GOAL: Agree to the Phase to Ground Clearance Values for 1.5 kV through 230kV

The WG and Survey results agreed to use the values contained in NEMA TR1-1980.
The NEMA TR1-1980 lists a single value for each voltage.
C57.12.00-2012, Table 4 lists multiple BILs for each voltage.
This proposed table attempts to merge the NEMA TR1-1980 values with the voltage and BIL.

NOTE: Clearance Values for 345kV and up are based on SIL and will be discussed AFTER we finalize the values for 1.5kV through 230kV.

Changes:
Expanded each voltage for BILs contained in C57.12.00, Table 4
Added Col 3 - 8
Provided clearances for Power Transformers for 1.5kV, 30 kV BIL
Provided clearances for Power Transformers for 121kV and 145kV, 450 kV BIL
Provided clearances for Power Transformers for 169kV and 242kV, 825 kV BIL
"Matched" Distribution Transformer 95, 110, 125 and 150 kV BIL with NEMA TR1-1980 values.

Graphs show proposed clearances, test gap spacing (50% flashover clearance) and 110% test gap spacing for reference.
Power Transformer clearances are shown on two graphs to clearly show the comparison of the values.

PROPOSED C57.12.00 TABLE 11

Maximum System Voltage (kV rms)	Nominal System Voltage (kV rms)	Winding line-end BIL (kV Crest) (from Table 4)		Minimum Clearance between live parts of one phase and ground				Minimum Clearance between live parts of different phases				Miminum clearance between top shed of insulator of bushings of different phases			
		Distribution Transformers	Power Transformers	Distribution Transformers		Power Transformers		Distribution Transformers		Power Transformers		Distribution Transformers		Power Transformers	
		(kV Crest)	(kV Crest)	mm	in	mm	in	mm	(in)	mm	(in)	mm	(in)	mm	(in)
Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8	Col 9	Col 10	Col 11	Col 12	Col 13	Col 14	Col 15	Col 16
1.5	1.2	30	30	25	1	51	2	25	1	51	2	25	1	25	1
1.5	1.2	---	45	---	---	51	2	---	---	51	2	---	---	25	1
3.5	2.5	45	45	51	2	51	2	51	2	51	2	25	1	25	1
3.5	2.5	---	60	---	---	76	3	---	---	76	3	---	---	38	1.5
6.9	5.0	60	60	64	2.5	76	3	64	2.5	76	3	38	1.5	38	1.5
6.9	5.0	---	75	---	---	89	3.5	---	---	102	4	---	---	51	2
11.0	8.7	75	75	89	3.5	89	3.5	102	4	102	4	51	2	51	2
11.0	8.7	---	95	---	---	114	4.5	---	---	127	5	---	---	64	2.5
17.0	15.0	95	95	114	4.5	114	4.5	127	5	127	5	64	2.5	64	2.5
17.0	15.0	110	110	127	5	152	6	140	5.5	165	6.5	76	3	89	3.5
26.0	25.0	125	---	146	5.75	---	---	178	7	---	---	114	4.5	---	---
26.0	25.0	150	150	203	8.0	203	8	228	9	229	9	152	6	152	6
36.0	34.5	125	---	146	5.75	---	---	178	7	---	---	114	4.5	---	---
36.0	34.5	150	---	203	8.0	---	---	229	9	---	---	152	6	---	---
36.0	34.5	200	200	305	12	305	12	330a	13	330	13	203	8	203	8
48.0	46.0	200	200	305	12	305	12	330a	13	330	13	203	8	203	8
48.0	46.0	250	250	381	15	381	15	432	17	432	17	305	12	305	12
72.5	69.0	250	250	381	15	381	15	432	17	432	17	305	12	305	12
72.5	69.0	350	350	584	23	584	23	635	25	635	25	483	19	483	19
121	115.0	---	350	---	---	584	23	---	---	635	25	---	---	483	19
121	115.0	---	450	---	---	762	30	---	---	838	33	---	---	686	27
121	115.0	---	550	---	---	940	37	---	---	1041	41	---	---	914	36
145	138.0	---	450	---	---	762	30	---	---	838	33	---	---	686	27
145	138.0	---	550	---	---	940	37	---	---	1041	41	---	---	914	36
145	138.0	---	650	---	---	1118	44	---	---	1245	49	---	---	1118	44
169	161.0	---	550	---	---	940	37	---	---	1041	41	---	---	914	36
169	161.0	---	650	---	---	1118	44	---	---	1245	49	---	---	1118	44
169	161.0	---	750	---	---	1321	52	---	---	1448	57	---	---	1321	52
169	161.0	---	825	---	---	1448	57	---	---	1600	63	---	---		
242	230.0	---	650	---	---	1118	44	---	---	1245	49	---	---	1118	44
242	230.0	---	750	---	---	1321	52	---	---	1448	57	---	---	1321	52
242	230.0	---	825	---	---	1448	57	---	---	1600	63	---	---		
242	230.0	---	900	---	---	1600	63	---	---	1778	70	---	---	1651	65
345	362.0		1050							2286[b]	(90)			2159	(85)
500	550.0		1550							4064[b]	(160)			3937	(155)
765	800.0		1925							c				c	
1000	1200.0									c				c	

a It should be noted that ANSI C57.12.22-1989 [B5] specifies a phase-to-phase clearance of 165 mm (6.25 in) for 25 kV and 229 mm (9 in) for 34.5 kV nominal system voltage. The smaller clearances are acceptable since the bushings are always located within a metal enclosure and are not subject to the same conditions that occur with bushings exposed to the elements.

b For phase-to-phase switching impulse voltages other than 3.8 per unit, the following formula may be used to establish the minimum external clearance for peak switching impulsevoltages between 1000 kV and 1800 kV only:

X = .121(Y) - 45

where

X is the minimum clearance between live parts of different phases (in)

Y is the switching impulse voltage from phase to phase (peak kV) (applicable only from 1000 kV and 1800 kV)

c Power transformers, at nominal system voltages of 765 kV and 1100 kV, are usually single phase so that clearances between live parts of different phases is not an issue.

C57.12.00-2010 Table 11

Nominal system voltage, rms	Maximum system voltage, rms (from ANSI C84.1)	Minimum Clearance between live parts of different phases				Miminum clearance between top shed of insulator of bushings of different phases			
		Distribution Transformers		Power Transformers		Distribution Transformers		Power Transformers	
(Kv)	(kV rms)	mm	(in)	mm	(in)	mm	(in)	mm	(in)
1.2	---	25.4	(1)	50.8	(2)	25.4	(1)	25.4	(1)
2.5	---	50.8	(2)	76.2	(3)	25.4	(1)	38.1	(1.5)
5.0	---	63.5	(2.5)	102	(4)	38.1	(1.5)	50.8	(2)
8.7	---	102	(4)	127	(5)	50.8	(2)	63.5	(2.5)
15	---	140	(5.5)	165	(6.5)	76.2	(3)	88.9	(3.5)
25	---	178[a]	(7)	229	(9)	114	(4.5)	152	(6)
34.5	---	330[a]	(13)	330	(13)	203	(8)	203	(8)
46	48.3	432	(17)	432	(17)	305	(12)	305	(12)
69	72.5	635	(25)	635	(25)	483	(19)	483	(19)
115	121.0			1041	(41)			914	(36)
138	145.0			1245	(49)			1118	(44)
161	169.0			1448	(57)			1321	(52)
230	242.0			1778	(70)			1651	(65)
345	362.0			2286[b]	(90)			2159	(85)
500	550.0			4064[b]	(160)			3937	(155)
765	800.0			c				c	
1000	1200.0			c				c	

a It should be noted that ANSI C57.12.22-1989 [B5] specifies a phase-to-phase clearance of 165 mm (6.25 in) for 25 kV and 229 mm (9 in) for 34.5 kV nominal system voltage. The smaller clearances are acceptable since the bushings are always located within a metal enclosure and are not subject to the same conditions that occur with bushings exposed to the elements.

b For phase-to-phase switching impulse voltages other than 3.8 per unit, the following formula may be used to establish the minimum external clearance for peak switching impulsevoltages between 1000 kV and 1800 kV only:

X = .121(Y) - 45

where

X is the minimum clearance between live parts of different phases (in)

Y is the switching impulse voltage from phase to phase (peak kV) (applicable only from 1000 kV and 1800 kV)

c Power transformers, at nominal system voltages of 765 kV and 1100 kV, are usually single phase so that clearances between live parts of different phases is not an issue.

Manufacturing

TR 1-0.06 EXTERNAL CLEARANCES BETWEEN BUSHING LIVE PARTS*†

Nominal Systems Voltage kV	Minimum Clearance Between Live Parts of One Phase and Ground		Minimum Clearance Between Live Parts of Different Phases or Live Parts of Different Windings		Minimum Clearance Between Top Shed of Porcelain of Bushings of Different Phases	
	Distribution Transformers in (mm)	Power Transformers in (mm)	Distribution Transformers in (mm)	Power Transformers in (mm)	Distribution Transformers in (mm)	Power Transformers in (mm)
1.2	1 (25.4 mm)	2 (50.8 mm)	1 (25.4 mm)	2 (50.8 mm)	1 (25.4 mm)	1 (25.4 mm)
2.5	2 (50.8 mm)	3 (76.2 mm)	2 (50.8 mm)	3 (76.2 mm)	1 (25.4 mm)	1.5 (38.1 mm)
5.0	2.5 (63.5 mm)	3.5 (88.9 mm)	2.5 (63.5 mm)	4 (101.6 mm)	1.5 (38.1 mm)	2 (50.8 mm)
8.66	3.5 (88.9 mm)	4.5 (114.3 mm)	4 (101.6 mm)	5 (127.0 mm)	2 (50.8 mm)	2.5 (63.5 mm)
15	5 (127.0 mm)	6 (152.4 mm)	5.5 (139.7 mm)	6.5 (165.1 mm)	3 (76.2 mm)	3.5 (88.9 mm)
25	5.75 (146.1 mm)	8 (203.2 mm)	7 (177.8 mm)	9 (228.6 mm)	4.5 (114.3 mm)	6 (152.4 mm)
34.5	12 (304.8 mm)	12 (304.8 mm)	13 (330.2 mm)	13 (330.2 mm)	8 (203.2 mm)	8 (203.2 mm)
46	15 (381.0 mm)	15 (381.0 mm)	17 (431.8 mm)	17 (431.8 mm)	12 (304.8 mm)	12 (304.8 mm)
69	23 (584.2 mm)	23 (584.2 mm)	25 (635.0 mm)	25 (635.0 mm)	19 (482.6 mm)	19 (482.6 mm)
92	...	30 (762.0 mm)	...	33 (838.2 mm)	...	27 (685.8 mm)
115	...	37 (939.8 mm)	...	41 (1041.4 mm)	...	36 (914.4 mm)
138	...	44 (1117.6 mm)	...	49 (1244.6 mm)	...	44 (1117.6 mm)
161	...	52 (1320.8 mm)	...	57 (1447.8 mm)	...	52 (1320.8 mm)
196	...	63 (1600.2 mm)	...	70 (1778 mm)	...	65 (1651 mm)
230	...	76 (1930.4 mm)	...	84 (2133.6 mm)	...	79 (2006.6 mm)

*The external clearances given in the above table are for transformers intended for operation at altitudes of 3300 feet (1000 meters) or less. For operation at altitudes in excess of 3300 feet (1000 meters), the external clearances shall be increased to compensate for the decrease in sparkover voltage at the rate of one percent (0.01) per 330 feet (100 meters) increase in altitude in excess of 3300 feet (1000 meters).

NEMA Standard 11-20-1980.

† Suitable grading of local stresses may allow smaller clearances.

Authorized Engineering Information 11-20-1980.

MANUFACTURING

TR 1-0.07 EXTERNAL CLEARANCES BETWEEN LIVE PARTS

Winding Insulation Class, Kv	Minimum Clearance Between Live* Parts of One Phase and Ground, Inches		Minimum Clearance Between Live Parts of Different Phases or Live Parts of Different Windings, Inches		Minimum Clearance Between Top Shed of Porcelain of Bushings of Different Phases, Inches	
	Distribution Transformers	Power Transformers	Distribution Transformers	Power Transformers	Distribution Transformers	Power Transformers
1.2	1	2	1	2	1	1
2.5	2	3	2	3	1	1.5
5.0	2.5	3.5	2.5	4	1.5	2
8.66	3.5	4.5	4	5	2	2.5
15	5	6	5.5	6.5	3	3.5
18	5.75	....	....	....	....	....
25	8	8	9	9	6	6
34.5	12	12	13	13	8	8
46	15	15	17	17	12	12
69	23	23	25	25	19	19
92	30	30	33	33	27	27
115	37	37	41	41	36	36
138	44	44	49	49	44	44
161	52	52	57	57	52	52
196	63	63	70	70	65	65
230	76	76	84	84	79	79
287.5	98	98	108	108	103	103

* This does not necessarily apply to the bushings themselves, the striking distances of which are determined by the bushing characteristics given in Table 9 of USAS C57.12.00-~~1966~~. 1973

NOTE—The external clearances given in the above table are for transformers intended for operation at altitudes of 3300 feet (1000 meters) or less. For operation at altitudes in excess of 3300 feet (1000 meters), the external clearances shall be increased to compensate for the decrease in sparkover voltage at the rate of one percent (0.01) per 330 feet (100 meters) increase in altitude in excess of 3300 feet (1000 meters).

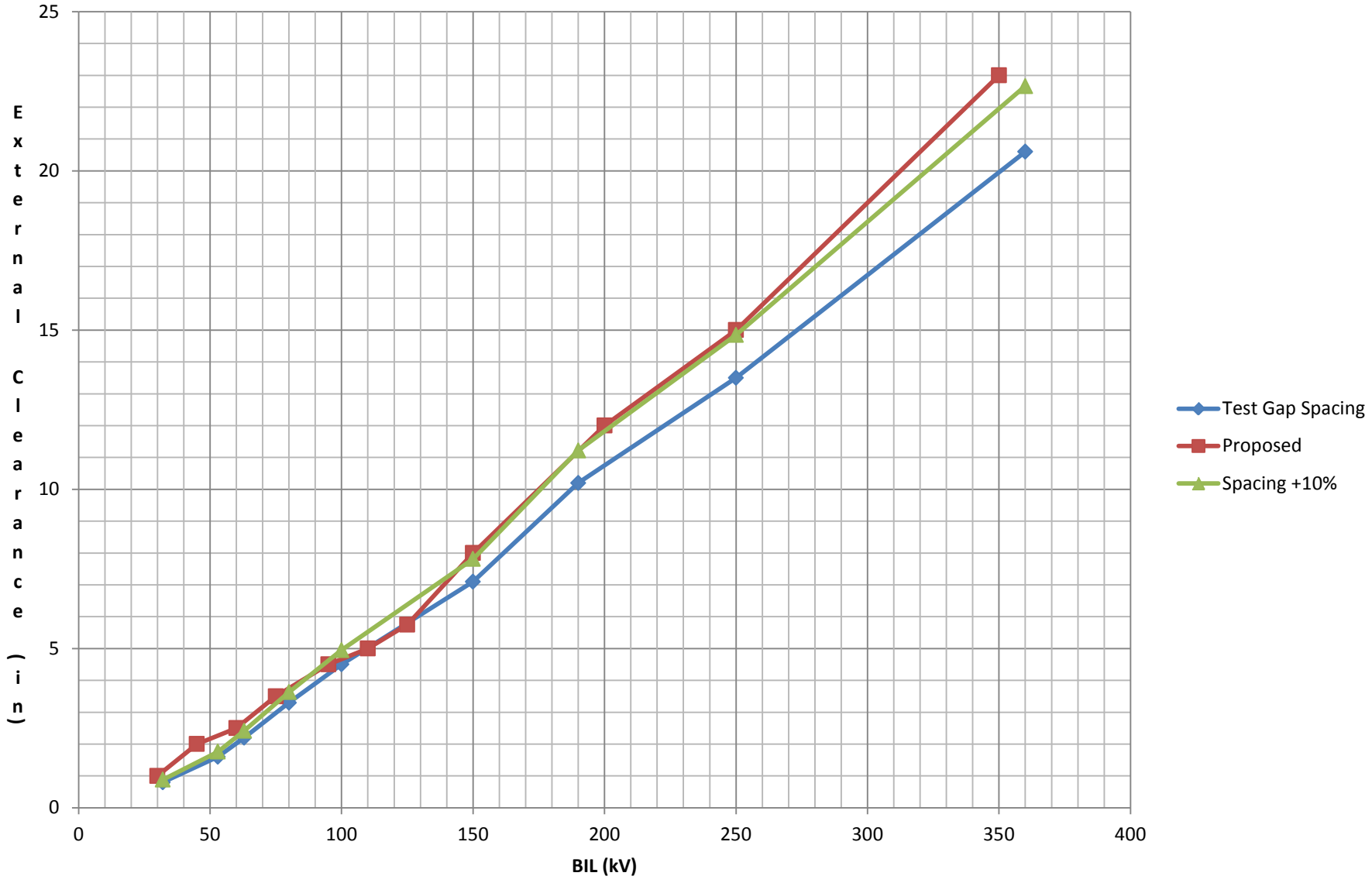
Authorized Engineering Information 12-9-1938, NEMA Standard 3-9-1960.

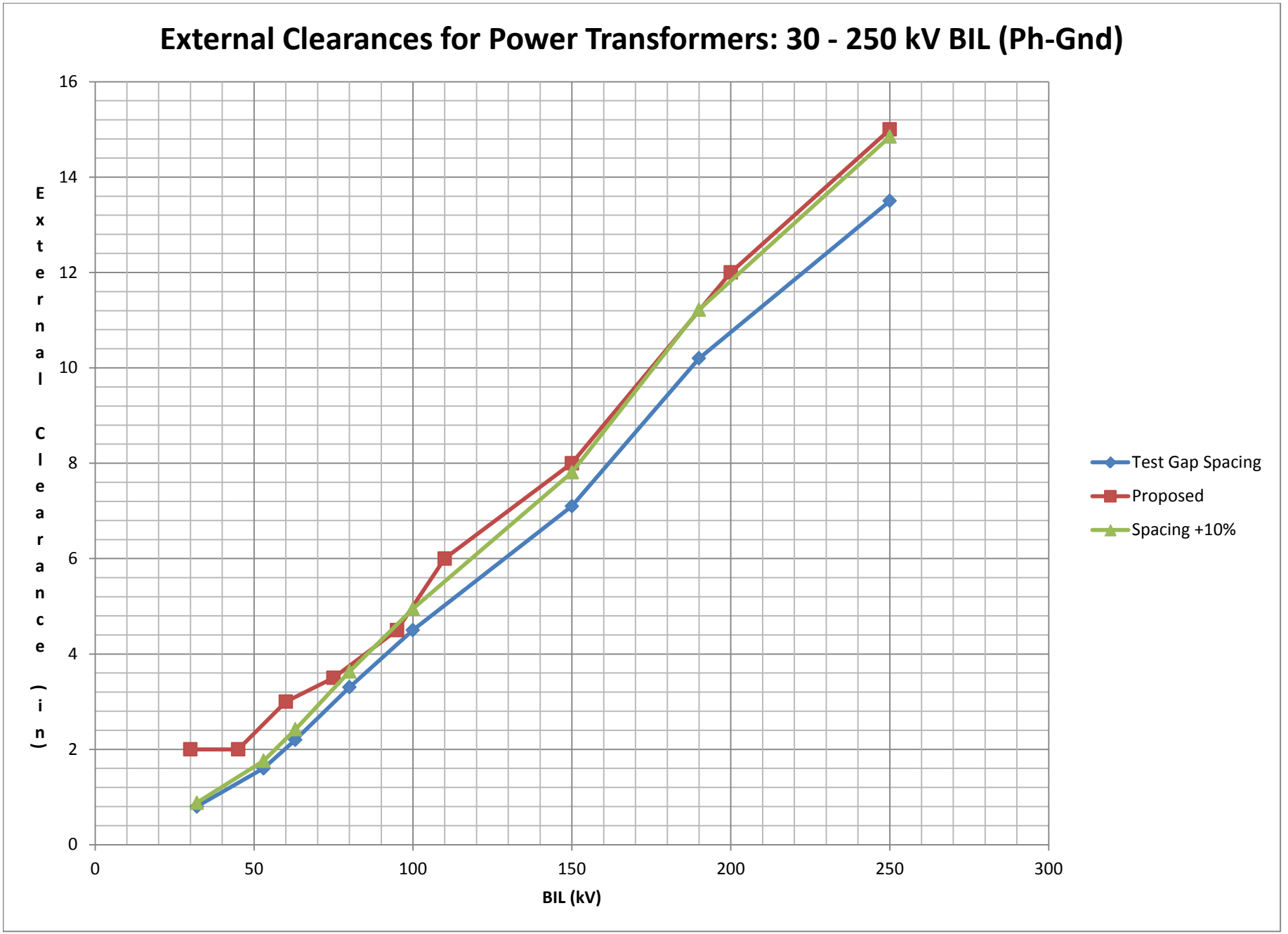
TR 1-0.08 VACUUM FILLING

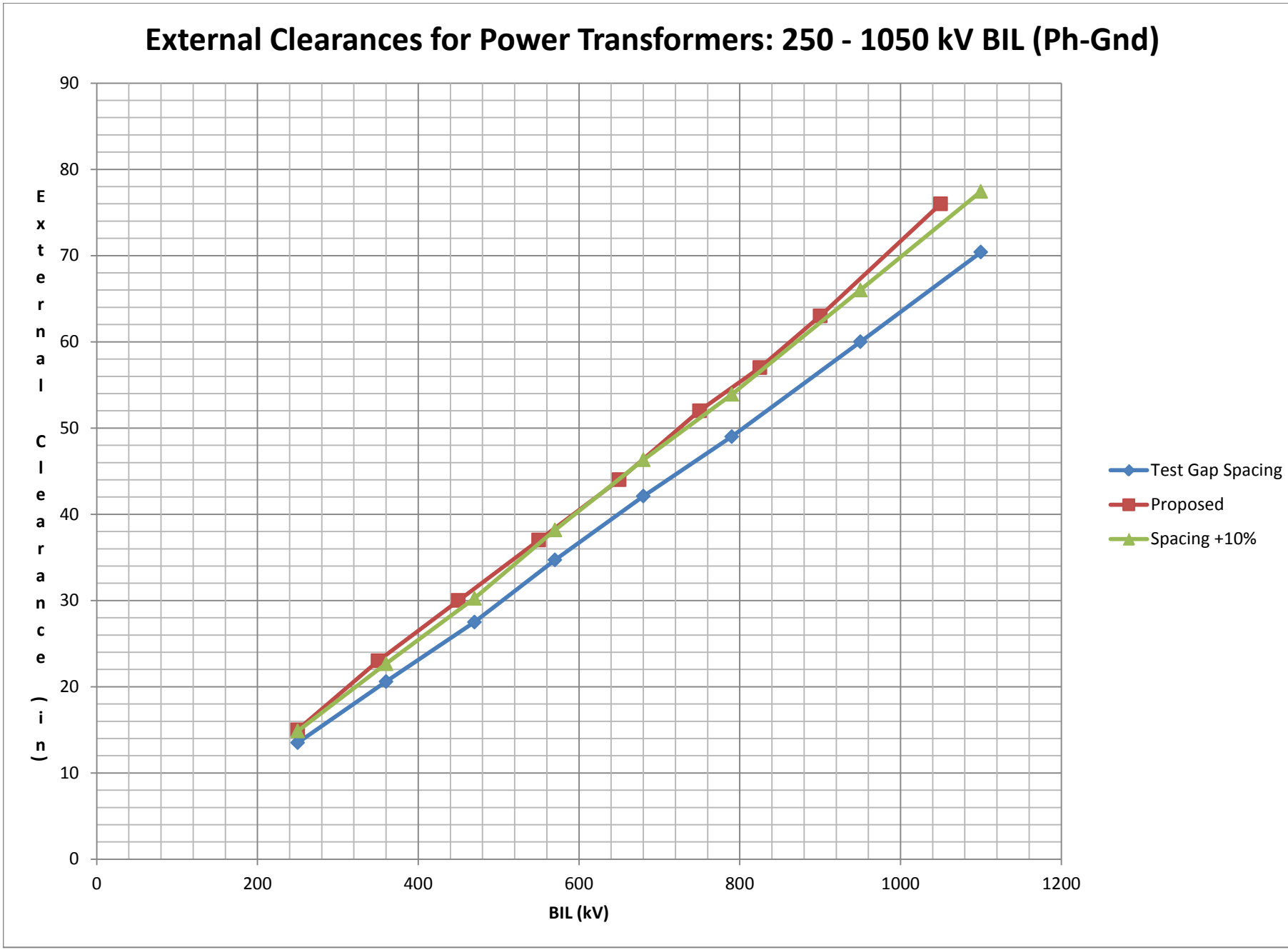
When transformers are to be designed for vacuum filling in the field, the tank shall be designed for and tested at approximately two inches of mercury, absolute pressure, because of limitations in commercial pumping equipment. It is to be understood that the purpose of vacuum filling is simply to quickly remove entrapped air which might have a temporary adverse effect on the dielectric strength.

Authorized Engineering Information 5-19-1939.

External Clearances for Distribution Transformers 30 - 350 kV BIL (Ph-Gnd)




External Clearances for Power Transformers: 30 - 250 kV BIL (Ph-Gnd)
External Clearance (in)
0
2
4
6
8
10
12
14
16
0
50
100
150
200
250
300
BIL (kV)
Test Gap Spacing
Proposed
Spacing +10%


External Clearances for Power Transformers: 250 - 1050 kV BIL (Ph-Gnd)
External Clearance (in)
0
10
20
30
40
50
60
70
80
90
0
200
400
600
800
1000
1200
BIL (kV)
Test Gap Spacing
Proposed
Spacing +10%