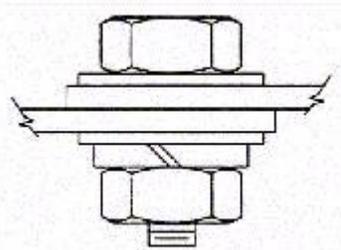


# Hardware for Bus Connections

July 5, 1994

What kind of hardware should be used for bus joints in metal-enclosed switchgear? While there may be several acceptable answers, for half a century or so the workhorse of the industry has been the Grade 5 carbon steel bolt, or, more properly, hex head cap screw. Each bolt is installed with two flat washers, a split-ring lock washer, and a hex nut. Zinc plated to retard corrosion and installed with the proper torque, this hardware has a long history of satisfactory performance with both copper and aluminum bus bars. The most common size used is 1/2-13, but 5/8-11 hardware is used for some very large joints and sizes down to 1/4-20 are used for smaller jobs, such as fastening terminals for small wire sizes.



**Figure 1 -Proper Bolt Assembly**

Proper assembly of the hardware is vital to a low-resistance joint. The hardware should be assembled as shown in Figure 1, with the flat washers next to the bus bars on both sides of the joint and the lock washer under the nut. The bolt should be long enough that a minimum of two full threads extend out of the nut when the bolt is tightened. For the 1/2-13 size, use a bolt one inch longer than the combined thickness of the bus bars being bolted together. Other bolt sizes may take longer or shorter bolts to compensate for differences in the thickness of the nuts and washers used. The bolt should not be longer than necessary, either, as extra bolt length usually decreases the clearance from the bolt end to the nearest other phase or to ground.

Proper bolt torque is vital to a good joint. Grade 5 hardware is used to allow high installation torque. Torques to be used for various size bolts are shown in the table. This information is given on a label installed in Powell switchgear near bolted field connections. Do not overtorque the bolts. Excessive torque can stretch the bolt past its elastic limit and cause failure. I've seen bolts which were barely half their original diameter in the middle removed from bus joints.

Bolt Size	5/8 - 11	1/2 - 13	3/8 - 16	1/4 - 20
Torque, pounds-feet	55-70	35-50	20-30	5-7

---

## Hardware for Bus Connections

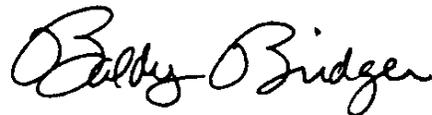
*page 2*

How about other types of hardware? Some users specify aluminum hardware for aluminum bus, bronze (usually Everdur) hardware for copper bus, or stainless steel for either bus material. There are two reasons usually given for this requirement. The first is the inhibition of corrosion cells where dissimilar metals made contact. This may be a valid reason for joints that are exposed to the weather, such as open buswork, or for installation in contaminated atmospheres. However, for the usual metal-enclosed switchgear, where all the bus joints are inside the enclosure and are expected to be warm and dry, the special hardware is usually not necessary.

The other reason for specifying hardware of a material similar to the bus bar is concern that differential expansion between the bus and the hardware may lead to loosening of the joint. For copper bus, which is used in almost all Powell switchgear, the difference between the expansion of the bus and the expansion of steel hardware is on the order of 0.0004 inch per inch of joint thickness, or 1 part in 2,500 over the entire 65°C allowable temperature rise. Offsetting any advantage of better-matched expansion characteristics, however, is the difficulty of finding high-strength hardware made of these alloys. Lower hardware strength may require reduced torque levels on the joints.

One other piece of hardware frequently requested is the spring washer, or Bellville washer. This washer is used to replace the split-ring lock washer, and is intended to compensate (within limits) for the differential expansion of the bus material and the hardware. In our experience, it may be of some value when aluminum bus is used with steel hardware, but is generally unnecessary when the bus is copper.

While Powell will be glad to furnish special bus joint hardware when our customers specify it, in our experience it is not needed for the usual installation of metal-enclosed switchgear or control equipment. There are many types of equipment, which have been in service for 50 years, or more using carbon steel bus joint hardware.



Baldwin Bridger, P.E.  
Technical Director