

# Delta Versus Wye Connected Capacitor Banks

## Introduction

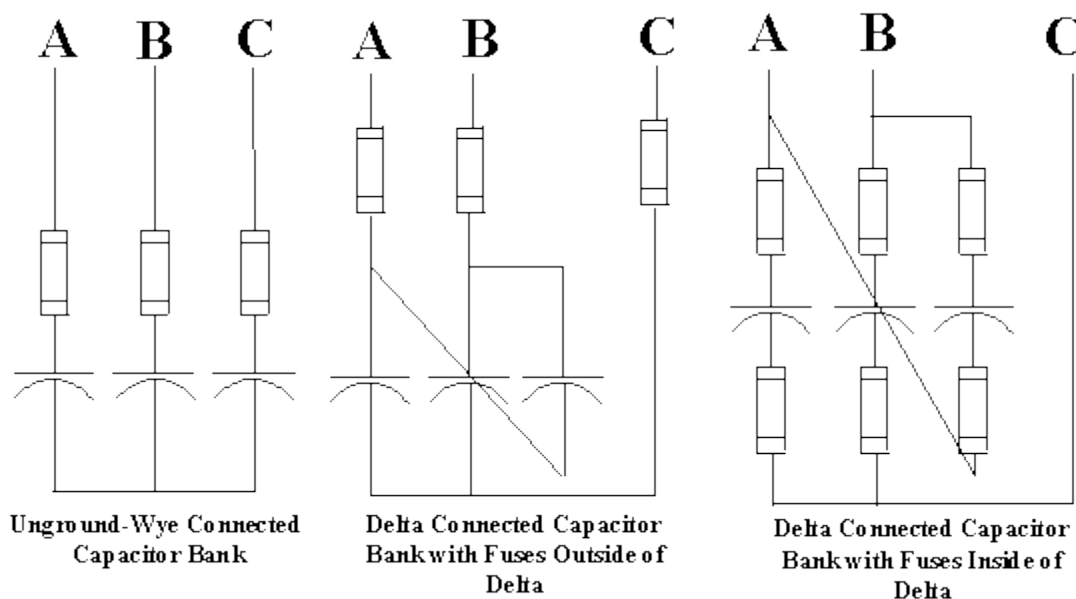
Delta connected capacitor banks are often specified for medium voltage (2.4kV to 34.5kV) systems. This is contrary to IEEE Std 1036-1992, "IEEE Guide for Application of Shunt Power Capacitors". This standard states that delta connected capacitors are generally only used at low voltages, e.g., 2400 V, where a standard capacitor rating is not available for a wye-connection. The standard further states that wye-connected capacitor installations are less complicated to construct, and are more economical.

The purpose of this bulletin is to discuss the basic aspects of the delta and ungrounded-wye connected capacitor bank. A related bulletin, titled, "Why Your Capacitor Bank Should be Left Ungrounded", [Link here](#) is available from NEPSI, and it discusses the aspect of grounded versus ungrounded-wye connected capacitor banks.

## Delta Versus Ungrounded-Wye

Figure 1 shows the capacitor bank connections that are the topic of this bulletin. The only other popular connection that is not shown is the grounded-wye and split wye-connected capacitor bank. The following key points can be made in regard to bank connection under normal and abnormal system conditions.

**Bus Bar Connections:** From looking at figure one, it should be evident that the ungrounded-wye connection is much simpler in design than either of the two delta connected banks. The cross-over connection that connects phase "A" to phase "C" to close the delta is complicated at the medium voltage level due to clearance requirements.



*Figure 1 -Connection and fusing arrangements for ungrounded-wye and delta connected capacitor banks*

**Fusing:** Figure one also shows common fusing practices for each of the bank arrangements. The figure shows that the delta connected bank can be protected by placing the fuses inside or outside of the delta. Two fuses per single phase capacitor are required when fusing inside of the delta, but their rating is decreased to 57% of the outside fuse rating. The fuses outside of the delta are sized in the same way as the fuses for the ungrounded-wye connected capacitor bank.

**Capacitor:** Except for voltage rating, the capacitors in both ungrounded-wye and delta-connected banks are the same and will have the same kvar rating. They consists of a double bushing design, meaning both terminals are fully insulated from their case (ground). On delta connected banks, the capacitors have a line-to-line voltage rating, and on a wye-connected banks, they have a line-to-neutral voltage rating.

**Fault Conditions:** A capacitor typically fails in two ways: 1) A bushing to case fault occurs. 2) The internal sections fail (commonly known as a dielectric fault), which basically shorts the capacitor terminals. Whether the capacitors are delta or wye-connected, a bushing fault will have the same impact on the power system.

Internal section faults, or dielectric faults appear differently to a power system. On a delta connected bank, an internal section fault subjects the power system to a phase-to-phase bolted fault. This fault will cause a major voltage sag on the facilities power system (until the capacitor fuse(s) blow) and may cause capacitor case rupture if not properly protected. It also subjects the power system to high magnitude fault currents which can impose mechanical and thermal stress on components in the fault path. On a wye-ungrounded capacitor bank, internal section faults subject the power system to a fault current that is three times the banks rating (until the capacitor fuse blows). Therefore, the voltage sag, mechanical and thermal stressing associated with the fault, and case rupture concerns are reduced.

### **Common Misconceptions**

The following misconceptions are common reasons why medium voltage capacitor banks are specified as delta connected:

- The system that the bank is being applied to is delta connected or high resistance grounded. So therefore the bank should be delta connected. (Statement Not True)
- It is a typical practice for low voltage (600 volts and below) systems, and therefore it must be appropriate for medium voltage systems. (Not technically appropriate for medium voltage systems)
- A faulted wye-connected capacitor bank will go undetected. (Not true when a blown fuse detection system is installed).
- Bank kvar rating will not be correct. (Not True)

All of the above reasons do not justify the use of a delta connection over an ungrounded-wye connection.

## **Conclusion**

Medium Voltage Capacitor Banks for commercial, industrial, and utility power system applications should be specified as wye-connected unless a standard voltage rating does not exist. This typically occurs for 2.4kV systems, because 1.38kV capacitors do not exist. At other medium voltage levels through 34.5kV, line-to-neutral rated capacitors are available and should normally be connected in an ungrounded-wye, or grounded-wye connection.

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