REPORT

ON

FAILURE OF

220 KV AND ABOVE VOLTAGE CLASS

SUBSTATION EQUIPMENT

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA
NEW DELHI

September, 2014

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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, equipment failure reports of failures occurring in various utilities are reported to CEA. CEA holds meetings with concerned utilities to discuss the reported failure cases. The final report alongwith minutes of the meeting is sent to Ministry of Power and utilities which reported failure after its approval by Chairperson, CEA.

The last meeting was held on 26th June, 2014, and prior to that the meeting was held on 26th November, 2013.

CEA has received 32 reports of failures between 1st October, 2013, and 31st March, 2014, in respect of following equipments from various utilities:

(i) Failure of 100 MVA, 220/66 kV Power Transformer at 220 kV Kharadpada substation, Electricity Department, Dadra & Nagar Haveli
(ii) Failure of 230 kV Circuit Breaker (R-phase) at 230 kV Gummidipoondi substation, Tamilnadu Transmission Corporation Ltd.
(iii) Failure of 230 kV Capacitor Voltage Transformer (Y-phase) at 230 kV Eachangadu substation, Tamilnadu Transmission Corporation Ltd.
(iv) Failure of 230 kV Lightning Arrester (R & Y-phase) at 230 kV Thiruvarur substation, Tamilnadu Transmission Corporation Ltd.
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(vi) Failure of 220 kV Potential Transformer (PT) (R-phase) at Idukki switchyard, KSEB
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(xvi) Failure of Lightning Arrester (R-phase) at 220 kV Bhakra Power Plant-I of BBMB

(xvii) Failure of 150 MVA, 400/220 kV Transformer at 400 kV Panipat substation of BBMB

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(xix) Failure of B-phase 400 kV Circuit Breaker (CB) X-7 of 400 kV Panipat-Dehar feeder at 400 kV Panipat substation of BBMB

(xx) Failure of 50 MVA, 220/33 kV Transformer at 220 kV Butibori substation of MSETCL

(xxi) Failure of Y-phase, 220 kV Potential Transformer (PT) at 220 kV Khaparkheda substation of MSETCL

(xxii) Failure of B-phase, 220 kV Lightning Arrester (LA) at 220 kV Gadchandur substation of MSETCL

(xxiii) Failure of 220 kV Potential Transformer (PT) at 220 kV Warora substation of MSETCL

(xxiv) Failure of Y-phase, 220 kV Lightning Arrester (LA) at 220 kV Hinganghat substation of MSETCL

(xxv) Failure of B-phase, 400 kV Current Transformer at 400 kV Warora substation of MSETCL

(xxvi) Failure of 250 MVA, 15.75/400 kV Generator Transformer (GT) (Unit 7) at Raichur Thermal Power Station of KPCL

(xxvii) Failure of Y-phase, 220 kV Circuit Breaker (CB) at Nagjhari Power House of KPCL

(xxviii) Failure of Y-phase, 220 kV Potential Transformer (PT) at 220 kV Chikkodi substation of KPTCL

(xxix) Failure of Y-phase, 220 kV Current Transformer (CT) at 220 kV Chikkodi substation of KPTCL

(xxx) Failure of R- phase Lightning Arrester of 220 kV Varahi-Kemar line-1 at 220 kV substation Kemar of KPTCL

(xxxi) Failure of Y-phase, 220 kV Capacitor Voltage Transformer (CVT) at 220 kV GSS, MIA, Alwar of RRVPNL

(xxxii) Failure of 100 MVA, 220/132 kV Power Transformer at 220 kV substation, Nokha of RRVPNL

The relevant information for each case as submitted by the utilities in the prescribed format is indicated in pages 5-44.The conclusion/recommendation of each case emerging from the discussion is indicated at sl. No. 17 of the prescribed format. The final summary of conclusions & recommendations is indicated at pages 45-46. The minutes of the meeting are enclosed at pages 47-51 and copy of order vide which Standing Committee was constituted is enclosed at pages 52-53.

2.0 Failure of 100 MVA, 220/66 kV Power Transformer at 220 kV Kharadpada substation, Electricity Department, Dadra & Nagar Haveli

1	Name of Substation	:	220/66/11 kV Kharadpada substation, Dadra & Nagar Haveli
2	Utility/Owner of substation	:	Electricity Department, D&NH, Silvassa
3	Faulty Equipment	:	100 MVA, 220/66 kV Power Transformer
4	Rating	:	100 MVA, 220/66 kV
5	Make	:	BHEL
6	Sr. No.	:	2031018
7	Year of manufacture	:	2011
8	Year of commissioning	:	2011 (1st October)
9	Date and time of occurrence/discovery of fault	:	19.07.13; 12:53 Hrs.
10	Information received in CEA	:	07.01.14
11	Fault discovered during	:	Operation (At 60% load)
12	Present condition of equipment	:	Failed transformer sent to BHEL, Jhansi, for repair. After repair received on 12.06.2014 at Kharadpada substation.
13	Details of previous maintenance	:	Capacitance and tan delta test on bushing were carried out on 28.03.13 and transformer oil was tested on 13.06.12. No abnormality was found.
14	Details of previous failure	:	Nil
15	Sequence of events/ Description of fault	:	

Transformer tripped on Differential relay and Buchholz relay. During detailed inside inspection some copper particles and carbonated paper were found in W-phase LV winding.

16	Details of Tests done after	:	Insulation resistance test, Voltage ratio

	failure		test, Magnetic balance test, Short circuit test, Open circuit test, Turns ratio test, and DGA of transformer oil were carried out.

17 Conclusion/recommendations :

Operation of differential relay and bucholz relay indicates towards internal fault and generation of gases inside the transformer. As per DGA test report thermal fault of high temperature is suspected. It may be due to large circulating current in tank and core or shorting links in core. W-phase winding puncture is suspected. Actual root cause analysis of the fault is awaited from BHEL. Periodic condition monitoring with the use of various diagnostic tools is recommended.

3.0 Failure of 230 kV Circuit Breaker (R-phase) at 230 kV Gummidipoondi substation, Tamilnadu Transmission Corporation Ltd.

1	Name of Substation	:	230 kV Gummidipoondi substation, Tamilnadu
2	Utility/Owner of substation	:	Tamilnadu Transmission Corp. Ltd. (TANTRANSCO)
3	Faulty Equipment	:	CB (R-phase of NCTPS-I feeder)
4	Rating	:	230 kV
5	Make	:	CGL
6	Sr. No.	:	11452C
7	Year of manufacture	:	1991
8	Year of commissioning	:	1993
9	Date and time of occurrence/discovery of fault	:	02.10.13; 14:05 Hrs.
10	Information received in CEA	:	26.11.13
11	Fault discovered during	:	Operation
12	Present condition of equipment	:	Replaced
13	Details of previous maintenance	:	Cleaning, Clamp tightening, Meggering, tripping and closing of breaker was carried out on 27.08.13.

14	Details of previous failure	:	Nil
15	Sequence of events/ Description of fault	:	

There was heavy rain and lightning. Main-I & II tripped. Earth wire broke at Loc. 2 and fell on the line. Breaker did not trip due to sluggishness and R-phase limb of CB got burst, hence Local Breaker Backup (LBB) acted. Complete substation became dead.

16	Details of Tests done after failure	:	No test was possible as CB got burst.
17	Conclusion/recommendations	:	

Periodic condition monitoring with the use of various diagnostic tools is recommended.

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

1	Name of Substation	:	230 kV Eachangadu substation, Tamilnadu
2	Utility/Owner of substation	:	Tamilnadu Transmission Corp. Ltd. (TANTRANSCO)
3	Faulty Equipment	:	CVT (Y-phase of Samayapuram feeder)
4	Rating	:	230 kV, single phase
5	Make	:	CGL
6	Sr. No.	:	8450
7	Year of manufacture	:	1995
8	Year of commissioning	:	1997 (7^{th} February)
9	Date and time of occurrence/discovery of fault	:	24.01.14; 11:30 Hrs.
10	Information received in CEA	:	07.03.14
11	Fault discovered during	:	Maintenance
12	Present condition of equipment	:	Replacement under progress

13	Details of previous maintenance	:	Maintenance carried out on 13.11.2013.
14	Details of previous failure	:	Nil
15	Sequence of events/ Description of fault	:	

During the monthly maintenance work on 230 kV Samaypuram feeder, very slight oil oozing in view glass and abnormal heating on the body in 'Y' phase 230 kV line CVT of Samaypuram feeder was noticed. Internal fault in the CVT was suspected. This CVT was isolated from the circuit. CVT was tested and on testing, error was found in ratio test for all cores of CVT and capacitance values were found to be very low due to internal fault.

16	Details of Tests done after failure	:	Ratio test on all cores and capacitance measurement test were carried out.
17	Conclusion/recommendations	:	

Periodic condition monitoring with the use of various diagnostic tools is recommended.

5.0 Failure of 230 kV Lightning Arrester (LA) (R & Y-phase) at 230 kV Thiruvarur substation, Tamilnadu Transmission Corporation Ltd.

1	Name of Substation	:	230 kV Thiruvarur substation, Tamilnadu
2	Utility/Owner of substation	:	Tamilnadu Transmission Corp. Ltd. (TANTRANSCO)
3	Faulty Equipment	:	LA (Auto Transformer-III) (R & Y-phase)
4	Rating	:	230 kV, single phase
5	Make	:	CGL
6	Sr. No.	:	9509119 (R-phase) 9509120 (Y-phase)
7	Year of manufacture	:	1996 (Both R & Y- phase)
8	Year of commissioning	:	1997 (3rd April) (Both R & Y- phase)
9	Date and time of occurrence/discovery of fault	:	03.02.14; 21:15 Hrs.

10	Information received in CEA	:	24.02.14
11	Fault discovered during	:	Operation
12	Present condition of equipment	:	Replaced
13	Details of previous maintenance	:	Maintenance carried out on 19.11.2013.
14	Details of previous failure	:	Nil
15	Sequence of events/ Description of fault	:	

On 03.02.14 at 21:15, HV & LV breakers of auto-transformer-III tripped. Y-phase LA had flashed over and burnt. The auto-transformer was isolated from service. Megger value of R-phase LA was found to be low.
Protection operated:
Differential; Restricted earth fault; Over frequency; HV overcurrent (Inst/IDMT)

16	Details of Tests done after failure	:	Meggering of R-phase LA was done and found to be low
17	Conclusion/recommendations	:	

Periodic condition monitoring including measurement of 3rd harmonic current with the use of various diagnostic tools is recommended. If harmonic current is found to be more than 150 µA, insulation resistance test should be done and for current values more than 350 µA, LA should be replaced.

6.0 Failure of 230 kV Lightning Arrester (LA) (R-phase) at 230 kV Thiruvarur substation, Tamilnadu Transmission Corporation Ltd.

1	Name of Substation	:	230 kV Thiruvarur substation, Tamilnadu
2	Utility/Owner of substation	:	Tamilnadu Transmission Corp. Ltd. (TANTRANSCO)
3	Faulty Equipment	:	LA (Auto Transformer-I) (R- phase)
4	Rating	:	230 kV, single phase
5	Make	:	CGL
6	Sr. No.	:	4900

7	Year of manufacture	:	1999
8	Year of commissioning	:	2002 (17th September)
9	Date and time of occurrence/discovery of fault	:	28.10.13; 17:05 Hrs.
10	Information received in CEA	:	10.12.13
11	Fault discovered during	:	Operation
12	Present condition of equipment	:	Replaced
13	Details of previous maintenance	:	Maintenance carried out on 24.09.2013.
14	Details of previous failure	:	Nil
15	Sequence of events/ Description of fault	:	

On 28.10.13 at 17:05 hrs, 230 kV R-phase LA of Auto Transformer-I flashed over and burnt while in service. HV and LV side breakers tripped and the Auto Transformer was isolated from service.

Protection operated:
Differential relay trip A,B,C; High Set A,B,C; Restricted Earth Fault; HV over current relay (instant/IDMT).

16	Details of Tests done after failure	:	LA flashed over and burnt. Megger values in R-phase were found short.
17	Conclusion/recommendations	:	

Periodic condition monitoring including measurement of 3rd harmonic current with the use of various diagnostic tools is recommended. If harmonic current is found to be more than 150 µA, insulation resistance test should be done and for current values more than 350 µA, LA should be replaced.

7.0 Failure of 220 kV Potential Transformer (PT) (R-phase) at Idukki switchyard, KSEB.

1	Name of Substation	:	Hydro Electric Switchyard, Idukki, Kerala
2	Utility/Owner of substation	:	Kerala State Electricity Board (KSEB)

3	Faulty Equipment	:	PT (R phase) (IDMD feeder)
4	Rating	:	220 kV, single phase
5	Make	:	TELK
6	Sr. No.	:	730016-4
7	Year of manufacture	:	1985
8	Year of commissioning	:	1985
9	Date and time of occurrence/discovery of fault	:	07.11.13; 17:23 Hrs.
10	Information received in CEA	:	26.11.13
11	Fault discovered during	:	Operation
12	Present condition of equipment	:	Planning to charge with 11 kV as this bay is not in service.
13	Details of previous maintenance	:	On 23.05.2013, tested by PET.
14	Details of previous failure	:	Nil
15	Sequence of events/ Description of fault	:	

PT flashed during 'in service' condition. There was lightning at the remote end.

16	Details of Tests done after failure	:	Investigation done by both KSEB & M/s TELK.
17	Conclusion/recommendations	:	

Periodic condition monitoring with the use of various diagnostic tools is recommended. PT had served for 28 years and ageing might be one of the reasons of failure.

8.0 Failure of 220 kV Circuit Breaker (CB) at Idukki switchyard, KSEB.

1	Name of Substation	:	Hydro Electric Switchyard, Idukki, Kerala
2	Utility/Owner of substation	:	Kerala State Electricity Board (KSEB)

3	Faulty Equipment	:	CB
4	Rating	:	220 kV
5	Make	:	HBB
6	Sr. No.	:	IB 103313
7	Year of manufacture	:	1985
8	Year of commissioning	:	1985
9	Date and time of occurrence/discovery of fault	:	03.11.13; 18:18 Hrs.
10	Information received in CEA	:	26.11.13
11	Fault discovered during	:	Operation
12	Present condition of equipment	:	Replaced
13	Details of previous maintenance	:	Monthly maintenance was carried out on 02.10.2013 and annual maintenance on 16.08.2012. Tested by PET.
14	Details of previous failure	:	Nil
15	Sequence of events/ Description of fault	:	

Unit 5 was synchronized at 18:15 hrs. Explosion of CB occurred after 3 minutes while loading the unit. Failure was due to mis-alignment of fixed and moving contacts.

16	Details of Tests done after failure	:	Investigation done by both KSEB and M/s ABB.
17	Conclusion/recommendations	:	

Circuit Breaker failure took place due to mechanical failure i.e. mis-alignment of fixed and moving contacts. By use of Dynamic Contact Resistance Measurement (DCRM) once every two year such type of failures could be avoided. Periodic condition monitoring with the use of various diagnostic tools is recommended.

9.0 Failure of 220 kV Lightning Arrester (LA) (B-phase) at 220 kV Kalamassery substation, KSEB.

1	Name of Substation	:	220 kV Kalamassery substation, Kerala
2	Utility/Owner of substation	:	Kerala State Electricity Board (KSEB)
3	Faulty Equipment	:	LA (B-phase) of 200 MVA Transformer-I
4	Rating	:	220 kV
5	Make	:	OBLUM
6	Sr. No.	:	Not visible
7	Year of manufacture	:	1986
8	Year of commissioning	:	1990
9	Date and time of occurrence/discovery of fault	:	13.09.13; 04:51 hrs
10	Information received in CEA	:	27.11.13
11	Fault discovered during	:	Operation
12	Present condition of equipment	:	Replaced
13	Details of previous maintenance	:	On 08.08.2012. Tested by PET.
14	Details of previous failure	:	None
15	Sequence of events/ Description of fault	:	

On 13.09.13, 220 kV LA on B-phase of 200 MVA transformer-I flashed.

16	Details of Tests done after failure	:	Physical inspection revealed the explosion.
17	Conclusion/recommendations	:	

Periodic condition monitoring including measurement of 3rd harmonic current with the use of various diagnostic tools is recommended. If harmonic current is found to be more than 150 µA, insulation resistance test should be done and for current values more than 350 µA, LA should be replaced.

10.0 Failure of 220 kV Lightning Arrester (LA) at 220 kV Brahmapuram substation, KSEB.

1	Name of Substation	:	220 kV Brahmapuram substation, Kerala
2	Utility/Owner of substation	:	Kerala State Electricity Board (KSEB)
3	Faulty Equipment	:	LA (Lower Periyar-II feeder)
4	Rating	:	220 kV
5	Make	:	OBLUM
6	Sr. No.	:	918261
7	Year of manufacture	:	1991
8	Year of commissioning	:	2013
9	Date and time of occurrence/discovery of fault	:	01.07.13
10	Information received in CEA	:	27.11.13
11	Fault discovered during	:	Operation
12	Present condition of equipment	:	Replaced
13	Details of previous maintenance	:	Maintenance carried out on 08.11.2012. Tested by PET.
14	Details of previous failure	:	Nil
15	Sequence of events/ Description of fault	:	

On 01.07.13, 220 kV LA of Lower Periyar-II feeder flashed. The bay had been kept idle for a long period. Physical inspection of LA revealed the explosion.

16	Details of Tests done after failure	:	Since LA had damaged no test was possible.
17	Conclusion/recommendations	:	

Periodic condition monitoring including measurement of 3rd harmonic current with the use of various diagnostic tools is recommended. If harmonic current is found to be more than 150 µA, insulation resistance test should be done and for current values more than 350 µA, LA should be replaced. There was about 22 years gap between manufacturing and commissioning. During this period how LA 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.

11.0 Failure of 160 MVA, 220/110 kV Transformer-I at 220 kV Brahmapuram substation, KSEB.

1	Name of Substation	:	220 kV Brahmapuram substation, Kerala
2	Utility/Owner of substation	:	Kerala State Electricity Board (KSEB)
3	Faulty Equipment	:	Transformer-I bank
4	Rating	:	160 MVA, 220/110 kV
5	Make	:	GEC Alstom
6	Sr. No.	:	B28825
7	Year of manufacture	:	1995
8	Year of commissioning	:	1999
9	Date and time of occurrence/discovery of fault	:	02.09.13; 16:05 hrs
10	Information received in CEA	:	27.11.13
11	Fault discovered during	:	Operation
12	Present condition of equipment	:	Repaired
13	Details of previous maintenance	:	On 16.03.2013, maintenance and condition monitoring tests were carried out.
14	Details of previous failure	:	Nil
15	Sequence of events/ Description of fault	:	

On 02.09.13, 160 MVA, 220/110 kV transformer-I bank tripped on OLTC Oil Surge Relay (OSR). On inspection gas contents were observed in the OLTC oil.

16	Details of Tests done after failure	:	Pending for overhauling.
17	Conclusion/recommendations	:	

Internal fault seems to be the reason behind failure of the transformer. Periodic

condition monitoring with the use of various diagnostic tools is recommended. There was gap of about 4 years between manufacturing and commissioning of transformer. If ever, it is required to keep the transformer at site without commissioning, it is always recommended to follow manufacturer's recommendation on storage, and of periodic inspection for moisture level of oil/pressure of nitrogen etc.

12.0 Failure of R-phase, 220 kV Circuit Breaker (CB) at 220 kV Pothencode Substation, KSEB.

1	Name of Substation	:	220 kV Pothencode Substation, Kerala
2	Utility/Owner of substation	:	Kerala State Electricity Board (KSEB)
3	Faulty Equipment	:	CB (R-phase pole) (EMPC-II)
4	Rating	:	220 kV
5	Make	:	CGL
6	Sr. No.	:	14222C
7	Year of manufacture	:	2001
8	Year of commissioning	:	2005
9	Date and time of occurrence/discovery of fault	:	08.10.13; 17:58 Hrs.
10	Information received in CEA	:	27.11.13
11	Fault discovered during	:	Maintenance
12	Present condition of equipment	:	Pole and mechanism replaced
13	Details of previous maintenance	:	External porcelain cleaning and power connection tightening were done on 08.10.2013
14	Details of previous failure	:	Nil
15	Sequence of events/ Description of fault	:	

Fault occurred while the circuit breaker was charged after a permit to work in the line. Mechanism of CB had jammed due to mechanical problem within the interrupter unit.

16	Details of Tests done after failure	:	On 10.10.2013 & on 18.10.2013.
17	Conclusion/recommendations	:	

By use of DCRM such failures could be avoided. DCRM test once every two years is recommended. Periodic condition monitoring with the use of various diagnostic tools is recommended. There was about 4 years gap between manufacturing and commissioning. During this period how CB 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.

13.0 Failure of 200 MVA Transformer-II (B-phase) at Kundara Substation, KSEB.

1	Name of Substation	:	Kundara Substation, Kerala
2	Utility/Owner of substation	:	Kerala State Electricity Board (KSEB)
3	Faulty Equipment	:	B-phase HV bushing of Transformer Bank-II
4	Rating	:	200 MVA
5	Make	:	BHEL
6	Sr. No.	:	6005859
7	Year of manufacture	:	2002
8	Year of commissioning	:	2008
9	Date and time of occurrence/discovery of fault	:	08.10.13; 22:36 Hrs.
10	Information received in CEA	:	27.11.13
11	Fault discovered during	:	Operation
12	Present condition of equipment	:	Bushing replaced
13	Details of previous maintenance	:	On 24.06.2013, PET tested.
14	Details of previous failure	:	Nil
15	Sequence of events/	:	

Description of fault
Bushing of B-phase transformer in 200 MVA bank-II failed during operation.

16	Details of Tests done after failure	:	On 15.10.2013, measurement of tan delta test was conducted and found to be 0.62 which was higher than previous measured value of 0.3.
17	Conclusion/recommendations	:	

Apart from absolute value of tan delta of bushing, its rate of rise should also be monitored and it should not be more than 0.1% per year. Periodic condition monitoring with the use of various diagnostic tools is recommended. There was gap of about 6 years between manufacturing and commissioning of transformer. If ever, it is required to keep the transformer at site without commissioning, it is always recommended to follow manufacturer's recommendation on storage, and of periodic inspection for moisture level of oil/pressure of nitrogen etc.

14.0 Failure of 220 kV Capacitor Voltage Transformer (R-phase) at 220 kV Budidampadu Substation, Transmission Corporation of A.P. Ltd.

1	Name of Substation	:	Badidampadu Substation, Andhra Pradesh
2	Utility/Owner of substation	:	Transmission Corporation of A.P. Ltd.
3	Faulty Equipment	:	CVT (R-phase) (KTPS-I feeder)
4	Rating	:	220 kV
5	Make	:	CGL
6	Sr. No.	:	8926
7	Year of manufacture	:	Information not available
8	Year of commissioning	:	1997 (31st March)
9	Date and time of occurrence/discovery of fault	:	31.10.13
10	Information received in CEA	:	27.11.13
11	Fault discovered during	:	Operation
12	Present condition of equipment	:	Replaced on 31.10.13

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

R-phase CVT was not delivering secondary voltage.

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.

15.0 Failure of 220 kV Current Transformer (Y-phase) at 220 kV Ongole Substation, Transmission Corporation of A.P. Ltd.

1	Name of Substation	:	Ongole Substation, Andhra Pradesh
2	Utility/Owner of substation	:	Transmission Corporation of A.P. Ltd.
3	Faulty Equipment	:	CT (Y-phase) (Nellore feeder)
4	Rating	:	220 kV
5	Make	:	HBB
6	Sr. No.	:	IB069886
7	Year of manufacture	:	1979
8	Year of commissioning	:	1990 (18th July)
9	Date and time of occurrence/discovery of fault	:	15.10.13; 10:20 Hrs.
10	Information received in CEA	:	27.11.13
11	Fault discovered during	:	Operation
12	Present condition of equipment	:	Replaced on 15.10.13
13	Details of previous	:	Information not available

	maintenance		
14	Details of previous failure	:	Information not available
15	Sequence of events/ Description of fault	:	
	Oil gushed out from the CT.		
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. There was about 11 years gap between manufacturing and commissioning. During this period how CT 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.		

16.0 Failure of Lightning Arrester (R-phase) 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 in R-phase of 400/220 kV ICT Bank-I
4	Rating	:	198 kV
5	Make	:	CGL
6	Sr. No.	:	51926
7	Year of manufacturing	:	2006
8	Year of commissioning	:	2010 (8th August)
9	Date and time of occurrence/discovery of fault	:	19.12.13; 03:37 Hrs.
10	Information received in CEA	:	14.02.14
11	Fault discovered during	:	Operation
12	Present condition of	:	Damaged LA was replaced on

	equipment		19.12.2013.
13	Details of previous maintenance	:	Scheduled maintenance of LA was done on 15.10.13 and no abnormality was found.
14	Details of previous failure	:	Nil
15	Sequence of events/ Description of fault	:	

LA was found diffused with damage to surge monitor. Surge monitor had blackened.
Protection operated:
Differential-A, B, & C; 400 kV side tripping relay; instantaneous relay; overcurrent relay; 220 kV side master trip relay & tripping relay.

16	Details of Tests done after failure	:	No test was possible as LA was damaged.
17	Conclusion/recommendations	:	

LA was damaged during normal course of working which may be due to foggy weather condition at the time of damage. Periodic condition monitoring including measurement of 3rd harmonic current with the use of various diagnostic tools is recommended. If harmonic current is found to be more than 150 µA, insulation resistance test should be done and for current values more than 350 µA, LA should be replaced. Leakage current should be measured twice a year preferably before and after monsoon as against the BBMB practice of once a year.

17.0 Failure of Lightning Arrester (R-phase) at 220 kV Bhakra Power Plant-I of BBMB

1	Name of Substation	:	220 kV switchyard of Bhakra Power Plant-I, Himachal Pradesh
2	Utility/Owner of substation	:	Bhakra Beas Management Board (BBMB)
3	Faulty Equipment	:	LA (R-phase) (220 kV Bhakra-Ganguwal-III)
4	Rating	:	198 kV
5	Make	:	CGL
6	Sr. No.	:	51961
7	Year of manufacturing	:	2006

8	Year of commissioning	:	2007 (7th November)
9	Date and time of occurrence/discovery of fault	:	29.12.13; 02:30 hrs.
10	Information received in CEA	:	01.01.14
11	Fault discovered during	:	Operation
12	Present condition of equipment	:	Replaced on 29.12.2013.
13	Details of previous maintenance	:	Annual maintenance was carried out on 25th & 26th October, 2013, and IR value was found to be 353 G-ohm.
14	Details of previous failure	:	Nil
15	Sequence of events/ Description of fault	:	

220 kV Bhakra-Ganguwal ckt III and Generating Unit-5 tripped on 29.12.13. Lightning Arrester and Surge Counter in R-phase of 220 kV Bhakra-Ganguwal ckt III were found burst, bushing was found cracked/broken.

Protection operated:
Distance protection trip; A/R lockout; A/R close; SOTF trip; Trip circuit supervision relay; Aux. relay; Tripping relay

16	Details of Tests done after failure	:	Testing was not possible as LA was damaged very badly.
17	Conclusion/recommendations	:	

LA and surge counter were damaged due to failure of insulation. Internal fault and increase of leakage current may be the reason. Periodic condition monitoring including measurement of 3rd harmonic current with the use of various diagnostic tools is recommended. If harmonic current is found to be more than 150 µA, insulation resistance test should be done and for current values more than 350 µA, LA should be replaced. Leakage current should be measured twice a year preferably before and after monsoon as against the BBMB practice of once a year.

18.0 Failure of 150 MVA, 400/220 kV Auto-transformer 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	:	Auto Transformer (T-1)
4	Rating	:	150 MVA, 400/220 kV
5	Make	:	TELK
6	Sr. No.	:	140019
7	Year of manufacturing	:	1978
8	Year of commissioning	:	1979 (19th September)
9	Date and time of occurrence/discovery of fault	:	21.12.13; 06:02 Hrs.
10	Information received in CEA	:	25.02.14
11	Fault discovered during	:	Operation
12	Present condition of equipment	:	The case for repair of transformer from TELK is under process.
13	Details of previous maintenance	:	Last maintenance was carried out on 31.08.13. No abnormality was observed.
14	Details of previous failure	:	As informed by BBMB, the transformer had tripped earlier on LA fault.
15	Sequence of events/ Description of fault	:	

On 21.12.13 at 06:02 Hrs. Differential protection and Restricted Earth Fault protection of auto transformer (T-1) operated.

16	Details of Tests done after failure	:	Measurement of magnetizing current was done and it was found out of permissible limit.
17	Conclusion/recommendations	:	

Operation of Differential & REF protection and higher magnetizing current values indicate towards fault inside the transformer. The transformer had served for more than 34 years and ageing might be one of the reasons for the failure. Transformers should be tested for DGA and SFRA after every through fault case as the fault fed by transformer during through faults may have effect on its winding structure.

19.0 Failure of Y-phase, 400 kV Circuit Breaker (CB) X-1 and Current Transformer (CT) of 400 kV Panipat-Dehar 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	:	CB X-1; CT (both from Y-phase, 400 kV Dehar feeder)
4	Rating	:	400 kV
5	Make	:	CGL (CB) BBC (CT)
6	Sr. No.	:	14262C (CB) 345058 (CT)
7	Year of manufacturing	:	2001 (CB) 1977 (CT)
8	Year of commissioning	:	2002 (18th April) (CB) 1979 (19th September)(CT)
9	Date and time of occurrence/discovery of fault	:	29.01.14; 22:28 Hrs.
10	Information received in CEA	:	25.02.14
11	Fault discovered during	:	Operation
12	Present condition of equipment	:	Replaced and charged on 09.02.2014. CB Pole replaced with new pole and the breaker is in working condition.
13	Details of previous maintenance	:	Last maintenance was carried out on 07.11.13. No abnormality was observed.
14	Details of previous failure	:	Nil
15	Sequence of events/ Description of fault	:	

Y-phase limb of breaker was damaged during manual switching off of the line (as per instructions of PC office BBMB Chandigarh) alongwith damage of Y-phase CT due to bursting effect of breaker limb.

Protection operated:
400 kV Bus-II Bus bar protection.

16	Details of Tests done after failure	:	Pole damaged, so no testing possible. For new pole, IR values, timings, contact resistances and all other tests are within permissible limits.
17	Conclusion/recommendations	:	

Circuit breaker was damaged during manually switching off of the line which may be due to high voltage at that time. It was informed by BBMB that line was operating without line reactor. The CBs should invariably be got type tested for capacitor switching. DCRM test for CB once every two years is recommended.

20.0 Failure of B-phase 400 kV Circuit Breaker (CB) X-7 of 400 kV Panipat-Dehar feeder at 400 kV Panipat substation of BBMB

1	Name of Substation	:	400 kV Sub Station, BBMB, Panipat
2	Utility/Owner of substation	:	BBMB
3	Faulty Equipment	:	CB X-7 (B-phase, 400 kV Dehar feeder)
4	Rating	:	400 kV
5	Make	:	CGL
6	Sr. No.	:	14261C
7	Year of manufacturing	:	2001
8	Year of commissioning	:	2002 (21st February)
9	Date and time of occurrence/discovery of fault	:	04.02.14, 21:45 hrs
10	Information received in CEA	:	20.03.14
11	Fault discovered during	:	Operation
12	Present condition of equipment	:	On 24.04.2014, the damaged pole was replaced with new pole and the breaker is in working condition.
13	Details of previous maintenance	:	Last scheduled maintenance was carried out on 07.11.2013.

14	Details of previous failure	:	Nil
15	Sequence of events/ Description of fault	:	

Breaker limb was damaged during manual switching off of the line (carried out as per instructions of PC office BBMB Chandigarh) which may be due to high voltage at that time. Complete Blue phase limb of breaker flashed/damaged.

16	Details of Tests done after failure	:	Nil
17	Conclusion/recommendations	:	

Circuit breaker was damaged during manually switching off of the line which may be due to high voltage at that time. DCRM test for CB once every two years is recommended.

21.0 Failure of 50 MVA, 220/33 kV Transformer at 220 kV Butibori substation of MSETCL

1	Name of Substation	:	220 kV Butibori substation, Maharashtra
2	Utility/Owner of substation	:	Maharashtra State Electricity Transmission Co. Ltd. (MSETCL)
3	Faulty Equipment	:	Transformer-II
4	Rating	:	50 MVA, 220/33 kV
5	Make	:	CGL
6	Sr. No.	:	T/8520/3
7	Year of manufacturing	:	1997
8	Year of commissioning	:	1997 (1st July)
9	Date and time of occurrence/discovery of fault	:	12.08.13; 06:26 Hrs.
10	Information received in CEA	:	18.02.14
11	Fault discovered during	:	Operation
12	Present condition of equipment	:	Sent for repair to M/s AVAL, Thane

13	Details of previous maintenance	:	Routine maintenance and tan delta was carried out on 12.06.13. DGA of transformer oil was carried out on 14.06.13 and the quantity and proportion of dissolved gases was found within the limits.
14	Details of previous failure	:	Nil
15	Sequence of events/ Description of fault	:	

On 12.08.13 at 06:26 Hrs., 50 MVA, 220/33 kV transformer–II tripped on differential protection. Master trip relay also operated.

16	Details of Tests done after failure	:	During testing water was found logged in B ph LA stack. Hence old existing LA replaced by new LA and following tests on transformer were carried out: IR value, open circuit test, short circuit test, magnetic balance test, IR values of LV side, stability test (reports may kindly be provided by MSETCL) After clearance from testing engineers, transformer was recharged at 14:51 hrs on 12.08.13 but it tripped immediately on main bucholz alarm, main bucholz trip, PRV trip, 3 phase trip relay. Further testing was carried out. HV/LV open circuit SFRA plots and B phase short circuit plots were found distorted as compared to signature plots.
17	Conclusion/recommendations	:	

Operation of differential protection indicates towards fault inside the transformer. As per testing results, transformer could not be charged and further investigation is required. Periodic condition monitoring with the use of various diagnostic tools is recommended.

22.0 Failure of Y-phase, 220 kV Potential Transformer (PT) at 220 kV Khaparkheda substation of MSETCL

1	Name of Substation	:	220 kV Khaparkheda substation
2	Utility/Owner of substation	:	Maharashtra State Electricity Transmission Co. Ltd. (MSETCL)
3	Faulty Equipment	:	Y-phase Synchronizing PT (GT-3 bay)

4	Rating	:	220 kV
5	Make	:	CGL
6	Sr. No.	:	Y-13047
7	Year of manufacturing	:	1999
8	Year of commissioning	:	2000 (12th April)
9	Date and time of occurrence/discovery of fault	:	17.12.13; 23:31 Hrs
10	Information received in CEA	:	18.02.14
11	Fault discovered during	:	Operation
12	Present condition of equipment	:	Replaced by new PT on 18.12.13.
13	Details of previous maintenance	:	Tan delta measurement was carried out on 29.06.13 and results were found to be satisfactory.
14	Details of previous failure	:	Nil
15	Sequence of events/ Description of fault	:	

On 17.12.13 at 23:31 hrs synchronizing PT of Y-phase GT-3 got burst.

16	Details of Tests done after failure	:	PT burst 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.

23.0 Failure of B-phase, 220 kV Lightning Arrester (LA) at 220 kV Gadchandur substation of MSETCL

1	Name of Substation	:	220 kV Gadchandur substation
2	Utility/Owner of substation	:	Maharashtra State Electricity Transmission Co. Ltd. (MSETCL)
3	Faulty Equipment	:	B-phase LA

4	Rating	:	220 kV
5	Make	:	WSI
6	Sr. No.	:	911359
7	Year of manufacturing	:	1991
8	Year of commissioning	:	1992 (1st August)
9	Date and time of occurrence/discovery of fault	:	11.09.13
10	Information received in CEA	:	18.02.14
11	Fault discovered during	:	Operation
12	Present condition of equipment	:	Replaced by new LA on 11.09.13.
13	Details of previous maintenance	:	No maintenance was carried out.
14	Details of previous failure	:	Nil
15	Sequence of events/ Description of fault	:	

On 09.08.12, the LCM value of LA was observed to be 417 micro amp. LA was replaced on 11.09.13.

16	Details of Tests done after failure	:	NA
17	Conclusion/recommendations	:	

Periodic condition monitoring including measurement of 3rd harmonic current with the use of various diagnostic tools is recommended. If harmonic current is found to be more than 150 µA, insulation resistance test should be done and for current values more than 350 µA, LA should be replaced. Leakage current should be measured twice a year preferably before and after monsoon.

24.0 Failure of 220 kV Potential Transformer (PT) at 220 kV Warora substation of MSETCL

1	Name of Substation	:	220 kV Warora substation

2	Utility/Owner of substation	:	Maharashtra State Electricity Transmission Co. Ltd. (MSETCL) (The circuit belongs to M/s WPCL, Warora)
3	Faulty Equipment	:	PT
4	Rating	:	220 kV/110 V
5	Make	:	SCT
6	Sr. No.	:	2009/1484
7	Year of manufacturing	:	2009
8	Year of commissioning	:	2009 (19th December)
9	Date and time of occurrence/discovery of fault	:	19.08.13; 12:24 hrs
10	Information received in CEA	:	18.02.14
11	Fault discovered during	:	Operation
12	Present condition of equipment	:	Faulty PT is lying at substation. No information available whether PT was replaced or not.
13	Details of previous maintenance	:	No maintenance was carried out.
14	Details of previous failure	:	Nil
15	Sequence of events/ Description of fault	:	

On 19.08.13 at 12:24 hrs, the PT burst.

16	Details of Tests done after failure	:	NA
17	Conclusion/recommendations	:	

The maintenance of the equipment belongs to M/s WPCL, Warora, and they have contacted the manufacturer. Periodic condition monitoring with the use of various diagnostic tools is recommended for all substation equipment.

25.0 Failure of Y-phase, 220 kV Lightning Arrester (LA) at 220 kV Hinganghat substation of MSETCL

1	Name of Substation	:	220 kV Hinganghat substation
2	Utility/Owner of substation	:	Maharashtra State Electricity Transmission Co. Ltd. (MSETCL)
3	Faulty Equipment	:	Y-phase LA (HGT-TSS-I ckt)
4	Rating	:	220 kV
5	Make	:	CGL
6	Sr. No.	:	42740
7	Year of manufacturing	:	2005
8	Year of commissioning	:	2007 (8^{th} January)
9	Date and time of occurrence/discovery of fault	:	31.10.13; 16:00 hrs
10	Information received in CEA	:	18.02.14
11	Fault discovered during	:	Operation
12	Present condition of equipment	:	Replaced by new LA on 01.11.13.
13	Details of previous maintenance	:	LCM was conducted on 23.09.13 and higher value of leakage current was found.
14	Details of previous failure	:	Nil
15	Sequence of events/ Description of fault	:	

LA burst on 31.10.13 at 16:00 hrs.

16	Details of Tests done after failure	:	NA
17	Conclusion/recommendations	:	

Periodic condition monitoring including measurement of 3^{rd} harmonic current with the use of various diagnostic tools is recommended. If harmonic current is found to be more than 150 μA, insulation resistance test should be done and

for current values more than 350 µA, LA should be replaced. Leakage current should be measured twice a year preferably before and after.

26.0 Failure of B-phase, 400 kV Current Transformer at 400 kV Warora substation of MSETCL

1	Name of Substation	:	220 kV Warora substation
2	Utility/Owner of substation	:	Maharashtra State Electricity Transmission Co. Ltd. (MSETCL) (Circuit belongs to M/s Adani)
3	Faulty Equipment	:	CT (400 kV Adani bay)-B phase
4	Rating	:	400 kV
5	Make	:	CGL
6	Sr. No.	:	38864
7	Year of manufacturing	:	2010
8	Year of commissioning	:	2012 (26th August)
9	Date and time of occurrence/discovery of fault	:	09.08.13; 04:41 hrs
10	Information received in CEA	:	18.02.14
11	Fault discovered during	:	Information not available
12	Present condition of equipment	:	Replaced on 09.08.13.
13	Details of previous maintenance	:	Information not available
14	Details of previous failure	:	Information not available
15	Sequence of events/ Description of fault	:	

On 09.08.12, the CT burst. No details of protection system operated provided by the utility.

16	Details of Tests done after failure	:	NA

17 Conclusion/recommendations :

Periodic condition monitoring with the use of various diagnostic tools is recommended.

27.0 Failure of 250 MVA, 15.75/400 kV Generator Transformer (GT) (Unit 7) at Raichur Thermal Power Station of KPCL

1	Name of Substation	:	Raichur Thermal Power Station
2	Utility/Owner of substation	:	Karnataka Power Corporation Ltd. (KPCL)
3	Faulty Equipment	:	Generator Transformer (Unit 7)
4	Rating	:	250 MVA, 15.75/400 kV
5	Make	:	TELK
6	Sr. No.	:	140115
7	Year of manufacturing	:	2002
8	Year of commissioning	:	2002 (5^{th} December)
9	Date and time of occurrence/discovery of fault	:	04.10.13; 05:49 hrs
10	Information received in CEA	:	22.11.13
11	Fault discovered during	:	Operation
12	Present condition of equipment	:	Replaced by CGL make transformer of 315 MVA, 16.5/400 kV capacity.
13	Details of previous maintenance	:	Periodical maintenance including measurement of IR values and protection checks were conducted during Nov 2012.
14	Details of previous failure	:	No failure.
15	Sequence of events/ Description of fault	:	

Y-phase bushing of HV side of the transformer exploded which resulted in Y-phase winding damage.

Parameters before fault:

Gen load – 171 MW, Gen voltage – 15.83 kV & Bus voltage – 417 kV
Following relays operated during fault:

a. Restricted earth fault (64RGT E/F)
b. Overall Differential Relay (87GTU A/B/C)
c. Generator Neutral Displacement Relay (51NGT)
d. Pole slip (78GS)
e. Backup impedance relay (21G1)
f. Negative phase sequence relay (46G1/G2)
g. GT oil temp. – very high
h. GT HV/LV winding temp – very high.
i. GT Pressure Relief Device I operated.
j. GT Pressure Relief Device II operated.
k. GT Buchholz protection operated.
l. GEN Master trip Relay (86GA1 class-A)
m. Turbine Master Trip Relay (86GB2 class-B)
n. GEN Master Trip Relay (86GC2 class-C)
o. Dead Machine relay (61B)
p. Dead machine lock out relay (86B)

16	Details of Tests done after failure	:	Exciting current (single phase) and magnetic balance tests were conducted.
17	Conclusion/recommendations	:	

Periodic condition monitoring with the use of various diagnostic tools is recommended

28.0 Failure of Y-phase, 220 kV Circuit Breaker (CB) at Nagjhari Power House of KPCL

1	Name of Substation	:	Nagjhari Power House, Kalinadi Hydro Electric Project-I
2	Utility/Owner of substation	:	Karnataka Power Corporation Ltd. (KPCL)
3	Faulty Equipment	:	CB (Y-phase) (Unit 5)
4	Rating	:	220 kV
5	Make	:	CGL
6	Sr. No.	:	A7644C
7	Year of manufacturing	:	1995
8	Year of commissioning	:	1996
9	Date and time of	:	20.08.13; 18:19 hrs

occurrence/discovery of fault

10	Information received in CEA	:	26.11.13
11	Fault discovered during	:	Operation
12	Present condition of equipment	:	Faulty pole replaced on 23.08.13.
13	Details of previous maintenance	:	Breaker pole overhauled on 24.05.10. Routine maintenance was carried out on 29.04.13.
14	Details of previous failure	:	Nil
15	Sequence of events/ Description of fault	:	

On 20.08.13, Generator unit no. 5 was synchronized at 18:19 hrs as per the requirement of SLDC while raising load to near 100 MW, the breaker pole blasted.

16	Details of Tests done after failure	:	Not possible
17	Conclusion/recommendations	:	

The breaker pole probably blasted due to arcing between contacts while raising load after synchronization. Periodic condition monitoring with the use of various diagnostic tools is recommended. DCRM test is recommended once every two years.

29.0 Failure of Y-phase, 220 kV Potential Transformer (PT) at 220 kV Chikkodi substation of KPTCL

1	Name of Substation	:	220 kV Chikkodi substation
2	Utility/Owner of substation	:	Karnataka Power Transmission Corporation Ltd. (KPTCL)
3	Faulty Equipment	:	PT (Bus-A, Y-phase)
4	Rating	:	220 kV/110 V
5	Make	:	SCT
6	Sr. No.	:	2010/1812
7	Year of manufacturing	:	2010

8	Year of commissioning	:	2011 (17th December)
9	Date and time of occurrence/discovery of fault	:	14.09.13; 07:05 hrs
10	Information received in CEA	:	27.02.14
11	Fault discovered during	:	Operation
12	Present condition of equipment	:	Replaced
13	Details of previous maintenance	:	The latest previous maintenance of 220 kV PTs was done on 13.11.2012 and 20.04.2013. Details are: 1) Cleaned the porcelain portion (petticoats) of PTs. 2) Visual inspection of the PTs for any cracks. 3) Checked and tightened the clamps of PTs. 4) Checked and tightened the secondary wiring interconnection of PTs. 5) Checked the oil level and oil leakage in the PTs and all were found intact & meggered with 5 kV megger, found 2000 Mohm.
14	Details of previous failure	:	Nil
15	Sequence of events/ Description of fault	:	

On 14.09.13, the following events occurred:
7:00 AM – The station was in normal condition, the 220 kV bus PT-I and II were connected to parallel Buses A & B. Both PT bus Gang Operated Switches (GOS) were in closed condition.
7:05 AM – The Y phase PT of 220 kV Bus A blasted at 7:05 AM. At the same time no relay operated at 220 kV R/S Chikkodi but distance relays (Zone 2, 3, Start and fault location – No data) of both 220 kV BC-I and II operated at 220 kV R/S Belgaum. At the same time 110 kV Sadalaga line tripped on 86 High Speed and Earth Fault Relay.
8:00 AM – The HV & LV CB of both 100 MVA Power Transformer-I & II, hand tripped.
8:00 AM – Isolated the blasted PT by opening PT Bus A GOS.
8:08 AM – Main power supply resumed from 220 kV Belgaum station.
8:12 AM – The CB of 110 kV Sankeshwar hand tripped for load control.
8:12 AM – The HV & LV CB of 100 MVA Power Transformer-I charged and stood OK.
8:13 AM – The HV & LV CB of 100 MVA Power Transformer-II charged and stood OK.
8:14 AM – The CB of Sankeshwar charged and stood OK.

8:28 AM – The CB of Sadalaga charged and stood OK.
8:29 AM – The CB of 110 kV Raibag-I hand tripped for changing PT selector switch.
8:29 AM – The CB of 110 kV Raibag line-I test charged and stood OK.
8:30 AM - The CB of 110 kV Raibag-II hand tripped for changing PT selector switch.
8:31 AM – The CB of 110 kV Raibag line-II test charged and stood OK.
10:30 AM – The CB of 110 kV Capacitor Bank charged and stood OK.

16	Details of Tests done after failure	:	NA (PT totally blasted)
17	Conclusion/recommendations	:	

Reason for failure of PT may be insulation failure. PT was designed for 300 VA burden. It could be a case of design failure. 50 VA burden is usually sufficient for numerical relays. Periodic condition monitoring with the use of various diagnostic tools is recommended.

30.0 Failure of Y-phase, 220 kV Current Transformer (CT) at 220 kV Chikkodi substation of KPTCL

1	Name of Substation	:	220 kV Chikkodi substation
2	Utility/Owner of substation	:	Karnataka Power Transmission Corporation Ltd. (KPTCL)
3	Faulty Equipment	:	CT (Y-phase, Ghataprabha line-II)
4	Rating	:	220 kV
5	Make	:	Shree Venkateshwara Electrical Industries Pvt. Ltd. (SVEI)
6	Sr. No.	:	313/1/29
7	Year of manufacturing	:	2004
8	Year of commissioning	:	Kept idle charged from 14.05.2008 & line commissioned on 02.10.2013.
9	Date and time of occurrence/discovery of fault	:	02.10.13; 12:50 hrs
10	Information received in CEA	:	27.02.14
11	Fault discovered during	:	Operation (kept idle charged)
12	Present condition of	:	Replaced

equipment

13	Details of previous maintenance	:	The latest previous maintenance of 220 kV CT was done on 27.12.2012 and 06.05.2013. Details are: 1) Cleaned the porcelain portion (petticoats) of CTs. 2) Visual inspection of the CTs for any cracks. 3) Checked and tightened the clamps of CTs. 4) Checked and tightened the secondary wiring interconnection of CTs. 5) Checked the oil level and oil leakage in the CTs and all were found intact & meggered with 5 kV megger, found 2000 Mohm.
14	Details of previous failure	:	Nil
15	Sequence of events/ Description of fault	:	

On 02.10.2013, the following events occurred:

12:40 PM	The station was in normal condition, the 220kV Bus couplers -I & II were connected to parallel buses A&B. Both bus Gang Operated Switches (GOS) were in closed condition. The line GOS of both 220kV Chikkodi- Ghataprabha –I&II were opened, The CTs were idle charged at 220kV R/S Chikkodi. Both GOS of Bus couplers were closed and CB was in closed condition.
12:50 PM	The Y phase CT of 220 kV Chikkodi -Ghataprabha -II ckt blasted at 12:50 PM. At the same time no relay operated at 220 kV R/S Chikkodi but distance relays of both 220kV BC-I & II operated at 220kV R/S Belgaum(96.00 km). At the same time 110 kV Sadalaga line tripped on earth fault relay.
13:20 PM	The breaker GOS of 220kV Chikkodi -Ghataprabha-II line opened and CB opened.
13:22 PM	Both TFR I&II HV side CB hand tripped.
13:25 PM	220 kV Belgaum-I & II line idle charged and stood OK.
13:27 PM	110 kV NPN and Sankeshwar line hand tripped to reduce load on both transformers.
13:30 PM	Both 100 MVA TFR-I&II charged and stood OK.
13:35 PM	110 kV NPN and Sankeshwar line charged and stood OK

13:45 PM 110 kV Sadalaga line charged & stood OK.

The fire continued till next day 6:00 hrs.

16	Details of Tests done after failure	:	Testing was not possible as CT had blasted.
17	Conclusion/recommendations	:	

Reason for failure of CT may be insulation failure. Periodic condition monitoring with the use of various diagnostic tools is recommended. There was about 4 years gap between manufacturing and idle charging. During this period how CT 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.

31.0 Failure of R- phase Lightning Arrester of 220 kV Varahi-Kemar line-1 at 220 kV substation Kemar of KPTCL

1	Name of Substation	:	220 kV Kemar
2	Utility/Owner of substation	:	Karnataka Power Transmission Corporation Ltd. (KPTCL)
3	Faulty Equipment	:	Lightning Arrester (R-phase) (Varahi-Kemar line-1 (MRS Shimoga))
4	Rating	:	220 kV
5	Make	:	Crompton Greaves
6	Sr. No.	:	9507300
7	Year of manufacturing	:	1995
8	Year of commissioning	:	1999
9	Date and time of occurrence/discovery of fault	:	25.12.2013, 13:15 hrs
10	Information received in CEA	:	27.02.2014
11	Fault discovered during	:	Operation
12	Present condition of equipment	:	Replaced
13	Details of previous maintenance	:	Nil

14	Details of previous failure	:	None
15	Sequence of events/ Description of fault	:	

KPTCL informed that lightning was observed in the area at the time of failure. The 'R' phase Lightning Arrester of 220 kV Varahi-Kemar line-1 (MRS Shimoga) failed on 25.12.2013 at 13:15 hrs with a heavy sound. The faulty lightning arrester is replaced by the spare lightning arrester available at the station.

16	Details of Tests done after failure	:	Nil
17	Conclusion/recommendations	:	

Periodic condition monitoring including measurement of 3rd harmonic current with the use of various diagnostic tools is recommended. If harmonic current is found to be more than 150 µA, insulation resistance test should be done and for current values more than 350 µA, LA should be replaced. Leakage current should be measured twice a year preferably before and after monsoon

32.0 Failure of Y-phase, 220 kV Capacitor Voltage Transformer (CVT) at 220 kV GSS, MIA, Alwar of RRVPNL

1	Name of Substation	:	220 kV GSS, MIA, Alwar
2	Utility/Owner of substation	:	RRVPNL
3	Faulty Equipment	:	CVT (Main bus-II) (Y-phase)
4	Rating	:	220 kV
5	Make	:	ABB
6	Sr. No.	:	Information not available
7	Year of manufacturing	:	2009
8	Year of commissioning	:	Information not available
9	Date and time of occurrence/discovery of fault	:	02.11.2013
10	Information received in CEA	:	29.01.2014
11	Fault discovered during	:	Information not available

12	Present condition of equipment	:	Information not available
13	Details of previous maintenance	:	Information not available
14	Details of previous failure	:	Information not available
15	Sequence of events/ Description of fault	:	

On 02.11.2013, CVT was showing zero output. Protection wing of RRVPNL tested the CVT on 07.11.13 and secondary voltage across Y-phase –to-neutral in all three cores was found to be very low. Y-phase CVT was declared defective.

16	Details of Tests done after failure	:	Secondary voltage measurement
17	Conclusion/recommendations	:	

Almost zero output in CVT indicates some internal problem in CVT. Reason for the failure is unknown. Periodic condition monitoring with the use of various diagnostic tools is recommended.

33.0 Failure of 100 MVA, 220/132 kV Power Transformer at 220 kV GSS, Nokha, RRVPNL

1	Name of Substation	:	220 kV GSS, Nokha
2	Utility/Owner of substation	:	RRVPNL
3	Faulty Equipment	:	Power Transformer
4	Rating	:	100 MVA, 220/132 kV
5	Make	:	EMCO
6	Sr. No.	:	HT1601/12321
7	Year of manufacturing	:	2004
8	Year of commissioning	:	2004 at Bhilwara 2012 (6th September) at Nokha
9	Date and time of occurrence/discovery of fault	:	17.03.2014, 04:35 hrs
10	Information received in CEA	:	28.03.2014

11	Fault discovered during	:	Operation
12	Present condition of equipment	:	Information not available
13	Details of previous maintenance	:	Oil testing was done on 13.12.13 and tan delta test was done on 20.06.13.
14	Details of previous failure	:	Nil
15	Sequence of events/ Description of fault	:	

On 17.03.2014 at 04:30 hrs, 220 kV side breaker of the transformer tripped and simultaneously 132 kV side breaker also tripped on intertrip. As soon as the breaker tripped, the persons on duty heard the noise of blasting in the yard. They immediately rushed outside the control room and observed that the transformer had caught fire. HV and LV side B-phase bushing had got damaged and transformer had caught fire at these bushings. All supplies of incomer and outgoing were tripped and fire brigade was called upon but they failed to quench the fire. A tractor full of sand was brought and with the help of JCB sand was thrown on the top and at the bottom of the transformer and the fire was extinguished at 05:30 hrs.

It was observed that following protection systems had operated:
Buchholz Relay; Oil Surge Relay (Relay 30 ABC); High speed 86 Trip (HS A-1 & A-2, HS B-1 & B-2); Backup relay on instantaneous over current and earth fault.

On inspection of the transformer at 07:00 hrs it was found that all bushings along with the wiring were damaged and oil leakage was observed from various places of transformer. The transformer oil was partially drained out and collected in drums. Fault recorder of differential relay indicated fault current of 5.383 kA in the C-phase of HV side of the transformer which caused the tripping of 220 kV and 132 kV side breakers with tripping time of 90 ms including breaker opening time. The high impedance differential and Restricted Earth Fault protection did not operate as these protections are exclusively provided for internal fault of the transformer. The disturbance record and event record could not be obtained from the relay as there was switching ON/OFF of DC supply to the panel which caused operation of digital inputs of numerical relays.

This failed transformer was manufactured in 2004 and was earlier commissioned in 220 kV GSS Bhilwara and later on it was shifted to Nokha S/s and commissioned on 09.09.12.

16	Details of Tests done after failure	:	IR values as taken by 5 kV Megger on 18.03.14 are as under (for 15 sec-60Sec): Tertiary to LV/HV: 75-81 Mega ohm Tertiary to Earth: 25-30 Mega ohm HV-Earth: 0

IR values were taken with damaged bushing condition.

17 Conclusion/recommendations :

The initiation of fault seems to be on account of the bursting of HV bushing of B phase of the power transformer thereby causing HV to earth fault outside the bushing current transformer (not involving windings) operating main differential protection as well as delayed over current and earth fault with simultaneous operation of Buchholz and OSR relay due to formation of some gases just below the HV bushing within transformer tank.

The fire due to bursting of HV bushing and thereafter of LV bushing spread outside the tank and the scattered pieces of B-phase bushings damaged other HV & LV bushings also. Fire was quenched externally with the help of fire brigade as well as throwing sand. Since fire couldn't enter the tank, chances are rare of winding damage. Had there been an operational fire protection system for transformer, the damage to the tank and bushing could have been minimized.

In the case when Power Transformer is dismantled from its original location, transported in pieces to other location, reassembled and commissioned there, its internal condition gets disturbed which not only derates/degrades its power handling capacity but also shortens its useful life. The degree of workmanship and precision in re-assembling is impossible to achieve up to the mark of the manufacturer who has facility of proper tool, tackles and instruments. So, it is worthwhile not to shift/re-locate a running power transformer from its original location (where it would be serving more effici63ently) to another location.

Old power transformers, which have outlived their useful life, must be replaced with higher rating new power transformer and then disposed off.

Power transformer should never be commissioned without adequate fire fighting system being in operational mode and fulfilling all other statutory safety requirements.

(i) Measurement of capacitance and tan delta value of transformer oil and bushings should be carried out half yearly and if there are substantial changes observed in these values then frequency of testing should be increased. If same or higher trend of changes continues then immediate remedial action should be initiated.

(ii) Regular DGA (Dissolved Gas Analysis) of transformer oil should be carried out and if any doubt is observed, then the results should be ensured in other Lab. Trend of dissolved gases shall be closely monitored and if sudden rise in the parameters, as compared to previous results is observed, then matter is to be reported to higher authorities/manufacturer of equipment so as to ensure timely remedial action.

(iii) Complete cleaning of grass/bushes etc. to be ensured at least close to oil filled equipments.

(iv) Trenches near oil filled equipments should be covered properly and filled with sand.

(v) Hot spot should be checked in complete yard and special attention be given to bushing terminals.

(vi) Oil sump tank shall be at least 100 feet away from transformer and main drain valve shall be provided close to oil sump tank to have easy/safe access during fire incidence.

(vii) Preventive mode of emulsifier protection system should be kept operative with every tripping of transformer. NRV (Non Return Valve) should also be provided in between conservator and main tank to block the conservator oil during fire incident.

34.0 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.
- 3^{rd} harmonic current measurement is a very good method for assessing healthiness of LA and it could be done on-line. If 3^{rd} harmonic current is more than 150 μA then Insulation Resistance (IR) value test should also be conducted and if current exceeds 350 μA then LA should be removed from service and replaced.
- While measuring tan delta of transformer bushing, apart from absolute value, rate of rise of tan delta should also be monitored and frequency of measurement should be increased in case rate of rise is more than 0.1% per year.
- Transformers should be tested for DGA and SFRA after every through fault case as the fault fed by transformer during through faults may have effect on its winding structure.
- Sometimes circuit breakers fail because of dielectric failure due to capacitive switching. The breakers should be type tested for capacitive switching.
- Dynamic Contact Resistance Measurement (DCRM) is a very important tool to gauge healthiness of circuit breaker and failures of breaker due to mis-alignment of contacts could easily be avoided by use of DCRM once in two years.

- 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 26.06.14 IN CEA, NEW DELHI, IN CONNECTION WITH REPORTED FAILURES FROM OCTOBER 2013 TO MARCH 2014 AT VARIOUS SUBSTATIONS IN THE COUNTRY

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

In the absence of Chief Engineer-I/c (SETD) due to health reasons, Director (Substation) and Member Secretary of the subject Standing Committee welcomed the participants. No representative from APTRANSCO & MSETCL attended the meeting. A draft report based on information provided by utilities between October 2013 and March 2014 was sent by post to concerned utilities prior to meeting. This draft report was discussed in the meeting and based on the inputs received in the meeting the same has been finalized.

Representative of Tamil Nadu Transmission Corporation Ltd. furnished missing information in draft report in respect of previously reported failures and reported some additional failures which were not reported earlier.

Representative of Electricity Department, Dadra & Nagar Haveli, furnished reports of routine tests conducted before and after failure of 100 MVA, 220/66 kV transformer.

Representative of KSEB furnished missing information in draft report in respect of previously reported failures. Following points were highlighted during deliberation of KSEB representative with the Committee:

1. KSEB stated that PTs in its substations cannot be tested as no test tap has been provided.
2. PGCIL pointed out that Dynamic Contact Resistance Measurement (DCRM) is a very important tool to gauge healthiness of circuit breaker and failures of breaker due to mis-alignment of contacts could easily be avoided by use of DCRM once in two years. KSEB submitted that they are slowly adopting this practice of using DCRM in its substations.
3. Measurement of wattloss is not reliable for testing of LA. 3^{rd} harmonic current measurement is very good method for assessing healthiness of LA and it could be done on-line. If 3^{rd} harmonic current is more than 150 µA then Insulation Resistance (IR) value test should also be conducted and if current exceeds 350 µA then LA should be removed from service. Infrared Scanning technique is also helpful and KSEB stated that they are planning to purchase the same.
4. While measuring tan delta of transformer bushing, apart from absolute value, rate of rise of tan delta should also be monitored and frequency of measurement should be increased in case rate of rise is more than 0.1% per year. Representative of KSEB stated that opening test tap of bushings of BHEL transformers installed in their substations is not easy and measurement of tan delta in these transformers is very difficult. However, it is learnt that BHEL has modified their design to mitigate this problem. For keeping a transformer idle for a long time the manufacturer needs to be consulted.

Representatives of BBMB furnished missing information in the draft report. Following are the gist of discussion:

1. BBMB practice is to measure leakage current of LA once every two years. The Committee was of the view that leakage current should be measured twice a year preferably before and after monsoon which is PGCIL practice also. As per PGCIL's experience more than 90% LA failures could be avoided by regularly measuring leakage current.
2. BBMB representative stated that LA is replaced in their substations if 3rd harmonic current exceeds 350 µA.
3. The committee was of the view that proper analysis and interpretation of test results is very important to take suitable action on the future of equipment.
4. It was felt that transformers should be tested for DGA and SFRA after every through fault case as the fault fed by transformer during through faults may have effect on its winding structure.
5. Sometimes circuit breakers fail because of dielectric failure due to capacitive switching. The breakers should be type tested for capacitive switching.

Representatives of Karnataka Power Corporation Ltd. (KPCL) furnished missing information in the draft report. Failures of equipment in the substations of KPCL and Karnataka Power Transmission Corporation Ltd. (KPTCL) were discussed in the meeting. KPTCL informed that 300 VA burden is specified for PT in their substations, which in the Committee's view is on higher side and it may be brought down to 50 VA maximum. Regarding LA failures, KPTCL informed that they don't have 3rd harmonic current measurement kit, however, they are in process of procuring these kits.

Representative of Rajasthan Rajya Vidyut Prasaran Nigam Ltd. (RRVPNL) narrated the incident which led to the failure of 100 MVA, 220/132 kV transformer at Nokha S/s, Rajasthan, and the case was discussed in the meeting. He was requested to furnish information regarding failure of 220 kV CVT in MIA S/s, ALwar.

Representative of PGCIL shared with participants their prevalent practices for following equipment:

CVT

- Only top and middle stacks are tested for tan delta.
- Capacitance variation of -5% to 10% is allowed.
- Secondary voltage measurement : half yearly
- If secondary voltage changes then measurement of capacitance should be done.

CT

- Pre-commissioning test: tan delta, Insulation Resistance
- After one month of charging and within one year: DGA
- Tan delta test is repeated every year.
- For higher failure rate of CTs of a particular make, DGA is conducted.

PT

- Tan delta, DGA: every year
- Tan delta on PT is carried out in GST mode after removing jumper.

CB

- DCRM once in 2 years.

Bushing

- Tan delta one a year, in GST mode (jumper need not be removed)
- DGA should be conducted if failure rate of a particular make is more.

PGCIL informed that, of late they had realised the importance of keeping only 3 nos. CTs per diameter in one and half breaker scheme of 400 kV substations as against conventionally employed 4 CTs. To this effect they are in the process of modifying their 400 kV substations. This will also help in reducing number of CT failures.

Director (SETD) remarked that 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 (Publication no. 294) may also be referred. The utility representatives were also requested to submit their failure reports in the revised format, which shall be uploaded on CEA's website.

The Member Secretary of the Committee thanked all participants.

Annexure - I

LIST OF PARTICIPANTS

Central Electricity Authority, New Delhi

1. Shri M.S.Satija, Director(Substation), SETD
2. Shri S.K.Ray Mohapatra, Director, SETD
3. Shri Y.K.Swarnkar, Deputy Director, SETD
4. Shri Faraz, Assistant Director, SETD

Powergrid Corporation of India Ltd.

1. Shri R.K.Tyagi, AGM
2. Shri Gunjan Agrawal, Manager

Central Power Research Institute, Bhopal

1. Shri B.M. Mehra, Joint Director

Kerala State Electricity Board

1. Shri Jayarajan C.N., Executive Engineer

Electricity Department, Dadra & Nagar Haveli

1. Shri H.C.Surma, Asstt. Engineer

Rajsthan Rajya Vidyut Prasaran Nigam Ltd.

1. Shri Mahesh Kr. Soni, Executive Engineer (C&M), Jodhpur

Bhakra Beas Management Board

1. Shri Chamanjit Singh, Director(P&C), Chandigarh
2. Shri N.K.Goel, Dy. CE
3. Shri Rajender Singh, AD

TANTRANSCO

1. Shri D.Pattabiraman, S.E.(Operation)

Karnataka Power Transmission Corporation Ltd. (KPTCL)

1. Shri K.Siddaraju, Chief Engineer
2. Shri D.Nagarjuna, Superintending Engineer
3. Shri B.V.Girish, Executive Engineer (Ele.)

Karnataka Power Corporation Ltd. (KPCL)

1. Shri M.Shivamallu, Chief Engineer
2. Shri S.R.Prakash, Superintending Engineer(Ele.), RTPS
3. Shri T.Sannappa, Resident Engineer

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(ISO :9001-2008)

No. CEA/SETD/220-O/2012/ 1-80

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.