# Work Methods Bulletin

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# 480V Delta Transformer Banks

## Important Information

Serious injury and equipment damage can result from primary voltage on a secondary if a 480V Delta service is energized without a secondary lightning arrester in place. This secondary arrester is also known as a "secondary voltage arrester" or "surge arrester."

An employee was burned when a secondary lightning arrester was removed from a faulted 480V Delta transformer bank that was energized. Several other 480V Delta services were identified as not having the secondary arrester in place since this event. 240V Delta transformer banks do not require a secondary arrester.

When the arrester is removed from the secondary side of the de-energized transformer for troubleshooting, the transformer secondary leads and service leads must be disconnected from the transformers. Temporary neutral connections must then be installed on the transformer secondary bushings before energizing the transformer(s) during troubleshooting. See DDI L-361 sections 5.1.2 and 5.7 and DDI L-364 sections 5.1, 5.2.5. and 5.2.6, as well as the Table at the end of this Bulletin.

## Incident Summary

A new 480V Delta Service was installed for a mining customer. The service was supplied from an overhead transformer bank consisting of three (3) 167 kVA transformers wired into a 480V ungrounded Delta configuration.

The 480V ungrounded Delta service configuration is a relatively uncommon wiring configuration (about 1100 companywide), but it is required by mining regulations. This configuration is used to avoid an arc or short circuit in the event of a phase contacting earth. When the crew was energizing the transformer bank, the middle phase transformer fuse and the secondary lightning arrester failed. This secondary arrester is required on 480V Delta transformer banks and is installed on Delta banks to deliberately cause transformer fuse failure in the event of a transformer internal winding failure. Unlike most arresters, the one used on the 480V Delta service has nothing to do with lightning. It is used only to provide a path to ground in the event of a transformer winding fault resulting in excessive voltage on the 480V service.

If the internal windings are shorted (i.e., insulation failure) from the primary to secondary voltage side inside the transformer, the transformer primary fuse will not fail unless there is a path to ground on the secondary side. This can result in the transformer passing primary voltage to the secondary voltage side. A ground or neutral is intentionally not installed on the 480V Delta bank secondary.

During troubleshooting, the secondary lightning arrester was removed, and the transformer bank and service were energized (this should not have been done). All transformer fuses held with the arrester disconnected.

Voltage readings between secondary lugs at the transformer were near 480V because there was not a ground reference. The actual voltage at the transformer secondary was near primary voltage, with a difference in potential of 480V. Had the linemen measured from a transformer secondary lug to ground, it would have caused the linemen's Tegam voltmeter to fail.

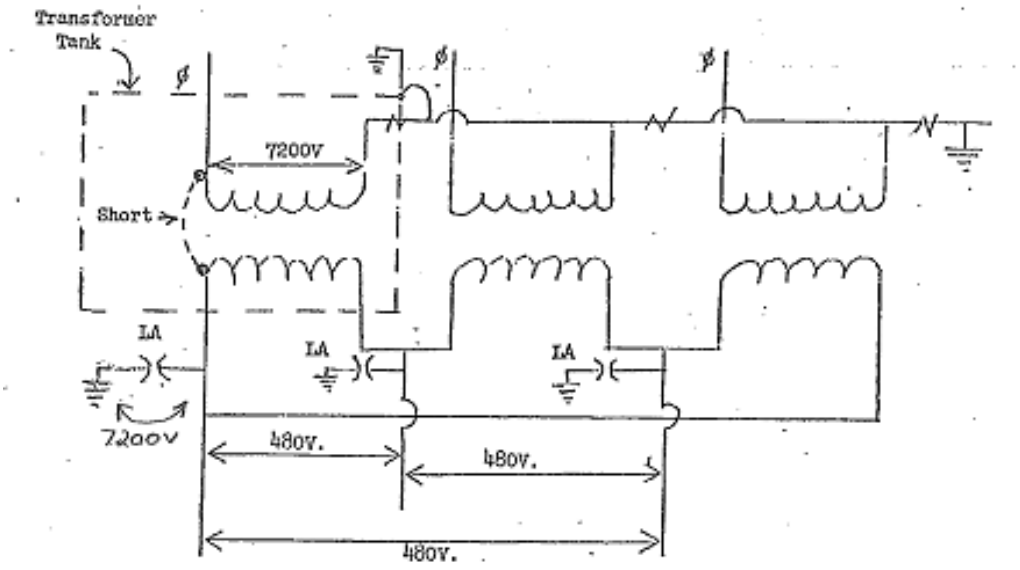
Employees then began to take voltage checks at the line side of the customer's (open) main circuit breaker. When applying the voltmeter leads to the circuit breaker, a flash occurred, injuring one employee.

## Investigation Finding

Transformer testing indicated one of the transformers in the ungrounded Delta bank had a winding failure from the primary to secondary winding. The 7,200 volt transformer winding was shorted to the 480V winding in one of the three transformers. The winding was not shorted to the transformer tank.

High voltage was present on one leg of the 480V service with respect to ground. Since the 480V service is ungrounded, this condition persisted until the Tegam voltmeter was applied to the customer's breaker within a grounded enclosure. The enclosure had tight clearances, resulting in a strong primary voltage electrical field. Applying the meter to the circuit breaker lugs within the grounded enclosure disturbed this strong field, triggering an arc. Once started, the electrical arc spread to all three phases within the enclosure. The arc was quickly extinguished by the operation of an upstream recloser.

Below is a diagram of the 480V Delta transformer configuration, showing the voltages that are present during this type of winding fault:



## Required Action

Supervisors are to review this information with employees and **complete a roster** using **PQS WMB011**. Completed rosters are to be sent or scanned and emailed to EU TRAING ADMIN at WALO by **January 31, 2014**.

### Key Messages for Employees

See Table on last page for a summary of reference documents.

- A 480V Delta service should never be energized without a secondary lightning arrester in place. When the arrester is removed from the secondary side for transformer troubleshooting, the transformer leads and service must be disconnected from the transformers. Temporary neutral connections must then be installed on the transformer secondary bushings before energizing the transformer(s) during troubleshooting. See DDI L-361 sections 5.1.2 and 5.7 and DDI L-364 sections 5.1, 5.2.5, and 5.2.6.

- Make sure the secondary arrester is in place whenever you encounter an energized 480V Delta bank. De-energize the bank before installing the secondary lightning arrester.

- Always wear proper PPE within the Flash Protection Boundary of exposed energized equipment. This distance is generally 10 ft. minimum or greater, as indicated in Section 8 of the Safety Rule Book. See Safety Rules 8.10, and Section 8, Attachments A & B.

- Always follow appropriate safety rules, department instructions, and proper procedures when troubleshooting transformers. See Safety Rules 0.13, DDI L-361 and DDI L-364.

- Always follow appropriate safety rules, department instructions and proper procedures for voltage testing. See DDI M-318, DDI M-107, Safety Rules 8.10, and Section 8, Attachments A & B.

### Human Performance Tools & Standards

- PPE is an individual's last line of defense. In this case, the injured employee did not plan to hold the voltmeter, but stepped in to aid his coworker taking the measurement. The FMTs also did not expect a fault to be present and an arc flash to occur. Remember to ask yourself the key question, "What is the worst thing that can happen?" and always wear proper PPE, including gloves, within the Flash Protection Boundary of exposed energized equipment. This distance is 10 ft. or greater, as indicated in Section 8 of the Safety Rule Book. (Refer to Safety Rules 8.10 and Attachments A & B).

- Have the courage to act and remind a peer of the need to wear PPE, even if you feel time pressure to complete a task.

- Always take a STOP/TIMEOUT when unexpected things happen. Operation of the transformer fuse and secondary lightning arresters is not an expected occurrence when installing a new transformer bank. Stop the work activity, place the equipment in a safe position and consult technical experts if needed to solve the problem. Only proceed when you are certain of the correct next steps and expected outcome (refer to Safety Rule 0.8).

- Infrequently performed non-routine tasks, such as troubleshooting a 480V Delta transformer bank and service, require enhanced situational awareness. When faced with a non-routine task, always follow the three steps below (refer to Safety Rule 0.13):

    - Identify
    - Locate
    - Review appropriate documents: Safety Rules, Department Instructions, and proper Procedures:

        - For a 480V 3-wire Delta transformer bank, Distribution Department Instructions (DDI) Sections L-361 (Sections 5.1.2 and 5.7); and

        - DDI L-364 (sections 5.1, 5.2.5 and 5.2.6) explain that a damaged low-lighting lightning arrester could indicate an internal transformer fault.

**NOTE**: See the Table below for a summary of reference document sections.

| Key Messages for Employees | | |
|---|---|---|
| **Document Reference** | **Sections** | **Content** |
| DDI L-361<br>Transformer Voltage Check | Sections 5.1.2 | Performing transformer voltage checks before making the secondary side connections |
| | Sections 5.7 | Voltage checks on a three phase 480 volt, closed Delta transformer bank with a 3 wire service |
| DDI L-364<br>Safe Energizing of Distribution Transformers and Single Phase Taps | Sections 5.1 | Looking for the Cause if the Transformer Fuse has Failed |
| | Section 5.2.5 | If no indications of external faults or an internal failure |
| | Section 5.2.6 | Re-energize the transformer with the proper K-link fuse |
| PPL Safety Rule Book | Section 8 | Working On or Near Energized Electrical Facilities |
| | Safety Rule 8.10 | Flash Protection Boundary |
| | Section 8<br>Attachments A & B | A-Task Matrix<br>B-Arc-Flash PPE System |
| PPL Safety Rule Book | Section 0 | Human Performance |
| | Safety Rule 0.13 | Employees Shall Practice Good Procedure Use |
| | Safety Rule 0.8 | STOP/Timeout |
| DDI M-318<br>Personal Protective Equipment (PPE) and Shock and Flash Protection Boundary Requirements for Large Power Metering | Table #12 | CT Cabinet, Switchgear Compartment, Overhead Rack or Overhead Structure, Service Voltage (Typical 480 Volt Services) above 240 Volts Nominal and less than 600 Volts, Work on Instrument Transformer Facilities |
| DDI M-107<br>Wiring & Checking Transformer-Rated Service Installations | Exhibit #7 | CSS Wiring |

**Communication Expectation:**

This information is to be reviewed with all crews that may come into contact with 480v Delta Bank transformers or techs that may be assisting those crews.

**Questions or Concerns:**

Please contact Rob Markiewicz, Manager Technical Development and Communication regarding any questions.