International Journal of Scientific Research in Science, Engineering and Technology
Print ISSN: 2395-1990 | Online ISSN : 2394-4099 (www.ijsrset.com)
doi : https://doi.org/10.32628/IJSRSET229464

Electrical Safety Related Isolation on Industrial Machines with Multiple Entry Points

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Article Info
Volume 9, Issue 4

Page Number : 387-392

Publication Issue :
July-August-2022

Article History
Accepted : 10 August 2022
Published: 27 August 2022

ABSTRACT

In industrial machine, there is often more than one entry point that might be used during the operation and maintenance functions. Typically, the lockout/tag-out procedures prior to entering the machine have been done using series-connected conventional load-break disconnect switches. Unfortunately, the required verification is problematic for applications requiring only one disconnect switch and is almost impossible when more than one disconnects switch is applied. Industrial equipment design must include safe methods to allow access for either maintenance or operational intervention. Although the overall safety elements of the industrial equipment design efforts are predominately a part of the mechanical machine's design, often, the motive forces that must be considered are directly or indirectly associated with the control of electrical energy. Considerations in selecting safe methods for intervention are those associated with ease of use (human factors) and those associated with equipment reliability. This Project new multiple entry point method is proposed industrial machines for Industrial Electrical Safety System.

Keywords : Electrical Safety System, Power System Control

I. INTRODUCTION

The "Permit to Work & Safety Tagging System (PTW & STS)" is the process, introduced in NDPL: -a power distribution utility- to put in place standard working practice which will promote a culture of safe working among its personnel while carrying out any work in electrical equipment/system. This in turn will ensure safety of personnel, safety of equipment and safety of society at large. This document defines the process of obtaining a permit to work on a certain electrical equipment of NDPL and also puts in place the usage of the relevant "Tags" to designate the electrical equipment under maintenance or during any activity that puts off the circuit or abnormal conditions. NDPL system requires 'Power System Control (PSC)', Distribution, Network, Grid Maintenance and Projects personnel to coordinate and to carry out the work on the equipment / system. PTW & STS then becomes a "Safety Contract" between all the personnel and facilitates a safe working environment. The STS is used in conjunction with PTW or otherwise to provide

visible cautions / signage about the area and dangers associated with handling of the electrical equipment / system.

II. SAFETY FROM THE SYSTEM

The erection of poles in accordance with this Live Working Procedure requires the issue of a detailed work instruction. This instruction shall define the work area by the provision of a detailed map or plan giving pole position and the precise Location of the new pole(s) which is (are) to be erected. The new pole construction type and height shall also be specified. All HV work on sites together with all associated Switching actions shall be carried out in accordance with a detailed Switching schedule. The detailed work instruction shall be issued by the Authorized Person in charge of the work. Throughout the course of the pole erection procedure, the Minimum Safe Working Clearance between any of the lifting equipment and the Live conductors, stipulated below, shall not be infringed

Minimum Safe Working Clearance at Low Voltage: 1.0m
Minimum Safe Working Clearance at High Voltage: 3.0

This clearance shall be applied in all directions from the Live conductor – it is NOT a vertical clearance only Throughout the pole erection process, the JCB or Hiab shall be effectively connected to earth via an Approved earth rod connected to the vehicle by an Approved Field Equipment Earth. Prior to the installation of the earth rod, it shall be verified that there are no underground services in the vicinity. The earth rod shall be positioned such that it does not pose a hazard to either the Controlling Craftsman throughout the course of the procedure or to the machine Operator who may require emergency egress from the machine. For HV work, and throughout the duration of the work the Control Person responsible for the circuit being worked on shall where practicable, ensure that, the circuit protection is set to "one shot to lockout". Where this is not practicable, the Control Person shall be notified. In the event of a Live conductor being brought down into contact with the vehicle carrying out pole erection.

III. AUTHORIZATION IN NDPL

a) Following are the functional areas in which staff will be identified for authorization to take charge of the equipment's for carrying out the activities of respective functions.
Distribution Network – Operation & Maintenance
Grid Substation & Transmission Lines – Operation & Maintenance
Projects Testing & Protection and Automation will work under the PTW availed by owner member
b) All 'Section Heads' of the aforesaid functions will identify the members of their group who they deem fit (based upon the work experience / knowledge of the system / level) for working on the electrical equipment of NDPL network pertaining to the purview of their functional area.
A list (herein after known as "Tagging List") based upon the aforesaid exercise will be formed & forwarded to PSC after the due approvals from the functional heads as mentioned below.

IV. IE RULES: AUTHORIZATION

The statutory document governing the criteria of authorization is "IE Rules 1956". Following are the References to the IE Rules pertaining to authorization
a) IE Rule – 3: Provides the details pertaining to the level of the individual who is to be authorized and the type of installation where he / she is purported to work
b) IE Rule – 36: Provides the details pertaining to the safety procedures and the related authorizations that need to be adopted while carrying out work on "Electric Supply Lines & Apparatus".

V. SAFETY TAGGING SYSTEM

The safety tagging system is intended to achieve following standards in the working lives of the personnel in NDPL –

a) Safety of the personnel and the public at large

b) Safety of equipment & property

c) Designate the abnormal conditions in the circuit of NDPL network

All circuits, equipment & systems are deemed to be in energized state unless the tags are placed to designate otherwise

VI. DO NOT OPERATE (DNoP) TAG

1. DNoP tags are associated with the outage of the circuit/equipment for which the PTW is obtained from Power System Control.
2. DNoP will have the same number as the PTW for the circuit/equipment.
3. DNoP has to be filled by the permit holder and to be necessarily placed at all the isolating/grounding points for the circuits/equipment's that are taken out or isolated from the system & are not energized.
4. The Permit Holder to notify the Power System Control about the number of DNoP tags placed on isolating/grounding points for the circuits/equipment's that are taken out or isolated from the system & are not energized.
5. DNoP tags are to be attached to open switches, breakers, isolators, disconnects. Jumpers, taps, GO Switches & other means through which known sources of electric energy may be supplied to the lines & equipment.
6. The DNoP tag acts as a lock. Once the tag is attached to a piece of equipment that equipment cannot be connected to known sources of electric energy, not even for test purposes.
7. Personnel carrying out isolation operations of the particular equipment is responsible for placement & removal of DNoP tags.

The DNoP tags are of specific dimensions & are for the purpose of preventing the personnel from charging the equipment under outage hence have "RED" Colour with the danger mark.

VII. TESTING STRUCTURES FOR INTEGRITY PRIOR TO UNDERTAKING WORK.

• Implementation of a fall protection program that includes training in climbing techniques and use of fall protection measures; inspection, maintenance, and replacement of fall protection equipment; and rescue of fall-arrested workers, among others.

• Establishment of criteria for use of 100 percent fall protection (typically when working over 2 meters above the working surface, but sometimes extended to 7 meters, depending on the activity). The fall protection system should be appropriate for the tower structure and necessary movements, including ascent, descent, and moving from point to point.

Open Bus Bar Substations Equipment used to designate a safe work area and access route within a Substation.

a) Safe Working Area: –

Red Cones (up to 7m apart), two orange ropes (10mm) used on each side of the yellow angled cross arm and Green Cones (up to 6m apart), define the safe working area within the roped perimeter. Only Authorized work may be conducted in these areas, with the approval of the safety document holder.

The higher side of the cross arm defines the safe side. Cones should be weighted with loose gravel for stability where appropriate. Access Route to Safe Working Area - Red Cones (up to 10m apart), used to define the access route, only one orange rope (10mm) on the high side of the yellow cross arm. Further procedures/information are contained in the Scottish Power Safety Rule, PSSI 6.

b) Transmission OHL`s: -

Tower Identification is determined by a number plate fitted adjacent to the property plate, which is fitted just

above the anti-climb device. This number provides a unique identification of every transmission tower.

Most towers carry more than one circuit, so each circuit has to be positively identified. Circuit Identification Colour Plates are located on each side of the tower, attached to the climbing leg above the anti-climb device.

Each circuit will be identified by a different Colour. There may be additional Colour plates on the tower at each cross arm.

c) Exclusion, Danger or Hazard Zone: -

Establishing and controlling an exclusion zone around the base of any structure being worked on, will prevent staff or third parties from injury due to falling objects, this is also considered demarcation. The demarcated area shall be physically controlled (minimum of continuous rope, chain or tape).

VIII. WORK ISOLATED ORIGINS OF THE "SAFETY-DISCONNECT-SYSTEM" DEVICE CONCEPT

The unseen failure to open the power circuit can happen with either conventional mechanical load-break disconnect switches or when power contactors are used. One example with a disconnect switch occurs when the connection between the control handle and the actual movement of the power contacts fail. A normal manual load-break disconnect switch ordinarily has some form of spring assistance, which is essential for the load make and break operating mechanism to accomplish the needed arc extinguishing and to avoid the possibility of "teasing" the contacts. The requisite mechanical snap action is a factor in limiting the mechanical life of the device. Undetected failures to open the power circuit have been experienced in these types of switches, despite the operating handle's requirement typically found in standards: "When the handle on a heavy-duty switch is moved to its full off position, it shall be capable of positively operating the contacts to their off position without requiring spring assistance".

National Fire Protection Association (NFPA) 79 and IEC 60204-1 allow the use of a contactor to remove motive power for limited operator intervention; some methods also included the use of local indicators for verification. This limited acceptance indicated that the basics are present for a safe design using a contactor as a component of a device or unit.

IX. SAFETY-DISCONNECT-SYSTEM CONCEPT EVOLUTION

Initial and subsequently later proposed disconnect-device or unit-design concepts were submitted to the Process Safety and Risk Management group at the Battelle Memorial Institute of Columbus, Ohio, to do an independent study of the risk seen by the operator. Battelle concluded that "the proposed (new) concepts were found to present the lowest risk to the operator". The Battelle studies were initially done in 1994 and later updated in 2001. The study results showed that the concept was directionally correct. The following items were submitted to the Office of Safety Compliance Assistance of the U.S. Department of Labor— Occupational Safety and Health Administration (OSHA), requesting a letter of interpretation/variance

• The initial safety-disconnect-system device concept description.

• The "results of the Battelle study" (1994).

• A "risk assessment of typical design requirements which were based upon the device concept;"

other documents outlining the existing comprehensive Industrial Hygiene and Safety program in which the safety-disconnect-system device would be deployed.

The resulting OSHA Interpretation letter agreed with the proposal and outlined the basic features of the safety disconnect-system device concept.

1) The system measures and ensures no (electrical) motive force to the drive system. Comment: Additional devices that incorporate the same concept to control

other motive forces on the machine such as pneumatic and hydraulic are being and have been developed.

2) The system provides fail-safe verification, i.e., defaults to the safe position. Comment: The devices being developed today use several mechanisms to make the fail-safe verification possible, either by prohibiting the machine from having motive force available or by preventing access to the hazardous portions of the machine.

3) Verification is provided by a system, which checks the position of the contactor and actively confirms zero energy state to the drives before the verification light comes on. Comment: This would also include checking the change of state of other related components, whether a contactor or some other component is used to achieve the zero-energy state.

4) When an individual initiates the lockout sequence by opening the system switch and placing a lock on it, then the verification light will come on, if the machine is at a zero-energy state (electrical motive energy).

Comment: From a generic point of view, the requirement is as follows:

The individual initiates the request to enter the machine, gets from the device a positive indication that the motive force has been safely controlled or removed, and

X. "SIE" DEVICE

The concept has been translated into design requirements which have resulted in several device designs. Many of the present executions of the concept are devices, which among their components include one or more power contactors. The contactor is only a component of the device or unit, NOT the complete System Isolation Equipment (SIE) device or unit. In order to correct this misinterpretation, several names have been tried for the devices)

- Safety Lockout System.
- Grounding Isolation System.
- SIE

The following general descriptions pointing toward the device concept have been published in application standards:

1) redundantly monitored remotely operated contactor isolating system that incorporates control lockout provisions and is listed for disconnection purposes.

2) any other switching device in accordance with an IEC product standard for that device and which meets the isolation requirements of IEC 60947-1 as well as a utilization category defined in the product standard as appropriate for on-load switching of motors or other inductive loads.

The term SIE is defined in the 2005 and 2008 editions of the National Electrical Code (NEC). 430.2 Definitions: SIE. A redundantly monitored remotely operated contactor-isolating system,

packaged to provide the disconnection/isolation function, capable of verifiable operation from multiple remote locations by means of lockout switches, and each having the capability of being padlocked in the OFF (open) position. The SIE is recognized as a disconnect means in the 2005 and 2008 editions of the NEC. 430.109(A): (7) SIE. A SIE shall be listed for disconnection purposes. SIE shall be installed on the load side of the over current protection and its disconnecting means. The disconnecting means shall be one of the types permitted by 430.109 (A) (1) through (A) (3). Comment 1: "SIE shall be installed on the load side of the overcurrent protection and its disconnecting means." See Figs. 1–3. Comment 2: The other 430.109 (A) types:

- motor circuit switch.
- molded case circuit breaker; and
- molded case switch.

A third-party listing standard of the SIE [Underwriters Laboratories Inc. (UL) 6420 draft] is in its final stages of development; it describes the performance requirements and the test methods to proof those requirements for the disconnecting devices that are intended to meet the device concepts described in this project.

XI. CONCLUSION

The control circuit components are selected to meet established construction and performance requirements. The proposed UL listing standard includes details of such requirements and methods for them to be evaluated. The severest hazard being mitigated by the SIE for connected equipment circuits is electrocution; thus, the overall design requirements of the SIE device would be for it to achieve the required behavior of safety-related parts to category 4. In order for the internal circuits and components of the SIE device to achieve the safety performance of category 4, they have to be designed so that the following are achieved.

1) A single fault in any of the safety-related parts does not lead to a loss of the safety function.

2) The single fault is detected at or before the next demand upon the safety functions, such as immediately, at switch on, or at the end of a machine operating cycle. If this detection is not possible, then an accumulation of faults shall not lead to a loss of the safety function.

3) If the detection of certain faults is not possible, for reasons of technology or circuit engineering, then the occurrence of further faults shall be assumed. In this situation, the accumulation of faults shall not lead to the loss of the safety function. The present designs for the SIE involve circuits and equipment that can be evaluated in a deterministic fashion, and thus, the use of safety performance categories is the present practice. If future systems develop beyond the usefulness of deterministic evaluation, then probabilistic methods would be required.

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Cite this article as :

Sathish Kumar R, Ravi Shankar R, Sathish Kumar S, "Electrical Safety Related Isolation on Industrial Machines with Multiple Entry Points", International Journal of Scientific Research in Science, Engineering and Technology (IJSRSET), Online ISSN : 2394-4099, Print ISSN : 2395-1990, Volume 9 Issue 4, pp. 387-392, July-August 2022. Available at doi : https://doi.org/10.32628/IJSRSET229464

Journal URL : https://ijsrset.com/IJSRSET229464