Destructive Testing of Stud Welds

BY LYNDSEY DECKARD

Most inspectors, and it is hoped, all CWIs are familiar with the mechanical destructive testing requirements for qualification of structural steel welds and welders. I have had occasion to qualify stud welds and welders for a three-mile, two-lane elevated steel guideway for an airport automated people mover. All propulsion power and control circuitry was suspended on outriggers along both sides of each lane. These outriggers and all of the weight supported by them were hung on the vertical wall of the guideway with a series of ½-in. weld studs.

The information for qualification of the stud applications by visual and mechanical testing is found in AWS C5.4-93, *Recommended Practices for Stud Welding*, used in conjunction with the applicable code, which in the case of the job just described was D1.5, *Bridge Welding Code*. Specific guidance for steel stud application qualification requirements can be found in C5.4 Sections 9.1 through 9.1.3. The sections of the document follows.

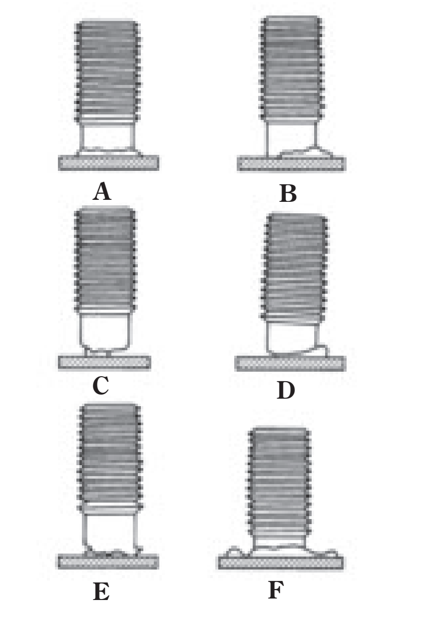

Fig. 1 — Satisfactory and unsatisfactory arc stud welds. A — Satisfactory stud weld with a good flash formation; B — stud weld in which plunge is too short; C — hang-up; D — poor alignment; E — stud weld with insufficient heat; F — stud weld with excessive heat.

"**9.1 Steel Studs**. Welded studs may be inspected visually for weld appearance and consistency, and also mechanically. Production studs can be proof tested by applying a specified load (force) on them. If they do not fail, the studs are considered acceptable. Production studs should not be bent or twisted for proof testing.

"**9.1.1 Visual Inspection**. The weld flash around the stud base is inspected for consistency and uniformity. Lack of a flash may indicate a faulty weld. Figure 1A shows satisfactory stud welds with a good weld flash formation. In contrast, Fig. 1B shows a stud weld in which the plunge was too short. Prior to welding, the stud should always project the proper length beyond the bottom of the ferrule. (This type of defect may also be caused by arc blow.) Figure 1C illustrates "hang-up." The stud did not plunge into the weld pool. This condition may be corrected by realigning the accessories to ensure completely free movement of the stud during lift and plunge. Arc length may also require adjustment.

"Figure 1D shows poor alignment, which may be corrected by positioning the stud gun perpendicular to the work. Figure 1E shows the results of low weld power. To correct this problem, the ground and all connections should be checked. Also, the current setting or the time setting, or both, should be increased. It may also be necessary to adjust the arc length. The effect of too much weld power is shown in Fig. 1F. Decreasing the current setting or the welding time, or both, will lower the weld power.

"**9.1.2 Mechanical Testing**. Mechanical tests should be made before initiation of production welding and after any equipment maintenance to ensure that the welding schedule is satisfactory. They may also be made during the production run or at the beginning of a shift to ensure that welding conditions have not changed. Arc stud welds are tested by bending the stud or by applying a proof tensile load.

"Bending may be done by striking the stud with a hammer or by bending it using a length of tube or pipe, as shown in Fig. 2. The angle through which the stud will bend without weld failure will depend on the stud and base metal compositions, conditions (cold worked, heat treated), and stud design. Acceptable bending should be determined when the welding procedure specification is established or from the applicable welding code. Bend testing may damage the stud; therefore, it should be done on qualification samples only.

"The method used to apply tensile load on an arc welded stud will depend on the stud design. Special tooling may be required to grip the stud properly without damage, and a special loading device may be needed. A simple method that can be used for straight threaded studs is shown in Fig. 3. A steel sleeve of appropriate size is placed over the stud. A nut of the same material as the stud is tightened against a washer bearing on the sleeve with a torque wrench. This applies a tensile load (and some shear) on the stud.

"The relationship between nut torque, T, and tensile load, F, can be estimated using the following equation:

$$T = kFd$$

where d = the nominal thread diameter and k = a constant related to such factors as thread angle, helix angle, thread diameters, and coefficients of friction

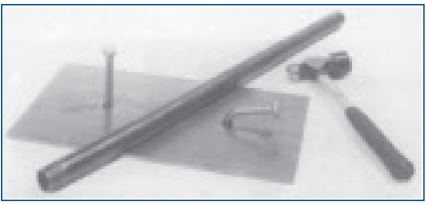

Fig. 2 — Bend test for welded studs to determine acceptable welding procedures.

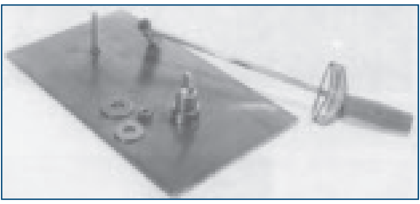

Fig. 3 — Method of applying a tensile load to a welded stud using torque. A bolt can be used for an internal thread.

between the nut and thread, and the nut and washer.

"For mild steel, *k* is approximately 0.2 for all thread sizes and for both coarse and fine threads. However, the many factors that influence friction will influence the value of *k*. Several factors are the stud, nut, and washer materials and surface finishes, and also their lubrication. For other materials, *k* may have some other value because of the differences in friction between the parts.

"The torque-tension formula is useful in determining a target torque. However, the only sure way to establish the 'correct' torque is through experimentation using the actual fasteners in the actual joint, or one that closely simulates it.

"9.1.3 Replacement of Defective Studs. Defective studs should be removed and the surface repaired sufficiently to permit welding a new stud at that location or suitably nearby. Governing specifications usually require repair welds to meet all requirements of the qualified welding procedure." ❖

*Lyndsey Deckard (*Deckard@pbworld.com*) is Quality Manager of the Vehicle Division of Parsons Brinckerhoff Transit & Rail Systems Inc. He is an AWS Senior Certified Welding Inspector, an ASQ Certified Quality Auditor, and a member of the AWS Certification Committee, the Examination Question Bank Subcommittee, and the Ethics Subcommittee.*