REPORT

ON

FAILURE OF

220 KV AND ABOVE VOLTAGE CLASS

SUBSTATION EQUIPMENT

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA
NEW DELHI

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1.0 Introduction

In order to investigate the failure of 220 kV and above substation equipment and recommend measures to avert recurrence, a Standing Committee under Section 73, Clause(1) of the Electricity Act, 2003, comprising experts in the field of design and operation of EHV Substations from CEA, various power utilities and research/academic institutes was constituted. As part of such activity, CEA has received reports of failures between 1st April, 2013, and 30th September, 2013, in respect of following equipments from various utilities:

a) Failure of 315 MVA, 400/220/33 kV Power Transformer at Jodhpur S/s of RVPNL, Rajasthan
b) Failure of 400 kV SF6 Current Transformer (B-phase) at 500 kV HVDC Kolar terminal station of Power Grid Corporation of India Ltd.
c) Failure of Bus Post Insulator at 500 kV HVDC Kolar terminal station of Power Grid Corporation of India Ltd.
d) Failure of R-phase, 220 kV Current Transformer (CT) at 220 kV switchyard of Srisailam Right Bank Power House, APGENCO
e) Failure of B-phase & Y-phase, 220 kV Current Transformers (CTs) at 220 kV switchyard of Srisailam Right Bank Power House, APGENCO
f) Failure of B-phase, 220 kV Capacitive Voltage Transformer (CVT) at 220 kV switchyard of Srisailam Right Bank Power House, APGENCO
g) Failure of 230 kV Capacitor Voltage Transformer (Y-phase) at 230 kV Pudukkottai substation, Tamilnadu Transmission Corporation Ltd.
h) Failure of 230 kV Current Transformer (Y-phase) at 230 kV Kadapperi substation, Tamilnadu Transmission Corporation Ltd.
i) Failure of 230 kV Capacitor Voltage Transformer (R-phase) at 230 kV Alundur substation, Tamilnadu Transmission Corporation Ltd.
j) Failure of 100 MVA, 230/110 kV Auto-Transformer-II at 230 kV Tondiarpet substation, Tamilnadu Transmission Corporation Ltd.
k) Failure of 230 kV Current Transformers (R & Y-phase) at 230 kV Siruseri substation, Tamilnadu Transmission Corporation Ltd.
l) Failure of 230 kV Capacitor Voltage Transformer (Y-phase) at 230 kV Alundur substation, Tamilnadu Transmission Corporation Ltd.
m) Failure of B-phase & Y-phase, 220 kV Current Transformer (CT) at 220 kV Samaypur substation of BBMB
n) Failure of B-phase, 220 kV Potential Transformer (PT) at 220 kV Jalandhar substation of BBMB
o) Failure of Y-phase, 198 kV Lightning Arrester (LA) of 220 kV Panipat-Kurukshetra feeder at 400 kV Panipat substation of BBMB
p) Failure of R-phase 220 kV Capacitor Voltage Transformer (CVT) of Narela-III feeder at 400 kV Panipat substation of BBMB
q) Failure of R-phase, 220 kV Current Transformer (CT) of bus sectionalizer at 220 kV Samaypur substation of BBMB

Salient features of each of the substations and analysis of failure of equipment are detailed in pages 4-25.

2.0 Failure of 315 MVA, 400/220/33 kV Power Transformer at Jodhpur S/s of RVPNL, Rajasthan.

1	Name of Substation	:	Jodhpur, Rajasthan
2	Utility/Owner of substation	:	Rajasthan Rajya Vidyut Prasaran Nigam Ltd.
3	Faulty Equipment	:	Power Transformer
4	Rating	:	315 MVA, 400/220/33 kV
5	Make	:	BHEL
6	Sr. No.	:	6006062
7	Year of manufacturing	:	2003
8	Year of commissioning	:	2005 (3rd January)
9	Date and time of occurrence/discovery of fault	:	20.05.13; 08:58 hrs
10	Information received in CEA	:	31.05.13
11	Fault discovered during	:	Operation
12	Present condition of equipment	:	Faulty transformer shifted to crane house; replacement under process
13	Details of previous maintenance	:	Monthly maintenance carried out on 20.03.13. Last quarterly, half yearly and annual maintenance carried out on 13.07.12. Capacitance & Tan delta tests were performed on transformer on 13.07.12 and results were same as obtained in pre-commissioning test. DGA and BDV of oil conducted on 21.07.12, BDV was 72.1 kV.
14	Details of previous failure	:	Nil
15	Sequence of events/ Description of fault	:	

The power transformer was damaged with heavy sound and fire was seen all around. It was observed by staff of RRVPNL that HV bushing (B-phase) fell down on emulsifier system with explosion and changed the direction of emulsifier nozzles. Emulsifier operated when fire came within the range of

sensors of emulsifier but it did not make any effect as broken bushing did some damage to it. Differential trip isolated the transformer from the power system. This transformer did not have any non return conservator valve. Oil came out of damaged bushings and caught fire. Fire was external and it damaged the tank. All bushings, nearby 400 kV side LAs, clamps & connectors were also damaged. Adjacent transformer narrowly escaped damage. Capacitance and Tan delta tests were performed on the transformer in July 2012 and results were same as obtained in pre-commissioning test. However, results were near the limit recommended in standards. Due to non-availability of shut down, these tests could not be repeated later on. Representative of BHEL, manufacturer of the transformer, also inspected the damaged transformer and as per their view transformer is beyond repair. RRVPNL is of the view that since LV test results are in order indicating that the core-winding structure is intact, transformer can be repaired.

16	Details of Tests done after failure	:	Magnetizing current, turns ratio, winding resistance, and IR measurement tests were conducted and results were found to be in order.

17 Conclusion/recommendations :

After fault, LV tests were performed on the transformer and results were found to be generally in order indicating that no fault took place inside the transformer. Fire was external and it damaged the tank. It was informed by RRVPNL that the utility in future plans to procure both water emulsifier system and Nitrogen based fire prevention system for all new transformers, which is a good move. RRVPNL felt that the oil sump should be 30 meter away from the transformer with valve near the sump. Although RRVPNL carry out periodic maintenance of Transformer, if test results in periodic maintenance are found to be deteriorating or close to limit values, extensive condition based monitoring using diagnostic tools is recommended, for which shut down may be necessary.

BHEL is of the view that the fire was due to external cause. RRVPNL is of the view that failure of B-phase bushing resulted in fire.

3.0 Failure of 400 kV SF_6 Current Transformer (B-phase) at 500 kV HVDC Kolar terminal station of Power Grid Corporation of India Ltd.

1	Name of Substation	:	500 kV HVDC terminal station, Kolar, Karnataka
2	Utility/Owner of substation	:	Power Grid Corporation of India Ltd.
3	Faulty Equipment	:	CT (B-phase)
4	Rating	:	400 kV

5	Make	:	Alstom
6	Sr. No.	:	20C09-T11
7	Year of manufacturing	:	Information not available.
8	Year of commissioning	:	Information not available.
9	Date and time of occurrence/discovery of fault	:	09.05.13; 04:11 Hrs.
10	Information received in CEA	:	16.05.13
11	Fault discovered during	:	Operation
12	Present condition of equipment	:	Replaced
13	Details of previous maintenance	:	Information not available
14	Details of previous failure	:	Information not available
15	Sequence of events/ Description of fault	:	Information not available
16	Details of Tests done after failure	:	Information not available
17	Conclusion/recommendations	:	

Periodic condition monitoring with the use of various diagnostic tools is recommended for all substation equipment.

4.0 Failure of Bus Post Insulator at 500 kV HVDC Kolar terminal station of Power Grid Corporation of India Ltd.

1	Name of Substation	:	500 kV HVDC Kolar terminal station, Karnataka
2	Utility/Owner of substation	:	PGCIL
3	Faulty Equipment	:	Bus Post Insulator for pole 1 side tie bay (B-phase Middle stack)
4	Rating	:	Information not available
5	Make	:	WSI

6	Sr. No.	:	20C08B Q62
7	Year of manufacturing	:	Information not available
8	Year of commissioning	:	Information not available
9	Date and time of occurrence/discovery of fault	:	23.04.13; 14:26 Hrs.
10	Information received in CEA	:	31.05.13
11	Fault discovered during	:	Operation
12	Present condition of equipment	:	Replaced
13	Details of previous maintenance	:	Information not available
14	Details of previous failure	:	Information not available
15	Sequence of events/ Description of fault	:	

Crack was observed in the middle stack insulator of BPI of pole-I side tie bay support during inspection of the switchyard. Insulator was replaced by availing shutdown of pole 1 on 23.04.13 from 14:26 Hrs to 17:00 Hrs.

16	Details of Tests done after failure	:	Information not available
17	Conclusion/recommendations	:	

Periodic condition monitoring with the use of various diagnostic tools is recommended for all substation equipment.

5.0 Failure of R-phase, 220 kV Current Transformer (CT) at 220 kV switchyard of Srisailam Right Bank Power House, APGENCO

1	Name of Substation	:	220 kV switchyard of Srisailam Right Bank Power House
2	Utility/Owner of substation	:	Andhra Pradesh Power Generation Corporation Ltd. (APGENCO)
3	Faulty Equipment	:	Current Transformer (Unit#6, R-phase)
4	Rating	:	220 kV, single phase

5	Make	:	BHEL, Jhansi
6	Sr. No.	:	2209417
7	Year of manufacturing	:	1984
8	Year of commissioning	:	1986 (30th October)
9	Date and time of occurrence/discovery of fault	:	25.03.13; 23:05 Hrs.
10	Information received in CEA	:	11.06.13
11	Fault discovered during	:	Operation
12	Present condition of equipment	:	Replaced
13	Details of previous maintenance	:	Periodic maintenance such as checking of oil leakage, checking of cracks of insulators, cleaning of insulators was carried out.
14	Details of previous failure	:	Nil
15	Sequence of events/ Description of fault	:	

The internal insulation of a post mounted 220 kV hermetically sealed oil filled dead tank CT catastrophically failed due to ageing. As a result, the oil contained within the CT caught fire. The shift staff extinguished the fire to a major extent with the help of fire extinguishers. The local fire service was called and the fire was completely extinguished by them. The fire damage was restricted to a 5-meter radius.

16	Details of Tests done after failure	:	CT was completely damaged, no test was possible
17	Conclusion/recommendations	:	

CT had served for more than 25 years. Ageing of CT appears to be a reason of failure.

6.0 Failure of B-phase & Y-phase, 220 kV Current Transformers (CTs) at 220 kV switchyard of Srisailam Right Bank Power House, APGENCO

1	Name of Substation	:	220 kV switchyard of Srisailam Right Bank Power House

2	Utility/Owner of substation	:	Andhra Pradesh Power Generation Corporation Ltd. (APGENCO)
3	Faulty Equipment	:	Current Transformer (Unit#7, B-phase & Y-phase)
4	Rating	:	220 kV, single phase
5	Make	:	BHEL, Jhansi
6	Sr. No.	:	2209420 (B-phase) 2209419 (Y-phase)
7	Year of manufacturing	:	1984
8	Year of commissioning	:	1987 (15th March)
9	Date and time of occurrence/discovery of fault	:	05.04.13; 15:15 Hrs.
10	Information received in CEA	:	11.06.13
11	Fault discovered during	:	Operation
12	Present condition of equipment	:	Replaced
13	Details of previous maintenance	:	Periodic maintenance such as checking of oil leakage, checking of cracks of insulators, cleaning of insulators was carried out.
14	Details of previous failure	:	Nil
15	Sequence of events/ Description of fault	:	

The internal insulation of a post mounted 220 kV hermetically sealed oil filled dead tank CT (unit#7, B-phase) catastrophically failed due to ageing. As a result, the oil contained within the CT caught fire. The shift staff extinguished the fire to a major extent with the help of fire extinguishers. The local fire service was called and the fire was completely extinguished by them. The fire damage was restricted to a 5-meter radius.

The post mounted 220 kV hermetically sealed oil filled dead tank CT (unit#7, Y-phase) failed due to flashover and ageing.

16	Details of Tests done after failure	:	B-phase CT was completely damaged, no test was possible. Information not

available for Y-phase CT.

17 Conclusion/recommendations :

CTs had served for more than 26 years. Ageing of CT appears to be a reason of failure.

7.0 Failure of B-phase, 220 kV Capacitive Voltage Transformer (CVT) at 220 kV switchyard of Srisailam Right Bank Power House, APGENCO

1	Name of Substation	:	220 kV switchyard of Srisailam Right Bank Power House
2	Utility/Owner of substation	:	Andhra Pradesh Power Generation Corporation Ltd. (APGENCO)
3	Faulty Equipment	:	CVT (Markapuram feeder, B-phase)
4	Rating	:	220 kV, single phase
5	Make	:	HBB
6	Sr. No.	:	IB048110
7	Year of manufacturing	:	1981
8	Year of commissioning	:	Information not available
9	Date and time of occurrence/discovery of fault	:	09.05.13; 20:00 Hrs.
10	Information received in CEA	:	11.06.13
11	Fault discovered during	:	Operation
12	Present condition of equipment	:	Replaced
13	Details of previous maintenance	:	Periodic maintenance such as checking of oil leakage, checking of cracks of insulators, cleaning of insulators was carried out.
14	Details of previous failure	:	Nil
15	Sequence of events/ Description of fault	:	

The secondary voltage is very low, 10V instead of 68 V.

16	Details of Tests done after failure	:	Ratio test was carried out
17	Conclusion/recommendations	:	

Ratio test results were found to be abnormal. Ageing of CVT appears to be a reason of failure.

8.0 Failure of 230 kV Capacitor Voltage Transformer (Y-phase) at 230 kV Pudukkottai substation, Tamilnadu Transmission Corporation Ltd.

1	Name of Substation	:	230/110 kV Pudukkottai substation, Tamilnadu
2	Utility/Owner of substation	:	Tamilnadu Transmission Corp. Ltd. (TANTRANSCO)
3	Faulty Equipment	:	CVT (Y-phase of Alundur feeder)
4	Rating	:	230 kV, single phase
5	Make	:	CGL
6	Sr. No.	:	9684
7	Year of manufacture	:	Information not available
8	Year of commissioning	:	Information not available
9	Date and time of occurrence/discovery of fault	:	18.05.13; 15:19 Hrs.
10	Information received in CEA	:	20.06.13
11	Fault discovered during	:	Operation
12	Present condition of equipment	:	Replaced
13	Details of previous maintenance	:	Information not available
14	Details of previous failure	:	Information not available
15	Sequence of events/ Description of fault	:	

On 18.05.13 at 15:19 hrs CVT burst out. It may be due to internal fault.

16	Details of Tests done after failure	:	CVT burst out so it was not possible to conduct any test after failure.
17	Conclusion/recommendations	:	

Periodic condition monitoring with the use of various diagnostic tools is recommended for all substation equipment.

9.0 Failure of 230 kV Current Transformer (Y-phase) at 230 kV Kadapperi substation, Tamilnadu Transmission Corporation Ltd.

1	Name of Substation	:	230/110 kV Kadapperi substation, Tamilnadu
2	Utility/Owner of substation	:	Tamilnadu Transmission Corp. Ltd. (TANTRANSCO)
3	Faulty Equipment	:	CT (Y-phase of Sriperumbudur feeder)
4	Rating	:	230 kV, single phase
5	Make	:	TELK
6	Sr. No.	:	230144/23
7	Year of manufacture	:	1988
8	Year of commissioning	:	1988 (11th January)
9	Date and time of occurrence/discovery of fault	:	31.05.13; 22:22 Hrs.
10	Information received in CEA	:	24.06.13
11	Fault discovered during	:	Operation
12	Present condition of equipment	:	Replaced on 01.06.13
13	Details of previous maintenance	:	Monthly maintenance work such as cleaning of insulators, checking of clamp and jumper tightness was carried out on 08.05.13.
14	Details of previous failure	:	Nil
15	Sequence of events/ Description of fault	:	

On 31.05.13, a heavy sound was heard and 230 kV bus bar protection system operated. On yard inspection it was found that 230 kV Sriperumbudur-I Y-phase CT had burst, porcelain insulator flashed and oil spilled out and caught fire. Due to burst impact insulator pieces flew away and damaged nearby R-phase CT petticoats and Y-phase breaker supporting insulator.

Protection operated:
230 kV Sriperumbdur-II: Main-I protection acted;
Bus bar protection panel: bus bar protection main and check relay acted; bus bar protection tripping relays acted; auto-transformer-I, II & III HV breakers tripped;
230 kV Sriperumbdur-I: Main-II protection acted.

16	Details of Tests done after failure	:	CT was fully damaged so it was not possible to conduct any test after failure.
17	Conclusion/recommendations	:	

CT had served for more than 24 years, hence ageing might have been the reason behind failure. Periodic condition monitoring with the use of various diagnostic tools is recommended for all substation equipment.

10.0 Failure of 230 kV Capacitor Voltage Transformer (R-phase) at 230 kV Alundur substation, Tamilnadu Transmission Corporation Ltd.

1	Name of Substation	:	230/110 kV Alundur substation, Tamilnadu
2	Utility/Owner of substation	:	Tamilnadu Transmission Corp. Ltd. (TANTRANSCO)
3	Faulty Equipment	:	CVT (R-phase of Thanjavur-II feeder)
4	Rating	:	230 kV, single phase
5	Make	:	CGL
6	Sr. No.	:	10029
7	Year of manufacture	:	1997
8	Year of commissioning	:	2002 (6^{th} February)
9	Date and time of occurrence/discovery of fault	:	19.04.13; 10:30 Hrs.
10	Information received in CEA	:	30.07.13
11	Fault discovered during	:	Operation

12	Present condition of equipment	:	Replaced with BHEL make CVT (sr. no. 6186922)
13	Details of previous maintenance	:	Monthly periodic maintenance was carried out on 21.03.13. Outer porcelain portion was cleaned and meggered. Jumper clamp bolts & nuts tightness was checked.
14	Details of previous failure	:	Nil
15	Sequence of events/ Description of fault	:	

During monthly maintenance work, it was noticed that oil was leaking from R-phase CVT of 230 kV Alundur-Thanjavur-II feeder. The bottom of the oil tank was very hot. The CVT was isolated from the circuit. No protective relays operated.

16	Details of Tests done after failure	:	IR value measurement test was conducted and values were found to be poor. DC resistance value of the secondary in all the three cores was found very low and so further tests were not conducted.
17	Conclusion/recommendations	:	

The oil might have leaked because of heavy pressure built up inside the tank due to internal fault. There was about 5 years gap between manufacturing and commissioning. During this period how CVT was stored is not known. Long storage period is not recommended, and if required due to unavoidable situations then manufacturer's recommendation for storage should be followed strictly. Periodic condition monitoring with the use of various diagnostic tools is recommended for all substation equipment.

11.0 Failure of 100 MVA, 230/110 kV Auto-Transformer-II at 230 kV Tondiarpet substation, Tamilnadu Transmission Corporation Ltd.

1	Name of Substation	:	230/110 kV Tondiarpet substation, Tamilnadu
2	Utility/Owner of substation	:	Tamilnadu Transmission Corp. Ltd. (TANTRANSCO)
3	Faulty Equipment	:	Auto-transformer-II (Y-phase OLTC assembly)

4	Rating	:	100 MVA, 230/110 kV
5	Make	:	CGL (OLTC-BHEL)
6	Sr. No.	:	5000676
7	Year of manufacture	:	1989
8	Year of commissioning	:	1989 (14th September)
9	Date and time of occurrence/discovery of fault	:	04.04.13; 16:28 Hrs.
10	Information received in CEA	:	01.08.13
11	Fault discovered during	:	Operation
12	Present condition of equipment	:	Replacement under process
13	Details of previous maintenance	:	OLTC oil was changed on 02.09.12. Oil BDV was tested on 23.01.13 and it was found to be 70 kV.
14	Details of previous failure	:	Nil
15	Sequence of events/ Description of fault	:	

Auto-transformer-II tripped on 04.04.13. Buchholz alarm & trip, OLTC (Y-phase) trip, differential relay, master relay acted. Complete assembly of Y-phase OLTC of auto-transformer failed, its safety diaphragm vent opened and oil spread out. R&B phase fixed and moving contacts were found damaged. After replacement of damaged parts auto-transformer was put into service on 29.05.13 at 17:33 Hrs. but the transformer again tripped on differential relay and again on 01.06.13 at 18:17 Hrs. due to actuation of PRV & master relays. Internal inspection was carried out and copper granules were found to be spread out over Y-phase pressure ring. Based on DGA results of oil and internal inspection, the transformer was declared faulty by the utility. Replacement of the transformer is under progress.

16	Details of Tests done after failure	:	DGA test on oil was conducted and considerable presence of gases was found. LV tests such as Magnetizing current measurement test, ratio test, short circuit test & DC resistance test were performed on the transformer but in the absence of pre-

			commissioning/factory test results, LV test results were non-conclusive.

17 Conclusion/recommendations :

DGA shows considerable presence of hydrogen & acetylene which indicate towards high discharge arcing. While changing the taps for short circuit test & DC resistance test, open circuit was observed in Y-phase. Auto-transformer had served for more than 24 years. Periodic condition monitoring with the use of various diagnostic tools is recommended for all substation equipment.

12.0 Failure of 230 kV Current Transformer (R & Y-phase) at 230 kV Siruseri substation, Tamilnadu Transmission Corporation Ltd.

1	Name of Substation	:	230/110 kV Siruseri substation, Tamilnadu
2	Utility/Owner of substation	:	Tamilnadu Transmission Corp. Ltd. (TANTRANSCO)
3	Faulty Equipment	:	CT (R & Y-phase of Shollinganallur feeder)
4	Rating	:	230 kV
5	Make	:	Alstom
6	Sr. No.	:	200610101 (R-phase) 200610106 (Y-phase)
7	Year of manufacture	:	2006
8	Year of commissioning	:	2007
9	Date and time of occurrence/discovery of fault	:	14.07.13; 04:40 Hrs.
10	Information received in CEA	:	07.08.13
11	Fault discovered during	:	Operation
12	Present condition of equipment	:	All 3 nos. CTs of the feeder replaced on 16.07.13
13	Details of previous maintenance	:	Quarterly maintenance work such as checking of clamp tightness, oil level and cleaning of insulators etc. was carried out on 11.05.13.

14	Details of previous failure	:	Information not available
15	Sequence of events/ Description of fault	:	

Spring charge motors of R & Y-phase CTs were burnt out. These motors are owned by PGCIL and thus need to be replaced by them.

16	Details of Tests done after failure	:	No test could be carried out on Y-phase CT as the CT was fully damaged. No information available regarding B-phase CT.
17	Conclusion/recommendations	:	

Internal fault is suspected. Periodic condition monitoring with the use of various diagnostic tools is recommended for all substation equipment.

13.0 Failure of 230 kV Capacitor Voltage Transformer (Y-phase) at 230 kV Alundur substation, Tamilnadu Transmission Corporation Ltd.

1	Name of Substation	:	230/110 kV Alundur substation, Tamilnadu
2	Utility/Owner of substation	:	Tamilnadu Transmission Corp. Ltd. (TANTRANSCO)
3	Faulty Equipment	:	CVT (Y-phase of Trichy-I feeder)
4	Rating	:	230 kV, single phase
5	Make	:	WSI
6	Sr. No.	:	693070491
7	Year of manufacture	:	1993
8	Year of commissioning	:	1994 (23rd August)
9	Date and time of occurrence/discovery of fault	:	10.09.13; 16:30 Hrs.
10	Information received in CEA	:	09.10.13
11	Fault discovered during	:	Operation
12	Present condition of equipment	:	Pending

13	Details of previous maintenance	:	Monthly periodic maintenance was carried out on 07.08.13. Outer porcelain portion was cleaned and meggered. Jumper clamp bolts & nuts tightness and oil leak was checked and found normal.
14	Details of previous failure	:	Nil
15	Sequence of events/ Description of fault	:	

On 10.09.13, monthly maintenance works were carried out on 230 kV Alundur-Trichy-I feeder. After completing the maintenance works and while tieing the feeder, no secondary voltage was found in the synchronizing circuit from the line CVT. After checking, the secondary fuse was found blown out. The fuse was replaced and again it blew out. Hence, failure of CVT was suspected.

16	Details of Tests done after failure	:	IR measurement test, capacitance measurement test and ratio test were conducted on the faulty unit. Capacitance values were found to be different from the name plate values. IR values were found satisfactory. The secondary voltage in all cores was found to be very high compared to the expected voltage.
17	Conclusion/recommendations	:	

CVT might have failed due to internal fault. It had served for 19 years. Periodic condition monitoring with the use of various diagnostic tools is recommended for all substation equipment.

14.0 Failure of B-phase & Y-phase, 220 kV Current Transformer (CT) at 220 kV Samaypur substation of BBMB

1	Name of Substation	:	220 kV Samaypur substation, Haryana
2	Utility/Owner of substation	:	Bhakra Beas Management Board (BBMB)
3	Faulty Equipment	:	CT (B-phase & Y-phase) in Samaypur-Badshahpur-I feeder
4	Rating	:	220 kV
5	Make	:	SCT

6	Sr. No.	:	99/126 & 99/125
7	Year of manufacturing	:	1988
8	Year of commissioning	:	2005 (January)
9	Date and time of occurrence/discovery of fault	:	21.05.13; 23:55 Hrs.
10	Information received in CEA	:	04.06.13
11	Fault discovered during	:	Operation
12	Present condition of equipment	:	Faulty CTs were replaced with new ABB make CTs on 16th & 17th June 2013.
13	Details of previous maintenance	:	Tightening of bolts etc. was done on 16.05.13. Insulation resistance and earth resistance measurements were done on 12.09.12 and result were found to be in order.
14	Details of previous failure	:	Nil
15	Sequence of events/ Description of fault	:	

CT connected in B phase of Samaypur-Badshahpur-I feeder burst and caught fire on 21.05.13. Busbar protection system operated tripping all feeders. Bursting of this CT caused damage to Y phase CT of the same feeder.

16	Details of Tests done after failure	:	CT burnt so it was not possible to conduct any test after failure.
17	Conclusion/recommendations	:	

It appears that internal fault developed inside B phase CT which caused bursting of the CT and subsequent damage to adjacent Y phase CT.

IR measurement and tan delta test kits are available with BBMB. However, it is not a common practice in BBMB to conduct tan delta and other tests regularly on equipment other than transformer apart from tightening of connections and cleaning etc. Periodic condition monitoring with the use of various diagnostic tools is recommended for all substation equipment. BBMB should make a list of tests needed to be performed for periodic maintenance of each equipment alongwith defined periodicity. All the equipment which have

served for 25 years and more should be tested more frequently and utility should be prepared for replacement of the equipment if trend of deteriorating results is observed. These CTs were manufactured in 1988 and stored for 17 years. It is not known how these CTs were stored. Long storage period is not recommended, and if required due to unavoidable situations then manufacturer's recommendation for storage should be followed strictly.

15.0 Failure of B-phase, 220 kV Potential Transformer (PT) at 220 kV Jalandhar substation of BBMB

1	Name of Substation	:	220 kV Jalandhar substation, Punjab
2	Utility/Owner of substation	:	Bhakra Beas Management Board (BBMB)
3	Faulty Equipment	:	PT (Jamalpur-II)
4	Rating	:	$\frac{220}{\sqrt{3}}$ kV/$\frac{110}{\sqrt{3}}$ V
5	Make	:	Hivoltrans Ltd.
6	Sr. No.	:	0553/26
7	Year of manufacturing	:	2010
8	Year of commissioning	:	2011 (14^{th} February)
9	Date and time of occurrence/discovery of fault	:	17.06.13; 03:03 Hrs.
10	Information received in CEA	:	25.06.13
11	Fault discovered during	:	Operation
12	Present condition of equipment	:	Replaced with TELK made PT
13	Details of previous maintenance	:	Last maintenance was carried out on 09.10.12. PT was found working satisfactorily. IR values measured were as follows: P-E: 90000 M ohm P-S: 90000 M ohm S-E: 7000 M ohm
14	Details of previous failure	:	Nil
15	Sequence of events/	:	

Description of fault

On 17.06.13, PT burst with a heavy noise and it caught fire. Its parts alongwith oil spread far and away in the switchyard. The flying porcelain splinters also damaged the LMU of Jalandhar-Jamalpur ckt I and porcelain portion/disc insulators of the other equipment installed around the bay. VT fail alarm operated.

16	Details of Tests done after failure	:	PT burst so it was not possible to conduct any test after failure.
17	Conclusion/recommendations	:	

PT blasted due to some internal fault during normal running condition. IR values measured on 09.10.12 were found to be satisfactory.

IR measurement and tan delta test kits are available with BBMB. However, it is not a common practice in BBMB to conduct tan delta and other tests regularly on equipment other than transformer apart from tightening of connections and cleaning etc. Periodic condition monitoring with the use of various diagnostic tools is recommended for all substation equipment. BBMB should make a list of tests needed to be performed for periodic maintenance of each equipment alongwith defined periodicity. All the equipment which have served for 25 years and more should be tested more frequently and utility should be prepared for replacement of the equipment if trend of deteriorating results is observed.

16.0 Failure of Y-phase, 198 kV Lightning Arrester (LA) of 220 kV Panipat-Kurukshetra feeder at 400 kV Panipat substation of BBMB

1	Name of Substation	:	400 kV Panipat substation, Haryana
2	Utility/Owner of substation	:	Bhakra Beas Management Board (BBMB)
3	Faulty Equipment	:	LA (220 kV Kurukshetra feeder)
4	Rating	:	198 kV
5	Make	:	WSI
6	Sr. No.	:	Z1-89-125
7	Year of manufacturing	:	1989
8	Year of commissioning	:	1991 (21st December)
9	Date and time of occurrence/discovery of fault	:	08.08.13; 19:23 Hrs.

10	Information received in CEA	:	30.08.13
11	Fault discovered during	:	Operation
12	Present condition of equipment	:	Replaced with Lamco make LA on 09.08.13.
13	Details of previous maintenance	:	Last maintenance was carried out on 24.04.13. No abnormality was observed. Resistive leakage current of LA as on 25.06.13 was found to be 184 µA.
14	Details of previous failure	:	Nil
15	Sequence of events/ Description of fault	:	

LA was found damaged along with damage of surge monitor on 08.08.13 during normal course of operation.
Protection operated:
Main-II protection trip zone-I
LED trip, Y-phase trip, zone –I trip, fuse fail.

16	Details of Tests done after failure	:	LA was damaged so it was not possible to conduct any test after failure.
17	Conclusion/recommendations	:	

The LA was 24 years old and ageing might be a cause for its failure. Weather was cloudy and lightning of high steepness taking place might have been the reason for failure of LA. Periodic condition monitoring with the use of various diagnostic tools is recommended for all substation equipment

17.0 Failure of R-phase 220 kV Capacitor Voltage Transformer (CVT) of Narela-III feeder at 400 kV Panipat substation of BBMB

1	Name of Substation	:	400 kV Panipat substation, Haryana
2	Utility/Owner of substation	:	Bhakra Beas Management Board (BBMB)
3	Faulty Equipment	:	CVT (R-phase) in Panipat-Narela-III feeder
4	Rating	:	220 kV
5	Make	:	WSI

6	Sr. No.	:	770065
7	Year of manufacturing	:	1977
8	Year of commissioning	:	1979 (2nd July)
9	Date and time of occurrence/discovery of fault	:	01.07.13; 19:50 Hrs.
10	Information received in CEA	:	09.09.13
11	Fault discovered during	:	Operation
12	Present condition of equipment	:	R-phase CVT was replaced with Y-phase CVT and Y-phase CVT was replaced with new PT.
13	Details of previous maintenance	:	Secondary voltage measurement and tightening in marshalling kiosks, terminal boxes and control panels was performed on 29.06.13.
14	Details of previous failure	:	Nil
15	Sequence of events/ Description of fault	:	

On 01.07.13 at 19:50 Hrs., 220 kV Panipat-Narela-III feeder was opened manually due to VT fuse failure. On checking voltage of the feeder at C&R panel, R-phase voltage was found missing, as a result the circuit was taken on PTW at 19:50 Hrs. for the replacement of the defective CVT.

16	Details of Tests done after failure	:	CVT burnt so it was not possible to conduct any test after failure.
17	Conclusion/recommendations	:	

CVT had served for 34 years. Ageing and internal fault may be the reasons for failure.

IR measurement and tan delta test kits are available with BBMB. However, it is not a common practice in BBMB to conduct tan delta and other tests regularly on equipment other than transformer apart from tightening of connections and cleaning etc. Periodic condition monitoring with the use of various diagnostic tools is recommended for all substation equipment. BBMB should make a list of tests needed to be performed for periodic maintenance of each equipment alongwith defined periodicity. All the equipment which have served for 25 years and more should be tested more frequently and utility should be prepared for replacement of the equipment if trend of deteriorating

results is observed.

18.0 Failure of R-phase, 220 kV Current Transformer (CT) of bus sectionalizer at 220 kV Samaypur substation of BBMB

1	Name of Substation	:	220 kV Samaypur substation, Haryana
2	Utility/Owner of substation	:	Bhakra Beas Management Board (BBMB)
3	Faulty Equipment	:	CT (R-phase) in Bus sectionalizer
4	Rating	:	220 kV
5	Make	:	TELK
6	Sr. No.	:	230160-17
7	Year of manufacturing	:	1989
8	Year of commissioning	:	1990 (14th April)
9	Date and time of occurrence/discovery of fault	:	16.09.13; 08:34 Hrs
10	Information received in CEA	:	24.09.13
11	Fault discovered during	:	Operation
12	Present condition of equipment	:	Replaced with new ABB make CT on 19.09.13
13	Details of previous maintenance	:	Tightening of connections was carried out on 30.05.13. Insulation resistance and earth resistance measurements were done on 12.09.12 and results were found to be in order. Capacitance & Tan delta measurement tests were done on 13.11.10 and results were found to be in order.
14	Details of previous failure	:	Nil
15	Sequence of events/ Description of fault	:	

CT had burst and caught fire. Bus bar protection operated.

16	Details of Tests done after	:	CT burst so it was not possible to

failure conduct any test after failure.

17 Conclusion/recommendations :

It appears that internal fault developed inside CT. The CT was 24 years old and ageing might be a reason for its failure.

IR measurement and tan delta test kits are available with BBMB. However, it is not a common practice in BBMB to conduct tan delta and other tests regularly on equipment other than transformer apart from tightening of connections and cleaning etc. Periodic condition monitoring with the use of various diagnostic tools is recommended for all substation equipment. BBMB should make a list of tests needed to be performed for periodic maintenance of each equipment alongwith defined periodicity. All the equipment which have served for 25 years and more should be tested more frequently and utility should be prepared for replacement of the equipment if trend of deteriorating results is observed.

19.0 Summary of Conclusions & Recommendations:

- Periodic maintenance and condition based monitoring with the use of various diagnostic tools as suggested in Central Electricity Authority (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations, 2010, is recommended for all substation equipment.
- If test results in periodic maintenance are found to be deteriorating or close to limit values, extensive condition based monitoring using diagnostic tools is recommended, even if shut down is necessary.
- Periodic oil testing in case of instrument transformers in addition to power transformers is recommended.
- Utilities should make a list of tests needed to be performed for periodic maintenance of each equipment alongwith defined periodicity. All the equipment which have served for 25 years and more should be tested more frequently and utility should be prepared for replacement of the equipment if trend of deteriorating results is observed.
- Long storage period for equipment is not recommended, and if required due to unavoidable situations then manufacturer's recommendation for storage should be followed strictly.
- Many utilities are facing problem of shortage of staff due to which regular maintenance of substation equipment becomes difficult. It is recommended that sufficient staff be posted at substations for efficient operation & maintenance.
- When an equipment fails, original equipment manufacturer (OEM) should also be consulted.

- Before procuring the instrument transformers utilities should make sure that the same have been subjected to type tests such as short circuit test and temperature rise test.

Submitted by

Dr. Prabhat Mohan
Chief Engineer-I/c (SETD) &
Chairman, Standing Committee to investigate the failure of 220 kV & above substation equipment

Sh. M.S.Satija
Director(Substation) &
Member Secretary, Standing Committee to investigate the failure of 220 kV & above substation equipment

MINUTES OF MEETING OF THE STANDING COMMITTEE OF EXPERTS TO INVESTIGATE THE FAILURE OF 220 KV AND ABOVE VOLTAGE CLASS SUBSTATION EQUIPMENT HELD ON 26.11.13 IN CEA, NEW DELHI, IN CONNECTION WITH REPORTED FAILURES FROM APRIL 2013 TO SEPTEMBER 2013 AT VARIOUS SUBSTATIONS IN THE COUNTRY

The list of participants is enclosed as **Annexure-1.**

Chief Engineer-I/C (SETD), and Chairman of the Standing Committee of Experts to investigate the failure of 220 kV and above voltage class substation equipment, welcomed the participants. No representative from TANTRANSCO, APGENCO & PGCIL attended the meeting.

Failure of 315 MVA, 400/220/33 kV Power Transformer at Jodhpur S/s of RVPNL, Rajasthan on 20.05.13:

Representatives of RRVPNL informed that the power transformer was damaged with heavy sound and fire was seen all around. It was observed by staff of RRVPNL that HV bushing (B-phase) fell down on emulsifier system with explosion and changed the direction of emulsifier nozzles. Differential trip isolated the transformer from the power system. This transformer did not have any non return conservator valve due to which oil came out of damaged bushings and caught fire. Fire was external and it damaged the tank. All bushings, nearby 400 kV side LAs, clamps & connectors were also damaged. After fault, LV tests were performed on the transformer and results were found to be generally in order indicating that no fault took place inside the transformer. Capacitance and Tan delta tests were performed on the transformer in July 2012 and results were same as obtained in pre-commissioning test. However, results were near the limit recommended in standards. Due to non-availability of shut down, these tests could not be repeated later on. Adjacent transformer narrowly escaped damage. Representative of BHEL, manufacturer of the transformer, also inspected the damaged transformer and as per their view transformer is beyond repair. RRVPNL is of the view that since LV results are in order indicating that the core-winding structure is intact, transformer can be repaired. It was informed by RRVPNL that the utility in future plans to procure both water emulsifier system and Nitrogen based fire prevention system for all new transformers, which is a good move and was appreciated by the Committee. RRVPNL felt that the oil sump should be 30 meter away from the transformer with valve near the sump. Further, one bay separation between transformers was considered as a must for future.

Failure of following equipment at various substations of Bhakra Beas Management Board (BBMB):

1. B-phase & Y-phase, 220 kV Current Transformer (CT) of Badshahpur-I feeder at 220 kV Samaypur substation on 21.05.13
2. B-phase, 220 kV Potential Transformer (PT) of Jamalpur-II feeder at 220 kV Jalandhar substation on 17.06.13
3. R-phase 220 kV Capacitor Voltage Transformer (CVT) of Narela-III feeder at 400 kV Panipat substation on 01.07.13

4. Y-phase, 198 kV Lightning Arrester (LA) of 220 kV Panipat-Kurukshetra feeder at 400 kV Panipat substation on 08.08.13
5. R-phase, 220 kV Current Transformer (CT) of bus sectionalizer at 220 kV Samaypur substation on 16.09.13

Representatives of BBMB were requested to provide missing information in the draft report at the earliest. BBMB informed that tan delta was performed in all the substations of BBMB in 2011. It was also informed that IR measurement and tan delta test kits are available with BBMB. However, it is not a common practice in BBMB to conduct tan delta and other tests regularly on equipment other than transformer apart from tightening of connections and cleaning etc. The Committee recommended that BBMB should conduct regular maintenance tests on all substation equipment. The Committee felt that B-phase CT on Badshahpur-I feeder at 220 kV Samaypur substation could have deteriorated during approximately five years' storage, and the manufacturer should invariably be consulted in regard to storage condition and pre-commissioning tests.

Utilities reported that they are facing problem of shortage of staff due to which it becomes very difficult to carry out maintenance of substation equipment regularly.

The Committee was of the view that various diagnostic tools as suggested in Central Electricity Authority (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations, 2010, should be used regularly for periodic maintenance and condition based maintenance of substation equipment. The Committee is also of the view that every utility should make a list of tests needed to be performed for periodic maintenance of each equipment alongwith defined periodicity. For comprehensive details CBIP Manual on Substation Equipment Maintenance may also be referred. All the equipment which have served for 25 years and more should be tested more frequently and utility should be prepared for replacement of the equipment if trend of deteriorating results is observed. Chairman of the Committee advised that when an equipment fails, original equipment manufacturer (OEM) should also be consulted. CPRI suggested that before procuring the instrument transformers utilities should make sure that the same have been subjected to type tests such as short circuit test and temperature rise test. CPRI also recommended periodic oil testing in case of CT/PT/CVT, and utilizing the services of mobile testing lab of CPRI.

The Chairman of the Committee thanked all participants.

Annexure - I

LIST OF PARTICIPANTS

Central Electricity Authority, New Delhi

1. Dr. Prabhat Mohan, Chief Engineer-I/C, SETD
2. Shri M.S.Satija, Director(Substation), SETD
3. Shri Y.K.Swarnkar, Deputy Director, SETD

Central Power Research Institute, Bhopal

1. Shri B.M.Mehra, Joint Director

Rajsthan Rajya Vidyut Prasaran Nigam Ltd.

1. Shri D.S.Jangid, S.E.(TCC-II), Jaipur
2. Shri Mahesh Kr. Soni, Executive Engineer (C&M), Jodhpur

Bhakra Beas Management Board

1. Shri Chamanjit Singh, Director(P&C), Chandigarh
2. Shri R.Sharma, Asstt. Director, Panipat

APTRANSCO

1. Shri A.Sree Ram Prasad, S.E.(O&M)

Kerala State Electricity Board

1. Shri Jayarajan C.N., Executive Engineer

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(ISO :9001-2008)

No. CEA/SETD/220-O/2012/ /-80 01.01.2013

Subject:- Constitution of a Standing Committee of Experts to investigate the failure of equipment at 220 kV & above sub-stations.

In order to investigate the failure of equipment at 220 kV & above sub-stations, it has been decided to constitute a Standing Committee comprising experts in the field of design and operation of EHV substation from Central Electricity Authority(CEA), various power utilities and research/academic institutes under section 73, clause(1) of the Electricity Act, 2003.

2. The Committee shall consist of the following members:

(i)	Chief Engineer (SETD), CEA	-Chairperson
(ii)	A representative from CPRI, Bangalore	-Member
(iii)	A representative from IIT, Hauz Khas, New Delhi	-Member
(iv)	A representatives from concerned State Utility/Generating Companies/Transmission Companies where Substation Equipment failure has taken place	-Member
(v)	Member Secretary of concerned RPC	-Member
(vi)	Director (SETD), CEA	-Member Secretary

3. The terms of reference of the Committee shall be as follows:

(a) To investigate the causes of failure of substation equipment in service
(b) To recommend remedial measures to avert recurrences of such failures in future.

4. Every incident of substation equipment failure needs to be immediately reported to Chairperson of the Standing Committee by a designated officer of the concerned organization.

5. The Power Utility where failure of substation equipment has taken place will provide all assistance required by the Committee in carrying out the investigations.

6. The TA/DA and other expenses shall be borne by the respective organizations of the members of the Committee.

The Chairperson of the Committee will prepare compendium of the analysis of the failures and recommendations every six months and submit the same to the Authority and MoP.

(M.S. Puri)
Secretary, CEA

To:

1. Director General, Central Power Research Institute, Professor Sir C.V. Raman Road, P.O. Box- 8066, Bangalore- 560080.
2. Director, Indian Institute of Technology, Hauz Khas, New Delhi- 110016.
3. Chairman/CMDs of State Utility/ Generating Companies and Transmission Companies.

With a request to nominate their representative as member of the Committee along with an alternative member.

4. Member Secretaries, Regional Power Committees:
    a) NRPC, New Delhi
    b) WRPC, Mumbai
    c) SRPC, Bangalore
    d) ERPC, Kolkata
    e) NERPC, Shillong
5. Chief Engineer (SETD), CEA
6. Director (SETD), CEA.