Traction Installation Directorate

सत्यमेव जयते

Government of India
Ministry of Railways

Instruction No. TI/IN/0024

For
Monitoring & analysis of Feeder Circuit Breaker Tripping for 25kV ac Traction systems

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ISSUED BY

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1.0 Scope

This instruction stipulates the action to be taken by Zonal Railways for monitoring & analysis of feeder CBs tripping and also suggests relevant check points for system improvements.

2.0 Background

In conventional 25 kV ac traction system, two feeder circuit breakers feed the traction power to the OHE on both sides of the TSS. As per the tripping data analyzed over the years, it is learnt that maximum numbers of faults occur on OHE only. With continuous increase in the number of trains at any time in the feeding zone due to increase in traffic density and automatic signaling, even a small interruption of traction supply results in to number of trains losing punctuality. The problem of signal getting blank is also observed if IPS (Integrated Power Supply) is not provided by signaling department. It is therefore essential to analyze the feeder CB tripping as a preventive and corrective action to ensure better reliability of OHE (traction power).

3.0 Analysis of faults on OHE

3.1 Every fault results in to flow of heavy current causes stress in the overhead equipment (OHE). The damage is more in case of arcing faults wherein cutting of some strands of catenary wire, pitting of contact wire and flashing / breakage of insulators shed etc. may also result.

3.2 Repeated transient faults occurring at same location may finally result in breakage of catenaries / contact wires or insulators resulting in permanent breakdown of OHE.

3.3 In case of permanent faults due to failure of any equipment e.g. insulators, substation/switching post equipment, lightening arresters and OHE breakdowns etc. feeder CB trips. The single shot auto re-closer automatically closes the CB after nearly 500 ms and it trips again and relay locks out. It is easier to locate such faults as in most of the cases damage is visible.

3.4 Traction Power controllers reclose the CB with different combinations of system configurations so as to identify & localize the faulty section.

3.5 It is observed from the details of feeder CB trippings as provided by Railways, that large number of tripping are of transient in nature i.e. CB holds after re-closing. Likely reasons of transient tripping attributed by Railways are tabulated as under. The remarks/remedial measures to be adopted by Railways have been suggested against each to minimize the tripping.

Likely reasons of transient tripping	Remarks/Remedial measures
Suspected bird/monkey/snake faults	RDSO has issued drawing of anti- climbing arrangement of OHE mast vide RDSO letter no. TI/OHE/INS/GEN/08 dated 03.11.2008 which should be adopted to reduce such menace.
Over loading on TSS (feed extension or low incoming voltage)	• Record loading data at TSS. Refer to RDSO instruction TI/IN/0019 (09/09). • Analyze voltage profile, whether voltage is falling below the minimum permissible limit. • Long term planning of feeding zone rationalization. • Consider options of ONAF, higher capacity & parallel operation of transformers.
Tree touching	• There are instructions for tree trimming before onset of monsoon
Flash overs on insulators / tracking & bad weather/extreme pollution conditions	• Minimum creepage distance of insulators has been increased from 840 mm to 1050 mm. • Ensure that insulators of correct type &creepage distance are provided based on the pollution level (calculation of ESDD) as per the policy directives issued from Rly. Bd./RDSO from time to time.
Faults on the roof or on HT side equipment of Loco	• Feeder CB tripping time with modern numerical relays is 100-110 ms (*30-40 ms for relay+ 60 ms for CB+ 10ms for MTR*). • The loco CB time (for both DJ and VCB types) is nearly same or more than this therefore even in case of fault in Loco HT equipment like transformer, bushing etc. TSS CB tripping may occur. • Tripping due to loco should be dealt as per Para 20521 of ACTM Vol-II Part-I and close interaction of TPC with TLC should be ensured.
Fault created by foreign materials like small wires etc.	Provision of standard jalis and boards on ROB & FOB apart from maintenance precautions taken at the time of birds nesting periods can reduce the problem.

3.6 There are some cases reported by Railways wherein a persistent arcing fault on OHE results in to severe damage to system e.g. melting of insulators or ferrous fittings etc. Such incidences occur mainly due to high resistive faults, which should be analyzed in detail as elaborated in Para 5.0 below.

3.7 In addition to above from the CB tripping data received from Railways, it is observed that large number of feeder CB tripping results if it is feeding to a nearby loco shed, long siding or a large yard.

3.7.1 In order to reduce tripping of feeder CB's, under these situation some Railways have provided separate feeder breakers for loco sheds/yards at the nearest switching post however as no time delay (grading) is permitted in distance protection both the feeder CB's connected in series trip simultaneously. However in such cases auto re-closer function in the CB feeding the loco shed/yards should be kept off so that it remains open while main feeder CB should reclose for identifying faults in loco sheds/yards. After confirming the cause of tripping by TPC from loco shed/yard, the CB may be closed.

3.7.2 Other possible options for this problem may be provision of a separate CB in the TSS and feeder line for loco sheds/yards based on techno economic considerations.

4.0 Use of numerical protection relays for fault analysis

Before 2009 the protective relays developed by RDSO for 25kV feeder protection were electromagnetic / static / microprocessor type, in these types of relays event recording, display of current, voltage, resistance & reactance parameters of fault was either not available or not standardized, however with the development of numerical type relays as per latest specification following features have been standardized:

4.1 Capability to store maximum 10 numbers of latest fault events with date and time stamping. Each event comprise of 45 pre and 5 post-fault waveforms.

4.2 Facility to retrieve the following data from relay through serial communication port for analysis:

- Peak, average and RMS value of fault current and voltage
- Fault clearing time
- R-X and phase angle
- Percentage harmonics analysis of fault current

4.3 Display of Voltage, current and R-X value of 5 latest faults with date and time on relay LCD display.

Railways should make use of above features to the maximum extant for fault analysis purpose.

5.0 High Impedance or High resistive faults

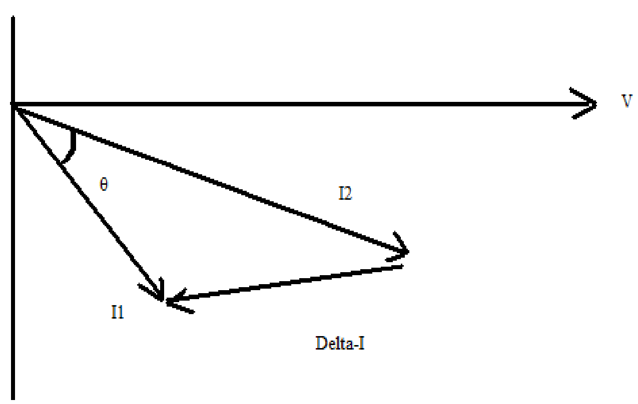
There are two characteristics of such faults on OHE i.e. low fault currents and arcing. Arcing is the result of air gaps due to the poor contact made with the ground or a grounded object.

The high impedance of the fault does not result in a substantial increase in current and due to this fault cannot be reliably detected & cleared using conventional protection relays like OCR & DPR.

5.1 To clear the high resistive faults scalar Delta-I relay was developed in 1998 and subsequently in order to increase its sensitivity, in place of scalar characteristics vectorial type relays were developed in 2003.

5.2 Δ-I relay monitors the vectorial difference between base current and fault current in pre defined time interval (generally 2-3 cycle), if vectorial difference is more than set current and other conditions are satisfied then relay executes trip command. By using Vectorial Δ-I relay the failure of OHE due to high resistive fault may be minimized.

Vectorial delta-I relay characteristic



I_1 and I_2 are two consecutive current values seen by Vectorial Δ I relay

5.3 RDSO has circulated setting guidelines for ΔI relay vide letter No.TI/PSI/PROTCT/STATIC/07 dated 23.04.2007 which should be followed. Main features of this protection relay are:

(a) It is a backup protection of DPR or OCR. Its operating time is above 200 ms. In view of this all cases wherein it has operated must be carefully examined for any possibility of fault in the system or mal-operation of the relay or tripping due to in correct setting. There are cases reported by Railways wherein this relay operates along with the DPR which means either the ΔI relay is not having correct setting or DPR operation might have resulted due to culmination of high resistive fault in to a solid earth fault after damage to the system or equipment.

(b) The suggested settings of Delta-I current are based on practical experiences however Railways must critically review and suggest any changes if required for increasing effectiveness of this protection.

(c) X-blinder value- This is the line reactance value monitored by relay and it does not trip if it is not less than the set value.

(d) There is a logic to differentiate between sudden rise in current due to load or fault i.e. generally load current has got high 3^{rd} harmonics therefore for 3^{rd} Harmonics contents < 15% relay trips for $\Delta I > 2A$, however for 3^{rd} Harmonics > 15% it automatically increases set value to $\Delta I > 4A$. Thus in this way it analyses 2^{nd} and 3^{rd} harmonics level to distinguish between load & fault currents.

6.0 Important points for monitoring & analyzing faults on OHE

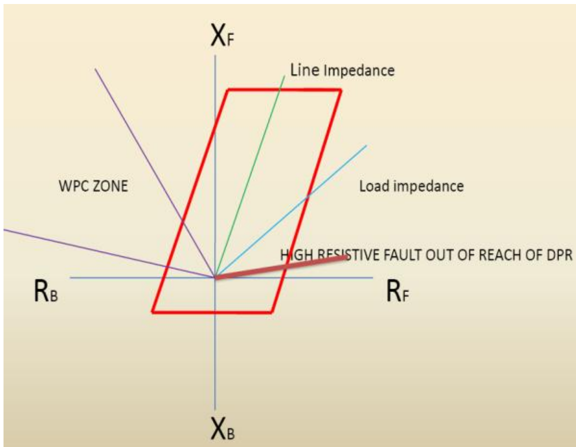
6.1 Transient faults

- Maintain the individual CB tripping detail history.
- Protection relay / element acted (DPR-{*OCR, WPC, PTFF*}, Panto flashover, Δ-I, IDMT etc.) should be clearly indicated for each tripping.
- If numerical type relays are provided for feeder protection the information as mentioned at Para 4.0 above must be retrieved. For each feeder, it should be stored chronologically in soft copies with date and location tags for analysis.
- Estimate the fault distance with the help of recorded reactance value i.e. X considering 0.3853 Ω/km reactance for single line and 0.2255Ω/km for double line sections.

- Compare the voltage, current, resistance & reactance of each tripping, if during transient tripping similar values of reactance are observed repeatedly for same CB, inspect the OHE surrounding the calculated fault distance (± 500 meters) and look for the flash mark on catenary and contact wire, cutting of catenary strands, flash mark / breakage on insulator shed, foreign material hanging on the catenary/ contact wire etc.

6.2 Additional important points for investigation of permanent faults resulting in to large scale damage to OHE or traction supply system

If relay has taken excessive time in clearing the fault or consequential damage to equipment/system is found to be substantial then following additional areas should also be studied to arrive at the root cause of problem.

Sr No.	Important points	Remarks
1	One of the most important reason of non/delayed operation of distance protection relays is that effective impedance (with predominantly resistive arc component) as seen by the relay falls outside the parallelogram characteristics as depicted in the diagram below. 	Condition/availability of earthing bonds at fault location should be checked. If possible earthing resistance can also be measured at fault location. The condition of bond joints with Rail should be carefully examined for signs of arcing, loose connections etc. If repeated cases of high impedance faults are observed from a single TSS then substation buried Rails and their connections to the Rails must also be checked.

2	Check how many times CB has been closed by TPC for fault localization. Repeated closing of CB under persisting fault condition may also result in to damage to system.	A fault localization control card should be readily available with TPC's in line with Para 20522 of ACTM Vol-II Part-I. While preparing the control card due consideration should be given to quick isolation of tripping prone loco sheds, yard lines.
3	Verification of the relay settings & calculations done earlier	Examine if in the recent past changes have been made in the feeding arrangements or layouts.
4	Distance of fault location from feeding post	Fault currents are more near to the feeding point.
5	Type of Delta I relay provided	Check whether scalar or vectorial Δ-I relay is provided. Vectorial Delta I relays are the latest and having better resolution.
6	Check the CB tripping time.	It should not be more than 60 ms.
	Testing of relays	Check functionality of relays at set values. Also check operating time of relay by secondary injection test kit. Features like Local Breaker Back up protection must also be checked. Find out errors, if any, in the relay operating values especially near boundary conditions. Examine the data recorded in relay (see Para 4.0 above)
7	Parallel operation of 2x21.6 MVA transformers	Parallel operation of 2x21.6 MVA transformers leads to nearly double the fault current for close in faults. New protection scheme suggested by RDSO vide TI/IN/0017 dated July 2008 should be adopted.

8	Feed condition (normal / extended) at the time of incidence.	If problem occurs in the extended feed zone verify the relay setting calculations carefully.
9	Power block status and its location.	There have been cases reported from some heavily loaded substations wherein power block of one subsector (i.e say DN line) between TSS & first SSP has resulted in to feeding of complete load current from single line OHE (i.e UP line in this case), thereby resulting in overloading and melting or damage to OHE/jumpers.
10	Flash overs due to breaking of load currents	If a moving loco/train crosses from the live section to dead section on an IOL at TSS/FP, the resulting flash over may cause parting of contact/catenary wires. Similar condition may occur on section insulators provided in yards or loco sheds especially under power block conditions. Even sudden lowering of the pantograph drawing heavy current may also result into arcing and damage to contact/catenary wires. Use of Panto flash over relays must be considered for all TSS/FP having IOL.