400KV HCB ISOLATORS FAILURES AFTER COMMISSIONING – DIAGNOSIS & RECTIFICATION AT NTPC/ VINDHYACHAL SWITCHYARD

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ABSTRACT

Repeated Hot spots / Failures of 400KV HCB Isolators of newly commissioned NTPC Vindhyachal stage- V Switchyard has let to root cause analysis and paved way for reviewing the design aspects of said HCB Isolators.

This paper highlights the case study and efforts for

- Diagnosis of repeated Hot spots of newly commissioned 400 KV HCB Isolators of Switchyard Stage-V by Thermovision scanning.
- Analysis and pinpointing of root reason for the said issue of Hot spots at Terminal Housing of HCB Isolators.
- Pursuing OEM M/S Siemens for analyzing and testing the said isolators at works to ascertain the issue.
- Root cause analysis and through testing which let for design changes by increasing the hardness, material composition and dimensions in the said Isolators.
- Testing and analysis of results on the modified HCB Isolators and further corrections.
- Making Road map for replacement of all HCB Isolators terminal housing with modified terminal housing at NTPC Vindhyachal Switchyrad Stage-V .
- Recommendation and communication to other NTPC Sites where such isolators are installed for modification and replacement of terminal housing.

INTRODUCTION

NTPC / Vindhyachal Super Thermal Power Station has the capacity of 4760 MW with following-

- Vindhyachal Stage-I 400KV Switchyard was commissioned in the year 1986
- Vindhyachal Stage-II 400KV Switchyard was commissioned in the year 1998
- Vindhyachal Stage-III 400KV Switchyard was commissioned in the year 2007.
- Vindhyachal Stage-IV 400KV Switchyard was commissioned in the year 2011.
- Vindhyachal Stage –V 400KV Switchyard was commissioned in the year 2015

400 KV Horizontal Centre Break (HCB) Isolators are there in the Switchyard for providing isolation in the Ckt for maintenance activities in that circuit. These Isolators are operated under no load condition i.e when the Circuit Breaker of that bay is in OFF condition.

Figure-01 HCB Isolator in 400KV Switchyard.

These isolators are operated under no load condition but during normal condition when the circuit is under load , these Isolator carries full load current and also during fault these isolators are designed for and carries heavy fault current .

Healthiness of Isolators are very critical for reliable operation of any electrical circuit as Hot spot in the Isolator may lead to

- Forced shut down of the Generator or Transmission Circuit for attending that hotspot or otherwise untoward situation may come as melting of Isolator part would be there .
- Restoration of system takes time as attending of hot spot of the Isolator may demand for Bus shut down isolation too , so outage losses may be huge.
- No continuous monitoring of the Hot spot are there as thermovision are been carried out in intervals of month so if any hot spot appears in between then that hot spot may go

unnoticed and may lead to untoward situation damaging the Isolator and then tripping the ckt and also pose safety hazards.

Material composition and design of Isolator plays a very vital role in long run as once installed these isolator are supposed to serve for >25 years . Design and Material composition testing at works before supply of materials to site ensures its healthiness in test conditions but through monitoring and observations after commissioning of Isolator on load conditions at site may ensure its healthiness in site conditions and maintenance free service for its life .

Testing and monitoring of Isolators after commissioning ensures its healthiness in site conditions and further if any issues are there then that can be taken up with the manufacturer at initial stages of its service for deliberation and rectification so that the system may be trouble free for long run.

Here is a Case Study of Repeated Hot spots / Failures of 400KV HCB Isolators of newely commissioned NTPC/ Vindhyachal stage- V Switchyard at site , which let to root cause analysis and paved way for reviewing the design aspects of said HCB Isolators.

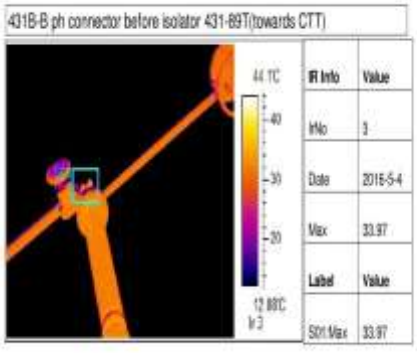
CASE STUDY—

400KV HCB Isolators , supplied by M/S Siemens was installed and commissioned at NTPC Vindhyachal Switchyard Stage-V in the year 2015 . Stage V Switchyard is on the platform of One & Half Breaker scheme , 32 sets of Isolators are Installed over there .

M/S Siemens has taken over the works of M/S Elpro at Hyderabad and from there they had supplied these Isolators in 2015 to NTPC Vindhyachal . M/S Siemens had also supplied HCB Isolators to other NTPC Sites like NTPC Lara , NTPC Kudgi etc in 2013-2014 and also to other Power Utilities.

After commissioning of these HCB Isolators in July 2015 , thermovision scanning has been carried out but nothing noticeable observed as load on the circuits were quite low as during initial stages of commissioning loads on the circuits used to be low , but after full commissioning and commercialization of Unit -13 in Oct 2015 load on the circuit increased and then after 06 months thermovision of the circuit reported for various Hot Spots .

The Hot spots were in the range of 40 -60 degree centigrade, OEM Siemens clarified that these Hot spots may be due to fine dust ingress at the contacts and may go out with time .



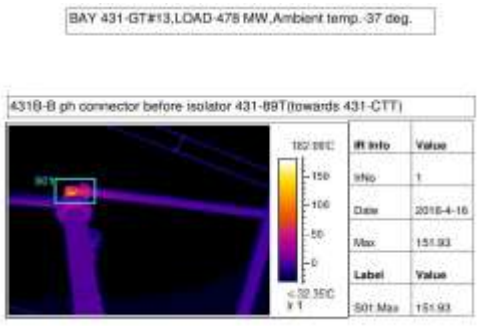


Figure 02 - Thermoscanning of Isolators.

Hotspots in the numbers of Isolators at full load that too just after the six months of commissioning was something that requires further investigation and attention and further it was apprehended that during fault conditions these Hot spots may even melt the contacts and pose serious issues. So decided to have through checking on the Isolators as during that time mandatory spares were there with NTPC for repair / replacement.

In the month of July 2016 , 02 sets of Isolators where 60-65 degree hotspot were there are taken out of service after being replaced with the available mandatory spare, these 02 Isolators then dismantled and following are the observations –

- Terminal stems of the Terminal Housing were found partially melted
- The contact grease found completely dried up.
- MultiLams contact could not be traced as completely burnt.
- Terminal stem of the moving contact assembly found stuck with each other, it was very hard to dismantle (they were found stuck due to melting).

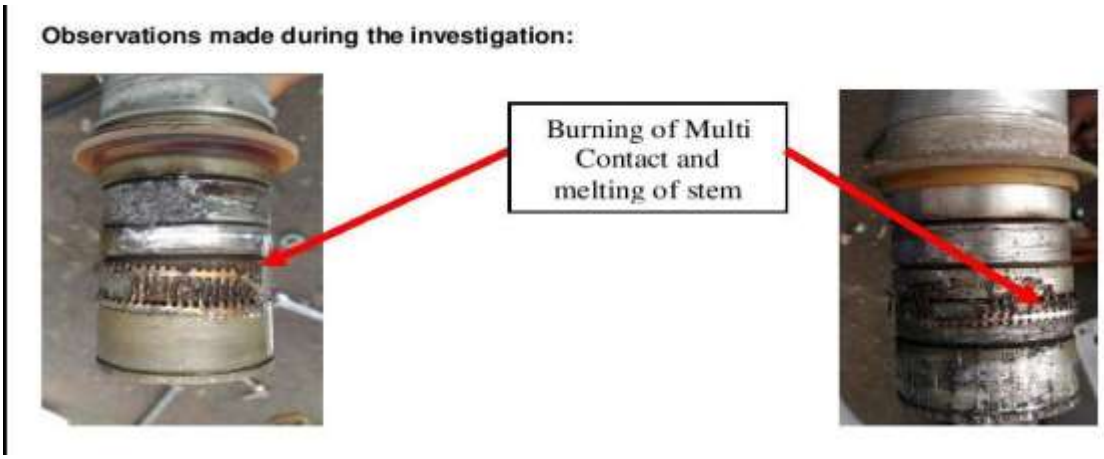


Figure-03 Terminal Housing Assembly

Observation on both set of Isolators are almost similar and at the same location so envisaged for similar type of problem.

In the month of Aug 2016 , 03 set of Isolator with 50-55 degree of Hot spot were taken out of service and dismantled for investigation, here also the observation are similar to above with some add-on like -

- One terminal assembly partially got burnt in one phase out of three phase Isolator.
- Two terminal assemblies got completely burnt in one phase of second Isolator.
- Third Isolator one terminal assembly got partially burnt in one of the three phases.
- Multi contacts found to be burnt and also pitting marks observed on the terminal stems and housing in partially burnt terminals.
- Rain hood cover to terminal housing become hard and brittle in one Isolator.
- Rain hood was found on two of the terminal stem assembly but in partially burnt condition.

- Circlips which keeps the terminal stem in position were found missing.
- POM bushes found change in color.
- Pitting mark observed at few locations in stem housing.
- Multilam are discolored and black slush deposited on the surface of multi contact lovers.

The matter then deliberated with M/S Siemens for Root cause analysis as Hot spots were similar in nature and occurring repeatedly at same location in the Isolator i.e at terminal housing.

Terminal Housing of the Isolator (05 no.) with terminal stems, multi contacts couriered to Siemens works at Hyderabad for further RCA and investigations.

On receipt of the burnt terminal stems, multi contacts and terminal housing at works, the investigation was carried out by M/S Siemens as –

Observations –

- Connector resting on circlip and no gap found between Circlip & Terminal Connector.
- Lower circlip missing.
- Remaining parts of the terminal housing assembly are not in reusable form due to suspected arcing resulting in pitting.
- Multi contacts were found to be dislocated.

Investigation-

- Progressively due to operation of Isolator, circlip lug got obstructed leading towards opening of circlip and thrown off, this may be due to tight fitment of terminal connector over the circlip.
- Circlip thrown off leads to lateral movement of stem and displacement of POM Bush resulting in disturbing the concentricity of stem with respect to stem housing which further results in non-uniform pressure between stem and multi contacts causing non-uniform flow of current resulting in overheating and burning of stem and melting of stem and stem housing.
- It is also suspected that the splashing of water during rains causing arcing between the terminal and multi contacts resulting in pitting of the contacts. Pitting on contacts resulted in increased resistance giving rise to hot spots due to excessive heating leading to burning of terminal stem first and multi contacts thereafter.

All these observation and investigation apprehended for workmanship issues during assembly of Isolator at site. As an immediate disposable action terminal housing spares sent to site by M/S Siemens along with their service engineer for carrying out required proper assemblies on the Isolators.

Later on again in the month of Sept 2016, Rectified Isolators were scanned with thermovision cameras and this time also Hot spots observed in the Isolators at the Terminal Housing locations .Owing to gravity of the situation it was decided for joint investigation at Siemens works .

Observations –

- Out of 8 Nos assemblies, the current transferring contact area of 06 Nos assemblies were burnt out.
- Discoloration of Multilam was observed in balance 02 Nos of assemblies .
- Impressions / fine grooves were observed at the contact area of the Multilam on the shaft.
- Black slush was found on Multilam.

- Contact resistance checked and found to be 500 micro-ohm, but after cleaning of the said slush the resistance improved to 13.2 micro ohm.

To understand the assembly, the team witnessed a new assembly and tested the contact resistance and found out 12 micro ohm.

Root cause –

- The cause of the Black slush may be rubbing powder generated during operation of Isolator and the Hot spot may be due to the impressions appearing on the stem which might be creating gap over a period of time causing heat generation. This may be due to inconsistency of hardness of the stem .
- The copper plating and the tin plating of the stem and the housing might not be consistent, due to which Multilam may become loose and thus subsequent increase in resistance cause heat generation leading to burning of stem.

On the basis of above following points were addressed on the HCB Isolators–

- **The terminal Stem material hardness reviewed and has been changed from 80 BHN to 95 BHN (AC 64)**
- **The terminal housing hardness reviewed and has been changed from 95 BHN to 120 BHN(AC 100)**
- **Copper and Tin plating check point has been included in the quality assurance plan.**
- **Locking ring has been provided on the multilam for securing the position as well as preventing the rotation on the stem.**
- **Rain hood cover material modified to PA 66 and also thickness increased to prevent breakage as well as withstanding to environment conditions.**
- **V seal arrangement has been provided to prevent ingress of dust and water in terminal housing assembly.**
- **Graphite oil is being used at contact locations.**
- **All POM Bushes (Bearing bushes) have been modified to TEFLON glass filled to enhance the mechanical strength as well as thermal withstand capability**

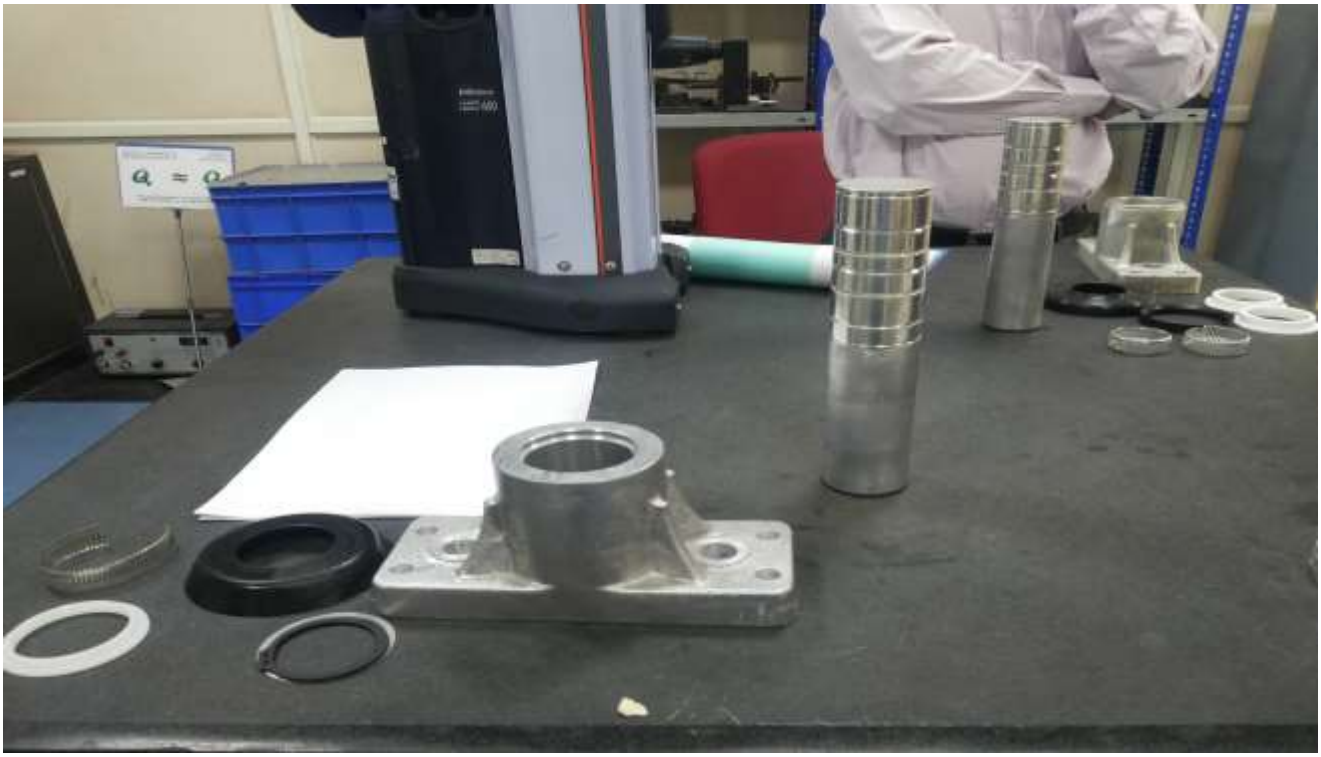


Figure -04 Terminal stem Hardness increased to 95 BHN , Housing Hardness increased to 120 BHN.

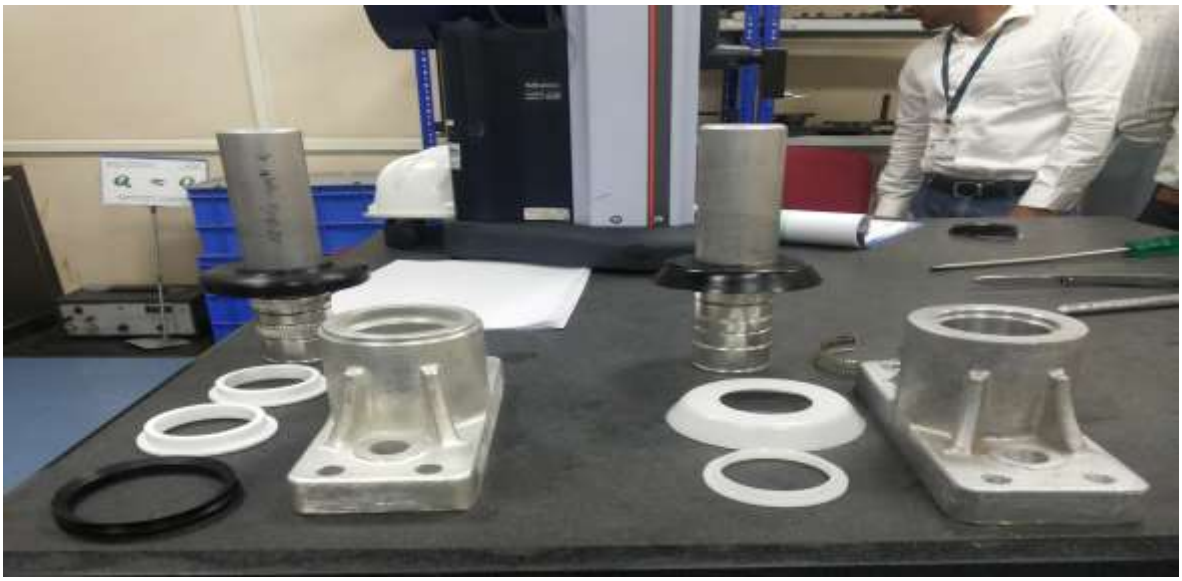


Figure -05 POM bushes modified to Teflon , V seal arrangement provided .

The 400KV Isolator with Terminal Assembly with above modifications has under gone Temperature rise test on the current path followed by Mechanical Endurance test for 2000 cycles.

Figure – 06 Temperature rise test on modified design Isolator

Figure -07 Mechanical Endurance test .

The test results of temperature rise carried out before and after 2000 close- open operation are found to be well with in the specification limits of IEC 62271-102.

Annexure – I

DATE: 8/11/2016

420KV-2000AMPS-HCB Disconnector

TIME	CURRENT PASSED IN AMPS	AMB TEMP IN °c	Temperature Measured at various points							
			1 (F)	2 (F)	3	4 (F)	5 (CM)	6 (C)	7	8
12.00	2000 A	26.4	26.4	29	28	29	29.5	26.6	26.8	26.9
13.00	2000 A	26.5	68	68.5	65.2	69	63.1	43	37	39
14.00	2000A	27	43.4	70.3	72.1	74	71	48.7	42	42
15.00	2000 A	27.1	44.3	72	75.1	76	72.1	50.4	41	43
16.00	2000 A	27	44.9	72.3	76.8	76.6	73.5	50.6	41	43.6
17.00	2000A	27	45.2	72.6	77.4	77.3	74.2	50.4	40.3	42.9

Resistance before test: 134 MΩ

Resistance after test: 130 MΩ

Ambient Temp before test: 26 °C

Ambient Temp after test: 25°C

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Annexure – VII

14/11/16

DATE: 14/11/16

420KV-2000AMPS-HCB Disconnector

TIME	CURRENT PASSED IN AMPS	AMB TEMP IN °c	Temperature Measured at various points							
			1 Fc stem	2 Fc arm	3 Fc Jaw	4 Mc tip	5 Mc arm	6 Mc stem	FC 7 Mc housing	MC 8 Fc housing
12.10	Initial	25.6	26.8	27.1	27.0	27.0	26.2	26.7	27.0	26.8
13.10	2000A	25.2	45	70	65	66.3	64.2	47	50	53
14.10	2000A	26.7	49.5	72.3	71.1	72.9	65	51.1	54	57
15.10	2000A	26.3	50.0	72.4	72.9	74.7	66.4	51.5	54.2	56.9
16.10	2000A	26.6	50.7	72.7	74.7	76.9	66.6	51.6	54.5	56.9
17.10	2000A	26.5	50.7	73.1	75.0	77.2	66.5	51.7	54.6	57.3

Resistance before test: 140 μΩ

Resistance after test: 141.8 μΩ

Ambient Temp before test: 25.6 °c

Ambient Temp after test: 25.9 °c.

15/11

Nilesh Ghosh 15/11

15/11/16

After completion of above tests , terminal housing was dismantled for inspection –

Observations –

- No dimensional variation is observed on the Terminal Housing and the stem.
- Slight impression has been observed on the terminal stem and on balance components no wear and tear is observed.
- Multilams are found to be in healthy condition.

For the slight impression on the terminal stem, it has been apprehended for increasing the hardness of the terminal stem similar to the terminal housing which is 120 BHN.

This solution has been implemented at site in 02 sets of Isolator in the month of Nov 2016 , Thermoscanning results are showing no Hot spot. Now the solution would be implemented in all 32 sets of 400 KV HCB Isolators of NTPC Vindhyachal Switchyard Stage-V.

This modified design would also be implemented at other sites of NTPC i.e at NTPC Lara , NTPC Kudgi .

Conclusions-

Early Diagnostic studies of Equipment in charged conditions at commissioning stage at site play a major role in prevention of forced outages later and for maintaining trouble free life of the equipments. Joint Diagnosis by User as well as by Manufacturer at the early stages has let for design changes in the equipment to suite the site conditions for trouble free , maintenance free and longevity of the equipment .

After installation and charging, the thermovision and analysis of newly installed 400 KV HCB Isolators at NTPC Vindhyachal at early stages let for no. of design modifications, upgradations and solutions which would ensure long trouble free service life of equipment. It has enhanced the reliability of NTPC Substations and also enhanced the manufacturing image of Siemens.

Detail of Authors:

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