

SCOPE

This design standard provides the allowable initial transformer design loading for balanced three-phase and single-phase estimated demands served by open-delta, closed-delta and three-phase padmounted transformer stations. This practice only applies to those transformer stations in which the single-phase load is equally divided among the three incoming phases.

PURPOSE

This standard was developed to provide improved initial transformer utilization considering allowable voltage drop and economic loading levels. Higher transformer loading may be achieved with Design Standards approval when the secondary/service voltage drop is less than 2.0 percent for single-phase and 1.0 percent for three-phase transformers.

DEFINITIONS

Initial Transformer Design Loading Range – the transformer loading criteria for the initial installation that allows for future load growth.

Estimated Demand – the chosen demand estimate based on the Demand Estimating Guidelines provided in Design Manual Section 5300.

Equivalent Demand – the calculated demand required to allow the proper transformer selection based on individual transformer winding load.

CRITERIA

TABLE-1 THREE-PHASE PADMOUNTED TRANSFORMERS

Transformer Size (kVA)	120/208V		277/480V	
	kVA	kW	kVA	kW
45	0–58	0–49		
75	59–100	50–85	0–100	0–85
150	101–187	86–159	101–184	86–157
225	188–294	160–250	185–331	158–281
300	295–405	251–344	332–435	282–370
500	406–735	345–625	436–695	371–591
750	736–1103	626–938	696–1103	592–938
1000	1104–1330	939–1131	1104–1470	939–1250
1500			1471–2040	1251–1734
2000			2041–2940	1735–2499
2500			2941–3675	2500–3124
3000			3676–4410	3125–3749

TABLE-2 SINGLE-PHASE PADMOUNTED TRANSFORMERS

Padmounted		
Transformer Size (kVA)	kVA	kW
15	0–20	0–18
25	21–35	19–31
50	36–79	32–71
75	80–126	72–113
100	127–167	114–150
167	168–281	151–253




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TABLE-3 SINGLE-PHASE POLEMOUNTED TRANSFORMERS

Transformer Size (kVA)	Polemounted			
	Residential		Commercial	
	kVA	kW	kVA	kW
10	0-16	0-14	0-9	0-8
15	17-22	15-20	10-21	9-19
25	23-42	21-38	22-37	20-33
50	43-84	39-76	38-64	34-58
75	85-126	77-113	65-83	59-75
100	127-168	114-151	84-109	76-98

NOTE: Initial transformer loading assumes Power Factor = .90

A. Single-Phase Transformer Stations

Use the diversified demand estimate determined from Design Standard 5322, "Residential Demand Estimating" to select the proper size transformer from table 2 or 3.

B. Three-Phase Transformer Stations

An attempt should be made to balance the single-phase load equally within the three-phase transformer station windings. This may be done by placing 1/3 of the total single-phase load between each pair of the three incoming phases (see Design Standard 5611, "Single-Phase Transformer Application").

1. 120/208V three-phase power is obtained from a three-phase padmounted transformer station. Use the total diversified three-phase and single-phase demand estimate determined from Design Standard 5311, "Three-Phase Demand Estimating Criteria" to select the proper size transformer from table 1.
2. 120/240V three-phase power is obtained from an open-delta or closed-delta overhead transformer station.
 - a. Closed Delta (large three phase loads with small single phase loads are served most efficiently by the closed delta configuration)

If the single-phase load is equally divided among the three transformers, use 1/3 of the total three-phase and 1/3 of the total single-phase demand estimate to select three equally sized single-phase transformers from table 2 or 3. Otherwise, select unequal transformers in accordance with Table 1 on OH Construction Standards page 1105.1.
 - b. Open Delta (small three phase loads with large single phase loads are served most efficiently by the open delta configuration)

If the single-phase load is balanced across the three-phase lines, use 58 percent of the total three-phase and single-phase demand estimate from Design Standard 5311 to select two equally sized single-phase transformers from table 2 or 3.

If all of the single-phase load is connected across only two lines, the two single-phase transformers may not be equally sized. To determine the proper size single-phase transformer:

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- i. Smaller Single-Phase Transformer – use 58 percent of the three-phase demand estimate from Design Standard 5311 to select the proper size transformer from table 2 or 3.
 - ii. Larger Single-Phase Transformer – use 58 percent of the three-phase and all of the single-phase demand estimate from Design Standard 5311 to select the proper size transformer from table 2 or 3.
3. 120/240V three-phase power obtained from the type HKB padmounted transformer is similar to the overhead closed delta station of subparagraph B.2.a. For unbalanced single-phase load simply add twice the single-phase load to the three-phase load to determine the three-phase kVA requirements.
4. 120/208 4W, 3Ø, an overhead station delta-wye bank, the procedure is to take 1/3 of the three phase load plus 1/3 of the total single phase load to equally size each transformer.

EXAMPLES:





1. Select the proper transformers to serve an estimated demand of 70 kW (60 kW non-motor load and 10 kW motor load) three-phase load and 10 kW of balanced (between the two PS legs) single phase load.

The load may be served from either an open-delta or closed-delta polemounted three-phase transformer station or a three-phase padmounted transformer station.

- a. Open-delta polemount:
 - determine the equivalent demand
 $70\text{kW}, 3\text{Ø} \times .58 = 40.6, 3\text{Ø}$
 $10\text{kW}, 1\text{Ø} \times 1 = 10\text{kW}, 1\text{Ø}$
 - determine total equivalent demand
 $40.6 + 10 = 50.6\text{kW}$
 - select the proper transformers
 2–50kVA transformers required
- b. Closed-delta polemount:
 - determine the equivalent demand
 $70\text{kW}, 3\text{Ø} \times 1/3 = 23.3\text{kW}, 3\text{Ø}$
 $10\text{kW}, 1\text{Ø} \times 1/3 = 3.3\text{kW}, 1\text{Ø}$
 - determine total equivalent demand
 $23.3 + 3.3 = 26.6\text{kW}$
 - select the proper transformers
 3–25kVA transformers required
- c. Three-phase padmount:
 - determine the equivalent demand
 $70\text{kW}, 3\text{Ø} \times 1 = 70\text{kW}, 3\text{Ø}$
 $10\text{kW}, 1\text{Ø} \times 1 = 10\text{kW}, 1\text{Ø}$
 - determine total equivalent demand
 $70 + 10 = 80\text{kW}$
 - select the proper transformer
 1–75kVA transformer required

2. Select the proper transformers to serve a three-phase estimated demand of 10kW with an additional single-phase demand of 70kW connect across one transformer.




The load should be served from either a polemounted or padmounted open-delta transformer station to prevent oversizing the transformers.

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- a. Open-delta polemount
 - determine the equivalent demand
 $10\text{kW}, 3\phi \times .58 = 5.8\text{kW}, 3\phi$
 $70\text{kW}, 1\phi \times 1 = 70\text{kW}, 1\phi$
 - determine the total equivalent demand
 $5.8 + 70 = 75.8\text{kW}$ on the larger transformer
 $5.8 + 0 = 5.8\text{kW}$ on the smaller transformer
 - select the proper transformers
 1-75kVA & 1-10kVA transformer required
 - b. 120/240V padmount
 - $10 + 2(70) = 150$
 - selected 150kVA
3. Select the proper transformer to serve three single-phase estimated demands of 10kW, 15kW and 20kW, respectively.
- a. Single-phase polemount
 - determine the total equivalent demand
 $10 + 15 + 20 = 45\text{kW}$
 - determine the proper diversity factor from table 3, Design Standard 5322, "Residential Demand Estimating"
 $45\text{kW} \times .75 = 33.8\text{kW}$
 - select the proper transformer
 1-50kVA transformer required
 - b. Single-phase padmount
 - using the equivalent diversified demand from above
 1-50kVA transformer required

References:

1. Design Standard 5311, Three-Phase Commercial Demand Estimating Criteria
2. Design Standard 5322, Residential Demand Estimating
3. Design Standard 5431, Underground Cable Voltage Drop and Flicker Nomograph
4. Design Standard 5432, Overhead Conductor Voltage Drop and Flicker Nomograph
5. Construction Standards 1105-1107, Transformer Loading Guide for 3 ϕ Stations with 1 ϕ Transformers

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