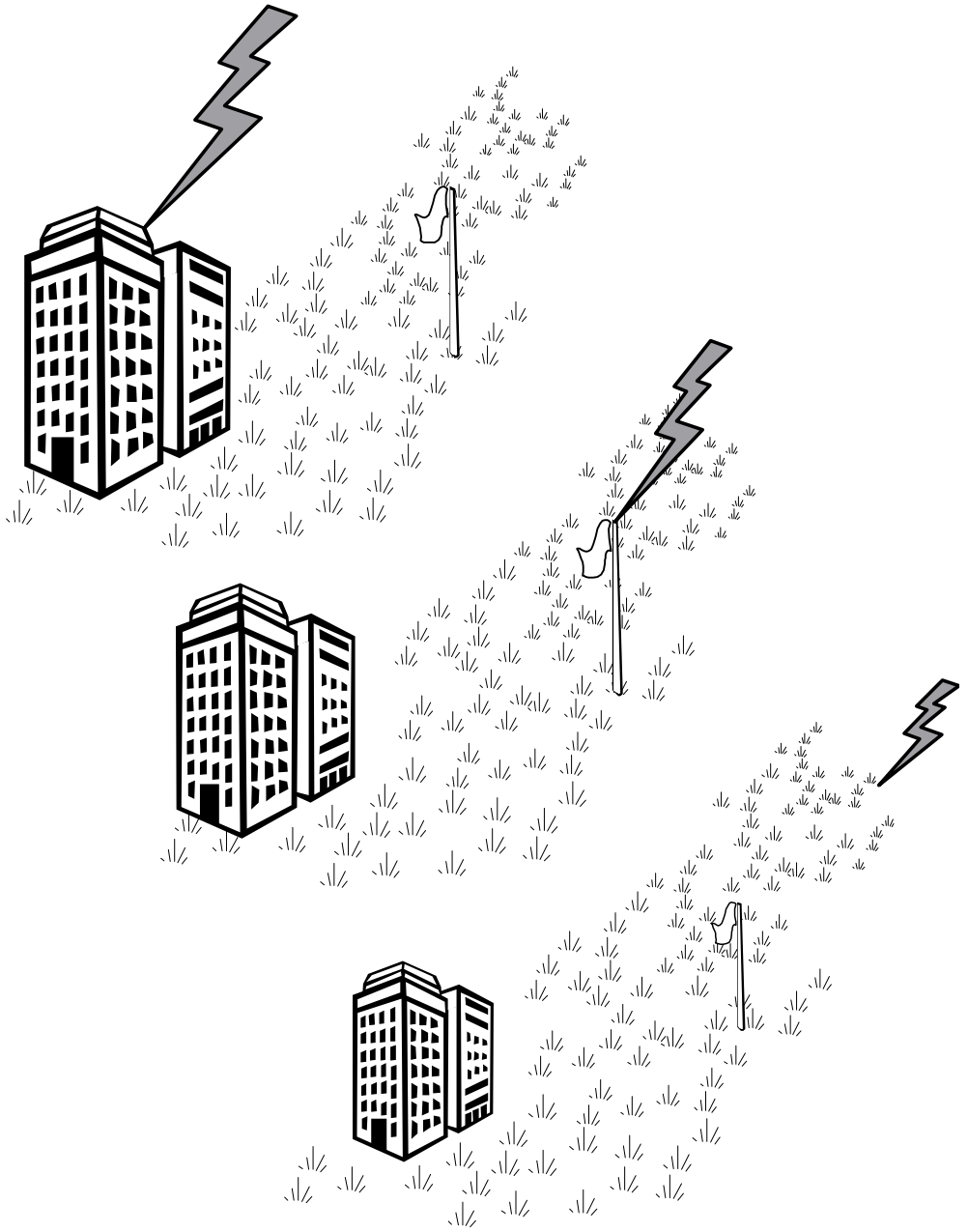
Lightning

- Physical, recognizable
- Most often associated with surges
- Effects can be prominent and devastating

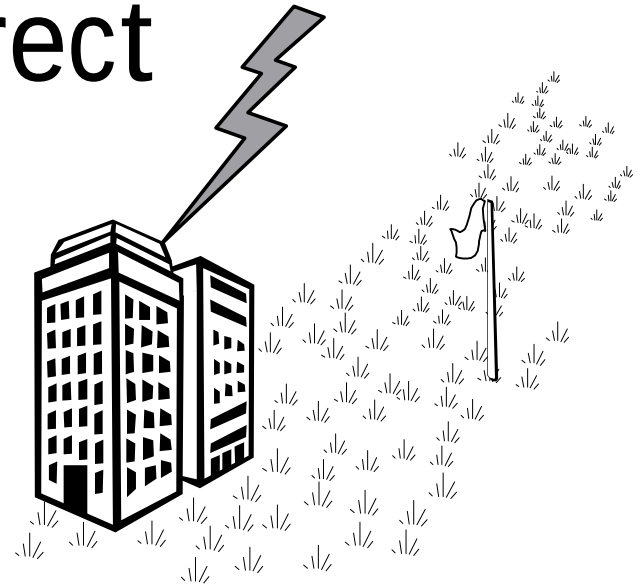
- Occurs much less frequently than switching surges

Lightning

- Direct strike
- Near strike
- Far strike



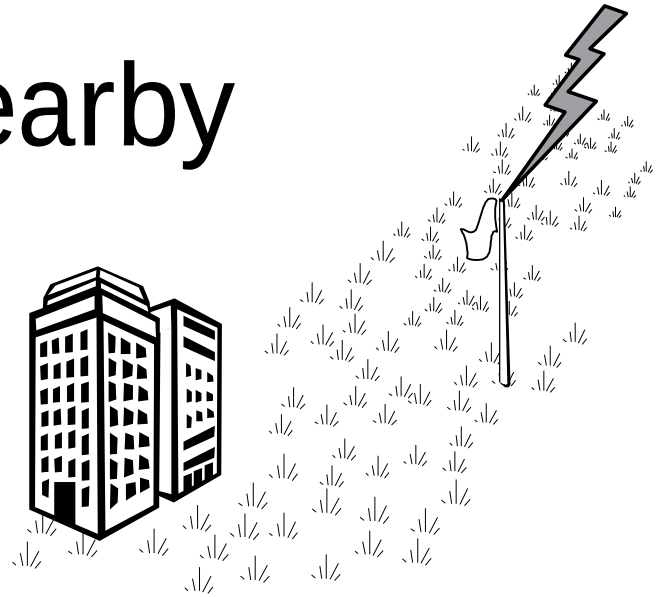
Lightning - Direct



- Most severe, high stress
- Immediately damaging to unprotected electronic components and electrical systems
- Mechanical failure
- Thermal overstress
- Permanent damage
- Intervention required (repairs)
- Involves near-by systems
- Multi-service interaction (communication systems, control circuits, etc.)

Lightning – Nearby

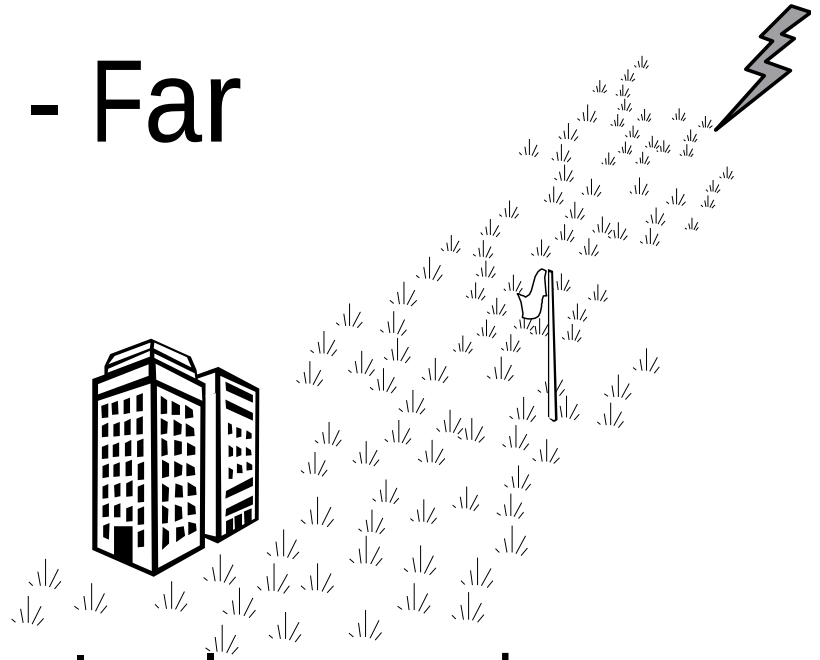
- A fraction of current from a direct strike due to coupling
- Medium to moderate stress
- Typically damaging to unprotected electronic components
- Possibly damaging to electrical systems



- Involves near-by systems
- Multi-service interaction (communication systems, control circuits, etc.)

Lightning - Far

- Less induced voltage and current
- Lesser stress than near or direct
- Typically upsetting to unprotected electronic components
- Repeated events can cause deterioration



- Involves near-by systems
- Multi-service interaction (communication systems, control circuits, etc.)

Switching Surges

- Less notable (not visible)
- Not always immediately recognized as being damaging or disruptive
- Occur as part of everyday intended operations
- Occur as part of abnormal or unintentional operations or conditions

Switching Surges

- Sources from Normal or Intentional Operations
  - Contactors, relays or breakers
  - Switching of capacitor banks
  - Stored energy systems
  - Discharge of inductive devices
  - Starting and stopping of loads
  - Fault or arc initiation

Switching Surges

- Sources from Abnormal or Unintentional Operations
  - Arcing faults or arcing ground faults
  - Fault clearing
  - Power system recovery
  - Loose connections
  - Lightning induced oscillatory surges

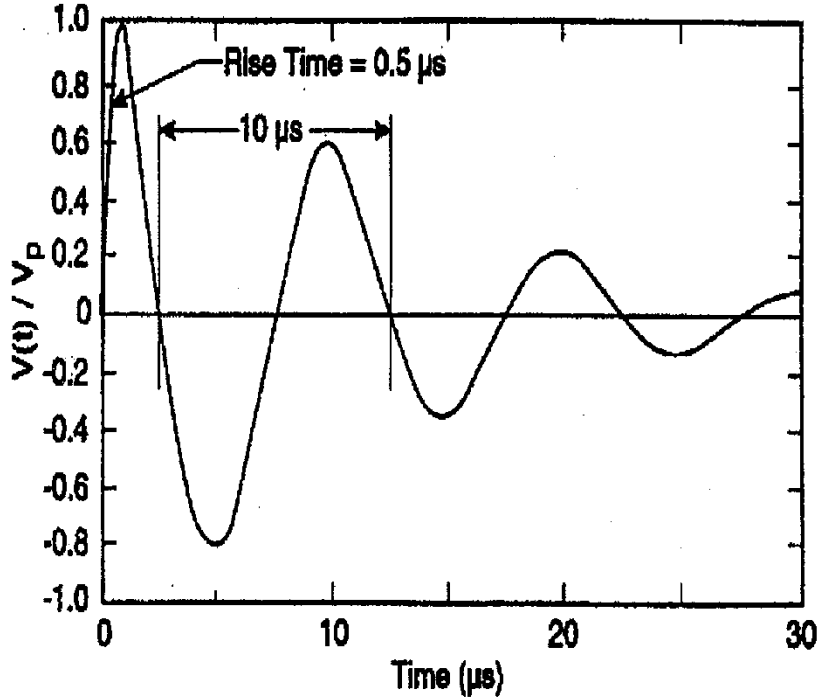
Switching Surges

- Frequency 350 Hz to 1000 kHz
- Often represented by 100 kHz
- Amplitudes typically range from a 2-3 times the operating voltage to 6,000 volts or higher
- Occur regularly and frequently – in some cases multiple times per cycle

Surge Testing, Waveforms and Amplitudes

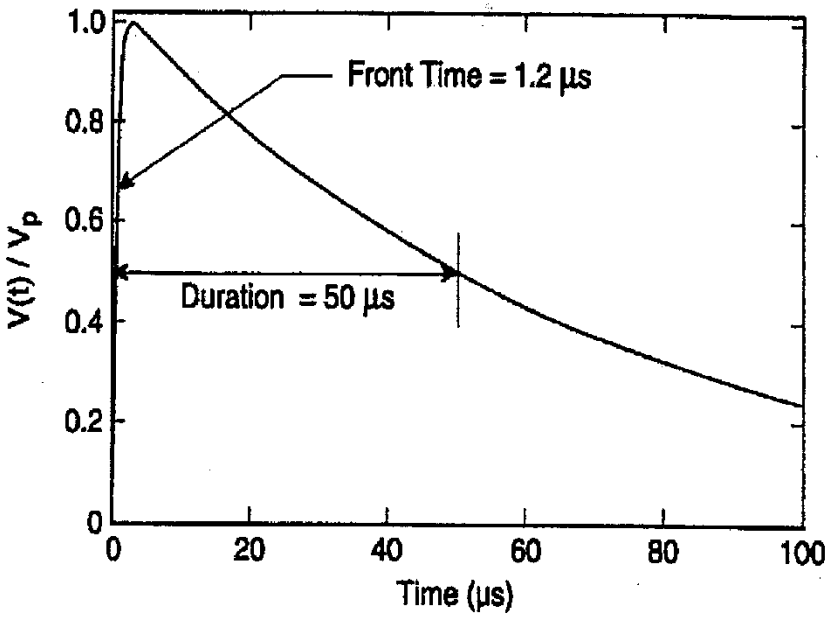
- IEEE Std C62.41.2™-2002
  - *IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and less) AC Power Circuits*
- IEEE Std C62.45™-2002
  - *IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000 V and Less) AC Power Circuits*
- IEEE Std C62.62™-2010
  - *IEEE Standard Test Specifications for Surge-Protective Devices (SPDs) for Use on the Load Side of the Service Equipment in Low-Voltage (1000 V and Less) AC Power Circuits*
- IEEE Std C62.72™-2007
  - *IEEE Guide for the Application of Surge-Protective Devices for Low-Voltage (1000 V or Less) AC Power Circuits*

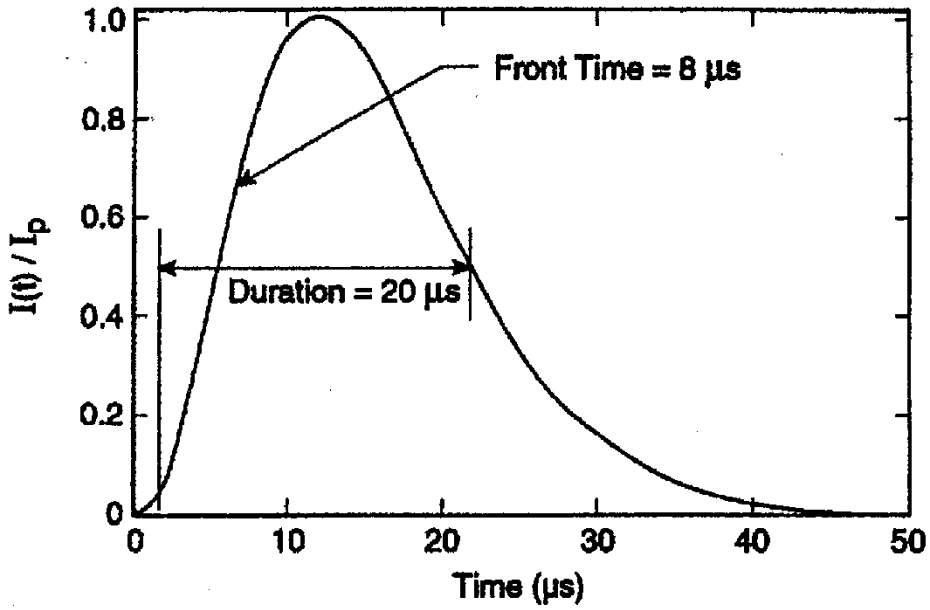
Switching Surges – Ringing/Oscillatory Transients



Represented by a voltage waveform

Lightning Surges – Impulse Transients





Represented by a combination of voltage and current waveforms (combination wave)

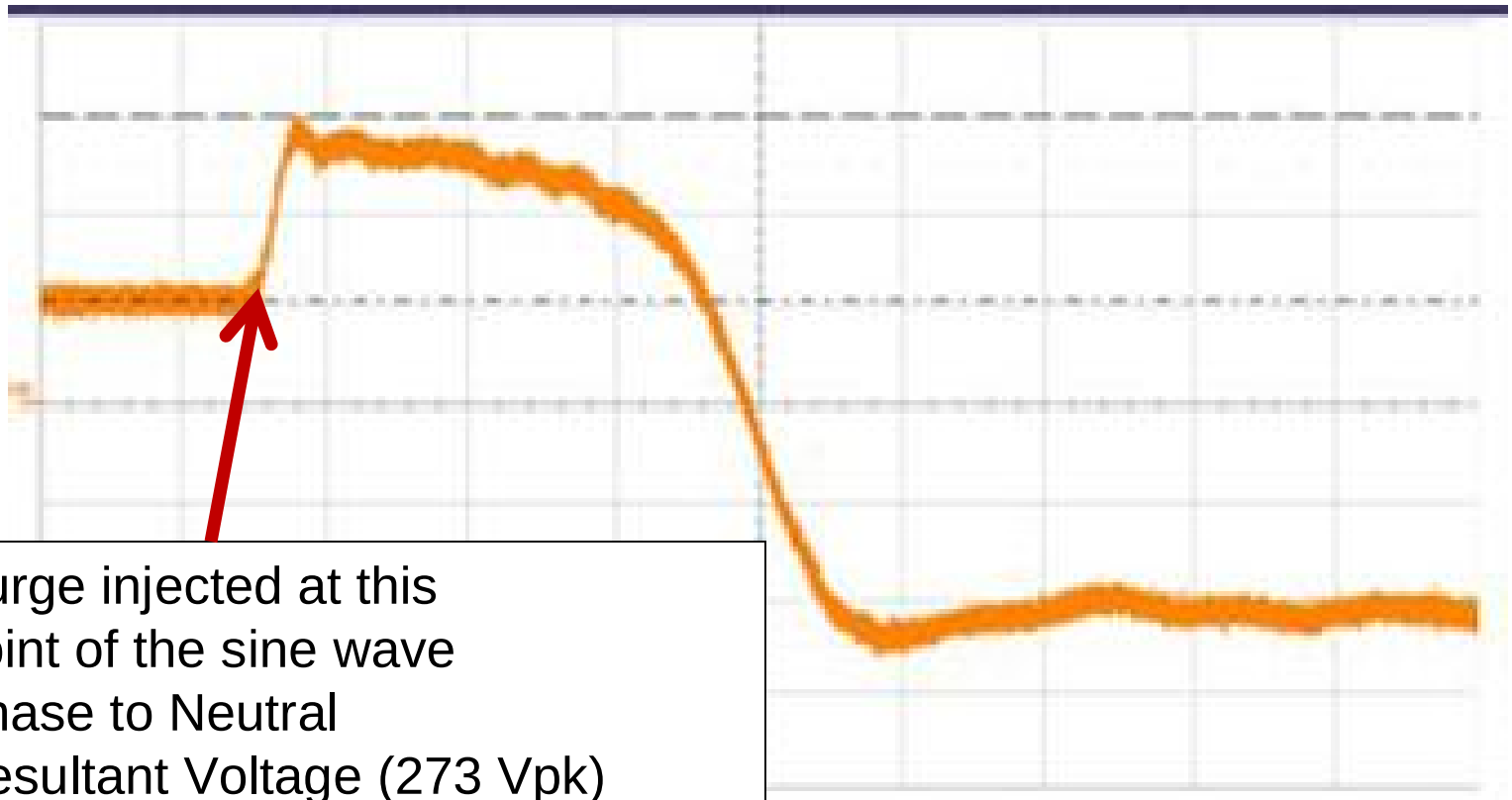
Amplitudes

Category C Location			
Exposure Level	**Waveform**	**Voltage**	**Current**
High	8/20 us Current	10 kV (minimum)	10 kA (driven through the SPD)
Low	Combination Wave	6 kV (open circuit voltage)	3 kA (short circuit current)
Category B Location			
High	Combination Wave	6 kV (open circuit voltage)	3 kA (short circuit current)
Low	100 kHz Ring Wave	6 kV (open circuit voltage)	0.5 kA (short circuit current)
Category A Location			
Low	Combination Wave	6 kV (open circuit voltage)	0.5 kA (short circuit current)
Low	100 kHz Ring Wave	6 kV (open circuit voltage)	0.2 kA (short circuit current)

Laboratory Testing of SPDs used with REMP Air Samplers

Measured Limiting Voltage Performance of Surge Suppression Incorporated SPDs Connected to REMP Air Samplers			
Mode	Nominal System Voltage	Tested per IEEE Std. C62.41.2™-2002, IEEE Std. C62.45™-2002 and IEEE Std. C62.62™-2010	
		Location Category A 100 kHz Ring Wave	**Location Category B/C Combination Wave Generator**
		Result from **2,000 V** surge amplitude applied to the input	Result from **6,000 V / 3,000 A** surge amplitude applied to the input
Phase to Neutral	120 V_{rms}	**15 V_{pk}**	**273 V_{pk}**
Phase to Ground	120 V_{rms}	**42 V_{pk}**	**289 V_{pk}**
Neutral to Ground	0 V_{rms}	**27 V_{pk}**	**434 V_{pk}**

Laboratory Testing of SPDs used with REMP Air Samplers



Surge injected at this
point of the sine wave
Phase to Neutral
Resultant Voltage (273 Vpk)
140 volts/div (peak volts vs. time)

Laboratory Testing of SPDs used with REMP Air Samplers

Conclusions

- The testing and data reported in this paper shows the improvement in the recently developed digital REMP air samplers with respect to low voltage conditions.
- Further, the achievement of greater reliability of the air samplers was shown when used in combination with a well performing Surge Protective Device.

Thank you!

Questions?