



Electron Beam Weld Specification for Turbo Wheel-to-Shaft

1 Scope

1.1 Material Description. This specification covers the acceptance criteria for electron beam (EB) welds for nickel based super alloy turbo wheels to steel shafts used in turbo charger assemblies without the use of weld filler. The application of the requirements of this specification is mandatory unless a specific note on the weld/engineering drawing establishes different weld criteria. Any exceptions from these requirements shall be approved by GM Global Propulsion Systems Materials Engineering.

1.1.1 Welds are considered satisfactory when they carry the intended or expected service loads for a required period and meet the requirements of this specification. Any attempted application of this document to other uses, such as turbine-wheel, post-crash weld quality assessment, may lead to an erroneous result or conclusion.

1.1.2 Welds are considered discrepant when they do not meet the criteria of this specification. Discrepant welds shall not be re-welded, they must be scrapped.

1.1.3 The welding source is responsible for establishing practices and test methods to assure that the criteria of this specification are met. Some of the requirements in this specification are referenced from ISO 13919-1.

1.2 Symbols. Not applicable.

1.3 Applicability. This specification applies to electron beam welds only in the instance that they are pertaining to nickel based super alloy turbo wheels and steel shafts in the turbo charger assembly. See Figure 1.

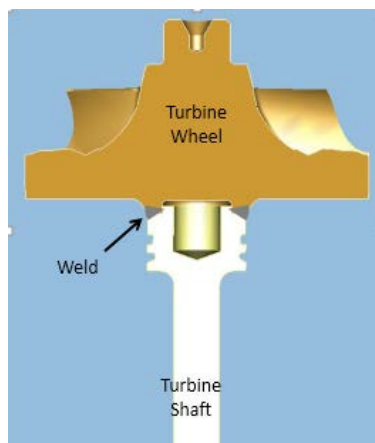


Figure 1: Turbo Wheel-Shaft Assembly

2 References

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

2.1 External Standards/Specifications.

ASTM E384

ISO 13919-1

2.2 GM Standards/Specifications.

GMW3059

3 Requirements

3.1 Requirements on Test Specimens. Requirements shall be verified on production intent wheel-shafts that are made from production intent processes. Samples shall be carefully cut and polished with at least a 3 micron polishing media, and if needed, they may be lightly etched with a 2% to 3% nital etchant. The weld start-stop location as well as a location 180 degrees away from the start-stop shall be examined. In cases where there is more than one weld start-stop, each start-stop location must be examined separately to qualify each weld beam as well as another point along the weld that is furthest away from any of the start-stop locations. Any locations that are tack welded prior to EB welding must also be examined to ensure they pass the weld requirements.

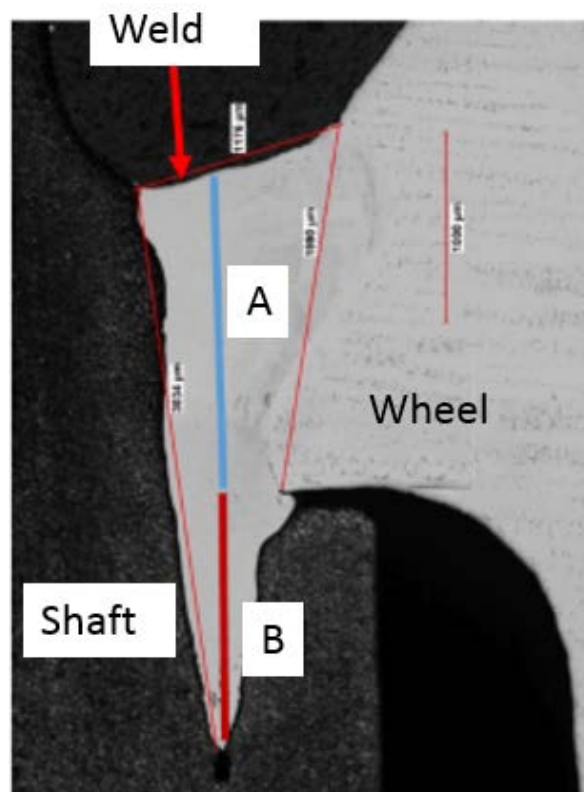
3.2 Sampling Size and Frequency. The number of samples examined for part qualification shall be based on the supplier's control plan and approved by GM Global Propulsion Systems Engineering. Once validated, the supplier shall sample a minimum of one weld once per shift per EB welder. The weld needs to be revalidated whenever changes to the weld process or materials are made including but not limited to changes with: base metal composition, base metal thickness, base metal preparation such as cleaning, weld flux, weld atmosphere conditions, weld temperature, weld time, joint design, joint clearance, weld position, and post weld heat treatment.

3.3 Weld Depth. The total weld depth is the maximum distance where fusion extends into the base metal from the surface melted during welding defined as Line A + Line B. See Figure 2.

3.3.1 Effective Weld Depth. The effective weld depth is defined as the distance from the weld surface to a depth equivalent to where the wheel edge butts against the shaft. This is the minimum weld depth required, Line "A" in Figure 2.

3.3.2 Extraneous Weld. This is the depth of the weld past the point where the wheel edge butts against the shaft, Line "B" in Figure 2. This portion of the weld depth does not contribute to the strength of the weld; however, it is necessary to accommodate any weld depth variation such that there is always 100% effective weld depth.

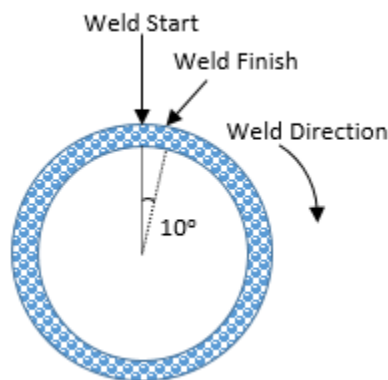
3.3.3 Fusion. Line A = Full fusion of wheel thickness. Line B = 0.7 mm maximum.



Note: The length of Lines A + B = Total Weld Depth. Line length A = Effective Weld Depth.

Figure 2: Effective and Total Weld Depth

3.4 Continuity. The full circular seam weld shall be made in a continuous single pass when using one electron beam to weld. If more than one electron beam or more than one pass is used to weld, it must be reported to GM Global Propulsion Systems Engineering. The weld shall have 10 degree minimum overlap at any weld start/finish location. No unfused areas, skips, pinholes, shrinkage cavities shall be present in the weld nor on either side of the weld seam when the surface is examined without any sample preparation at 10x magnification. The weld solidification pattern shall be consistent and be free of restarts or sudden changes for each electron beam. See Figure 3.



Note: Welds shall be 370 degrees minimum around the circumference of the wheel-shaft joint to allow for a 10 degree minimum overlap past the weld start location.

Figure 3: Clockwise Weld

3.5 Internal Porosity – Single Pore. Maximum dimension of a single pore “l” or “h” shall be less $\leq 0.3A$, See Figure 4 and Figure 5. Where l_1 and l_2 are dimensions in the cut plane and h is the height of the pore. A = Effective Weld Depth.

3.6 Internal Porosity – Combined Pore. The distances between the individual pores, ΔL , in clustered or linear porosity shall be measured. Any two pores closer than 50% of the effective weld depth ($0.5A$) shall be considered as a combined pore. A combined pore is permitted, provided the affected weld length L_c is less than the effected electron weld depth (A) multiplied by the weld width (W): $L_c \leq (A \cdot W)$. See Figure 5 and Figure 6.

3.7 Pore projection area is defined as $f = l_1 \times l_2$ where projection is in a direction parallel to the surface and perpendicular to the weld axis, see Figure 5. The summation of the projected areas of the pores (f) shall be less than or equal to 0.7% of the total weld area which is an area of effective weld depth, A , multiplied by weld length pore to pore, L_c . Described mathematically as: $(f) \sum_{i=1}^n f_i \leq [0.007(A)(L_c)]$ where n = the total number of pores.

3.8 Surface Porosity. If weld seam surface porosity is present when viewed under 10x magnification, maximum dimension of individual surface pore is 0.4 mm or less. Total surface pores shall be four or less. Spacing between pores or clustered porosity shall be 3 mm minimum.

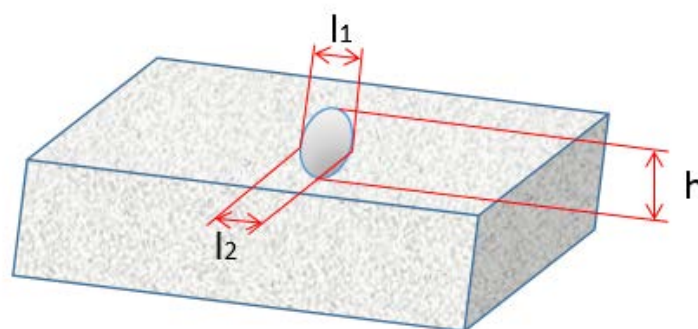


Figure 4: Void Dimensions

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