

Aluminum Friction Stir Welding Qualifications

Maria Posada

Naval Surface Warfare Center, Carderock Division

Acknowledgements:

Catherine Wong, NAVSEA 05P2 Non-Ferrous TWH

Johnnie DeLoach, NSWCCD Code 611

Jennifer Wolk, NSWCCD Code 611

Kevin Colligan, CTC

This brief is provided for information only and does not constitute a commitment on behalf of the U.S. Government to provide additional information.

NSWCCD Consulted NAVSEA Technical Warrant Holder and Publications

NAVSEA Technical Authority

identifies who has technical cognizance

T9074-AX-GIB-010/100

Ensures material/process meets quality and performance requirements for the intended application

DISTRIBUTION STATEMENT: APPROVED FOR LIMITED APPLICATION; LIMITED DISTRIBUTION.

PUBLISHED BY DIRECTION OF COMMANDER, NAVAL SEA SYSTEMS COMMAND



0910LP0174760

29 JANUARY 1999

S9074-AQ-GIB-010/248

NAVSEA Technical Publication

Ensures that quality and performance are consistently maintained in production

DISTRIBUTION STATEMENT A: APPROVED FOR LIMITED APPLICATION; LIMITED DISTRIBUTION.



FABRICATION
US NAVY S

With modification based on 4 April 2002 rewording of paragraph 6.1.1 of 48

NONDESTRUCTIVE TESTING
METHODS



DISTRIBUTION STATEMENT A: APPROVED FOR LIMITED APPLICATION; LIMITED DISTRIBUTION.

PUBLISHED BY DIRECTION OF COMMANDER, NAVAL SEA SYSTEMS COMMAND

30 APRIL 1997



The information presented herein applies to procedure and qualification requirements only. Fabrication requirements were presented herein.

Steps taken in developing FSW procedure, qualification and fabrication requirements

Reviewed existing FSW data.

ManTech effort in place to develop property data.

Friction stir welds must demonstrate that relevant properties are acceptable for the intended application; either by existing test data/service experience, or test data to be developed.

Reviewed existing FSW specifications and existing Navy documentation for conventional arc welds. NSWCCD provided technical warrant holder a recommended FSW procedure and operator qualification package

NSWCCD recommendations submitted to NAVSEA TWH for consideration. Final approval and decision is made by NAVSEA TWH.

Provided recommendations for expanding it use to include various Al alloys, forms, and primary structure



Carderock Division's Steps Toward Recommended FSW Procedure and Qualification Package

- NSWCCD reviewed several documents to provide technical warrant holder a recommended FSW procedure and operator qualification package
 - Draft ISO International Standard Document ISO TC 44/SC 10 N titled *Friction Stir Welding of Aluminum – General Requirements (Parts 1 – 5)*
 - AWS Specification Document AWS D17.3/D17.3M:2010 titled *Specification for Friction Stir Welding of Aluminum Alloys for Aerospace Applications*
 - Lloyd's Register for Shipbuilding
 - Consulted with personnel at NASA and Lockheed Martin
 - Technical Publication S9074-AQ-GIB-010/248 titled *Requirements for Welding and Brazing and Performance Qualification*
 - ABS Documents
- **Developed and recommended a list of FSW essential elements**
- Developed and recommended a list of FSW testing requirements
- Developed and recommended a list of FSW procedure and performance qualification limits

Carderock Division's Recommended Procedure Qualification

NSWCCD recommended that the FSW fabricator

- develop an FSW procedure (i.e., Weld Procedure Specification (WPS))
 - FSW procedure need to follow the FSW essential elements
 - The WPS is submitted to NAVSEA TWH for acceptance
- qualify weld procedures (adhering to qualification limits)
 - Provide documentation (PQR) demonstrating process control and the ability to fabricate welds to the systems requirements representing the fabrication environment to the extent possible
 - Perform the destructive and non-destructive tests established for the intended application
 - Provide documentation showing that they have successfully met the non-destructive and destructive test requirements
 - Submit documentation to NAVSEA TWH for approval
- qualify repair welding procedures
- qualify FSW operators
 - Demonstrate competence by setting up and performing a weld using a WPS based on the approved WPQR
 - Performing non-destructive tests and meeting the requirements established for the intended application
 - Performing destructive tests and meeting the requirements established for the intended application



Carderock Division's Recommended Essential Elements for Friction Stir Welding

Essential elements will be presented in 4 categories

Materials Related

Hardware Related

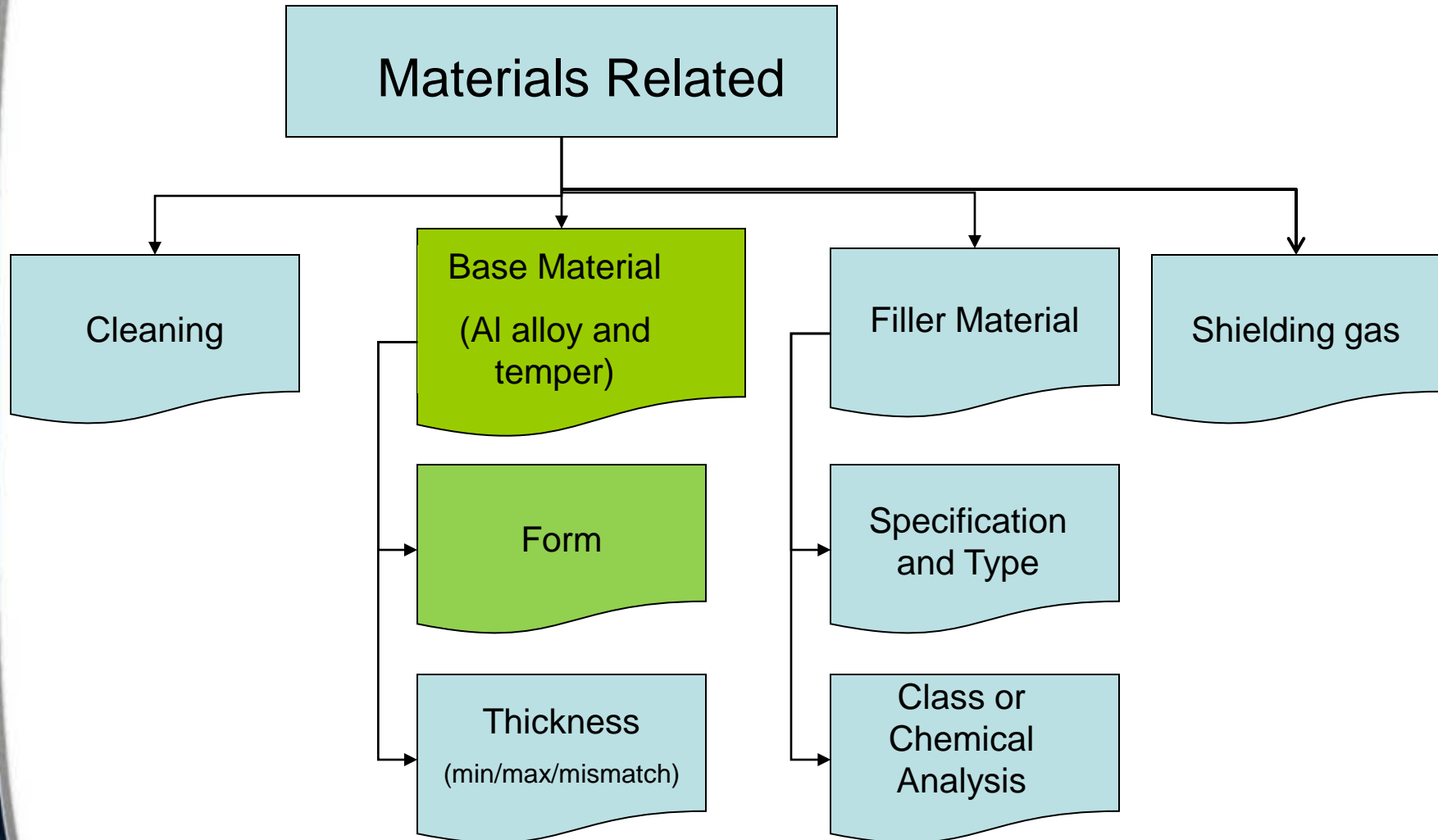
Process Related

Procedure Related



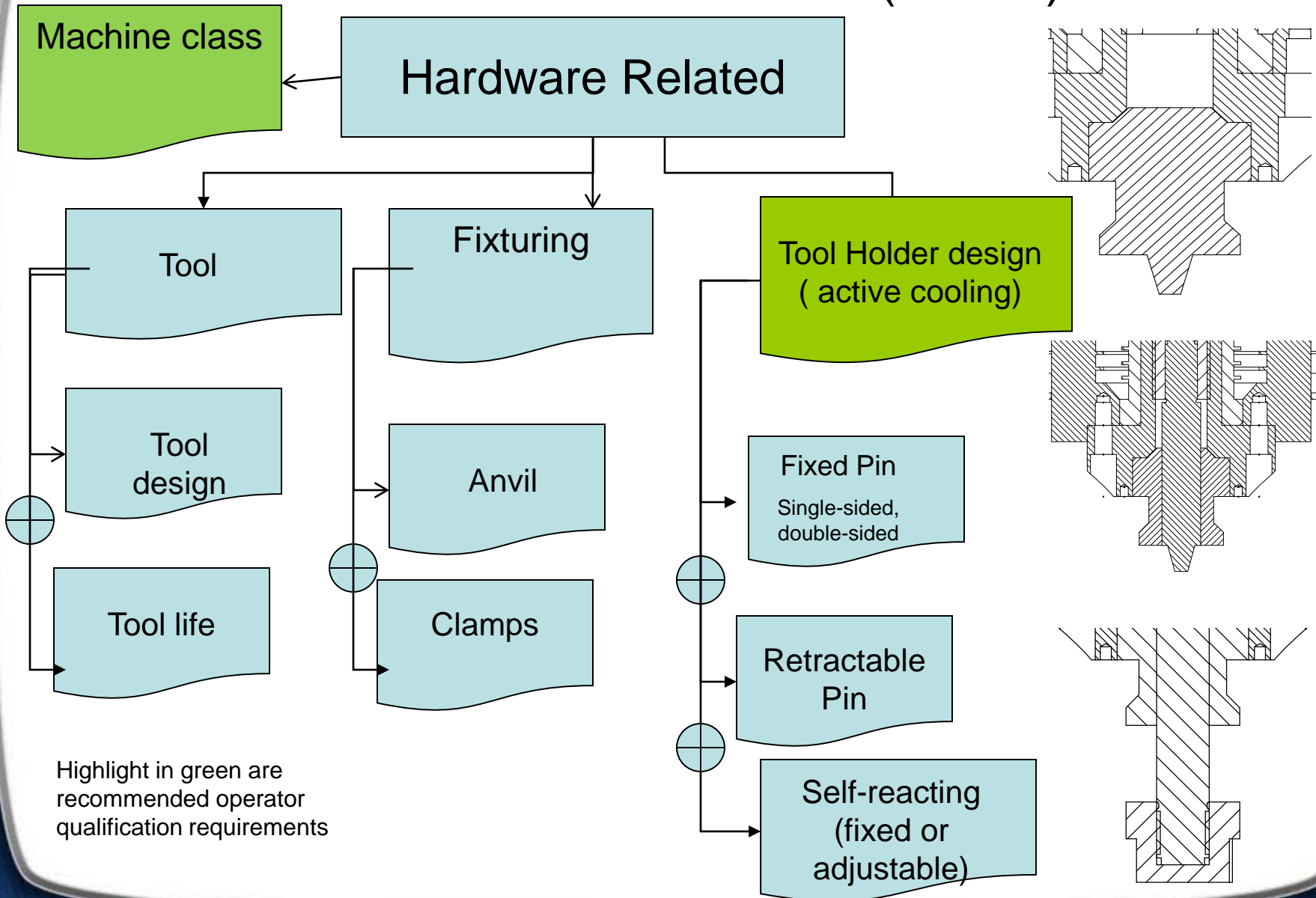
Note that there are interactions between and within categories

Carderock Division's Recommended FSW Essential Elements (cont'd)



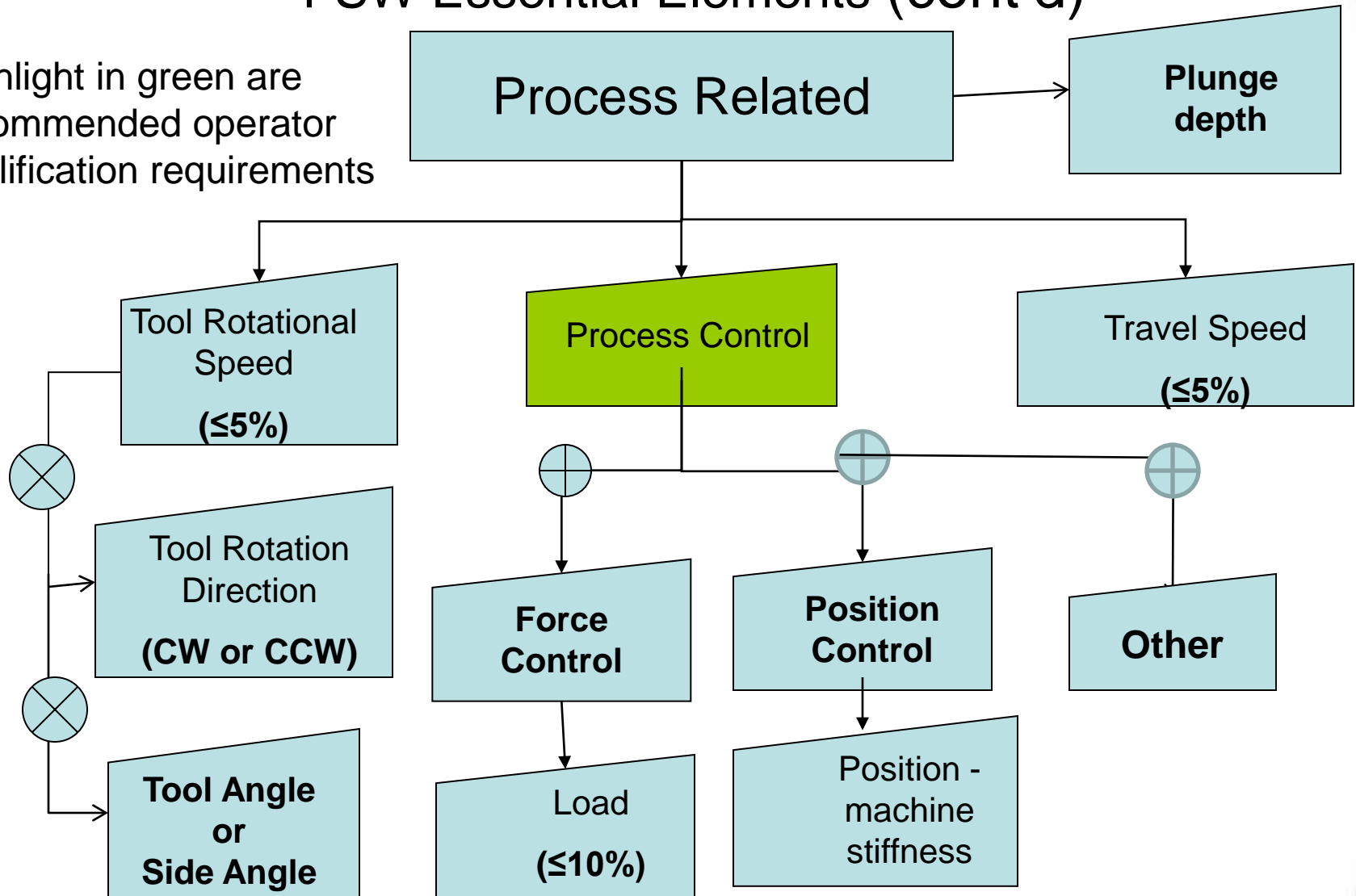
Highlight in green are recommended operator qualification requirements

Carderock Division's Recommended FSW Essential Elements (cont'd)

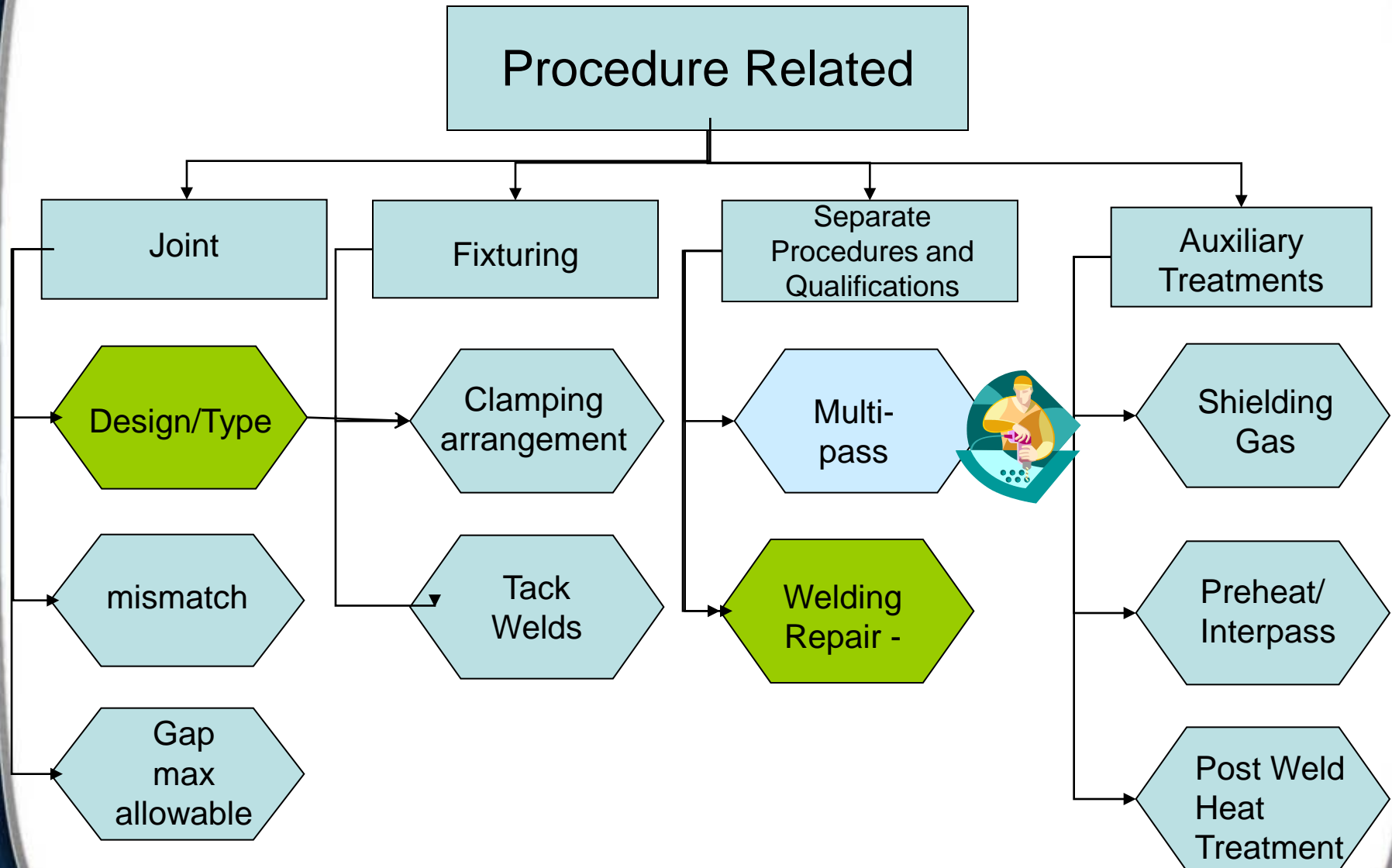


Carderock Division's Recommended FSW Essential Elements (cont'd)

Highlight in green are recommended operator qualification requirements

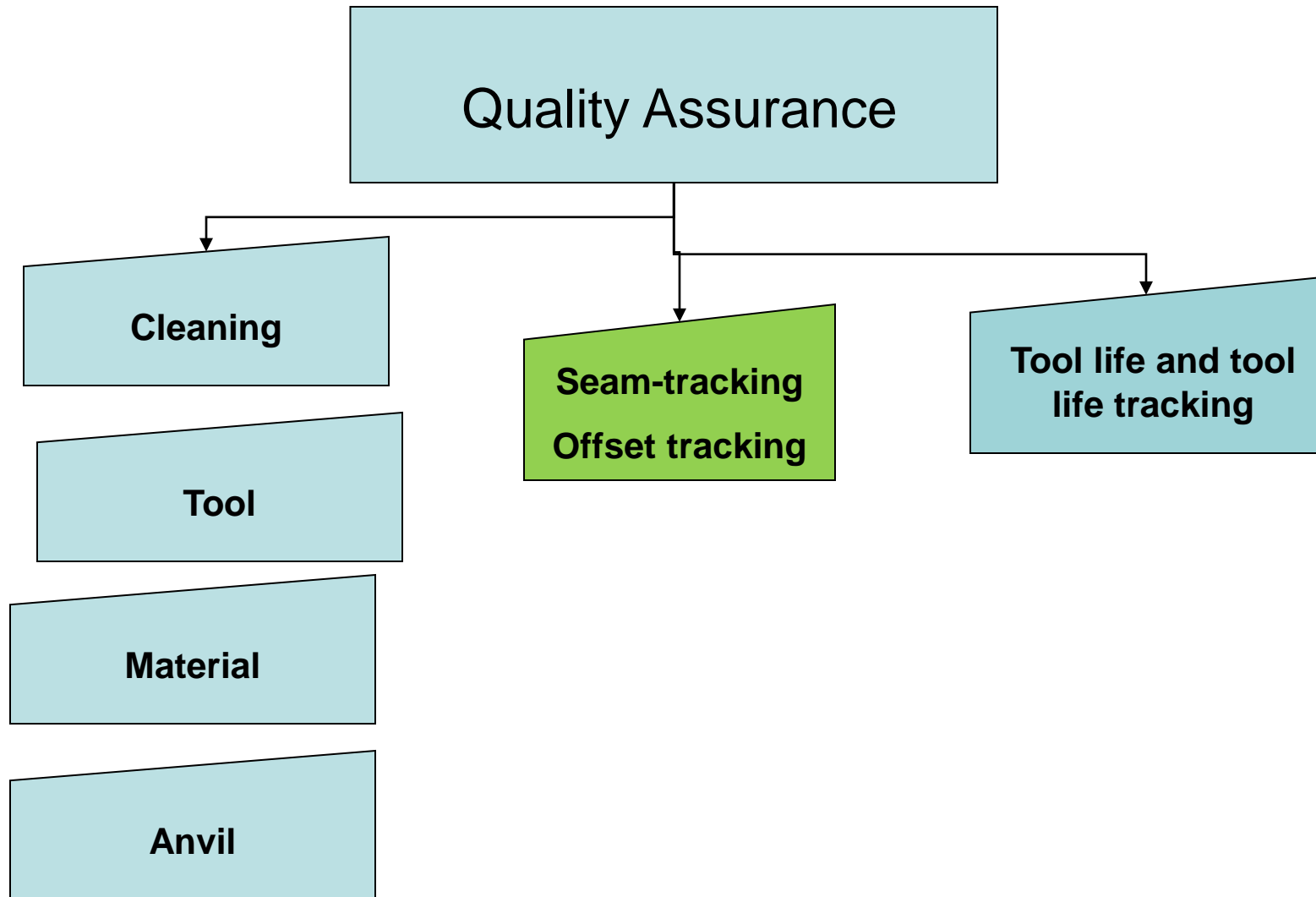


Carderock Division's Recommended FSW Essential Elements



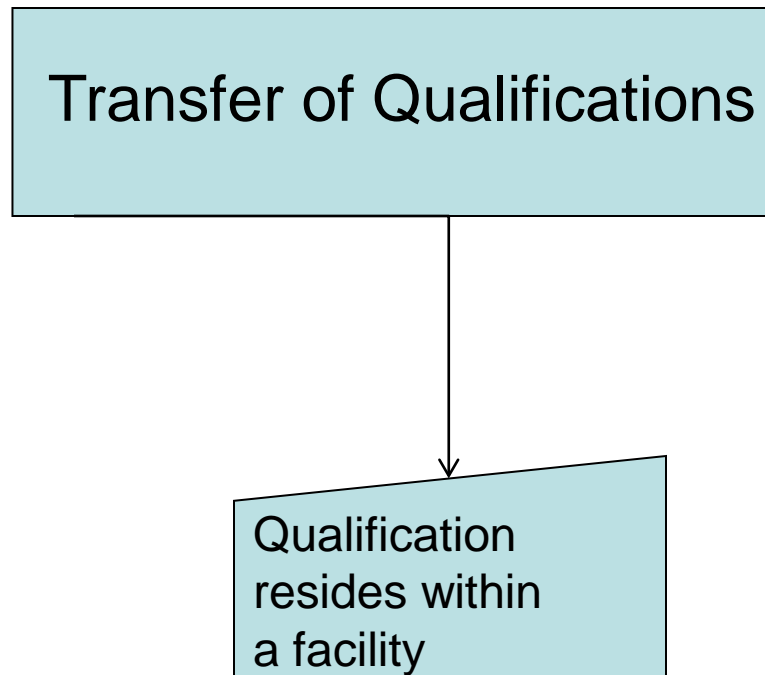
Highlight in green are recommended operator qualification requirements

Carderock Division's Recommended FSW Essential Elements (cont'd)



Highlight in green are recommended operator qualification requirements

Carderock Division's Recommended FSW Essential Elements (cont'd)



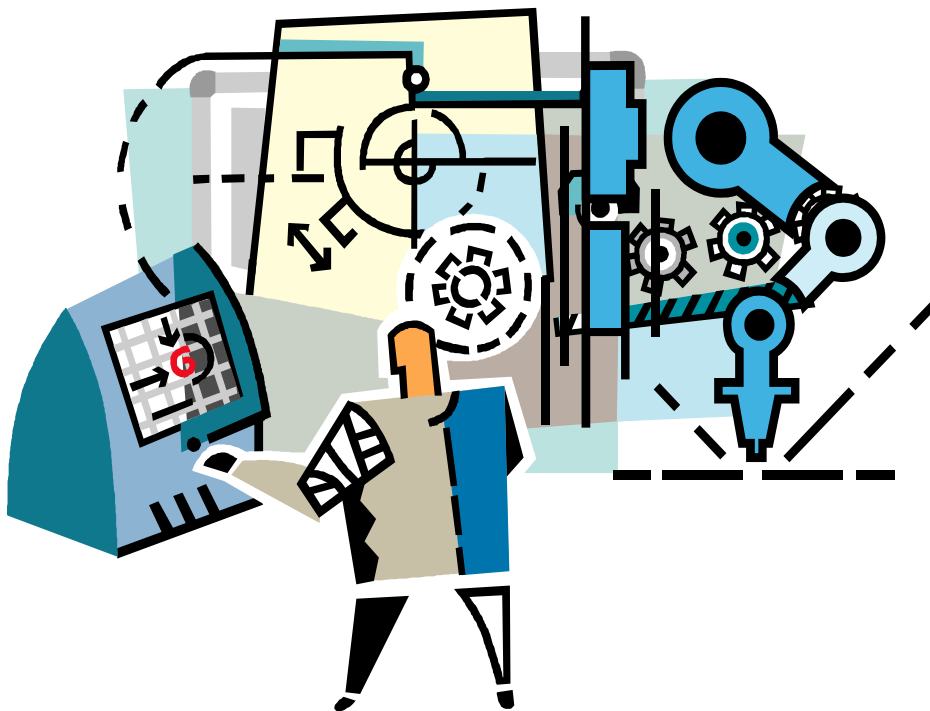
Highlight in green are recommended operator qualification requirements

Carderock Division's Steps Toward Recommended FSW Procedure and Qualification Package

- **Reviewed several documents to provide technical warrant holder a recommended FSW procedure and operator qualification package**
 - Draft ISO International Standard Document ISO TC 44/SC 10 N titled *Friction Stir Welding of Aluminum – General Requirements (Parts 1 – 5)*
 - Draft AWS Specification Document AWS D17.3/D17.3M:200X titled *Specification for Friction Stir Welding of Aluminum Alloys for Aerospace Applications*
 - Lloyd's Register for Shipbuilding
 - ABS Documents
 - Consulted with personnel at NASA and Lockheed Martin
 - Technical Publication S9074-AQ-GIB-010/248 titled *Requirements for Welding and Brazing and Performance Qualification*
- Developed and recommended a list of FSW essential elements
- **Developed and recommended a list of FSW testing requirements**
- **Developed and recommended a list of FSW procedure and performance qualification limits**

Carderock Division's Recommended FSW Operator Qualification Tests and Limits

The operator must be able to demonstrate that he/she can friction stir weld adhering to the essential elements discussed earlier within the limits established.



- ✓ Material alloy and form
- ✓ Machine Model or Type
- ✓ Tool Holder Model or Type
- ✓ Process Control
- ✓ Joint Design
- ✓ Joint Type
- ✓ Placement of exit hole
- ✓ Welding repair – separate qualification

The operator's qualification weld must meet the nondestructive and destructive test requirements detailed in the technical publications or supplemental FSW documentation.

NSWCCD Recommended Qualification Nondestructive Tests

- Visual Inspection
 - 100% required prior to other NDT
 - Exit hole uniformity
 - Flash
 - Chevron markings
 - Dimensional variation in thickness
 - Misalignment
 - Inspected to class 1



- Radiography/Ultrasonic
 - 100% required
 - Inspected to class 1
- Etched Dye Penetrant
 - 100% required prior to other NDT
 - Inspected to class 1
 - Etch procedure requires NAVSEA approval prior to use.

NSWCCD Recommended Qualification Destructive Tests

Transverse Tensile Test
Face Bend Test
Root Bend Test
Macro
Transverse Tensile Test
Face Bend Test
Root Bend Test
Macro
Transverse Tensile Test
Face Bend Test
Root Bend Test
Macro

This brief is provided for information only. The information discussed in this brief are NSWCCD's recommendations provided to NAVSEA for their review and approval.

Still accepting government and industry comments.

Philosophy

FSW requirements are going to be incorporated into the technical publications 248, 271, 1689, 2035 and ABS NVR 2012 instead of being a stand alone document.

The information presented herein applies to procedure and qualification requirements only. Fabrication requirements were presented herein.