Process Specification for the Manual ARC Welding of Developmental and Experimental Hardware

Engineering Directorate

Structural Engineering Division

June 2020

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
Houston, Texas

Process Specification for the Manual ARC Welding of Developmental and Experimental Hardware

Prepared by:	Signature on File Daniel J. Rybicki Materials and Processes Branch/ES4	06/10/2020 Date
Reviewed by:	Signature on File Sarah E. Luna Materials and Processes Branch/ES4	06/10/2020 Date
Reviewed by:	Signature on File Clinton Deny Quality and Flight Equipment Division NT4	06/10/2020 Date
Approved by:	Signature on File Brian Mayeaux Materials and Processes Branch/ES4	06/10/2020 Date

REVISIONS		
VERSION	**DESCRIPTION**	**DATE**
Baseline	Original version	06/1/1995
A	Revised version	07/8/1997
B	Formatting, changed process owner, rewrite numerous sections for clarification and simplification, deleted requirement for WIR.	07/07/1999
C	Major revision of document; changed the scope from non-structural to developmental and experimental hardware. Creating a new weld class, "Class E".	07/12/2016
D	Reviewed and revised for audit purposes. Several formatting corrections. Added definitions.	06/02/2020

1.0 SCOPE

This process specification provides the minimum requirements that govern the manual arc welding of experimental hardware that is non-structural and non-flight. Procedural and quality assurance requirements are given. All work instructions used during welding shall satisfy the requirements of this process specification and its applicable documents. This process specification is not intended for work performed by vendors or outside contracted organizations.

2.0 APPLICABILITY

This process specification applies to manual arc welding of experimental hardware that is fabricated on-site and under the authority of NASA/Johnson Space Center (JSC) by any of the following types of welding processes:

a. Flux Cored Arc Welding (FCAW).
b. Gas Metal Arc Welding (GMAW).
c. Gas Tungsten Arc Welding (GTAW).
d. Shielded Metal Arc Welding (SMAW).

Typical welds use a qualified welding procedure to ensure metallurgical and mechanical soundness of the weld based on Class A, B, or C classifications. Welds made on developmental and experimental hardware made under this PRC have no guarantee of weld quality and will be designated as Class E.

This specification can only be used for parts that are non-critical and are not flight related, man-rated, load bearing, pressure retaining, and will not create a hazard to personnel or related equipment in the event of failure. Class E is the lowest integrity of welds produced and comes with no guarantee of weld quality.

Welds created for coupon level testing of weld processes for the development of qualified weld schedules are not welded in accordance of this specification as they are covered under development of the qualified schedule in accordance with the appropriate PRC.

3.0 USAGE

This process specification shall be called out on the engineering sketch or drawing by a drawing note with the following general format. Official engineering drawings are not required for hardware fabricated under this specification:

WELD PER NASA/JSC PRC-0007, Class E

4.0 REFERENCES

The specifications and standards listed are for reference only.

a. NASA/JSC Documents

NASA/JSC PRC-0001	Manual Arc Welding of Aluminum Alloy Hardware NASA/JSC
NASA/JSC PRC-0002	Manual Arc Welding of Titanium Alloy Non-flight Hardware
NASA/JSC PRC-0005	Manual Arc Welding of Carbon Steel and Nickel Alloy Hardware
NASA/JSC JPR 8500.4	Engineering Drawing System Requirements
SOP-007.1	Preparation and Revision of Process Specifications

b. American Welding Society (AWS)

ANSI/AWS A2.4	Standard Symbols for Welding, Brazing and Nondestructive Testing
ANSI/AWS A3.0	Standard Welding Terms and Definitions
ANSI/AWS A5.12	Specification for Tungsten Arc Welding Electrodes
ANSI/AWS B2.1	Standard for Welding Procedure and Performance Qualification

5.0 MATERIAL REQUIREMENTS

All materials used in the welding of hardware, including the base metals, should meet the requirements of the hardware being welded. Welding electrodes and filler metal should be stored in clean, dry areas protected from contamination and physical damage. Specific conditions of storage and handling should conform to the manufacturer's recommendations at a minimum.

6.0 PROCESS REQUIREMENTS

Work instructions are typically approved as Detailed Process Instructions (DPIs) that describe in a detailed, step-by-step format the required procedures, equipment, and materials to be used for conducting a given process. For welds made to this specification, a DPI is not required. Instead, hardware owners must work directly with manufacturing engineers and the welder(s) to communicate the desired steps to be taken during welding. It is the responsibility of the hardware owner to communicate all necessary steps that must be taken.

The manufacturing process record (Form 1262, Appendix A) shall be used for each weld to document rationale for Class E welds. Review of the welding procedure and welder qualification by a welding engineer or other representative from the responsible Materials and Processes organization is not required. The additional page titled “PRC-0007 Weld Sheet” should be used if no qualified WPS is used, however, completion of all fields is not required.

7.0 PROCESS QUALIFICATION

The welding process may be selected and applied as required by the welder or hardware owner. No specific Welding Procedure Specification (WPS) is required. The specific intent of Class E welds is for development or experimental work only, no process requirements are in place to control and inspect the welds. Therefore, if a design using a Class E weld needs to be upgraded to a higher weld like Class A, B, or C (critical, load bearing, pressure containing, safety critical, etc.), the weld needs to be qualified per the relevant PRC. The hardware will need to be rebuilt and welded using the relevant PRC and qualified weld schedules. Class E welds cannot be upgraded by inspection or analysis.

8.0 PROCESS VERICATION

The requirements for visual and other types of weld inspection are at the discretion of the hardware owner and should be specified when working with the manufacturing engineer and welder(s) and may also be specified on the drawing.

9.0 TRAINING AND CERTIFICATION OF PERSONNEL

Welders shall be qualified and certified to AWS B2.1. Welders in training may be allowed to weld on hardware fabricated under this specification to facilitate on-the-job training, however, only under the supervision of a qualified welder(s).

10.0 DEFINITIONS

The following definitions (and associated acronyms) shall apply to this entire document:

1. **Repair** – an action taken to correct a production deficiency in the hardware that results in the hardware not meeting the original design but is fully functional and serviceable as intended by the design.
2. **Rework** – an action taken to correct a production deficiency in the hardware that results in the hardware meeting the original design and is fully functional and serviceable as intended by the design.
3. **Welding Procedure Specification (WPS)** – a detailed written procedure that is used by a welder to ensure that the execution of the qualified process is carried out as intended.

Appendix A: MANUFACTURING PROCESS RECORD (MPR)

To Be Filled Out By Hardware Owner

Hardware Owner Name:

Hardware Name/Title:

Description/Purpose of Part/System:

What are the effects and impacts to the part/system should the weld fail? Are there any safety concerns?

Why are you (hardware owner) willing to accept the risk?

Customer initials

Are any inspections required?

Known Risks (defects, etc.):

Customer initials

MANUFACTURING PROCESS RECORD (MPR) Page 2 of 2

Part/Assembly Number:	Serial Number (if any):	Work Order Router Number (include suffix #):
Part/Assembly Description:		Router Sequence:

Work Center: 7030 **Process Standard:** PRC-0007, Rev. C

Step:	Description:	Tech's Initials/ Date:
1	**VERIFY CURRENT PRC REVISION**	
2	**VERIFY SAFETY REQUIREMENTS**	
3	**SUPERVISION ASSIGN WELDERS:**	
4	**WPS Used or Indicate PRC-0007 Weld Sheet Used:**	
5	**PREPARE WORK AREA**	
6	**VERIFY AND RECORD FILLER MATERIAL PEDIGREE** Manufacturer:_____ **Type/Alloy/Size:**_____ NASA/JSC CofC #: _____	
7	**VERIFY AND RECORD SHIELD GAS(ES) CERTIFICATION** **(1) If gases used were from liquid supply, check box (1)** **(2) If cylinder gases were used, record NASA/JSC EHL gas traceability number on line below and check box (2):**	**(1)** ☐ **(2)** ☐
8	**PREPARE COMPONENTS AND FIXTURING (TACK WELD, IF NEEDED)**	
9	**VERIFY LAYOUT AND FITUP**	
10	**WELDING**	
11	**CLEAN WELDS**	
12	**SUBMIT HARDWARE TO WCC**	

PRC-0007 Weld Sheet

Attach to 1262 if used on Step 4

Welder _____ Date _____ Welding Process _____ WPS _____

If a qualified WPS does not exist, record welding parameters below, as needed.

Joint Design Sketch (as required):

Base Metal _____ Thickness _____ Diameter _____

To:

Base Metal _____ Thickness _____ Diameter _____

Filler Metal _____ Diameter _____ AWS Specification _____

Shielding Gas(es) _____ Composition _____ Flow Rate _____

Welding Current: AC ( ) DCEN ( ) DCEP ( )

Tungsten Electrode Type _____ Tungsten Electrode Size _____

Transfer Mode (GMAW) Short-circuiting ( ) Globular ( ) Spray ( ) Pulsed ( )

Comments/Notes:

_____

_____

Welder's Signature: _____