http://waterheatertimer.org/What-is-3-phase-electric.html

http://waterheatertimer.org/How-to-identify-transformer-wiring.html

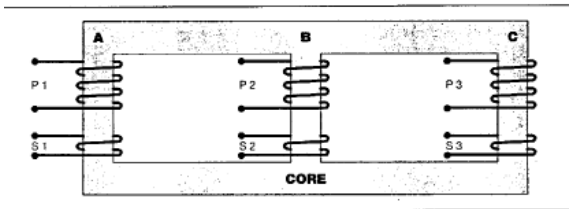
CHAPTER 3 – THREE PHASE TRANSFORMERS

SINGLE PHASE VS. THREE PHASE POWER SYSTEMS

Up to this point in the manual, we have focused primarily upon single-phase transformers. Single-phase meaning (2) power lines as an input source; therefore, only (1) primary and (1)secondary winding is required to accomplish the voltage transformation. However, most power is distributed in the form of three-phase A.C. Therefore, before proceeding any further you should understand what is meant by three-phase power. Basically, the power company generators produce electricity by rotating (3) coils or windings through a magnetic field within the generator . These coils or windings are spaced120 degrees apart. As they rotate through the magnetic field they generate power which is then sent out on three (3) lines as in three-phase power. Three-Phase transformers must have (3) coils or windings connected in the proper sequence in order to match the incoming power and therefore transform the power company voltage to the level of voltage we need and maintain the proper phasing or polarity.

Three phase electricity powers large industrial loads more efficiently than single-phase electricity. When single-phase electricity is needed, It is available between any two phases of a three-phase system, or in some systems , between one of the phases and ground. By the use of three conductors a three-phase system can provide 173% more power than the two conductors of a single-phase system. Three-phase power allows heavy duty industrial equipment to operate more smoothly and efficiently. Three-phase power can be transmitted over long distances with smaller conductor size.

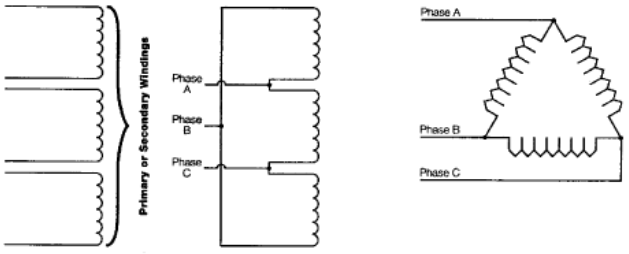
In a three-phase transformer, there is a three-legged iron core as shown below. Each leg has a respective primary and secondary winding.



The three primary windings (P1, P2, P3) will be connected at the factory to provide the proper sequence (or correct polarity) required and will be in a configuration known as Delta. The three secondary windings (S1, S2, S3) will also be connected at the factory to provide the proper sequence (or correct polarity) required. However, the secondary windings, depending on our voltage requirements, will be in either ?Delta? or a ?Wye? configuration.

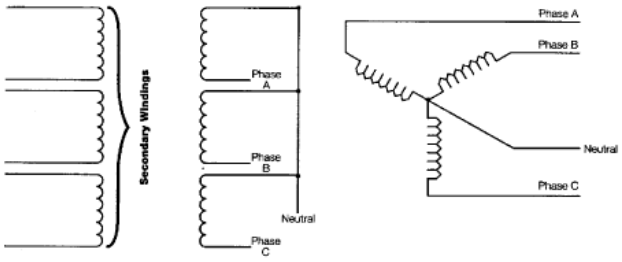
DELTA AND WYE CONNECTIONS

In a three-phase transformer, there is a three-legged iron core as shown below. Each leg has a respective primary and secondary winding.



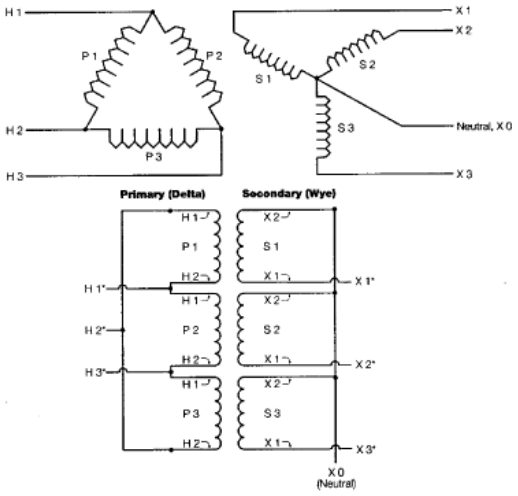
WINDING COMBINATION

As can be seen, the three-phase transformer actually has 6 windings (or coils) 3 primary and 3 secondary. These 6 windings will be pre-connected at the factory in one of two configurations:



Configuration 1. Three primary Windings in Delta and Three Secondary Windings in Wye

Note: These are the designations which are marked on the leads or terminal boards provided for customer connections and they will be located in the transformer wiring compartment. In both single and three-phase transformers, the high voltage terminals are designated with an “h” and the low voltage with an “X”



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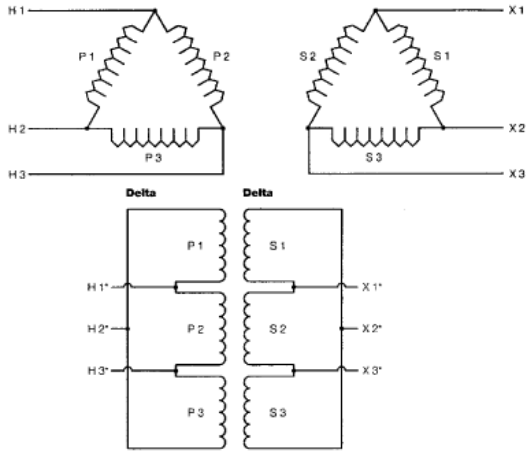
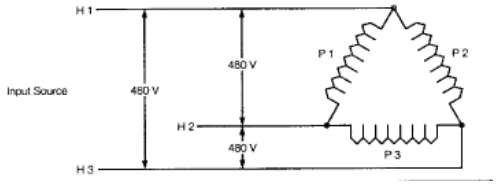
VOLTAGE IN DELTA AND WYE CONNECTIONS

All Federal Pacific three-phase transformers have their primary windings pre-connected in a Delta configuration. Therefore, when connected to a three-phase source, each primary winding will have the same voltage across it.



For Example: 480V Three-Phase Source

If the secondary windings are also connected Delta then they have equal voltages across each winding. Of course, this voltage will be either higher or lower than the primary depending upon the “turns ratio”.



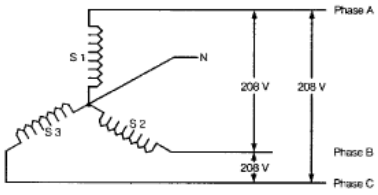
480V Primary Source with 240V Secondary Output @ 2/1 Turns Ratio (Delta-Delta)

Note: it is important to note that three-phase transformers with Delta-connected primaries when connected to a 30, 4-wire supply system do not utilize the 4th wire or neutral.

Image Missing

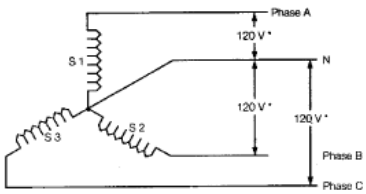
Wye: If the secondary is not connected in Delta it will be pre-connected at the factory as a Wye secondary. All Wye connections provide two voltages due to the common point or neutral connection. A typical rating would be 208/120V. The 208Y indicates the voltage between phases of the secondary windings.

For Example:



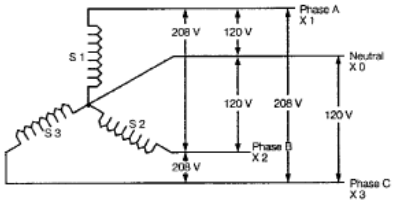
The 120 volt portion indicates the voltage from each phase to the common point or neutral

For Example:



This Phase-to-Nuetral voltage in a Wye is always equal to the Phase-to-Phase voltage divided by

For Example



Therefore a three-phase transformer with its secondary connected in a Wye configuration for 208Y/120 volts will have the available: Common Three-Phased Transformer Voltage Combinations

SPECIAL THREE PHASE DELTA CONNECTED TRANSFORMERS

There are certain situations where only a very small portion of a building loads require 120V single-phase . A special transformer is available and you should be familiar with it.

Primary Delta		Secondary Delta
480	–	240
600	–	240
4160	–	240

NOTE: Special voltage combinations are available

Primary Delta		Secondary Wye
208	–	480Y/277
240	–	208Y/120
480	–	208Y/120
480	–	480Y/277
600	–	208Y/120
2400	–	208Y/120
2400	–	480Y/277
4160	–	208Y/120
4160	–	480Y/277
208	–	208Y/120

The 240 Volt 30 Delta Connected Secondary With 120 Volt 10 Lighting Tap

As you can see there is no point in a Delta at which an equal potential to all three lines and the grounded neutral can be made. This is a disadvantage of a Delta compared to a Wye secondary connection.

This Delta secondary connection has only one winding (S3) with a neutral conductor. The mid-point of winding S3 is tapped which gives the Xl and X3 to neutral a voltage reading of 120 volts. In a three=phased system, winding S3 is the workhorse; it has to carry all the 120V lighting and appliance loads plus one-third of all the three-phased loads. (The 120V loads must not exceed 5% of the nameplate KVA, and the total of the nameplate KVA must be derated by 30%). Winding S1 and S2 cannot carry any 120 volt loads as there is no neutral connection to these windings. Windings S1 and S2 can only carry one-third of the three-phase loads each, and the 240 volt single-phase loads. *Caution: A240 volt Delta connected transformer with a 120 volt neutral tap creates a condition called “high leg” As indicated in the above diagram, the voltage between Phase B (X2) and the neutral tap will be 208 volts; therefore, no 120 volt single-phase loads can be connected between X2 and the neutral tap.

SINGLE PHASE TRANSFORMERS CONNECTED TO FORM THREE PHASE BANK

Normally , when three-phase is required, a single enclosure with three primary and three secondary windings wound on a common core is all that is required. However three single-phase transformers with the same rating can be connected to form a three-phase bank. Since each single-phase transformer has a primary and a secondary winding, then 3 single-phase transformers will have the required 3 primary and 3 secondary windings and can be connected in the field either Delta-Delta or Delta-Wye to achieve the required three-phased transformer bank, as shown below.

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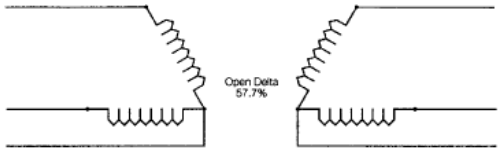
DELTA-DELTA

Utilizing 3 single-phase transformers is normally not done because it is more expensive than utilizing 1 three-phase transformer. However, there is an advantage which is called the open Delta or V-Connection and it functions as follows: A defective single-phase transformer in a Delta-Delta three-phase bank can be disconnected and removed for repair. Partial service can be restored using the remaining single-phase transformer open-Delta until a replacement transformer is obtained. With two transformers three-phase is still

obtained, but at reduced power. 57.7 of original power. This makes it a very practical transformer application for temporary emergency conditions.



THREE PHASE LOADS AND SINGLE PHASE LOADS

If the load is three-phased , then both the supply and the transformer must be in three-phase. If the load is single-phase the supply can either be single or three-phase but the transformer need only be single-phase with the primary being connected to two lines on the three phase circuit. With single-phase loads, an attempt to use a transformer with three-phase input and only one phase connected at the output to convert the loading on the line to three-phase is not practical.