eQuaLified	**Program Document HTBOK**	**PD 6103** **HTBoK-009/PL-2 REV. N/A** Issued **24-Aug-15** Revised: **N/A** Superseding **N/A**

BODY OF KNOWLEDGE:

ROLE DESCRIPTION: Titanium Alloy Heat Treatment Planner
SPECIAL PROCESS: Titanium Alloy Heat Treatment
SCOPE/METHOD: Performance of Titanium Alloy Heat Treat Requirements
LEVEL: Planner

All eQuaLified examinations are created using the applicable eQuaLified Body of Knowledge (BoK), which defines the baseline knowledge and experience required to be considered competent to perform the specified job role in aerospace special process manufacturing.

All eQuaLified BoKs are created by subject matter experts through an exhaustive job analysis process as detailed in the eQuaLified Program Document 6100: Industry Managed Special Process Bodies of Knowledge. All eQuaLified BoKs are updated periodically according to the requirements of the current eQuaLified PD6100 document to ensure they are consistent with current industry practice.

1. INTRODUCTION

This document has been created by the eQuaLified Heat Treat Body of Knowledge Review Board (HT BoKRB) according to the requirements of eQuaLified Program Document PD6100 Industry Managed Special Process Bodies of Knowledge.

This document constitutes the eQuaLified BoK for Titanium Alloys Planner. It defines the baseline knowledge and experience required to be considered competent to perform this role.

Unless otherwise stated, the HT BoKRB has followed guidelines as detailed in the current version of IAQG Guidance International Aerospace Quality Group PCAP 001 (Competence Management Guideline) to develop this BoK.

The information in this BoK will provide guidance for the following:

- Training providers who wish to develop training courses intended to support eQuaLified examination candidate preparation
- Heat Treat Examination Review Board (HT-ERB) for the development of eQuaLified examinations
- Candidates taking eQuaLified examinations who wish to prepare in advance

2. REFERENCES

eQuaLified documents:

PD6000	Governance & Administration of eQuaLified Program
PD6100	Industry Managed Special Process Bodies of Knowledge
PD6200	Industry Managed Special Process Examinations System

IAQG documents:

IAQG Guidance PCAP 001 Competence Management Guideline

3. DEFINITIONS

Definitions described within are specific to the Special Process BoK. For program-specific definitions, please refer to either the PD 6000 or the eQuaLified Dictionary.

BODY OF KNOWLEDGE (BoK): Baseline knowledge and experience required to be considered competent for a target position.

GENERAL EXAMINATION: The General Examination is designed to ascertain the candidate's general knowledge required for a particular job, role or activity. All of the questions will be derived from the corresponding BoK.

EXPERIENCE: The accumulation of knowledge or skill that results from direct participation in events or activities over a period of time.

KNOWLEDGE: Information / understanding acquired over a period of time. Information acquired through study and retained over that period of time (education, training, experience etc.) The combination of data and information, to which is added expert opinion, skills and experience, to result in a valuable asset which can be used to aid decision making and problem solving.

LEVEL: A class or division of a group based on education, training and experience. There are 3 levels: Operator, Planner and Owner. Please refer to the current version of PD 6000 for definitions

METHOD: A well-defined division of a SPECIAL PROCESS widely recognised by industry. A specific area of a special process for example anodizing within Chemical Processing

NON-SPECIAL PROCESS RELATED REQUIREMENTS: Miscellaneous requirements such as Health and Safety, Environmental, etc.

PERSONAL ATTRIBUTES: A quality or characteristic expected and required for a particular job, role or activity.

PRACTICAL EXAMINATION: The Practical Examination shall consist of a demonstration of proficiency in performing tasks that are typical of those to be accomplished in the performance of the candidate's duties. The examination content is derived from the corresponding BoK.

SKILL: Ability to perform a particular task. The quality of being able to do something that is acquired or developed through training or experience.

SPECIFIC EXAMINATION: The Specific Examination shall cover requirements and use of the specifications, codes, equipment, operating procedures and test techniques the candidate may use in the performance of his/her duties with the employer. Examination content will be derived from the corresponding BoK where applicable

WEIGHTING: The "weighting" of each line item, using a scale of 1, 3, 7, 10, (1 being least important; 10 being most important) indicates the relative importance of that aspect of the BoK and will determine the likelihood and frequency of a question on that topic appearing in the examination

4. GUIDANCE TO EXAMINATION CANDIDATES

All eQuaLified examination candidates are recommended to read all documents referenced in section 2 of this document.

As stated in eQuaLified PD6200, every eQuaLified exam question shall relate directly to and be derived from the information as detailed in the current version of the BoK.

Re-assessment to this BoK is required every 5 years, unless otherwise specified.

Candidates are therefore advised to ensure familiarity with all aspects of the BoK as detailed in Table 1. This can be done through:

- Self-study
- Completion of internal training
- Completion of external training (a list of eQuaLified approved providers can be found at www.eQuaLified.com)

Records of all qualified personnel shall be maintained and include:

- Date of Qualification
- Results of Written
- Results of Practical (if applicable)
- Results of Experience

5. LEVELS

	Level		
Descriptors	**Operator (OP)** *Understand and perform the hands-on operations of the special process for which qualification is sought.*	**Planner (PL)** *Capable of selecting manufacturing processes and interpreting process procedures to conform to customer specification and requirements.* *Capable of problem solving and resolving day to day issues.*	**Owner (OW)** *Capable of writing, reviewing and approving processes, procedures and qualifications of Operators and Planners. Capable of designing new processes and resolving issues among other levels.*
Titanium Alloy Specific Criteria	Basic understanding of the HT / Titanium Alloy process including Quenching, Annealing, Aging, over aging and when vacuum HT is required	In addition to knowing what the Operator does, the Planner must: Be capable of interpreting customer requirements and converting them into clear work instructions at the proper level of operator understanding.	In addition to knowing what the Operator and Planner do, the Owner must: Manage people that perform the work and evaluate and reviews reports; must have knowledge of "how" to run the testing.
Technical Knowledge	Basic knowledge of the special process, its main processes, methods and tools.	Good level of knowledge in all aspects of the special process, all its processes, methods and tools. Ability to coach others on contents and methods in the context of their workplace.	High or extensive knowledge in all aspects of the special process, all its processes, methods and tools to assess and validate improvements. Able to contribute to set externally recognized standards. Ability to define contents and methods for using knowledge effectively in influencing and developing international processes. Ability to influence the process with one's knowledge.
Experience	Sufficient experience to deal with recurrent activity.	Has enough experience to deal with unforeseen issues.	Wide proven experience of the subject. Is recognized specialist within the special process.
Personal Attributes	Takes into consideration behavioral characteristics such as but not limited to: team working, communication, direction and purpose, innovation and problem solving, mutual trust and respect, confidentiality and trustworthiness.		
Skills	Describes the activities necessary to perform each level of job function to comply with the Body of Knowledge		
Non-Special Process Related Requirements	Health & Safety, Environmental, Quality System Requirements.		

Special Process Bodies of Knowledge Review Boards must complete Table 1 to form the BoK

TABLE 1

ROLE DESCRIPTION: Titanium Alloy Heat Treatment---Planner
SPECIAL PROCESS: Titanium Alloy Heat Treatment
SCOPE / METHOD: Performance of Titanium Alloy Heat Treat Requirements
REFERENCE GUIDELINES: AMS2801, AMS-H-81200, AMS2769, AMS2750, AC7102, AC7102/8, AS9100
Revisions are as shown in Addendum 1

Row #	COMPETENCE	Level (e.g. OP, PL, OW, T1)	Weight (1,3,7,10)	Exam Type Gen/Specific /Practical	Reference Guidelines
1	**KNOWLEDGE:** The basic knowledge of the special processes, methods and tools				
2	**General Quality Systems Knowledge:**				
3	Knowledge and understanding of Aerospace Quality Systems and compliance.	PL	7	GEN	AS9100, AC7102, AC7102/8 8.0
4	Full and complete understanding of company practices for content of internal work instructions as well as interpretation of industry standards (see Addendum -1 of this document)	PL	7	GEN	AS9100, AC7102, AC7102/8
5	Knowledge and understanding of how non-conformance is controlled using tools such as Root Cause Corrective Action	PL	7	GEN	AS9100, AC7102
6	Knowledge and understanding of safety compliance requirements as applicable.	PL	7	GEN	AS9100, AMS2769
7	Knowledge and understanding of traceability of calibration to NIST or equivalent agencies.	PL	7	GEN	AC7102/8 2.1.2
8	Knowledge and understanding that contracts and incoming purchase orders must be reviewed and flowed down internally and to subcontractors	PL	7	GEN	AC7102 3.2.1
9	Knowledge and understanding that there must be a procedure in place to address software control, that there must be evidence to support this. In addition software revisions must be verified by first lot inspection to ensure compliance with customer requirements	PL	7	GEN	AC7102 3.10
10	Knowledge and understanding that identification, count and quality discrepancies must be resolved prior to processing of parts and that incoming customer documents remain traceable to specific jobs, as applicable.	PL	7	GEN	AC7102 5.1.1, 5.1.2
11	Knowledge and understanding that the acceptance status and any test data are recorded on the shop paper only after the operation for that job has been completed.	PL	7	GEN	AC7102 6.1.4
12	Knowledge and understanding that sampling plans have requirements based on specification and customer requirements	PL	7	GEN	AC7102 6.2
13	Knowledge and understanding that current operating manuals or instructions must be available to furnace operators, maintenance personnel and other personnel requiring the information.	PL	7	GEN	AC7102 9.1.1.1
14	Knowledge and understanding that all components of each furnace that can affect the functionality are inspected and maintained in accordance with a documented preventative maintenance schedule.	PL	7	GEN	AC7102 9.2.1
15	Knowledge and understanding that internal procedures must specify how atmospheres are to be controlled and monitored to ensure conformance to requirements of specifications and customer requirements.	PL	7	GEN	AC7102 9.3.1
16	Knowledge and understanding that flow meters be operational and appropriate for the gas and flow rates used, that inspection and maintenance schedule include periodic checks of flow meters, and that there should be an internal procedure to address the safety shut-off valves and the emergency gas purges.	PL	7	GEN	AC7102 9.4.1, 9.4.2, 9.4.3
17	**GENERAL METALLURGICAL KNOWLEDGE RELATED TO HEAT TREATING TITANIUM ALLOYS (Applicable to all specifications):**				
18	Understand the importance of generating work instructions that incorporate Pyrometry requirements including temperature sensors, instrumentation, thermal processing equipment, system accuracy tests, and temperature uniformity surveys and reporting of non-conformance.	PL	7	PRAC	AS9100, AMS2750
19	Knowledge and understanding that when re-heat treatment is performed it must be checked for its allowance and requirements	PL	7	PRAC	AC7102 3.3.2
20	**Understanding of Heat Treatments applied to Titanium Alloys:**				
21	Anneal Solution Heat Treat Beta Anneal Beta Solution Heat Treat Recrystallization Anneal Duplex Anneal Age Stress Relief Cold Work and Age Beta Solution Treat and Overage	PL	7	GEN	AMS-H-81200, AMS2801

	Solution Treat and Age Solution Treat and Overage				
22	Understanding of the importance of clear planning to allow for meeting and documenting Quench Delay times.	PL	7	GEN	AMS-H-81200, AMS2801, AC7102
23	**Understanding of the definitions and importance of terms applicable to Heat Treatment of Titanium Alloys**				
24	Set Temperature Recovery Time Start of Soak End of Soak Quench Delay Alpha Case Beta Transus Leak Rate Hydrogen Pickup or Contamination Alpha Alloys Beta Alloys Alpha-Beta Alloys	PL	7	GEN	AMS-H-81200, AMS2801, AMS2769, AC7102
25	Understanding of why correct selection and flow down to operators of set temperatures and furnace uniformity is important.	PL	7	GEN	AMS-H-81200, AMS2801, AMS2769, AC7102
26	Understanding of the importance of selecting minimum and maximum treatment times, including clear definition to operators as to how start and end of soak are determined and whether they are based on furnace (controller) readings or actual metal temperature (load thermocouples).	PL	7	GEN	AMS-H-81200, AMS2801, AC7102
27	Knowledge and understanding of when planning requires the use of a vacuum and the level of vacuum required.	PL	7	GEN	AMS-H-81200, AMS2810
28	Knowledge and understanding that planning must reflect use of heat treating equipment and instruments for the heat treatment of titanium alloys that are in accordance with applicable specifications.	PL	7	GEN	AC7102, AC7102/8
29	Knowledge and understanding that planning must specify heat treating facilities that possess the correct temperature uniformity, instrument accuracy and resolution for the heat treating of titanium alloys in accordance with applicable specifications.	PL	7	GEN	AC7102, AC7102/8
30	Knowledge and understanding that above 1000 °F (538 °C) titanium alloy planning must incorporate the applicable testing, atmosphere, protective coating and restrictions.	PL	7	GEN	AMS-H-81200, AMS2801, AMS2769
31	Knowledge and understanding of uniqueness of titanium heat treating with regards to the formation of alpha case and sensitivity of mechanical properties (strength, ductility, and notch and fracture toughness) to solution temperature.	PL	7	GEN	AMS-H-81200 6.3.2, AMS2801, AMS2769
32	**Racking, Fixturing and Spacing**				
33	Knowledge and understanding that planning must include specially designed fixturing and racking method, if required.	PL	7	GEN	AMS-H-81200, AMS2801, AMS7102 9.14
34	Knowledge and understanding that planning include internal procedures, racking sketches or other means to ensure spacing is adequate for circulation of the heating medium and coolant/quenchant as required by the applicable specification.	PL	7	GEN	AMS-H-81200, AMS2801, AMS7102 9.14
35	Knowledge and understanding that planning must have internal procedures to require that racks are examined for integrity, cleanliness (as required by specification) and repaired or scrapped as necessary.	PL	7	GEN	AAMS-H-81200, AMS2801, AMS2769 AMS7102 9.14
36	Knowledge and understanding of material to be used for racks, supports or fixturing.	PL	7	GEN	AMS-H-81200, AMS2769
37	**Quench Delay**				
38	Knowledge and understanding that planning must include that quench mechanisms must be capable of meeting the maximum quench delay provisions of the applicable specifications	PL	7	GEN	AC7102 9.9
39	**Spray Quench**				
40	Knowledge and understanding of when spray quench is allowed.	PL	7	GEN	AMS-H-81200
41	**Quenchant Maintenance**				
42	Knowledge and understanding that planning must include that quenchant temperature must be controlled and documented for applicable specifications.	PL	7	GEN	AMS2750, AMS2801, AC7108/8 4.4.3, AC7102 9.10.1
43	Knowledge and understanding that for planning that includes quenchant temperature, the recording and controlling equipment must be calibrated.	PL	7	GEN	AMS2750. AMS2801, AC7102 9.10.2
44	Knowledge and understanding that planning must require agitation or circulation as applicable to certain specifications.	PL	7	GEN	AMS2801, AC7102 9.10.3
45	**Polymer Quenchants**				
46	Knowledge and understanding that planning must include requirement that polymer quenching only be used when permitted by specification for the alloy and metal thickness.	PL	7	GEN	AMS2801, AC7102 9.11.1
47	Knowledge and understanding that planning must define polymer concentration when used and that concentration be recorded.	PL	7	GEN	AMS2801, AMS2769, AC7102 9.11.2
48	**Quench Effectiveness/Testing**				
49	Knowledge and understanding that planning must include testing that validates the quench effectiveness and its consistency per the applicable specification.	PL	7	GEN	AMS2801, AMS-H-81200, AC7102 9.12.2

50	Knowledge and understanding that planning specify the frequency and method for testing oil quenchants when specified by customer requirements.	PL	7	GEN	AC7102 7.1, 9.12.1
51	Knowledge and understanding that planning must include a system to control test coupons/specimens/blanks and their use when required.	PL	7	GEN	AMS-H-81200, AMS2801. AMS2769. AC7102 7.9.1
52	Knowledge and understanding that documentation must support that the use of coupon/specimens/blanks is in accordance with procedures and applicable specifications	PL	7	GEN	AC7102 7.9.2 AMS-H-81200, AMS2801
53	Knowledge and understanding that planning must include procedures for the control of hydrogen pickup/ contamination that meets the method and frequency of customer requirements and applicable specifications.	PL	7	GEN	AMSH-81200, AMS2801, AC7102 7.9.3
54	Knowledge and understanding that special customer requirements may include fatigue strength, fracture toughness, and microstructure and macrostructure conformity, in addition to tensile and surface contamination requirements.	PL	7	GEN	AMSH-81200, AMS2801, AC7102 12.14
55	**Quench Gas**				
56	Knowledge and understanding that planning for vacuum heat treating must include the quench gas purity and/or dew point requirements per the applicable specifications.	PL	7	GEN	AMS2769, AMS2801, AMS-H-81200, AC7102 11.2.1
57	**Cleanliness**				
58	Knowledge and understanding that procedures for cleaning Titanium alloys must exclude the use of halogenated substances or require additional cleaning.	PL	7	GEN	AMS2801, AMS-H-81200, AC7102 5.4.1
59	Knowledge and understanding that planning must include the cleaning requirements of both finished and non-finished surfaces depending on the applicable specification.	PL	7	GEN	AMS2801, AMS-H-81200, AC7102 5.4.2
60	Knowledge and understanding that planning must include procedures or documentation specifying cleaning of parts and baskets/fixtures/racking/tooling to ensure freedom from contamination during vacuum heat treating.	PL	7	GEN	AMS2769, AC7102 11.1.1
61	**Vacuum Furnaces**				
62	Knowledge and understanding that planning must include leak testing per applicable specification.	PL	7	GEN	AMS2769, AMS-H-81200, AMS2801, AC7012 11.2.1
63	Knowledge and understanding that planning must include a condition cycle (clean-up, bake-out, burn-out) per applicable specification.	PL	7	GEN	AMS2769, AMS7102 11.2.1
64	Knowledge and understanding that planning must include periodic checking of the dew point for partial pressure atmosphere, as the gas enters the furnace per the applicable specification(s).	PL	7	GEN	AMS2769, AMS-H-81200, AMS2801, AC7102 11.2.1
65	Knowledge and understanding that planning must include the calibration interval and acceptance criteria of the vacuum system's sensor, recorder and control panel meet the applicable specifications.	PL	7	GEN	AMS2769, AC7102 11.2.2-.4
	REQUIREMENTS SPECIFIC TO PRODUCT PROCESSED (in accordance with the relevant AMS):				
1	**SPECIFIC REQUIREMENT RELATED TO HEAT TREATMENT OF TITANIUM AND TITANIUM ALLOY MILL PRODUCTS (RAW MATERIAL) INCLUDING WROUGHT AND CAST PRODUCTS TO AMS-H-81200 (ONLY APPLICABLE IF PROCESSING TO AMS-H-81200)**				Paragraph references are for AMS-H-81200 Unless otherwise specified
2	Knowledge and understanding that this specification covers the heat treatment of titanium and titanium allow mill products (raw material), including wrought and cast products, by material producers. AMS-H-81200 also covers furnace equipment requirements, test procedures, and general information for heat treating procedures, heat treating temperatures and material test procedures for the heat treatment of titanium and titanium alloys. AMS-H-81200 also describes procedures that, when followed, have produced the desired properties within the limitations of the respective alloys.	PL	7	GEN	1.1
3	Knowledge and understanding of that the specification applies to specific alloys and heat treatments.	PL	7	GEN	1.2 and 1.3
4	Knowledge and understanding of the order of precedence that AMS-H-81200 has with referenced specifications.	PL	7	GEN	2.3
5	**REQUIREMENTS**				3
6	Knowledge and understanding that heating and quenching procedures applied shall yield products complying with the requirements of appropriate acquisition documents. Also that deviations from process requirements or the application of processes different from AMS-H-81200 may be used, provided compliant products result, the exceptions have been proven satisfactory, and that they are made known to the purchaser with accompanying data or other justification prior to application of the deviant process. In addition, equipment and procedures shall be designed to minimize the introduction of hydrogen, oxygen, nitrogen or other contaminants as well as being compliant with levels established by the acquisition documents.	PL	7	GEN	3.1
7	Knowledge and understanding that heat treat response samples shall conform to AMS2801 and that parts (as opposed to raw material) shall be heat treated in accordance with AMS2801	PL	7	GEN	3.1.1

<table>
<tr><td></td><td>unless, for specific parts, that AMS-H-81200 was used and was acceptable to the purchaser.</td><td></td><td></td><td></td><td></td></tr>
<tr><td>8</td><td>Batch Furnaces</td><td></td><td></td><td></td><td></td></tr>
<tr><td>9</td><td>Knowledge and understanding that only certain heat sources and atmospheres for batch furnaces are allowable.</td><td>PL</td><td>7</td><td>GEN</td><td>3.2.1.1</td></tr>
<tr><td>10</td><td>Knowledge and understanding that inert gases must be circulated and that there is a dew point requirement for inert gases.</td><td>PL</td><td>7</td><td>GEN</td><td>3.2.1.2</td></tr>
<tr><td>11</td><td>Knowledge and understanding that vacuum furnaces used for outgassing hydrogen must be capable of reducing hydrogen concentrations to the requirements of appropriate acquisition documents. Also that vacuum furnaces and retorts used for prevention of surface contamination must be capable of yielding product conforming to appropriate acquisition documents (ref. Para. 3.1, general requirements)</td><td>PL</td><td>7</td><td>GEN</td><td>3.2.1.3</td></tr>
<tr><td>12</td><td>Knowledge and understanding that furnaces heated by the combustion of gas or oil in air contain a slightly oxidizing gas mixture and that no flame shall impinge on the furnace charge.</td><td>PL</td><td>7</td><td>GEN</td><td>3.2.1.4</td></tr>
<tr><td>13</td><td>Knowledge and understanding that there are prohibited atmospheres for batch furnaces.</td><td>PL</td><td>7</td><td>GEN</td><td>3.2.1.5</td></tr>
<tr><td>14</td><td>Knowledge and understanding of that there are purging requirements and they differ depending on the atmosphere to be used.</td><td>PL</td><td>7</td><td>GEN</td><td>3.2.1.6
AC7102 9.5.1</td></tr>
<tr><td>15</td><td>Knowledge and understanding that batch furnaces be controlled to maintain a temperature applicable to the material and heat treatment being processed. (Table 1, 3, 4 or 5). Knowledge that the minimum and maximum temperatures given in said tables are valid set points and that, for a given process and set point, applying offsets as applicable, the temperature uniformity tolerances are:
<table>
<tr><th>Heat Treatment</th><th colspan="2">Temperature Uniformity Tolerance</th></tr>
<tr><th></th><th>°F</th><th>°C</th></tr>
<tr><td>Annealing</td><td>±25</td><td>±14</td></tr>
<tr><td>Beta annealing or beta solution heat treating</td><td>±25</td><td>±14</td></tr>
<tr><td>Recrystallization annealing</td><td>±25</td><td>±14</td></tr>
<tr><td>Duplex annealing</td><td>±25</td><td>±14</td></tr>
<tr><td>Solution heat treating</td><td>±25</td><td>±14</td></tr>
<tr><td>Stress relieving</td><td>±25</td><td>±14</td></tr>
<tr><td>Aging</td><td>±25</td><td>±14</td></tr>
</table></td><td>PL</td><td>7</td><td>GEN</td><td>3.2.1.7</td></tr>
<tr><td>16</td><td>Continuous Furnaces</td><td></td><td></td><td></td><td></td></tr>
<tr><td>17</td><td>Knowledge and understanding that only certain heat sources for continuous furnaces are allowable.</td><td>PL</td><td>7</td><td>GEN</td><td>3.2.2.1</td></tr>
<tr><td>18</td><td>Knowledge and understanding that continuous induction heating shall be applied only to the annealing of thin-walled tubing and extrusions of thin sections and that the technique shall be such that the work piece being heated is of uniform temperature around the perimeter of its cross-section. Also prior to production, values of the process parameters that produce acceptable product shall be determined and documented.</td><td>PL</td><td>7</td><td>GEN</td><td>3.2.3</td></tr>
<tr><td>19</td><td>Quenching</td><td></td><td></td><td></td><td></td></tr>
<tr><td>20</td><td>Knowledge and understanding that quenching baths are primarily designed to meet properties after subsequent aging and that mechanical stirring is allowed.</td><td>PL</td><td>7</td><td>GEN</td><td>3.3.1</td></tr>
<tr><td>21</td><td>Knowledge and understanding that the use of salt baths for quenching is prohibited.</td><td>PL</td><td>7</td><td>GEN</td><td>3.3.4</td></tr>
<tr><td>22</td><td>Thermal Treatment Parameters</td><td></td><td></td><td></td><td></td></tr>
<tr><td>23</td><td>Knowledge and understanding that heat treatments covered by AMS-H-81200 are covered per the applicable table, except when beta annealing or beta solution is specified, in which case instructions are per paragraph 3.5.6 (beta annealing).</td><td>PL</td><td>7</td><td>GEN</td><td>3.5</td></tr>
<tr><td>24</td><td>Knowledge and understanding that for heat treatments not covered explicitly by AMS-H-81200, all units of a lot shall be heated uniformly and on the whole piece, never on a portion only. For coiled product heated within a continuous furnace or straight product heated within an induction coil, the product shall be heated uniformly in its cross-section.</td><td>PL</td><td>7</td><td>GEN</td><td>3.6.1</td></tr>
<tr><td>25</td><td>Knowledge and understanding that surfaces of material to be heat treated must be free of anything that will cause the product to become noncompliant. However material coated with light oils need not be cleaned prior to thermal treatment, provided that the oil either vaporizes or burns off during preheating. Furthermore halogenated solvents and methanol can be used to degrease work pieces, provided work pieces are subsequently cleaned using an alkaline solution or an acid pickle before thermal treatment.</td><td>PL</td><td>7</td><td>GEN</td><td>3.6.2</td></tr>
<tr><td>26</td><td>Knowledge and understanding that excessive hydrogen concentration found in a lot may be reduced to an acceptable concentration by heating the lot in a vacuum furnace conforming to AMS-H-81200 requirements. However, such action shall be reported to the purchaser. Also heating under vacuum that results in over aging of a lot shall be cause for rejection of that lot. Salvage by re-solution heat treating and aging shall be performed only with the consent of the purchaser. Records of all re-heat treatments shall be prepared and maintained in accordance with other furnace record requirements.</td><td>PL</td><td>7</td><td>GEN</td><td>3.6.5.1</td></tr>
<tr><td>27</td><td>Knowledge and understanding that surface contamination after heat treatment must be removed by chemical or mechanical means. The surfaces of machined, ground, blasted or acid-pickled work pieces shall not exhibit the effects of absorbed oxygen or nitrogen to the degree that the</td><td>PL</td><td>7</td><td>GEN</td><td>3.6.6</td></tr>
</table>

	surface contamination of the product exceeds the levels specified in the acquisition documents when tested metallographically in accordance with AMS-H-81200				
28	**Monitoring**				
29	Knowledge and understanding that periodic monitoring of heat treated work pieces to determine compliance with specification must include evaluation of tensile and bend properties, as applicable.	PL	7	GEN	3.7
30	Knowledge and understanding that tensile properties be in compliance with applicable acquisition documents and be In accordance with AMS-H-81200 unless otherwise specified in acquisition documents.	PL	7	GEN	3.7.1
31	Knowledge and understanding that bend properties apply to flat-rolled product of 0.1874 inch (4.76 mm) nominal thickness or less and that sample prepared, tested and examined per AMS-H-81200.	PL	7	GEN	3.7.2
32	**QUALITY ASSURANCE PROVISIONS**				
33	Knowledge and understanding that the absence of any inspection requirements in the specification shall not relieve the producer of the responsibility of ensuring that all products or supplies submitted to the purchaser for acceptance comply with all requirements of the purchase document. Sampling inspection, as part of manufacturing operations, is an acceptable practice to ascertain conformance to requirements, however, this does not authorize submission of known defective material, either indicated or actual, nor does it commit the purchaser to accept defective material.	PL	7	GEN	4.1.1
34	Knowledge and understanding that the following periodic tests are requirements and unless otherwise specified by customer, the frequencies, as applicable to furnace type, are: a. Daily check of the dew point of the inert gases. b. Weekly checks for hydrogen pickup or contamination, except for processes wherein every thermally treated lot is analyzed, or for treatments in a vacuum furnace or in inert gas. c. At least one surface contamination examination weekly of product thermally treated in a vacuum furnace or in inert gas, in order to detect possible leakage. d., e., f. Instrument calibration, SATs and TUS's in accordance with AMS2750.	PL	7	GEN	4.2.1
35	Knowledge and understanding that preproduction tests are required before any production heat treating can occur and that those tests, as applicable to furnace type, are: a. Furnace temperature uniformity or distribution in accordance with paragraph 4.4(survey requirements), as applicable. b. Pyrometry system accuracy in accordance with AMS2750. c. Furnace instrument calibration in accordance with AMS2750. d. Dew point of the inert gas when such gas is used. e. Hydrogen contamination. f. Leak rate	PL	7	GEN	4.2.2
36	Knowledge and understanding that pyrometric calibration, heat treating equipment testing and procedures for checking the accuracy of pyrometric systems shall be in accordance with AMS2750	PL	7	GEN	4.3, 4.5
37	**Survey Requirements**				
38	Knowledge and understanding that unless otherwise specified, survey requirements shall be in accordance with AMS2750	PL	7	GEN	4.4
39	Knowledge and understanding that for continuous furnaces, all gaseous atmospheres, thermocouples shall be placed in the furnace in the number and locations that will enable the determination of entry-to-exit temperatures profiles at each working temperature. A minimum of two thermocouples shall be attached to each furnace charge and accompany the charge through the furnace.	PL	7	GEN	4.4.4.2
40	Knowledge and understanding that for continuous furnaces, Vacuum, when the furnace charge cannot be wired with thermocouples without destroying the vacuum, the survey shall entail inspections of product after thermal treatment. Such inspections shall include, but not be limited to: tension tests, bend tests, determination of hydrogen concentration, and metallographic examinations. Such inspections shall be performed on the first lot of each product passed through a new or refurbished furnace	PL	7	GEN	4.4.5.2
41	Knowledge and understanding that only solution heat treating, stress relieving, and annealing treatments shall be carried out by induction heating. The survey temperatures of max, min and separation of 600°F (ref. Para. 4.4.2 and AMS2750) shall be considered as non-mandatory. Other temperatures appropriate to products to be heat treated may be selected, provided that the requirements of general requirements of paragraph 3.1 are met.	PL	7	GEN	4.4.6.1
42	Knowledge and understanding that for induction heating, to determine uniformity of temperature around the cross-sectional perimeter of a work piece, a minimum of four thermocouples shall be attached around such perimeter approximately 90 degrees apart.	PL	7	GEN	4.4.6.2
43	Knowledge and understanding that for induction heating, work pieces with thermocouples attached shall be passed through the induction coil at a rate and power density that will result in sufficient heating to accomplish the desired result. Temperature readings need not be taken while the thermocouple hot junctions are within the induction coil. Several work piece passages at various rates and power densities may be needed before proper conditions can be determined.	PL	7	GEN	4.4.6.3
44	**Sampling for Product Monitoring**				
45	Knowledge and understanding that sampling shall be for inspection for conformance to paragraph 3.1, general requirements. The sampling and planning requirements of the subparagraphs of paragraph 4.6 (sampling for product monitoring) shall not apply to a product covered by a sampling plan within a product specification. Subject to the purchaser's approval, product specification test results may be used to satisfy any one of the inspections specified in paragraph 4.7 (tensile, bend, hydrogen, metallographic), to demonstrate conformance to general	PL	7	GEN	4.6

	requirements.				
46	Knowledge and understanding that a lot shall consist of a group of product units of the same heat, mechanically and thermally treated to substantially the same properties using the same pieces of equipment, such treatment being applied to the units as a batch, or to the group unit-by-unit over essentially a continuous time interval not to exceed 8 hours, and inspected at the same time. A unit of inspection is defined as one piece of rod, bar, sheet, plate, or shape, one coil of strip, or one forged or cast semi-finished part.	PL	7	GEN	4.6.1, 4.6.2
47	Knowledge and understanding that specimens for each inspection (tensile, bend, hydrogen, metallographic) shall be selected in accordance with the type of product (wrought, not forging; forging; standard products (nuts and bolts); cast part or induction heated product) and/or type of sampling (hydrogen concentration, surface contamination), as applicable. Specimens of suitable dimensions shall be removed from product where configuration and dimensions permit. Where such removal is impossible, specimens shall be taken from a sample piece of appropriate dimensions and of the same heat as a product unit that the sample is heat treated. Sampling requirements in governing specifications for the product may be used instead of AMS-H-81200 paragraph 4.6.3 subparagraphs.	PL	7	GEN	4.6.3
48	**Test Methods**				
49	Knowledge and understanding that unless other test methods are specified in other product acquisition documents, the test methods specified in AMS-H-81200, paragraph 4.7 (tensile, bend, hydrogen analysis, metallographic examinations) apply.	PL	7	GEN	4.7
50	Knowledge and understanding that when beta annealing of an alpha-beta alloy is specified, representative samples from the lot to be so annealed shall be taken for solution heat treating and quenching. Each test specimen shall be of such dimensions that its center will cool faster than the critical rate during the quench. A range of solution heat treating temperatures spanning the nominal beta transus shall be applied using a different temperature for each specimen. Following quenching, specimens for metallographic examination shall be prepared in accordance with ASTM E 3, as applicable, etched in a suitable solution, and examined at magnifications to 500X to determine the amount of primary alpha phase present. The temperature that this phase is no longer present shall be deemed the beta transus of the lot. Such temperature may be determined by interpolation. In lieu of metallography, a beta transus may be determined by means of a differential thermal analyzer.	PL	7	GEN	4.7.4.1
51	Knowledge and understanding that specimens selected for surface contamination shall be prepared according to ASTM E 3, as applicable, etched in a suitable solution, and examined at 400X or higher magnification to determine conformance to applicable acquisition documents.	PL	7	GEN	4.7.4.2
52	**Record Retention**				
53	Knowledge and understanding that unless otherwise specified in the acquisition documents, inspection records shall be on file for 5 years and shall be available for examination by the purchaser.	PL	7	GEN	4.8.1
54	Knowledge and understanding that furnace records relative to the identification and history of usage of each furnace shall be maintained as evidence of compliance with AMS-H-81200. Information recorded shall include as a minimum the furnace number or description, size, temperature range of usage, type(s) of thermal treatment applied (solution heat treatment, annealing, etc.), temperature(s) that uniformity was surveyed, dates of each survey, number and locations of thermocouples during each survey, and dates and other specifics of substantial repairs or alterations. These records shall be kept for 5 years after the date of performance or as otherwise specified in the acquisition documents.	PL	7	GEN	4.8.4
55	Knowledge and understanding that during a hydrogen outgassing treatment, the working temperature, the soaking time, and absolute pressure within the furnace shall be recorded.	PL	7	GEN	4.8.5
56	**Noncompliance**				
57	Knowledge and understanding that if any test result fails to meet the requirements specified herein, the cause of failure shall be determined and the equipment repaired if applicable. If tests indicate improper heat treatment, the equipment and process shall not be used for heat treatment of titanium alloys until the deviation(s) is corrected and satisfactory performance is re-established. Questionable material shall be investigated, categorized as conforming or non-conforming and disposed of accordingly. Evaluation of the equipment and/or material shall be documented and the appropriate corrective action shall be taken and documented. The quality assurance organization shall notify the purchaser of nonconformance when previously heat treated lots are suspect.	PL	7	GEN	4.8.6
58	**Shape Influence**				
59	Knowledge and understanding that most of the published literature and the data in this specification are based on tests of round specimens of various diameters. In order to apply these data successfully to actual parts, it is convenient to visualize the parts as simple geometric shapes such as rounds, hexagons, squares, plates or tubes. These shapes can then be considered as the size round that will have approximately the same cooling rates as that of the simple shape. The relationship between the various simple shapes and the corresponding rounds is shown in Figure 1 of AMS-H-81200.	PL	7	GEN	6.3.8
1	**SPECIFIC REQUIREMENT RELATED TO HEAT TREATMENT OF TITANIUM AND TITANIUM ALLOY PARTS TO AMS2801 (ONLY APPLICABLE IF PROCESSING TO AMS2801)**				
2	Knowledge and understanding that AMS2801covers the engineering requirements for specific heat treatments by part fabricators (users) or their vendors or subcontractors, of parts made from the specific alloys defined in AMS2801. Parts are defined as finished and semi-finished parts, including raw material, heat treated by the parts fabricators, or their vendors or subcontractors, during the fabrication process. Furthermore heat treatment of parts made from wrought raw material is any heat treatment not performed by or for a material producer. Parts, at the time of heat treatment, may resemble raw material.	PL	7	GEN	1.1, 1.1.2, 1.4, 8.2.2

<table>
<tr><td>3</td><td>Heat Treatment</td><td></td><td></td><td></td><td></td></tr>
<tr><td>4</td><td>Knowledge and understanding that AMS2801 may be used for heat treatment of parts made from alloys other than those specified, provided temperatures, times, and quenchants are specified by the cognizant engineering organization. It is also permissible, for specific parts, to use equipment, practices, and test methods which conformed to AMS-H-81200 or MIL-H-81200 and were previously acceptable to the purchaser.</td><td>PL</td><td>7</td><td>GEN</td><td>1.1.1</td></tr>
<tr><td>5</td><td>Knowledge and understanding that the temperature, soaking time, and cooling rate requirements specified in AMS2801 are applicable to testing of raw material by material producers, warehouses/distributors, and forge shops for capability to respond to heat treatment when some or all of these requirements are not included in the procurement specification.</td><td>PL</td><td>7</td><td>GEN</td><td>1.2</td></tr>
<tr><td>6</td><td>Knowledge and understanding that heat treatment shall be performed as specified in AMS2801 unless an alternate treatment has been specified by the cognizant engineering organization. Treatments for alloys not covered in AMS2801 shall be as specified by the cognizant engineering organization. In both cases, the treatment specified should include the name (e.g., anneal, age), the set temperature, the soaking time, and quench or cooling medium.</td><td>PL</td><td>7</td><td>GEN</td><td>3.2.3</td></tr>
<tr><td>7</td><td>Knowledge and understanding that heat treatment by material producers, forge shops, and warehouses/distributors, or their vendors, of sheet, plate, foil, bar, rod, wire, tubing, extruded shapes, forgings, and castings should be performed in accordance with the procurement specification.</td><td>PL</td><td>7</td><td>GEN</td><td>1.3</td></tr>
<tr><td>8</td><td>TECHNICAL REQUIREMENTS</td><td></td><td></td><td></td><td></td></tr>
<tr><td>9</td><td>Knowledge and understanding that pyrometry shall conform to AMS 2750.</td><td>PL</td><td>7</td><td>GEN</td><td>3.1.1</td></tr>
<tr><td>10</td><td>Knowledge and understanding that temperature uniformity shall be:

<table><tr><th>Heat Treatment</th><th colspan="2">Temperature Uniformity Tolerance</th></tr><tr><th></th><th>°F</th><th>°C</th></tr><tr><td>Annealing</td><td>±25</td><td>±14</td></tr><tr><td>Solution heat treating</td><td>±25</td><td>±14</td></tr><tr><td>Stress relieving</td><td>±25</td><td>±14</td></tr><tr><td>Aging</td><td>±15(1)</td><td>±8</td></tr></table>
(1)±10 °F (t6 °C) for parts made from the following five alloys if temperature is 1025 °F (552 °C) or lower: 6Al-6V-2Sn, 13V-11Cr-3Al, 15V-3Cr-3Al-3Sn, 10V-2Fe-3Al, and 3Al-8V-6Cr-4Mo-4Zr.</td><td>PL</td><td>7</td><td>GEN</td><td>3.1.2.1</td></tr>
<tr><td>11</td><td>Heating Media</td><td></td><td></td><td></td><td></td></tr>
<tr><td>12</td><td>Knowledge and understanding that air and non-inert atmospheres shall be free of reducing gases and other contaminants which may produce surface contamination in excess of that to be removed (descaled) or which may result in excess hydrogen pickup/contamination. Direct fired furnaces shall be controlled so that the flame is slightly oxidizing and there is no flame impingement on the parts. A coupon as defined in paragraph 3.1.2.2.5 shall accompany one load each week, heated above 1200 °F (649 °C), and be subsequently tested for excess hydrogen pickup and for surface contamination in excess of that to be removed. Parts with net dimensions shall not be heated above 1000 °F (538 °C) in air or non-inert atmosphere furnaces unless coated with a protective coating approved by the cognizant engineering organization.</td><td>PL</td><td>7</td><td>GEN</td><td>3.1.2.2.1, 3.1.2.2.1.2</td></tr>
<tr><td>13</td><td>Knowledge and understanding that parts heated above 1000 °F (538 °C) shall have requirements for surface contamination (i.e., alpha case) flowed down to vendors and operators.</td><td>PL</td><td>7</td><td>GEN</td><td>3.1.2.2.1, 3.1.2.2.1.2; AC7102 3.2.1</td></tr>
<tr><td>14</td><td>Knowledge and understanding that air and non-inert atmosphere furnaces to be used above 1200 °F (649 °C which have contained a contaminating atmosphere (e.g., endothermic, dissociated ammonia)) shall be equipped so as to prevent leakage of the contaminating atmosphere into the working zone. Such furnaces shall be purged and tested for hydrogen pickup before heat treating the first load of titanium parts.</td><td>PL</td><td>7</td><td>GEN</td><td>3.1.2.2.1.1</td></tr>
<tr><td>15</td><td>Knowledge and understanding that inert atmospheres (Helium and Argon) shall meet the composition requirements of MIL-PRF-27407, Type I, MIL-A-18455, or BB-H-1168 as applicable. The dew point of the gas shall be -65 °F (-54 °C) or lower as it enters the furnace. For loads to be heated above 1000 °F (538 °C), containing parts having surfaces from which no material will be removed, one coupon as defined in paragraph 3.1.2.2.5 shall accompany each load and be subsequently tested for alpha case. Test coupons are not needed for heat treatments under 1000 °F (538 °C).</td><td>PL</td><td>7</td><td>GEN</td><td>3.1.2.2.2</td></tr>
<tr><td>16</td><td>Knowledge and understanding that for vacuum furnaces, vacuum pressure and leak rate shall be determined at room temperature before heating each load. Vacuum pressure shall be lower than 0.1 µm of mercury and leak rate shall be lower than 3 µm of mercury per one-quarter hour with the vacuum pump isolated from the furnace chamber. Cooling may be accelerated by back-filling with inert gas conforming to paragraph 3.1.2.2.2. For loads to be heated above 1000 °F (538 °C) containing parts having surfaces from which no material will be removed, one coupon as defined in paragraph 3.1.2.2.5 shall accompany each load and be subsequently tested for alpha case. Test coupons are not needed for heat treatments under 1000 °F (538 °C).</td><td>PL</td><td>7</td><td>GEN</td><td>3.1.2.2.3</td></tr>
<tr><td>17</td><td>Knowledge and understanding that molten salt and fluidized beds are prohibited</td><td>PL</td><td>7</td><td>GEN</td><td>3.1.2.2.4</td></tr>
<tr><td>18</td><td>Knowledge and understanding of that coupons (for hydrogen and/or surface contamination) be of AMS 4901 (Titanium Sheet, Strip, and Plate, Commercially Pure, Annealed, 70.0 ksi (485 MPa))composition, nominally 0.020 inch (0.51 mm) thick by 1 inch (25 mm) wide shall be used to</td><td>PL</td><td>7</td><td>GEN</td><td>3.1.2.2.5</td></tr>
</table>

	confirm conformance with heating media requirements. Hydrogen pick-up by coupons heated in air and other non-inert atmosphere furnaces shall not exceed 25 ppm when analyzed in accordance with ASTM E 1447. Coupons heat treated in vacuum or inert gas atmosphere furnaces shall be free from surface contamination determined in accordance with either the microhardness or bend test of AMS 4901 or a metallographic technique approved by the cognizant quality assurance organization.				
19	Knowledge and understanding that for heat treat loads containing small parts (e.g., fastener components; rivets, bolts, nuts) such parts may be substituted for the coupons specified in paragraph 3.1.2.2.5.	PL	7	GEN	3.1.2.2.5.1
20	**Quenching**				
21	Knowledge and understanding that quench tanks shall be of sufficient size to permit complete immersion of parts and free movement of the quench medium adjacent to all surfaces of parts. Equipment shall be provided for agitation or circulation of the quench medium and/or the parts. The volume of quenchant, and any auxiliary cooling equipment, shall be sufficient to maintain (1) a water quench below 100 °F (38 °C) during the quench, (2) a polymer quench below 120 °F (49 °C), and (3) an oil quench between 60 and 160 °F (16 and 71 °C) at the start of the quench and below 200 °F (93 °C) during a quench. In addition, quench oils shall be used within the temperature range recommended by the oil manufacturer.	PL	7	GEN	3.1.4
22	**Cleaning**				
23	Knowledge and understanding that parts shall be cleaned, prior to heat treatment, in accordance with ASTM B 600 or other method approved by the cognizant engineering organization. Part surfaces shall be free of halogen compounds, such as residue from halogenated solvents and coolants, and salt from perspiration. Surfaces of parts, fixtures, racks, etc. shall be clean and free of dirt, water, oil, grease, paint, ink, crayon markings, die pick-up, fingerprints, and other foreign material. After cleaning and prior to heat treatment in inert gas or vacuum furnaces, personnel handling parts shall wear clean, white cotton gloves, or equivalent.	PL	7	GEN	3.2.1
24	Knowledge and understanding that verification of cleanliness per 3.2.1 before heat treat is essential and the last chance for verification.	PL	7	GEN	3.2.1
25	**Racking**				
26	Knowledge and understanding that part, other than rivets, bolts, nuts, and other small parts, shall be racked to ensure uniform heating and cooling throughout the load. These parts shall not be nested unless tests with load thermocouples (1) have established the necessary additional soaking time required and (2) have demonstrated that the arrangement will not affect uniformity of heating and cooling.	PL	7	GEN	3.2.2.1
27	Knowledge and understanding that rivets, bolts, nuts, and other small parts, with maximum thickness of 0.5 inch (13 mm), may be racked as parts, or heated and soaked in baskets or continuous furnaces. When processed in baskets, maximum thickness of layers and minimum space between layers shall be 1 inch (25 mm). When processed in continuous furnaces, parts shall not be layered.	PL	7	GEN	3.2.2.2
28	**Control Instruments**				
29	Knowledge and understanding that control instruments shall be set either at the set temperature specified or at an offset temperature based on the last temperature uniformity determination. The offset temperature shall be within 5 °F (3 °C) for aging and 10 °F (6 °C) for other treatments of the specified set temperature and shall be posted on the instrument. The offset temperature shall be selected to optimize the temperature distribution within the furnace so that the highest and lowest temperatures are equidistant from the set temperature. For solution heat treatment of loads without load thermocouples in air and atmosphere (inert and non-inert), furnaces shall be stabilized at the set or offset temperature before loading parts.	PL	7	GEN	3.2.4
30	Knowledge and understanding that the posting of offset temperatures shall preclude misinterpretation by specifying both the “desired” temperature and the corresponding “set” temperature (e.g., “When 700 °F is desired, set at 704 °F”).	PL	7	GEN	3.2.4.1
31	**Start of Soaking Time**				
32	Knowledge and understanding that for batch furnaces there are four methods for determining the start of soak. Method 1 is: When the furnace temperature, as shown by the controlling indicating or recording instrument(s), reaches the set or offset temperature.	PL	7	GEN	3.2.5, 3.2.5.1
33	Knowledge and understanding that for batch furnaces, determining the start of soak by Method 2 is: When the furnace temperature, as shown by the controlling indicator or recording instrument(s), reaches the *minimum of the applicable range* defined as the temperature described by the set or offset temperature minus the tolerance specified for furnace temperature uniformity.	PL	7	GEN	3.2.5.2, 3.2.5.2.1
34	Knowledge and understanding that for batch furnaces when Method 2 is used for determining the start of soak, at least 75% of soaking time shall be after the furnace temperature has reached the *half-tolerance temperature*. The *half-tolerance temperature* is the temperature described by the set or offset temperature minus half of the tolerance specified for furnace temperature uniformity.	PL	7	GEN	3.2.5.2.2, 3.2.5.2.2.1
35	Knowledge and understanding that for batch furnaces, determining the start of soak by Method 3 is: When the temperature of at least two load sensors in contact with parts reaches the *minimum of the applicable range* defined as the temperature described by the set or offset temperature minus the tolerance specified for furnace temperature uniformity.	PL	7	GEN	3.2.5.3, 3.2.5.2.1
36	Knowledge and understanding that for batch furnaces, determining the start of soak by Method 4 is: When the temperature of at least two load sensors in contact with parts, positioned so as to reflect the temperature at the center of the *coldest parts*, reaches the *half-tolerance temperature*. If this method is used, the soaking time may be reduced to that	PL	7	GEN	3.2.5.4, 3.2.5.4.1, 3.2.5.2.2.1

	shown in Table 2 for 0.10 inch (2.5 mm) thickness. The *coldest parts* are those in the coldest portion of the furnace as shown by the last temperature uniformity test. The *half-tolerance temperature* is the temperature described by the set or offset temperature minus half of the tolerance specified for furnace temperature uniformity.				
37	Knowledge and understanding that for continuous furnaces the soaking time starts when parts enter the zone of the furnace shown by the last temperature uniformity test to be within the range described by the set temperature and the applicable tolerance.	PL	7	GEN	3.2.5.5
38	**Thermal Treatment Parameters**				
39	Knowledge and understanding that solution heat treating shall be performed in accordance with Table 2. Re-solution treatment is permitted only when approved by the cognizant engineering organization.	PL	7	GEN	3.2.6
40	Knowledge and understanding that aging shall be performed in accordance with Table 4. Environment during cooling after aging shall be compatible with the heating environment, i.e., it shall not increase alpha case thickness.	PL	7	GEN	3.2.7
41	Knowledge and understanding that stress relieving shall consist of soaking for 2 hours ± 0.25 at 1100 °F (593 °C) and air or furnace cooling with the follow exceptions: • Parts made from beta alloys and any parts which have been solution heat treated (and not aged) shall not be stress relieved. • For aged parts, the stress relieving temperature shall be 50°F (28°C) below the aging temperature.	PL	7	GEN	3.2.8, 3.2.8.1, 3.2.8.2
42	Knowledge and understanding that annealing shall consist of soaking for 2 hours ± 0.25 at 1300 °F (704 °C) and air or furnace cooling with the follow exceptions: • Parts made from beta alloys and parts which have been solution treated (and not aged) shall not be annealed. • Parts made from 6Al-6V-2Sn alloy shall be cooled to 1000 °F (538 °C) at a rate of not over 300 °F (167 °C) degrees per hour. • Parts made from 5Al-2.5Sn alloy shall be annealed for 2 hours ± 0.25 at 1500 °F (816 °C) and air or furnace cooled.	PL	7	GEN	3.2.9, 3.2.9.1, 3.2.9.2, 3.2.9.3
43	Knowledge and understanding that descaling is required for parts heated above 1000 °F (538 °C) in an environment other than an inert atmosphere or vacuum. Sufficient material shall be removed to ensure uncontaminated material on all surfaces. Metal removal may be accomplished mechanically, by immersion in molten salt, by a chemical method in accordance with ASTM B 600, or by other method acceptable to purchaser. It need not be done immediately after heat treatment. It may be postponed until later in the manufacturing schedule. Table 5 provides an approximate guide for metal removal after heating in air.	PL	7	GEN	3.2.10, 3.2.10.1
44	**Qualification of Vendors (Subcontractors)**				
45	Knowledge and understanding that facilities performing heat treatment in accordance with this specification shall be approved in accordance with ARP1962 or other established procedures acceptable to purchaser. In addition personnel performing or directing the performance of heat treatment in accordance with this specification shall be approved in accordance with ARP1962 or other established procedures acceptable to purchaser.	PL	7	GEN	3.3.1, 3.3.2
46	**QUALITY ASSURANCE PROVISIONS**				
47	**Record Retention**				
48	Knowledge and understanding that records shall be available to purchaser for not less than five years after heat treatment. The records shall contain all data necessary to verify conformance to the requirements of this specification.	PL	7	GEN	4.2
49	**Logs**				
50	Knowledge and understanding that a record (written or electronic storage media), traceable to temperature recording information (chart(s) or electronic storage media) and to shop travelers or other documentation, shall be kept for each furnace and load. The information on the combination of documents shall include: equipment identification; approved personnel's identification; date; part number or product identification; number of parts; alloy; lot identification; actual thermal processing times and temperatures used. When applicable, atmosphere control parameters, quench delay, maximum thickness, quenchant type, polymer concentration and quenchant temperature shall be recorded. The maximum thickness recorded shall be the minimum dimension of the heaviest section of the part. The heat treat processor shall document instructions for measuring, logging, and reporting actual processing times and temperatures.	PL	7	GEN	4.4
51	**Report/Certification**				
52	Knowledge and understanding that the heat treating processor shall furnish, with each shipment of parts, a certified quality assurance report, traceable to the heat treat control number(s), stating that the parts were processed in accordance with the requirements of this specification. The report shall include: purchase order number; part number or product identification; alloy; temper/strength designation; quantity of parts in the shipment; identification of furnace(s) used; actual thermal processing times and temperatures used. When applicable, the report shall include: atmosphere type; quenchant (including polymer concentration range); hot straightening temperature and method of straightening (e.g. press, fixtures); actual test results, (e.g., hardness, conductivity, tensile, shear, etc.) and their conformance/nonconformance to requirements. The heat treat processor shall document instructions for measuring, logging, and reporting actual processing times and temperatures.	PL	7	GEN	4.5
53	**PREPARATION FOR DELIVERY**				
54	Knowledge and understanding that identification of parts provided to the heat treatment processor	PL			5.1, 5.2

	shall be maintained on the parts at delivery and that parts shall be packaged to ensure protection from damage during shipment and storage.				
55	**REJECTIONS**				
56	Knowledge and understanding that parts not meeting the requirements of this specification, or to modifications authorized by the cognizant engineering organization, will be subject to rejection and shall be submitted for disposition in accordance with purchaser's procedures for nonconformance.	PL			7.
1	**SKILLS:** Defined within these rolls describes the range of skills. The skills required to perform a particular special process task				
2	Capable of understanding, interpreting and complying with various customer requirements for precedence of documents	PL	7	GEN	General Industry
3	Capable of understanding, interpreting and complying with various customer requirements for how to handle documents which have been revised, superseded or canceled	PL	7	GEN	General Industry
4	Ability to interpret specification requirements and customer flow-down requirements	PL	7	GEN	General Industry
5	Has knowledge and understanding to be able to recognize conflicts within customer requirements and deviations from specifications and to assure that they are resolved prior to issue of final planning	PL	7	GEN	General Industry
6	Capable of generating clear and complete work instructions consistent with company practices and higher level quality requirements for general and specific procedures, operator training and approvals.	PL	7	GEN	General Industry
7	Capable of reviewing and approving records required to demonstrate compliance with customer requirements including • Set temperature • Soak Time • Quench delay time • Quench concentration • Quench temperature before and after quench • Cooling rate • Leak rate • Dew point • Periodic and lot acceptance test requirements and results	PL	7	GEN	General Industry
8	Capable of evaluating the potential product impact of deviation from process parameters or other events which may have a negative impact on product quality	PL	7	GEN	General Industry
9	Basic understanding of the operation, maintenance and calibration requirements for equipment used for testing, evaluation and acceptance or the specifications used for such testing, evaluation and acceptance (e.g., tensile testing, hydrogen pickup)	PL	7	GEN	General Industry
10	Basic understanding of pyrometry testing requirements including instrument calibrations, SAT and TUS testing	PL	7	GEN	General Industry
11	Capable of reviewing calibration, SAT and TUS reports when required	PL	7	GEN	General Industry
12	Capable of documenting an on-going plan for pyrometry compliance at site level per AMS2750	PL	7	GEN	General Industry
13	Capable of providing timely notification of calibration requirements	PL	7	GEN	General Industry
14	Capable of conducting periodic self-audits	PL	7	GEN	General Industry
15	Capable of conducting internal personal qualification exam in order to comply with HT BoK ERB requirements	PL	7	GEN	General Industry
16	Understands the safety concerns involved with heat treatment including the need to include in planning instructions for the proper use of handling tools and personal protective equipment	PL	7	GEN	General Industry
17	Understands precautions to be taken when handling thermocouples to avoid damage	PL	7	GEN	General Industry
18	Understanding of the Preventive Maintenance Program and how it is incorporated into planning	PL	7	GEN	General Industry
19	**Sequencing**				
20	Has an appropriate understanding of where titanium heat treating and contingent processes fall in the sequence of events and how to reflect that in planning so that operators can also understand it.	PL	7	GEN	General Industry
1	**PERSONAL ATTRIBUTES:** Are statements that will enable judgment of the person's personal attributes				
2	Willingness to train and mentor co-workers	PL	7	GEN	
3	Good communicator at all levels, especially with respect to clear written instructions	PL	7	GEN	
4	Understands and responds positively when operators challenge work instructions that do not appear to conform to specification or customer requirements	PL	10	GEN	
5	Personal integrity	PL	7	GEN	
6	Attentive to details	PL	7	GEN	
1	**EXPERIENCE:** Are the minimum experience requirements expected to demonstrate their competence.				
2	**NOTE**: ARP 1962 (Aerospace Recommended Practice -Training and Approval of Heat-Treating Personnel) requires that suppliers have a documented personnel training program including documented training to an established outline and initial and periodic evaluation of the competency. Evaluation to the requirements of this program should be used in completing this section. The following are recommendations and would be superseded by the supplier's specific documented program. The supplier program may define alternative criteria, waivers and equivalences.	PL			ARP1962, 3.1
3	**Recommended** **Minimum Classroom Training**	PL	10	GEN	ARP1962, Table 1

	Heat Treatment – 80 hours; Paperwork – 40 hours; Test, Inspection, Maintenance – 40 hours ***or*** Continuing Education Unit (CEU) Heat Treatment – 8 hours; Paperwork – 4 hours; Test, Inspection, Maintenance – 40 hours ***or*** Heat Cap Lessons (Heat Treating Certificate of Educational Achievement Program) Heat Treatment – 20 hours; Paperwork – 10 hours; Test, Inspection, Maintenance – 10 hours				
4	**Recommended Minimum On-the-Job-Training** **Material or Process Category (1)** / **Minimum Months of Total On-The-Job Training (2)(3)** Air atmosphere: 9 Controlled atmosphere: 12 Inert gas atmosphere: 12 Vacuum: 12 Titanium alloys: 12 (1) If two or more categories apply to the same job, the more stringent category applies. (2) Training in multiple alloys and processes may be covered concurrently providing substantial time is devoted to each category and function. (3) On-the-job training for various categories may run concurrently; however, all categories must be thoroughly covered.	PL	10	GEN	ARP 1962, Table 2
5	**Testing and Evaluation** Initial and periodic evaluation of personnel is required. The type of frequency of the evaluation shall be determined by the company employing the individual, except that each individual shall be evaluated at least every 5 years. This shall be defined in a formal written program. Personnel shall be evaluated as necessary to ensure adequate knowledge of those functions, materials, and processes for which they are responsible and will be approved. Evaluation may consist of any combination of written or oral examination or testing, structured checklist review, employee performance appraisal, company employee specific audit program or other appropriate methodology defined in the formal written program.	PL	10	GEN	ARP 1962 3.3.1.4, 3.3.1.4.1, 3.3.1.4.2
1	**NON-SPECIAL PROCESS RELATED REQUIREMENTS:** Defined within these rolls are other general or prerequisite needed				
2	Must have a thorough understanding of general Quality Systems (AS9100) or equivalent.	PL	7	GEN	General Industry
3	Must have a thorough understanding of customer specific requirements.	PL	7	GEN	General Industry
4	Must have a thorough understanding of Control of Nonconformance for equipment and product including containment, customer notification and disposition.	PL	7	GEN	General Industry

ADDENDUM 1

LIST OF INTERNATIONAL STANDARDS FOR (SPECIAL PROCESS)

SPECIAL PROCESS	DOCUMENT TITLE	DOCUMENT NUMBER
Heat Treating	Nadcap Audit Criteria for Heat Treating	**AC7102 H**
Heat Treating	Nadcap Audit Criteria for Heat Treating Pyrometry	**AC7102/8 N/A**
Heat Treating	SAE Aerospace Material Specification - Pyrometry	**AMS2750 E**
Heat Treating	SAE Aerospace Material Specification – Heat Treatment of Parts in a Vacuum	**AMS2769 B**
Heat Treating	SAE Aerospace Material Specification – Heat Treatment of Titanium Alloy Parts	**AMS2801 B**
Heat Treating	SAE Aerospace Material Specification - Heat Treatment of Titanium and Titanium Alloys	**AMS-H-81200 D**
Heat Treating	SAE Aerospace Recommended Practice - Training and Approval of Heat Treating Personnel	**ARP1962 A**
Quality	SAE Aerospace Standard - Quality Management Systems - Requirements for Aviation, Space and Defense Organizations	**AS9100 C**