

Figure 12-18

► **Primary Phase Current Example**

What is the primary phase current for a 480V to 120/240V, 150 kVA, three-phase transformer? **Figure 12-18A**

- (a) 416A      (b) 360A      (c) 180A      (d) 104A

• Answer: (d) 104A

$$I_{\text{Phase}} = \text{VA}_{\text{Phase}} / E_{\text{Phase}}$$

$$\text{VA}_{\text{Phase}} = 150,000 \text{ VA} / 3 \text{ Phases}$$

$$\text{VA}_{\text{Phase}} = 50,000 \text{ VA}$$

$$I_{\text{Phase}} = 50,000 \text{ VA} / 480\text{V}$$

$$I_{\text{Phase}} = 104\text{A}$$

► **Secondary Phase Current Example**

What is the secondary phase current for a 480V to 120/240V, 150 kVA, three-phase transformer? **Figure 12-18B**

- (a) 416A      (b) 360A      (c) 208A      (d) 104A

• Answer: (c) 208A

$$\text{Phase Power} = 150,000 \text{ VA} / 3 \text{ Phases}$$

$$\text{Phase Power} = 50,000 \text{ VA}$$

$$I_{\text{Phase}} = 50,000 \text{ VA} / 240\text{V}$$

$$I_{\text{Phase}} = 208\text{A}$$

**12.6 Delta Phase versus Line Current**

Since each line conductor from a delta transformer is actually connected to two transformer windings (phases), the effects of loading on the line (conductors) can be different than on the phase (winding).

**Phase VA (Three-Phase)**

Because each line from a delta-configured transformer is connected to two transformer phases, the line current from a three-phase load will be greater than the phase current by a factor of 1.732.

$$I_{\text{Line}} = \text{VA}_{\text{Line}} / (E_{\text{Line}} \times 1.732)$$

$$I_{\text{Phase}} = I_{\text{Line}} / 1.732$$

$$I_{\text{Phase}} = \text{VA}_{\text{Phase}} / E_{\text{Phase}}$$

A 240V, 36 kVA, three-phase load has the following effect on a delta system: **Figure 12-19**

Line: Total line power = 36 kVA

$$I_{\text{Line}} = \text{VA}_{\text{Line}} / (E_{\text{Line}} \times 1.732)$$

$$I_{\text{Line}} = 36,000\text{VA} / (240\text{V} \times 1.732)$$

$$I_{\text{Line}} = 87\text{A}$$

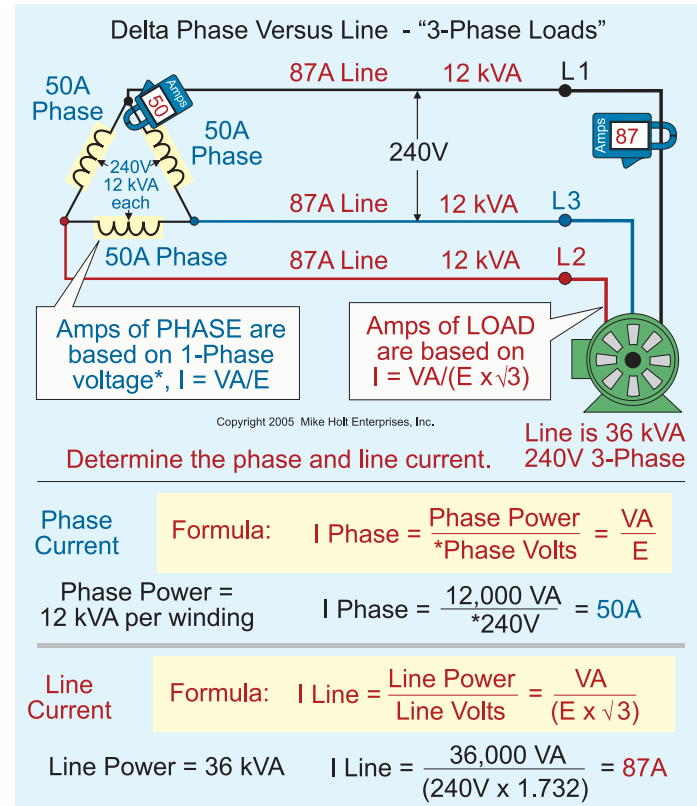


Figure 12-19

### ▶ Transformer Size Example

What size transformers are required?

- (a) three 30 kVA, single-phase transformers
- (b) one 90 kVA, three-phase transformer
- (c) a or b
- (d) none of these

• Answer: (c) a or b  
 Phase A = 30 kVA  
 Phase B = 28 kVA  
 Phase C = 24 kVA (12 kVA x 2)

### ▶ High-Leg Voltage Example

What is the high-leg voltage to the grounded conductor ?

- (a) 120V
- (b) 208V
- (c) 230V
- (d) 240V

• Answer: (b) 208V

The voltage relationships between transformer windings of “A” and “C1” or transformer windings of “B” and “C2” are such that the voltages are not a simple addition of the phase winding voltages. There is an out-of-phase relationship between the phases which requires a vectorial addition that is beyond the scope of this textbook. The resulting voltage from the high-leg to the grounded conductor can be found by multiplying the line-to-grounded conductor voltage by 1.732. High-leg voltage = 120V x 1.732 = 208V.

### ▶ Neutral kVA Example

What is the maximum kVA on the grounded conductor?

- (a) 3 kVA
- (b) 6 kVA
- (c) 7.5 kVA
- (d) 9 kVA

• Answer: (d) 9 kVA

*Note: If the Phase C2 loads are not on, then phase C1 neutral loads would impose a 9 kVA load to the neutral. (4.5 kVA + 4.5 kVA). This does not include the 6 kVA on transformer “C” from the heater load since there are no neutrals involved.*

### ▶ Maximum Unbalanced Current Example

What is the maximum unbalanced load on the grounded conductor?

- (a) 25A
- (b) 50A
- (c) 75A
- (d) 100A

• Answer: (c) 75A

$$I = VA/E$$

$$I = 9,000 \text{ VA}/120\text{V}$$

$$I = 75\text{A}$$

*Note: The grounded conductor must be sized to carry the maximum unbalanced current, which in this case is 75A.*

### ▶ Neutral Current Example

What is the current on the grounded neutral conductor?

- (a) 0A
- (b) 13A
- (c) 25A
- (d) 50A

• Answer: (b) 13A

$$L1 = 9,000 \text{ VA}/120\text{V}$$

$$L1 = 75\text{A}$$

$$L2 = 7,500 \text{ VA}/120\text{V}$$

$$L2 = 62.5\text{A}$$

$$\text{Neutral Current} = 75\text{A} - 62.5\text{A}$$

$$\text{Neutral Current} = 12.5\text{A}$$

### ▶ Phase Load (Single-Phase) Example

What is the phase load of each 3 hp, 240V, single-phase motor?

- (a) 1,855 VA
- (b) 3,910 VA
- (c) 978 VA
- (d) none of these

• Answer: (b) 3,910 VA

$$\text{FLC} = 17\text{A [Table 430.248]}$$

$$\text{VA} = 230\text{V} \times 17\text{A}$$

$$\text{VA} = 3,910 \text{ VA}$$

On a delta system, a 240V, single-phase load is 100% on one transformer.

### ▶ Phase Load (Three-Phase) Example

What is the phase load for the 10 hp, three-phase motor?

- (a) 11,154 VA
- (b) 3,718 VA
- (c) 5,577 VA
- (d) 6,440 VA

• Answer: (b) 3,718 VA

$$\text{VA} = \text{Volts} \times \text{Amperes} \times 1.732$$

$$10 \text{ hp FLC} = 28\text{A [Table 430.250]}$$

$$\text{VA} = 230\text{V} \times 28\text{A} \times 1.732$$

$$\text{VA} = 11,154 \text{ VA}$$

$$\text{Phase Load} = 11,154 \text{ VA}/3 \text{ phases}$$

$$\text{Phase Load} = 3,718 \text{ VA per phase}$$

### ▶ High-Leg Conductor Size Example

If only the three-phase, 18 kVA load is on the high-leg, what is the current on the high-leg conductor?

- (a) 25A
- (b) 43A
- (c) 73A
- (d) 97A

• Answer: (b) 43A

To calculate current on any conductor:

$$I = VA/(E \times 1.732)$$

$$I = 18,000 \text{ VA}/(240\text{V} \times 1.732)$$

$$I = 43.3\text{A}$$

### ► Voltage Ratio Example

What is the phase voltage ratio of the transformer?

(a) 4:1

(b) 1:4

(c) 1:2

(d) 2:1

• Answer: (d) 2:1

480 primary phase volts to 240 secondary phase volts

Turns Ratio = 480V/240V

Turns Ratio = 2:1

### ► Panel Loading—VA Example

Balance the loads on the panelboard in VA.

	Line 1	Line 2	Line 3	Line Total
Space Heating 18 kVA, 240V, three-phase	6,000 VA	6,000 VA	6,000 VA	18,000 VA
Ranges 14 kVA, 240V, single-phase	7,000 VA	7,000 VA		14,000 VA
Ranges 14 kVA 240V, single-phase		7,000 VA	7,000 VA	14,000 VA
Water Heater 240V, single-phase	5,000 VA	5,000 VA		10,000 VA
3 hp, 240V, single-phase Motor		1,955 VA	1,955 VA	3,910 VA
3 hp, 240V, single-phase Motor		1,955 VA	1,955 VA	3,910 VA
Dishwasher 120V, single-phase	<b>4,500 VA</b>			4,500 VA
Lighting (8 circuits) 120V, single-phase	<b>+ 4,500 VA</b>		<b>+ 7,500 VA</b>	<b>+12,000 VA</b>
	27,000 VA	28,910 VA	24,410 VA	80,320 VA

**Bold** indicates neutral (120V) loads.

### ► Panel Sizing—Amperes Example

Balance the loads from the previous example on the panelboard in amperes.

	Line 1	Line 2	Line 3	Ampere Calculation
Space Heating 18 kVA, 240V, three-phase	43A	43A	43A	18,000 VA/(240V x 1.732)
Ranges 14 kVA, 240V, single-phase	58A	58A		14,000 VA/240V
Ranges 14 kVA, 240V, single-phase		58A	58A	14,000 VA/240V
Water Heater 10 kVA, 240V, single-phase	42A	42A		10,000 VA/240V
3 hp, 240V, single-phase Motor		17A	17A	FLC
3 hp, 240V, single-phase Motor		17A	17A	FLC
Dishwasher 120V, single-phase	<b>38A</b>			4,500 VA/120V
Lighting (8 circuits) 120V, single-phase	<b>+ 38A</b>	<b>+ _____</b>	<b>+ 63A</b>	7,500 VA/120V
	219A	235A	198A	

**Bold** indicates neutral (120V) loads.