TASK FORCE - Table 2 – Cantilever Design Test Requirements – Dan Sauer

Cantilever Test Procedure.
The bushing shall be rigidly mounted to a transformer tank wall with the gasket and bushing clamp specified for the specific bushing. The transformer tank wall material and thickness shall be representative of the thinnest that the bushing is installed onto. The hardware securing the bushing clamps shall be installed to the minimum torque level specified in the bushing installation instructions. The test tank shall be filled with standard transformer mineral oil. Tests shall be applied to the external terminal of the bushing with the load applied normal to the longitudinal axis of the bushing. During the cantilever test, the bushing internal pressure (gage) shall be 70 kPa (10.2 psi). The temperature shall be approximately 20°C. The bushing and tank shall be pressurized and allowed to sit for a period of at least 10 minutes prior to the cantilever test to insure that there is no leak with no additional load applied. The moment arm used to calculate the load, per Table 4 below, in ft.-lbs. shall be the distance between the transformer tank wall and the point where the load is applied to the external terminal. The load shall be applied as either a static load or using a tensile/compression testing machine at a crosshead speed of no greater than 0.5 inches per minute. The specified leak test load shall (per table 4) be applied for a period of 1 minute. There shall be no oil leakage on the external (air) side of the bushing at any time during the test or within 10 minutes after removal of the load. Leaks shall be detected by using either an oil sensitive powder or UV light leak detection system. Inspect for leaks around the gasket, around the conductor to bushing interface and thru the bushing material itself. Note; care shall be taken to insure that no cantilever load is applied to the bushing while the support system is installed.

Following the cantilever load leak test, the bushing shall be loaded at the max withstand level (per table 4) without clamp or support failure.

Environmental: Containment shall be provided to catch all of the possible oil volume that could leak out of the tank in the event of a complete failure of the bushing.

	Unsupported		With Supports	
Nominal Rated Current	Leak Test Withstand	Max Withstand without Failure	Leak Test Withstand	Max Withstand without Failure
500A	75	100	NA	NA
1500A	100	150	NA	NA
2500A	100	150	250	400
4500A	150	250	500	800
Note: The above values are torques, for equivalent force loads the above values must be divided by the length in feet from the center of the mounting surface wall to the loading point.				

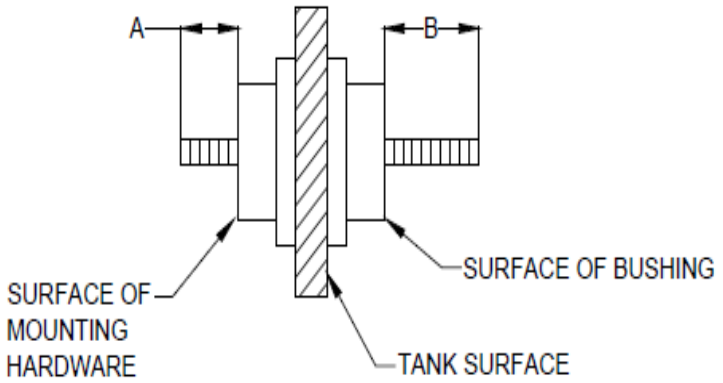
Table 4 Cantilever Requirement

TASK FORCE - Figure 1 –Thermal Scheme for LV Distribution Bushings – Dave Geibel

Previously Proposed Stud/Bolt Sizes

Stud and Thread Size	Nominal Rated Current (A)	Stud Extension Inside Tank (A)	Stud Extension Outside Tank (B)
1/4–20 UNC-2A	49		
3/8–16 UNC-2A	110	XX (0.75)	
1/2–13 UNC-2A	196		
5/8–11 UNC-2A	316	32 (1.250)	
3/4–16 UNC-2A	442		
1–14 UNS-2A	785	44 (1.750)	
1 ⅛–12 UNS-2A	994		
1 ¼–12 UNF-2A	1227	67 (2.625)	
NOTE — All dimensions are in millimeters (inches) and are minimums.			

Figure 1— Standard Stud Sizes



Comments & Assumptions

- Ratings for each stud size is already proposed.
- Oil rise and ambient are standardized
- Bushing insulation (and structure) are often “plastic”
- Typically CU bolt is short (6” or less) and covered length is limited to 4” or less
- C57.19.00/.01 standards don’t apply to such a bushing very well

More Comments & Assumptions

- Application can vary among xfrm manufactures
  - Fluid used
  - Cable rise (size, quantity & insulation)
  - Connector rise (size, quantity)
- Application can vary among users
  - Cable rise (size, quantity & insulation)
  - Connector rise (size, quantity)
  - Compartment rise above ambient

Important…… (or not)

- Bolt temperature not important on its own
  - Temperature of CU is not the issue.
- Temperature of stud in contact with oil is important
  - Temperature of stud will damage oil if over 125C
- Temperature of bolt in contact with “plastic” is important
  - Temperature of Bolt will affect plastic if above Tg, for example.
  - Heat from Bolt must not damage gasket.
- Temperature of air side termination not important on its own
- Temperature of insulation on air side cable is important
  - Heat from stud/connector must not damage cable insulation.

Things I believe (think what you like)

- The cables and connectors have an overwhelming influence on the temperature rise of the short bolt. Both oil and air side.
- Oil temperature criteria is 65K rise over 30C ambient = 95C
- A reasonable temperature for bolt is =<115C at rated current
  - Leaves *some room* for overload
  - Protects Nitrile mounting gaskets
  - Protects polymers used to mold bushing body
  - Protects air side cable insulation

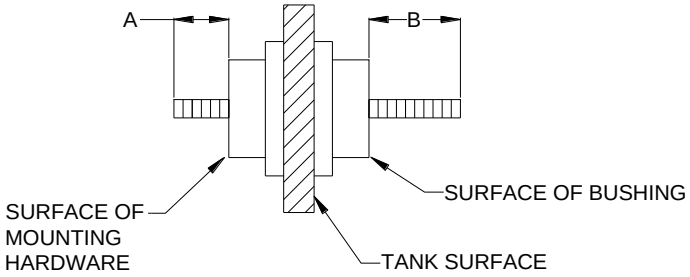
I Propose, for starters (and I'm game for suggestions):

- Bolt rise limit =< 20K over oil with:
  - Oil side connection (cable & connector, 30mm from bolt) self heating rise of 15K over oil (min to test bushing/max to apply bushing)
  - Air side connection (cable & connector, 30mm from bolt) self heating rise of 60K over ambient (min to test bushing/max to apply bushing)
- Rise must be limited to suit material selected for the body and verified/declared/established
  - Tg testing
  - Leak testing after load/thermal cycling
  - Well established material acceptance

Maybe?

TASK FORCE - Figure 1 – Standard Stud Sizes and Figure 3 – Termination Configurations – Al Traut

PC57.19.02 – Fig 1 Present Draft



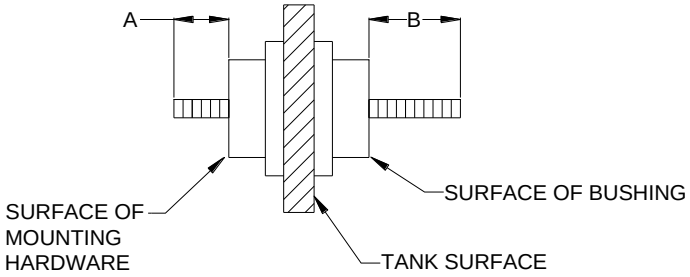
Stud and Thread Size	Nominal Rated Current (A)	Minimum Usable Thread Length Inside Tank (A)	Minimum Usable Thread Length Outside Tank (B)
1/4–20 UNC-2A	49		
3/8–16 UNC-2A	110	XX (0.75)	
1/2–13 UNC-2A	196		
5/8–11 UNC-2A	316	32 (1.250)	
3/4–16 UNC-2A	442		
1–14 UNS-2A	785	44 (1.750)	
1 ⅛–12 UNS-2A	994		
1 ¼–12 UNF-2A	1227	67 (2.625)	
NOTE — All dimensions are in millimeters (inches) and are minimums.			

PC57.19.02 – Fig 1

Stud and Thread Size	Nominal Rated Current (A)	Overhead Transformers	1ph Padmount Transformers	3ph Padmount 3ph Submersible Transformers	External Exposed Stud Length
1/4–20 UNC-2A	49	n/a	n/a	n/a	n/a
3/8–16 UNC-2A	110	208*	n/a	n/a	n/a
1/2–13 UNC-2A	196	416*	n/a	n/a	n/a
5/8–11 UNC-2A	316	625*	361	416	32 (1.25)
3/4–16 UNF-2A 3/4-10 UNC-2A	442	833*	n/a	n/a	n/a
1–14 UNS-2A	785	1388	1042	832	44 (1.75)
1 ⅛–12 UNF-2A	994	n/a	n/a	n/a	n/a
1 1/4–12 UNF-2A	1227	2083	No rating	1388	67 (2.62) 64 (2.5)

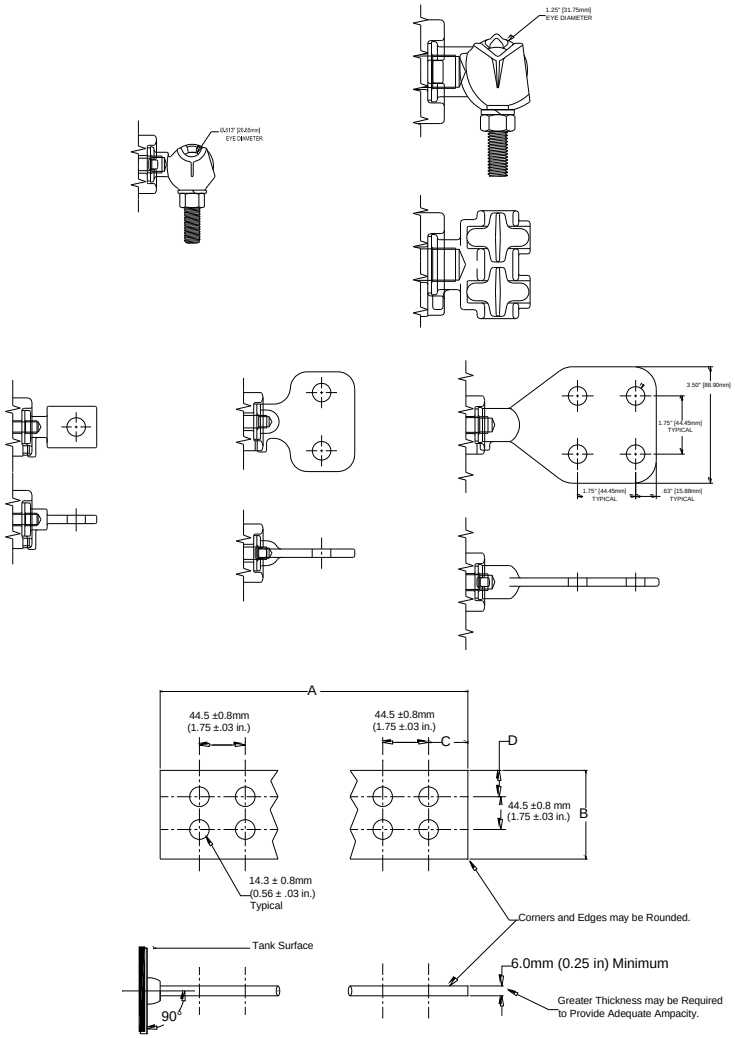
- ¾ stud is used with UNF and UNC threads
- 1-1/8-12 is UNF not UNS
- * rating based on parallel 120V connection
- Product standards do not specify internal stud length

PC57.19.02 – Fig 1 Proposed



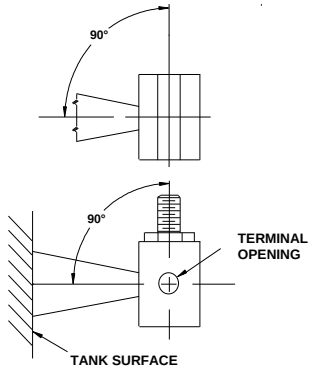
Stud and Thread Size	Nominal Rated Current (A)	Minimum Internal Useable Stud Length (A)	Minimum External Useable Stud Length (B)
1/4–20 UNC-2A	49	Delete this column	n/a
3/8–16 UNC-2A	208		n/a
1/2–13 UNC-2A	416		n/a
5/8–11 UNC-2A	625		32 (1.25)
3/4–16 UNF-2A 3/4-10 UNC-2A	833		n/a
1–14 UNS-2A	1388		44 (1.75)
1 ⅛–12 UNF-2A	??		n/a
1 1/4–12 UNF-2A	2083		67 (2.62)

PC57.19.02 – Fig 3 Present Draft



- Break into two figures
- Fig 3a – Eyebolt Terminals
  - Use Fig 5a and Table 9 from C57.12.20
- Fig 3b – Spade Terminals
  - Consolidate from C57.12.20, C57.12.24, C57.12.34, C57.12.38

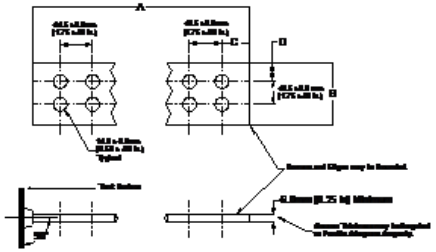
PC57.19.02 – Fig 3a Proposed



a) Threaded parts of connector shall be removable without removing bushings.
b) Connector Clamping Bolts shall be 3/8, 1/2, 5/8, or 3/4 NC threads, class 2 fit.
c) One or two connector clamping bolts may be used, but U-bolts or J-bolts shall not be used.
d) Terminal of low-voltage windings 600 V and below shall be arranged for vertical takeoff.
e) Terminals are to be tin plated and aluminum conductors are to be properly prepared.

Eyebolt Opening	Rated Current (A)	Cable size range	External eyebolt hex nut size
7.9 (0.31)	70	#8 AWG solid to #2 AWG Solid	3/8-16 UNC-2A
15.9 (0.63)	208	#6 AWG solid to #4/0-19 stranded	3/8-16 UNC-2A
20.6 (0.81)	416	#2 AWG solid to 350-19 kcmil stranded	1/2-13 UNC-2A
23.8 (0.94)	625	#1/0 solid to 500-37 kcmil stranded	1/2-13 UNC-2A
31.8 (1.25)	833	#2/0 solid to 1000-61 kcmil stranded	1/2-13 UNC-2A
NOTE — All dimensions are in millimeters (inches) and are minimums.			

PC57.19.02 – Fig 3b Proposed



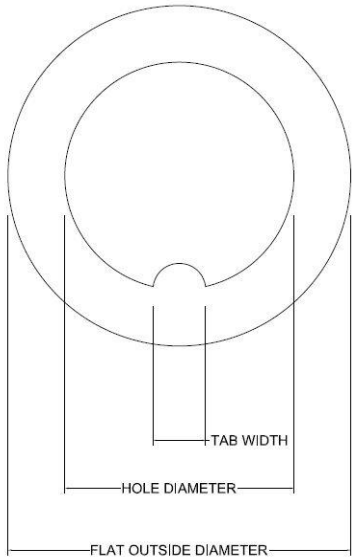
Sizes from C57.12.20, 12.24, 12.34, 12.38

UNDER DEVELOPMENT

Number of Holes	A	B	C	D	E	Rated Current (A)
1						
2						
4	86 (3.38)	89 (3.50)	16 (0.63)	22 (0.88)	6.35 (0.25)	1042
4	114 (4.50)	102 (4.00)	22 (0.88)	29 (1.12)	6.35 (0.25)	2083
6	137 (5.38)	102 (4.00)	22 (0.88)	29 (1.12)	6.35 (0.25)	1805
10	225 (8.88)	102 (4.00)	22 (0.88)	29 (1.12)	15.88 (0.63)	3000
12	305 (12.00)	102 (4.00)	22 (0.88)	29 (1.12)	19.05 (0.75)	4500

NOTE — All dimensions are in millimeters (inches) and are minimums.

TASK FORCE – Figure 2 – Standard Mounting Holes – Martin Rave



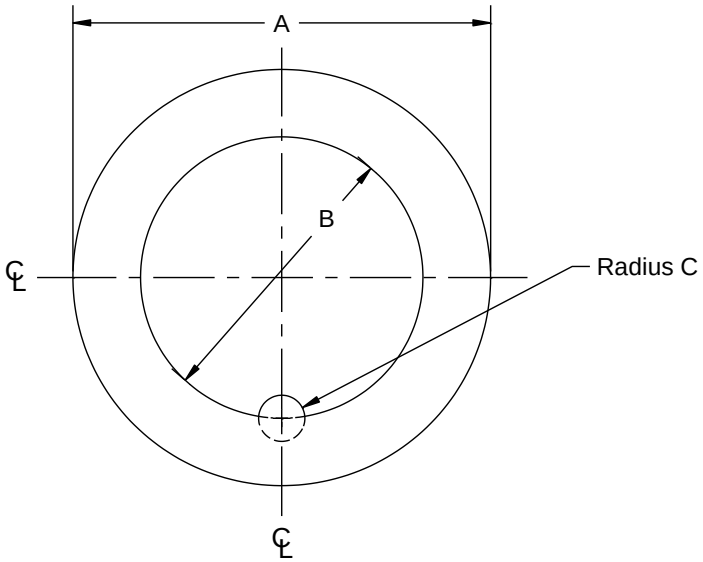


Figure 2 Standard Mounting Holes

Mounting Hole Designation	*Flat Outside Diameter (A) TOL. +/- 1.57 (+/-0.062)*	*Hole Diameter1 (B) TOL. +/-0.41 (+/-0.016)*	*Tab Radius (C) TOL. +/-0.008 (+/-0.003)*	
	(2.125)	*(1.4375)*	*(0.118)*	*MARCH 2017 DRAFT*
SA	(2.0 Min.)	(1.438 +/-0.016)	(.118 +/-0.003)	Bushing MFG A
	(2.0 Min.)	(1.438 +/-0.016)	(.118 +/-0.01)	Transformer MFG A
	(2.0 Min.)	(1.438 +/-0.016)	(0.120 +/-0.005)	Transformer MFG B
	(2.0 Min.)	(1.438 +/-0.016)	(0.118 +/-0.003)	Transformer MFG C
	(2.0 Min.)	**(1.438 +/-0.016)**	**(.118 +/-0.01)**	**TF Recommendation**
S	(2.75 Min.)	(1.813)	(0.19)	Bushing MFG A
	(2.75 Min.)	(1.800 +/-0.016)	(.185 +/-0.01)	Transformer MFG A
	(2.75 Min.)	(1.813 +/-0.016)	(0.19 +/-0.005)	Transformer MFG B
	(2.75 Min.)	(1.813 +/-0.016)	(0.188 +/-0.003)	Transformer MFG C
	(2.75 Min.)	**(1.800 +/-0.016)**	**(.185 +/-0.01)**	**TF Recommendation**
S1	N/A	N/A	N/A	Bushing MFG A
				Transformer MFG A
	(3.2 Min.)	(2.27 +/-0.016)	(0.13 +/-0.005)	Transformer MFG B
	N/A	N/A	N/A	Transformer MFG C
	(3.2 Min.)	**(2.27 +/-0.016)**	**(0.13 +/-0.01)**	**TF Recommendation**
S2	(3.75 Min.)	(2.75 +/- 0.0156)	(0.219)	Bushing MFG A
	(3.75 Min.)	(2.75 +/-0.016)	(.240 +/-0.01)	Transformer MFG A
	(3.75 Min.)	(2.75 +/-0.016)	(0.219 +/- 0.005)	Transformer MFG B
	(3.75 Min.)	(2.803 +/-0.020)	(0.218 +/- 0.003)	Transformer MFG C
	(3.75 Min.)	**(2.75 +/-0.016)**	**(.220 +/-0.01)**	**TF Recommendation**

NOTE - All dimensions are in millimeter (inches)

Note - Flat Outside Diameter is a minimum dimension

Note - Hole Diameter and Tab Radius are required dimensions after paint.