New Concept & Methodology to Check the Insulators Health to Enhance the Performance of Overhead Lines by Measurement of Tower Leakage Current & Ultrasound Detection

SUMMARY

The Transmission Line insulators are subjected to many stresses like electrical, mechanical, vibration, excessive heat, cold, dirt, pollution etc. which gradually deteriorates it's IR values over the period of time. More the number of weak insulators in a string, there are more chance of breakdown of the line. Hence one must keep checking the strength of insulators periodically.

Leaky Insulator Detection is a new way of finding out weak insulators in the line, very easily, safely and quickly without climbing up the tower. This paper highlights the concept and importance of Leakage Current measurement on Transmission Tower Leg & Ultrasound Detection on Insulators to Identify the Leaky Insulators for predictive & preventive maintenance.

Essentially two Equipment's are used in this system. One is Tower Leakage Current Meter and the other one is Ultrasound Detector.

Tower Leakage Current Meter: Tower leakage current measurement meter is connected to all the four legs of the tower & leakage current is measured.

Ultrasound Detector: Using Ultrasound Detector, the noise emitted by weak insulators is captured.

The Weak Insulator leaks current to ground and when the leakage current is measured at the tower footing, it shows higher values compared to other towers confirming the deterioration of the insulator. The weak insulator also produces arcing sound internally, which can be picked up by Ultrasound detection method to pin point the leaky insulator.

KEYWORDS

Leaky Insulator, Ultrasound Detection on Insulators,Punctured Insulator, arcing sound, Arcing & Corona

INTRODUCTION

The weak Insulator leaks current to ground and when the leakage current is measured by Leakage Current Detector at the tower footing, it shows higher readings of leakage current compared to other towers confirming the deterioration of the insulator. The weak insulator also produces arcing sound internally, which can be picked up by Ultrasound Partial Discharge detection method to pin point the leaky insulator.

How deterioration of the Insulators lead to Leakage Current & Ultrasound Partial Discharge:

- The Puncture insulator causes leakage current due to loss of insulation. This will lead to flow the leakage current from the tower leg to ground & can be measured with Tower Leakage Current measurement method as discussed below.
- This puncture is associated with arcing noise internally. Detection of Arcing can be done with Ultrasound Detection method as discussed below.
- Gradually over a period of time arcing will deteriorate the insulators & will fail tripping the line.

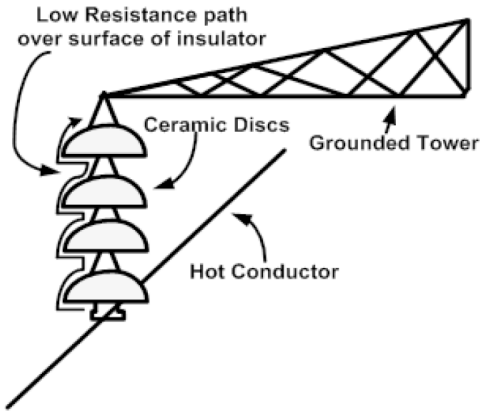


Fig. 1. Low resistance path over the surface of an insulator.

Leakage Current Facts:

The Leakage Current is directly proportional to the Degradation of Insulator.

Arcing & Corona: Leakage Current increases with Arcing and Corona

Good Earthing: This helps the leakage current to dissipate quickly

So, the high value of Leakage Current is the primary information of the Tower healthiness.

Advantages of using LID

- **Analyzing the leakage current of the tower from the ground by tower leakage current measurement methodology will help O&M team for taking right decision towards pin pointing tentative flash over / shorted insulators.**
- **Ultrasound measurement methodology uses to pin point the particular string of the tower by taking leakage currents results.**
- **From ground level leaky Insulators can be identified. No need to climb on tower, no shut down required.**
- **No skill manpower required, Easy & Simple operating procedure.**
- **Single Instrument for all type of Transmission Line Insulators (Glass, Porcelain & Polymer).**
- **Single instrument to locate Leaky Insulators, Corona discharge, Loose hardware Joints & improper addition earthing installation.**

NEW CONCEPT & METHODOLOGY TO CHECK THE LEAKY INSULATOR

New concept has been found to check the Leaky Insulator by measuring the Tower Leakage Current measurement & conducting the Ultrasound Detection typically with on Insulator Strings to Identify the Leaky Insulators. Basically, Methodology has been categorized in two parts as mentioned below.

Fig-A

Step-1:

1. Measurement of Leakage Current at Tower Legs, two setup has been shown & explained: (Any one setup can be used as per requirement of the site)

a) 400mm Diameter CT Sensor- Shown in Fig-2

Step-2:

2. Ultrasound Detection on Insulator Strings to Identify the Leaky Insulators – Shown in Fig-3

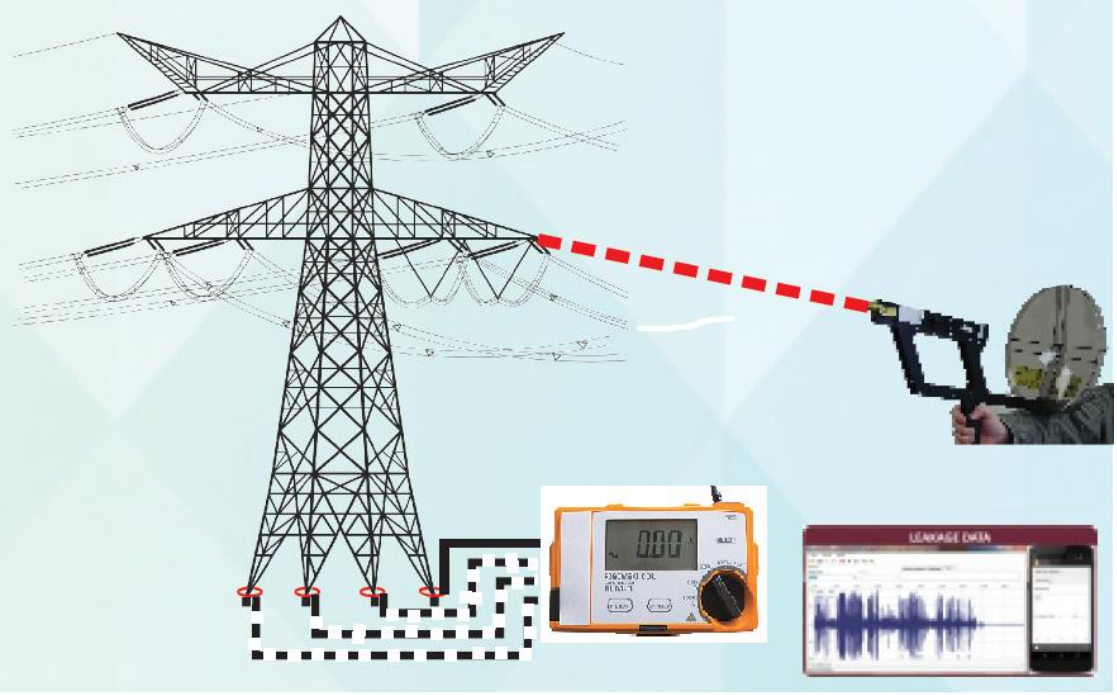


Fig-B

TESTING METHODOLOGY:

Step-1:

MEASUREMENT OF TOWER LEAKAGE CURRENT

1. Clamp the whole leg after the breaching.
2. Extend the whole wire properly so that there should not be any turn.
3. Stretch the whole wire so that it should not touch the ground.
4. Hold the Display unit as low as possible.
5. Power ON the Display unit, select range, wait for 10-15 second to get the stable leakage current value
6. Note down the Leakage Current

400mm Diameter CT Sensor

Fig-1

In First method Leakage current measurement instrument was used having CT diameter of 400mm. CT was clamped on whole leg landing on Tower stub. Equipment display unit was placed on the ground for obtaining the data Shown in Fig 1.

Step-2:

A) Ultrasound Detection on the Leaky Insulator

Ultrasound Detection method has been used to pinpoint the leaky insulator on the transmission tower.

1. Put the gain in "full gain "●" mode
2. On the Receiver, Select 3~3.5 Sensitivity
3. Aim the tower insulator using rifle Structure
4. While scanning, the focussing part of object, Rifle sights and operator's eye should be in Straight Line as shown in fig-5 to pin point the location of Ultrasound discharge & to identify the Leaky Insulator.

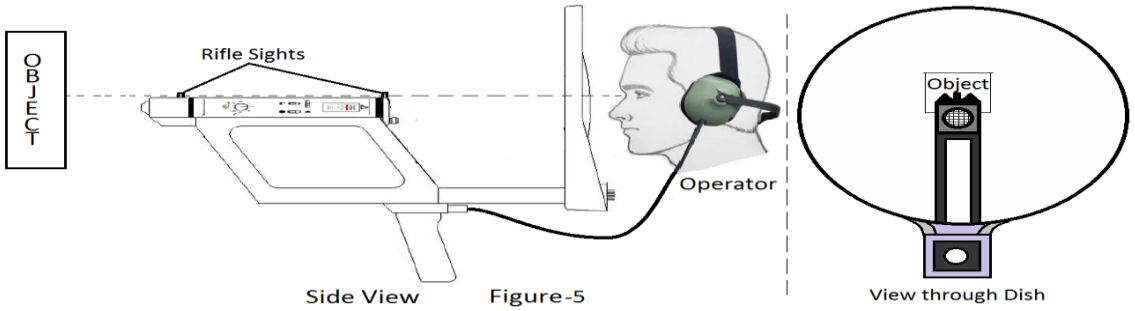


Figure-5

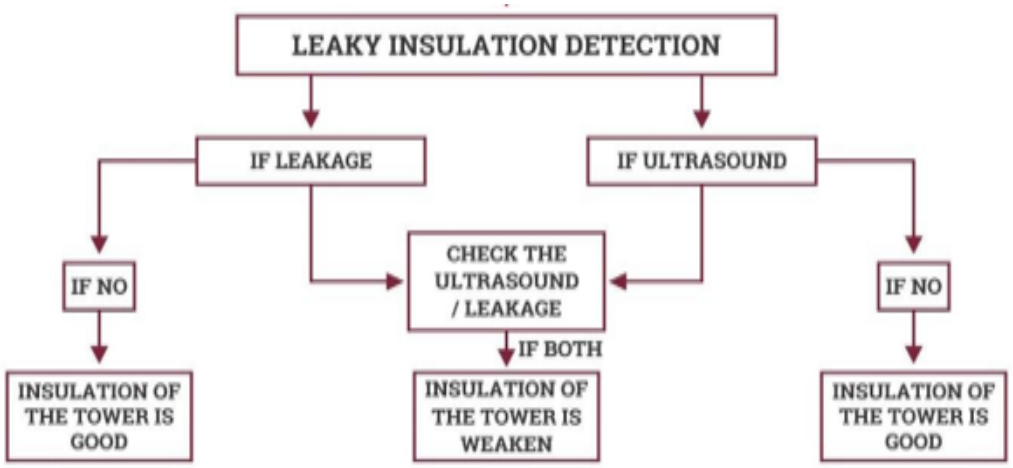
Ultrasound Detection Pinpoint of Leaky Insulator

5. Provision of software analysis:-There is provision of measurement of PD through external devices such as mobile which can directly connected to Ultrasound detector and we can see the output graphs and can confirm the fault/leaky insulators.

Tolerance Level of Leakage Current

HVAC Transmission line voltage level	Abnormal Tower AC leakage current in mA
132 KV Single Circuit	150 mA
132 KV Double Circuit	180 mA
220 KV Single Circuit	200 mA
220 KV Double Circuit	250 mA
400 KV Single Circuit	350 mA
400 KV Double Circuit	400 mA
765 KV Single Circuit	800 mA
765 KV Double Circuit	1000 mA

DECISION CHART:



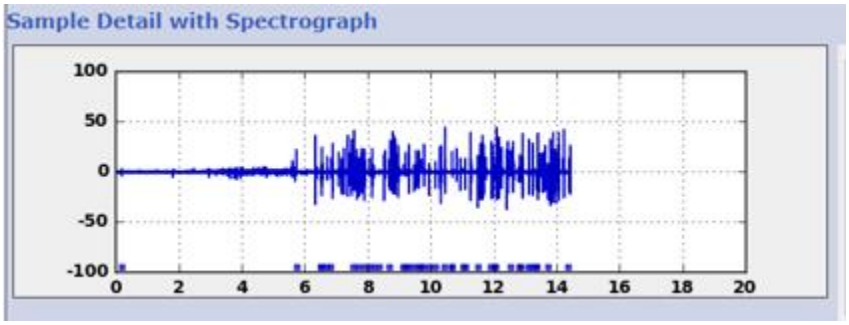
Case studies

PGCIL WR I

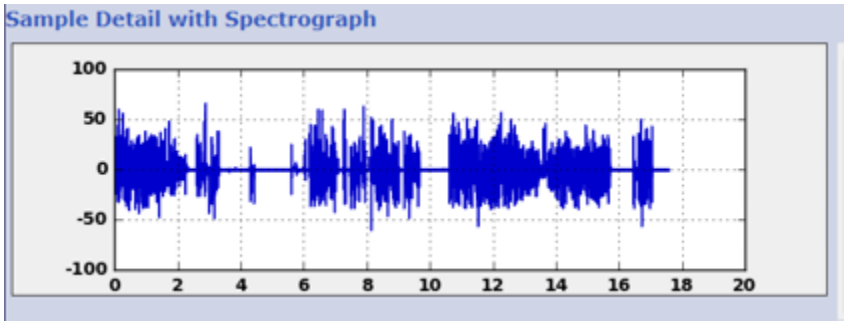
Same is demonstrated in 400 KV SC Korba Bhatapara line and results are as follows;

Sl No	Line Name	Tower Location No	Insulator Type	Tower Leakage Current (mA)				Total leakage current (mA)	Partial Discharge(Ultrasound)Scanning	PID report
				Leg A	Leg B	Leg C	Leg D			
1	400kV Korba – Bhatapara line	193	Porcelain	94	78	114	112	398	Partial Discharge (Ultrasound)observed in Y phase and B phase	Matched with the report
2	400kV Korba – Bhatapara line	194	Porcelain	126	67	98	78	369	Partial Discharge (Ultrasound)observed in Y phase	”
3	400kV Korba – Bhatapara line	202	Porcelain	78	32	114	88	312	Partial Discharge (Ultrasound)observed in Y phase and R phase.No Partial discharge found in PH B	”

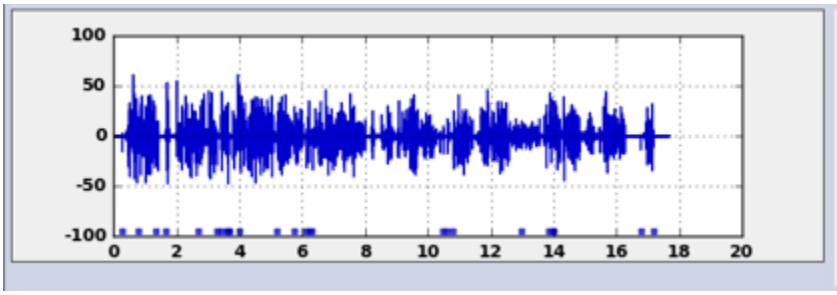
Partial discharge graph (400 KV S/C Korba Bhatapara LOC NO 193 (Y phase)



Partial discharge graph (400 KV S/C Korba Bhatapara LOC NO 194 (Y phase)



Partial discharge graph (400 KV S/C Korba Bhatapara LOC NO 202 (B phase)



CASE STUDY (From POWERGRID Bilaspur):

In 400 KV Korba Bhatapara line measurement of Tower Leakage & Ultrasound Detection carried out to check the healthiness of the Insulators. PID results were already available with Bilaspur TLM team both results have been cross checked with the Data received with new methodology (Tower Leakage Current Measurement & Detection of Ultrasound Noise on the insulator strings)

As per the testing done by POWERGRID Bilaspur team for Tower Leakage Current & Ultrasound Detection, below are the locations where the problematic reading were found

1. Tower Location-218: Observed higher leakage current & Ultrasound has been observed on R & Y Phase. And previous PID data also indicating problem on the same R & Y Phase.

2. Tower Location-219: Observed higher leakage current & Ultrasound has been observed on R Phase. And previous PID data also indicating problem on the same R Phase.

3. Tower Location-224: Observed higher leakage current & Ultrasound has been observed on B Phase. And previous PID data also indicating problem on the same B Phase.

POWERGRID has found the new methodology to measure the tower leakage current & ultrasound detection

Transmission Line Tower data collection Sheet														
sl no	Date	Tower no	Tower type	Leg-A		Leg-B		Leg-C		Leg-D		PDD scanning	PGCIL previous PID report	Remark
				Leg (mA)	Earthing (mA)	Leg (mA)	Earthing (mA)	Leg (mA)	Earthing (mA)	Leg (mA)	Earthing (mA)			
1	5/2/2018	218	A+0	30		123		29		46		Ultra sound observed on R Ph ,Y ph	Problematic Insulator was observed in PID graph	Matched
2	5/2/2018	219	C+0	102	63	29	7	95	31	51	37	Ultra sound observed on R Ph	Problematic Insulator was observed in PID graph	Matched
3	5/2/2018	226	A+0	51		61		11		81		No sound observed	No Problematic Insulator was observed in PID graph	Matched
4	5/3/2018	231	A+0	41		80		22		56		No sound observed	No Problematic Insulator was observed in PID graph	Matched
5	5/3/2018	207	A+0	90	93	-	-	224	216	-	-	No sound observed	No Problematic Insulator was observed in PID graph	Matched
6	5/3/2018	198	A+0	216	251	9	30	89	167	158	44	No sound observed	No Problematic Insulator was observed in PID graph	Matched
7	5/4/2018	224	A+0	30	77	170	168	55	74	60	117	Minute non Continuous sound observed on B ph	Current PID report shows problematic insulators	Matched
8	5/4/2018	227	A+0	289	361	224	351	68	55	173	125	Minute non Continuous sound	Current PID report shows problematic insulators	Matched

to check the healthiness of the insulators is useful for the identification of faulty insulator stings before PID, which will help in predictive & preventive maintenance and to optimise the uptime of the transmission line

Case study at PGCIL NR I

Same results have also been checked for 220 KV and 400 KV transmission lines having polymer insulators and results are as below;

Tower No	Line Name	Leakage Current in mA					Ultrasound Remarks
		Leg-A	Leg-B	Leg-C	Leg-D	Total	
4	400 kV KOTA-MERTA	55	89	56	49	249	No Ultrasound found
3	400 kV KOTA-MERTA	33	47	49	40	169	No Ultrasound found
21	220 kV RAPPB-DEBARI	24	32	60	78	194	No Ultrasound found
21	220 kV RAPPB-CGH	77	70	35	56	238	No Ultrasound found
21	400 kV RAPP-KOTA	140	20	40	40	240	No Ultrasound found
23	400 kV RAPP-KANKROLI	6	60	75	118	259	No Ultrasound found
22	400 kV RAPP-KANKROLI	120	160	168	169	617	Ultrasound found on Y-phase CKT-II
14	400 kV RAPP-KANKROLI	113	110	67	120	410	Ultrasound found on bottom phase CKT-I
15	400 kV RAPP-KANKROLI	26	97	80	85	288	No Ultrasound found
16	400 kV RAPP-KANKROLI	110	60	30	180	380	Ultrasound found on R-phase CKT I
17	400 kV RAPP-KANKROLI	30	-	-	-	-	No Ultrasound found
18	400 kV RAPP-KANKROLI	50	30	70	60	210	No Ultrasound found
20	400 kV RAPP-KANKROLI	50	130	110	120	410	Ultrasound found on R and Y phase CKT I
21	400 kV RAPP-KANKROLI	30	20	90	50	190	No Ultrasound found
6	400 kV RAPP-KANKROLI	70	60	110	40	280	No Ultrasound found
5	400 kV RAPP-KANKROLI	20	60	20	50	150	No Ultrasound found

Case study at PGCIL SR II

400 kV NNTPS-ARYL Powergrid Transmission Line (Polymer Insulators)						
Tower No.	Leakage Current Measurements in milli-Amp on 31st August 2021					
	Leg A	Leg B	Leg C	Leg D	Total	Weak Insulator String scanned by (Ultra Sound detector)
141	46	124	98	125	393	B Phase ARYL Right side ckt 2 Y Phase ARYL Left side ckt 2 Y Phase NNTPS Right Side ckt 1 B Phase ARYL Right Side ckt 1 R Phase NNTPS Right Side ckt 1 R phase ARYL Left side ckt 2
166	188	158	126	131	603	B phase NNTPS Right Side ckt 2 Y Phase ARYL Right Side ckt 1 R phase ARYL Left Side ckt 1
167	57	71	88	26	242	No Weak Insulator Found

Case Study at PGCIL ER II

400 kV Dual Circuit MLD-NPRN Transmission Line (Polymer Insulator)						
Tower No	Leg A	Leg B	Leg C	Leg D	Total mA	Weak Insulator String scanned by (Ultra Sound detector)
1126	28	45	120	8	201	No Ultrasound Detected
1127	59	19	41	69	188	No Ultrasound Detected
1125	4	7	27	30	68	No Ultrasound Detected
1124	144	28	153	32	357	Ultrasound detected on Ckt-1 R phase
1122	36	11	28	14	89	No Ultrasound Detected
1120	22	13	23	7	65	No Ultrasound Detected
1119	30	33	6	64	133	No Ultrasound Detected

Case Study at OPTCL

220kV MENDHASAL-CHANDAKA CKT-III Line										
Tower No.	Leakage Current Measurements in milli-Amp on 7th & 8th October 2020									Ultrasound Remark
	Leg A	Earth	Leg B	Earth	Leg C	Earth	Leg D	Earth	Total	
499	3	167	1	179	6	2	1	NA	359	CKT-IV-B PHASE STRING, CKT-II B PHASE HARDWARE JOINT
482	3	NA	9	NA	3	NA	6	Na	21	CKT - III Ultrasound on B Phase Hardware Joints
220kV MENDHASAL-CHANDAKA CKT-I & II Line										
55	4	32	2		17	NA	9	NA	64	CKT-II Y Phase Hardware Joint Towards Mendhasal

From the above result it is found that abnormal leakage current was found in the tower legs having faulty polymer insulators and same is also cross verified by detection of ultrasound in faulty insulators.

Conclusion:

All weak insulator towers have high leakage current. And the above-mentioned methodology to measure the tower leakage current & ultrasound (Arcing) Detection along with the tower footing resistance & impedance measurement is the latest combined methodology to identify the faulty insulators on the EHV/UHV Transmission Line. Remedial action based on the findings using above method can enhance the performance of Overhead Lines.

Using this technique thousands of towers are checked for healthiness of insulators and this method is found very effective.