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Power System Reliability improvement by proper application of Problem Solving Tool

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Abstract:

This Paper is aimed at analyzing the few important Power System equipment failures generally occurring in the Industrial Power Distribution system. Many such general problems if not resolved it may lead to huge production stoppage and unforeseen equipment damages. We can improve the reliability of Power system by simply applying the problem solving tool for every case study and finding out the root cause of the problem, validation of root cause and elimination by corrective measures. This problem solving approach to be practiced by every day to improve the power system reliability. This paper will throw the light and will be a guide for the Practicing Electrical Engineers to find out the solution for every problem which they come across in their day to day maintenance activity.

Introduction

The Article titled ***"Power System reliability improvement in industrial power distribution system***" aimed at reducing Power Distribution System Network and Equipments failure . Electrical fault is the deviation of voltage and current from normal values or states. Under normal operating condition, Power system equipment or lines carry normal voltage and currents which results in safe operation of the system. but the when the fault occurs, it causes excessively high current to flow which causes damage to equipment and devices. Fault detection and analysis is necessary to select or design suitable power system network equipments like switch gears, protective relays, cables etc. On the other hand usage of power electronics devices , non linear loads etc are increasing day by day for the need of process capability improvement, process automation and process optimization .Increased usage of Power Electronics devices is also degrading the power quality which leads to the failure of Power System equipments . The Power supply is the main source for operating the industry and hence any interruption in the power system equipments leads to unplanned production stoppage, increased cost of maintenance, Energy Loss , product scrape, increased maintenance man hour etc.

Hence a systematic approach and review of failure analysis and Problem Solving is required for implementing necessary corrective action and to improve the reliability of Power system equipments.

Objective

The Objective of this Paper is to analyse the various common failures generally occurring in the industrial power Distribution system network equipments and providing necessary solution to eliminate the root cause of the failure and to improve the Power System reliability in a typical industry. A few general case study of problem with power system equipment failure and necessary corrective action carried out to improve the power system reliability has been discussed in this paper and the following relevant guide lines and relevant tools is also kept in consideration and applied suitably while carrying out improvement plan.

- Standard practices in the Selection, Installation and maintenance of Power Distribution system equipments.
- Adhering to regulatory guidelines
- Adhering to fire and safety standards
- Adhering to usage of PPE as per risk category
- Practicing improvement techniques like FMEA,PDCA,KAIZEN,Problem solving techniques like Why Why Analysis etc
- Principles of Energy Management System , Environment Management system and quality management system

Power System Reliability Improvement - Case Study#1

Conventional single phase power distribution system

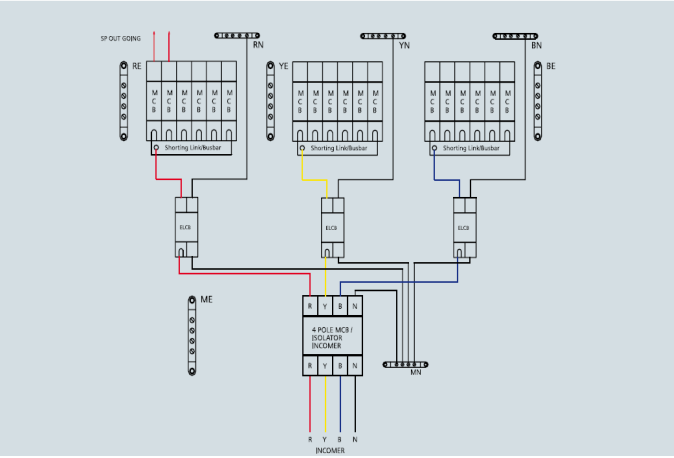

Fig.1 Single Phase Power Distribution System

The scheme in Fig.1 shows the traditional way of Power distribution scheme for Single phase equipments in industry or in domestic application. In this scheme when ever incoming neutral connection is cut or disconnected due to loose connection, Over voltages appear across single phase equipments when the load is unbalanced. Hence the complete circuit elements and equipments gets damaged. Neutral disconnection /loose is general recurring problem in the domestic service connection and as well as in industry. But if we fail to detect and isolate the supply, there will be a severe damage to the equipments

Hence when ever the incoming neutral failures occur, equipments will get damage

due to the over voltage appearing across the equipment when the load is not balanced in the three phases.

Problem Statement: In the Three Phase to Single Phase power Distribution board, All the Single Phase Devices connected in the distribution circuit failed during incoming neutral failure.

Root Cause Analysis

Why did single phase equipment fails in the Three phase to Single phase PDB during Incoming Neutral link failure?

Ans: Because of Over voltage appeared in the Single Phase equipments.

Why did over voltage appear in the Single Phase equipment when the three Phase voltage is within the limits?

Ans: Because of incoming neutral failure in the three phases to Single Phase power distribution board, Over voltage appears in the circuit due to unbalanced loading.

Why can't we prevent the Unbalanced loading ?

Ans: We can only balance the connected load in the circuit but the loading varies depends upon utilization/operation.

Why can't we prevent the Failure of Incoming neutral continuity?

Ans: During Preventive maintenance, The tightness is ensured, But man is with errors, Hence the possibility neutral loose connection could not be eliminated?

Why can't we detect and isolate the circuit when over voltage appears in the Single Phase distribution circuit?

Ans : By installing suitable Power frequency over voltage protection device across the single phase sub incomer, We can prevent the damages caused during incoming failure

Voltage Triangles of Un balanced loading system when neutral is cut

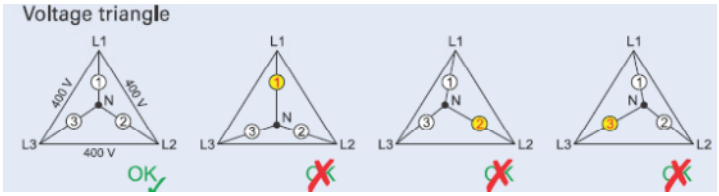

Fig.2 Voltage triangles of Unbalanced loading system when neutral is disconnected

Root Cause validation

After installing Power frequency over voltage protection device in Single Phase Power Distribution Board, Equipment damages eliminated due to over voltage incase of incoming neutral failure

Power System Reliability Improvement - Case Study-2

Existing System

In the Existing system, when there is LG fault in the down stream, the near by breaker did not clear the fault but instead the next upstream breaker tripped. Hence unintended power outage to other equipments instead of the respective faulted zone.

LV Power Distribution Scheme

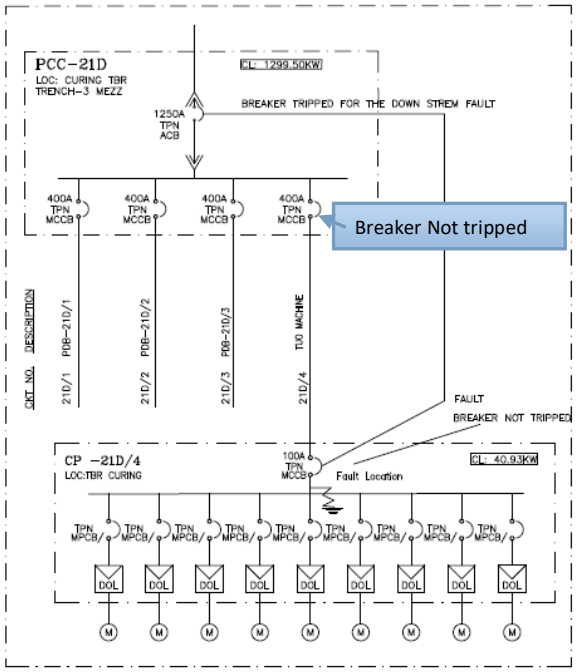

Fig.3 LV Power Distribution Scheme

In the LV distribution scheme shown in fig 3, all the three breakers are having OL+SC+Earth fault protection. There is clear discrimination with respect to symmetrical short circuit but when there is unsymmetrical fault like LG fault, The fault was cleared by 1200 Amps ACB instead nearest Up stream breaker like 100 A or 400A CB. The earth fault current setting is 20 Amps at 100 Amps CB, 80 amps at 400 A CB and 400 Amps at 1200 Amps ACB. Under this condition when there is LG fault below the 100 Amps MCCB, The fault was cleared by super upstream CB. Hence there is unintended power outage to other equipments other than faulted equipments. The actual fault current recorded during this incident is 4.3 KA.

Problem Statement: Unintended power outage to other equipments other than the faulted equipments in the LV distribution system when there is L-G fault.

Problem Solving approach:

Why did the power outage happen other than the faulted equipment?

Ans: Because the LG fault current is higher than the Ground fault setting of the all the breaker from downstream to upstream breaker. (Note: 1200 A is highest permitted setting in the 3200 Amps ACB as per IEC standard but the LG fault current is in the order of several KA).

Why can't we have intelligence in the Breaker to establish the communication to isolate the faulted Zone alone?

Ans: Yes, If the breaker is intelligent, we can establish Zone Selective Interlock through the communication system.

Root Cause validation

Zone Selective Interlock implemented in the MV Distribution. After implementation of Zone Selective Interlock, there is no power outage to other than the faulted Zone.

Power System reliability Improvement – Case Study-3

Introduction

In Industrial LV power distribution system cable termination failures are very common in nature and it is frequently occurring at various pats of the plant. Though the corrections are carried out the technician level, it is important to analyse the route cause and carry out the corrective and preventive action to prevent recurrent of such failures. Hence by implementing the corrective action for cable termination failure, the power system reliability will be improved to a great extent. The image of

temperature rise at the faulty cable termination and improved termination is explained in this case study.

Thermal Image of faulty cable termination

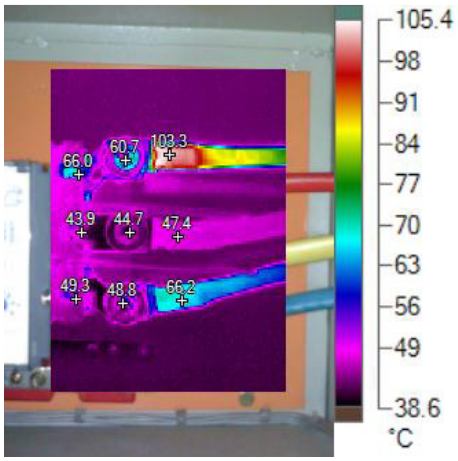

Fig.4 :Thermal Image of faulty cable termination

In the above figure 5 , R Phase cable termination is defective and it is not in intact. Hence there is abnormal temperature rise in the R Phase cable termination when compare to other two phase. If we continue to operate at this condition, R phase cable socket will fail with in the short period of time. This will lead to unintended equipment stoppage. The correction required will consume labor, materials, Some times if there is extra length cable, we need to prepare additional joint to extend the connection. This additional joint is another problem prone area. Hence the more no of joints will have more termination issue. Hence by applying proper corrective action for such type of failure, will help to improve the power system reliability.

Problem Statement:

Abnormal temperature rise in the end termination Power cable which leads to cable termination failure / fire and affects the power system reliability

Y-Phase - 66 C (deg centigrade).

R-Phase - 105 C (deg centigrade).

Problem Solving Approach

Why did the temperature at End termination one phase is higher than the other when each phase carries same magnitude of current?

Ans : Because the temperature rise depends up on (I^2Rt), Hence when I and t is same, The Resistance should be varying

Why the resistance at One termination is different from other ?

Ans: Because of the difference in the effectiveness of crimping.

Why the effectiveness of crimping varies from one termination to other termination?

Ans : Because of the difference in quality of Workmanship, cable socket surface, Area of jointing contact preparation, Improper contact during crimping leads to vary jointing resistance.

Why can't the jointing resistance be checked immediately after crimping ?

Ans : Yes, the Jointing resistance can be checked after crimping by conducting Mili volt drop test and verify that the voltage is drop is <than 10 milli volt across the jointing to avoid abnormal temperature

Thermal Image after rectification cable termination

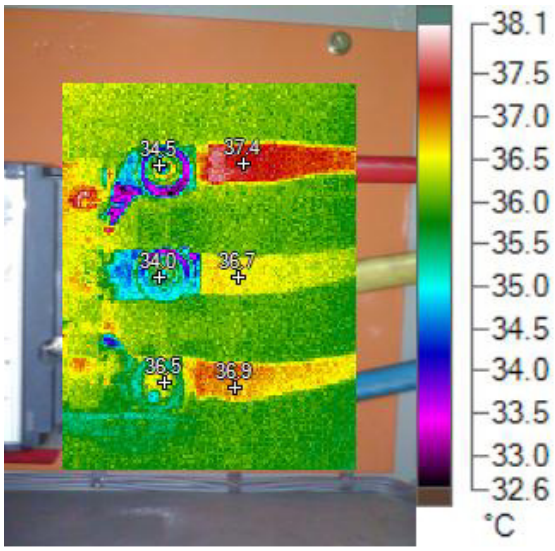

Fig.5Thermal Image after rectification cable termination

This fig 5 shows the thermal image after rectification cable termination fault.

The temperate of all the three phases are at equal temperature and no abnormality. If we continue to operate at this condition , the termination failures are remote and hence the power system reliability will be improved

Root Cause Validation : After retermination , Milli volt drop test conducted and it was < than 10 milli volt at the jointing, After putting in to service thermal imaging carried out after 6 hours of operation. No abnormal temperature rise was found and it is monitored periodically during periodical condition monitoring . Hence the corrective action and evaluation carried out after corrective action is effective. and the temperature is

Conclusion:

Based on the failure analysis, It is noted that most of the failures are relating to human error in the selection and installation and maintenance of Power system equipments. Solutions are available for all technical problems. Hence by application of problem solving tool for each and every problem, we can eliminate the root cause of problem and improve the Power system reliability day by day and it is a continuous improvement journey for all practicing engineers

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