



NATIONAL POWER TRAINING INSTITUTE HOT LINE TRAINING CENTRE

**An ISO 9001 : 2015 Organization
(Under Ministry of Power, Govt. of India)**

4 Days Onsite Training Programme On Live Line Punctured Insulator Detection (PID)

**30th Batch
From 03/01/2022 To 06/01/2022**

**26TH KM KANAKAPURA ROAD
BANGALORE – 560 082.
TEL – 080 - 28432596, 28432053, 28432212.
FAX - 080 - 28432596
e-mail – directorhltc@gmail.com**

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INTRODUCTION

1.1.GENERAL

The ever-increasing demand for Electrical Energy reflecting on National productivity and economy necessitates higher requirements as regards to reliability in transmission and distribution of electrical energy.

Increasing complexity of transmission net works, coupled with inter – regional / inter state ties transporting huge quantum of power has rendered shut downs on transmission lines / substations almost impossible, thus resulting in the need for Live Line techniques. Hence Live Line working up to 220 kv has been introduced in our country. 220 kv lines in operation all over the country along with the growing networks of 400 kv systems forms the back bone of the transmission network leading to the emergence of the national grid. Power flow on these lines will be regulated by National / Regional / State Load Dispatch Centers and it is obvious that for system stability and for ensuring quality of power supply to the consumers, an almost uninterrupted availability of the transmission lines is required. The need gets further reinforced considering the fact that the use of electricity has grown phenomenally over the years in all sectors like domestic, agricultural, industrial etc. Providing redundancy in transmission lines though could be a solution, which however is quite costly and therefore preventive maintenance deploying Live Line Maintenance Techniques (LLMT), proves to be the best solution.

1.2.HISTORY

Hot Line Maintenance, as the name implies, involves working on a line while in energized condition to inspect and replace if necessary, the defective parts to avoid costly forced outages.

The principle of Hot Line Maintenance could be said to have been first introduced long ago when disconnect sticks were used to open energized switches on distribution lines. The operation proved that log dry poles could be equipped with fittings, which could enable linemen to work safely on Live Lines. However, it was many years later this idea was used to develop tools for Hot Line Maintenance work.

The earliest tools were manufactured in 1913 in Ohio, USA. They were home made, crude and bulky but they were the forerunners of the present efficient and refined tools. In the year 1916, a tool that was known as an "electrical hook" was introduced in Atlanta, Georgia. This was essentially a spring type clamp for tapping energized circuits.

The electrical hook necessitated a hot stick for installation purposes, and its use suggested additional tools which were soon developed for grant and jumper service, applying parallel groove clamps, handling conductors, pulling cotter pins and manipulating tie wires. Soon tools like hacksaw, a hot line cum-a-long and saddles followed which could be attached to the poles for supporting certain tools. One by one, a number of Hot Line tools were introduced and developed over the years like electrical hook, hacksaw, saddles, clamps, clamp sticks, wire tongs and numerous hand tools. These tools led to the development of universal hand tools with inter changeable heads. Considerable credit goes to the far sighted individuals who visualized the time when power circuits could not be easily de energized while insulators, cross arms, poles and other equipment were being replaced. It was realized that duplicate circuits for service purposes would be entirely too costly, and with the rapid growth of electrical users and the extended use of electric power for operating home appliances, farm equipment etc. would demand that electrical power be maintained without interruption. Linemen were perhaps the first group of men to realize this need. In almost every case, it was the lineman who prompted development of the various Hot Line tools, which eventually led to the present universal practice of Hot Line Maintenance.

Initially, Hot Line work was restricted to lines up to 22 kv, but gradually as the linemen gained confidence, the working voltage increased. 220 kv lines were first worked Hot in the late thirties, 330 kv in 1954 and 500 kv in 1957. In 1959, the new light weight epoxy glass handle for Hot Line Tools were introduced and by 1964 these were used in all EHV lines in USA and Canada including 735 kv, almost eliminating the use of wooden tools for EHV.

Weight is an important factor in hot line work, as fatigue must be kept to minimum. Therefore, considerable attention was given to making the tools lighter, stronger, and safer. In 1947, A.B. Chance & Co, USA introduced the heat-treated aluminium alloy heads and other fittings for hot line tools to augment the light weight Sitka spruce tools, and later epoxy glass. In designing a hot line tool the insulation characteristic and strength of the tool are of major importance, as it involves linemen's safety. The ease of the tool handling, relief from fatigue, the manner in which it operates when engaging a tie wire, strain clamp insulator or conductor etc. are some important aspects in the design of hot line tools. These, as a rule, have to be field tested before they are put in to actual operation to ensure their utility and safety to linemen.

1.3. LIVE LINE MAINTENANCE:

Hot line work can be classified into three types:

1.3.1. HOT STICK METHOD:

In this method the linemen will be at ground potential working with Hot Sticks (tools) keeping safe clearance from the line.

1.3.2. BARE HAND METHOD:

Here the lineman will be working at line potential keeping safe clearance from ground. For this conductive suits made up of 25% microscopic stainless steel and 75% Nomex will be provided.

1.3.3. COMBINATION:

This method is a combination of above two methods.

HISTORY OF HOT LINE TOOLS DEVELOPMENT

Hot lines tools refer to hot sticks used to carry out hot line works. They have to be light in weight but mechanically strong and highly insulated (Dielectric strength). Easiness in handling and installing has to be other features.

1.4 History and development of hot line maintenance tools:

1913 First hot line tools were made in Wapakoneta, Ohio. Wooden sticks were used. They are crude, bulky and difficult to handle.

1916- Electrical hook in Atlanta Georgia, USA and developed wooden tools for grounding and jumpering P.G. Clamps handling conductors, hacksaw, wire grips, saddles etc.

1918- Tips tools and company at Taylorville, Illinois began manufacturing hot line tools, wire tongs, tree trimmers, saddles, hand tools and universal tools for tension without using set of rope block.

1937- Tips tools company was purchased by M/s. A.B. Chance Co., and manufacturing facilities were moved to Centralia, Missouri, where the research and development of Hot Line tools were accelerated.

Hot Line Maintenance practice:

Hot Line tools were first accepted for working on 34 kv but the line men were hesitant. Many companies restricted work to 22 kv and less.

1940- With improved tools and safety on hot line the maintenance work carried out up to 110 kv level.

1948- Mr. O.G. Anderson and Mr. N.R. Parkinson of A.B. Chance carried out operation on 287 kv.

1950- Fibre Glass tools were introduced.

1954- Operation carried out on 330 kv with improved moploc coated wooden tools.

1959 - A. B. Chance Epoxy glass came into existence.

1960- The tools were used on 400 kv. Also Bare Hand method introduced.

1964- The tools were used on 11 EHV lines including 735 kv.

1958 - Introduced in India. Also two Hot Line Training Centres for voltage levels up to 110 kv were established one at Bangalore and other at Ganguwal (Punjab). But both centres were closed in 1964-65 as sufficient trainees were trained.

1974- Training Centre restarted at Bangalore for voltage levels up to 220 kv.

1st one week Live Line Insulator Testing (PID) training course was conducted at HLTC during the year 2009 for PGCIL participants and 4 courses were conducted for PGCIL till 2011. Training program from 5th course to till 11th was conducted for MSETCL and other power utilities. **The 1st 4 days onsite training on live Line Insulator Testing (PID 12th batch) was conducted from 05/03/2014 to 08/03/2014 at MSETCL, Training centre Padghe, Maharashtra. The 13th Batch scheduled from 17/03/2014 to 21/03/2014 at this institute for M/s: PGCIL.**

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SAFETY RULES

1. Only authorized persons (Certificate Holders) should carry out hot line maintenance work.
2. Make sure that weather is clear and there is no chance of rain.
3. Make proper plan to carry out the work in advance. Line man should clearly understand the operation with drawing, tools used etc. Inspect the tools to be used and clean all the tools.
4. See that the pole/Tower is strong enough to take the load of crew and the tools.
5. Remove wrist watch or other ornaments before climbing the pole.
6. Equip yourself with helmet, safety shoes (conductive shoes) and safety belt.
7. Do not climb towards the jumper. If clearance is less, push the jumper or cover it with insulated guards.
8. Take proper position on the pole and ensure that you are safe to work with both hands.
9. Keep high degree of co-ordination among all the members of the team while working.
10. Do not lose temper, work calm and cool even if it is time consuming.
11. If anybody on the pole/tower wants to change his position, he should tell his colleague and to the in-charge before doing so.
12. While working clear all doubts what so ever regarding the work immediately with the in-charge.
13. Ground person should not come under the work spot to avoid any accident.
14. In-charge of work should not do work with his own hands. He should take a position on the ground from where he can see all the working persons and can instruct them properly.
15. If due to any reason in-charge of work leaves the work spot, workmen should stop working till he comes back.

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Safe clearance:-

Voltage in KV	Clearance required in	
	FEET	METRES
11	2'0	0.61
33	2'4"	0.71
66	3'0"	0.91
110	3'4"	1.02
132	3'6"	1.07
220	5'0"	1.52
400	7'0"	2.13

SAFE WORKING DISTANCE FOR HOT LINE OPERATIONS

Voltage range Phase to phase in kv	Metres	Feet
2.1 to 15	0.61	2
15.1 to 35	0.71	2'4"
35.1 to 46	0.76	2'6"
46.1 to 72.5	0.91	3'
72.6 to 121	1.02	3'4"
138 to 145	1.07	3'6"
161 to 169	1.12	3'8"
230 to 242	1.52	5'
345 to 362	2.13	7'
500 to 552	3.35	11'
700 to 765	4.57	15'

Effect of current flow in body:

0 – 1 mA	Cannot feel anything
1 – 8 mA	Can feel but no pain
8 – 12 mA	Painful but can let it go.
12 – 20 mA	Freeze, cannot let go
20 – 50 mA	Breathing stops
50 – 200 mA	Heart stops
200 and above	Sever Burns

TESTING OF LIVE INSULATORS

In a string of insulators, voltage distribution across various insulators is as shown in the graph on the accompanying page. If any insulator is faulty, other insulators as shown by the dotted line take up their share. So, if an insulator takes a voltage the value of which is less than that shared by the insulators on either side of it, it is considered a faulty insulator.

To carry out the above test, we use an indicating instrument with 2 prongs in association with a Hot Stick.

Current passing through an insulator is proportional to the voltage absorbed by the insulator. Hence instrument deflection is proportional to voltage across the insulator.

When testing a string of insulators, each insulator is consecutively brought in shunt contact with the instrument prongs and the meter deflection is observed. Any sudden dip in the meter deflection across an insulator indicates that the insulator is faulty and signifies replacement.

Mainly five Methods are adopted to test the Insulators in Live Condition.

- Insulator Testing using Buzzer method : In this method two metal rods of brass, fabricated as shown in the Figure
- Volt meter Method
- Neon Lamp Method
- Positron make Punctured Insulator Tester (PID)

Buzzer method of Insulator Testing: Here two prongs are kept across the metal portion of each Disc insulator. Because of the potential difference, the arc starts between gap and sound is heard. This is very basic method it has drawback as perfect judgement cannot be taken and in small string of insulators there are more chances of flash over.



By voltage measurement: With the help of Hot Stick, voltage detector is moved across each insulator on the string to measure voltage across each disc. Based on the voltage across each disc the defective insulator can be identified. It is recommended that the faulty string and healthy string for the same voltage level may be compared to find out the defective insulator. The basic principle is to measure field across the insulator, there are again draw backs as analog meter readings are not accurate and visibility on higher level voltage line is difficult to measure because of long distances. This is suitable up to 132 Kv. Lines with satisfactory results.



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Neon Lamp Method: The principle of Working is same i.e. measurement of field across the Live Insulator, if the lamp glows the insulator is said to be OK otherwise it is considered as punctured. In this method Neon Lamp is the costly part and the method is categorised as **Go or No Go** test.

By Electric field method: Electric field detector mounted on the plastic sled is moved across each disc over a string with the help of hot stick from top to bottom and back to top. The instrument records the electric field across each insulator. In the case of punctured insulator the electric field across the punctured disc is considerably less. Some instruments have an instant reporting feature to tell about the number of punctured insulator present in the string at the time of scanning. Alternatively the data can be down loaded on computer to find out the position of punctured insulator present in the string.

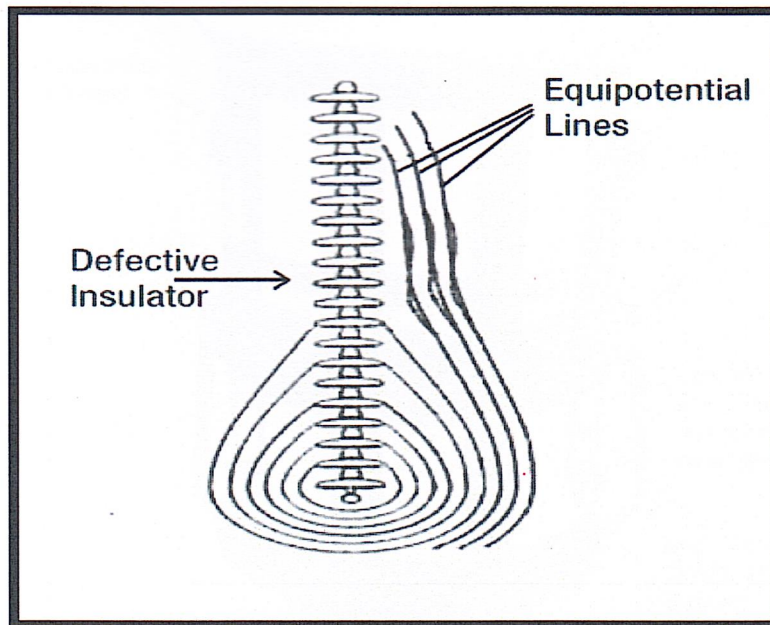
Live Line Insulator Testing using PID kit (Positron): This is the latest instrument developed and is used successfully by most of the Power utilities to test insulator Strings in Live Condition up to 765Kv, in India. The results are accurate in nature. This equipment can be interfaced with PC. It has a memory chip which can store approximately records of 300 strings. Provision is there to keep the sequence of testing like serial no. of starting tower etc. The instruction and typical test results are enclosed as Annexures.



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Porcelain Insulator Tester

Working Principal of Positron

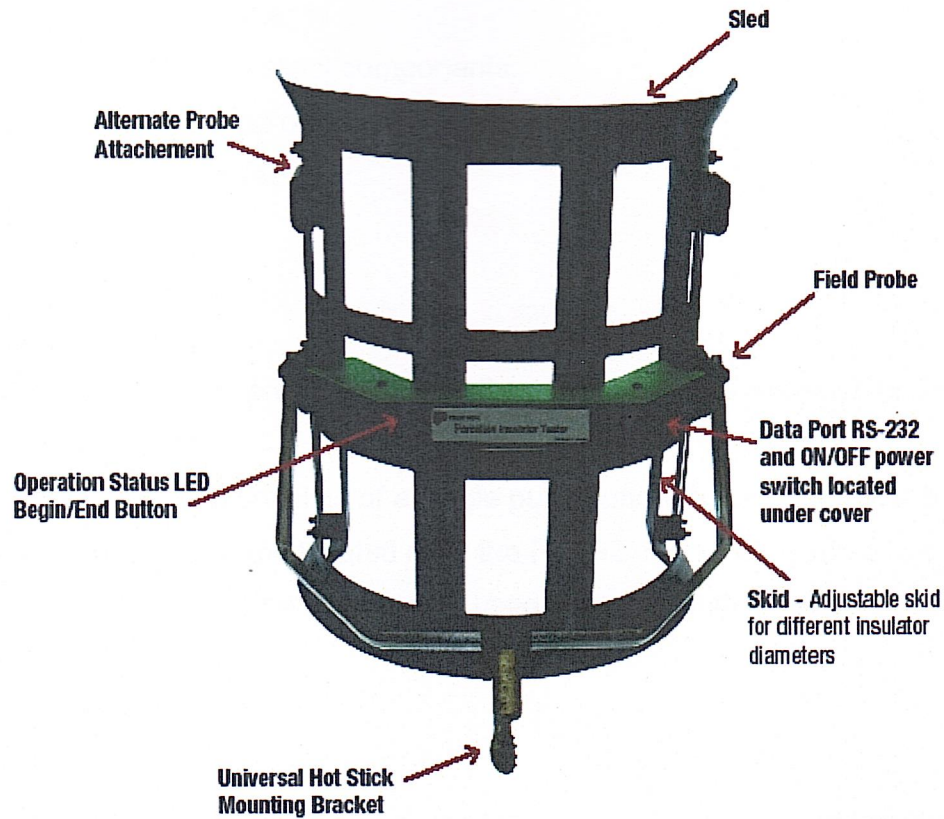


- ✓ The Insulator Tester measures the **AC electric field** surrounding porcelain insulators.
- ✓ The field is proportional to the voltage across an insulator and drops at a defect location.
- ✓ The electric field is read and stored at each insulator

Single button operation makes the Porcelain Tester very easy to use. The operator simply turns on the unit, slides the Tester across the string and the test is complete. There is no direct electrical contact so danger is minimized on marginal insulators.

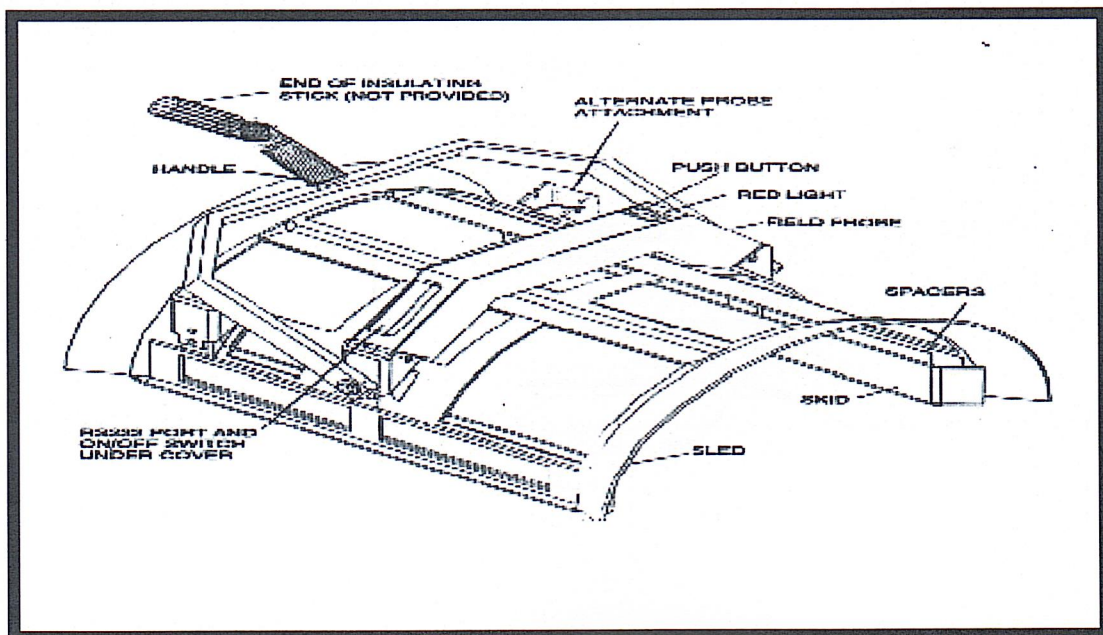
- Used for Porcelain and Glass insulators.
- Sled mounted (custom design sled is available).
- Best for insulator strings of 4 bells or more.
- Captures up to 15,000 readings.
- Rechargeable battery.
- Adjustable skid for different insulator diameters from 9" to 13" (22.9 to 33 cm).

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The PID kit is used to detect the Punctured insulator discs in the charged line condition. It consists of the three major parts namely Field Probe, Sled and Telescopic Epoxy Glass Stick. The arrangement of the kit is shown in fig.1.

Punctured Insulator Detector



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Description of Tester Elements

The tester consists of five distinct components:

1. A field probe mounted on a sled.
2. A sled or actuator assembly.
3. A charger cable.
4. A carrying case.
5. A logger (optional).

In addition, a customer-provided personal computer (PC) is required for the transfer and analysis of data.

The operator interface consists of a single push button, a red light and a buzzer. In addition, an internal switch located near the RS232 connector is used to turn off the power when the field probe is not being used for an extended period of time (more than 2 days).

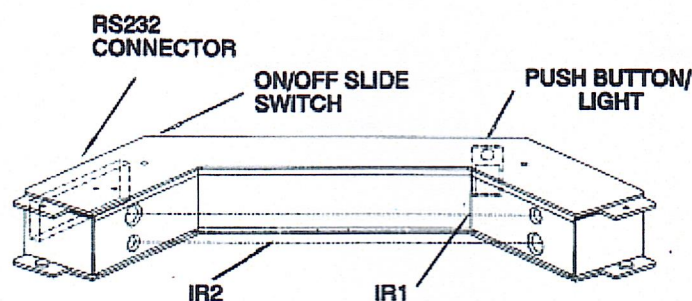
NOTE:

When the power is turned off (by moving the slide switch away from the RS232 connector) the synchronization and the accumulated data are lost.

Field Probe

The field probe uses two infrared detectors to identify the direction of the scanning motion. These two infrared detectors are identified as IR1 and IR2.

Figure: Infrared Detectors (IR1 and IR2)



The logger (Optional):

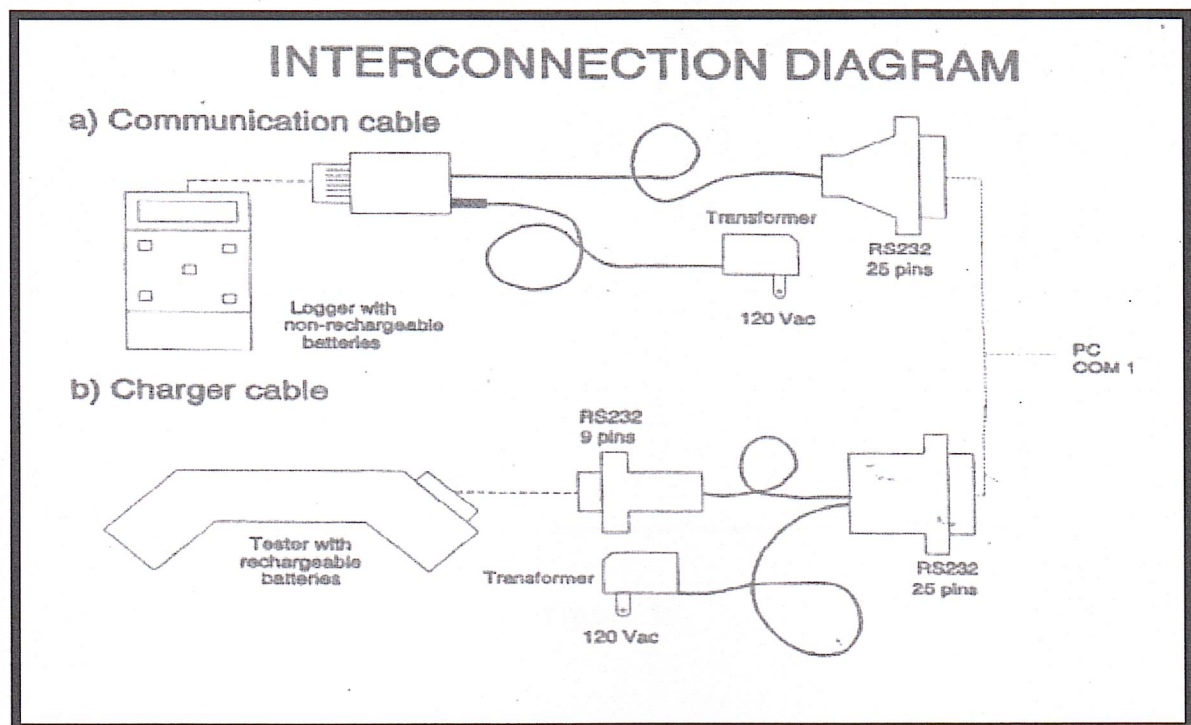
The logger is used to store the working schedule and to identify each insulator string. Its memory has a list of all the strings identifications to be tested. This logger contains a 9 volt non- rechargeable alkaline battery that will last from 2 to 6 months depending on its use.

The battery charger cable:

The Probe battery charger consists of a wall transformer connected to a cable with a 9-pin RS 232 female connector which connects to the field probe at one end, and a 25-pin RS 232 female connector which connects to the PC at other end. The charger cable is used to up load the data to a PC and to recharge the probes battery weight.

Inter connection diagram of PID probe:-

The inter connection diagram of the field probe is shown in fig 2.



Introduction

The Positron Porcelain Insulator Tester (PIT) measures the Ac electric field along all types of insulator strings: horizontal-, and vertical. Use of the tester helps you to quickly and easily pinpoint faulty insulator on an insulator string. For an illustration of the components required to scan an insulator string, refer to figure 1.

The Positron Composite Insulator Tester (CIT) operates in the same manner as PIT, except that the AC electric field is measured at each skirt along an insulator string. For an illustration of the components required to scan an insulator string, refer to figure 1.

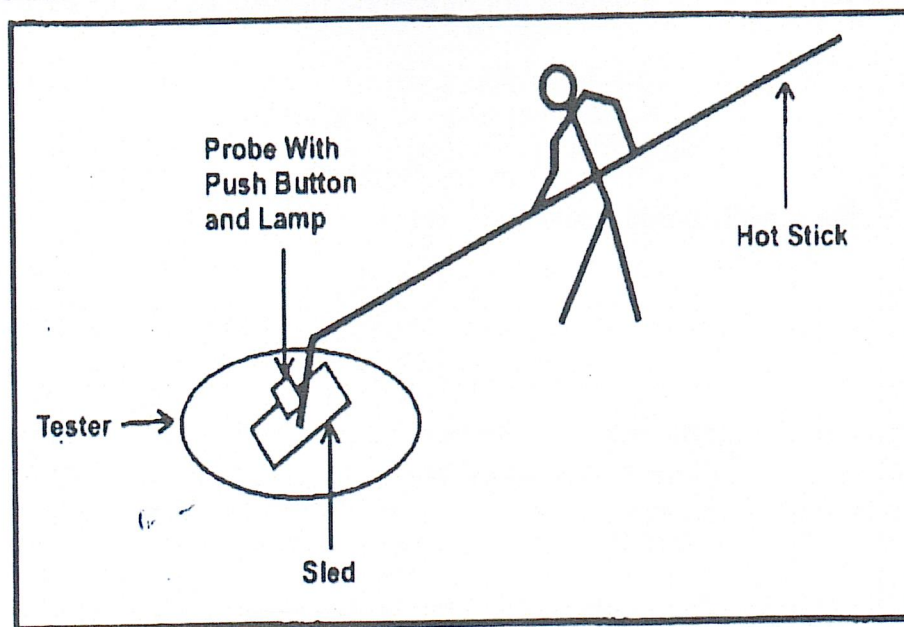


Figure 1

Scanning an insulator string

When the PIT or the CIT is used to scan insulators (also called as bells) or skirts of horizontal, V-, or Vertical insulator strings, two scanning methods are available:

Preferred method:

This method can be used when access to the insulator string is from a position that is directly above the start point (ground end). This method produces the most accurate results. For an illustration of a horizontal or 'V' string scan using preferred method, refer to figure 2. For an illustration of a vertical string scan using preferred method, refer to figure 4.

Alternate Method:

This method can be used when access to the insulator string is from a position that is not directly above the start point.

Two types of scans can be performed on an insulator string. These are:

Full scan:

The tester is moved from the start point of the insulator string to the end point, and then back again to the start point. The tester passes over each insulator string twice. Two curves per tester graph are produced. This type of scan is recommended when using the preferred scanning method. Figure 2 illustrate the motion of the tester during a full scan.

One-Way Scan:

The tester is moved from the start point of the insulator string to the end point, and then lifted away from the insulator string. The tester passes over each insulator or skirt on the insulator string once. Only one curve per tester graph is produced. This type of scan is recommended when using the alternate scanning method. Figure 5 illustrates the motion of the tester during a one-Way scan.

To scan a horizontal, V-, vertical insulator string using the preferred method.

1. The hot stick should be as parallel as possible to the insulator string to facilitate the manipulation of the tester.

If required, adjust the attachment angle of the hot stick as shown in figure 3.

2. Before placing the tester on the insulator string, press the push button on the probe to activate the red lamp. The lamp begins to flash.
3. Place the tester on the 3rd or 4th insulator of the string and pull it toward you, to the beginning of the insulator string (start point/ground end).
4. Keep the tester on the insulator string while waiting at least 10 seconds for the tester to produce a beep. This beep indicates that you can begin the scan.
5. After the beep, apply pressure toward insulator string to keep the tester's sled firmly and constantly against the insulator string. Move the tester to the end point of the insulator string then bring it back to the start point (full Scan). A short beep is heard each time a insulator or skirt is successfully scanned.
6. Remove the tester from the insulator string and make sure you hear a continuous buzzing sound. This sound indicates that the scan was successful and that data has been stored in the tester's memory.
7. Press the push button on the probe to turn off its lamp.

Note: The preceding steps enable you to perform a full scan of the insulator string. To perform a one-way scan follow steps 1 to 4. In step 5, don't bring the tester back to the start point. After the end point of the insulator string has been reached, lift the tester away from the insulator string and continue with steps 6 and 7.

Preferred method of scanning for "V" String

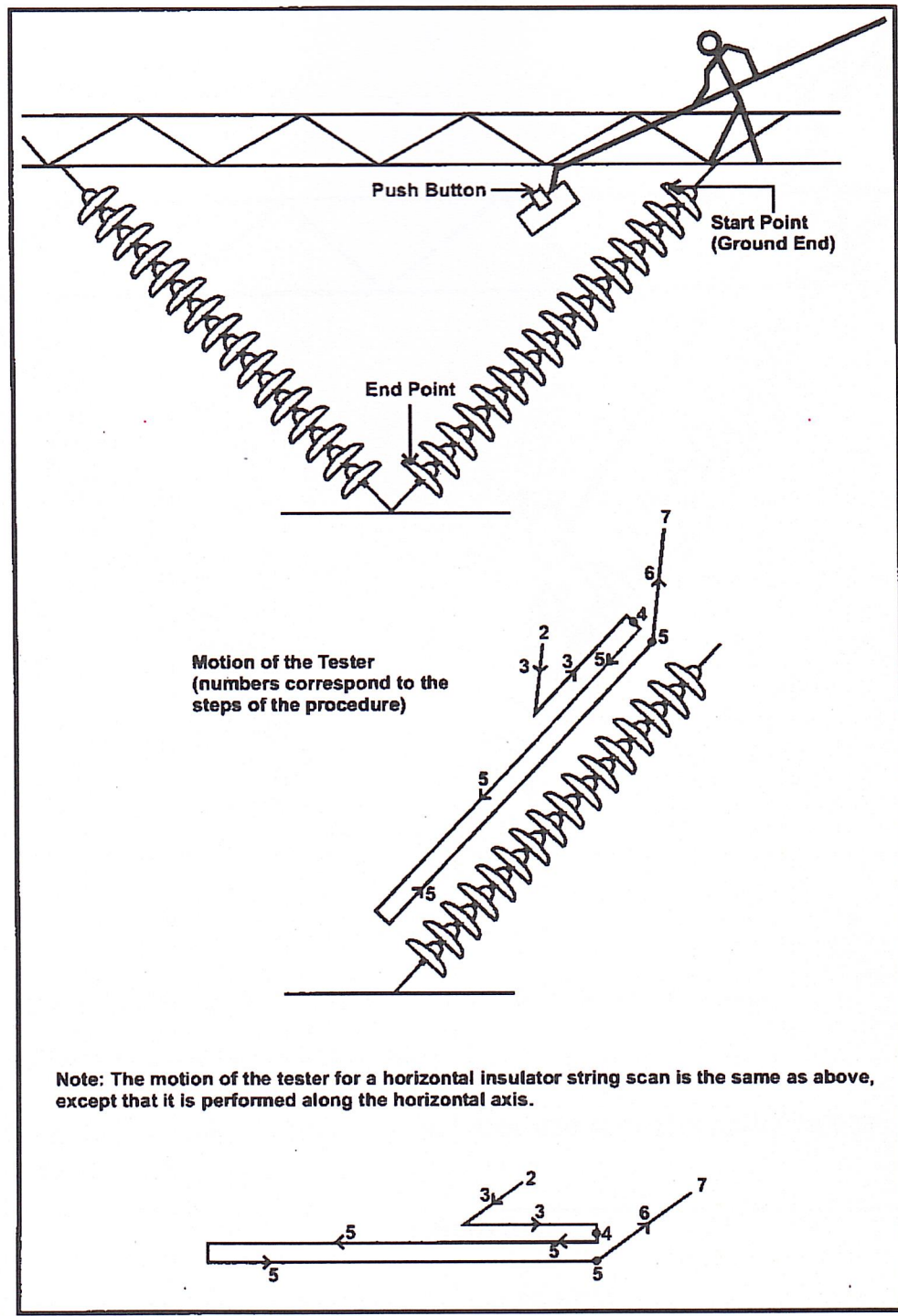


Figure 2

Adjustment of attachment angle of hot stick

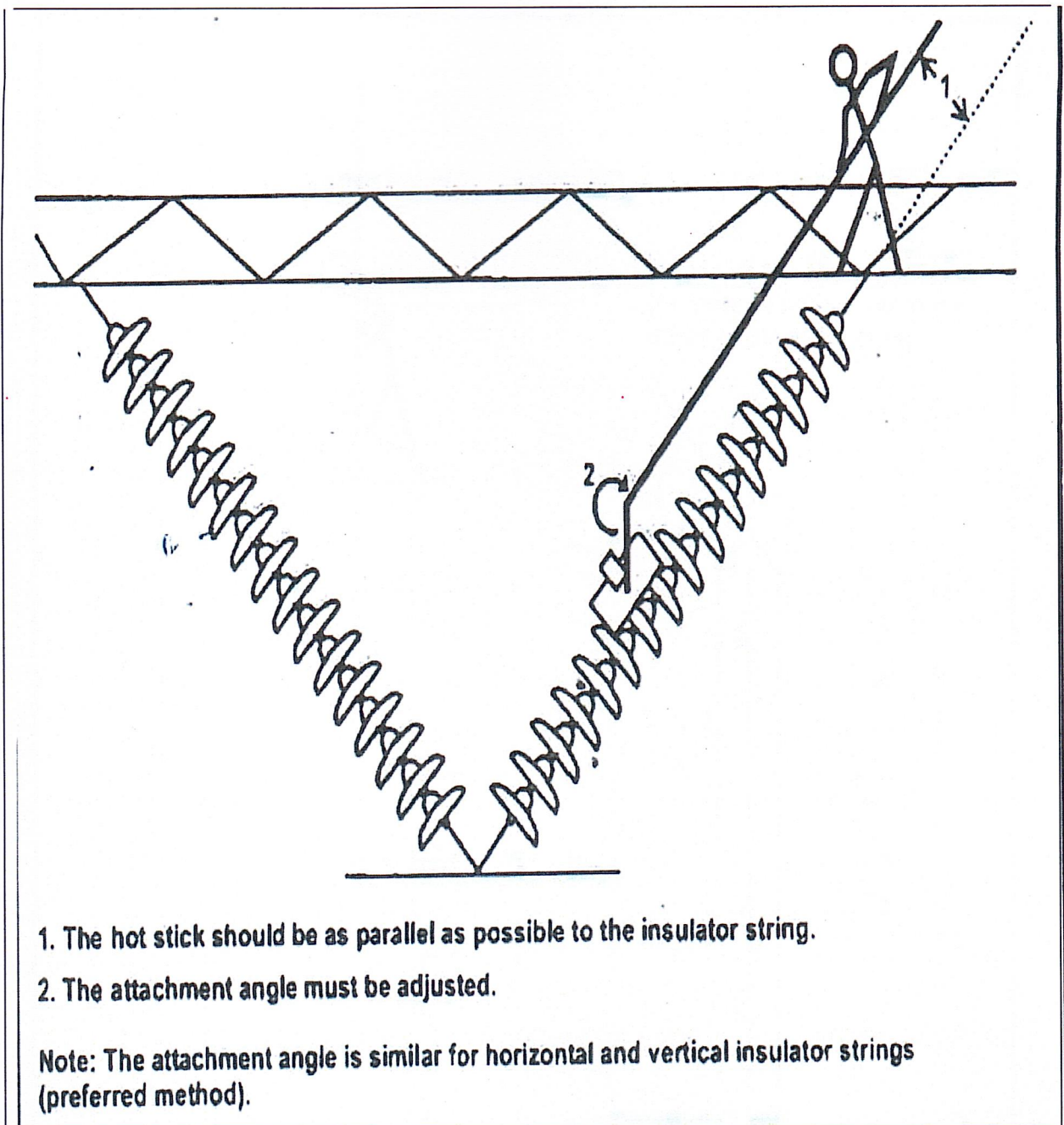


Figure 3

Preferred method for scanning vertical string

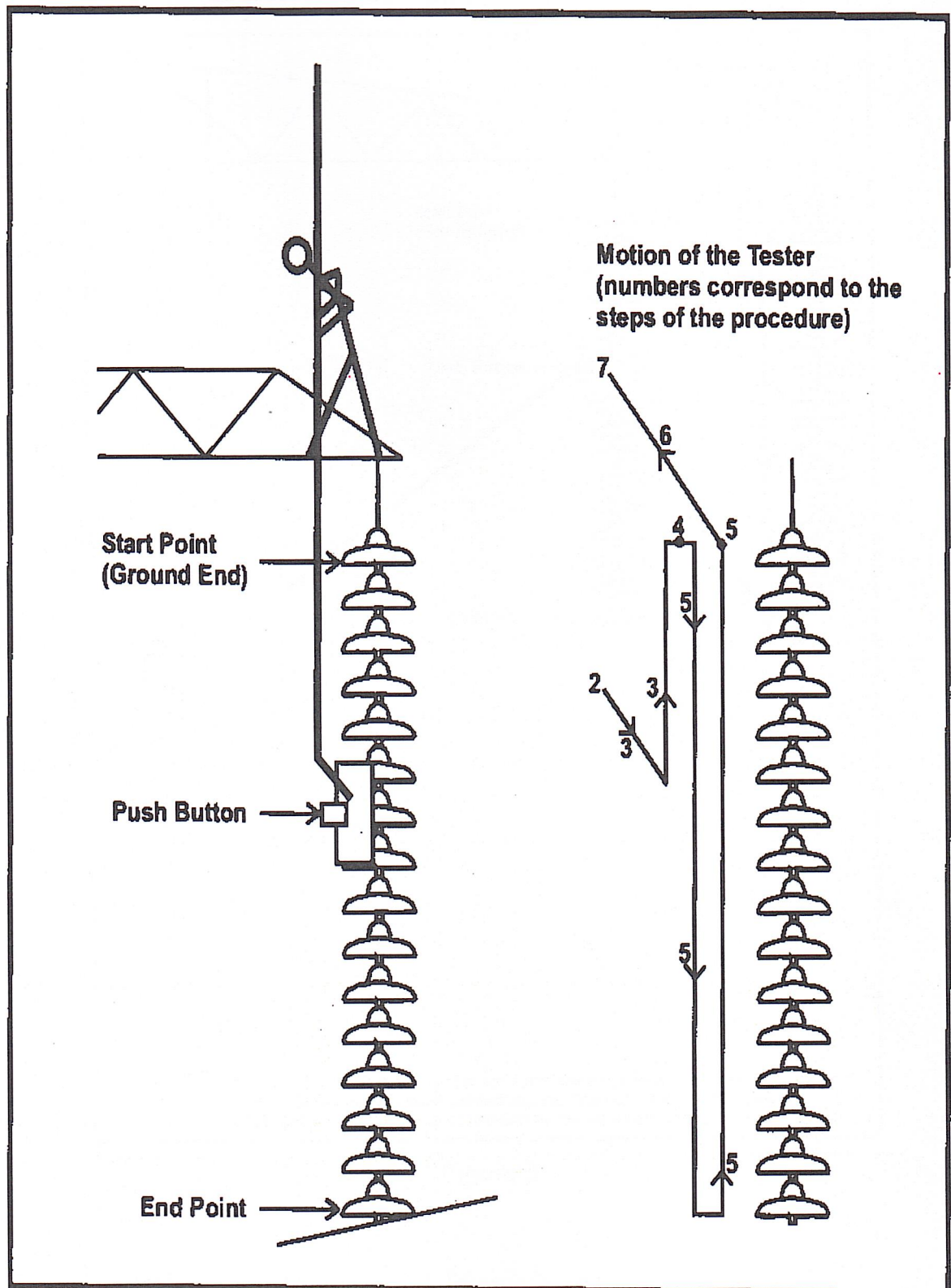


Figure 4

Alternate method for scanning vertical string

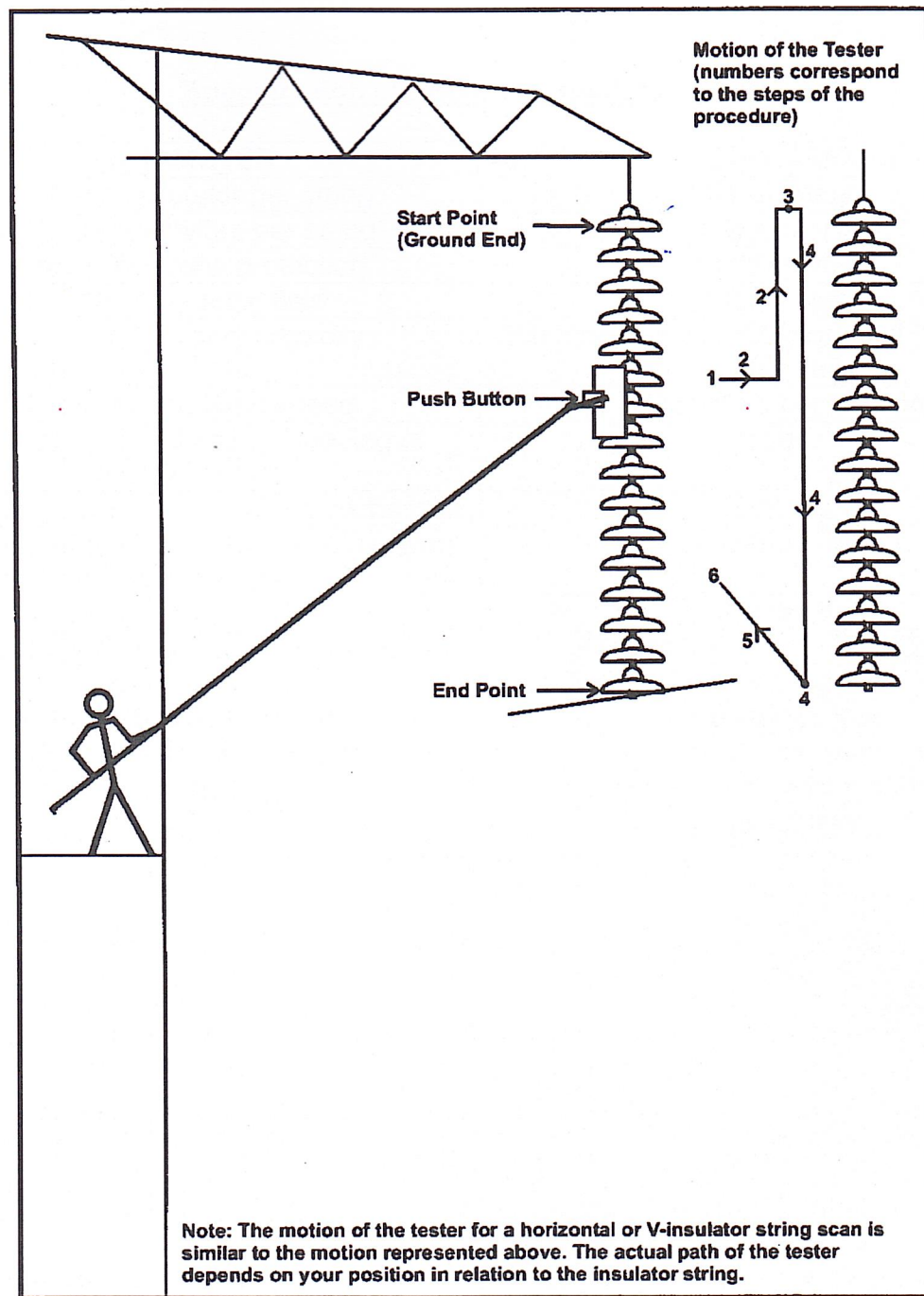


Figure 5

Specification of Porcelain Insulator Tester

PARAMETER	SPECIFICATIONS
Maximum insulator per string	55 insulators
Minimum insulators per string	4 insulators
Maximum corona protection	1 million volt
Minimum electric field	10kv/meter
Maximum memory capacity	300 strings or 15,000 readings, whichever comes first
Maximum scanning speed	6 insulators per second
Maximum time between uploading of cumulative data	10 days
Maximum time between battery recharges	12 hours
Minimum time required for full recharging battery	10 hours(one night)
Time tag update interval	16 seconds
Operating temperature range for probe	-30° C to 50° C (-22° F to 122° F)
Dimensions	35.5 cm x 48 cm x 23 cm (14"x10"x9")
Weight (logger excluded)	1.59 kg (3.5 lbs)
Size of insulator(diameter)	23 cm to 33 cm (9" to 13")
Calibration	500 linear graphical units = 100 kV/meter longitudinally

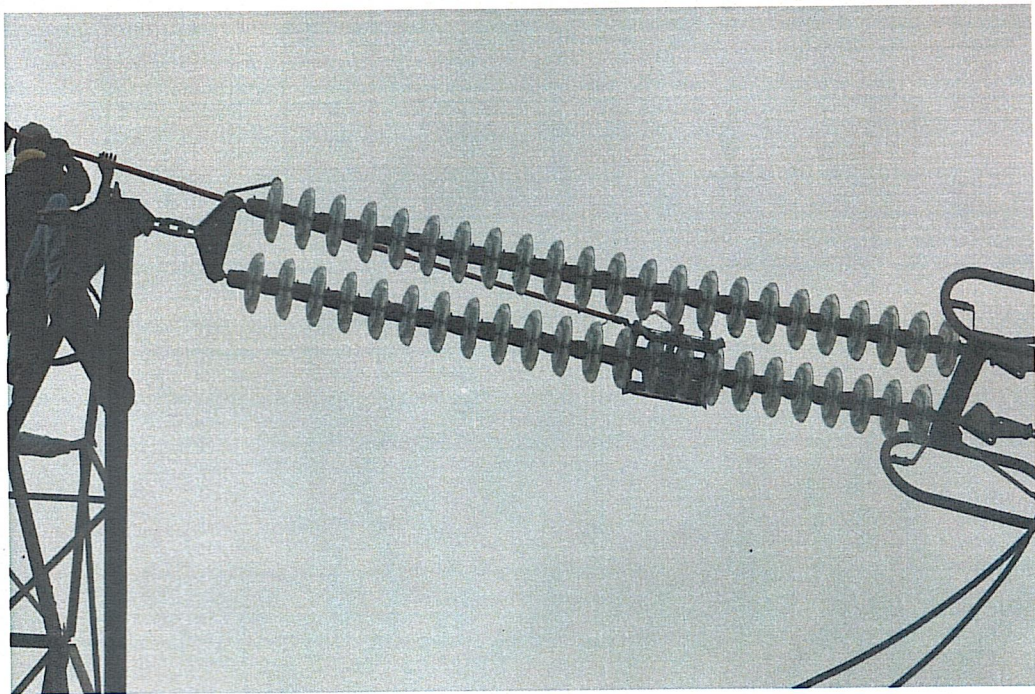
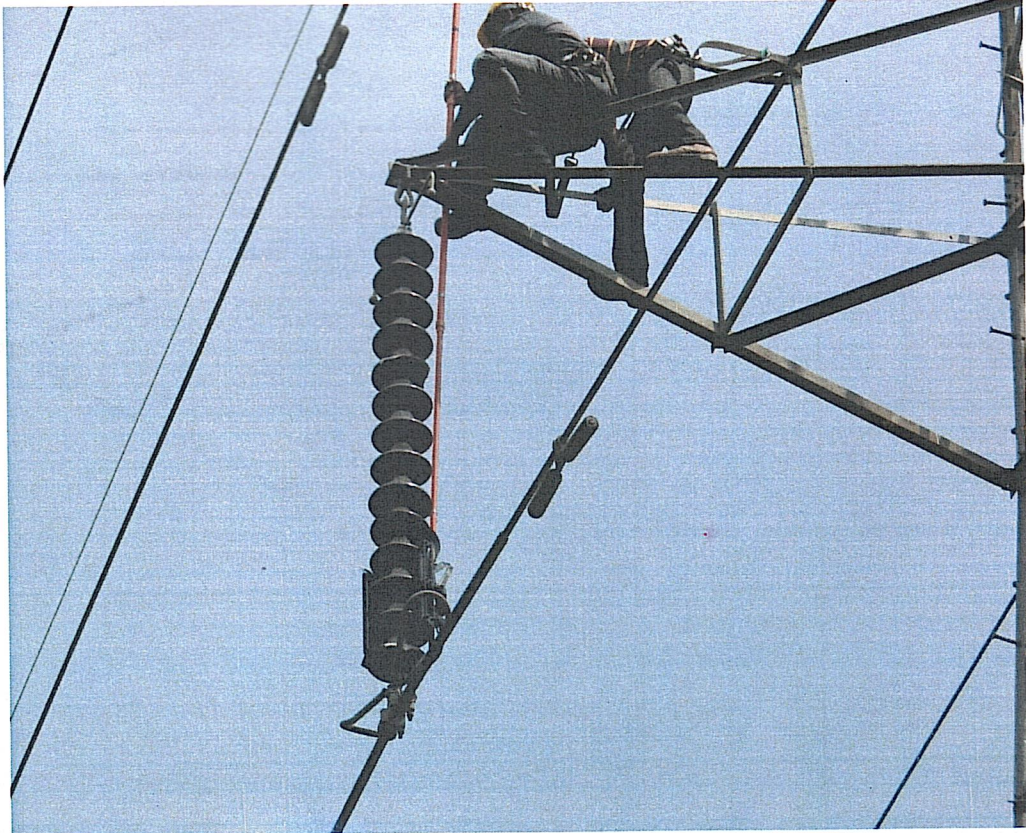
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Live Insulator Testing On 400Kv Tension String



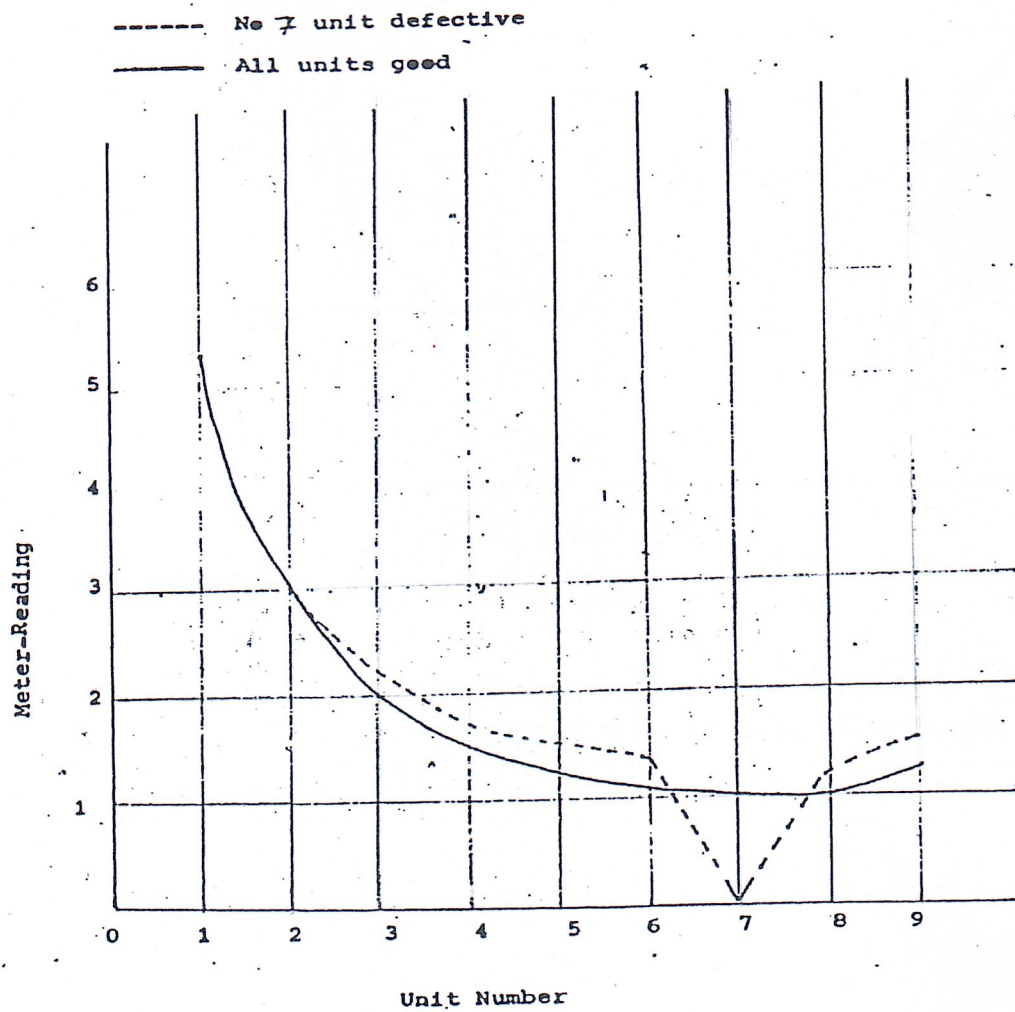
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400 Kv Tension String Testing

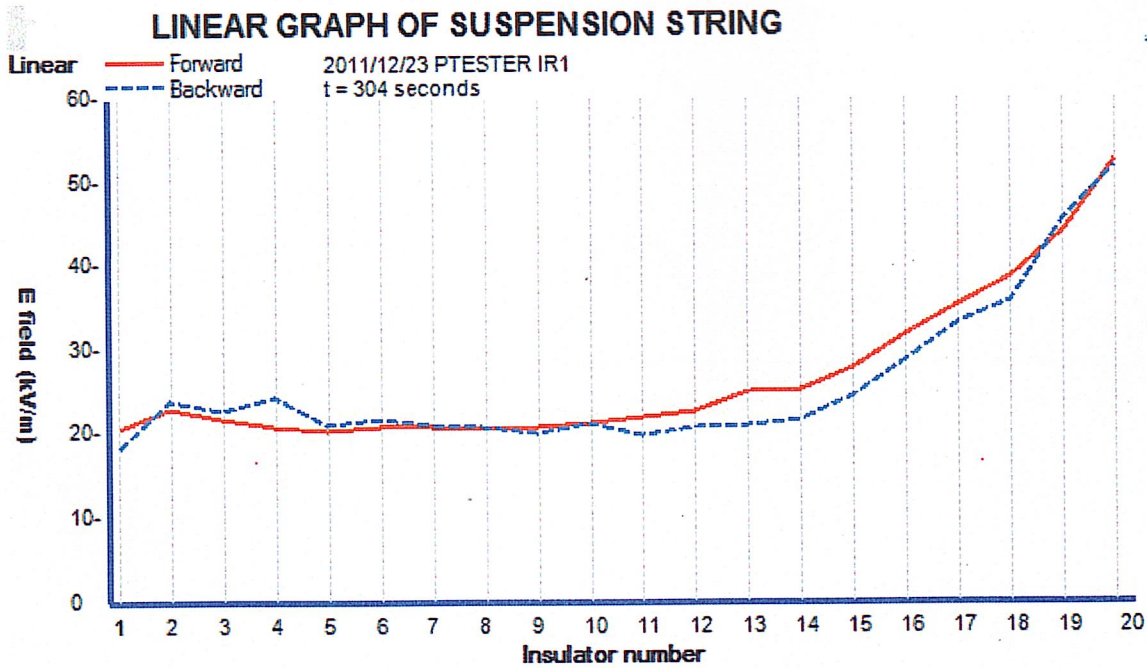
Two preng stick test made on 9 units 64,000 Volts
to grounds.



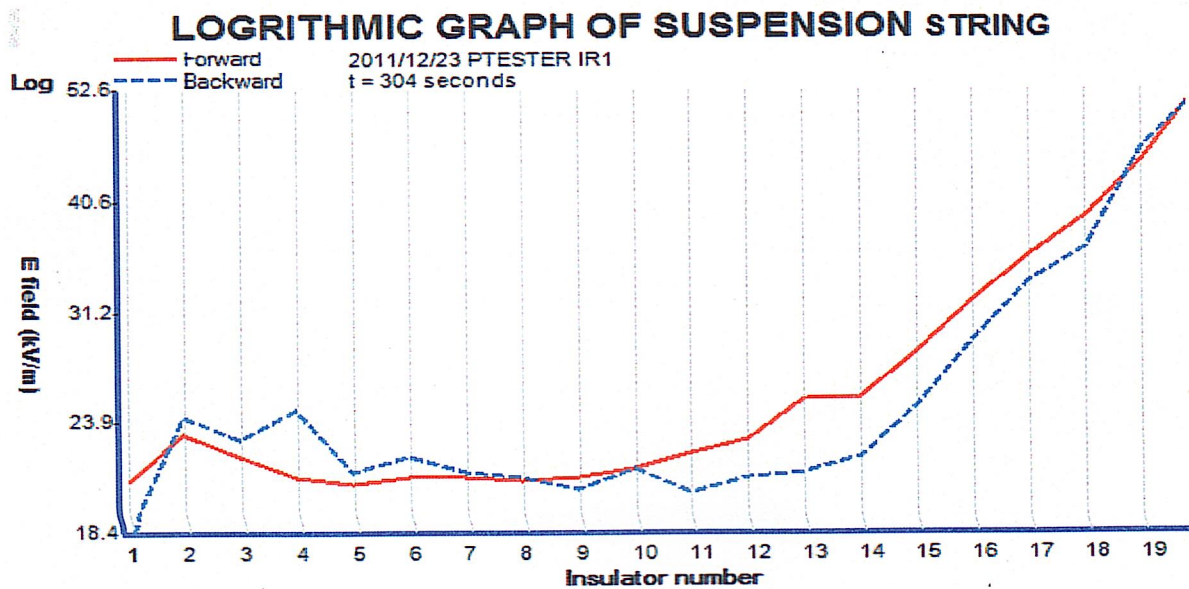
VOTAGE- DISTRIBUTION CURVE

:25:

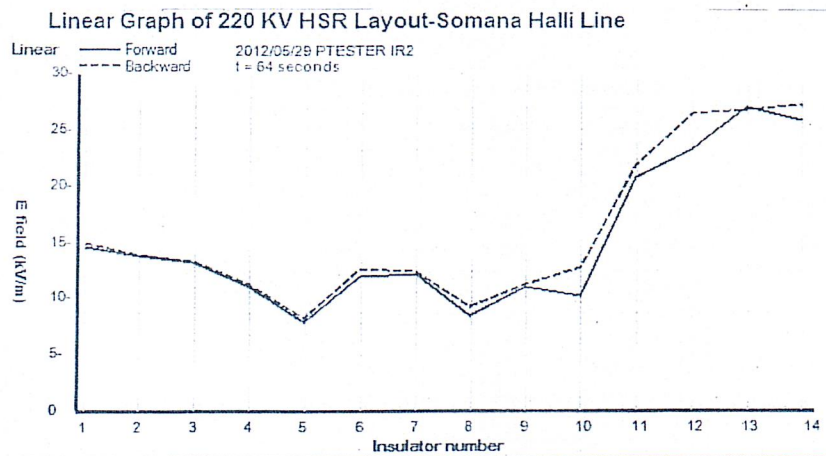
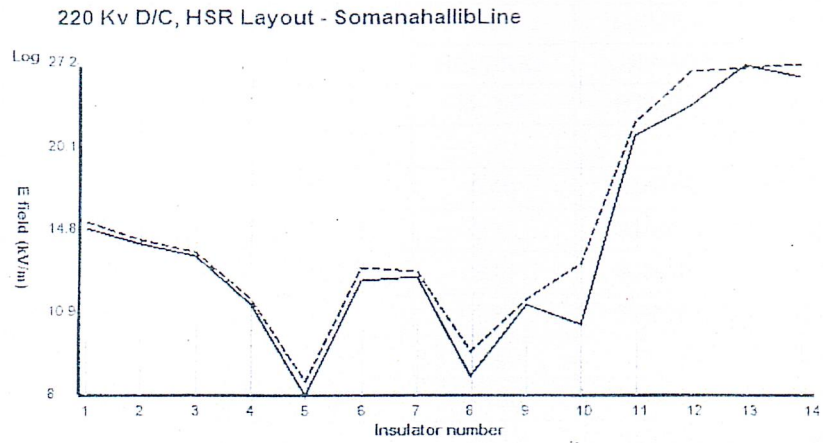
Linear and logarithmic graphs of insulators tested



NELMANGALA GOOTY 400KV S/C LINE



NELMANGALA GOOTY 400KV SINGLE CIRCUIT LINE



Graphs showing faulty insulators

:27:

PID TEST ANALYSIS

Name of the line :		220 Kv, Tension ckt. No. I, Bangalore - HSR Layout				DATE :	09-02-2012
LOC :	001	CIRCUIT:	-	PHASE :	Left (Rφ)	STRING :	Glass
SL. NO	FORWARD	REVERSE	ONWARD	REVERSE	ONWARD	REVERSE	REMARKS
	UNIT MEASURE	UNIT MEASURE	% DIP	% DIP	STATUS	STATUS	
1	88	89	0.00	0.00	IGNORE	IGNORE	5th batch
2	81	83	7.95	6.74	IGNORE	IGNORE	PID Course
3	78	80	3.70	3.61	IGNORE	IGNORE	
4	78	79	0.00	1.25	IGNORE	IGNORE	
5	80	85	-2.56	-7.59	IGNORE	IGNORE	
6	85	90	-6.25	-5.88	IGNORE	IGNORE	
7	91	92	-7.06	-2.22	IGNORE	IGNORE	
8	101	107	-10.99	-16.30	IGNORE	IGNORE	
9	123	135	-21.78	-26.17	IGNORE	IGNORE	
10	141	158	-14.63	-17.04	IGNORE	IGNORE	
11	179	200	-26.95	-26.58	IGNORE	IGNORE	

PID TEST ANALYSIS

Name of the line :		220 Kv, Tension ckt No. I, Bangalore - HSR Layout D/C				DATE :	09-02-2012
LOC :	002	CIRCUIT:	-	PHASE :	Middle (Yφ)	STRING :	Glass
SL. NO	FORWARD	REVERSE	ONWARD	REVERSE	ONWARD	REVERSE	REMARKS
	UNIT MEASURE	UNIT MEASURE	% DIP	% DIP	STATUS	STATUS	
1	74	74	0.00	0.00	IGNORE	IGNORE	
2	70	70	5.41	5.41	IGNORE	IGNORE	
3	66	68	5.71	2.86	IGNORE	IGNORE	
4	55	55	16.67	19.12	ALERT	ALERT	
5	38	40	30.91	27.27	CRITICAL	CRITICAL	
6	60	62	-57.89	-55.00	IGNORE	IGNORE	
7	61	62	-1.67	0.00	IGNORE	IGNORE	
8	43	48	29.51	22.58	CRITICAL	ALERT	
9	54	55	-25.58	-14.58	IGNORE	IGNORE	
10	50	61	7.41	-10.91	IGNORE	IGNORE	
11	104	113	-108.00	-85.25	IGNORE	IGNORE	
12	114	129	-9.62	-14.16	IGNORE	IGNORE	
13	135	137	-18.42	-6.20	IGNORE	IGNORE	
14	129	140	4.44	-2.19	IGNORE	IGNORE	

Calculation Sheet for 220 Kv Bangalore-HSR Layout D/C Line, Tension String
Location No: 2

Analysis of Sample Table:

% of DIP of nth Disc = $\frac{(C_n - 1) - C_n}{(C_n - 1)} \times 100$. (Where n indicates Position of Insulator)

- If the dip Value equals to 25% or more then the respective insulator is in a CRITICAL State and it should be replaced with good disc.
- If the dip Value is in between 15% and 25%, then the insulator is in an ALERT State.
- if the dip value is below 15%, then the insulator is in IGNORE state.

1. "n" = 3: C3=66, C2=70

$$\% \text{ of DIP} = \frac{(C_2 - C_3)}{C_2} \times 100 = \frac{(70 - 66)}{70} \times 100 = 5.71 = \text{IGNORE}$$

2. "n" = 4: C3=66, C4=55

$$\% \text{ of DIP} = \frac{(C_3 - C_4)}{C_3} \times 100 = \frac{(66 - 55)}{66} \times 100 = 16.66 = \text{ALERT}$$

3. "n" = 5: C5=38, C4=55

$$\% \text{ of DIP} = \frac{(C_4 - C_5)}{C_4} \times 100 = \frac{(55 - 38)}{55} \times 100 = 30.90 = \text{CRITICAL}$$

(* refer to the above table)

NOTE: Where C_n = nth number of Disc insulator.

:29:

PID TEST ANALYSIS							
Name of the line :	Nelamangala - Bangalore 400 kV S/C line					DATE :	03/05/2012
LOC :	798/A+0	CIRCUIT:	-	PHASE :	Towards (Bφ)	STRING :	Porcelain
SL. NO	FORWARD	REVERSE	ONWARD	REVERSE	ONWARD	REVERSE	REMARKS
UNIT MEASURE	UNIT MEASURE		% DIP	% DIP	STATUS	STATUS	Tension String
1							
2	300	312	0.00	0.00	IGNORE	IGNORE	
3	282	305	6.00	2.24	IGNORE	IGNORE	
4	266	279	5.67	8.52	IGNORE	IGNORE	
5	254	274	4.51	1.79	IGNORE	IGNORE	
6	210	180	17.32	34.31	ALERT	CRITICAL	
7	134	143	36.19	20.56	CRITICAL	ALERT	
8	166	192	-23.88	-34.27	IGNORE	IGNORE	
9	231	259	-39.16	-34.90	IGNORE	IGNORE	
10	256	265	-10.82	-2.32	IGNORE	IGNORE	
11	279	298	-8.98	-12.45	IGNORE	IGNORE	
12	300	312	-7.53	-4.70	IGNORE	IGNORE	
13	317	327	-5.67	-4.81	IGNORE	IGNORE	
14	254	223	19.87	31.80	ALERT	CRITICAL	
15	249	284	1.97	-27.35	IGNORE	IGNORE	
16	339	349	-36.14	-22.89	IGNORE	IGNORE	
17	391	374	-15.34	-7.16	IGNORE	IGNORE	
18	454	429	-16.11	-14.71	IGNORE	IGNORE	
19	489	485	-7.71	-13.05	IGNORE	IGNORE	
20	510	465	-4.29	4.12	IGNORE	IGNORE	
21	545	520	-6.86	-11.83	IGNORE	IGNORE	
22	1007	916	-84.77	-76.15	IGNORE	IGNORE	

**Calculation Sheet for 400 Kv Nelamangala-Bangalore S/C Line, TensionString
Location No: 798**

1. "n" = 5: C4=266, C5=254

% of DIP = $\frac{(C4-C5)}{C4} \times 100$. $\frac{(266-254)}{266} \times 100 = 4.51 = \text{"IGNORE"}$

C4 266

2. "n" = 6: C5=254, C6=210

% of DIP = $\frac{(C5-C6)}{C5} \times 100$. $\frac{(254-210)}{254} \times 100 = 17.32 = \text{"ALERT"}$

C5 254

3. "n" = 7: C6=210, C7=134

% of DIP = $\frac{(C6-C7)}{C6} \times 100$. $\frac{(210-134)}{210} \times 100 = 36.19 = \text{"CRITICAL"}$

C6 210