X/R Ratios

Typical values for generators, synchronous motors, power transformers, induction motors, utility sources, and reactors. (From ANSI Standard C37.010)

A. Large generators and hydrogen-cooled sychronous condensers

Range	Typical
40-120	80

B. Generators and synchronous motors (See TABLE 8A)

C. Power transformer (See TABLE 8B)

D. Induction motors (See TABLE 8C)

E. Utility source

1. Near generating plant
   Range: 15-30
2. Long open-wire line
   Range: 2-16
3. Typical
   Range: 5-12

F. Reactors

Range	Typical
40-120	80

TABLE 9—Primary Substation Transformers (501-5000 kVA 1ϕ, 501—10,000 kVA 3ϕ) 65C rise ANSI C57.12.00

STANDARD IMPEDANCES

High-voltage Winding BIL kV	Low-voltage Winding BIL kV	Percent Impedance*
110	45	5.75
	60-110	5.5
150	45	5.75
	60-110	5.
200	45	7.25
	60-150	7.0
250	45	7.75
	60-200	7.5
350	60-250	8.0
450	60-350	8.5
550	60-450	9.0
650	60-550	9.5

* For load tap changing (LTC) transformers, add 0.5 to values listed.

TABLE 10—Network Transformers Three-phase (Low Voltages 216Y/125 or 480Y/277 volts)

STANDARD IMPEDANCES

kVA	Percent Impedance
1000 kVA and Below	5.0
Above 1000 kVA	7.0

TABLE 8B

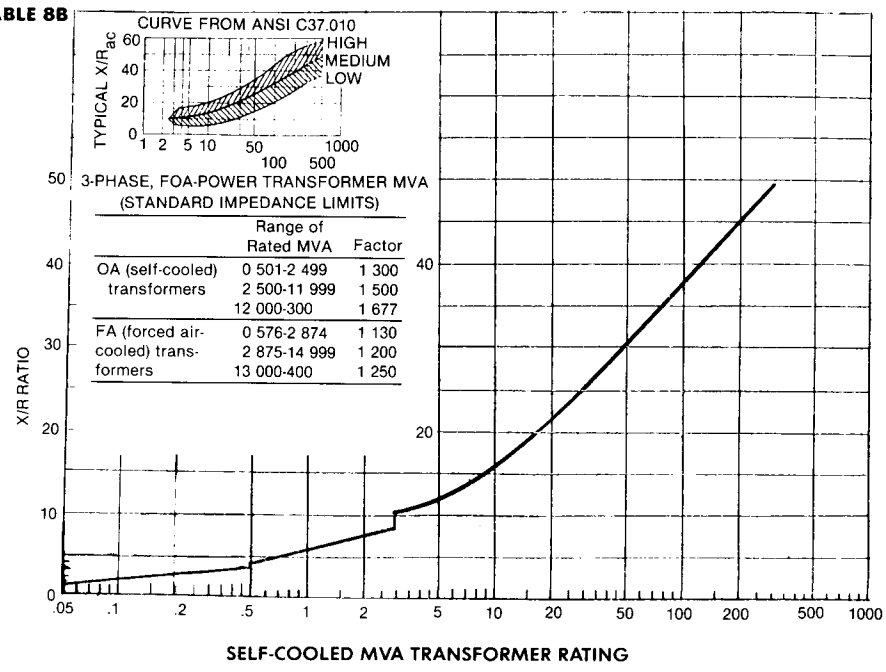
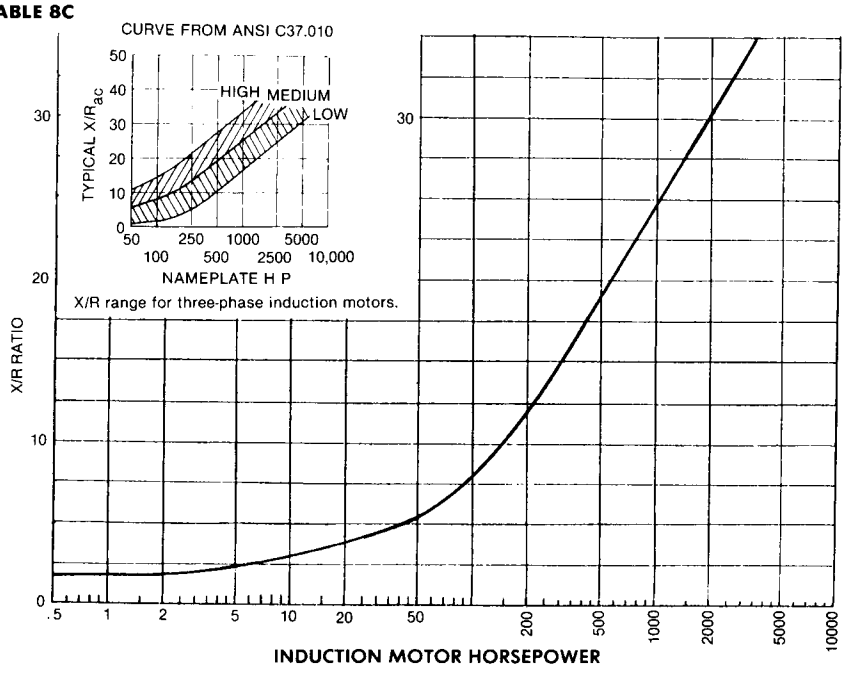


TABLE 8C



Appendix

TABLE 11—Distribution Transformers—Single-phase

kVA	Low Voltage	%IR	%IX	%IZ
HIGH VOLTAGE 2400/4160Y				
10		2.4	0.9	2.6
15		2.2	1.4	2.6
25		1.6	1.9	2.5
37½	**120/240**	1.6	2.3	2.8
50		1.6	1.9	2.2
75		1.0	2.1	2.3
100		0.8	2.1	2.3
167		1.0	1.9	2.1
10		2.4	0.8	2.5
15		2.2	1.3	2.5
25		1.6	1.8	2.4
37½	**240/480**	0.9	1.5	1.8
50		1.2	1.6	2.0
75		0.9	1.9	2.1
100		0.7	1.9	2.0
167		0.9	1.6	1.8
HIGH VOLTAGE 4160/7200Y				
10		2.4	0.8	2.5
15		2.1	1.4	2.5
25	**120/240**	1.6	1.9	2.4
37½		1.6	2.3	2.8
50		1.1	1.8	2.1
75		1.0	1.9	2.2
100		0.8	2.1	2.2
10		2.4	0.8	2.5
15		2.1	1.2	2.5
25		1.4	2.0	2.4
37½	**240/480**	0.9	1.5	1.8
50		1.1	1.6	1.9
75		0.9	1.7	1.9
100		0.7	1.7	1.8
HIGH VOLTAGE 4800/8320Y				
10		2.4	0.8	2.5
15		2.0	1.5	2.5
25		1.6	1.8	2.4
37½	**120/240**	1.6	2.2	2.7
50		1.1	1.9	2.2
75		1.0	1.9	2.2
100		0.8	2.2	2.3
167		1.0	1.9	2.1
10		2.4	0.8	2.5
15		2.1	1.3	2.4
25		1.4	2.0	2.5
37½	**240/480**	1.0	1.3	1.7
50		1.2	1.6	2.0
75		0.9	1.7	1.9
100		0.7	1.8	1.9
167		0.9	1.6	1.8

kVA	Low Voltage	%IR	%IX	%IZ
HIGH VOLTAGE 7200/12470 or 12470GRDY/7200				
10		2.5	0.9	2.6
15		2.1	1.6	2.6
25		1.6	2.0	2.6
37½	**120/240**	1.6	2.5	3.0
50		1.2	2.0	2.3
75		1.0	2.0	2.3
100		0.8	2.2	2.3
167		1.0	2.0	2.2
10		2.5	0.8	2.6
15		2.1	1.5	2.6
25		1.6	1.9	2.5
37½	**240/480**	1.0	1.5	1.8
50		1.1	1.8	2.1
75		0.9	1.8	2.0
100		0.7	1.8	2.0
167		0.9	1.7	1.9
HIGH VOLTAGE 7620/13200Y OR 13200GRDY/7620				
10		2.5	0.9	2.6
15		2.1	1.6	2.6
25		1.6	2.0	2.6
37½	**120/240**	1.6	2.5	3.0
50		1.2	2.0	2.3
75		1.0	2.0	2.3
100		0.8	2.2	2.3
167		1.0	2.0	2.2
10		2.5	0.8	2.6
15		2.1	1.5	2.6
25		1.6	1.9	2.5
37½	**240/480**	1.0	1.5	1.8
50		1.1	1.6	2.1
75		0.9	1.8	2.0
100		0.7	1.8	2.0
167		0.9	1.7	1.9
HIGH VOLTAGE 14400/24940GRDY OR 24940GRDY/14400				
10		1.9	1.3	2.3
15		2.2	1.6	2.7
25		1.6	2.1	2.6
37½	**120/240**	1.7	2.3	2.9
50		1.2	1.9	2.2
75		1.0	2.1	2.3
100		0.8	2.1	2.3
10		2.0	1.1	2.3
15		1.2	1.5	2.7
25		1.6	2.0	2.5
37½	**240/480**	1.0	1.7	1.9
50		1.1	1.8	2.1
75		0.9	1.8	2.0
100		0.7	1.8	2.0

TABLE 12—Distribution Transformers—Three-phase Padmount—Single-voltage Primary Maximum Line-to-Line Primary Voltage—25 kV Wye—18 kV Delta

kVA	Low Voltage						kVA	Low Voltage					
	208Y/120			480Y/277				208Y/120			480Y/277		
	%IZ	%IR	%IX	%IZ	%IR	%IX		%IZ	%IR	%IX	%IZ	%IR	%IX
75	2.9	1.8	2.2	2.6	1.7	2.0	500	4.90	1.20	4.70	4.40	1.20	4.20
112.5	3.9	1.8	3.5	3.9	1.8	3.5	750	5.75	1.40	5.50	5.75	1.30	5.70
150	4.4	1.6	4.0	4.2	1.7	3.8	1000	5.75	1.30	5.70	5.75	1.20	5.70
225	4.1	1.5	3.8	4.0	1.4	3.7	1500	.....	.....	.....	5.75	0.72	5.70
300	4.6	1.4	4.4	4.7	1.4	4.5	2000	.....	.....	.....	5.75	0.68	5.71
							2500	.....	.....	.....	5.75	0.61	5.72

Table 13—Transformers for secondary unit substation and Integral Distribution Centers. Liquid filled (oil, silicone and vapor-tran*) and dry-type (including encapsulated coil).

kVA	Dry-Type 480V %Z	Dry-Type 480V X/R †	Dry-Type 2400–4800V %Z	Dry-Type 2400–4800V X/R †	Dry-Type 6900–15,000V %Z	Dry-Type 6900–15,000V X/R †	Liquid-Filled 2400–15,000V %Z	Liquid-Filled 2400–15,000V X/R †
75	3	0.83	6.2	2.15				
112.5	4.6	1.63	4.5	1.77	6.1	1.93		
150	5.5	2.08	4.2	1.95	5.3	2.33		
225	5.9	4.58	4.6	1.75	6.1	2.45	2.0‡	2.0
300	4.9	2.50	5.2	3.57	6.0	3.22	4.5‡	2.8
500	6.1	3.69	5.8	4.33	6.4	4.43	4.5‡	3.0

kVA	2400–15,000V %Z	2400–15,000V Dry X/R	2400–15,000V Cast Coil X/R	Liquid-Filled 2400–15,000V %Z	Liquid-Filled 2400–15,000V X/R †
500	5.75		6.0		
750	5.75	5.0	6.1	5.75	4.00
1000	5.75	5.7	6.2	5.75	4.10
1500	5.75	6.5	6.8	5.75	4.50
2000	5.75	7.2	7.00	5.75	5.00
2500	5.75	7.5	7.00	5.75	5.35

† Typical ratios based on several manufacturer's data
‡ Minimum impedance

TABLE 14—Dry-type transformers—Type QHT, % Impedance, Reactance and Resistance ‡

kVA	Single-phase %IX	Single-phase %IR	Single-phase %IZ	Three-phase kVA	Three-phase %IX	Three-phase %IR	Three-phase %IZ
5	1.68	2.94	3.4	6	1.72	2.72	3.2
7.5	1.84	2.42	3.0	9	1.16	2.31	2.6
10	1.92	2.04	2.75	15	1.82	2.1	2.8
15	2.02	1.60	2.6	30	1.37	3.8	4.0
25	2.3	1.4	2.7	45	1.73	2.52	3.1
37.5	2.7	3.6	4.5	75	1.91	2.27	3.0
50	2.8	3.1	4.2	112½	3.87	2.43	4.6
75	3.7	2.48	4.45	150	5.0	2.35	5.5
100	3.55	2.12	4.14	225	5.5	1.15	5.9
167	3.25	1.60	3.63	300	4.5	1.8	4.9
				500	5.9	1.6	6.1

‡ Typical values based on data from several manufacturers.

TABLE 15—Standard Current Limiting Reactors

60 Volt Insulation Class, Indoor Service 3ø Amperes	Fault△ Current 1 second Duration	OHMS per Phase	5 kV Insulation Class, Single-phase and Three-phase Continuous Current Amperes	OHMS per Phase	15 kV Insulation Class, Single-phase and Three-phase Continuous Current Amperes	OHMS per Phase
1000	23,000	0.015	200	0.25	30	0.50
1000	34,000	.010		.40		.63
						.80
800	12,000	.0285	300	.10		1.0
800	34,000	.010		.16		1.6
				.25		2.5
600	15,000	.0285				
600	15,000	.0230	400	.10	400	.40
600	20,000	.0170		.16		.50
600	25,000	.0130		.25		.63
600	25,000	.010				.80
600	25,000	.0046	600	.063		1.0
				.10		1.6
400	8,000	.0485		.16		
400	15,000	.0285		.25	600	.25
400	15,000	.0230				.40
400	20,000	.0170	1200	.04		.50
400	25,000	.0130		.063		.63
400	25,000	.010		.10		.80
400	25,000	.0046		.16		1.0
225	12,500	.0285				
			2000	.04	1200	.16
				.063		.25
				.10		.40
						.50
						.63
					2000	.10
						.16
						.25
						.40

△ Maximum allowable sustained symmetrical rms amperes

* Trademark of General Electric Company.

TABLE 16—Approximate Machine Reactances

A. Induction Motors

The short-circuit reactance of an induction motor or induction generator in percent of its own kVA base, assuming rated voltage and frequency applied, may be taken as:

$$X''_d\% = \frac{100}{\text{Times normal stalled rotor current}}$$

The reactance will generally be approximately (in percent on own kVA base).

Reactance	Range	Average
Subtransient X''_d	15–25	16.7
Transient X'_d	∞	∞

B. Synchronous Machines

Percent Values on Machine kVA Rating

(A) Generators	X''d Range	X''d Mean	X'd Range	X'd Mean
(1) Turbo Generators (distributed pole)				
2 pole, 625-9375 kVA	6-13	9		
2 pole, 12,500 kVA-up	8-12	10		
4 pole, 12,500 kVA-up	10-17	14		
(2) Salient-pole Generators (without amortisseur)				
12 poles or less	15-35	25		
14 poles or more	25-45	35		
(3) Salient-pole Generators[θ] (with amortisseur)				
12 poles or less	10-25	18		
14 poles or more	18-40	24		
(B) Synchronous Condensers	9-38	24		
(C) Synchronous Converters				
600 V dc	17-22	20		
250 V dc	28-38	33		
(D) Synchronous Motors				
2-6 pole	7-23	15	10-30	20
8-14 pole (incl.)	11-29	20	20-38	29

θ Nearly all salient-pole generators built by GE since 1935 have amortisseur windings.

C. Grouped Small Motors

In many short-circuit studies the number size and type of low-voltage motors (perhaps up to 250 hp, induction or synchronous) is not known precisely, but the short-circuit contributions from these motors must be estimated. In such cases, to account for a group of a large number of low voltage induction and synchronous motors in the first-cycle network, use a reactance of 25 percent based on the total rated kVA of the group. This first cycle estimated reactance is a combination of several X″ times multiplying factor values, see text page 18.