



Furnace and Induction Brazing Requirements and Evaluation

1 Introduction

Note: Nothing in this standard supercedes applicable laws and regulations.

Note: In the event of conflict between the English and domestic language, the English language shall take precedence.

1.1 Purpose. This standard describes the general requirements for the quality and equipment of furnace or induction brazed connections of material types: steel, stainless steel, nickel, nickel alloy, copper, copper alloy, and heat or corrosion resistant materials. This standard contains general requirements for the brazing procedure, unless otherwise described in detail on the engineering drawings.

1.2 Applicability. This standard can be used for furnace or induction brazed connections. Vacuum furnace brazing and aluminum brazing are not included in this specification.

1.3 Remarks. Brazed connections in this specification are classified similarly to the classifications within American Welding Society (AWS) brazing specifications. The classification is based on design requirements and consequences of failure. This classification controls the type of inspection method and acceptable limits.

1.4 Process Descriptions

1.4.1 Furnace Brazing. Furnace Brazing is a process in which assembled components, with brazing filler metal and flux material preplaced, are loaded into a furnace and uniformly heated to a certain temperature (generally above the liquidus of the brazing filler metal, but lower than the melting point of the base metals). The components are protected by an inert or reducing gas atmosphere within the brazing furnace. The heating and cooling rates are controlled to prevent distortion and other undesirable metallurgical reactions such as sensitization and embrittlement.

1.4.2 Induction Brazing. Induction brazing is a process in which two or more materials are joined together by a filler metal that has a lower melting point than the base materials using induction heating. In induction heating, usually ferrous materials are heated rapidly from the electromagnetic field that is created by the alternating current from an induction coil. Induction heating can be targeted to provide heat to small areas within tight production tolerances. Only those areas of the part near the joint are heated; the rest of the part is not affected. The heating and cooling rates are controlled to prevent distortion and other undesirable metallurgical reactions such as sensitization and embrittlement.

1.5 Joint Type.

Type A: Type A is typically chosen for connections subject to high stresses, cyclic stresses, or both, the failure of which could result in significant risk to persons or property, or significant operational failure.

Type B: Type B is typically chosen for connections subjected to low or moderate stresses, cyclic stresses, or both, the failure of which could result in significant risk to persons or property, or significant operational failure.

Type C: Type C is typically chosen for connections subject to low or moderate stress, cyclic stresses, or both, the failure of which would have no risk to persons or property.

No Type Defined: When no type is specified, Type B shall apply.

Note: Fluid carrying connections shall be classified as Type A or Type B.

2 References

Note: Only the latest approved standards are applicable unless otherwise specified.

2.1 External Standards/Specifications.

ASTM E1742/E1742M	AWS C3.5M/C3.5	AWS A5.8M/A5.8
AWS C3.6M/C3	AWS C3.8M/C3.8	

2.2 GM Standards/Specifications.

GMW3059

2.3 Additional References.

- Engineering Drawings
- Supplier DFMEA
- Supplier PFMEA
- Supplier Process Control Plan

3 Requirements

3.1 General Acceptance Criteria. Not applicable.

3.2 Visual Acceptance Criteria. Not applicable.

3.3 Measurable Acceptance Criteria. Not applicable.

3.4 Disposition/Repair Procedure. Not applicable.

3.5 Equipment.

3.5.1 Furnace Brazing.

Furnace brazing equipment per AWS C3.6M/C3.6 section 5.2.

3.5.2 Induction Brazing.

Induction brazing equipment per AWS C3.5M/C3.5 section 5.2.

3.6 Materials.

Brazing materials and braze coverage locations shall be defined on the engineering drawing. If a solid insert or braze foil is used, the location and composition shall be defined on the engineering drawing.

Brazing filler metals or brazing paste shall meet the requirements of AWS A5.8M/A5.8, Specification for Filler Metals for Brazing and Braze Welding and designation of the filler material shall be called out on the engineering drawing. If the composition of the filler or paste is not within AWS A5.8M/5.8, the composition of the major alloying elements shall be defined by the supplier and be called out on engineering drawing.

Care shall be exercised to ensure the brazing material is metallurgically compatible with the base metal and brazing process as well as fit for the component's specific service application. All brazing materials must comply to GMW3059.

Brazing flux usage is acceptable when required for the brazing process. Flux residue shall be removed to avoid corrosion caused by remaining active chemicals.

3.7 Process Requirements.

This section applies to furnace brazing and induction brazing.

3.7.1 Surface Preparation.

The faying surfaces and adjacent areas of components to be brazed shall be free of oil, grease, dirt, oxides, paint, scale, or other foreign substances that can interfere with the brazing process or contaminate the braze joint. Burrs shall be removed as required prior to final cleaning to permit proper assembly and brazing filler metal flow.

3.7.2 Joint Clearance.

3.7.2.1 Joint Clearance Furnace Brazing.

The supplier is responsible for establishing proper joint clearance. The assembly of the components, tolerance of each component, thermal effects and the amount of braze paste/filler shall be considered when designing joint clearance. Joint clearance between surfaces to be furnace brazed shall be controlled by the assembly

procedures so that proper joint clearance at the brazing temperature is provided. When one of the surfaces is cross-hatched or straight-line knurled in the direction of brazing filler metal flow into the joint, a line to line fit is permitted. Interference fit joint loading shall be monitored during assembly.

3.7.2.2 Joint Clearance Induction Brazing.

The supplier is responsible for establishing proper joint clearance. The assembly of the components, tolerance of each component, and thermal effects shall be considered when designing joint clearance. In areas where there is no contact, the joint does not heat up until the braze wafer melts into the joint, and a thermal shock can occur, potentially causing issues such as liquid metal embrittlement. Interference fit joint loading shall be monitored during assembly.

3.7.3 Tack Welding.

Tack welding should be avoided; however, when tack welding is required to maintain proper positioning of components, the tack weld size, location, and welding filler metal shall be approved by General Motors Engineering and specified on the engineering drawing. Tack welds shall be applied with adequate inert gas shielding to assure the oxide contamination of the braze joint surface does not occur. Tack welds cannot be applied in areas of high stress per Finite Element Analysis (FEA).

3.7.4 Rebrazing.

Rebrazing procedures shall be agreed upon between the supplier and General Motors engineering during the Advanced Product Quality Planning (APQP) process and documented in the supplier process control plan. For rebrazing, the original brazing process or brazing filler metal shall be used. The number of times a joint can be rebrazed shall be agreed upon between the supplier and General Motors Engineering and is limited to no more than two rebrazements. Disassembly and reassembly of the joint components is not acceptable. Additional specified brazing filler metal may be used for rebrazing. When the original brazing metal filler application side is closed, additional brazing filler metal may be added, if needed, to the opposite side of the joint. Traceability for rebrazing shall be agreed upon between the supplier and General Motors Engineering.

3.7.5 Postbrazing Operations.

Assemblies shall be cooled after brazing in such a manner that cracking of the brazing filler metal or base metal does not occur and residual stresses are minimized. Post-braze heat treatments, or combined brazing and heat treating cycles, if required, shall be performed per the engineering drawing. If required, flux of stopoff residues shall be removed by suitable means. Post-braze cleaning or passivation treatments that will dissolve brazing filler metal or result in any adverse effects to the filler or base metal (e.g., nitric acid passivation of silver or copper brazed assemblies) shall not be used.

3.8 Quality.

It is the responsibility of the supplier to ensure all products meet the requirements of this specification and the engineering drawing. The supplier shall have a system of quality control and documentation that assures and can attest that all required operations and procedures have been performed.

Furnace and induction brazed joints may be inspected at the assembly or subassembly level, provided the entire joint is accessible for inspection.

Brazements requiring post-braze heat treatment shall be inspected after the heat treatment has been completed, unless otherwise agreed upon between the supplier and General Motors Engineering and specified within the supplier process control plan.

When brazed joints are inspected in process prior to the machining of joint edges, reinspection shall be required after machining to assure that the brazed joint has not been damaged in the machining operations.

Inspection shall be performed after post-braze cleaning.

3.8.1 Required Inspection of Brazed Joints

Required inspection of the brazed joints shall be defined by the supplier Design Failure Mode and Effect Analysis (DFMEA) and process control plan. Types of testing are defined as follows.

3.8.1.1 Destructive Testing.

The destructive testing of assemblies or samples shall be performed as required for process qualification or corrective action. The preferred method for destructive testing is a peel test to look for presence and adherence of filler material. To perform a peel test of a brazed pipe, section into quadrants, pull apart the joint and examine the cross-section over the 360 degrees to ensure the minimum fill quantity as defined in 3.8.2.2.1 is met.