

(1/32 inch) from a true circle for 85 percent of the holes in a contiguous group, and not more than 1.6 mm (1/16 inch) for the remainder.

Punched holes shall be made with a die whose diameter does not exceed that of the punch by more than 1.6 mm (1/16 inch). Reaming and drilling shall be done with twist drills and, wherever possible, the reamer shall be directed by mechanical means. Holes for shop bolts shall be subpunched or subdrilled 5 mm (3/16 inch) less in diameter than the nominal diameter of the bolt, and shall be reamed to size with the parts assembled, except:

1. A709 grade 36 material thicker than 19 mm (3/4 inch) and grade 50 or 50W steel thicker than 16mm (5/8 inch) shall not be punched.
2. Materials assembled and adequately clamped together may be drilled full size.
3. Secondary and detail material of A709 Grade 36 steel not thicker than 19 mm (3/4 inch) and grade 50 or 50W steel not thicker than 16 mm (5/8 inch) fastened with high strength bolts may be punched full size.

Holes for field bolts shall be made in the same manner as holes for shop bolts except:

1. Field splices in and connections to main material shall be reamed or drilled assembled. See 863.26.
2. Assemblies such as floor beams to girders and rolled beam spans connected by diaphragms may be made through steel templates.

All holes punched full size, subpunched, or subdrilled shall be located with sufficient accuracy such that after assembling (before subpunched or subdrilled holes are reamed) a cylindrical pin 3 mm (1/8 inch) less in diameter than the nominal size of the punched hole may be entered perpendicular to the face of the member without drifting in not less than 75 percent of the contiguous holes in the same plane. All holes shall permit a pin 5 mm (3/16 inch) smaller than the nominal size of the punched holes to be inserted in the above manner. After holes are reamed or drilled full size, 85 percent of the holes in any contiguous groups shall have no offset greater than 0.8 mm (1/32 inch) between adjacent plies. The remainder of the holes shall not be offset more than 1.6 mm (1/16 inch) between adjacent plies. Plugging of improperly located holes is not permitted unless written approval has been obtained from The OSE. Steel templates shall have hardened bushings in holes accurately located in relation to the centerline of the connection as inscribed on the template. Where holes are made using a roto-broach, shell drill or other similar tool, hardened bushings need not be used in the template. The template shall be accurately positioned and bolted or clamped firmly in place prior to its use in reaming or drilling full size holes.

Templates used for reaming matching members or the opposite faces of a single member shall be exact duplicates. Templates used for connections on like parts or members shall be located with sufficient accuracy that the parts or members are duplicates and require no individual match marking.

Holes through multiple plies shall be reamed or drilled full size only when the plies of the joint are held tightly together with bolts or clamps. The joint shall also be pinned if the holes have been subpunched or subdrilled. The plies shall be disassembled and cleaned of burrs and shavings prior to final assembly. Other methods of preparing holes for high strength bolts may be given consideration upon written request to the OSE. The QCFS shall document that holes have been performed per specification.

**863.21 High-Strength Steel Bolts, Nuts and Washers.** High strength steel bolts, nuts and washers shall meet the provisions of 711.09.

1. General. The Engineer shall be furnished the necessary access to the work in order to observe the installation, tightening and checking of the bolts.

Based on the experience gained by the Engineer and Contractor during the use of the below described installation and inspection procedures for a particular bridge, the Engineer may elect to modify the amount of testing specified in order to expedite the work while still accomplishing properly compacted joints and tightened bolts. Consideration will be given to the use of other fastening systems or assemblies and bolt tightening procedures, if a written request is submitted to the Office of Structural Engineering in accordance with 108.05. The required bolt length shall be determined by adding to the grip the value shown in Table 1. The table values are generalized, with an allowance for manufacturing tolerances, to provide for the nut and positive "stick-through" at the end of the bolt. For each hardened flat washer that is used, add 4 mm (5/32 inch); and for each beveled washer, add 8 mm (5/16 inch). The length determined by the use of Table 1 should be adjusted to the next longer 6 mm (1/4 inch); when installed, the end of the bolt shall be flush with or project several thread lengths outside the face of the nut.

**TABLE 1**

Bolt Size	To determine required bolt length, add to grip*
mm	mm
M16	24
M20	28
M22	31
M24	35
M27	38
M30	41
M36	47