

REFERENCE 2.7 – QUALIFICATION AND PROCEDURAL REQUIREMENTS FOR LASER CLAD WELDING AND THERMAL SPRAY APPLICATION IN SUPPORT OF 3810E47601-A05

1.0 The purpose of this document is provide qualification and procedural guidance for the accomplishment of 3810E47601-A05. If vendor's process has not been previously approved by SRF-JRMC Detachment Sasebo, the requirements of this document must be met before accomplishing the repair work identified in Statement of Work 3810E47601-A05 Accomplish Repair of Magnetic Minesweeping Gas Turbine Generator (MMGTG) Flywheel Shaft Bearing Journal.

1.1 Perform and validate Japanese commercial laser clad process with NAVSEA standards using test specimens.

1.2 Fabrication of sample shafts: Fabricate sample shaft to simulate end use condition.

1.3 Laser clad fabricated sample shaft: Perform laser clad on fabricated sample shaft.

1.4 Inspections of laser clad sample shaft: Perform final machining, NDT, destructive testing and inspections on sample shaft.

1.5 Thermal spray of fabricated sample shaft: Perform thermal spray using Inconel 625 alloy wire on fabricated sample shaft.

1.6 Inspections of thermal spray sample shaft: Perform final machining, NDT, destructive testing and inspections on sample shaft.

2.0 REFERENCES

2.1 S9074-AQ-GIB-010/248, REQUIREMENTS FOR WELDING AND BRAZING PROCEDURE AND PERFORMANCE QUALIFICATION

2.2 S9074-AR-GIB-010/278, REQUIREMENTS FOR FABRICATION WELDING AND INSPECTION, AND CASTING INSPECTION AND REPAIR FOR MACHINERY, PIPING, AND PRESSURE VESSELS

2.3 MIL-STD-2035, NONDESTRUCTIVE TESTING ACCEPTANCE CRITERIA

2.4 Sample Performance Qualification Record Figure 7-18 of reference (2.1)

2.5 Sample Shaft Fabrication Drawing

2.6 Sample Shaft Final Machining Drawing

2.7 T9074-AA-GIB-010/1687, THERMAL SPRAY PROCESSES FOR NAVAL SHIP MACHINERY APPLICATIONS AND NONSKID APPLICATIONS, DTD 12 JUNE 2017

2.8 ASTM C633, STANDARD TEST METHOD FOR ADHESION OR COHESION STRENGTH OF THERMAL SPRAY COATINGS; DTD 2017DWG

2.9 Wire Arc Spray Process and Parameter Record Figure 3-2 of 2.7.

3.0 REQUIREMENTS

LASER CLAD REPAIR PROCESS

NOTE: Performing activity need not comply with personnel qualification requirements of references 2.1, 2.2, 2.3 and 2.7; however, all personnel involved with welding and inspection shall be qualified to accomplish the work in accordance with local standards. Copies of qualification paper work and local standard used shall be furnished to SRF for review. Acceptance criteria for inspections of references 2.1, 2.2, 2.3 and 2.7 shall be met.

3.1 Accomplish welding performance qualification in accordance with paragraph 5-3.4. of 2.1.

3.1.1 Fabricate test specimen in accordance with Figure 7-17A of 2.1. Material must be CRES (Nitronic 50). Diameter shall be 126.5000 mm – 127.000 mmm (4.980”-5.000”) in accordance with 2.5. Solid shaft or thickness of D/2 (where D is diameter) is acceptable for test specimen fabrication.

(V)(G) "LASER CLAD WELDING"

3.1.2 Accomplish laser clad welding on test specimen using Stellite 21 material in accordance with figure 7-17A of 2.1

(I)(G) "NONDESTRUCTIVE TESTING"

3.1.3 Accomplish nondestructive testing. Perform visual and dye penetrant testing in accordance with paragraph 5-3.4.a and table 7-11 of 2.1 and paragraph 5-4 of reference 2.1.

3.1.3.1 Acceptance criteria shall be in accordance with 2.3 Class I.

3.1.4 Accomplish hardness testing in in accordance with note 7.(a).(c) of figure 7-17A of 2.1.

3.1.4.1 Hardness Criteria is 20 HRC minimum.

(I)(G) "DESTRUCTIVE TESTING"

3.1.5 Accomplish macro-etch examination in accordance with paragraph 5-3.4.a, table 7-11 and paragraph 5-4 of 2.1.

3.1.5.1 Acceptance criteria shall be in accordance with paragraph 4-5.2.6.a of reference 2.1.

REPORT: WELDING PERFORMANCE QUALIFICATION REPORT AND SAMPLES

3.1.6 Submit one legible copy in English, in hard copy or approved transferrable media, of Object Quality Evidence (OQE), reports, procedures, a completed copy of 2.4, and all test samples generated as a result of 3.1 to the GOVERNMENT.

**** STOP WORK See Note 5.1.3. ****

3.2 Fabricate samples shaft in accordance with 2.5.

3.2.1 Material shall be Nitronic 50.

3.2.2 Sample shaft blanks shall measure 150 mm by 400 mm.

(V) "FABRICATION DIMENSION VERIFICATION"

3.2.3 Measure and record the fabricated dimensions of the test specimen. Provide measurement record to the Technical POC for review.

(V)(G) "LASER CLAD WELDING"

3.2.4 Accomplish Laser Clad welding on fabricated sample shaft in areas identified in 2.5 in accordance with the performing activities procedure qualified in 3.1.

- 3.2.5 Final machine sample shaft to final diameter of 129.999mm – 130.007mm (5.1181”-5.1184”) in accordance with 2.6.

(V)(G) "FINAL FABRICATION DIMENSION VERIFICATION"

- 3.2.5.1 Measure and record the final fabricated dimensions of the test specimen.

(I)(G) "NONDESTRUCTIVE TESTING"

- 3.3 Perform visual inspection of laser clad welds in accordance with paragraph 10.3.6. of reference 2.2.

- 3.3.1 Acceptance criteria is class 2 from 2.3 in accordance with Table XI of 2.2.

- 3.4 Perform dye penetrant (PT) in accordance with paragraph 10.3.6. of 2.2.

- 3.4.1 Acceptance criteria is class 2 from 2.3 in accordance with Table XI of 2.2.

- 3.4.2 Accomplish hardness testing in accordance with note 7.(a).(c) of figure 7-17A of 2.1.

- 3.4.2.1 Hardness Criteria is 20 HRC minimum.

(I)(V) "DESTRUCTIVE TESTING"

- 3.5 Accomplish destructive testing.

- 3.5.1 Cut sample shaft in two (2) locations in the area of laser clad repair for inspection of the cross section.

- 3.5.1.1 Cut locations shall be well within laser clad area and away from adjacent edges and surfaces.

- 3.5.2 Accomplish macro-etch examination in accordance with paragraph 5-3.4.a and table 7-11 and paragraph 5-4 of 2.1.

- 3.5.2.1 Acceptance criterial shall be in accordance with paragraph 4-5.2.6.a of reference 2.1.

(I)(V) "MICROSCOPIC EXAMINATION"

- 3.6 Accomplish microscopic examination using 2.1 for guidance based on specific specimen size, material and welding process. This microscopic examination will be performed on the sample shaft.

REPORT: SAMPLE SHAFT FABRICATION AND TESTING REPORTS AND SAMPLES

- 3.7 Submit one legible copy in English, in hard copy or approved transferrable media, of Object Quality Evidence (OQE), reports, procedures, a completed copy of 2.4, and all test samples to the GOVERNMENT.

THERMAL SPRAY REPAIR PROCESS

REPORT: SPRAYING PROCEDURES

- 3.8 Submit one legible copy in English, in hard copy or approved transferrable media, of written spraying procedures including the elements of and using 2.9 for guidance.

- 3.9 Furnish Two (2) test specimens for visual examination and bend testing.

- 3.9.1 Test specimens shall be CRES (Nitronic 50) material and approximately 3 by 2 inches by 0.050 inch (min) to 0.063 inch (max).

- 3.9.2 The spray material shall be Inconel 625 alloy wire corresponding to spray material code P7 in accordance with table 4-2 of reference 2.7.

- 3.9.3 Accomplish the spray application of material in accordance with the procedure provided in 3.8.
- 3.9.4 The coating thickness shall be 0.008 ± 0.002 inch, or the maximum thickness recommended by the coating manufacturer, whichever is smaller.
- 3.9.5 Two-coat samples shall have 0.002 to 0.003 inch bond coat and at least 0.005 inch top coat.

(V)(G) "IN PROCESS MONITORING"

- 3.9.6 Accomplish in process monitoring.
 - 3.9.6.1 Prior to spraying each component to verify surface preparation of the anchor-tooth surface utilizing profile tape profile tape. Each sample shall be free of moisture, oil grit, contaminations, blisters, cracks, chips, pits, or coating separation.
 - 3.9.6.2 Document completion of required essential elements from the procedure of 3.8.
 - 3.9.6.3 The end item inspection of sprayed coatings shall include a visual examination. The finished coating, when examined with a X 10 magnification, shall be free of defects such as cracks, blisters, chips or loosely-adhering particles, oil or other contaminants which bleed out through the coating, pits exposing the undercoat or substrate, and coating separation.
 - 3.9.6.4 Verify final dimensions meet requirements.

(V)(G) "VISUAL INSPECTION"

- 3.9.7 Accomplish a visual inspection of each of the as-sprayed test specimens at X 20 to X 50 magnification.
 - 3.9.7.1 Acceptance criteria the as sprayed coating shall have a uniform appearance and shall be free of the following:
 - 3.9.7.1.1 Blisters
 - 3.9.7.1.2 Cracks
 - 3.9.7.1.3 Chips
 - 3.9.7.1.4 Loosely adhering particles
 - 3.9.7.1.5 Evidence of oil or other contaminants
 - 3.9.7.1.6 Pits exposing the undercoat or substrate
 - 3.9.7.1.7 Coating separation
 - 3.9.7.1.8 Spatter
 - 3.9.7.1.9 Un-melted particles.

(V)(G) "BEND TEST"

3.9.8 Accomplish a bend test the sprayed test specimens shall be bent approximately 180 degrees on a ½ inch diameter mandrel. The coating shall be on the tensile side of the bend.

3.9.8.1 Inspect the bend test specimens visually without aid of magnification.

3.9.8.2 Acceptance criteria the specimens shall exhibit No flaking, delamination, or gross cracking of the coating shall occur due to bending. Small hairline cracks or “alligatoring” of the coating in the vicinity of the bend are permissible. Ceramic coatings may exhibit flaking associated only with the edges of the bend specimen.

3.10 Furnish Two (2) test specimens for microscopic examination.

3.10.1 Test specimens shall be CRES (Nitronic 50) material and approximately 3 by 2 inches by 0.050 inch (min) to 0.063 inch (max).

3.10.2 Spray Inconel 625 alloy on one of the large faces using the appropriate spraying procedure. The coating thickness shall be 0.008 ± 0.002 inch, or the maximum thickness recommended by the coating manufacturer, whichever is smaller.

3.10.3 Two-coat samples shall have 0.002 to 0.003 inch bond coat and at least 0.005 inch top coat.

(V)(G) “IN PROCESS MONITORING”

3.10.4 Accomplish in process monitoring.

3.10.4.1 Prior to spraying each component to verify surface preparation of the anchor-tooth surface utilizing profile tape profile tape. Each sample shall be free of moisture, oil grit, contaminations, blisters, cracks, chips, pits, or coating separation.

3.10.4.2 Document completion of required essential elements from the procedure of 3.8.

3.10.4.3 The end item inspection of sprayed coatings shall include a visual examination. The finished coating, when examined with a X 10 magnification, shall be free of defects such as cracks, blisters, chips or loosely-adhering particles, oil or other contaminants which bleed out through the coating, pits exposing the undercoat or substrate, and coating separation.

3.10.4.4 Verify final dimensions meet requirements.

(I)(G) "MICROSCOPIC EXAMINATION"

3.10.5 Accomplish a microscopic examination, a section 0.75 to 1.00 inch long by 0.25 to 0.50 inch wide shall be cut from each of the prepared test specimens. The section shall be mounted on the longer side of the cross-section and then prepared metallographically. Cross-sections shall be examined at X 100 to X 200 magnification for the final examination. The oxide and porosity contents shall be determined by the use of line-intercept, grid-area, or optical comparison techniques, or by using comparison photographs, as shown on figure 3-5 of 2.7.

3.10.5.1 Acceptance criteria the constituents of the coating shall be uniformly distributed and there shall be no separations between the coating and substrate, or within the coating. The porosity and oxide content shall not exceed the limits specified in table 3-1 of 2.7 for Inconel 625 (wire). Bond-line

contamination (such as, abrasive blasting grit, disbondment and oxidation at the substrate and coating interface) shall be less than 10 percent. Unreacted globular particle shall be less than 10 percent of the coating cross-sectional areas with the average diameter of the particle not exceeding 0.002 inch.

3.11Furnish Five (5) test specimens for bond testing. The specimens shall be CRES Nitronic 50 and shall be machined and tested in accordance with 2.8.

3.11.1 Spray test specimens in accordance with the procedure provided in 3.8.

3.11.1.1 Areas not to be sprayed shall be masked on the outer diameter to prevent over spraying.

3.11.1.2 The as-sprayed thickness shall be greater than 0.015 inch.

3.11.1.3 The coating shall be applied as evenly and uniformly as possible to maintain the squareness of the machined test specimen. If the squareness of the machined test specimen cannot be maintained during the coating, grinding is permissible to restore the squareness, provided the coating thickness is not reduced below the minimum thickness stipulated by the manufacturer.

3.11.1.4 After grinding, the test specimen may be cleared by vapor degreasing or solvent washing.

(V)(G) "IN PROCESS MONITORING"

3.11.2 Accomplish in process monitoring.

3.11.2.1 Prior to spraying each component to verify surface preparation of the anchor-tooth surface utilizing profile tape profile tape. Each sample shall be free of moisture, oil grit, contaminations, blisters, cracks, chips, pits, or coating separation.

3.11.2.2 Document completion of required essential elements from the procedure of 3.8.

3.11.2.3 The end item inspection of sprayed coatings shall include a visual examination. The finished coating, when examined with a X 10 magnification, shall be free of defects such as cracks, blisters, chips or loosely-adhering particles, oil or other contaminants which bleed out through the coating, pits exposing the undercoat or substrate, and coating separation.

3.11.2.4 Verify final dimensions meet requirements.

(V)(G) "BOND TESTING"

3.11.3 Accomplish bond testing in accordance with 2.8.

3.11.3.1 Acceptance criteria bond failure at or in excess of 3,000 to 4,000 psi.

REPORT: TESTING REPORTS AND SAMPLES

3.12Submit one legible copy in English, in hard copy or approved transferrable media, of Object Quality Evidence (OQE), reports, procedures, a completed copy of 2.9, and all test samples to the GOVERNMENT.

**** STOP WORK See Note 5.1.3. ****

3.13Fabricate sample shaft in accordance with 2.5.

3.13.1 Material shall be Nitronic 50.

3.13.2 Sample shaft blanks shall measure 150 mm by 400 mm.

(V) "FABRICATION DIMENSION VERIFICATION"

3.13.3 Measure and record the fabricated dimensions of the test specimen. Provide measurement record to the Technical POC for review.

(V)(G) "THERMAL SPRAY"

3.13.4 Accomplish thermal spray on sample shaft on fabricated sample shaft in areas identified in 2.5 in accordance with the performing activities procedure qualified in 3.8.

3.13.5 Final machine sample shaft to final diameter of 129.999mm – 130.007mm (5.1181”- 5.1184”) in accordance with 2.6.

(V)(G) "FINAL FABRICATION DIMENSION VERIFICATION"

3.13.5.1 Measure and record the final fabricated dimensions of the test specimen.

(V)(G) "VISUAL INSPECTION"

3.13.6 Accomplish a visual inspection of the sample shaft.

3.13.6.1 Acceptance criteria the as sprayed coating shall have a uniform appearance and shall be free of the following:

3.13.6.1.1 Blisters

3.13.6.1.2 Cracks

3.13.6.1.3 Chips

3.13.6.1.4 Loosely adhering particles

3.13.6.1.5 Evidence of oil or other contaminants

3.13.6.1.6 Pits exposing the undercoat or substrate

3.13.6.1.7 Coating separation

3.13.6.1.8 Spatter

3.13.6.1.9 Un-melted particles.

(V)(G) "HARDNESS TEST"

3.13.7 Accomplish hardness testing after NDT and machining to the affected area; four evenly spaced hardness readings shall be taken on the surface.

3.13.7.1 Hardness Criteria is 20 HRC minimum.

(I)(G) "DESTRUCTIVE TESTING"

3.14 Accomplish destructive testing.

3.14.1 Cut sample shaft in two (2) locations in the area of thermal spray repair for inspection of the cross section.

3.14.1.1 Cut locations shall be well within thermal spray area and away from adjacent edges and surfaces.

(I)(G) "MICROSCOPIC EXAMINATION"

3.15 Accomplish microscopic examination of cut sample shaft. Cross-sections shall be examined at X 100 to X 200 magnification. The oxide and porosity contents shall be determined by the use of line-intercept, grid-area, or optical comparison techniques, or by using comparison photographs, as shown on figure 3-5 of 2.7.

3.15.1 Acceptance criteria the constituents of the coating shall be uniformly distributed and there shall be no separations between the coating and substrate, or within the coating. The porosity and oxide content shall not exceed the limits specified in table 3-1 of 2.7. Bond-line contamination (such as, abrasive blasting grit, dis-bondment and oxidation at the substrate and coating interface) shall be less than 10 percent. Unreacted globular particle shall be less than 10 percent of the coating cross-sectional areas with the average diameter of the particle not exceeding 0.002 inch.

REPORT: SAMPLE SHAFT FABRICATION AND TESTING REPORTS AND SAMPLES

3.16 Submit one legible copy in English, in hard copy or approved transferrable media, of Object Quality Evidence (OQE), reports, procedures, a completed copy of 2.4, and all test samples to the GOVERNMENT.

3.17 Upon completion ship crated material to: SRF/JRMC Sasebo Japan Tategami-cho Sasebo-city, Nagasaki prefecture, Japan Bldg #480/1F, 857-0063.