PCORE Electric's Comments on Draft -2 of C57.19.100 received on 3/10/08 **3/13/08**

Clause	Original Text in Draft-2	Comments	Proposed Change	
4.1.2.5 Stray magnetic flux	Additional heating may occur in bushings placed in the stray magnetic field of the windings and leads. The heating results from induced eddy current flowing in the metallic portions of the bushing below the mounting flange. The magnetic flux increases with the load current. Induced fields can create high eddy current losses in tanks, flanges, and bus enclosures during overload conditions, causing them to reach high temperatures. High temperatures of the part itself may not be of concern, but the heat may transfer to the bushing causing high temperatures in the bushing, which are of concern.		Additional heating may occur in bushings placed in the ~~stray~~ magnetic field of the windings and leads. The heating results from ~~induced~~ eddy current flowing in the metallic portions of the bushing below the mounting flange. The magnetic flux increases with the load current. ~~Induced~~ Magnetic fields can create high eddy current losses in tanks, flanges, and bus enclosures during overload conditions, causing them to reach high temperatures. High temperatures of the part itself may not be of concern, but the heat may transfer to the bushing causing high temperatures in the bushing, which are of concern.	
4.1.3 Limitations	In order to coordinate the performance of bushings with the transformers in which they are mounted, the following limits are recommended for loading beyond nameplate rating: a) Ambient air temperature: 40°C maximum b) Immersion oil temperature: 110°C maximum c) Maximum emergency current: Two times rated current of the bushing d) Bushing hottest spot: The hottest spot of the conductor in contact with temperature index 105 insulation should be limited to 150°C. e) Air-end terminal connections: Although the air-end terminal connections do not greatly affect hottest-spot rise at rated current, they can become an important factor when loading beyond nameplate rating. Leads and connectors should be sized to meet the usual service conditions of IEEE Std C57.19.00-1991, 4.1(5). f) Oil-end terminal connections: The large surface area of the connector fastened to the inboard end of the bushing tends to stabilize that point so that it generally has only a small rise over the oil temperature. However, the terminal rise, and indirectly the bushing hottest-spot rise, can also be influenced by the temperature of the lead connected to the terminal. Therefore, the inboard lead should be limited to an 80°C rise over ambient air at rated current.	Bushings do not have active cooling method (fan, radiator, pump) like transformers. A current of double busing nameplate rating is not a justified way of overloading. Actually it is very dangerous. We overloaded one bushing to 2X rated current. The smell of burnt oil spread all over within 10 minutes. The oil expansion was not a problem since the overall oil did not have time to expand quickly.	To eliminate this recommendation until we can establish a better way of defining it.	

Clause	Original Text in Draft-2	Comments	Proposed Change	
5.4 Draw-Lead Application - Bushing current rating	… thermally uprated	More commonly used as "thermally upgraded"	To change to "thermally upgraded"	
	The 100 K hottest spot temperature rise limit is based on maximum oil temperature of 140°C with maximum ambient air temperature of 40°C. Operation at hottest spot temperature above 140°C may result in gassing of oil/paper insulation. …. Attach the thermocouples to the draw-lead cable/conductor 20 – 30 cm (8 – 10 inch) apart.	The distance between thermocouples is too large to detect hottest spot in most cases. And it is almost impossible to drill the strands to detect the accurate temperature. The actual hottest-spot could be higher than 140°C with the thermocouple setup.	To reduce 100 K rise to 90 K rise, or 140°C to 130°C, to give some margin.	
	Like the draw-lead cable, the current carrying capacity of the draw-lead conductor is determined by the size and type of the conductor used by the bushing manufacturer. The current is limited to the rating specified on the bushing nameplate.	In Clause 3 "Definition" of this application guide, "draw-lead conductor" includes cable.	To reword. Also, consider reword "the current is limited to the rating specified on the bushing nameplate" to "the operating current shall be below the rating specified on the bushing nameplate."	
8.1 Allowable line pull (cantilever loading) - General	The continuous cantilever loading (i.e., line pull, wind loading, ice loading, etc.) applied to the bushing terminal should not exceed 50% of the test value, for the bushing ratings given in IEEE Std C57.19.01-2000, Table 8. The cantilever loading applied to a bushing terminal as a result of continuous cantilever loading plus dynamic or short-time loading (i.e., short-circuit forces, seismic but not including seismic forces generated by the mass of the bushing itself) should not exceed 85% of the bushing test value given in IEEE Std C57.19.01-2000, table 8. Cantilever loading should not exceed allowable values for the equipment in which the bushing is installed.	The "short-time" shall be specified as how long. The seismic force on the bushing is the bushing mass times the actual acceleration. No mass, no seismic force. Therefore, this sentence is incorrect.	To clarify "short-time", i.e., what is the time period to be considered as short-time. To remove "but not including seismic forces generated by the mass of the bushing itself."	

Clause	Original Text in Draft-2	Comments	Proposed Change	
8.2 Mounting angles greater then 20 degrees	When a bushing is mounted at an angle that exceeds 20 degrees from the vertical recommended in C57.19.00 under Unusual Service Conditions, it may be subjected to excessive bending moment. If the bushing is not designed for such an application, it may be subjected to excessive force that may result in leaks or damage to the bushing. Standard bushings may not be acceptable for replacements on Mobile Transformers or Substations. Always consult with the bushing manufacturer regarding the specific application before selecting a replacement. Generally bushings selected for these applications require special, high strength porcelain or bushings supplied with a Silicone Rubber Insulator (SRI).	PCORE bushings have been used for mobile transformers or substations for decades without mechanical problems. Besides, the mechanical shock in IEEE 693 seismic test is much more stringent than what a bushing experience on mobile transformers or transportations. PCORE bushings passed the high level of seismic test in IEEE 693.	*) To remove paragraph 2nd paragraph (highlighted in yellow).	
	The following guidelines can be used to ensure the proper application 1. The manufacturer should be made aware of the requirement so that the bushing can be designed and tested according to the special application. 2. When a bushing has been designed for usual service conditions as per C57.19.00 and needs to be applied at an angle greater than 20 degrees from the vertical, it should be tested for cantilever requirements as per note 2 of Table 4, C57.19.01-2000. The note basically specifies the following simplified formula: For angles greater than 22 degrees an equivalent force appearing at the top terminals due to the weight of the bushing should be added to the design test values of Table 4 when testing the bushing in the vertical position. The equivalent force due to the weight of the bushing can be calculated by using the following simplified formula: Equivalent force = [W x A x Sine(T)] / [B x Sine (T)] Where **W** = Bushing Weight **T =** Angle of mounting from the vertical, degrees **A** = Distance of bushing center of gravity from the mounting flange **B** = Distance of mid point of top terminal from the flange mounting surface The actual cantilever test force when tested in the vertical position would be: **Cantilever test force = Cantilever test value as per Table 4 + Equivalent Force** The bushing should be tested in the vertical position using the above cantilever test force.	The cantilever test is a bushing design test. It is basically impractical to ask manufacturer to do the cantilever design test for every specific application. The proposed method here does not have any restrictions on bushing design. We have not heard any report that a bushing manufactured in the US actually failed mechanically because of mounting angle; *) Theoretically the equation is incorrect as sin(T)'s are canceled.	To delete this because this is a bushing application guide rather than a bushing standard. To remove sin(T) in the denominator.	

Clause	Original Text in Draft-2	Comments	Proposed Change	
8.2 Circuit breaker applications	Due to changes in the breaker industry, oil/air bushings have been replaced in many new breakers with gas/air bushings. If the bushing is not identified as being TBI (Transformer Breaker Interchangeable) the manufacturer needs to be contacted to insure that the bushing will withstand the forces of the breaker operation.	Irrelevant statement.	To delete the first sentence (in yellow).	
9.1.5 Countermeasures	b) Apply protective coatings. Protective coatings can be applied to the surface of the bushings to improve their dielectric performance. There are temporary coatings, such as silicone grease, that require periodic replacement and permanent coatings that are nonremovable.	Protective coating could attract contaminants such as dust and cause irregular (higher, lower or even negative) power factor test results. We have seen some cases. As a manufacturer, we do not recommend doing this.	To add "the protective coatings may attract contaminants and cause bushing power factor testing issues."	
9.3 Application of Outdoor Bushings in Indoor Locations	c) If personnel safety and or fire safety is an issue consider selecting solid dialectic bushings (Without oil) or Oil filled bushings with a nonceramic outdoor insulator. These technologies can reduce the risk of explosions and fire.	This statement is incorrect and could cause legal issue in the future. Such statement shall have scientific reports to back up. Meanwhile, it's also related to bushing failure frequency and failure mode. The safety & hazard concern for transformers is specified in NESC & NEC.	To eliminate this part because the user shall follow the safety & hazard requirement for transformers in NESC and NEC codes rather than this bushing application guide.	
9.4 Bushing Monitors	Bushing monitors are installed on bushing test taps to allow for on-line testing and monitoring. These allow for continuous monitoring or periodic testing of bushings without removing the bushing from service. Since the monitors replace the existing test tap cover the user should insure proper fit of the monitor to prevent moisture ingress into the test tap. A voltage is then brought from the monitor to an accessible area of the transformer to perform the monitoring. The user should consult with the manufacturer of the monitor to determine the voltage levels that are normally expected and the maximums that could be reached should the device fail. Operational guidelines can then be developed by the user to determine the level of safety requirements and experience of personnel who should have access to the devices	As IEEE standards distinguish "test tap" and "voltage tap" for different voltage bushings, text here shall be also revised following standards.	To change all "test tap" to "tap" or "voltage/test tap".	

<table>
<tr><th>Clause</th><th>Original Text in Draft-2</th><th>Comments</th><th>Proposed Change</th><th></th></tr>
<tr><td>10.3.1 Power/dissipation factor and capacitance</td><td>While the test tap (C2) insulation is not controlled during the manufacturing process, significant changes in either the C2 capacitance and/or power/dissipation factor from an initial value are indicative of a problem. Note: I know of several instances of new bushings whose C2 did not match nameplate were returned and the manufacturer reported no problems found. Please comment from your experience or suggest wording to address this issue.</td><td>See the “C2 power factor” test requirement from different standards.</td><td>To add “generally C2 value of bushing with test tap may vary significantly from nameplate or factory test values. It is advised to follow each manufacturer’s guidelines in this issue.”</td><td></td></tr>
<tr><td></td><td colspan="3"><table>
<tr><th>Standard</th><th colspan="2">IEEE Std. C57.19.00/01</th><th colspan="2">IEC Std. 60137</th><th colspan="2">CSA Std. C88.1</th></tr>
<tr><td>Lower-voltage Bushings</td><td>69 kV & below Test Tap</td><td>No</td><td>Below 72.5 kV</td><td>No</td><td>72.5 kV & below Test Tap</td><td>10% Max.</td></tr>
</table></td><td></td></tr>
<tr><td>10.3.2 Gas-in-oil</td><td>This test is not recommended as a routine test because it requires that the bushing be opened up and exposed to the outside atmosphere. This introduces the possibility of moisture entering the bushing while the bushing is open or after improper sealing of the opening. While this test if performed by some companies the degree of expertise to perform and interpret it makes it impractical for most users.

The gas-in-oil test should only be used for diagnostic purposes on bushings that are suspect due to high power or dissipation factor measurements or other reasons. Gas-in-oil results should be compared with test results from other bushings and not with power transformer test results. The different mix of materials in bushings and in transformers will give different results. Experts with experience in interpreting bushing gas-in-oil tests should be consulted if help is needed.

The bushing manufacturer should be consulted for assistance in taking samples and interpreting results. The bushing oil level should be checked and adjusted if needed after oil samples are taken.</td><td>There is no DGA limits for bushings in IEEE standards or guides.

IEC 61464 provides some reasonable limits for bushings.</td><td>To add “there is no IEEE DGA values for bushings. IEEE DGA values are based on transformers. The ratio to paper/oil in a transformer is dramatically different than that found in a bushing. The user may use IEC 61464 as a reference while IEEE develops its own guide or standard.”</td><td></td></tr>
<tr><td>10.4 BUSHING STORAGE</td><td>Bushing technology is evolving and new materials are being used. Since they are designed to be used in oil filled equipment, storing them out of oil exposes them to air, moisture, and possibly UV rays. In order to insure they are usable when needed, the manufacturer should be consulted for storage information. This is for both short and long term storage.</td><td>Irrelevant statement (in yellow).

The storage instructions are different among manufacturers. Manufacturers ship storage instructions with bushings.</td><td>To replace the paragraph with “The user shall follow each bushing manufacturer’s recommendations for bushing storage. The manufacturer should be contacted if bushing storage is a concern.”</td><td></td></tr>
</table>

Clause	Original Text in Draft-2	Comments	Proposed Change	
10.5 Bushing replacement	Bushing replacement is a common practice, taking place thousands of times every year. The most critical item to remember when replacing existing bushings is that you do not change the electrical geometry inside the transformer. Any change to the electrical clearances or insulation structure inside the transformer may lead to a transformer failure. When replacing an existing bushing a number of key items need to be addressed before a replacement bushing is selected. The following is a list of items to be considered: • Bushing mounting flange configuration; bolt circle diameter and number of bolt holes • Bushing length below the flange, this is normally noted on the nameplate as the "L" dimension • How is the bushing connected to the transformer winding? Via draw lead cable or conductor or connected to the bottom of the bushing • Bottom terminal; threaded stud, two-hole spade or bottom plate • Height of bushing above the mounting flange • Bushing current rating	The dimensional requirements in IEEE bushing standard were designed to establish the interchangeability of bushings between different manufactures. Misuse of this standard can eliminate interchangeability. We have heard several utilities complaining about problems in finding replacement bushings.	To add at the beginning "When specifying bushings for transformers, the future replaceablity should be seriously considered."	
10.5.1 Replacing Bottom Connected Bushings	If the replacement bottom connected bushing meets all the dimensional requirements below the mounting flange as the existing bushing the only other item to consider is the shielding. Additional shielding is used on bushings rated 46 kV and above. (At 46 and 69 kV only a few designs utilized bottom plates that required additional shielding) The key item to confirm is the thickness and diameter of the bottom plate, it must not be thicker then the existing bushing's bottom plate nor larger in diameter. If all the dimensions of the replacement bushing bottom plate are the same as the existing bushing and there is no damage to the original shield and terminal, it is recommended to utilize the original shield and terminal. This will avoid any changes to the original electrical design inside the transformer. If the original shield has been damaged you should consult with the original transformer manufacturer or industry recognized consultant on the replacement of the shield.	Bushings shields are related to both bushing design and transformer design. It is improper to simply specify which shield to use in the bushing application guide.	To change the part to "Whether or not a replacement bushing needs a bottom shield depends on the original bushing design and transformer design."	
10.5.2 Replacing Draw Lead Connected Bushings	Another issue that may come up is different types of draw lead studs. Historically the draw lead stud was a threaded stud which transferred the load current to the top terminal of the bushing. In recent years new draw lead stud designs have been introduced into the marketplace. These new designs do not use threads to transfer current but rather multi-spring contacts. When you need	The statement here is too commercial.	To change this part to "The user is encouraged to discuss with the manufacture of replacement bushing for possible draw-lead connection issue."	

	to replace a bushing with this new design with a bushing that requires a threaded stud, option two above must be used during the replacement of the bushing. For more details regarding draw lead bushing replacement refer to the instructions provided by the replacement bushing manufacturer.			