RECOMMENDATIONS FOR THE USE OF
CONDENSER BUSHINGS IN
BUS DUCT APPLICATIONS
The typical bus duct application requires a low voltage, high current bushing. These bushings are relatively short in length with large diameter conductors. Because of this unique geometry, most of the heat generated inside of the bushing is conducted directly to the bushing’s terminals. One set of terminals is immersed in the bus duct environment and is connected to the bus. The other set of terminals is immersed in the transformer oil environment and is connected to the transformer cables. The air temperature inside the bus duct rises because it has to dissipate the heat from the bus to the bus duct or to the air circulating/cooling system. This bus duct air temperature is, usually, far in excess of the 40°C maximum temperature, which is specified in the IEEE bushing standard as the normal ambient temperature. In addition, the maximum bus temperature according to the ANSI/IEEE C37.23 standard can be as much as 105°C.

Standard condenser bushings are designed to operate properly in the standard temperature conditions, which are specified in IEEE C57.19.00, Paragraph 4.1. These are summarized below.

### Usual Service Conditions

- Ambient air temperature is no greater than 40°C and no less than 30°C.
- The altitude is not greater than 1000 meters.
- The temperature of the transformer insulating oil in which the oil side of the bushing is immersed does not exceed 95°C averaged over a 24-hour period.
- The external terminal and bus connections, when operated alone at rated current, do not exceed a 30°C rise.
- The bushing is mounted at an angle of inclination to the vertical not exceeding 20°.

Under these defined “standard conditions” and with the bushing carrying rated current, the bushing’s hottest spot temperature rise is permitted to be 65°C.

A condenser bushing with the standard insulation system and standard gasket/sealing system will operate properly, at rated current, when: 1) the ambient air temperature does not exceed 40°C; 2) the temperature of the external line connection does not exceed 70°C and 3) the transformer top oil temperature averages 95°C over any 24 hour period. Proper operation means that the
hottest spot temperature rise of the bushing does not exceed 65°C at rated current.

Stated in another way, the standard operating conditions are:

- Maximum ambient temperature 40°C.
- Maximum bushing hottest spot temperature 105°C.
- Top oil temperature of 95°C based on 55°C rise and 40°C maximum ambient.
- External terminal/bus temperature of 70°C based on 30°C rise over 40°C maximum ambient

See Figure 1 for a graphic demonstrating these standard conditions.

**Thermal Conditions for Bushings Applied in Bus Duct**

In the bus duct environment, the thermal conditions on the airside of the bushing are very different than those defined as “normal or usual” as discussed above. The bushing’s top terminal/conductor is connected to the bus. If under rated current conditions, the bus temperature is 105°C (as permitted under ANSI/IEEE C37.23) and the transformer oil temperature remains at 95°C (averaged over a 24-hour period), the bushings hottest spot temperature will exceed the 65°C rise limit. This limit will be exceeded because the bushing’s ability to dissipate heat by conduction through its end connections is severely restricted due to the relatively high temperatures on the airside of the bushing.

For example, if at rated current, the airside terminal connection is at 105°C vs. 70°C in free air; part of this increase of 35 degrees will be added to the hottest spot temperature of the bushing. Assume that the hot spot temperature is increased by half of this 35 degrees or 17.5°C; the bushing hottest spot rise above ambient air temperature would now be 82.5°C or 122.5°C in a 40°C ambient.

In addition to this thermal stress which is placed on the bushing’s condenser insulation, similar stresses are placed on the bushing’s gasket seals. In a “standard” transformer application, the bushing gaskets are either sealing against an ambient air temperature no greater than 40°C or they are sealing against the transformer oil at 95°C with the oil inside of the bushing at some value dictated by the 65°C hottest spot rise in the bushing. In the bus duct situation, the gasket can see an ambient air temperature greater than the standard 40°C and an internal bushing temperature higher than that created under standard conditions (due to the higher than standard bushing hot spot temperature rise). Sealing materials that work properly under “standard” conditions can be compromised in the bus duct application. Another factor that must be considered is the amount of expansion space that is provided within the bushing to accommodate the oil volume increase due to temperature. What is sufficient expansion space for a bushing applied in free air may not be sufficient for a bushing applied in bus duct. Lack of sufficient expansion space will place additional mechanical stress on the bushing seals.

Regarding the mounting of the bushing: the thermal conditions are different depending on whether the bushing is mounted horizontally, vertically, or somewhere in between. ABB high current bushings are designed specifically for the mounting position specified, i.e., a vertical bushing can only be used vertically and a horizontal bushing can only be used in the horizontal position.

The table that follows compares standard thermal conditions to potential bus duct thermal conditions.
<table>
<thead>
<tr>
<th></th>
<th>IEEE/ANSI Standard C57.19.00 Standard Thermal Conditions for Condenser Bushings</th>
<th>Typical Bus Duct Thermal Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambient air temperature</td>
<td>40ºC, maximum</td>
<td>&gt;&gt; 40ºC</td>
</tr>
<tr>
<td>Transformer oil temp. rise</td>
<td>55ºC, maximum</td>
<td>55ºC</td>
</tr>
<tr>
<td>External bus/connector temp. rise</td>
<td>30ºC, maximum</td>
<td>&gt; 30ºC (65ºC per C37.23)</td>
</tr>
<tr>
<td>Bushing hottest spot temp. rise</td>
<td>65ºC, maximum</td>
<td>&gt;&gt; 65ºC</td>
</tr>
</tbody>
</table>

These conditions are shown in Figure 2.

![Figure 2](image)
**Recommendations**

Because of the considerations outlined in this document, ABB’s recommendation is to use the ABB High Temperature Type T bushing for all bus duct applications. These bushings have been specifically designed for application in a high temperature environment; in these bushings, Nomex insulation is used instead of cellulose paper for the condenser insulation and Viton rubber gaskets are used for all sealing. These special materials are rated for application at temperatures of 200ºC. The incorporation of these special high temperature materials into the High Temperature Type T bushing allow these bushings to operate properly in the bus duct environment without de-rating. These bushings are designed to operate at rated current in an enclosed bus duct where the enclosure air temperature can be as high as 90ºC and the temperature of the bus connected to the bushing is 105ºC with the transformer oil temperature at 95ºC averaged over any 24 hour period. ABB has created a standard series of high temperature bushing designs, which cover the current range of 4,500 amperes through 12,000 amperes at 25 kV and 7500 amperes at 34.5kV. In this standard series, bushings are available for vertical or horizontal mounting with a 28.5-inch creep distance and a 21-inch or 11-inch CT space. High temperature bushings are also available for currents greater than 12,000 amperes (ask your ABB representative for details).

Some customers have been applying standard condenser bushings in bus ducts. These bushings are either aging faster than is normal and/or they are being operated at loads well below the name plate rating and/or the bus duct has sufficient cooling means to keep the bus temperatures well below the 105º C limit. Because of the very special nature of high-current, bus duct applications, ABB advises caution when applying a standard bushing in bus duct.
Renewal Parts

If renewal parts are required, order them through the nearest ABB Power T&D Company Inc. representative. Please provide the item description and the identification numbers (model, style, and catalog) from the unit’s nameplate.

Technical Support

If a technical question arises regarding the product detailed in this Technical Data, please contact ABB.

DISCLAIMER OF WARRANTIES AND LIMITATION OF LIABILITY

THERE ARE NO UNDERSTANDINGS, AGREEMENTS, REPRESENTATIONS, OR WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OTHER THAN THOSE SPECIFICALLY SET OUT BY AN EXISTING CONTRACT BETWEEN THE PARTIES. ANY SUCH CONTRACT STATES THE ENTIRE OBLIGATION OF SELLER. THE CONTENTS OF THIS DOCUMENT SHALL NOT BECOME PART OF OR MODIFY ANY PRIOR OR EXISTING AGREEMENT, COMMITMENT, OR RELATIONSHIP.

The information, recommendations, description, and safety notations in this document are based on our experience and judgement. THIS INFORMATION SHOULD NOT BE CONSIDERED TO BE ALL-INCLUSIVE OR COVERING ALL CONTINGENCIES. If further information is required, ABB Power T&D Company Inc. should be consulted.

NO WARRANTIES, EXPRESSED, OR IMPLIED, INCLUDING WARRANTIES OF FITNESS FOR A PARTICULAR PURPOSE OR MERCHANTABILITY, OR WARRANTIES ARISING FROM COURSE OF DEALING OR USAGE OF TRADE, ARE MADE REGARDING THE INFORMATION, RECOMMENDATIONS, DESCRIPTIONS AND SAFETY NOTATIONS CONTAINED HEREIN.

In no event will ABB Power T&D Company Inc. be responsible to the user in contract, in tort (including negligence), strict liability or otherwise for any special, indirect, incidental or consequential damage or loss whatsoever including but not limited to damage to or loss or use of equipment, plant or power system, cost of capital, loss of profits or revenues, cost of replacement power, additional expenses in the use of existing power facilities, or claims against the user by its customers resulting from the use of the information, recommendations, description, and safety notations contained herein.