DOC-9 AM

DOC – ENGINEERING CONTROLLED SPECIAL PROCESSES

1. SCOPE

1.1. Purpose

This document defines the term Special Process and the approval process necessary to use these Special Processes to manufactured hardware for Woodward products. Approval of these special processes is obtained by meeting the necessary qualification requirements listed in this specification.

1.2. Definitions

Auditor
A member who is trained and accredited in the auditing process.

Certifying Agent
A member of the Materials Lab and / or NDT Level III with educational and technical expertise to be consulted for approval or an individual approved by the Materials Lab. A list of Certifying Agents for Special Processes as defined in DOC-9 is documented in AL 6254.

Production Part Approval Process (PPAP)
The review of the physical characteristics and paperwork for conformance.

Certificate of Conformance (COC)
Paperwork which certifies conformance to the engineering and/or processing requirements listed on the certificate.

Special processes
Manufacturing operations whose performance is vital to the proper function of the product but whose results cannot be fully verified except by destructive testing. For the purpose of this document, they are identified by one of the major categories in the “SPECIAL PROCESSES” section below. Exception: Processes used during the manufacturing of nameplates, as defined in SP-278, are not considered special processes due to the application requirements.

Product Definition
Woodward technical documentation to fully define and describe a product, in one of three formats:
1 - Drawing graphic sheets
2 - Drawing graphic sheets and 3D models (when 3D model is specified on drawing graphic sheets)
3 - Annotated model (when there is no drawing graphic sheet)

1.3. Application

This document applies when a manufacturing organization desires to use special processes which are not called out on the engineering product definition; when qualifying a special process specified on the product definition; or when changing a previously qualified special process. These requirements apply to the following and must follow the Requirements section below:

- Woodward Designed Parts (whether produced within Woodward or at Suppliers)
- Woodward Designed Altered Items
- Supplier Designed Component (under Woodward SP-896 control)

This document does not apply to the following:

- Catalog/Commercial “Off-the-Shelf” Item where SP-896 is not specified.

- Standard Parts (A part or material that conforms to an established industry or US government-published specification MS, NAS, AN etc)

2. REFERENCES

2.1. The following documents are listed for reference only.

2.2. See section 4

2.3. The following form part of this document.

F27761 Supplier Request for Special Process Approval per Doc-9

WPQR-9100 Quality Systems Requirements

AL6254 Certifying Agents for Special Processes

SS-163 Symbols and Markings (specifically, the symbols denoting the various divisions)

3. REQUIREMENTS

3.1. Implementing Special Processes Not Specified on Product Definition

Requirements in this section apply when implementing a special process on parts where the process is not specified on the product definition.

3.1.1. Woodward Designed Part manufactured at Woodward

3.1.1.1. Manufacturing Engineering submits request (form F27761) to Production Engineering and Materials Engineering for approval. The request is to identify process parameters, which will be maintained and controlled during the implementation of the special process, and which part features the special process apply.

3.1.1.2. Production Engineering and Materials Engineering determine whether the special process can be used on the part without affecting part performance and any other requirements and whether the processes specified are properly controlled to assure repeatability of the process.

3.1.1.3. Production Engineering and Materials Engineering determine qualification requirements necessary to satisfy all part requirements, Woodward standards (SP, ESS, etc.) and Industry standards (AMS, ASTM, MIL-Std, etc.) where applicable. Production Engineering and Materials Engineering perform required qualification and produce documentation to demonstrate compliance to the part requirements.

3.1.1.4. Materials Engineering approves the process if acceptable.

3.1.1.5. Manufacturing Engineering establishes a process for the parts in accordance with the process parameters in the approved request (F27761).

3.1.1.6. Written documentation of this procedure (hardcopies, e-mails, faxes, etc.) is acceptable provided the approvals/qualification requirements and results determined by the Product Engineering/Materials Engineering are documented in the routing change record.

3.1.2. Woodward Designed Part Manufactured by Supplier

3.1.2.1. Supplier submits request (form F27761) to Woodward Supplier Controlling Agent (Buyer) for approval. The Supplier's request shall identify process parameters which will be maintained and controlled

during the implementation of the special process and which part features the special process apply.

3.1.2.2. Supplier Controlling Agent notifies Manufacturing Engineering of the request and Woodward Supplier Controlling Agent submits request (form F27761) to Production Engineering and Materials Engineering for approval.

3.1.2.3. Production Engineering and Materials Engineering determine whether the special process can be used on the part without affecting part performance and other requirements and whether the processes specified are properly controlled to assure repeatability of the process.

3.1.2.4. Production Engineering and Materials Engineering determine qualification requirements necessary to satisfy the special process meets all part requirements, Woodward standards (SP, ESS, etc.), and Industry standards (AMS, ASTM, MIL-Std, etc.) where applicable. NOTE: If there is no standard to follow, the Supplier should contact Woodward Materials Engineering to establish qualification requirements for that process.

3.1.2.5. Production Engineering and Materials Engineering or designees (non Woodward Lab) perform the required qualification and documentation to demonstrate compliance to the part requirements.

3.1.2.6. Materials Engineering approves the process if appropriate. Woodward's approval is accomplished by completing and returning the approved form F27761. Suppliers are responsible for treating the approved form as a quality record and for maintaining the documentation per record retention requirements. (This approval documentation is to be made available to Woodward upon request).

3.1.2.7. Woodward Supplier Controlling Agent notifies supplier of approval. The Supplier is then authorized to processes parts to the specified process parameters and is to maintain these parameters as defined. Supplier Controlling Agent also is responsible to assure any subsequent operations defined in the qualification requirements are performed. (This last requirement refers to any subsequent operations done at Woodward or at other facilities that are not done by the original supplier.)

3.1.3. Supplier Designed Component

3.1.3.1. Supplier to perform review similar to Paragraph 3.1.1 and 3.1.2. After completion of requirements of 3.1.1, Supplier to submit documentation of change to Supplier Controlling Agent for approval. (The supplier controlling agent is to obtain necessary approval from materials and production engineering for the change.)

3.2. **Changes to Special Processes that are Specified on Product Definition**

Requirements of this section apply to implementing changes of special processes when the special process is specified on the product definition (this includes process changes to controlled parameters and rework of special processes).

3.2.1. Woodward Designed and manufactured by Woodward.

3.2.1.1. If changes to the process parameters, as listed in Appendix A, are made, the change shall be substantiated to the minimum requirements in Appendix A, unless the requirements are waived by Materials and Production Engineering.

3.2.1.2. Manufacturing Engineering and or Materials Engineering when applicable approves process changes.

3.2.1.3. Written documentation of this procedure (hardcopies, e-mails, faxes, etc.) is acceptable provided the approvals/qualification requirements defined in Appendix A are documented in the routing change record.

3.2.2. Woodward Designed Part manufactured by Supplier

3.2.2.1. Supplier submits request (form F27761) to Woodward Supplier Controlling Agent (Buyer) for approval. The Supplier's request shall identify process parameters which are being changed on the special process and which part features the special process apply.

3.2.2.2. Supplier Controlling Agent notifies Manufacturing Engineering of the request and Woodward Supplier Controlling Agent submits request (form F27761) to Production Engineering and Materials Engineering for approval.

3.2.2.3. Materials Engineering and Production Engineering (if the Materials Engineering deems necessary) determine whether the special process change can be used on the part without affecting part performance and other requirements and whether the processes specified are properly controlled to assure repeatability of the process.

3.2.2.4. Materials Engineering and/or Production Engineering determines qualification requirements necessary to satisfy the special process meets all part requirements, Woodward standards (SP, ESS, etc.), and Industry standards (AMS, ASTM, MIL-Std, etc.) where applicable.

3.2.2.5. If the part process change represents a global process change, the change is submitted to a Special Process Review committee to determine acceptability based on qualification of the process.

3.2.2.6. Materials Engineering or designee perform required qualification and documentation to demonstrate compliance to the part requirements. Metallurgical mounts, hardness checks, NDT, etc may be required to verify process.

3.2.2.7. Materials Engineering approves the process change/rework of process if acceptable.

3.2.2.8. Woodward Supplier Controlling Agent notifies supplier of approval. The Supplier is then authorized to processes parts to the specified process parameters and is to maintain these parameters as defined. Supplier Controlling Agent also is responsible to assure any subsequent operations defined in the qualification requirements are performed. (This last requirement refers to any subsequent operations done at Woodward or at other facilities that are not done by the original supplier.)

Written documentation of this procedure (hardcopies, e-mails, faxes, etc.) is acceptable within Woodward provided the approvals/qualification requirements determined by Materials Engineering are documented in the routing change record.

3.2.3. Supplier Custom Designed Component

Supplier is to establish a system defining the review process and performs an evaluation of the process change similar to Paragraph 3.2.1 through 3.2.2.

3.3. **Changes to Special Processes Not Specified on Product Definition**

Requirements for implementing changes to special processes on parts where the process is not specified on the product definition.

3.3.1. Woodward Designed Part manufactured internally

3.3.1.1. Manufacturing Engineering determines whether the change affects the process parameters, as listed in Appendix A.

3.3.1.2. Substantiation is required per the requirements in paragraph 3.1.1 if the process change would invalidate the previous substantiation. Otherwise Manufacturing Engineering implements the change to the process which does not affect the previous substantiation data.

3.3.2. Woodward Designed Part manufactured by Supplier

3.3.2.1. Supplier consults with Supplier Controlling Agent to determine if re-substantiation is necessary due to a proposed change to a process. Supplier Controlling Agent is to consult Appendix A and Material Engineering as to whether the change affects the process parameters.

3.3.2.2. Supplier initiates qualification process in paragraph 3.1.2 when the changed process invalidates current substantiation. After evaluation, supplier implements change to the process that meets the qualification of the defined parameters.

3.3.3. Supplier Designed Components

3.3.3.1. Supplier determines whether the change invalidates the substantiation of the requirements specified in the qualification process. Supplier to consult Woodward if it cannot be determined by the supplier that the new process invalidates current substantiation.

3.3.3.2. Supplier initiates qualification process similar to the requirements in paragraph 3.1.1 and 3.1.2. After completion of requirements, Supplier to submit documentation of change to Woodward for approval.

3.4. **Initial Special Process Requirements**

Requirements for this section apply to validating/approving the special processes on parts where the special process is listed on the product definition.

3.4.1. Woodward Designed Part manufactured internally

3.4.1.1. When “Aerospace requirements” apply (this is identified by the symbol in the title block per SS-163), the special process is to be approved by the certifying agent to determine the process is acceptable. This approval may be process or part specific.

3.4.1.2. When “Aerospace requirements” do not apply (this is identified by the symbol in the title block per SS-163), the special process is to be approved by the certifying agent to determine the process is acceptable. This approval may be process or part specific.

3.4.2. Woodward Designed Part manufactured by Supplier

3.4.2.1. When “Aerospace requirements” apply, the special process is to be approved by the certifying agent to determine the process is acceptable. This approval may be process or part specific.

3.4.2.2. When “Aerospace requirements” do not apply, then a certificate of conformance is required to be submitted for each Special Process on the product definition as part of the PPAP submission. Additional validation may be required at the discretion of Woodward.

3.4.3. Supplier Designed Components

3.4.3.1. When “Aerospace requirements” apply, a Woodward Auditor is required to validate the supplier has processes in place which adequately verify the methods, controls, and evaluation of results of the special process.

3.4.3.2. When “Aerospace requirements” do not apply, then a COC is required to be submitted for each Special Process on the Woodward product definition as part of the PPAP submission.

4. SPECIAL PROCESSES

Each of the major categories below contains examples of special processes, which are listed as a guide only and are not considered a complete listing. The types of processes listed below are considered subject to the requirements of this document. The following section and the appendix specify the minimum requirements process substantiation requirements, unless waived by Materials or Production Engineering.

4.1. Non-Mechanical / Non-Conventional Machining

Example Processes	**Recommended/Required Specifications**	**Appendix A parameter table**
Electro discharge machining (EDM)	SP-1084, XLO-PD-1033	N
Laser beam cutting	SP-1162, XLO-PD-1038	P
Water jet machining		None
Plasma cutting	AWS C5.2	P
Electro chemical machining (ECM)	XLO-PD-1033	None
Chemical milling	MIL-C-81769	None
Electron beam machining	XLO-PD-1038	P

4.1.1. Non-mechanical/non-conventional machining processes may be used without approval under the following conditions:

4.1.1.1. Where used as a preliminary machining operation provided all traces of affected material are subsequently removed.

4.1.1.2. Electro chemical deburr may be used without approval unless parts have been previously joined using a special process or subsequent operations requiring dyed anodize.

4.2. Surface Coating / Treatment

Example Processes	Recommended/Required Specifications	Appendix A parameter table
Anodize	SP-822, MIL-A-8625, AMS 2471	B
Hardcoat (hard anodize)	SP-222, MIL-A-8625, XLO-PD-1062, AMS 2469	C
Passivation	SP-151, ASTM A-967, XLO-PD-1024, AMS 2700	None
Nickel plate (electroless and electrolytic)	SP-1046, AMS 2403, AMS 2404, ASTM B 733	O
Chromium plate	AMS 2438	O
Shot Peen	SP-176, AMS 2430, XLO-PD-1049, XLO-PD-1090, MIL-S-13165	A
Chemical Conversion Coating (chromate conversion coating)	SP-870, MIL-DTL-5541	None
Chemical Conversion Coating (tri-valent chrome)		None
Chemical Conversion Coating (non-chromium)		None
Corrosion Preventative Film	SP-949	None
Solid Film Lubricant	SP-929, MIL-PRF-46010, SP-1196	None
Zinc plate	ASTM B633	O
Black Oxide	SP-866	None
Impreglon	SP-1101	None
Nibron	SP-1124	O
Plasma Coating	XLO-PD-1039	None
Thermal Spray Carbide coating	SP-905	L
Impregnation of Castings	SP-178, MIL-I-17563	None
Electro polish	ASTM B912	None
Gold plate	AMS 2422	O
Painting	ESS-007, SP-606	None
Harperize	SP-964	None
ID Carbide	SP-937	L
HVOF coatings	AMS 2447	None
Flame Deposition Chromium Carbide	XLO-PD-1026	None
Diamond Like Carbon Coating	SP-1192	None
Self Lubricating Bearing	SP-1189	None

4.2.1. Surface coating/treatment processes may be used without approval under the following conditions:

4.2.1.1. Parts may be passivated for manufacturing ease to clean heat-treat scale or other contamination by adding a passivation operation to the

process plan if all the requirements of SP-151 are met. When used as an in-process cleaner, the engineering product definition need not state passivate per SP-151.

4.2.1.2. When harperize is used as a clean/deburr operation and is not a requirement of the engineering product definition.

4.3. Thermal Treatment (material specific)

Example Processes:	**Recommended/Required Specifications**	**Appendix A parameter table**
Heat treatment of Aluminum	SP-950, SP-1152, AMS 2770, AMS 2771,MIL-H-6088	D
Heat treatment of Steels	SP-908, SP-1090, ESS-010, ESS-039, ESS-055, AMS-H-6875, AMS 2759, AMS 2769, XLO-PD-1005, XLO-PD-1029, XLO-PD-1031, XLO-PD-1100, XLO-PD-1113	D
Heat treatment of Titanium	SP-908, SP-1150, AMS-H-81200, AMS 2801, XLO-PD-1005	D
Heat treatment of Copper	SP-908, ESS-005, AMS 2728	D
Heat treatment of Nickel and Cobalt alloys	SP-908, ESS-083, AMS 2773, AMS 2774, XLO-PD-1005, XLO-PD-1054	D
Nitride: gas, plasma, ion, salt bath	SP-908, AMS 2759	D
Hydrogen Anneal	ESS-001	None
Induction Hardening of Steel	ARP 4715	None
Carburizing/carbonitriding	SP-908, AMS 2759, AMS 2762	None

4.3.1. Thermal treatment processes may be used without approval under the following conditions:

If following the default hardness requirement for 410 and 416 stainless steels called out in SS-112: All parts made of 410 and 416 stainless steel shall be hardened to
18-32 HRC per SP-908 unless a specific heat treat requirement is defined on the engineering product definition. EXCEPTION: 410 and 416 stainless steel parts manufactured per SS-159 shall be 32 HRC max unless a specific SP-908 heat treat requirement is defined on the engineering product definition.

4.4. Joining

Example Processes:	**Recommended/Required Specifications**	**Appendix A parameter table**
Soldering: mechanical	SP-244, SP-304, SP-984, EMS-50, ESS-004-1, ESS-800, SP-876	H
Soldering: electrical	ESS-004-1, J-STD-001	none
Brazing: torch, induction	SP-865, SP-972, ESS-038, SP-934, XLO-PD-1027, XLO-PD-1032, XLO-PD-1081, XLO-PD-1087, AMS 2670	F, G
Brazing: furnace vacuum and hydrogen	SP-865, SP-934, ESS-009 plus others from cell above	E, Q
Aluminum Braze	SP-865, SP-934, Mil-B-7883, AWS C3.7	M
Welding: electron beam, GTAW, resistance, laser	SP-901, SP-1151, AMS-STD-2219, MIL-W-6858, MIL-W-8611, MIL-W-46132, AMS-W-6858, MIL-STD-2219, AWS D17.1, AMS 2680, AMS 2681, XLO-PD-1025, XLO-PD-1030, XLO-PD-1093, XLO-PD-1094, XLO-PD-1118, XLO-PD-1120	I, J
Adhesive Bonding	SP-260, SP-573, SP-921, SP-1029, SP-1035, ESS-063, XLO-PD-1052, XLO-PD-1065, XLO-PD-1107	K
Potting and Embedding	EMS-110	None
Encapsulation	ESS-006, EMS-110	None

4.4.1. Joining processes may be used without approval under the following conditions:

Where used in process for fixturing, etc., provided all remnants of the filler metal, joint, or heat-affected zone are subsequently removed from the completed part.

4.5. Non-Destructive Testing

Qualification of these processes is required only when this process is specified on the engineering product definition or special process specification or when these processes are required on the qualification form as part of another special process.

Example Processes	**Recommended/Required Specifications**	**Appendix A parameter table**
Fluorescent Penetrant Inspection	SP-916, ASTM E1209, ASTM E1417, MIL-STD-6866	None
Visual Penetrant Inspection	SP-1129, ASTM E1417	None
Magnetic Particle Inspection	SP-917, ASTM E1444, ASTM E709, MIL-STD-1949	None
Radiographic/Radioscopic Inspection	SP-333, SP-1149, ASTM E1742, ASTM E1255, MIL-STD-453	None
Ultrasonic Inspection	ASTM specifications: A577, A578, A745, A898, B548, B594, B773, E114, E164, E213, E215, E587, E588, E1001, E1158, E1495, E1736, E1901, E2375	None

4.6. Special Material Requirements

Example Processes	**Recommended/Required Specifications**	**Appendix A parameter table**
Handling of Zirconium and Titanium	SP-914, XLO-PD-1019	None
Handling of Incoloy 909 spring wire	SP-1115	None
Special Alloy Wire (3920 and 4920)	SP-959	None
Pickling of Waspaloy	XLO-PD-1037	None
Etching Cast or Forged Super Alloys	XLO-PD-1075	None
Casting: investment	SP-1128, ESS-011	None
Casting: sand	3-09-3396	None
Casting: shell	3-09-3396	None

Appendix A

Alphabetical List of Tables

Adhesive Bonding	**K**
Anodize	**B**
Brazing, Aluminum	**M**
Brazing, Furnace	**E and Q**
Brazing, Induction	**F**
Brazing, Torch	**G**
Carbide, SP-905 and SP-937	**L**
Cutting, Thermal	**P**
EDM	**N**
Hardcoat	**C**
Heat Treating	**D**
Plating	**O**
Shot Peening	**A**
Soldering	**H**
Welding, EB	**I**
Welding, GTAW	**J**

A. SUBSTANTIATION FOR SHOT PEENING

Process Change	Qualification Requirements
1. Shot size , Hardness, Type, and Shape	A, B
2. Number of Nozzles and Cycles	
3. Cycle Time	
4. Table Rotation/Nozzle Oscillation	
5. Air Pressure	
6. Wheel Speed	
7. Coverage	

Qualification

A. Visual at 7X minimum magnification for coverage and masking effectiveness

B. Almen strip

B. SUBSTANTIATION FOR HARDCOAT AND ANODIZE

Process Change	Qualification Requirements
1. Cleaning	A, B, C, D
2. Voltage or Current Density	
3. Solution Chemistry	
4. Sealing process	B, C
5. Racking	A, B
6. Masking	
7. Solution Additive(s)	A, B, C, D
8. Additive Concentration	A, B, C, D
9. Agitation method	
10. Agitation intensity (air flow, impellor or pump speed, for example)	

Qualification

A. Dimensional analysis of plating thickness (can use nondestructive means where applicable)

B. Visual inspection

C. Salt fog

D. Coating weight

C. SUBSTANTIATION FOR HARDCOAT (HARD ANODIZE)

Process Change	Qualification Requirements
1. Cleaning	A, B, C
2. Voltage or Current Density	
3. Solution Chemistry	
4. Solution Temperature	
5. Racking	A, B
6. Masking	
7. Solution	A, B, C
8. Additive Concentration	A, B, C
9. Agitation method	A, B, C
10. Agitation intensity (air flow, impellor or pump speed, for example)	A, B, C

Qualification

A. Dimensional analysis of plating thickness (can use nondestructive means where applicable)

B. Visual inspection

C. Taber wear testing

D. SUBSTANTIATION FOR HEAT TREATING

Process Change	Qualification Requirements
1. Process Cycle (Time, Temperature, Rates)	A, B, C
2. Quench Media	
3. Quench Pressure	
4. Atmosphere Circulation	
5. Furnace Type*	
6. Racking	D
7. Furnace loading	A
8. Atmosphere Composition	A, B
9. Masking	F

Qualification

A. Hardness testing (macrohardness or microhardness)

B. Metallographic evaluation (especially at surface for atmosphere reaction)

C. NDT testing with either visual (7X minimum), fluorescent penetrant, or magnetic particle

D. Dimensional inspect

E. Tensile Testing

F. Metallographic evaluation for case depth (e.g. nitride or carburize) or other microstructural requirement (e.g. 440c microstructure per SP-908)

NOTE: Re-verification of joint integrity for any joined hardware after all subsequent thermal processing has been completed MUST be considered.

***Examples of Furnace Types: vacuum, air, electrically heated, gas fired, pit, side loading, integral quench**

E. SUBSTANTIATION FOR FURNACE BRAZING

Process Change	Qualification Requirements
1. Heating/Cooling rates	A, B, C, D
2. Hold time	
3. Temperature	
4. Atmosphere	
5. Brazing Method	
6. Joint configuration Clearance or Length	
7. Braze alloy form/application	B, C, D
8. Surface preparation	
9. Furnace loading	A, B, C, D
10. Racking	
11. Flux/stop-off usage	
12. Fixturing	
13. Tack Welding	

Qualification

A. Dimensional analysis

B. Metallographic sectioning

C. Visual inspect at 7X minimum

D. Functional test when indicated by the engineering print (x-ray, leak check, load test, etc.)

NOTE: Re-verification of joint integrity after all subsequent thermal processing has been completed MUST be considered.

F. SUBSTANTIATION TESTING FOR INDUCTION BRAZING

Process Change	Qualification Requirements
1. Atmosphere	A, B, C, D
2. Brazing method	
3. Joint configuration Clearance or Length	
4. Braze alloy form.application	B, C, D
5. Surface preparation	
6. Coil Configuration Size Location	
7. Flux/stop-off usage	A, B, C, D
8. Fixturing	
9. Tack Welding	

Qualification

A. Dimensional analysis

B. Metallographic sectioning

C. Visual inspect at 7X minimum

D. Functional test when indicated by the engineering print (x-ray, leak check, load test, peel test, etc).

NOTE: Re-verification of joint integrity after all subsequent thermal processing has been completed MUST be considered.

G. SUBSTANTIATION TESTING FOR TORCH BRAZING

Process Change	Qualification Requirements
1. Atmosphere	A, B, C, D
2. Brazing method	
3. Joint configuration Clearance or Length	
4. Braze alloy form/application	B, C, D
5. Surface preparation	
6. Torch Specialty tips (if required) Fuel	
7. Flux/stop-off usage	A, B, C, D
8. Fixturing	
9. Tack Welding	

Qualification

A. Dimensional analysis

B. Metallographic sectioning

C. Visual inspect at 7X minimum

D. Functional test when indicated by the engineering print (x-ray, leak check, load test, etc.)

NOTE: Re-verification of joint integrity after all subsequent thermal processing has been completed MUST be considered.

H. SUBSTANTIATION TESTING FOR SOLDERING

Process Change	Qualification Requirements
1. Heating/Cooling rates	A, B, C, D
2. Hold time	
3. Temperature	
4. Soldering Method	
5. Solder alloy form/application	B, C, D
6. Surface preparation	
7. Flux/stop-off usage	A, C, D
8. Fixturing	
9. Post cleaning	

Qualification

A. Dimensional analysis

B. Metallographic sectioning

C. Visual inspect at 7X minimum

D. Functional test when indicated by the engineering print (x-ray, leak check, load test, peel test, etc.)

NOTE: Re-verification of joint integrity after all subsequent thermal processing has been completed MUST be considered.

I. SUBSTANTIATION TESTING FOR EB WELD

Process Change	Qualification Requirements
1. Accelerating voltages	A, B, C
2. Beam current	
3. Welding speed	
4. Focusing current	
5. Standoff	
6. Vacuum level	
7. Joint configuration Depth Diameter Length	
8. Tooling	A, B
9. Fixtures	
10. Surface preparation	A, B, C, D
11. Tack weld for fit-up	
12. Weld geometry	
13. Location of weld	
14. Machine (EB welder) change	

Qualification

A. Dimensional analysis

B. Visual inspect at 7X minimum

C. Metallographic inspect

D. Any applicable testing required by the engineering print (magnetic particle, fluorescent penetrant, leak test, load test, etc.)

J. SUBSTANTIATION TESTING FOR GTAW WELDING

Process Change	Qualification Requirements
1. Current	B, C, D
2. Polarity	
3. Power supply type	
4. Arc voltage	
5. Travel speed	
6. Electrode type	
7. Filler metal composition	
8. Torch type	
9. Gas type/flow rate	
10. Cup size	
11. Tooling	A, B
12. Fixtures	
13. Travel Rate, Passes	A, B, C, D
14. Number of passes	
15. Surface cleaning procedure	
16. Weld Geometry	
17. Location of weld	

Qualification

A. Dimensional analysis

B. Visual inspect at 7X minimum

C. Metallographic inspect

D. Any applicable testing required by the engineering print (magnetic particle, fluorescent penetrant, leak test, load test, etc.)

NOTE: Re-verification of joint integrity after all subsequent thermal processing has been completed MUST be considered.

K. SUBSTANTIATION TESTING FOR ADHESIVE BONDING

Process Change	Qualification Requirements
1. Cleaning procedure	A, B, C
2. Change in material or ratio of resin, hardener, additive(s), filler(s)	
3. Application procedure	
4. Amount applied	
5. Fixturing	
6. Racking	
7. Curing Time Temperature Thermocouple	

Qualification

A. Dimensional inspect

B. Visual inspect at 7X minimum

C. Functional test if required by the engineering print

NOTE: Re-verification of joint integrity after all subsequent thermal processing has been completed MUST be considered.

L. SUBSTANTIATION TESTING FOR I.D. & O.D. CARBIDE PER SP-905 & SP-937

Process Change	Qualification Requirements
Any change	Qualification in appropriate SP/MS including A through E below

Qualification

A Microstructure, including porosity, cracks, and bond line (see appropriate baseline micrographs)

B. Hardness (OD carbide only)

C. Adhesion

D. Sintered appearance (looking especially for cracks, crack patterns, shrinkage gaps, and discontinuities)

E. Machining – honing (ID carbide only)

NOTE: Re-verification of joint integrity after all subsequent thermal processing has been completed MUST be considered.

M. SUBSTANTIATION TESTING FOR ALUMINUM BRAZE

Process Change	Qualification Requirements
1. Heating/Cooling Rates	B, C, D, E, F, G
2. Brazing Temperature	
3. Atmosphere	B, D, E, F
4. Surface Preparation	
5. Stop-off Usage	B, F, G
6. Fixturing	A, B, D, E, F, G

Qualification

A. Dimensional Analysis

B. C-scan and/or X-ray

C. Hardness

D. Tensile

E. Visual inspection, no magnification

F. Pressure Test i.e. proof, burst, or working pressure

G. Flow testing

N. SUBSTANTIATION TESTING FOR EDM

Process Change	Qualification Requirements
1. Machine/power supply	A, B, C, D
2. Machine type	
3. Electrode geometry	
4. On/Off time or frequency	
5. Nominal gap voltage	
6. Peak current	
7. Capacitance	
8. Sensitivity or servo/servo adjustment	
9. Dielectric	
10. Electrode polarity	
11. Electrode material	

Qualification

A. Dimensional Analysis

B. Finish (if applicable)

C. Visual Inspection, 7X minimum

D. Metallurgical section/evaluation

O. SUBSTANTIATION TESTING FOR PLATING

Process Change	Qualification Requirements
1. Surface Prep (mechanical (blasting etc.), organic solvent, chemical, electrochemical, reverse current, …)	B
2. Masking	A
3. Racking	
4. Plating solution composition changes of outside of the manufacturer's suggested operating range*	A, B, C
5. Current density changes outside of the manufacturer's suggested operating range*	
6. Decrease in frequency of chemical analysis of plating solutions.	
7. Exceeding manufacturer's recommended metal turns	

Qualification

A. Dimensional Analysis for plating thickness

B. Adhesion test, ASTM B571

C. Surface morphology - compare to samples from before the change – for wear resistant coatings, 500x suggested magnification (coating type dependent). Changes in nodularity will affect performance.

* "Manufacturer's suggested range" applies to purchased plating formulations. For self-formulations, substitute "established operating range"

P. SUBSTANTIATION TESTING FOR THERMAL CUTTING – Laser, Plasma, Electron Beam processes

These processes are characterized by their high energy density.

For Laser cutting, SP-1162 can be used equivalently.

Changes may affect post-cutting treatment requirements.

Process Change	Qualification Requirements
1. Different machine	A, B
2. Cutting rate	
3. Power	
4. Spot size	
5. Pulse frequency	
6. Pulse duration	
7. Pulse energy	
8. Pulse rate	
9. Working distance	
10. Location of focus in relationship to the work	
11. Assist gas composition	
12. Assist gas pressure	
13. Assist gas flow rate	
14. Shielding medium	
15. Workpiece cooling method	

Qualification

A. Microstructure: surface irregularity, recast layer, cracks in the recast layer, cracks in the base metal, oxide layer thickness. Definitions and acceptance criteria can be found in SP-1162.

B. Dimensional inspection

Q. SUBSTANTIATION FOR HYDROGEN FURNACE BRAZING

Process Change	Qualification Requirements
1. Belt Speed	A, B, C, D
2. Temperature	
3. Atmosphere	
4. Filler Metal	
5. Joint configuration Clearance or Length	
6. Braze alloy form/application	B, C, D
7. Surface preparation	
8. Furnace loading	A, B, C, D
9. Racking	
10. Flux/stop-off usage	
11. Fixturing	
12. Tack Welding	

Qualification

A. Dimensional analysis

B. Metallographic sectioning

C. Visual inspect at 7X minimum

D. Functional test when indicated by the engineering print (x-ray, leak check, load test, etc.)

NOTE: Re-verification of joint integrity after all subsequent thermal processing has been completed MUST be considered