Agenda Item: 653-2044

Title: **Friction Stud Welding for Bolted-On Retrofits and Repairs**

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Purpose: Include “friction stud welding” in API 653 to allow tank retrofits and repairs to be made using friction stud welding.

Source: Adoption of friction stud welding in accordance with ASME Section IX.

Revision: 2~~1~~

Impact: Cost savings through fewer unplanned tank outages, through a reduction in hydrocarbon emissions and heat-induced damage, and through improved safety.

Background: Friction stud welding can be used to ~~permanently~~ retrofit and repair in-service tanks where conventional welding would be unachievable due to the risk of igniting flammable vapors. Friction stud welding reduces and in many cases eliminates the chance of ignition by substantially lowering temperatures for shorter durations over smaller surface areas.

Proposal: Include “friction stud welding” as an additional welding method allowed by API 653. This requires the addition of Section 11.5 in API 653 as shown below.

Rationale: Utilizing a controlled energy process, friction stud welding provides a new option for retrofits and repairs to in-service tanks and can provide additional safety, environmental, and cost benefits. The lower temperatures of friction stud welding helps to avoid damage to protective coatings, and minimizes the need for pre and post weld heat-treating. With friction welding, the human hazard of burns to skin and eyes and breathing toxic vapors, both associated with fusion welding, can be eliminated.

New requirements for friction stud welding in API 653 will ensure that bolted-on retrofits and repairs are installed in accordance with accepted engineering practices. ASME Section IX defines friction welding as shown below.

ASME Section IX, QG-109.2 “Definitions”

Welding, friction, inertia and continuous drive: processes and types of friction welding (solid state welding process) wherein coalescence is produced after heating is obtained from mechanically induced sliding motion between rubbing surfaces held together under pressure. Inertia welding utilizes all of the kinetic energy stored in a revolving flywheel spindle system. Continuous drive friction welding utilizes the energy provided by a continuous drive source such as an electric or hydraulic motor.

The repair organization shall develop, qualify and certify a WPS in accordance with ASME Section IX for their “friction stud welding” process.

Proposed Changes to API 653 Section 11, Section 12 and Annex F

Add the following sections:

11.5 Friction Stud Welding

Rotary friction welding may be used to install ~~permanent threaded~~ studs on in-service and out-of-service tanks including, but not limited to tank shells, roofs and floating roofs by agreement between the Repair Organization and the Tank Owner/Operator.

Welding procedure specifications (WPSs) and welding operators shall be qualified in accordance with Section IX of the ASME Code and both shall be certified. A WPS shall be created by the Repair Organization for each material P-No. in ASME Section IX. If the stud material is different than the base material, then a WPS shall be created for each material P-No. combination. Impact testing is not required for procedure qualification record (PQR) testing.

The work shall be performed in accordance with the requirements of API 650 Section 9 and the following requirements:

a. The design of retrofits and repairs attached with friction welded studs shall be approved by a Storage Tank Engineer. The design shall consider all anticipated loading conditions and combinations, potential settlement movements, high strains and rotations at structural discontinuities such as the shell-to-bottom joint and shell penetrations, inability of bolted joints to share load with welds due to lesser stiffness, gasket sealing forces, material compatibility, internal and external coatings and life span requirements.

b. Installations on in-service tanks shall address risks related to the safety of workers and ignition of flammable tank contents specifically addressed in Section 1.4 of this standard. The Repair Organization shall demonstrate ignition safety by testing and submitting a written report to the Tank Owner/Operator. The Tank Owner/Operator and Repair Organization shall agree on the safety criteria and protocols to be used to demonstrate that the potential ignition safety issues have been addressed, providing that the side of the tank opposite to the friction stud welding does not create an ignition source.

~~b.~~ NOTE: See “Forge Bonding: A Safer Metal Joining Process”, D. Rybicki, M. Rybicki, Proceedings of the AIChE 2016 Spring Meeting and Global Congress on Process Safety, April, 2016

c. Areas to be friction welded shall be ultrasonically examined for remaining substrate thickness. A stud shall not be friction welded to a tank with less than 0.15” of remaining metal thickness without special consideration for ignition safety, stud strength and quality of the remaining metal.

d. Preheating and PWHT are not required by this standard.

Section 12—Examination and Testing

12.1 NDE

12.1.11 Friction Stud Welds

Friction welded studs shall be visually examined and torque tested in accordance with ASME Section IX torque test requirements. The stress applied to the stud during the torque test shall not yield the stud material. The NDE of the friction welded studs shall apply for all tank and stud P-No. materials.

Add to existing Table F.1;

Annex F
(normative)

NDE Requirements Summary

Table F.1—NDE Requirements Summary

Process	Welds Requiring Inspecting	Reference Section
VE	Friction stud welds.	API 653, 12.1.11
TT	Friction stud welds.	API 653, 12.1.11

Add to Table F.1 Definitions

TT = Torque Test