CHAR SYSTEM
OPERATION & TRAINING

Module 4
Insulation Resistance Measurement

LEARNING OBJECTIVES

At the conclusion of this module, the expectation is to:

- Understand Insulation Resistance (IR) fundamentals
- Evaluate IR data collected using the CHAR System

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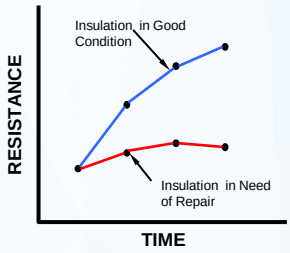
INSULATION RESISTANCE (IR)

- 80% of electrical maintenance involves IR testing of electrical wiring
- A constant DC voltage is applied between isolated conductors by the CHAR System while current is measured over a period of time
- Commonly used DC test voltages for AC rated equipment:

Rated Cable Voltage	IR Voltage Applied
100 VAC	100 to 250 VDC
100-500 VAC	500 to 1000 VDC
1000-2400 VAC	1000 to 2500 VDC
2400-4160 VAC	1000 to 5000 VDC



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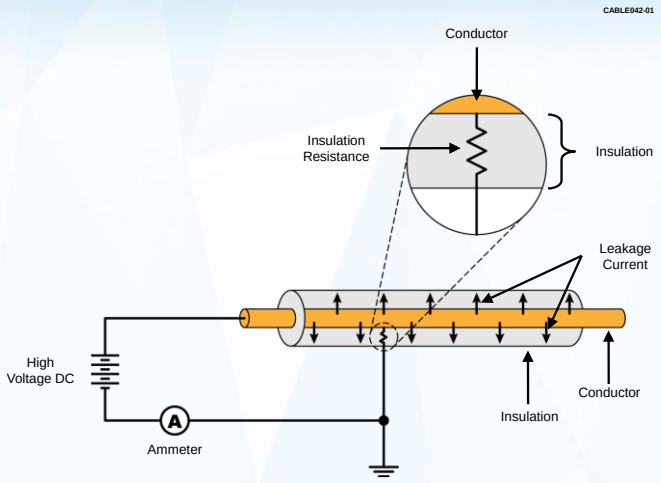
IR GRAPHICAL ILLUSTRATION



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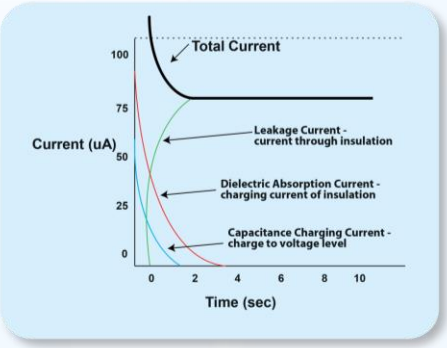
IR CURRENTS

- Dielectric Absorption Current
- Capacitance Charging Current
- Insulation Leakage Current



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INSULATION RESISTANCE RATIOS

$$DAR = \frac{IR\ at\ 60\ sec}{IR\ at\ 30\ sec}$$

If < 1.25, suspect moisture intrusion

$$PI = \frac{IR\ at\ 10\ min}{IR\ at\ 1\ min}$$

Motor Testing typically uses the PI test

If PI < 1.0, suspect moisture or corona

$$PR = \frac{IR\ at\ 3\ min}{IR\ at\ 1\ min}$$

If PR < 1.0, suspect moisture or high leakage current

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SELECTING IR TEST VOLTAGE

- Default is 15 VDC
  - Protects solid state circuitry
- Recommend testing to Manufacturer's specification
  - Low voltage (<600V) electrical systems (without electronics) can safely be tested to ~ 150% of peak operating voltage

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SELECTING IR TEST VOLTAGE (CONT'D)

- 2012 System IR tests are not intended to stress insulation
  - Increasing voltage is sometimes necessary to reduce noise interference
- It is possible to break down a cable's insulation with a **DC High Voltage** test (such as withstand and partial discharge tests):
  - Exceed the withstand voltage
    - Instantaneous
  - Create partial discharges and let the leakage current damage the insulation until it breaks down
    - May take minutes or hours

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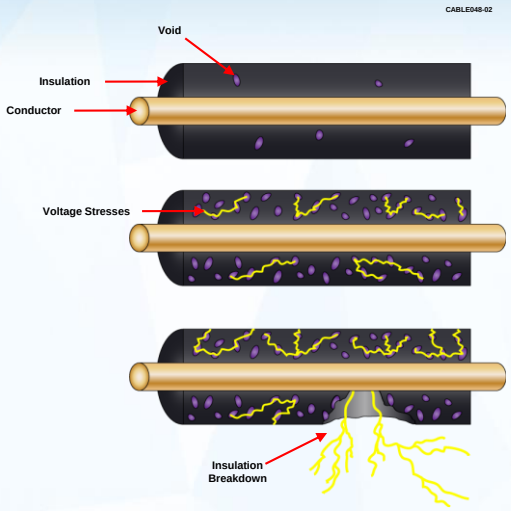
Would you use a cable after you just broke down the insulation?



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VOLTAGE STRESS ON THE INSULATION

The high potential test stress on the insulation is a function of:

- Voltage level
- Distance between conductors
- The dielectric
- The shape of the conductors
- Polarity of the charge

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CORRELATING IR DATA WITH CAPACITANCE DATA

- Increasing C – Wet insulation
- Decreasing C – Insulation may be baking out (drying)
- Decreasing DF* - Insulation may be baking out
- Increasing DF* - wet or resistive film on conductor to ground

*Dissipation Factor

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EVALUATING IR CURVE

- Increasing slope - good, dry insulation
- Flat slope - resistive or possible moisture intrusion
- Decreasing slope - ionization effects of moisture or partial discharge

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LAB EXERCISE: IR MEASUREMENT ON POWER CABLE

Perform IR Test at: 10, 100, and 1000 Volts, using the three listed conditions:

- Dry Cable
- Wet-Jacket Cable
- Wet-End Cable

(See Lab 2 "Insulation Resistance" in Lab Handout)

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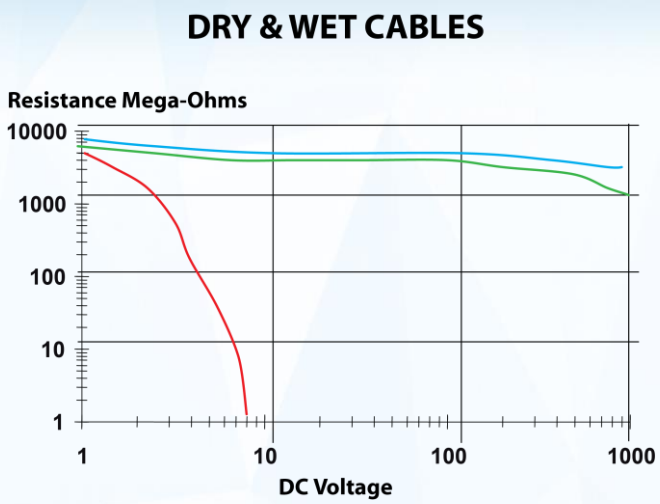
PLOT RESISTANCE vs. VOLTAGE



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COMPARE CAPACITANCE AND IR TO IDENTIFY MOISTURE INTRUSION

Description	Capacitance @ 1kHz	DC Resistance (Ohms)	Insulation Resistance @ 100 VDC (Ohms)
Baseline (newly installed cable)	410.67 pF	988.67 M	1.77 G
Middle of cable (water submergence present)	436.85 pF	820.79 M	1.22 G
Cable end in water (failed PM test)	496.96 nF	754.84 k	N/A

Characterization Summary Report

Equipment ID: IR DEMO (ORANGE CABLE) **Device Type:** CABLE **Cable Type:** 2C-PWR **Sequence:** 33
Description: 10' power cable **Frequency:** 1 KHz

Atc	Test Date	Time	Type	Rac	L/C	Q/D	Rdc	IR	P.R.	V Ck	Positive Lead	Negative Lead
[C] 2	8/21/2018	12:15:46	Open Circuit	3.21 k	410.67 pF	8.29 m	988.67 M	1.77 G	2.14	162.78 mV	White Wire	Black Wire
[C] Comment: 100V. Baseline/newly installed cable (dry).												
[C] 5	8/21/2018	12:17:31	Open Circuit	3.27 k	436.85 pF	8.97 m	820.79 M	1.22 G	1.82	167.39 mV	White Wire	Black Wire
[C] Comment: 100V. Cable submerged (middle section in water).												
[C] 8	8/21/2018	12:21:07	Open Circuit	1.10 k	496.96 nF	3.45	754.84 k			62.95 mV	White Wire	Black Wire
[C] Comment: 100V. Cable failed PM test (ends in water).												

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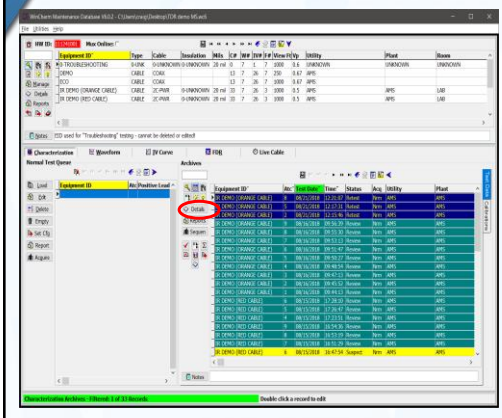
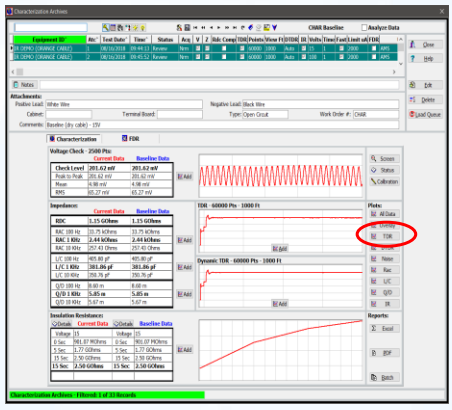
OVERLAY TDR PLOTS AT 15 VOLTS FROM THE ARCHIVES

Select "Details" to access Archives



Select attachment 1 in list. Click <TDR>



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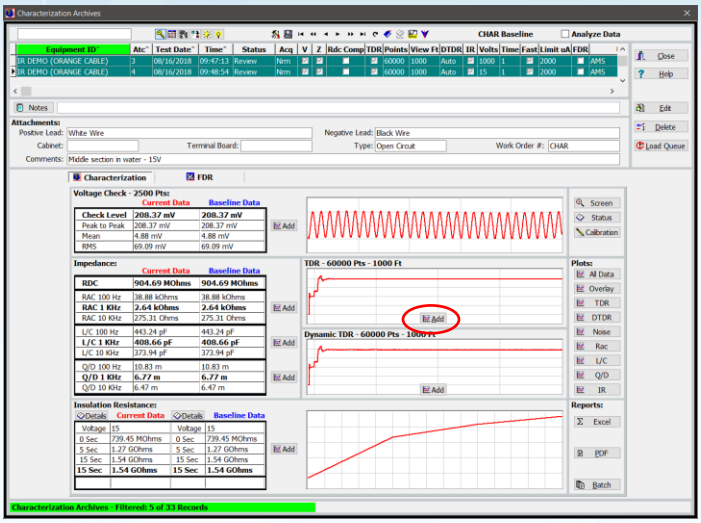
SELECT ATTACHMENTS 4 AND 7 THEN CLICK "ADD"



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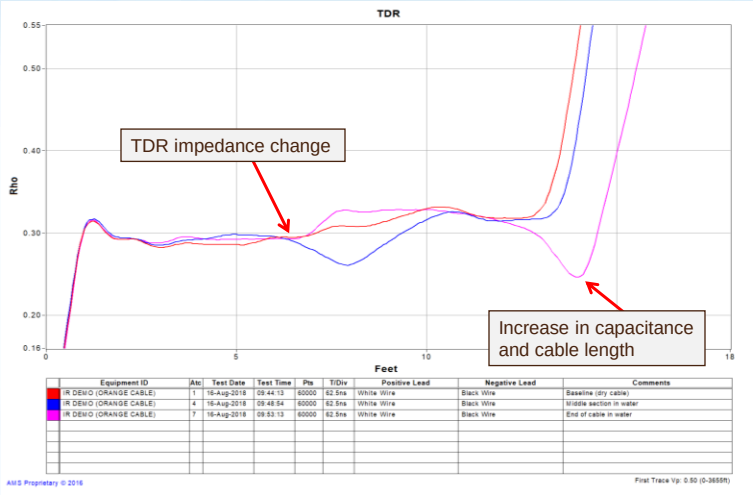
MOISTURE INTRUSION LOCATED USING TDR COMPARED TO BASELINE



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PERFORM LAB EXERCISE

- OBJECTIVE:
  - To understand the effect of moisture on a cable, and to use the archives as a baseline to see changes in cable characteristics.
- IR Lab Sessions
  - Each group will perform the exercises in the Lab Procedure Manual.

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QUESTIONS

- How did moisture affect the capacitance?
- How did moisture affect the TDR plot?
- What is the difference between resistance and capacitance on a TDR plot?
- How do characteristic impedance changes affect TDR?

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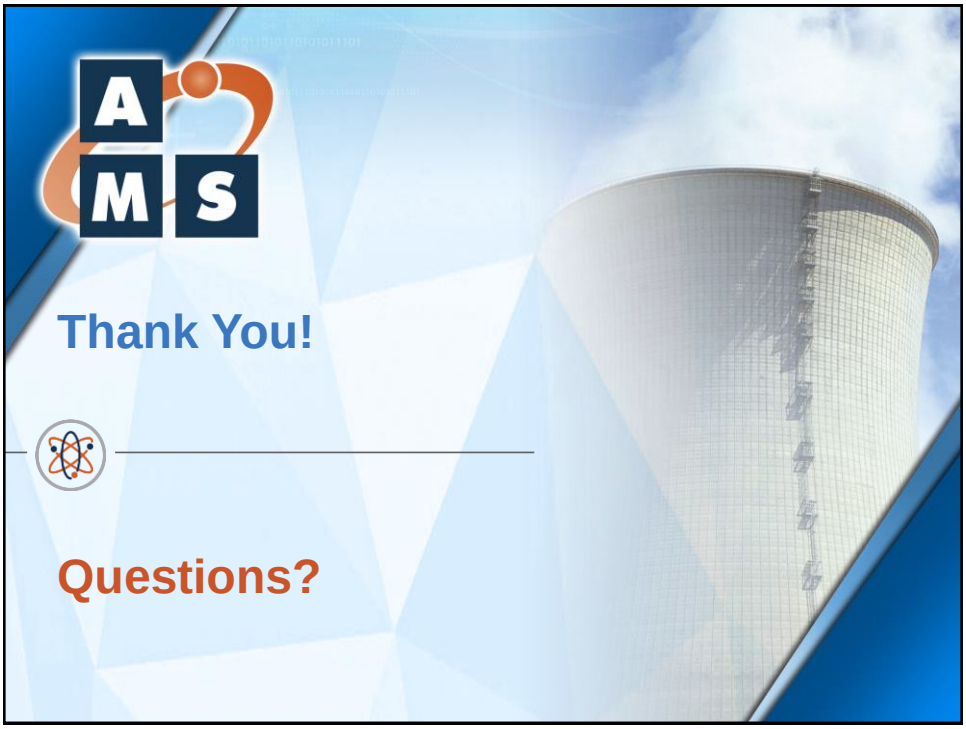
Thank You!
Questions?