PRESENTATION
ON
PROTECTION AUDIT OF
GENERATION AND
TRANSMISSION SYSTEM

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PROTECTION AUDIT

• Title Coined by NRPC and Delhi Transco

• Aim was to ensure that unwanted / unintended trippings of generators and transmission lines do not occur during Common Wealth Games in Delhi
PROTECTION AUDIT

• Process of systematically identifying the inadequacy, healthiness, inappropriate application of individual elements associate with equipment and transmission line protection

• Identifying and weeding out obsolete protection related equipment

• Checking adequacy and appropriateness of protection settings and schemes
PROTECTION AUDIT

• Carried out on a sample system and also some recorded abnormal generator / transmission line tripping conditions are investigated
PROTECTION AUDIT

Involves

• All types of protective relays and their settings
• CTs, PTs, CVTs
• DC power supply
• Event recorders / loggers
• PLCC, Optic Fiber links
• Testing and maintenance records of all relays, circuit breakers, etc.
SCOPE OF AUDIT

Review of the implemented protection schemes / philosophy and settings with reference to CBIP Publication No. 274 (revised), NRPC Recommendations on settings, NERC recommendations on relay loadability and any other best practice for:

- 400 kV & 220 kV feeders
- Generator, Transformer, Reactor, Circuit Breaker, Bus Bar and Series Compensation Device
- To carry out relay coordination studies for the different protection schemes.

- To check for the adequacy/healthiness of the Primary & Back up protection scheme & settings. Recommend corrective action for any additional protection and disabling any unwanted setting/protection.
SCOPE OF WORK CONTINUED…


- Review of availability/healthiness of communication links like PLCC, optical fiber used for protection

- Review of availability/healthiness of recording instruments – Disturbance Recorder, Event Logger

- Review of availability/healthiness of time synchronization unit.
SCOPE OF WORK CONTINUED...

- Review of test reports for assessing the healthiness of Circuit Breaker – Trip and close coil healthiness, breaker close & open timings, SF6 & operating media pressure settings for alarm, Auto re-close lock out and Pole discrepancy operation, etc.

- Review of field-testing on all protection relays (including end to end testing), PLCC along with simulation of Disturbance Recorder & Event Logger signals individually for 400kV & 220kV Feeders.
SCOPE OF WORK CONTINUED...

- Field inspection of existing protection devices for obsolescence of technology, suitability, healthiness (based on test reports).

- The test reports of relays available at site to be compared against POWERGRID norms or other best norms in the knowledge of the consultant.

- Prepare a directory of the protection system.

- Conduct Training Course
STAGES OF AUDIT

STAGE -1: Field visits for discussions and collection of data

STAGE-2: Visit for relay testing inclusive of end-to-end testing of distance protection, DC system, fibre optic network and PLCC

STAGE-3: Preliminary Recommendations of settings

STAGE-4: Recommendations on complete protection philosophy, relay obsolescence, protection directory, etc
Methodology
FACILITIES IN CPRI
MAJOR FACILITIES AVAILABLE IN POWER SYSTEM PROTECTION SECTION

FREJA 300 RELAY TESTING SYSTEM
POWER SYSTEM SIMULATOR-F6150
GPS Synchronised End-to-End testing of Distance Protection Setup
RELAY COORDINATION SOFTWARE

MiPOWER- Developed by M/s Power Research & Development Consultants Pvt Ltd., Bangalore

• OVER CURRENT AND IMPEDANCE / DISTANCE RELAY COORDINATION
ACCREDITATIONS

• POWER SYSTEMS DIVISION HAS ISO 9001:2008 CERTIFICATION

• RELAY TESTING LABORATORY IS ACCREDITED BY NABL ISO/IEC:17025:2005

• RELAY TESTING LABORATORY IS ALSO ACCREDITED BY BIS
Delhi Transco Ltd. Protection Audit
System Considered for Audit

1. 400 kV Substations: 4
2. 220 kV Substations: 8
3. 400 kV Lines: 4
4. 220 kV Line: 7
5. 400 kV Transformers: 2
6. 220 kV Transformers: 7
7. Generating Stations: 3
CBIP 400 kV line protection philosophy

As per CBIP manual 400 kV Transmission lines shall be provided with the following protections:
(i) There should be two independent main protection schemes with at least one of them being carrier aided non switched three zone distance protection. The other protection may be phase segregated current differential, phase comparison, directional comparison type or carrier aided non switched distance protection
(ii) If Main 1 and Main 2 are both distance protection schemes then they should preferably of different types
(iii) Both protections should be suitable for single and three phase tripping
(iv) Two stage over voltage protection (optional)
(v) Auto re-close relay suitable for 1ph/3ph re-closure (with dead line charging and Synchro- check facility
(vi) Sensitive IDMT directional E/F
CBIP 220 kV line protection philosophy

As per CBIP guidelines, the following protection shall be in place for 220 kV lines:
There should be at least one carrier aided non switched three zone distance protection scheme.
Another non switched/switched distance scheme or directional over current and earth fault relays as back up
Main protection should be suitable for single or three phase tripping
Auto re-closure relay suitable for 1 ph / 3 ph (with dead line charging and synchrocheck facility)
v. In case both line protections being distance protection, IDMT Type E/F relay shall also be provided additionally
CBIP Transformer Protection Philosophy

Transformer Protection

Protections recommended in the CBIP guidelines for 400 kV and 220 kV transformers

(i) Transformer Differential protection
(ii) Over fluxing protection
(iii) Restricted earth fault protection
(iv) Back up O/C + E/F protection on HV side
(v) Back up O/C + E/F protection on LV side
(vi) Protection and monitors built in to Transformer (Buchholz, relay, winding and oil temperature indicators, Oil level indicators and pressure relief Device)
(vii) Protection of tertiary winding
(viii) Over load Alarm
CBIP Generator Protection Philosophy

As per CBIP manual, the various Electrical hazards in a Generator unit that requires to be considered are:
- Stator Insulation failure
- Over voltage
- Rotor faults
- Loss of synchronism
- Over/under frequency
- Overload
- Unbalanced loading
- Loss of excitation
- Reverse power
- Inadvertent energisation of generator
CBIP Bus bar Protection philosophy

Bus bar protection must be provide for all 400 kV and 220 kV substations.
It shall be three phase type and operate selectively for each bus section.
It shall operate on differential principle and provide independent zones.
CT supervision feature shall be provided.
DC supply supervision feature shall be provided.
Relay Setting Calculation Philosophy

The settings for the protection relays must ensure the fastest possible fault clearance without compromising on selectivity. In this section the philosophy applied for calculating the settings for the line, transformer protection, bus bar and generator relays are described. This philosophy have been based on the following documents,
Relay Setting Calculation Philosophy contd….

CBIP publication no. 274 (revised) titled “Manual on Protection of Generators, Generator Transformers and 220kV and 400kV networks”
Recommendations of 10th Protection sub-Committee of NRPC Determination and Application of Practical Relaying Loadability Ratings, by North American Electric Reliability Corporation
Expertise of the investigators in similar systems
Extracts from the relevant portions of the above document is provided in this section for easy reference.
Recommendations made
Protection of 400 kV Transmission lines

• Any one of the Main 1 or Main2 relays shall be replaced with differential protection. Differential protection is preferred because of the reasons that it is stable during power swing conditions, differential protection with Fibre optic links are reliable.

• A separate E/F Protection shall be provide of all the lines.
Protection of 220 kV Transmission Lines

- Carrier aided distance protection schemes shall be used for distance protection of 220kV lines which helps in faster clearance of faults over the entire line length. (Ref: CBIP guidelines)

- In places where main1 and main 2 are distance relays, one of the protections shall be replaced with differential protection and an additional relay shall be provided for E/F(51N). In case of Numerical Distance relay, the built in E/F function can be used.

- Single phase Auto reclosure feature shall be enabled to avoid mal operations during transient faults.
Adopted Philosophy for Transmission Line Protection

• **Zone 1:**
  • Set to cover 80% of the protected line. There is no intentional time delay for this zone.

• **Zone 2:**
  • Set to (Protected line impedance + 50% of adjacent shortest line impedance). This will ensure that the zone2 element does not reach beyond zone1 of the relay on the shortest adjacent line.
  • The time delay of the zone2 element has to be only co-ordinated with the downstream zone 1 element. The zone2 time delay in this case is set to 0.3s.
  
  $300 \text{ ms} = 50\text{ms for downstream zone1} + 100\text{ms for the circuit breaker operation} + 50\text{ms for the upstream zone2 element reset} + 100\text{ms safety margin}.$
Resistive Reach

The resistive reach setting is constrained by the following:

• Less than the maximum expected load to avoid load encroachment
• Less than or equal to the zone R/X ratio suggested by the relay manufacturer
NERC PRC-023 recommendations

• Set transmission line relays so it does not operate at or below 150% of the highest seasonal *Facility Rating* of the line for the available defined loading duration nearest 4 hours (expressed in amperes).

\[ Z_{\text{relay}30} = 0.85 \times V_{L-L} / \sqrt{3} \times 1.5 \times I_{\text{rating}} \]
Resistive Reach contd..

The limiting reach for the relay characteristic along the 30° line (assuming a worst case power factor angle of 30°), is calculated as per the NERC guideline, using the formula:

\[ Z_{\text{relay} \, 30} = 0.85 \times \frac{V_{\text{L-L}}}{\sqrt{3}} \times 1.5 \times I_{\text{rating}} \]

where:

- \( Z_{\text{relay} \, 30} \) = Relay reach in primary Ohms at a power factor angle of 30°
- \( V_{\text{L-L}} \) = Rated line-to-line voltage
- \( I_{\text{rating}} \) = Facility Rating
Resistive Reach contd..

- Most manufacturers specify a limit for the quadrilateral characteristics R/X ratio. This limit is specified to ensure accuracy. This limit is more relevant for the instantaneous under reaching zone1, as we do not want the zone1 to overreach beyond the protected line due to the inaccuracies arising out of large R/X ratio of the zone. Hence, wherever the manufacturer has specified a R/X ratio limit for the distance protection zone, this ratio is also verified for zone 1.
- For R/X ratio limit for zone2 and zone3 is taken to be 10 and 15 respectively, uniform for all type of relays.
- The resistive reach setting finally adopted is the lower of the above two constraints imposed by the line loadability criteria and zone R/X ratio.
Relay Setting Procedures

Relay setting Procedures are given for the following relays

• MICOM P442
• MICRO MHO
• QUADRA MHO
• REL 511
• REL 670
• GRZ 1000
Line Protection - Additional recommendations

- Tripping due to defective line hardware. Tripping of bus differential protection or line due to defects of the line hardware have been reported. Existing line hardware should be replaced by jumper (preferably compression type). If PG clamp is used then it shall be minimum 4 bolt type (spring loaded).
PROTECTION OF TRANSFORMERS
Recommendation

• Overload protection relays shall be provided for all transformers and it shall be set for alarm and not for tripping.
TRANSFORMER PROTECTION SETTINGS
Transformer Differential Relay Setting procedures

Relay Setting Procedures are given for the following Relays

- DTH 32
- MBCH
- KBCH
- RADSBB
- MICOM P633
Transformer Protection setting

It is recommended that DTL shall change High impedance REF protections using interposing CT’s to low impedance type so that lower pick up can be adopted and use of interposing current transformers is avoided to reduce measurement error.
BACK UP
OVER CURRENT
AND
EARTH FAULT RELAY SETTINGS

DTL & CPRI, 09.05-2011, New Delhi
SYSTEM SIMULATION
Short Circuit Studies

Carried out for

- Single Bus – Bus couplers closed
- Double Bus- Bus coupler open

- Three phase faults
- Single line to Ground faults
Results of Short circuit Calculations
Back up Relay Setting calculations

Transmission Line Protection

• The pick-up setting of the directional over current relays have been set to 100% of the CT secondary rating. Since the actual load currents for the feeders are much lower than this, considering 100% of the CT rating will ensure that the relay does not pick-up for any transient over loading.

• The maximum fault currents are obtained from the short circuit studies.

• The time multiplier setting of the directional over current relay is selected to ensure that the directional over-current relay of the protected line will operate before the upstream distance relay’s zone 3 for a fault at the remote end of the protected line.
Back up Relay Setting calculations

Transformer Protection

- Fault current for a fault on the Transformer secondary side are obtained from the short circuit studies

- The pick-up setting of the over current protection is set to 150% of the rated current of the transformer. This is to avoid its pick-up for any transient over load.

- The time multiplier setting of the HV relay on all 220/66 & 220/33kV transformers are chosen to ensure co-ordination with the LV over current protection.
Generator Protection
Settings
Generator protection setting

At Pragathi and GTPS

It is recommended that the earth fault, restricted earth fault of Pragathi and Gas turbine power station shall be increased, since the existing settings are very sensitive and will mal operate for an external fault. The back up impedance relay settings shall also be revised as per the recommendations.
Review of Circuit Breaker Test Reports

Tests to be carried out for evaluation of Circuit Breaker performance

- Measurement of No load timings
- Coil Current Measurement
- Measurement of Operating Coil resistance
- Static Contact Resistance Measurements
- Dynamic contact resistance measurement
Review of Circuit Breaker Test Reports

- Measurement of air / oil pressure drop during duty cycle of operation
- Checking of air compressor / hydraulic pump operation
- Checking of Pressure setting of switches
- Checking of pole discrepancy
- Checking of interlocks (if Applicable)
- Checking of operating Lockouts
- Checking of Healthiness operation counter
Recommendations

Geeta Colony

i) Breaker No: 403875 – PPG CKT1 – Erosion of contact tips

ii) Breaker No: 403872 – SOW Ckt 2 – Erosion of contact tips

iii) Breaker No: 403870 ICT2 – Bpole

The above breakers need attention for overhauling and replacements of contact tips.

In order to have the clarity regarding the healthiness of the circuit breakers it is recommended that a standard format of test have to be adopted.
Healthiness of PLCC

- The faults in the carriers, protection couplers and wiring have to be addressed immediately with the help of respective suppliers to restore carrier protection at 9 out of 16 links.
- As the ABB make ETI carriers and NSD 61 protection couplers have served for more than 9 years and as the spare support will not be available from the OEM, and further as these equipment are in critical and important 400 kV links, it is suggested that 60% of these shall be shifted and relocated for important 220 kV links, and 40% can be retained as spares. The 400 kV links shall be provided with new ABB make ETL carriers and NSD 50 protection couplers, which are found to be very reliable and stable.
Healthiness of fiber optic links

- Of the 144 No of optical fiber links tested at 8 substations, 31 numbers were found to be faulty. The list of optical fibres having problems and the action to be taken is given.
DC System

- 400 kV substations
- In Bamnauli the DC System was found to be not satisfactory multiple faults were found in source 1 path.
- In Bawana the DC System condition is unsatisfactory. Multiple faults were found in source 1 path. Battery no 24 &67 are recommended for replacement.
  i) PGCIL I/CT-terminal burnt out and oxidized, recommended to be repaired.
  ii) Fault location – interlocking coil of isolators, it is recommended that interlocking coils shall be replaced.
220 kV substations

**Patparganj**
(i) Battery connecting plates are to be properly cleaned to avoid oxidation.
(ii) The cross over between J1 and J2 position is suspected which needs to be investigated further.

**Geeta colony**
Maintenance of battery is need to be improved by applying petroleum jelly.

**Saritha Vihar**
DC system condition is not satisfactory. It is recommended that the identified faults are rectified for overall improvement. Battery no.85 is recommended to be replaced.

**IP-Station**
It is recommended that the DCDB and the associated wiring shall be replaced.
220 kV substations

Maharanibagh

It is suggested that the charging voltages can be kept at lower level for longer life of batteries.

Pragathi Generating Station

Identified fault path and recommended for immediate correction. Battery banks of source 1 and source 2 are to be cleaned by removing the connecting plates of the individual batteries. Charger at DCDB needs to be rectified.
Time synchronizing unit

SNTP & IRIG-B protocol facility shall be enabled in the TSU in all 220 & 400 kV substations. Faulty TSU shall be replaced by new one in Geetha Colony 220 kV Substation.
Disturbance Recorder and Event Logger
healthiness and suitability

Where ever static relays are present, they are to be replaced by Numerical relays with suitable IRIG-B and SNTP cards. Existing numerical relays are to be upgraded with IRIG-B and SNTP cards as all of the existing numerical relays do not have the time stamping features.
Field test procedure for Relays

The detailed test procedures formats (format 1- format 18) for different relays used in DTL system is recommended as the existing procedures were found to be not exhaustive.
End to End testing

End to end testing carried out on 4 identified circuits.
The recommendation to overcome this for each of the tested lines are:
Line Barnaul to Ballabgarh CKT-2 (400 kV)
- Relay at Bamnauli (Micromho) shall be tested separately for its performance
- Relay at Ballabgarh (REL521)-the Relay is not sending the carrier signal, Configuration to be checked
Bamnauli to Mundka ckt-I 400 kV–PLCC channel is faulty to be rectified
Mandola-Bawana Line CKT-1 (400 kV) At Bawana Substation, the cable connection from Relay to PLCC channel to be checked
Mandola to South of Wazirabad CKT-1 (220 kV)- PLCC Panel at Mandola is Faulty to be Rectified

DTL & CPRI, 09.05-2011, New Delhi
Field Inspection of Existing Protection Relays for Obsolescence of Technology, Suitability and Healthiness

Obsolescence of protective relays has been checked & recommendation has been made to replace with suitable relays of latest technology. In all 180 number of relays have been declared obsolete and recommended for replacement.
Training

Conducted three days training course in two batches for DTL Engineers
THANK YOU
3.0 METHODOLOGY FOR PROTECTION AUDIT

The following Methodology / Detailed Procedure are proposed for carrying out the study:

(i) Review of Implemented Protection schemes

- Details of protection schemes/philosophy and relay settings adopted by state utilities will be collected.
- The protection schemes / philosophy for each circuit will be reviewed and compared against the recommendations of CBIP Publication no. 274 (revised). Any deviations noticed will be reported for ensuring compliance with CBIP recommendations.
- The optimum settings for the Protection relays will be calculated for all circuits in the scope of work (i.e. identified generator, transformer, transmission Lines, bus bar, reactor and circuit breaker) based on the CBIP guidelines and NRPC recommendations. Compliance with the loadability as per NERC criteria PRC-023-1 will be checked. Any deviations will be reported along with recommended settings and corrective action. Adequacy of the relay settings suggested by CPRI is ensured by choosing the settings in such a way that it will have maximum sensitivity for protected zone and proper coordination for primary and back up protection.
- Features to be enabled in Numerical distance relays will be recommended.

(ii) Relay Coordination study for different protection schemes

- Following System data will be collected –Single Line Diagram, Individual equipment parameters, locations of the relays, relay details, etc.
- System will be simulated using Relay Co-ordination software with proposed setting as obtained in (i) above and checked for proper coordination for over current / Earth fault and Distance Protection relays.
Based on this study, further changes in the relay setting for proper coordinated protection will be arrived at.

The Relay coordination of the primary and back up relays will be checked considering the Protection Settings of individual equipments. Setting will be recommended to ensure maximum sensitivity for protected zone faults, stability for external faults and coordination for primary and back up relays.

At the end of activities under Sl No: (i) and (ii) above, a through review of protection will be made and suitable philosophy will be formulated if any shortcomings are identified in CBIP procedure and recommended.

(iii) Checking adequacy/Healthiness of Primary & Back up Protection Scheme and setting

Adequacy of the existing protection scheme and existing relay settings are checked as per Section 3 (i).

(iv) Checking healthiness/ adequacy of 220/110/50V DC System available at Substations for protection/PLCC and suggest corrective measures in case of any problem

Procedure proposed to be followed for D.C. earth fault locating is as follows:

The process of locating D.C. Earth Fault in an on-line condition begins at the D.C. Distribution Board of the particular Sub-Station / Generating Station.

The basic principle is to establish in the first place the faulty pole at the D.C.D.B.

This is achieved by using a simple procedure, measurement of the bus voltages with reference to ground using a millimeter.

For example, if it is determined that either of the poles i.e., + ve or –ve reads a value less than the other pole then it is determined that the pole reading the lower voltage is affected by D.C. grounding.
On a 220 volts D.C. system the ideal bus voltage would be +ve to ground 110volts –ve to ground 110volts, and on a 110volts D.C. system it should read as 55 volts on either pole.

The procedure to start locating D.C. Earth Fault is to connect an Earth Fault Locating Equipment to the D.C.D.B.

For the safety of the equipment a ground reference is taken with the earth mat.

A 9 volt pulsating D.C. signal which is generated by a transmitter (battery operated) at 11.5 Hz is injected on the faulty pole.

The signal thus injected is reflected through out the sub-station on the pole on which the signal is injected, eg; if it is on –ve the signal travels along the –ve path and if it is +ve the signal travels along the +ve path.

The next procedure would be by using the receiver section of the instrument with appropriate sized probe to check all outgoing cables with reference to the faulty pole from the D.C.D.B.

The tracing procedure is conducted on all the circuits available at the sub-station.

The concept of the receiver is to trace the return path of the injected signal.

The receiver while being used to check will reflect various degree of deflection and will cease to reflect beyond the faulty point.

With respect to the notes made while conducting the test appropriate remedial measures can be adopted by the protection and metering division. Some times correction procedure calls for enforcing a shutdown.

It is also important to ascertain if A.C. mixture is present. To achieve this set the multi-meter to get the A.C. readings, then connect the +ve lead from the multi-meter to -ve pole at D.C.D.B. and the –ve lead of the multi-meter to +ve pole at D.C.D.B. the multi-meter should read zero volts, if this condition is achieved then it can be concluded that there is no A.C. mixture.

(v). Review of availability/ healthiness of communication links like PLCC, optical fiber used for Protection.
The healthiness of PLCC will be checked as per IS: 13968:1994. The following checks will be performed:

- Audio frequency, Intermediate frequency and High frequency signals at various levels
- Checking of Power supply status
- Ripple level
- Percentage modulation
- Radio frequency output level
- High frequency coupling level
- Co-axial check - expected receiver level
- Checking automatic gain control function
- Intermediate frequency and audio frequency levels at receiver
- Overall frequency response

The procedure of fiber optical testing will be as follows:

- Visit the site, check the no. of fibre hairs.
- Testing fibre using OTDR from End A to End B, End B to End A and average.
- The reports are saved in OTDR.
- The reports obtained consist of Length of the fibre, Losses and location where the losses are happening. A report with above parameters in excel sheet with a route network diagram will be submitted

(vi) Review of availability/ Healthiness of recording instruments - Disturbance Recorder, Event Logger (inbuilt in the relay or stand alone)

- The fault signal will be applied to the Distance protection Relays using Relay test kit with GPS features.
- The correctness of the recording of fault signal generated by the test kit and recorded by Disturbance recorder and Event logger will be compared. The parameters of the
recorded signals like amplitude, frequency of the voltage and current signals & the recording timing of the instant of applied fault will be checked in the Numerical Relays/Stand alone recorders for comparison with the fault signal generated by the Relay test kit.

(vii) Review of availability/ Healthiness of Time synchronization unit (TSU).

- The remote master clock of GPS is connected to TSU under test.
- One of the spare potential free contacts of TSU is connected to binary input of relay test kit with GPS. The test kit is configured to trigger on 1ppm of GPS synchronous pulse. The TSU potential free contact is expected to output 1ppm with 30 second on and 30 second off in synchronism with GPS clock which is the default setting (refer manual of TSU). On GPS 1ppm, test kit gets triggered and the pulse width based on potential free contact output which is connected to binary input of the kit is measured and compared with the default setting of the TSU. In addition, GPS timing of TSU will be compared with the time displayed in relay test kit which is taken as reference.

(viii) Review of test reports for assessing the healthiness of Circuit Breaker

- The test report will be reviewed for trip and close coil healthiness, Breaker close & open timings, SF6 & operating media pressure settings for alarm, Auto re-close lock out and Breaker operational lockout & Pole discrepancy operation.
- Procedure adopted for measurement will be reviewed against the standard procedure given in standard - IEC 62271 with latest amendments

(ix) Review of protection testing procedures benchmarked against best practices in the knowledge of the consultant being adopted around the world

- Details regarding the existing test procedure will be collected from utility
- Test procedure for individual protection (line, transformer, bus bar and generator) based on the standards (IS: 9124:1979, EPRI Report, CIGRE 34.10) will be collected
and compared with the procedure adopted by the utility. Changes required in the existing procedure followed by the utility, if any, will be suggested.

(x) Review of Field testing on all protection relays (including end to end testing), PLCC along with simulation of Disturbance Recorder & Event Logger signals individually for 02 No. 400kV & 02 No. 220kV Transmission lines. The testing will be carried out in the presence of Testing & Commissioning personnel of respective Substation.

Fault Locator validation
- The field test reports of relays available with the utility will be reviewed to check the healthiness of the relays.
- Field testing of all line protection relays of lines identified for end-to-end testing will be carried out (IS:9124:1979, EPRI Report, CIGRE 34.10).
- GPS synchronized end-to-end testing of distance protection of the four identified lines will be carried out as per the document of IEEE working group C11 Draft 2, 2006
  (Important Note: Relay field testing and end-to-end distance protection requires the line to be taken on outage. This shall be arranged by the utility as per the schedule of CPRI).
- Utilities shall arrange necessary shutdown
- Fault Locator will be validated using steady state fault waveform using Relay test kit. Tests with simulated fault waveforms is an involved study hence can not be carried out

as part of Protection audit

Important note:
(i) The equipment/line to be tested shall be taken on outage by the utility for the test duration
(ii) Utility shall depute a protection engineer conversant and authorized to change/restore the setting of the relay required for testing. The utility shall
have all the necessary software and tools for viewing existing settings, down
load and change settings.
(iii) All test connections shall be supervised by utility engineer

(xi) Field inspection of existing protection devices for obsolescence of technology,
suitability, healthiness (based on test reports).

- CPRI will visit the substations to identify the obsolete relays based on test report of
  the utility by checking the parameters like deviations in the accuracy of the operating
  value, operating time, relay characteristics, continuity check and insulation
  resistance.
- Relay model, type, sl.no, relay firmware version, date of commissioning, date of last
  settings file version will also be checked

(xii) Comparison of Protective relay test reports available at site against
POWERGRID

  norms or other best norms in the knowledge of CPRI

- CPRI will compare relay site test reports of the utility against Powergrid’s relay
  site test reports
- The standard IS:9124:1979 & CIGRE 34.10 for testing of relays in the field will
  be referred for additional requirements of site testing and report preparation.
- Periodicity of testing will also be reviewed

(xiii) Preparation of directory of the protection system. The format would
cover the details such as Sunstation, equipment relay used and their
settings

CPRI will prepare a directory of protection system consisting of the following:
- Name of substation
Name of Equipment
Relay settings

(xiv) Presenting the finding of the study and conducting 2 day tutorial/workshop to the concerned engineers.

CPRI will present the findings of the study by conducting 2 day Tutorial/Workshop covering the following:

- Protection philosophy as per the standard
- Existing Protection Philosophy
- Deviation if any and CPRI’s recommendation
- Setting procedures for Protection of Generators, Transformers, Transmission lines, Bus bar, Circuit breaker and Reactor
- Relay Co-ordination
- Protection testing procedures
- Test procedure for other equipment for DR, EL, DC circuits, PLCC, Optical Fibre, circuit breakers, Time Synchronization Unit

(xv) Preparation of study report on the protection review which shall include the details of recommended protection philosophy, setting calculation procedures for different protections, recommended settings for relays and suitable solutions for rectification of identified problems.