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Program Document HTBOK

PD 6103

HTBoK-007/OP-1 REV. A

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BODY OF KNOWLEDGE:

ROLE DESCRIPTION: Operator/Technician
SPECIAL PROCESS: Heat Treatment
METHOD: Performance of Stainless and PH Steel Alloys Requirements

All PRI Qualification[SM] program examinations are created using the applicable PRI Qualification[SM] program 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 BoKs are created by subject matter experts who participate in the PRI Qualification[SM] Body of Knowledge Review Boards. All BoKs are updated periodically according to the latest revision of PRI Qualification[SM] program documentation (PD6100: Industry Managed Special Process Bodies of Knowledge) to ensure consistency with current industry practice.

1. INTRODUCTION

This document has been created by the PRI Qualification[SM] program Heat Treat Body of Knowledge Review Board (HT-BoKRB) according to the requirements of PD6100.

This document constitutes the PRI Qualification[SM] program BoK for Stainless and PH Steels, Operator. 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 International Aerospace Quality Group (IAQG) Guidance 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 PRI Qualification[SM] program examination candidate preparation
- Heat Treat Examination Review Board (HT-ERB) for the development of PRI Qualification[SM] program examinations
- Candidates taking PRI Qualification[SM] program examinations who wish to prepare in advance

2. REFERENCES

PRI Qualification[SM] program documents:

PD6000	Governance & Administration of PRI Qualification[SM] 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 PRI Qualification[SM] 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.

IN-HOUSE (or IN-SOURCING): Keeping responsibility and control of key or critical processes inside an organization by using available internal resources In house control (Insourcing) is often preferred to ensure compliance of critical with specific customer or statutory requirements – The opposite of Outsourcing

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/Technician, 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.

OUT-SOURCED: is the contracting out of a business process to a third-party (external) supplier. It relates to both product and services

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.

SERVICE PROVIDER: A company or individual that provides a service or product. Service provider is generally used to refer to external or outsourced (third party) suppliers of services and product although large organizations may have Internal Service Providers for example IT. Examples may include Instrument calibration, Periodic Tests (TUS, SAT), analysis or testing which is outside the capability of internal resources. Service providers may also be suppliers of goods for example thermocouples pure gases etc

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 PRI Qualification[SM] program examination candidates are recommended to read all documents referenced in section 2 of this document.

As stated in PRI Qualification[SM] program document PD6200, every 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 Approved Training Providers can be found at https://p-r-i.org)

Records of all qualified personnel shall be maintained and include:

- Date of Qualification
- Results of Written Exam
- Results of Practical Exam (if applicable)
- Summary of Experience (Owner Level only)

5. LEVELS

Level			
Descriptors	***Operator (OP)/Technician (T)*** ***For descriptions, please refer to current version of PD6000***	***Planner (PL)*** ***For descriptions, please refer to current version of PD6000***	***Owner (OW)*** ***For descriptions, please refer to current version of PD6000***
Stainless and Precipitation Hardening Steels - Specific Criteria	Basic Understanding of the specific requirements for HT of Stainless and Precipitation Hardening steel s –including cleaning, loading, start and end of soak, atmospheres quenching tempering and Refrigeration	In addition to knowing what the Operator does, the Planner must: Manage HT shop that contracts the service provider and reviews reports. Technician must have higher understanding and be able to conduct and analyze output from TUS/SAT testing.	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.	

6. TABLE 1

ROLE DESCRIPTION: Operator
SPECIAL PROCESS: Heat Treatment
METHOD: Performance of Stainless and PH Steel Alloys Requirements
REFERENCE GUIDELINES: ***Addendum 1 is a list of the International Standards and Reference Documents applicable to Heat Treatment processes***

Row #	COMPETENCE	Weight (1,3,7,10)	Exam Type Written/ Practical	Reference Guidelines
	Understands: **The basic knowledge of the special processes, methods and tools**			
1.	**GENERAL QUALITY SYSTEMS KNOWLEDGE:**	7	GEN	AS9100
2.	Awareness and understanding of Aerospace Quality systems and compliance in so far as it applies to their day to day work.	7	GEN	AS9100
3.	Full and complete understanding of internal work instructions as well as a working understanding of industry standards as they apply to internal work instructions. (see Addendum -1 of this document)	7	GEN	AS9100
4.	Awareness and understanding of how non-conformance are controlled using tools such as Root Cause Corrective Action and 5 Why's.	7	GEN	AS9100
5.	Awareness and understanding of the need to meet safety compliance requirements as applicable.	10	GEN	AS9100
6.	Awareness and understanding of the requirements for traceability of calibration to NIST or equivalent agencies for Pyrometry equipment. (In sourced or Out sourced)	7	GEN	AS9100
	PYROMETRY			
7.	Awareness and understanding of the importance of compliance with all Pyrometry requirements including temperature sensors, instrumentation, thermal equipment, system accuracy tests, and temperature uniformity surveys and including reporting of non-conformance.	7	PRAC	AMS2750
8.	Awareness and understanding of the importance of compliance with work instructions to pyrometry and furnace class (uniformity) as required by customer or material specifications.	10	PRAC	AMS2750
	WARNING NOTE – Heat Treatment of Stainless and PH steels shall not be implemented without a prerequisite understanding of the pyrometry requirements which affect these materials types.			
	GENERAL METALLURGICAL KNOWLEDGE RELATED TO HEAT TREATING STAINLESS AND PH STEELS (Applicable to all specifications including AMS 2759 and AMS2769)			
9.	Understanding of the different types of Stainless steels – Austenitic; Martensitic and Precipitation Hardening / Maraging.	7	GEN	AMS2759/3, AMS2759/4, AMS2759/5-
	The ability to execute Heat Treatment instructions applied to Stainless and Precipitation Hardening Steels including the following			
10.	• Annealing • Stress relieving • Stabilization (Dimensional) • Solution Heat Treating • Austenite Conditioning • Aging/Precipitation Heat Treating • Carbide Solution Treatment (For AM-355) • Preheating • Hardening (Austenitizing and Quenching) • Tempering • Low Temperature /Cryogenic treatments	7	GEN	AMS2759, AMS2769, AMS2759/3, AMS2759/4, AMS2759/5
	Awareness and understanding of the definitions and importance of terms applicable to Heat Treatment of Stainless and PH Steels			
11.	• Set temperature (Set Point) • Recovery time • Heating • Start of soak • Soak time • End of soak	10	GEN	AMS 2759, AMS 2769

	• Interruptions • Quench delay • Temper / Cryogenic delay • Protective Coatings • Cleaning • Homogenization (effects on Heat treatment response)			
12.	Knowledge and understanding of the need to control the use and application of protective compounds to minimize possible contamination from furnace atmospheres. Coatings must be applied according to Customer / Prime requirements.	7	GEN	AMS2759, AMS2759/3, AMS2759/4, AMS2759/5 & AMS-H-6875
13.	Knowledge and understanding that equipment and instruments for the heat treatment of stainless and PH steels must be in accordance with AMS2750 and all customer requirements.	10	GEN	AMS2759, AMS2759/3, AMS2759/4, AMS2759/5 & AMS-H-6875
	Pyrometry			
14.	Knowledge and understanding that thermal processing equipment including refrigeration equipment must meet the requirements of AMS2750. Furnaces shall have a minimum of Type D instrumentation.	10	GEN	AMS2759
	Furnace Equipment			
15.	Knowledge and understanding that Furnace Classes are as defined in AMS2750 and are based on the minimum requirements for temperature uniformity. Unless otherwise specified in the applicable specification, furnace classes shall be as follows: •Furnaces for annealing, subcritical annealing, normalizing, hardening, austenitizing or solution treating, and stress relieving shall be Class 5 (+/- 25°F (14°C)) or better •Furnaces for tempering or aging/precipitation hardening shall be Class 3 (+/- 15°F (8°C)) or better. CAUTION: Furnace requirements for certain specific materials and processes may be contained in the individual specification.	7	GEN	AMS2759
	Heating Environment			
16.	Knowledge and understanding that Classes of Atmospheres are defined in AMS2759 as follows •Class A: Argon, hydrogen, helium, nitrogen, nitrogen-hydrogen blends, vacuum, or neutral salt. Nitrogen from dissociated ammonia is not permitted. •Class B: Endothermic, exothermic, or carbon-containing nitrogen-base. •Class C: Air or products of combustion.	7	GEN	AMS2759
	Atmosphere Control			
17.	Knowledge and understanding that atmosphere furnaces shall be controlled as directed in work instructions to assure that surfaces meet specification requirements.	7	GEN	AMS2759
	Class A Atmospheres			
18.	Knowledge and understanding that the dew point of the gas shall be -60 ºF (-51 ºC) or lower as the gas enters the furnace and shall be verified at least quarterly and also when the piping transmitting the gas is disturbed. In lieu of sampling the dew point at each furnace, the gas may be sampled at the end of each leg of supply piping, at the furthest point from the supply.	5	GEN	AMS2759
	Servicing and Calibration of Atmosphere Control Equipment			
19.	Knowledge and understanding that instrumentation used to control furnace atmosphere shall be calibrated and serviced in accordance with heat treater's documented procedures	7	GEN	AMS2759
	Types of Parts			
20.	Knowledge and understanding that parts shall be controlled by type, as follows, and that they be heat treated in the class of atmosphere permitted for that type. Type 1 - Parts with 0.020-inch (0.51 mm) or more to be removed from all surfaces after heat treatment and parts with hot finished (as-forged, as-cast, or hot mill) surfaces at time of heat treatment with all surfaces to be removed after heat treatment. Type 2 - Parts with finished surfaces, surfaces with less than 0.020 inch (0.51 mm) to be removed after heat treatment (including hot finished surfaces that will remain on the part), or combinations of these.	10	GEN	AMS2759
21.	Knowledge and understanding that if part type cannot be determined the part shall be processed as Type 2.	10	GEN	AMS2759
22.	Knowledge and understanding that parts with protective coating on all surfaces shall be processed in an atmosphere that will not destroy the coating during heat treatment.	10	GEN	AMS2759
	Auxiliary Equipment			
23.	Knowledge and understanding that fixtures and fixture materials shall not cause contamination of parts.	5	GEN	AMS2759
	Sub-Zero Cooling or Deep Freeze			
24.	Knowledge and understanding that when required by work instructions to complete transformation and provide desired microstructure, parts shall be cooled to a temperature within the range specified, held at the selected temperature for a time commensurate with section thickness as directed by work instructions, and warmed in air to room temperature.	5	GEN	AMS2759
	Quenching Media			
25.	Knowledge and understanding that when liquid quenching is required, only quenching media as specified in work instructions may be used.	7	GEN	AMS2759

26.	Knowledge and understanding that oil quenchants shall be in the range of 60 to 160 °F (16 to 71 °C) at the initiation of the quench operation.	10	GEN	AMS2759
27.	Knowledge and understanding that polymer quenchants shall be in the range of 60 to 110 °F (16 to 43 °C) at the initiation of the quench.	7	GEN	AMS2759
	Quenching from Salt Bath Furnaces			
28.	Knowledge and understanding that water shall be monitored to ensure salt content does not exceed 2% by weight and that polymers shall be monitored to ensure salt content does not exceed 6% by weight.	5	GEN	AMS2759
	Polymer Quenchants			
29.	Knowledge and understanding that polymer quenching may only be employed when specified by work instructions.	7	GEN	AC7102
	Heat Treatment			
30.	Knowledge and understanding that heat treatment must be in accordance with AMS2759/3, AMS2759/4 or AMS2759/5 as specified on the work instructions.	10	GEN	AMS2759
	Cleaning			
31.	Knowledge and understanding that parts shall be in a clean condition before heat treatment. Parts shall be visually inspected to verify freedom from grease, dirt, oil, corrosion and corrosion preventive coatings. All salt residue shall be removed from parts processed in salt baths or quenched in brine.	7	GEN	AMS2759
32.	Knowledge and understanding that following heat treatment operations, parts shall be cleaned when specified. Post heat treat cleaning is not required unless specified.	7	GEN	AMS2759 AC7102
33.	Knowledge and understanding that for vacuum heat treatment, parts, fixtures, and materials charged into the heating chamber shall be free of contaminants which might evaporate and react with the material being heat treated or the furnace components. Handling of cleaned parts and fixtures shall be such as to prevent contamination prior to charging into the furnace.	7	GEN	AMS2769
	Racking			
34.	Knowledge and understanding that parts must be racked and supported, or otherwise oriented to ensure access of the heating, cooling, and quenching media to all surfaces of all parts and to minimize warpage.	7	GEN	AMS2759
35.	Knowledge and understanding that internal procedures, racking sketches, or other directions must be followed to ensure that spacing between the parts is adequate for circulation of the heating medium and coolant/quenchant and records kept to demonstrate that these procedures are followed	7	GEN	AC7102
36.	Knowledge and understanding that any specially designed racks and fixtures must be identified, and their condition monitored and documented. Specific fixtures or racks must be used for the specific parts for which they are designed.	5	GEN	AC7102
37.	Knowledge and understanding that racks/fixtures/baskets must be examined for integrity, and repaired or scrapped as necessary and records must indicate that the procedures are followed	5	GEN	AC7102
	Purging			
38.	Knowledge and understanding that whenever atmosphere types are changed any work instructions for purging must be followed. prior to heating of parts.	10	GEN	AMS2759 AC7102
	Loading			
39.	Knowledge and understanding that parts must not be loaded into a furnace with the temperature higher than the set temperature, unless load thermocouples are attached to the part to ensure the part temperature does not exceed the set temperature.	7	GEN	AMS2759
	Set Temperature			
40.	Knowledge and understanding that control instrument(s) shall be set at the temperature specified by the work instructions.	7	GEN	AMS2759
	Heat Treatment in Vacuum Furnaces			
41.	Knowledge and understanding that cleaning of parts, tooling and baskets must be by methods and with materials that ensure freedom from contamination during vacuum heat treating	7	GEN	AC7102
42.	Knowledge and understanding that internal procedure, photographic evidence, or other documentation must be followed for placement of load thermocouples, racking of parts, and furnace loading	5	GEN	AC7102
43.	Knowledge and understanding that vacuum furnaces must be capable of achieving the vacuum levels and leak rates specified.	7	GEN	AMS2769
44.	Knowledge and understanding of requirements to check condition of door and other seals (e.g. thermocouple entry ports) which must be clean and free from damage or tears. Also understanding of the requirements for cleaning and greasing different types of sealing material which must be documented on work instructions, the traveler / data card, or in specific internal instructions.	5	GEN	AMS2769
45.	Knowledge and understanding of the need for documenting repairs or changes of seals particularly on doors, thermocouple entry ports and gauges.	5	GEN	AMS2750
	Soak			
46.	Knowledge and understanding of why adherence to set temperatures and furnace uniformity is critical and that work instructions must be followed.	10	GEN	AMS2759
47.	Knowledge and understanding of criteria for start and end of soak in accordance with work instruction requirements.	10	GEN	AMS2759

	Quench			
48.	Knowledge and understanding that quench mechanisms (manual or automated) must be capable of meeting the maximum quench delay and results recorded and verified for each individual load	7	GEN	AC7102
49.	Knowledge and understanding that the temperature of quench media must be controlled and documented in accordance with work instruction requirements.	10	GEN	AC7102
50.	Knowledge and understanding that records must demonstrate that quench media has been at the specified temperature before, during and after the parts were quenched.	7	GEN	AC7102
51.	Knowledge and understanding of the requirement to verify that agitation of quench media or the parts during quenching conforms to applicable specifications.	5	GEN	AC7102
	Gas Quenching in Vacuum Furnaces			
52.	Knowledge and understanding of the importance of following work instructions for quench gas type (e.g. Nitrogen/Argon/Helium), gas pressure during quench, and cooling direction	7	GEN	AMS2769
53.	Knowledge and understanding of how to check cooling rates on gas quenching when there are specific requirements.	5	GEN	AMS2769
	Low Temperature Treatment			
54.	Knowledge and understanding of the importance of meeting the maximum permitted process delays between Quench/Temper and Quench/Freeze/Temper, and the effect that exceeding the requirement might have on the mechanical properties of the product. In-process delay times must be recorded and subject to review if they are exceeded.	10	GEN	AC7102
55.	Knowledge and understanding that records must show that cooling after quench is in compliance with requirements specified in procedures or shop planning.	7	GEN	AC7102
56.	Knowledge and understanding of time/temperature limits for sub-ambient/subzero treatments	7	GEN	AC7102
57.	Knowledge and understanding of the requirement to record the temperature in each refrigeration cycle to allow verification against requirements	7	GEN	AC7102
	Records			
58.	Knowledge and understanding of the need for collection of the appropriate data so that a furnace log, or equivalent documentation such as shop travelers, traceable to temperature recorder chart(s), shall be maintained.	10	GEN	AMS2759
	Additional Processes			
59.	Knowledge and understanding that parts must not be subjected to thermal operations other than those specified in the work instructions	10	GEN	AMS2759
	Acceptance Tests			
60.	Knowledge and understanding that acceptance testing and documentation must be as specified in the work instructions	7	GEN	AMS2759
61.	Periodic Testing Knowledge and understanding that periodic testing must be scheduled and documented.	5	GEN	AMS2759 AMS2769
	Hardness Testing			
62.	Knowledge and understanding that after final operation (hardening and tempering, aging, etc.), every part must be hardness tested unless otherwise directed by work instructions.	10	GEN	AMS2759
63.	Knowledge and understanding of the need to provide for the collection of data necessary to comply with specification and customer requirements for Logs, Records and Reports/Certification.	5	GEN	AMS2759
	Corrosion Protection			
64.	Knowledge and understanding that parts susceptible to corrosion (e.g., martensitic stainless steels) shall be protected from corrosion during processing and storage as directed by work instructions.	5	GEN	AMS2759
	Process Verification			
65.	Knowledge and understanding that each heat treatment cycle is reviewed for job traceability, correct temperature, time at temperature and all other related parameters and that this review is documented	10	GEN	AC7102
	REQUIREMENTS SPECIFIC TO PRODUCT PROCESSED IN ACCORDANCE WITH SPECIFIC AMS STANDARDS DESCRIBED ABOVE (Competence)			
	A) SPECIFIC REQUIREMENTS RELATED TO THE PROCESSING OF: Precipitation-Hardening Corrosion-Resistant and Maraging steel parts AMS 2759/3			
66.	Knowledge and understanding that this specification establishes the heat treatment of PARTS manufactured to AMS2759/3.	7	GEN	AMS2759/3
	PYROMETRY			
67.	Knowledge and understanding of the requirements of AMS2759 and AMS 2750 (Pyrometry).	7	GEN	AMS2759/3
68.	Knowledge and understanding that equipment must conform to the Furnace Class requirements of AMS2750 as listed below: a) Furnaces used at temperatures of 1400 °F (760 °C) and higher and for stress relieving: Class 5. (+/- 25°F (14°C)) b) Furnaces used at temperatures from 1300 to 1375 °F (704 to 746 °C): Class 3. (+/- 15°F (+/-8°C)) c) Furnaces used at temperatures below 1300 °F (704 °C): Class 2. (+/- 10°F (+/- 6°C)) d) Furnaces shall have a minimum of type D instrumentation in accordance with	7	GEN	AMS2759/3

	AMS2750.			
	Heating Environment / Atmospheres			
69.	Knowledge and understanding that atmospheres must be controlled in compliance with work instructions such that they do not contaminate parts being treated. Parts being heat treated shall be suitably isolated from products of combustion. Materials that could attack or contaminate metal shall not contact parts during heat treatment.	7	GEN	AMS2759/3
70.	Knowledge and understanding that furnaces used to heat treat other classes of steel using atmospheres that could contaminate precipitation-hardening, maraging, or secondary hardening steel parts, such as endothermic, exothermic, carbon-containing nitrogen-base, etc., shall have purge cycle run as specified in the work instructions.	7	GEN	AMS2759/3
71.	Knowledge and understanding that composition and maintenance of salt baths shall be such as to prevent contamination of the parts and in compliance with work instructions.	7	GEN	AMS2759/3
	Heating Environment			
72.	Knowledge and understanding of the following •Type 1 parts shall be heat treated in air or protective atmosphere. •Type 2 parts shall be heat treated in air or protective atmosphere when heating at or below 1450 °F (788 °C) and shall be heat treated in a protective atmosphere when heating above 1475 °F (802 °C).	10	GEN	AMS2759/3
73.	Knowledge and understanding that acceptable protective atmospheres shall be in accordance with AMS2759, and are limited to helium, argon, hydrogen, neutral salt, nitrogen, nitrogen-hydrogen blends, and vacuum in accordance with AMS2769.	7	GEN	AMS2759/3
74.	Knowledge and understanding of the following •Nitrogen and nitrogen-hydrogen blends are permitted below 1475 °F (802 °C). •Nitrogen and nitrogen-hydrogen blends are permitted at or above 1475 °F (802 °C) for Type 1 parts only. •Nitrogen and nitrogen-hydrogen blends are permitted up to 1975 °F (1079 °C) as a backfill quench for vacuum furnaces. •The use of nitrogen from dissociated ammonia is prohibited.	7	GEN	AMS2759/3
	Coatings			
75.	Knowledge and understanding that a supplemental coating is permitted when specified on the work instructions to minimize oxidation of parts heated in air.	7	GEN	AMS2759/3
	Cleaning			
76.	Knowledge and understanding that cleaning shall be in accordance with work instructions.	7	GEN	AMS2759/3
77.	Knowledge and understanding that all PH steel parts with any finish machined surfaces are handled with clean gloves after cleaning	7	GEN	AC7102
	Soaking			
78.	Knowledge and understanding that Start of Soak shall be in accordance with work instructions. When a load thermocouple is used it shall be in contact with the thickest cross-section within each furnace load.	10	GEN	AMS2759/3
	Start of Soaking			
79.	When only furnace control sensors are used, soaking time starts when the temperature indicated by the furnace control instrument recovers to within 5 °F (3 °C) of the set heat treating temperature. When furnace control sensors and recording thermocouples are used, soaking time starts when the temperature indicated by all recorded sensors reaches the minimum of the required temperature tolerance applicable to the set heat treating temperature. When load thermocouples are used, soaking time commences when the part temperature reaches the minimum of the required temperature tolerance for the set heat treating temperature.	10	W	AMS 2759
	Normalizing of Secondary Hardening Grades			
80.	Knowledge and understanding that normalizing shall be accomplished by heating to the temperature specified, soaking for the time specified, and cooling in air or a protective atmosphere to ambient temperature.	5	GEN	AMS2759/3
	Annealing of Secondary Hardening Grades			
81.	Knowledge and understanding that annealing shall be accomplished by heating to the specified temperature and soaking for the time specified, and cooling in air or a protective atmosphere to ambient temperature.	5	GEN	AMS2759/3
	Re-Solution of Secondary Hardening Grades			
82.	Knowledge and understanding that re-solution treatment shall be accomplished by heating to the required temperature and soaking for the time specified.	5	GEN	AMS2759/3
	Solution Heat Treating (Solution Annealing), Austenite Conditioning, and Aging (Precipitation Heat Treating)			
83.	Knowledge and understanding that these processes shall be accomplished by heating to the temperature specified, soaking for the time specified, and cooling as specified.	7	GEN	AMS2759/3
	Stress Relieving			
84.	Knowledge and understanding that Stress Relieving, if required, shall be performed in accordance with work instructions.	7	GEN	AMS2759/3
	Straightening			
85.	Knowledge and understanding that straightening may be accomplished when specified on work instructions at ambient temperature, during aging, or after aging by heating to not	7	GEN	AMS2759/3

	higher than 50 °F (28 °C) below the final aging temperature. Straightening performed after aging shall be followed by stress relieving,			
	Acceptance Tests			
86.	Knowledge and understanding that hardness and tensile are acceptance tests and shall be performed on each lot of parts in accordance with work instructions.	7	GEN	AMS2759/3
	B) SPECIFIC REQUIREMENTS RELATED TO THE PROCESSING OF: Heat Treatment of Austenitic Corrosion Resistant Steel Parts AMS 2759/4			
87.	Knowledge and understanding that that this specification establishes the heat treatment of PARTS manufactured to AMS2759/4.	7	GEN	AMS2759/4
	PYROMETRY			
88.	Knowledge and understanding of the requirements of AMS2759 and AMS 2750 (Pyrometry).	7	GEN	AMS2759/4
89.	Knowledge and understanding equipment must at a minimum conform to the AMS2750 Class 5 requirements (+/- 25°F (14°C)).	7	GEN	AMS2759/4
	Heating Environment / Atmospheres			
90.	Knowledge and understanding that that atmospheres must comply with work instructions and are controlled such that they do not contaminate parts being treated including vacuum and salt baths.	7	GEN	AMS2759/4
91.	Knowledge and understanding that furnaces used to heat treat other classes of steel using atmospheres that could contaminate austenitic corrosion-resistant steel parts shall have purge cycles run in accordance with work instructions.	7	GEN	AMS2759/4
92.	Knowledge and understanding that parts being heat treated shall be suitably isolated from products of combustion. Materials that could attack or contaminate metal shall not contact parts during heat treatment.	7	GEN	AMS2759/4
93.	Knowledge and understanding that parts shall be heat treated in either air or protective atmosphere. Acceptable protective atmospheres include argon, helium, hydrogen, neutral salt, and vacuum.	7	GEN	AMS2759/4
94.	Knowledge and understanding that the use of nitrogen manufactured by the dissociation of ammonia is prohibited.	10	GEN	AMS2759/4
	Protective coating			
95.	Knowledge and understanding that the use of protective coatings is permitted only when specified on the work instructions.	7	GEN	AMS2759/4
96.	Knowledge and understanding that fixtures and fixture materials shall not cause contamination of parts and shall not reduce heating, or cooling rates to less than that required to prevent carbide precipitation.	7	GEN	AMS2759/4
	Cleaning			
97.	Knowledge and understanding that cleaning is in accordance with work instructions.	7	GEN	AMS2759/4
	SOAKING			
	Solution Heat Treatment and Austenite Conditioning			
98.	Knowledge and understanding that heating shall be controlled such that either the heating medium or the part temperature, as applicable, is maintained at the required set temperature for the specified soak time. The start of soaking time shall be in accordance with work instructions.	7	GEN	AMS2759/4
99.	Knowledge and understanding that annealing shall be as required by work instructions.	7	GEN	AMS2759/4
100.	Knowledge and understanding that heat treating, or slow cooling of materials covered by AMS2759/4 between 875 and 1500 °F (468 and 816 °C) is prohibited unless specifically directed by work instructions.	7	GEN	AMS2759/4
	Straightening			
101.	Knowledge and understanding that straightening shall be accomplished at ambient temperature with a post-straightening stress relief in accordance with work instructions.	7	GEN	AMS2759/4
	C)) SPECIFIC REQUIREMENTS RELATED TO THE PROCESSING OF Heat Treatment Martensitic Corrosion-Resistant Steel Parts to AMS2759/5			
102.	Knowledge and understanding that this specification establishes the heat treatment of PARTS manufactured to AMS2759/5.	7	GEN	AMS2759/5
	Pyrometry			
103.	Knowledge and understanding of the requirements of AMS2759 and AMS 2750.	7	GEN	AMS2759/5
104.	Knowledge and understanding that equipment must conform to the Furnace Class requirements listed below: a) Annealing, subcritical annealing, hardening, straightening, stress relieving and baking shall be a minimum of Class 5 (+/- 25°F (14°C)) b) Tempering shall be a minimum of Class 3 (+/- 15°F (+/-8°C))	7	GEN	AMS2759/5
	Heating Environment / Atmospheres			
105.	Knowledge and understanding that parts must controlled through work instructions by type and only the class of atmosphere permitted for that type used when heating above 1250°F (677°C).	7	GEN	AMS2759/5
106.	Knowledge and understanding that when treating below 1250°F (677°C) atmosphere types A, B or C may be used.	7	GEN	AMS2759/5
107.	Knowledge and understanding that if the part type cannot be determined it shall be processed as Type 2 – Parts with finished surfaces, surfaces with less than 0.020 inch	7	GEN	AMS2759/5

	(0.51 mm) to be removed after heat treatment (including hot finished surfaces that will remain on the part), or combinations of these.			
108.	Knowledge and understanding that atmospheres shall be limited to those permitted by work instructions.	7	GEN	AMS2759/5
	Cleaning			
109.	Knowledge and understanding that cleaning shall be in accordance with work instructions.	7	GEN	AMS2759/5
	Soaking			
110.	Knowledge and understanding that start of soak shall be in accordance with work instructions	7	GEN	AMS2759/5
111.	Knowledge and understanding that parts protected by copper plating or coated with reflective coatings which tend to reflect radiant heat shall have their soaking time increased through work instructions by 50% when processing at setpoints above 1200 °F (649 °C), unless load thermocouples are used.	7	GEN	AMS2759/5
112.	Knowledge and understanding that annealing shall be accomplished by heating to the specified temperature for the required time and cooling to below the specified temperature at the rate shown followed by air cooling or equivalent to ambient temperature.	7	GEN	AMS2759/5
113.	Knowledge and understanding that when Subcritical Annealing is required, it shall be performed prior to hardening by heating in the specified temperature range, soaking for the required time, and cooling to ambient temperature.	7	GEN	AMS2759/5
114.	Knowledge and understanding that Hardening (Austenitizing and Quenching) shall be accomplished by heating to the Austenitizing temperature specified, soaking for the specified time, and quenching as required. The parts shall be cooled to or below the liquid quenchant temperature or to a temperature low enough to achieve complete transformation before tempering.	7	GEN	AMS2759/5
115.	Knowledge and understanding that quench gases shall be in accordance with work instructions.	7	GEN	AMS2759/5
116.	Knowledge and understanding that after quenching and prior to tempering, subzero cooling may be required and must be in accordance with work instructions.	7	GEN	AMS2759/5
117.	Knowledge and understanding that Tempering shall accomplished by heating quenched parts to the temperature specified.	7	GEN	AMS2759/5
118.	Knowledge and understanding that initial tempering should begin within 2 hours from end of quench or within 2 hours from when subzero cooled parts have reached ambient temperature.	5	GEN	AMS2759/5
119.	Knowledge and understanding that Soaking time shall be in accordance with work instructions and shall be not less than 2 hours plus 1 hour additional for each inch (25 mm) of thickness or fraction thereof greater than 1 inch (25 mm). When load thermocouples are used, the soaking time shall be not less than 1 hour.	7	GEN	AMS2759/5
120.	Knowledge and understanding that when multiple tempering is specified by the planning, parts shall be cooled to ambient temperature (or below, if specified) between tempering treatments.	7	GEN	AMS2759/5
121.	Knowledge and understanding that if parts cannot be tempered within 2 hours from end of quench or within 2 hours from when subzero cooled parts have reached ambient temperature, parts may be snap tempered for a minimum of 2 hours at 300 °F (149 °C). If the tempering temperature is below 325 °F (163 °C) the snap temper shall be no greater than 25 °F (14 °C) degrees below the final tempering temperature.	7	GEN	AMS2759/5
	Straightening			
122.	Knowledge and understanding that straightening of heat-treated parts shall only be performed in accordance with work instructions.	7	GEN	AMS2759/5
123.	Knowledge and understanding that when required stress relieving shall be in accordance with work instructions.	7	GEN	AMS2759/5
	Hardness			
124.	Knowledge and understanding that parts shall conform to the minimum hardness required and that the frequency of hardness testing shall be in accordance work instructions.	7	GEN	AMS2759/5
	Acceptance Tests			
125.	Knowledge and understanding that hardness is an acceptance tests and shall be performed on each lot of parts as directed by work instructions. Surface contamination for Type 2 parts with tensile strength 220 ksi (46 HRC) or above is an acceptance test and shall be performed on each lot except as allowed in AMS2759/5.	7	GEN	AMS2759/5
126.	Knowledge and understanding that heating below 1400 °F (760 °C) with Class B atmosphere containing 5% or more of hydrogen (H2), carbon monoxide (CO), or methane (CH4), may result in explosion and fire.	10	GEN	AMS2759/5
	D) SPECIFIC REQUIREMENTS RELATED TO THE PROCESSING OF: Heat Treatment of Raw Material to AMS-H-6875 parts B, C and D			
127.	Knowledge and understanding that this specification establishes the heat treatment of Raw Materia. It does not apply to the treatment of parts.	7	GEN	AMS H 6875
128.	Knowledge and understanding that in terms of Stainless and PH Steels this specification only applies to types B, C and D.	7	GEN	AMS H 6875
	Furnace Media and Protective Coatings			
	Atmospheres			
129.	Knowledge and understanding that gases used as furnace atmospheres must only be used	7	GEN	AMS H 6875

	for the appropriate class of parts as specified by work instructions. Supplementary protective coatings may be used where required by work instructions.			
130.	Knowledge and understanding that atmospheres are controlled in accordance with work instructions such that they do not contaminate parts being treated including vacuum and salt baths.	7	GEN	AMS H 6875
131.	Knowledge and understanding of the need or requirement to carry out purges in accordance with work instructions before treating materials in furnaces whose use is not limited solely to aerospace work.	7	GEN	AMS H 6875
132.	Knowledge and understanding that salt baths may only be used for Class B steels (Martensitic Corrosion Resistant Steels) and must be tested at least weekly to prevent carburization, decarburization, IGA, IGO.	7	GEN	AMS H 6875
	Temperature Uniformity			
133.	Knowledge and understanding of the requirements of AMS 2750 (Pyrometry).	7	GEN	AMS H 6875
134.	Knowledge and understanding that furnaces must have instrumentation to a minimum of Type D.	7	GEN	AMS H 6875
135.	Knowledge and understanding that Furnace Class requirements are per AMS2750 as follows: Aging of (Class D) PH stainless steels at 1025 °F (552 °C) and below - Furnace Class 2 (+/-10°F (+/- 6°C)) Aging of (Class D) PH stainless steels above 1025 °F (552 °C) - Furnace Class 3 (+/- 15°0F (+/-8°C)) and All Other Processes - Furnace Class 5 (+/-25°F (+/-14°C)).	7	GEN	AMS H 6875
	Quench Tanks			
136.	Knowledge and understanding that Quench tanks must permit total immersion and provide adequate circulation to produce the required properties in the largest material processed.	7	GEN	AMS H 6875
137.	Knowledge and understanding that for Oil Quenching medium must be between 60°F and 160°F (15°/71°C) at the beginning of the quench and shall not exceed 200°F (93°C) at any time.	7	GEN	AMS H 6875
138.	Knowledge and understanding that Aqueous Polymer Quenchants may be used when specified by work instructions. Baths must have adequate circulation.	7	GEN	AMS H 6875
	Quenching from Salt Bath Furnaces			
139.	Polymer quenching baths when used in conjunction with salt bath furnaces shall be monitored weekly so that the salt content of the bath shall not exceed 6% by weight of the bath. All salt residues shall be removed from parts processed in salt-bath furnaces or quenched in brine, during or immediately following quenching.	7	GEN	AMS H 6875
	Thermal Treatment			
140.	Knowledge and understanding that heating rates must be controlled in accordance with work instructions to prevent damage to material.	7	GEN	AMS H 6875
141.	Knowledge and understanding that material in Class B shall be hardened by Austenitizing, Quenching and Tempering.	7	GEN	AMS H 6875
142.	Knowledge and understanding that Austenitizing temperature and times shall conform to work instructions.	7	GEN	AMS H 6875
143.	Knowledge and understanding that Quenching shall be carried out in the quenchant specified in the work instructions.	7	GEN	AMS H 6875
144.	Knowledge and understanding that if hardened material cannot be tempered within 2 hours after quenching material may be Snap Tempered at 400°F +/- 25°F (204°C +/- 14°C) for 1 hour or as appropriate to prevent cracking.	10	GEN	AMS H 6875
145.	Knowledge and understanding that Tempering shall be carried out in compliance with work instructions.	7	GEN	AMS H 6875
146.	Knowledge and understanding that Class D steel parts shall be hardened by precipitation heat treatment of material which has been either solution heat treated, or solution treated and cold worked. Thermal treatment for Type D material shall conform to work instructions.	7	GEN	AMS H 6875
147.	Knowledge and understanding that annealing (full annealing) or sub-critical (partial) annealing of Class B or C material shall be accomplished in accordance with work instructions	7	GEN	AMS H 6875
	Stress Relieving			
148.	•Knowledge and understanding that stress relieving after hardening of Classes B material shall be accomplished by heating to a maximum temperature of 50 °F below the tempering temperature. Stress relieving after hardening is prohibited on parts that have been peened or cold deformed; e.g., roll threaded. •Knowledge and understanding that stress relieving of Class C material shall be accomplished by either heating to 875 °F ± 25 maximum or to 1900 °F and rapid cooling as specified in work instructions. •Knowledge and understanding that hardened Class D material shall be stress relieved for a minimum of 1 hour at 30 °F below the aging temperature.	7	GEN	AMS H 6875
	Cleaning			
149.	Knowledge and understanding that material shall be cleaned in accordance with work instructions prior to heat treatment to remove contaminants and leave no substance that could have a deleterious effect.	7	GEN	AMS H 6875
	Spacing			
150.	Knowledge and understanding that material shall be racked or supported as specified in	7	GEN	AMS H 6875

	work instructions to allow circulation of heating and quenching media exposure to heating or quenching media and to minimize warpage.			
151.	Knowledge and understanding that furnaces used for Heat Treatment above 1250°F(676°C) must be controlled to preclude carburizing or nitriding.	7	GEN	AMS H 6875
	Quenchant effectiveness			
152.	Knowledge and understanding that the consistency of quenchant effectiveness must be determined in each quench tank at least quarterly.	7	GEN	AMS H 6875
	Control Records			
153.	Knowledge and understanding that that records of system accuracy tests, furnace temperature surveys, calibration of control and recording instruments and date, time, temperature, and quenchant used in heat treating material must be collected and maintained as directed by company procedures.	5	GEN	AMS H 6875
	SKILLS: **The skills required to perform a particular special process task**			
	Within these Rows enter text that describes the range of skills specified in the Body of Knowledge.			
154.	Has knowledge and understanding to be able to recognize and report in real time deviations from process parameters or other events which may have a negative impact on product quality.	7	GEN	AS9100
155.	Read and understand written instructions.	7	GEN	AS9100
156.	Ability to understand specification requirements and customer flow-down requirements.	7	GEN	AS9100
157.	Recognition of the importance of following work instructions.	7	GEN	AS9100
158.	Understands the safety concerns involved with heat treatment including the proper use of handling tools and personal protective equipment.	7	GEN	General Industry
159.	Understands precautions to be taken when handling thermocouples to avoid damage.	7	GEN	General Industry
160.	Capable of generating and maintaining accurate and complete 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 after quench including refrigeration temperature •Periodic and lot acceptance test requirements and results	7	GEN	AC7102
161.	If properly delegated, ability to review and approve heat treatment processing records.	7	GEN	AMS2750, AC7102, AS9100
162.	Has knowledge and understanding of the proper operation, maintenance and calibration requirements for equipment used for testing, evaluation and acceptance. (e.g., hardness, conductivity)	7	GEN	AC7102/5
163.	Awareness and understanding of the Preventive Maintenance Program.	7	GEN	AC7102, AS9100
	Sequencing			
164.	Has an appropriate understanding of where this process falls in the sequence of events and why it should not deviate without customer/end user permission.	10	GEN	
	PERSONAL ATTRIBUTES: ***Are statements that will enable judgment of the person's personal attributes***			
	Define within the following rows statements from the Body of Knowledge or statements from Company sources that will enable judgment of the person's personal attributes.			
165.	Willingness to train and mentor co-workers.	7	GEN	
166.	Good communicator at all levels.	7	GEN	
167.	Takes responsibility to challenge work instructions that do not appear to conform to specification or customer requirements.	10	GEN	
168.	Personal integrity	7	GEN	
169.	Attentive to details	7	GEN	
	EXPERIENCE: ***Are the minimum experience requirement expected to demonstrate their competence.***			
	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.			
	Recommended Minimum Classroom Training			
170.	Heat Treatment – 80 hours Paperwork – 40 hours Test, Inspection, Maintenance – 40 hours	10	GEN	ARP 1962
	Recommended Minimum On-the-Job-Training			
171.	Furnace atmospheres and atmosphere control –12 months	10	GEN	ARP 1962

	Stainless and PH Steels – annealing, stress relief and dimensional stabilization– 12 months All other treatments except those above - 24 months			
	Testing and Evaluation			
172.	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 the formal written program. 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.	10	GEN	ARP 1962
	NON-SPECIAL PROCESS RELATED REQUIREMENTS: **Defined within these rolls are other general or pre-requisite needed**			
173.	Must have a thorough understanding of general Quality Systems (AS9100) or equivalent.	7	GEN	AS9100
174.	Must have a thorough understanding of customer specific requirements.	7	GEN	AS9100
175.	Must have a thorough understanding of Control of Non-Conformance for equipment and product including containment, customer notification and disposition.	7	GEN	AS9100

7. DOCUMENT REVISION HISTORY

REVISION DATE	SUMMARY
1 May 2018	Updated template
1 October 2018	Reviewed by eQualified Content Developer to ensure document is up to date.
4 December 2019	Editorial revision to update program name from eQualified to PRI Qualification[SM.]

ADDENDUM 1

LIST OF INTERNATIONAL STANDARDS & REFERENCE DOCUMENTS FOR HEAT TREATMENT OF STAINLESS AND PH STEELS

SPECIAL PROCESS	DOCUMENT TITLE	DOCUMENT NUMBER
Heat Treating	Nadcap Audit Criteria for Heat Treatment	AC7102
Heat Treating	Nadcap Audit Criteria for Hardness and Conductivity Testing	AC7102/5
Heat Treating	Nadcap Audit Criteria For Heat Treating Pyrometry	AC7102/8
Heat Treating	SAE Aerospace Materials Specification – Pyrometry	AMS2750
Heat Treating	SAE Aerospace Materials Specification –Heat Treatment of Steel Parts General Requirements	AMS2759
Heat Treating	SAE Aerospace Materials Specification – Precipitation-Hardening Corrosion-Resistant and Maraging Steel parts	AMS2759/3
Heat Treating	SAE Aerospace Materials Specification – Heat Treatment of Austenitic Corrosion-Resistant Steel Parts	AMS2759/4
Heat Treating	SAE Aerospace Materials Specification – Heat Treatment Martensitic Corrosion-Resistant Steel Parts	AMS2759/5
Heat Treating	SAE Aerospace Materials Specification – Heat Treatment of Parts in Vacuum	AMS2769
Heat Treating	SAE Aerospace Recommended Practice - Training and Approval of Heat-Treating Personnel	ARP1962
Quality	AS9100 Quality Management Systems - Requirements for Aviation, Space and Defense Organizations	AS9100
Quality	Quality Standards	ISO9001