Assessment of some Diagnostic Techniques for PILC Cables

J.P. Crine*, V. Buchholz, S. Cherukupalli**
Powertech Laboratories Inc., Vancouver

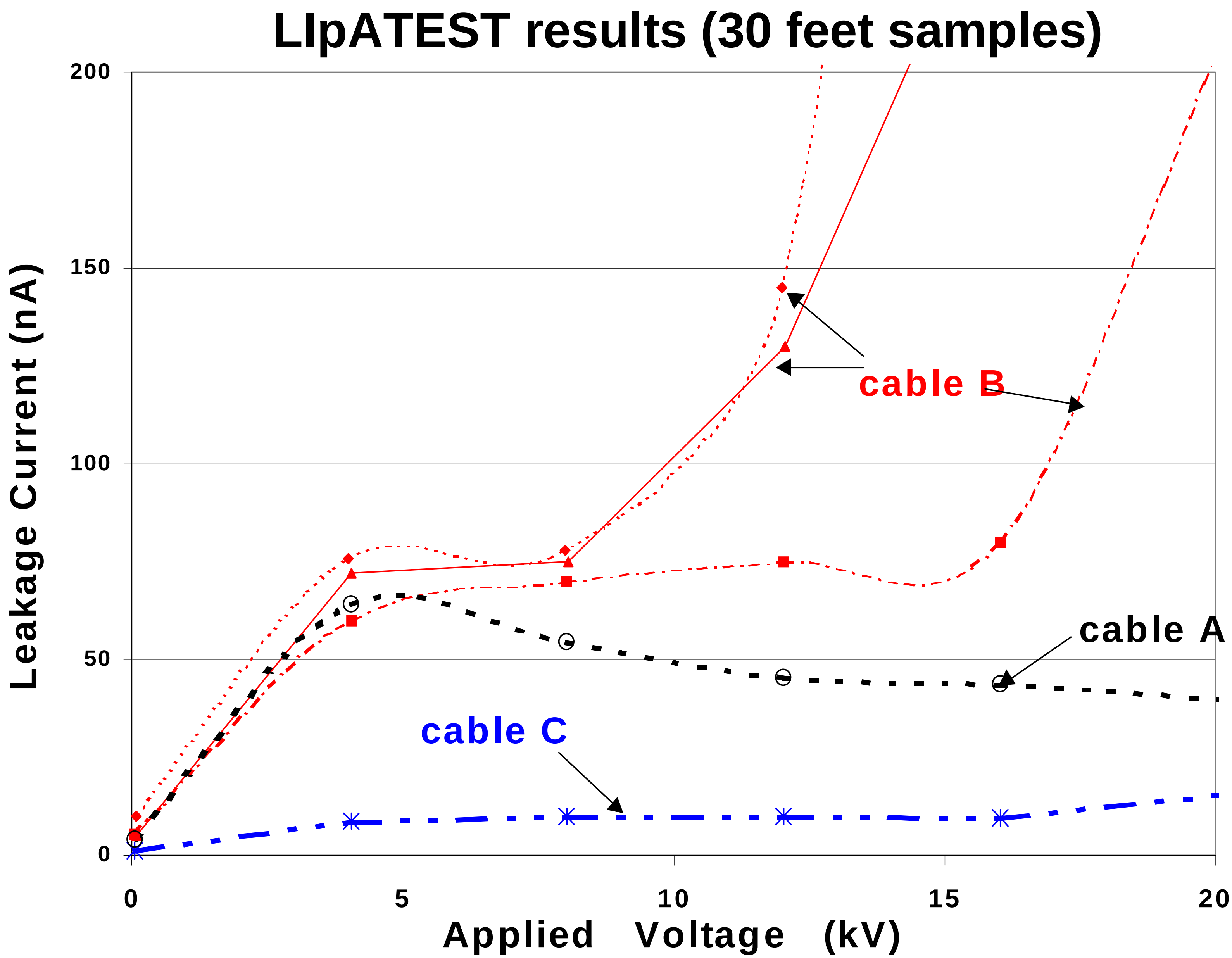
B.S . Bernstein

EPRI

*:***consultant*** **: ***BC Hydro***

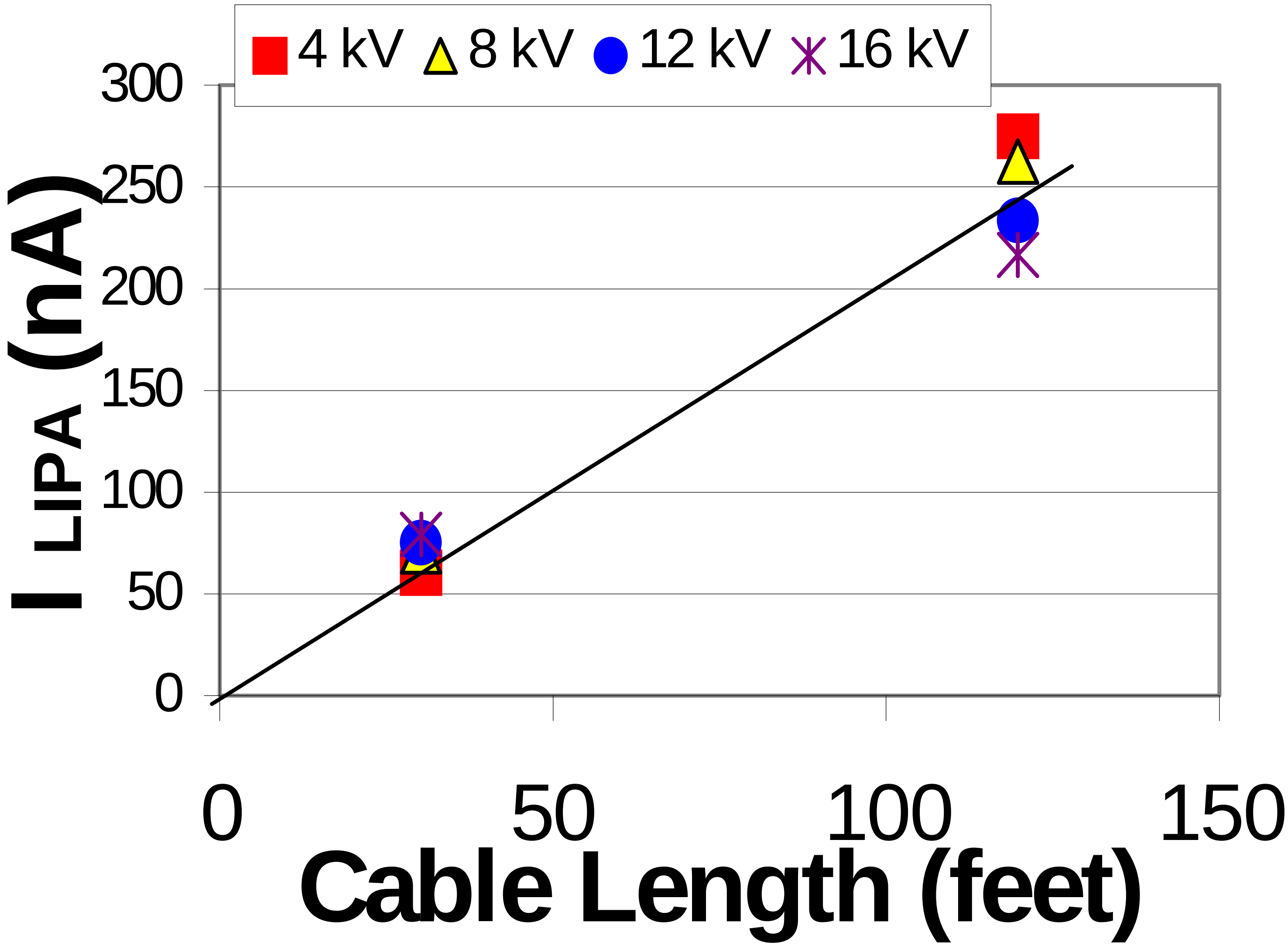
Introduction

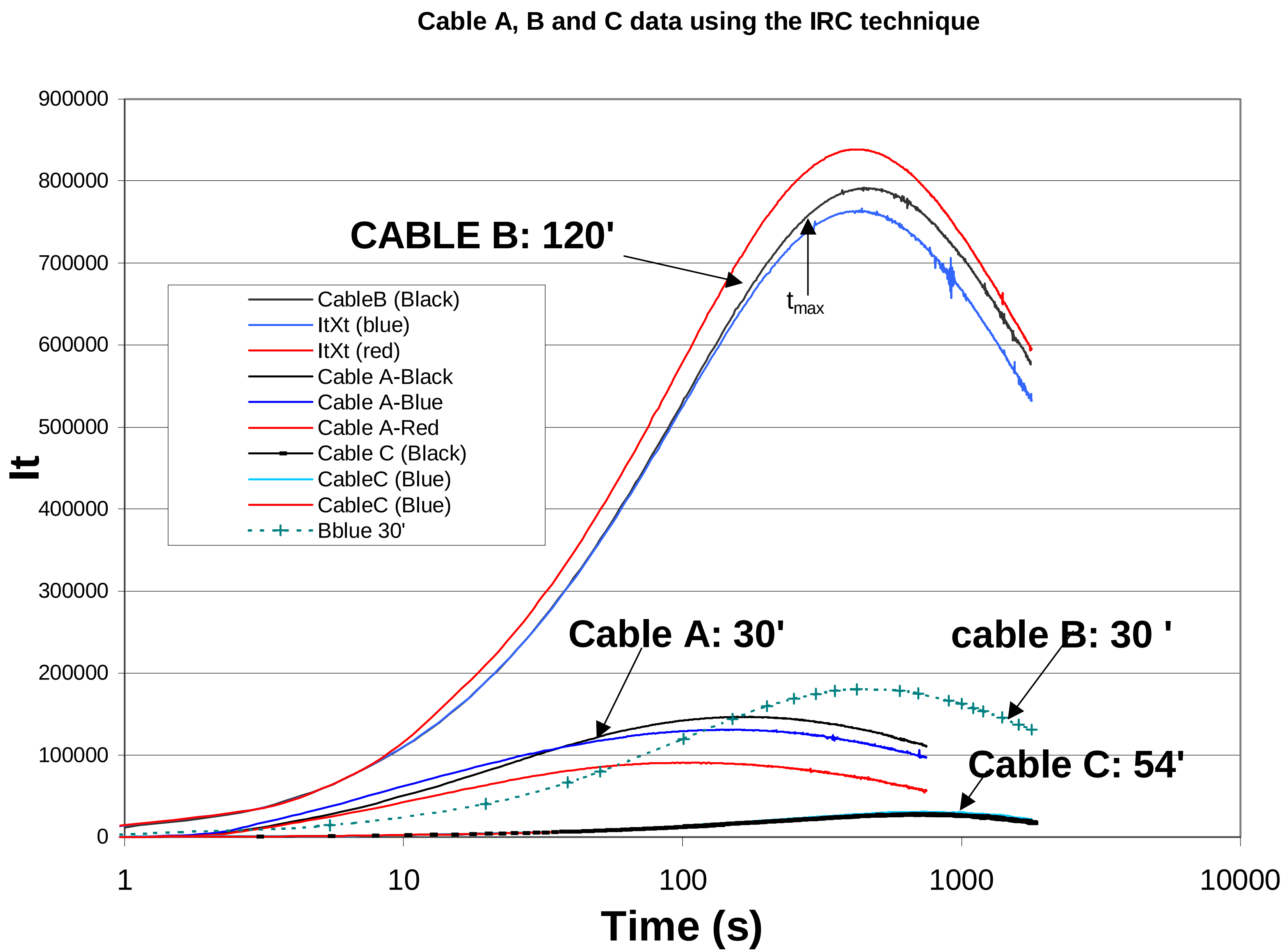
- Three PILC cable samples were tested in the lab using three different instruments.
- Samples were also dissected and chemical tests performed using Dielectric Thermal Analysis (DETA) and FTIR spectroscopy.
- Instruments used on the full size samples employed these techniques:
  - Isothermal Relaxation Current (IRC)
  - Recovery Voltage Method (RVM)
  - Leakage Current (LIpATEST)

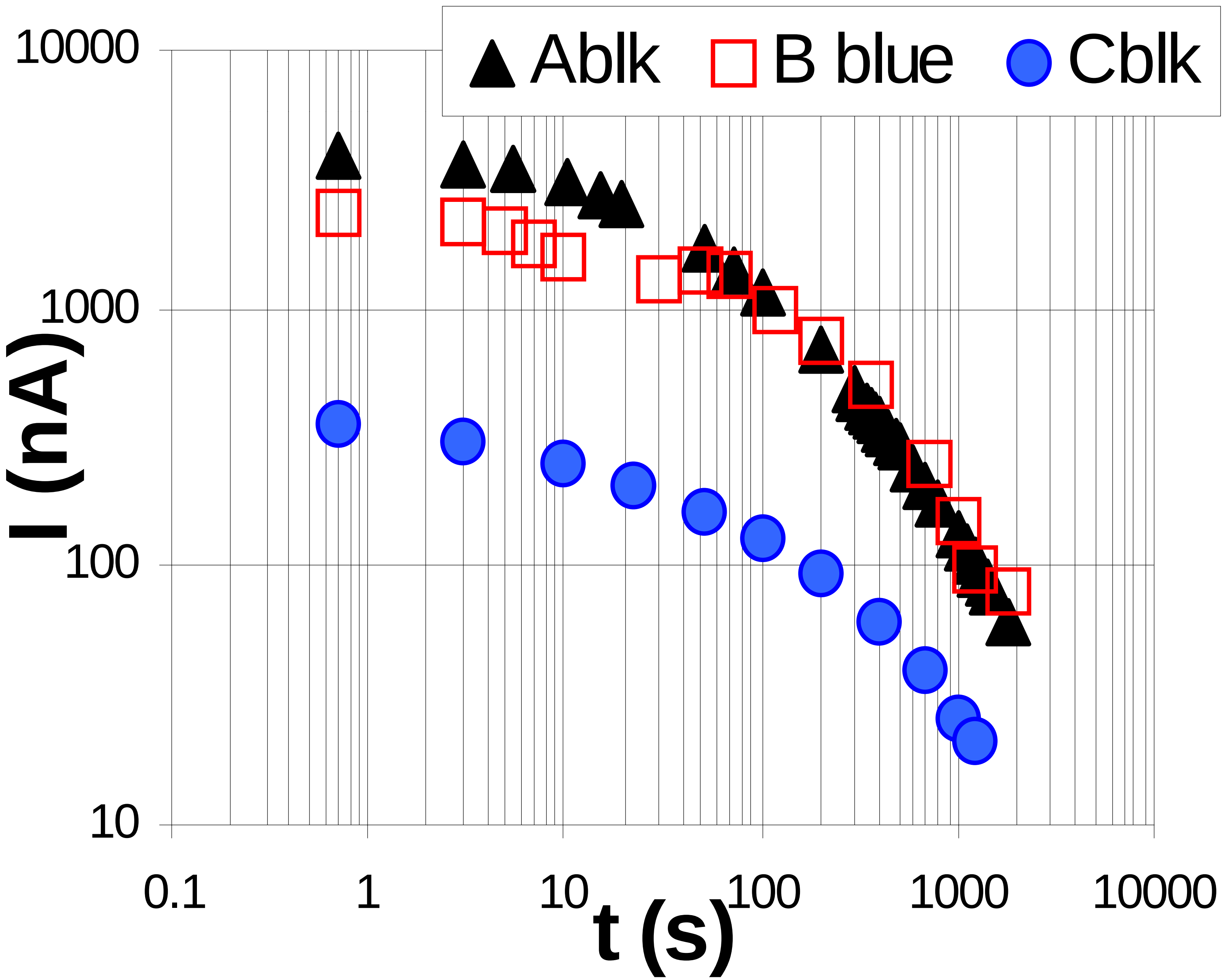


LIpATEST results (30 feet samples)
Leakage Current (nA)
200
150
100
50
0
0
5
10
15
20
Applied Voltage (kV)
cable B
cable A
cable C

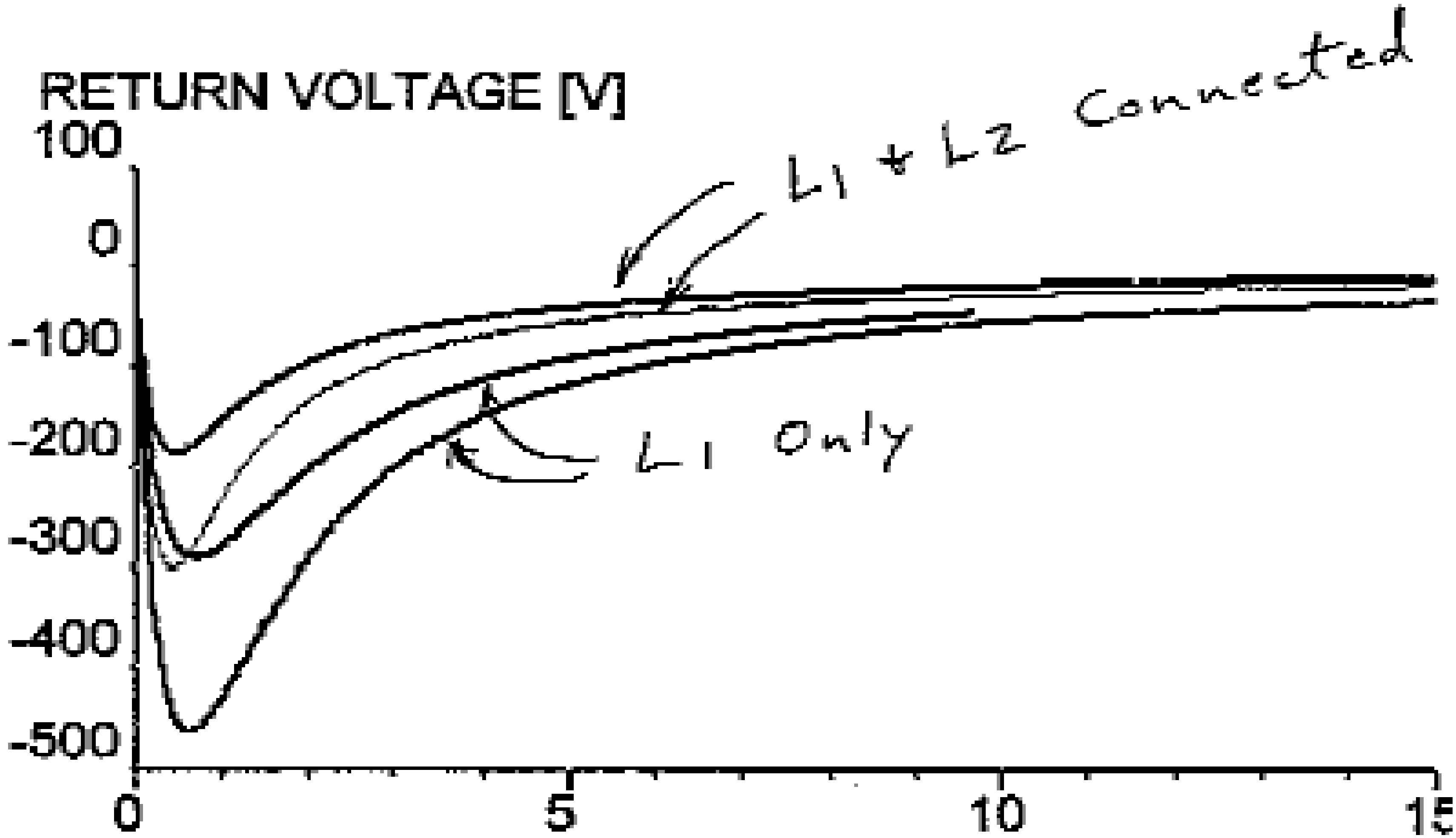
Influence of sample length




Cable A, B and C data using the IRC technique
CABLE B: 120'
t_{max}
Cable A: 30'
cable B: 30 '
Cable C: 54'
CableB (Black)
ItXt (blue)
ItXt (red)
Cable A-Black
Cable A-Blue
Cable A-Red
Cable C (Black)
CableC (Blue)
CableC (Blue)
Bblue 30'
It
Time (s)
900000
800000
700000
600000
500000
400000
300000
200000
100000
0
1
10
100
1000
10000

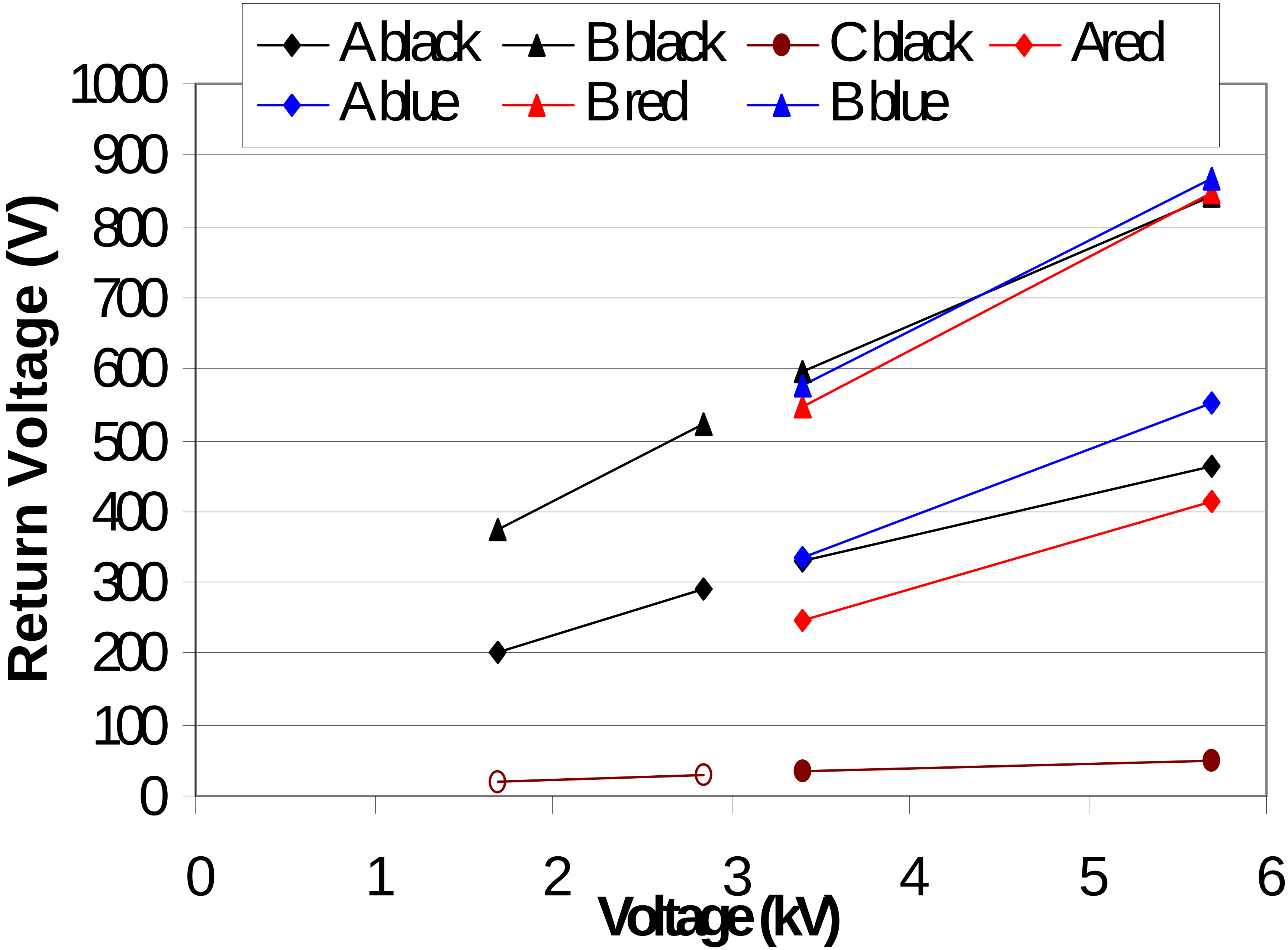


Ablk
B blue
Cblk
10000
1000
100
10
I (nA)
0.1
1
10
100
1000
10000
t (s)



RETURN VOLTAGE [V]
100
0
-100
-200
-300
-400
-500
0
5
10
15
L1 + L2 Connected
L1 Only

Time (min.)


A black
B black
C black
A red
A blue
B red
B blue
Return Voltage (V)
1000
900
800
700
600
500
400
300
200
100
0
0
1
2
3
4
5
6
Voltage (kV)

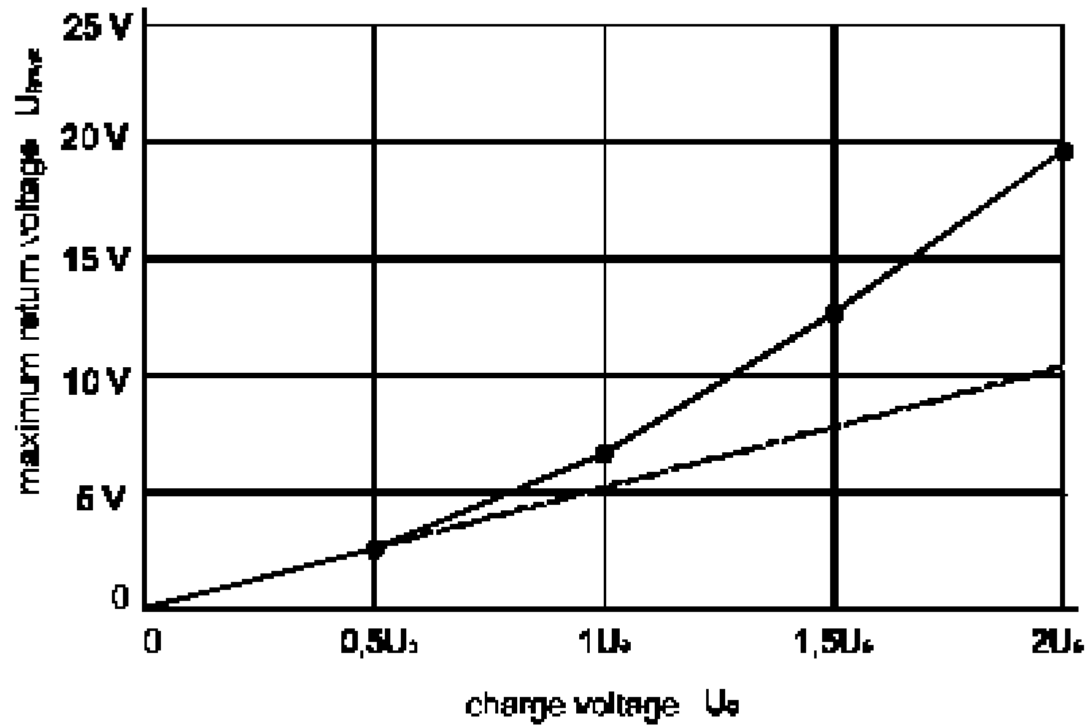


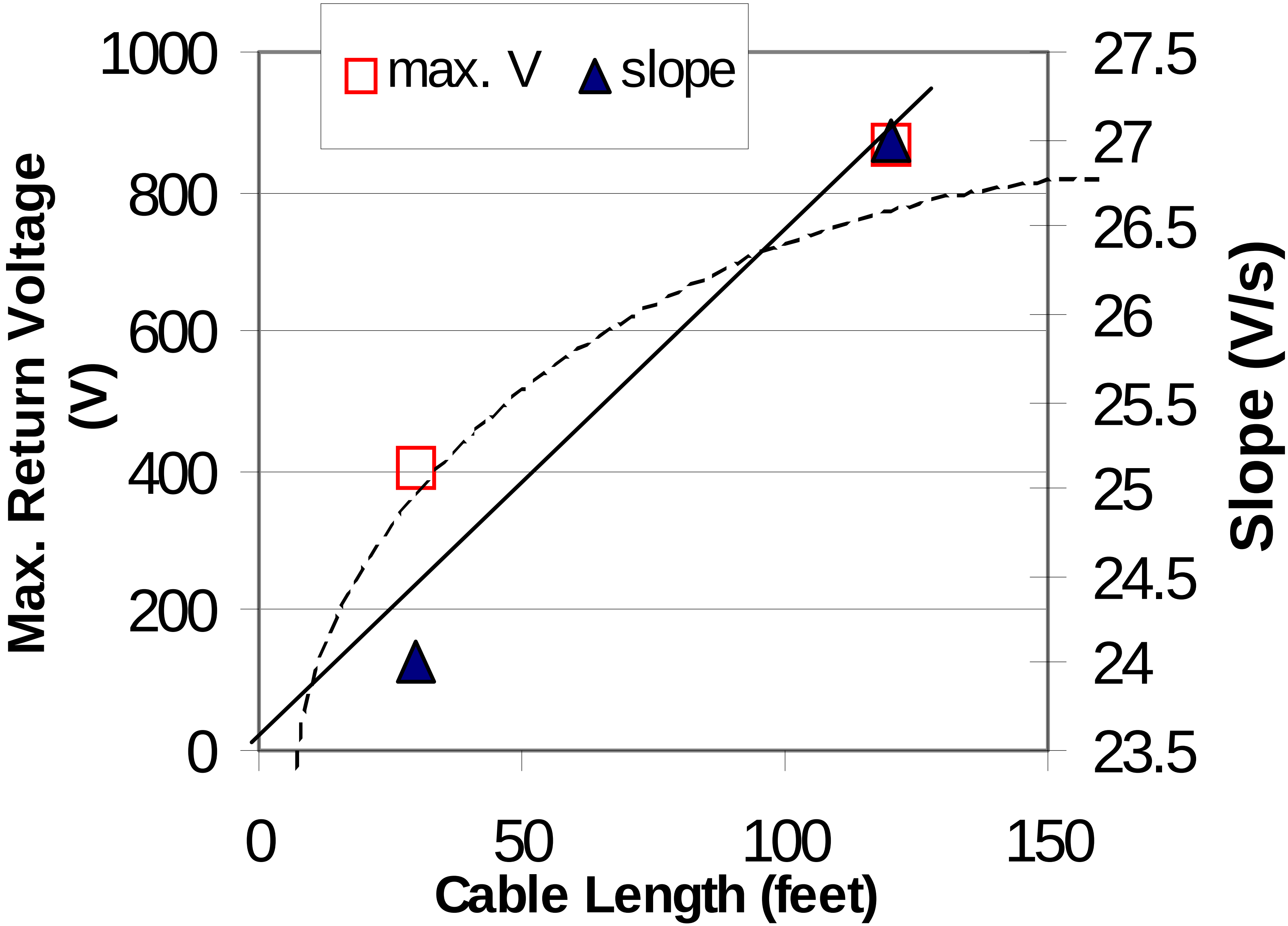
Fig. 3-4 Diagnosis Diagram

This diagram represents the result of the diagnostic test. For a new cable without any fault the curve is almost linear.

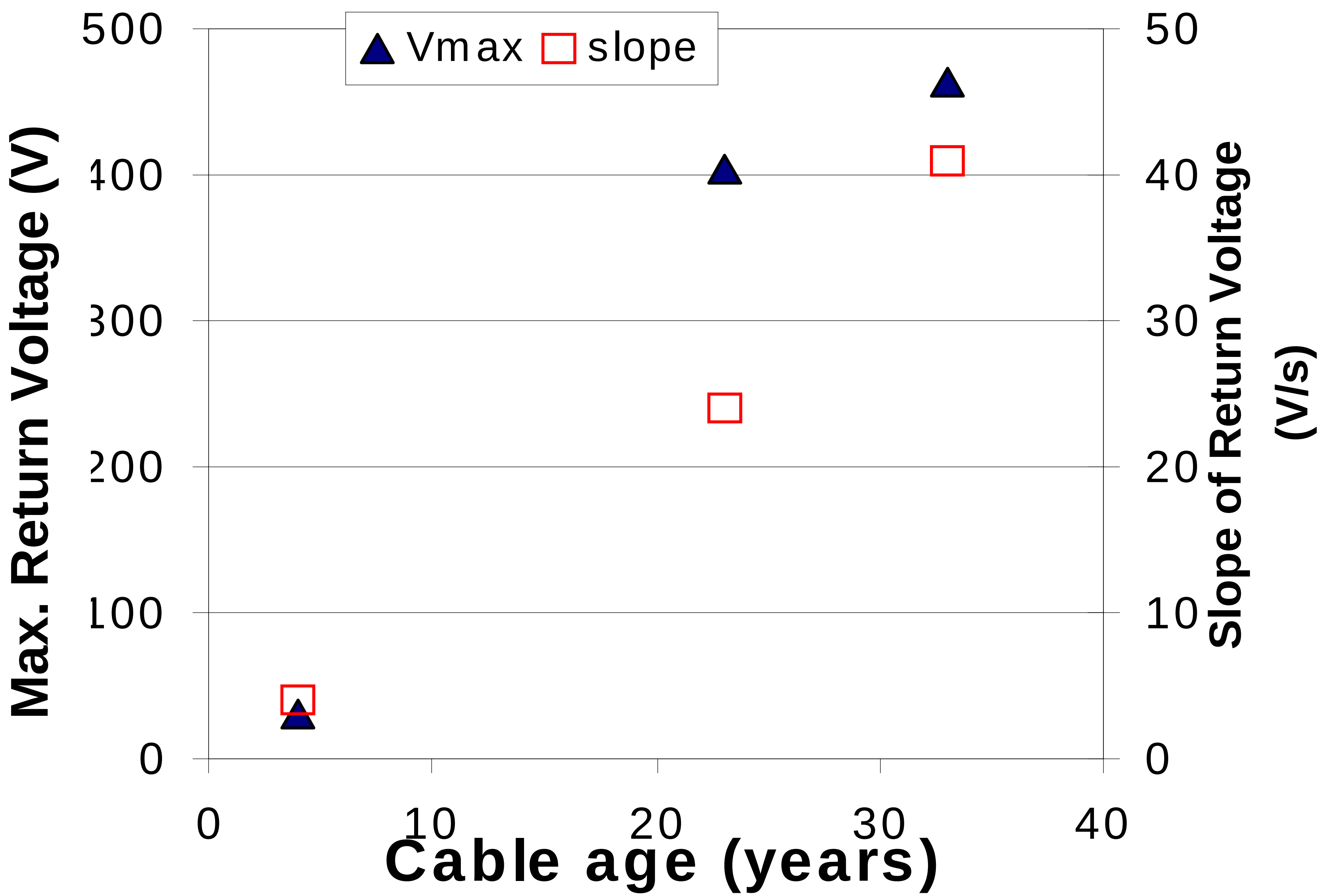
The greater the deviation from the linear course at high charge voltages, the worse the cable.

The Linearity Factor L is derived from the diagnostic diagram by using the following equation:

$$L = \frac{U_{Rmax}(2Uo)}{U_{Rmax}(1Uo)}$$



max. V
slope
1000
800
600
400
200
0
27.5
27
26.5
26
25.5
25
24.5
24
23.5
0
50
100
150
Cable Length (feet)
Max. Return Voltage (V)
Slope (V/s)



Vmax
slope
500
400
300
200
100
0
50
40
30
20
10
0
0
10
20
30
40
Max. Return Voltage (V)
Slope of Return Voltage (V/s)
Cable age (years)

Conclusions

- Electrical tests are highly sensitive to the sample length. Comparisons can only be made for identical length samples.
- The two commercial instruments used (IRC and RVM) were not designed for PILC. However significant information can be drawn from both.
- Plotting IRC data on a log I vs. log t graph reveals more about the insulation condition than the present It vs. log t graph.
- The LIpATEST proved to be simple to use and the cable ranking was consistent with the other two electrical test methods used in this study.

Conclusions

- The FTIR spectroscopy analysis has shown the presence of acids in the oil of cable B, which could be one possible cause for the larger polarization currents under high voltages (LIpATEST) and slightly larger depolarization currents after long charging times (IRC) in that cable.
- The fact that the tan δ values of cables A, B and C (obtained albeit at very low voltage) were similar in magnitude despite the oil of cable B being more degraded suggests a moderate degradation.