PRI Qualification
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Program Document HTBOK

PD 6103

HTBoK-008/PL-2 REV. A

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BODY OF KNOWLEDGE:

ROLE DESCRIPTION: ALUMINUM ALLOYS PLANNER
SPECIAL PROCESS: Aluminum Alloys
LEVEL: Planner

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 Aluminum Alloys, 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***
Aluminum Alloys Specific Criteria	Basic understanding of the HT / Aluminum Alloy process including Quench and Refrigeration	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.	

6. TABLE 1

ROLE DESCRIPTION: PLANNER
SPECIAL PROCESS: HEAT TREATMENT OF ALUMINUM AND ITS ALLOYS
METHOD: Performance of Heat Treatment processes on Aluminum and its alloys to comply with customer specific / international standard requirements.
REFERENCE GUIDELINES: ***Addendum 1 is a list of the International Standards and Reference Documents applicable to Heat Treating processes.***

Row #	COMPETENCE	Weight (1,3,7,10)	Exam Type Written/ Practical	Reference Guidelines (See description above)
	Understands: **The basic knowledge of the special processes, methods and tools**			
1.	**GENERAL QUALITY SYSTEMS KNOWLEDGE:**			
2.	Knowledge and understanding of Aerospace Quality Systems and compliance.	7	GEN	AS9100, AC7102/2
3.	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)	7	GEN	AS9100, AC7102/2
4.	Knowledge and understanding of how non-conformance is controlled using tools such as Root Cause Corrective Action and 5 Why's.	7	GEN	AS9100, AC7102/2
5.	Knowledge and understanding of safety compliance requirements as applicable (some aluminum alloys treated in the wrong media could cause serious explosions).	10	GEN	AS9100, AC7102/2
6.	Knowledge and understanding of traceability of calibration to NIST or equivalent agencies.	7	GEN	AS9100, AC7102/2
7.	**GENERAL METALLURGICAL KNOWLEDGE RELATED TO HEAT TREATING ALUMINUM ALLOYS (Applicable to all specifications):**			
8.	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.	7	PRAC	AMS2750, AC7102/8
9.	**Understanding of Heat Treatments applied to Aluminum Alloys -**			
10.	• Solution Heat Treatment • Aging • Annealing • Stress relieving • Quenching • Refrigeration	7	GEN	AMS2771, AMS2772, AMS 2770, & AC7102/2
11.	Understanding of the importance of clear planning to allow for meeting and documenting Quench Delay times and time to aging or to refrigeration	7	GEN	AMS2771, AMS2772, AMS 2770 & AC7102/2
12.	**Understanding of the definitions and importance of terms applicable to Heat Treatment of Aluminum Alloys** • Set temperature • Recovery time • Start of soak • End of soak • Interruptions • Quench delay • Eutectic Melting • Temp Heating Rate • Composition • Homogenization effects on Heat treat	7	GEN	AMS2771, AMS2772, AMS 2770 & AC7102/2
13.	Understanding of why correct selection and flowdown to operators of set temperatures and furnace uniformity is critical especially for solution treatment	7	GEN	AMS2771, AMS2772, AMS 2770 & AC7102/2
14.	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)	7	GEN	AMS2771, AMS2772, AMS 2770 & AC7102/2
15.	Knowledge and understanding of when planning needs to require the use of protective compounds (ammonium or sodium fluoborate, or other equivalent moisture reducing compounds) or the replacement of protective compounds with the monthly check for high temperature oxidation. (Aluminum treated to high temperature in humid environments can develop porosity related to the generation of hydrogen. Entrapped water must be prevented from entering the furnace. The loading of parts directly from a water-containing quench tank (i.e., wet parts),	7	GEN	AC7102/2

	into a furnace is prohibited by many specifications. Fluoborate compounds act as drying agents to reduce any residual moisture)			
16.	Knowledge and understanding that planning must reflect use of heat treating equipment and instruments for the heat treatment of aluminum alloys that are in accordance with customers' requirements	7	GEN	AMS 2750, AC7102/2
17.	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 aluminum alloys in accordance with customers' requirements	7	GEN	AMS2750, AC7102/2, & AC7102/8
18.	Knowledge and understanding that, when required by specification, planning for furnaces used above 400F (200C) must specify operation such that the products of combustion that could contaminate the load do not enter the heat treating furnaces	7	GEN	AC7102/2
19.	Knowledge and understanding that planning must include that salt bath be tested periodically for pH in accordance with the applicable heat treating specification	7	GEN	AC7102/2
20.	**Racking, fixturing and spacing** Knowledge and understanding that planning must include the identification of specially designed racks and fixtures which must be used for the specific parts they are designed for	7	GEN	AC7102/2
21.	Knowledge and understanding that planning must include that racks, fixtures and/or baskets must be free from entrapped quenchant	7	GEN	AC7102/2
22.	Knowledge and understanding that planning must include that parts must be spaced in order to ensure adequate circulation of the heating medium and quenchant	7	GEN	AC7102/2
23.	**Quench** Knowledge and understanding that planning must include that quench mechanisms must be capable of meeting the maximum quench delay provisions of the specifications	7	GEN	AC7102/2
24.	Knowledge and understanding that planning must include that quench delay requirements must be met and documented for each individual load	7	GEN	AC7102/2
25.	**Spray or forced air quench** Knowledge and understanding that planning must include that spray or forced air quenching may only be used on alloys and product forms when allowed by the governing specification	7	GEN	AC7102/2
26.	Knowledge and understanding that planning must include that periodic electrical conductivity tests must be performed when required to verify the effectiveness of the spray and/or forced air quench and that these periodic conductivity checks meet (do not exceed) maximum conductivity and uniformity requirements for each surface of the alloy tested.	7	GEN	AC7102/2
27.	Knowledge and understanding that planning must include maintenance to assure that nozzles and jets are not blocked and are oriented at the same position as qualified	7	GEN	AC7102/2
28.	**Quenchant Control** Knowledge and understanding that planning must include that quenchant temperature must be controlled and documented	7	GEN	AC7102/2
29.	Knowledge and understanding that planning must include that records on or traceable to the traveler must demonstrate that quenchants have been at the specified temperature before, during and after the parts were quenched	7	GEN	AC7102/2
30.	Knowledge and understanding that planning must include that quenchant agitation and/or agitation of the parts during quenching must conform to applicable specifications	7	GEN	AC7102/2
31.	**Water/Polymer Quenchant Solutions** Knowledge and understanding that planning must include that water/polymer quenchant solutions must be checked for concentration by a method and at frequencies required by the customer	7	GEN	AC7102/2
32.	Knowledge and understanding that planning must include that the quenching in water/polymer solution is only used when permitted by the customer and specification for the specific alloy and metal thickness	7	GEN	AC7102/2
33.	Knowledge and understanding that planning must include that records must document that all water/polymer quenchant solutions have been checked for concentration by a method and at frequencies required by the customer	7	GEN	AC7102/2
34.	Knowledge and understanding that that if quenchant concentration is checked by refractive index, planning must include that the refractometer be periodically calibrated using standard solutions	7	GEN	AC7102/2
35.	**Water/Polymer Quenchant Used in Conjunction with the Salt Baths** Knowledge and understanding that planning must include that water/polymer quenchant solutions, used in conjunction with the salt baths must be checked for salt contamination using calibrated known solutions as required by applicable specification.	7	GEN	AC7102/2
36.	Knowledge and understanding that planning must include records that show that contamination does not exceed 6% and/or other requirement defined in applicable customers' specifications	7	GEN	AC7102/2
37.	**Refrigeration When Required by Specification** Knowledge and understanding that planning must include procedures addressing cooling requirements after quench.	7	GEN	AC7102/2
38.	Knowledge and understanding that planning must include records that show that cooling after quench is in compliance with customer requirements	7	GEN	AC7102/2
39.	Knowledge and understanding that planning must include the time/temperature limits for retention of the "As Quenched" condition.	7	GEN	AC7102/2
40.	Knowledge and understanding that planning must include requirements to record the temperature in each refrigeration or cold storage unit.	7	GEN	AC7102/2

41.	**Handling Fasteners** Knowledge and understanding that planning must include customer requirements for special handling of fasteners after quenching	7	GEN	AC7102/2
42.	**Aluminum Solution Heat Treating Furnaces with the Heat Source in Walls** Knowledge and understanding that planning must include periodic determination that radiant tubes and/or electric heating elements are shielded or positioned to prevent the radiation heating of parts and that radiation tests must be made in accordance with AMS 2750 prior to initial production use and after any repair or adjustments that might alter radiation characteristics	7	GEN	AC7102/2
43.	**Testing** Knowledge and understanding that planning must include that hardness and/or conductivity testing must be performed in accordance with specification or customer requirements.	7	GEN	AC7102/2
44.	Knowledge and understanding that planning must include periodic testing as required by customer to verify the aluminum heat treating (e.g. monthly quench effectiveness testing - tensile testing, eutectic melting, intergranular corrosion, clad diffusion, etc.)	7	GEN	AC7102/2
45.	Knowledge and understanding that planning must include that periodic testing must be performed per customers' requirements	7	GEN	AC7102/2
46.				
47.	**REQUIREMENTS SPECIFIC TO PRODUCT PROCESSED (in accordance with the relevant AMS):**			
48.	**SPECIFIC REQUIREMENT RELATED TO HEAT TREATMENT OF WROUGHT ALUMINUM ALLOY PARTS TO AMS 2770 (NOT APPLICABLE IF NOT PROCESSING TO AMS 2770)**			
49.	Knowledge and understanding that this specification covers the engineering requirements for heat treatment, by part fabricators (users) or their vendors or subcontractors, of parts. It also covers heat treatment by warehouses or distributors converting raw material from one temper to another temper.	7	GEN	AMS 2770
50.	Knowledge and understanding planning must include work instructions as to pyrometry and furnace class (uniformity) as required by AMS 2770.	7	GEN	AMS 2770
51.	**Heating Media** Knowledge and understanding that planning must include that media shall be air, molten salt bath, oil bath, or fluidized bed. The products of combustion and other materials that could contaminate parts shall not come into contact with parts during solution heat treating, annealing or stress relieving. Electrical heating elements and radiant tubes shall be shielded to prevent parts from being exposed to direct radiation. Shield construction and placement shall be such as to prevent parts from being exposed to re-radiation of heat from electrical elements or radiant tubes. Composition and maintenance of salt baths and fluidized beds shall be such as to prevent attack of the parts.	7	GEN	AMS 2770
52.	**Temperature Uniformity Test Recovery Requirements** Knowledge and understanding that when performing temperature uniformity tests for all solution heat treat and aging furnaces, planning must include that the lag time between recovery of the first test thermocouple and the last test thermocouple to within 10 °F (6 °C), or 5 °F (3 °C) as applicable, of the set temperature during furnace uniformity tests shall not exceed the following: • 20 minutes for furnaces tested without a load • 40 minutes for furnaces tested with a load • TE: For solution heat treating of parts made from alclad product under 0.125 inch (3.18 mm) thick, the furnace recovery time shall not exceed 30 minutes and for parts made from heavier alclad product, shall not exceed 60 minutes.	7	GEN	AMS 2770
53.	**Refrigeration Equipment** Knowledge and understanding that planning must include that refrigeration equipment must be capable of temperature recovery to within 5 °F (3 °C) of the set temperature within 20 minutes of door closing after insertion or removal of parts.	7	GEN	AMS 2770
54.	**Cleaning** Knowledge and understanding that planning must include that prior to solution heat treating or annealing, parts shall be clean and visually free of contaminants such as dirt, metal residues, lubricants and solvent residues.	7	GEN	AMS 2770
55.	**Racking and Fixturing** Knowledge and understanding that planning must include that racking and fixturing must be constructed so as to preclude entrapment of water, molten salt and/or water/polymer solutions	7	GEN	AMS 2770
56.	Knowledge and understanding that planning must include that parts be racked or supported to permit free access of the heating and quenching media to all surfaces of parts in all portions of the load. (Rivets and other small parts may be heated and soaked in baskets or in continuous furnaces. Arrangement in baskets may be either orderly or random. Parts may touch but shall not be nested in a manner that prevents free access of the quench media to most surfaces. Maximum thickness of layers of rivets or parts in baskets or on a moving belt, and minimum space between layers, shall be 2 inches (51 mm).)	7	GEN	AMS 2770

57.	Knowledge and understanding that planning must include that during Solution Heat Treating, parts, 0.250 inch (6.35 mm) and under in nominal thickness, shall be separated by not less than 1 inch (25 mm). Thicker parts shall be separated by at least 1 inch (25 mm) plus the part thickness. (Complex parts and parts of large plan form may require greater separation.)	7	GEN	AMS 2770
58.	Knowledge and understanding that planning must include that during Aging, Annealing and Stress Relieving, parts shall be separated by not less than 1 inch (25 mm) except thin parts may be nested providing thickness of nested stacks does not exceed 1 inch (25 mm) and stacks are at least 1 inch (25 mm) apart.	7	GEN	AMS 2770
59.	Knowledge and understanding that planning must include that parts that can entrap salt shall be racked so as to preclude salt entrapment as much as practicable.	7	GEN	AMS 2770
60.	**Soak** Knowledge and understanding that planning must include that soaking time starts when all temperature control, recording and monitoring sensors reach the minimum of the uniformity tolerance range. **Load sensors should not be used to determine start of soaking time.**	7	GEN	AMS 2770
61.	Knowledge and understanding of the importance of generating work instructions that specify and require maintaining documentation of minimum soak time (and maximum for alclad product)	7	GEN	AMS 2770
62.	**Interruptions** Knowledge and understanding that planning must include that during solution heat treatment, soaking must be performed without interruption.	7	GEN	AMS 2770
63.	Knowledge and understanding that planning must include that during aging, annealing, stress relieving, and heat treatment to the O1 (formerly T411) temper, a maximum of four interruptions, with doors open for not more than 2 minutes during each, is permissible for removal or loading of parts. Door opening durations greater than 2 minutes are permitted provided the time between the door opening and recovery of furnace temperature is not included in the total time.	7	GEN	AMS 2770
64.	**Stabilization** Knowledge and understanding of the importance of generating clear work instructions for solution treating temperature and for stabilization of furnace prior to loading parts.	7	GEN	AMS 2770
65.	**Prevention of Hydrogen Induced Porosity** Knowledge and understanding that planning must include that entrapped water shall be prevented from entering the furnace. The loading of parts directly from a water-containing quench tank (i.e., wet parts), into a furnace is prohibited. Ammonium fluoborate, or equivalent, should be used in air furnaces as necessary; however, purging the furnace with fresh air may be necessary to prevent discoloration of subsequent loads of parts made from alclad product.	7	GEN	AMS 2770
66.	Knowledge and understanding that planning must include that for solution heat treating of parts made from alclad product under 0.125 inch (3.18 mm) thick, the furnace recovery time shall not exceed 30 minutes and for parts made from heavier alclad product, shall not exceed 60 minutes.	7	GEN	AMS 2770
67.	**Multiple Solution Heat Treatments of Alclad Product** Knowledge and understanding that planning must include that parts made from product over 0.125 inch (3.18 mm) in nominal thickness shall be limited to two solution heat treatments in addition to any by the material producer. Parts made from product 0.020 to 0.125 inch (0.51 to 3.18 mm) in nominal thickness, shall be limited to one additional solution heat treatment in addition to any by the raw material producer. For parts made from product under 0.020 inch (0.51 mm) in nominal thickness, additional solution heat treatments are prohibited.	7	GEN	AMS 2770
68.	**QUENCH** **Quenchant Temperature** Knowledge and understanding that planning must include that at the start of quench, quenchant temperature shall not exceed 90 °F (32 °C) except when water quenching parts made from forgings. When quenching parts made from forgings, the start of quench water temperature shall conform to AMS 2770.	7	GEN	AMS 2770
69.	**Temperature Rise of Quenchant During Quenching** Knowledge and understanding that planning must include that quenchant temperature shall not exceed the maximum start-of-quench temperature by more than 10 °F (6 °C) at any time during quenching. In addition, the quenchant temperature shall not increase more than 25 °F (14 °C) from the starting temperature as a result of quenching any single load.	7	GEN	AMS 2770
70.	Knowledge and understanding of the importance of generating clear planning for controlling and documenting Quench Delay Times.	7	GEN	AMS 2770
71.	**Agitation** Knowledge and understanding that planning must include that parts and/or quenchant shall be agitated during quenching. For thin parts (minimum dimension in heaviest section is under 0.105 inch (2.67 mm), movement into the quenchant during immersion is sufficient agitation.	7	GEN	AMS 2770
72.	**Quenchants Other Than Water or Water/Polymer Solutions for 6061, 6063, 6066 and 6951 Alloy Parts** Knowledge and understanding that thin parts under 0.125 inch (3.18 mm) in nominal thickness, made from 6061, 6063, 6066 and 6951 alloys, may be quenched in an air blast, water spray or fog, providing that quality assurance provisions are supplemented by tensile and hardness tests as specified in AMS 2770	7	GEN	AMS 2770

73.	**Immersion Time** Knowledge and understanding that planning must include that parts racked or in baskets shall be kept immersed in the quenchant for not less than 1 minute per inch (25.4 mm) of maximum thickness, or fraction thereof, or for not less than 1 minute after all evidence of boiling ceases, whichever is longer. Sheet metal parts less than 0.125 inch (3.18 mm) thick may be removed from the quenchant as soon as all boiling ceases.	7	GEN	AMS 2770
74.	Knowledge and understanding that when water quenching from a salt bath, if the water quench tank does not have an overflow system to preclude salt build-up in the quench tank, planning must include that parts be rinsed in fresh water to preclude the possibility of salt residue on parts	7	GEN	AMS 2770
75.	**Water/Polymer Solutions** Knowledge and understanding that planning must include that water/polymer solutions shall conform to AMS3025, Type 1 or Type 2, that concentrations shall comply with AMS 2770 and that the pH of water/polymer solutions shall be maintained between 7.5 and 9.2.	7	GEN	AMS 2770
76.	Knowledge and understanding that planning must include that after quenching into a water/polymer solution, parts shall be thoroughly rinsed with fresh water to remove the residual polymer	7	GEN	AMS 2770
77.	**Polymer Concentration Control** **Test Methods** Knowledge and understanding that planning must include that determination of concentration shall be based on tests of viscosity (in accordance with ASTM D 445) or by refractive index using a refractometer, e.g., °Brix, glycol coolant, salinity, specific gravity, Abbe, etc., calibrated in accordance with AMS2770. A refractometer scaled in °Brix is preferred.	7	GEN	AMS 2770
78.	**Test Frequency** Knowledge and understanding that planning must include that concentration shall be determined quarterly by viscosity. In addition, concentration shall be determined weekly, and when concentration is changed, by viscosity or refractive index.	7	GEN	AMS 2770
79.	Knowledge and understanding that planning must include that when refractometer concentration measurement is made, the concentration of the tank shall be recorded as the value determined by the corrected refractive index measurement	7	GEN	AMS 2770
80.	**Quenchants Used With Salt Bath Furnaces** Knowledge and understanding that planning must include that when a refractometer is used, and a test of the quenchant shows that its salt content has changed by 1% or more since the last viscosity test, a new multiplying factor shall be determined. Determination of the new multiplying factor shall be based on a new viscosity test or calibration against solutions of similar concentration.	7	GEN	AMS 2770
81.	Knowledge and understanding that planning must include that when a viscosity concentration measurement is taken, the reading shall be compared to the corrected refractive index concentration measurement taken on the same sample. For the purpose of comparison, the viscosity value and refractive index value shall be rounded to the nearest 0.5% polymer concentration. If the concentration value of the two measurements differs by 2% or less, the concentration of the tank shall be recorded as the value determined by the refractive index measurement. If the rounded corrected concentration values of the two measurements differ by more than 2%, the reasons for the variance shall be determined and corrective action taken.	7	GEN	AMS 2770
82.	**Equipment** Knowledge and understanding that planning must include that refractometers used for determination of concentration shall be temperature compensating, and of a range suitable for the concentration being measured.	7	GEN	AMS 2770
83.	Knowledge and understanding that planning must include that refractometers, when checked against standards, shall have a measurement accuracy of ±0.5% polymer or ±0.3° Brix as applicable, with a scale resolution or minimum indication of ±0.2° Brix (or equivalent).	7	GEN	AMS 2770
84.	**Calibration of Refractometers** Knowledge and understanding that planning must include that refractometers shall be calibrated at 90-day intervals. The method of calibration shall be documented, and a seal stating the date of calibration shall be affixed to the refractometer. Calibration shall be by Method A or Method B of AMS 2770 or other method when approved by the cognizant engineering organization.	7	GEN	AMS 2770
85.	**Salt Contamination** Knowledge and understanding that planning must include that salt content in polymer/water quenchants shall not exceed 6.0% by weight. Water/polymer quenchants used with salt bath furnaces shall be tested for salt content weekly. The method used shall be calibrated against solutions containing known amounts of both polymer and salt, and the procedure documented. Meters used to determine the salt concentration shall be calibrated every 90 days. Quench tanks which exceed 6.0% salt content shall not be used until the salt content has been reduced below 6% or the quenchant has been replaced	7	GEN	AMS 2770
86.	Knowledge and understanding that planning must include that parts requiring retention of the as quenched (AQ) condition after solution heat treatment shall, after quenching, be refrigerated in conformance with the requirements of AMS 2770.	7	GEN	AMS 2770

87.	Knowledge and understanding that planning may include that parts, prior to refrigeration, may be prechilled by immersion in a cooled liquid to accelerate cooling.	7	GEN	AMS 2770
88.	Knowledge and understanding of the importance of generating clear planning controlling aging times and temperatures as specified in AMS 2770.	7	GEN	AMS 2770
89.	**Straightening After Aging** Knowledge and understanding that planning must include that straightening of parts in the following tempers is prohibited unless approved by the cognizant engineering organization: T6, T6X, T7, T7X, T8 and T8X as well as parts in the T4 and T4X tempers which have aged sufficiently at room temperature to meet either the hardness or conductivity minimum of AMS2658.	7	GEN	AMS 2770
90.	Knowledge and understanding of the importance of generating clear planning covering requirements for annealing/stress relieving in compliance with AMS 2770.	7	GEN	AMS 2770
91.	**O1 (Formerly T411) Temper** Knowledge and understanding that planning must include that parts required to be in the O1 temper shall be heated to the solution heat treating temperature and soak time specified in AMS2770, and air cooled to room temperature.	7	GEN	AMS 2770
92.	Knowledge and understanding of the importance of generating clear planning for hardness and conductivity sampling and testing required by AMS 2658.	7	GEN	AMS2658 AMS 2770 AC7102/5
93.	**Logs** Knowledge and understanding that planning must include 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, AMS2770 (or other applicable specification) and revision level, actual thermal processing times and temperatures used. When applicable, atmosphere, quench delay, quenchant type, polymer concentration, and quenchant temperature shall also be recorded. The maximum thickness, when process parameters are based on thickness, shall be recorded and shall be taken as the minimum dimension of the heaviest section of the part. The log data shall be recorded in accordance with the heat treater's documented procedures.	7	GEN	AMS 2770
94.	Knowledge and understanding that if planning is for a warehouse, distributor or similar organization which converts raw material to a different temper it must include that such material must be heat treated and tested in accordance with the requirements of this specification. The marking, testing and reporting shall be in accordance with AMS2772 and the material specification.	7	GEN	AMS 2770
95.	Knowledge and understanding that, if any work is subcontracted, planning must include that facilities performing heat treatment in accordance with this specification shall be approved by the cognizant quality assurance organization.	7	GEN	AMS 2770
96.	**Records** Knowledge and understanding that planning must include that records shall be kept available for five years after heat treatment. The records shall contain all data necessary to verify traceability and conformance to the requirements of this specification. **NOTE** – Many customers have substantially longer record retention requirements which take precedence over the five year period.	7	GEN	AMS 2770
97.	**Final Inspection** Knowledge and understanding that planning must include inspection of heat treated parts per AMS 2770 as follows	7	GEN	AMS 2770
98.	**For Parts Other Than Rivets and Similar Small Standard Parts** • 7xxx Alloy Parts in T7X Tempers - Every part shall be conductivity tested at the thickest section. Additionally, every part shall be hardness tested except, when approved by the cognizant engineering organization, hardness testing frequency may be reduced to not less than 25%. (Parts which exhibit low conductivity and/or high hardness may be given additional aging (See AMS 2770) and retested.) • 6013, 6061, 6063, 6066 and 6951 Alloy Parts - Every part shall be hardness tested. Parts made from these materials should not be conductivity tested and shall not be rejected for failure to meet conductivity requirements of AMS2658. • Air Blast, Water Spray or Fog Quenched 6xxx Series Alloy Parts - In addition to hardness testing, tensile specimens shall be taken from each heat treat load. The specimens may be made from parts having the lowest hardness, or sample material representing the thickest section of the parts, located near the center of the load. Tensile properties shall conform to the applicable material specification. • Other Alloys or Other Tempers - Each lot of parts in a "T" temper shall be hardness and conductivity tested. (Hardness and conductivity testing is not required for parts in the annealed or stress relieved condition.) Testing shall be in accordance with one of the following. o Every part shall be hardness tested and 10% of the parts shall be conductivity tested. The conductivity tested parts should include those having the highest and lowest hardness.	7	GEN	AMS 2770

	○ Every part shall be conductivity tested and 10% of the parts shall be hardness tested. The hardness tested parts should include those having the highest and lowest conductivity. ○ Tensile or Shear Testing - Alternatively, when tensile or shear testing is required, it may be substituted for the 10% hardness testing. Specimen(s) shall be made from a part selected at random, or a prolongation thereof, or from a sample of the product from which the parts were fabricated. The specimen(s) shall represent the maximum thickness of each lot of parts in each heat treat load. If any test result fails to meet to the applicable requirements, the entire lot shall be rejected and referred to the customer for disposition. ○ Sampling and Testing - In lieu of testing each part, random samples of each lot may be tested for both hardness and conductivity when sampling is approved by the cognizant quality assurance organization. The sampling frequency shall not be less than 25 percent.			
99.	Knowledge and understanding that planning must include that testing and acceptance criteria for parts whose size or shape does not permit hardness or conductivity testing shall be as follows: • Either the hardness or conductivity testing may be omitted provided every part is tested by the remaining method. If this option is used, the report shall reflect that the parts could not be hardness (or conductivity) tested due to size or shape, and that all parts were conductivity (or hardness) tested. • If parts can neither be hardness nor conductivity tested, testing and acceptance criteria shall be as specified by the cognizant quality assurance organization.	7	GEN	AMS 2770
100.	**Rivets and Similar Small Standard Parts** Knowledge and understanding that planning must include that if mechanical testing (e.g., tensile, shear) is not required on each lot, hardness testing is required on each lot of parts. In addition, conductivity testing is required on each lot of 7xxx alloy parts. Sampling shall be at the same frequency as required for the strength parameter by the part specification or drawing. For parts whose size or configuration precludes the above testing, representative (in alloy, thickness, and temper) coupons shall be tested based on furnace used as follows: • Parts Solution Heat Treated and Aged in Batch Type Furnaces - A minimum of three test coupons per lot shall have been randomly placed in each solution heat treatment and age load. • Parts Solution Heat Treated and/or Aged in Continuous Furnaces - A minimum of one test coupon per lot shall have been placed in each solution heat treating and aging furnace during each shift or 12 hours, whichever is less.	7	GEN	AMS 2770
101.	**Failures** Knowledge and understanding that planning must include that if any part or coupon fails to meet either the hardness or the conductivity requirements of AMS2658, every part (which can be tested) in the lot shall be tested. Parts, and parts represented by coupons, which fail to meet either requirement shall be rejected and referred to the customer for disposition.	7	GEN	AMS 2770
102.	**Report/Certification** Knowledge and understanding that planning must include 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 AMS2770 (or other applicable specification) and revision level. This 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 a statement of their conformance/non-conformance to requirements. This data shall be reported in accordance with the heat treater's documented procedures.			AMS 2770
103.	**Use of Load Sensors** Knowledge and understanding that planning must include that the mandatory soaking times for air furnace solution heat treatment and aging are based on using control sensors reflecting furnace air temperature. They include allowance for the lag between air temperature and metal temperature. Therefore basing the start of soaking on load sensors, and soaking for the specified times, will result in excess soaking time. In the case of aging, this may result in reduced properties; in the case of solution heat treatment, it will increase clad diffusion. Use of load sensors should be limited to confirming that parts reached and, during soaking, remained within the allowable range, i.e., the range defined by applying the furnace temperature uniformity tolerance to the specified temperature	7	GEN	AMS 2770
104.	Knowledge and understanding that planning must take into account that solution heat treatment soak times include allowances for the more uniform temperature distribution in salt baths/fluidized beds than air furnaces and the extra lag time needed for part temperatures to reach the heating medium temperature in air furnaces.	7	GEN	AMS 2770
105.	**Mill Furnished Tempers** Knowledge and understanding that the tempers listed below are normally furnished by producers and cannot be produced by users. Consequently, parts for which product in one	7	GEN	AMS 2770

	of these tempers is specified should not be re-solution heat treated, annealed, or heat treated to the O1 (formerly T411) temper unless authorized by the cognizant engineering organization: T3, T31, T36, T361, T37, T81, T86, T87, T351, T451, T651, T851, T861, T3510, T3511, T4510, T4511, T6510, T6511, T8510, T8511, T7651, T7351, T76510, T73510, T73511, T736510, T736511, T652, T654, T7352, T7354, T73651, T73652, T73654, T7451, T7452, T7454, T74510, T74511.			
106.				
107.	**SPECIFIC REQUIREMENTS RELATED TO HEAT TREATMENT OF ALUMINUM ALLOY CASTINGS TO AMS 2771 (NOT APPLICABLE IF NOT PROCESSING TO AMS 2771)**			
108.	Knowledge and understanding that this specification covers the engineering requirements for heat treatment of aluminum alloy castings and for parts machined from castings.	7	GEN	AMS2771
109.	**Equipment** Knowledge and understanding that planning must include that equipment used for thermal processing shall conform to the requirements of this specification and AMS2750, except (1) requirements for working zone controls, instruments and sensors shall apply to all heating zones of continuous and semi-continuous furnaces and (2) recordings from instruments may be stored on magnetic or optical media providing a hard copy is available on request.	7	GEN	AMS2771
110.	**Heating Media** Knowledge and understanding that planning must include that media shall be air, protective atmosphere, combusted gases, molten salt bath, oil bath, or fluidized bed. Electrical heating elements and radiant tubes shall be shielded to prevent direct radiation from striking any part. The products of combustion in the furnace, and the composition and maintenance of salt baths and fluidized beds shall be such as to prevent attack or contamination of the castings. Ammonium fluoborate, or equivalent, may be used in air furnaces as necessary. Nitrate salt baths shall not be used to heat treat 520.0 alloy due to a potential explosion safety hazard.	7	GEN	AMS2771
111.	**Salt Entrapment** Knowledge and understanding that planning must include that castings that will entrap salt shall not be heated in a molten salt bath.	7	GEN	AMS2771
112.	Knowledge and understanding of the importance of generating clear instructions for pyrometry and furnace class (uniformity) as required by AMS 2771	7	GEN	AMS2771
113.	**Polymer Quenchants** Knowledge and understanding that planning must include that polyalkalene glycol shall meet the requirements of AMS3025. Other synthetics may be used provided that they are not detrimental to the material and that the parts meet the required specified properties in the final heat treated condition. Polymer concentration shall be established for the particular casting configuration prior to use.	7	GEN	AMS2771
114.	**Salt Contamination of Polymer Quenchants** Knowledge and understanding that planning must include that contamination shall not exceed 6% by weight.	7	GEN	AMS2771
115.	**Cleaning** Knowledge and understanding that planning must include that equipment shall be provided to clean castings, as necessary for heat treatment, and to remove residual quenchant after solution heat treatment. Examples include: water rinse to remove polymer quenchant residue, detergent and rinse to remove oil quenchant residue, and fresh water overflow to remove salt quenchant residue.	7	GEN	AMS2771
116.	**Refrigeration** Knowledge and understanding that planning must include that refrigeration or liquid baths shall be provided for cold storage of castings when prevention of natural aging is necessary to produce required properties or is used at the discretion of the producer to facilitate straightening.	7	GEN	AMS2771
117.	**Procedures** Knowledge and understanding that planning must include that cast parts that require heat treatment to a T4X, T6X, or T7X temper shall be solution heat treated (including quenching), refrigerated after quenching, when necessary, and aged, when required, as specified herein. Castings in the T5X condition shall be refrigerated after casting, when necessary, and aged as specified herein. Heat treatment shall be performed only on entire castings, never on a portion of a part.	7	GEN	AMS2771
118.	**Racking and Spacing** Knowledge and understanding that planning must include that product shall be supported or hung and spaced to permit flow of the heating and cooling media over all surfaces to ensure that the castings will meet the specified requirements. Alternate racking methods are acceptable if tests have been performed to demonstrate that all castings so racked will meet specified requirements. Written instructions, drawings, photographs, etc. shall be used to ensure proper spacing. Small castings be heated and soaked in baskets or continuous furnaces. Care must be used to provide access for heating and quench media and to prevent damage during loading and quenching. Arrangement in baskets may be either orderly or random provided that the castings meet the required specified properties in the final heat treated condition.	7	GEN	AMS2771
119.	**Water Entrapment**	7	GEN	AMS2771

	Knowledge and understanding that planning must include that racks and fixtures used for solution heat treatment shall be constructed to preclude entrapment of water.			
120.	**Loading** Knowledge and understanding that planning must include that the temperature of the furnace during part loading shall not exceed the solution treating temperature of the castings being heat treated	7	GEN	AMS2771
121.	**Post quench reload to furnace** Knowledge and understanding that planning must include that batch type furnaces that momentarily reload the freshly quenched material back into the furnace work zone as part of the unloading/quench tank transfer sequence is allowed provided objective evidence is available to qualify this process. The evidence shall demonstrate the thinnest material processed is not heated above 212 °F (100 °C) by this post quench process using radiation survey process in AMS2750. The castings shall not be held in the furnace for more than 5 minutes during this post-quench sequence. The process used to provide the objective evidence shall be performed at the minimum furnace open time established by the heat treater's documented process after quenching the castings. The documented process shall include the maximum temperature of the furnace as measured by the control thermocouple or a specified minimum furnace cooling time prior to raising the load into the furnace.	7	GEN	AMS2771
122.	**Set Temperature** Knowledge and understanding that planning must include that control instrument(s) shall be set at the temperature specified in AMS 2770 for solution treating and aging, and should be set at the recommended annealing temperature specified. Sensor/control offsets, if used, shall comply with AMS2750.	7	GEN	AMS2771
123.	**Soaking** Knowledge and understanding that planning must include that soaking time starts when all temperature control sensing elements and load thermocouples (if used) are within 10 °F (6 °C) of the set or offset temperature.	7	GEN	AMS2771
124.	Knowledge and understanding planning must include that interruption limits comply with the requirements of AMS 2771 as follows	7	GEN	AMS2771
125.	**Batch Furnaces** Interruptions during solution treatment are permitted provided the minimum soak time is met and at least a 2-hour soak time occurs after the interruption. When acceptable to the cognizant engineering organization, producer may use a shorter soak time after interruption that is documented and based on test results and data applicable to the castings being processed. During aging and annealing treatments a maximum of four interruptions are permitted for removal or loading of castings. The time between door opening and furnace or load thermocouple recovery is not to be counted as part of the total aging time.	7	GEN	AMS2771
126.	**Continuous and Semi-Continuous Furnaces** During soaking, a drop in temperature indicated by furnace instrument(s) is permissible provided (1) that temperature does not drop more than 20 °F (11 °C) below the minimum of the specified range, (2) time below the minimum of the specified range does not exceed 5 minutes, and (3) soaking is continued for not less than 10 minutes after recovery before quenching. If furnace temperature does not drop more than 20 °F (11 °C) below the minimum of the specified range, but does not recover to the minimum of the specified range within 5 minutes, the total soaking time, if less than 1 hour was required, shall be increased by 1/2 hour. If 1 hour or more was required, the total soaking time shall be increased by 1 hour. Load thermocouples shall be used, when needed, to determine and control metal temperature and heating time or when required by the cognizant engineering organization	7	GEN	AMS2771
127.	**Logs** Knowledge and understanding that planning must include 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 castings, alloy, lot identification, AMS2771 or other applicable specification, actual thermal processing times and temperatures used. When applicable, atmosphere control parameters, quench delay, quenchant type, polymer concentration and quenchant temperature shall also be recorded. The maximum thickness, when process parameters are based on thickness, shall be recorded and shall be taken as the minimum dimension of the heaviest section of the part. The log data shall be recorded in accordance with the heat treater's documented procedures.	7	GEN	AMS2771
128.	**Cleaning** Knowledge and understanding that planning must include that castings shall be clean of contaminants that will react during heat treatment or cause adverse effects. Residue from heating and quenching media shall be removed from castings after solution heat treatment.	7	GEN	AMS2771
129.	**Solution** Knowledge and understanding of the importance of generating clear planning including requirements for set temperature requirements, start of soak, minimum soak time and end of soak comply with AMS2771	7	GEN	AMS2771
130.	**Variations**	7	GEN	AMS2771

	Knowledge and understanding that solution treating set temperatures may vary from these set temperature requirements to obtain required properties for a specific casting configuration.			
131.	**Quenching** **Quenchant Temperature** Knowledge and understanding that planning must include that during the quench, the quenchant temperature shall not rise more than 25 °F (14 °C). To prevent excessive warpage and possible cracking, castings may be quenched in oil or water with temperature varying from cold to hot (212 °F (100 °C)) or in a polymer quenchant at room temperature providing it is substantiated that the combination of quench and solution temperature will produce mechanical properties meeting the material specification. Exceptions to the temperature rise are permitted provided that it has been demonstrated by testing and documentation that the castings meet the required specified properties in the final heat treated condition. Unless otherwise specified in a drawing or procurement document, castings of Alloy 520.0 shall be quenched by total immersion in oil heated to 300 °F (149 °C) and castings of Alloy 242.0 shall be air-quenched.	7	GEN	AMS2771
132.	**Quench Delay Time** Knowledge and understanding that planning must include that the quench delay time shall not exceed 15 seconds. The delay shall be measured from the time the furnace door of an air furnace starts to open, or the first portion of the load emerges from a fluidized bed or salt bath, to complete immersion of the load in the quenchant. This delay time may be exceeded providing that the cooling rate does not result in a loss of any mechanical property typically obtained by the established process for that casting configuration.	7	GEN	AMS2771
133.	**Agitation** Knowledge and understanding that planning must include that castings, quenchant, or both shall be agitated during quenching. Small parts heated and soaked in baskets may be quenched by dumping when basket loads are too heavy to allow adequate quenching by immersion of the full basket and provided that the castings are not damaged by dumping. Exceptions to the use of agitation are permitted provided that it has been demonstrated that the castings meet the required specified properties in the final heat treated condition.	7	GEN	AMS2771
134.	**Quenchant Contact Time** Knowledge and understanding that planning must include that castings which are quenched by immersion shall be kept immersed in the quenchant for not less than 2 minutes per inch of thickness, or fraction thereof in the thickest section. Alternatively, castings shall be kept immersed in the quenchant for not less than 2 minutes after boiling ceases. Castings quenched in boiling water shall remain immersed for not less than 2 minutes. Castings quenched in an air blast shall remain in contact with the air blast until surface temperatures are reduced to 212 °F (100 °C).	7	GEN	AMS2771
135.	**Temper After Treatment** Knowledge and understanding that planning must include that all alloys are in the AQ temper immediately after quenching. After 45 minutes at room temperature or after the maximum refrigerated storage time has elapsed, they are in the W temper which is unstable, i.e., their properties are continuously changing. After an appropriate delay at room temperature, unless otherwise noted herein, the tempers shall be as shown in AMS 2771.	7	GEN	AMS2771
136.	**Refrigeration** Knowledge and understanding that when a material specification or a fixed process agreement requires retention of the AQ condition to attain the required mechanical properties, planning must include that castings shall be refrigerated within 45 minutes after quenching and storage conditions shall be documented by a temperature recorder with record of casting traceability.	7	GEN	AMS2771
137.	Knowledge and understanding that when the producer determines that refrigeration is required for a casting to facilitate straightening, the castings may be refrigerated as necessary to facilitate straightening. There is no requirement for traceability records, temperature recorder, nor pyrometry testing of the refrigeration device.	7	GEN	AMS2771
138.	**Aging** Knowledge and understanding that planning must include that castings requiring aging shall be aged as specified in AMS2771 to obtain the final temper and required mechanical properties except Aging set temperature and/or soak time may vary from the requirements of Table 2 to obtain required properties for a specific casting configuration; however, alloys 201 and A201 shall not be aged below a minimum temperature of 360 °F (182 °C) unless the T6 condition is specifically called for in the procurement documents. Departure of more than 30 °F (17 °C) from the required set temperature shall require approval of the cognizant engineering	7	GEN	AMS2771
139.	**Annealing** Knowledge and understanding that planning must include that heating, soaking, and cooling parameters in AMS 2771 are recommended for annealing of castings. If a partial anneal (stress relief) is required, it shall be as specified by the cognizant engineering organization.	7	GEN	AMS2771
140.	Knowledge and understanding that planning must include that straightening after final heat treatment shall not be performed unless authorized by the cognizant engineering organization	7	GEN	AMS2771
141.	**Qualification of Suppliers**	7	GEN	AMS2771

	Knowledge and understanding that planning must include that facilities performing heat treatment in accordance with this specification shall be approved by the cognizant quality assurance organization			
142.	**Acceptance** Knowledge and understanding that planning must include that castings shall meet the hardness and tensile property requirements of the applicable material specification. When hardness or tensile properties are not specified, the test method, test specimens (i.e., separately cast specimens, integrally attached specimens, specimens machined from prolongations, or specimens machined from casting sections), and acceptance criteria shall be agreed upon by purchaser and vendor.	7	GEN	AMS2771
143.	**Inspection** Knowledge and understanding that planning must include that the cognizant quality assurance organization shall review heat treating records and the results of tests and inspections to verify that heat treatment conformed to specified requirements.	7	GEN	AMS2771
144.	**Records** Knowledge and understanding that planning must include that records shall be kept available to purchaser for not less than five years after performance of heat treatment. The records shall contain all data necessary to verify conformance to the requirements of this specification. **NOTE** – If the heat treating procedure is considered proprietary, the vendor may certify that the information is proprietary and is on file. The procedures shall be available for review by personnel representing the cognizant engineering organization. **NOTE** – Many customers have substantially longer record retention requirements which take precedence over the five year period.	7	GEN	AMS2771
145.	**Process Control** Knowledge and understanding that planning must include that the cognizant quality assurance organization may perform any inspections, surveillances, tests, and statistical process control analyses necessary to ensure that castings are heat treated in accordance with this specification.	7	GEN	AMS2771
146.	**Reports** Knowledge and understanding that planning must include that the vendor shall furnish with each shipment a report referencing the heat treatment log number, the results of tests to determine conformance to this specification, and a statement that the castings were processed in accordance with the requirements of this specification. This report shall include the purchase order number, AMS2771 and revision level, alloy designation and material specification number, casting number, and quantity.	7	GEN	AMS2771
147.	Knowledge and understanding that to facilitate straightening, castings should be refrigerated within 45 minutes after quenching and the maximum refrigeration storage time should not exceed seven days at 10 °F (-12 °C), 30 days at 0 °F (-18 °C), or 90 days at -10 °F (-23 °C) maximum temperatures.	7	GEN	AMS2771
148.				
149.	**SPECIFIC REQUIREMENTS RELATED TO HEAT TREATMENT OF ALUMINUM ALLOY RAW MATERIAL TO AMS 2772 (NOT APPLICABLE IF NOT PROCESSING TO AMS 2772)**			
150.	Knowledge and understanding that this specification covers requirements and recommendations for the heat treatment of wrought aluminum alloy raw materials by producers.	7	GEN	AMS2772
151.	Knowledge and understanding of the importance of generating clear work instructions with respect to selection of equipment due to specific equipment qualification requirements. Any questions about the qualification status of equipment must be brought to the attention of the process owner.	7	GEN	AMS2772
152.	**PYROMETRY** Knowledge and understanding of the importance of generating clear work instructions as to pyrometry and furnace class (uniformity) as required by AMS 2772 Pyrometry shall conform to AMS2750 except (1) it is not applicable to furnaces used only for stress relieving or full annealing below 825 °F (441 °C), (2) recordings from instruments may be stored on magnetic or optical media providing a hard copy is producible on request, and (3) in continuous and semi- continuous furnaces, the requirements applicable to controls, instruments, and sensors in the working (soaking) zone shall also be applicable to the heating (heat-up) zone	7	GEN	AMS2750 AMS2772
153.	**Temperature Uniformity Tests** Planning for temperature uniformity tests shall be modified from the requirements of AMS2750 as follows: • Load Condition - Initial tests shall be performed with a typical load. Subsequent tests may be performed with any load or no load. Furnaces which have only been tested with a heavy load (in anticipation of only heat treating heavy loads) shall not be used to heat treat light loads unless load sensors and recording instruments are employed to (1) preclude any portion of the load exceeding the maximum specified temperature on heat-up and (2) ensure soaking within the specified range for the required time.	10	GEN	AMS2750 AMS2772

	• Load Sensors - When all production loads are heavy and a temperature uniformity test load is heavy, load sensors may be used in lieu of uniformity test sensors. • Loaded Furnaces - During the heat-up portion of uniformity tests performed on a loaded batch furnace and during the period that a load is in the heating (heat-up) zone(s) of continuous and semi-continuous furnaces, the temperature of the heating medium may exceed the maximum of the range being tested providing that the metal temperature does not exceed that maximum. • Uniformity Requirements - During the test period, the temperature of all working and test sensors in the working (soaking) zone shall be within the following allowable ranges (these ranges supersede the ± temperature tolerances specified in AMS2750): o 50 °F (28 °C) range for furnaces used only for full annealing at 825 °F (441 °C) and higher. Annealing temperatures shall be controlled so as to preclude any material exceeding the lowest solution heat treating temperature for the alloy being annealed. o For furnaces used only for full annealing below 825 °F (441 °C) and for stress relieving, there are no temperature uniformity requirements. o 30 °F (17 °C) range for furnaces used only for solution heat treatment of those 6xxx alloys for which a range of 30 °F (17 °C) degrees or more is specified. o 20 °F (11 °C) range for furnaces used for solution heat treatment of 6xxx alloys for which a range of less than 30 °F (17 °C) is specified. o 20 °F (11 °C) range for furnaces used for solution heat treatment of other alloys except 10 °F (6 °C) range for furnaces used for solution heat treatment of 8090 sheet. o 20 °F (11 °C) range for furnaces used for aging treatments. o 20 °F (11 °C) range for furnaces used for processing to the -O1 temper.			
154.	Knowledge and understanding that planning must include that heating media for solution heat treatment shall be air, protective atmosphere, combusted gases, molten salt bath, or fluidized bed. However, no protective atmosphere, combusted gas or fluidized bed environment shall be used unless it has been shown by test on the alloy/form to be heat treated, to yield product which is free from heat treat induced porosity. Composition of salt baths and fluidized beds shall be maintained to prevent attack of the product.	7	GEN	AMS2772
155.	**Cleanliness** Knowledge and understanding that planning must include that prior to heat treating, product shall be free from surface contaminants which could have a detrimental effect on the material	7	GEN	AMS2772
156.	**Racking and Spacing** Knowledge and understanding of the importance of generating clear work instructions for racking and spacing requirements due to validation requirements including load sensor placement during validation Knowledge and understanding that planning must include that during solution heat treatment, product shall be supported or hung and spaced to permit flow of the heating and cooling media over all surfaces to ensure that all product will meet the specified requirements. During aging, product shall be supported or hung and spaced so that it will be heated and soaked as required to meet the specified requirements. Random racking (not nested) or layering of forgings, 1-inch (25-mm) and under in thickness is permissible for (1) solution heat treating (providing quenching is by immersion), (2) aging, and (3) annealing, providing product so racked has been demonstrated by test to meet the specified requirements. Layer thickness shall not exceed 3 inches (76 mm) and distance between layers shall be at least 3 inches (76 mm) (not required for load arrangements which have been previously validated in accordance with AMS-H-6088 or a previous issue of AMS2772).	7	GEN	AMS2772
157.	**Temperatures** Knowledge and understanding that planning must include that furnace temperatures shall be controlled so as to ensure that the metal temperature does not exceed the maximum of the range. When a load is charged into a batch furnace whose indicated temperature is higher than the maximum of the specified range, a recording load sensor, in contact with the thinnest material on the outside of the load, shall be used to verify that the metal temperature did not exceed the maximum of the range.	7	GEN	AMS2772
158.	**Solution Heat Treatment** Knowledge and understanding that planning must include that product shall be soaked, in accordance with AMS2772 requirements, within the temperature range specified and quenched as specified. Quenching directly from a furnace or salt bath is required. Extrusion press quenching and rolling mill quenching are not permitted by AMS2772.	7	GEN	AMS2772
159.	**Start of Soak** Knowledge and understanding that planning must include that soaking time shall start when the readings of all load sensors indicate that the temperature of the load has reached the minimum of the required temperature range. Alternatively, determination that the temperature of the load has reached the minimum of the required temperature range (start	7	GEN	AMS2772

	of soaking time) may be based on readings of furnace instruments providing the lag between their readings and load temperature has been determined in a similarly arranged load.			
160.	**Duration** Knowledge and understanding that planning must include that the load shall be maintained within the required temperature range for a time which has been previously shown, by tensile tests, to produce the specified properties (not required for soaking times which have been previously validated in accordance with AMS-H-6088 or a previous issue of AMS2772). Recommended soaking times are listed in AMS 2772.	7	GEN	
161.	**Knowledge and understanding of interruption limits** Planning must take into account the following limits During soaking in a semi-continuous air furnace, a drop in temperature indicated by furnace instrument(s) is permissible providing that: • The temperature indicated by any instrument does not drop more than 20 °F (11 °C) below the minimum of the specified range. • Time below the minimum of the specified range does not exceed 5 minutes. • Soaking is continued for not less than 10 minutes after recovery to the minimum of the solution heat treatment temperature range before quenching. If furnace temperature does not drop more than 20 °F (11 °C) below the minimum of the specified range, but does not recover to the minimum of the specified temperature range within 5 minutes, the total soaking time within the specified range shall be increased; if less than 1 hour was required, it shall be increased by 1/2 hour; if 1 hour or more was required, it shall be increased by 1 hour.	7	GEN	AMS2772
162.	**QUENCH** Knowledge and understanding that planning must include that 2xxx and 7xxx alloy forgings shall be quenched by immersion. Quenching of other forms of 2xxx and 7xxx alloys and all forms of other alloys shall be by immersion, spray or, in a suitable chamber, by air blast.	7	GEN	AMS2772
163.	**QUENCHANT** Knowledge and understanding that planning must include that quenchant or immersion and spray quenching shall be water or an aqueous solution of a residual stress/distortion reducing additive such as polymer. Quenchant volume, velocity, distribution and agitation (of quenchant and/or product) shall be sufficient to ensure that all products will meet specified requirements after aging.	7	GEN	AMS2772
164.	Knowledge and understanding of the importance of clear work instructions for Quench Delay (Immersion quenching shall be per AMS 2772. For air blast and spray quenching, maximum allowable quench delays shall conform to those established based on tests of tensile properties and, when required, tests for susceptibility to inter-granular corrosion)	7	GEN	AMS2772
165.	**Rinsing** Knowledge and understanding that planning must include that product heat treated in salt bath furnaces and product quenched in an aqueous solution of polymer shall be rinsed as necessary to ensure that it will be free from corrosion and detrimental foreign materials	7	GEN	AMS2772

166.	Knowledge and understanding of the importance of generating clear work instructions for quenchant temperature as specified for various product forms in AMS 2772
	• Forgings and Impact Extrusions
	  ○ Quenchant - Water, with or without a Non-Polymer Additive - Recommended quenchant temperature ranges are 140 to 180 °F (60 to 82 °C) for 2014 and 2024 alloys and 140 to 160 °F (60 to 71 °C) for other alloys except, when final temper of T41 or T61 temper is specified, immersion quenching in boiling water is required.
	  ○ Quenchant - Water with a Polymer Additive - Quenchant temperature shall not exceed 130 °F (54 °C) at the completion of the quench.
	• Immersion Quenching of Other Forms of 2xxx and 7xxx Alloys - If the quenchant is water or an aqueous solution of a non-polymer additive, quenchant temperature shall not exceed 100 °F (38 °C) at the start of quench and 110 °F (43 °C) at the completion of the quench. If the quenchant is an aqueous solution of polymer, quenchant temperature shall not exceed 130 °F (54 °C) at the completion of the quench.
	• Spray Quenching of Other Forms of 2xxx and 7xxx Alloys - The quenchant temperature is not restricted but the quenchant temperature used shall be supported by analysis of data.
		7	GEN	AMS2772

167.	**Salt Contamination in Aqueous Solutions of Additives** Knowledge and understanding that planning must include that when an aqueous solution of additive is used for quenching product heat treated in a salt bath furnace, salt contamination in the quenchant shall not exceed 6% by weight.	7	GEN	AMS2772
168.	**Quench Completion** **Immersion** Knowledge and understanding that planning must include that product under 0.250 inch (6.35 mm) in thickness shall remain in the quenchant at least until boiling emanating from the product (not the rack) ceases. Product 0.250 inch (6.35 mm) and over in thickness shall remain in the quenchant for not less than 2 minutes per inch (25 mm) of thickness, or fraction thereof, or for not less than 2 minutes after boiling ceases.	7	GEN	AMS2772
169.	**Spray or Air Blast**			AMS2772

	Knowledge and understanding that planning must include that product quenched by spray or air blast shall remain in contact with the quenchant until the temperature of the product is below the boiling point of water.			
170.	**Knowledge and understanding of Restrictions on Alclad Products** **Heat-Up Time** Knowledge and understanding that planning must include that the time required for sheet material to reach the minimum of the specified temperature range shall not exceed 30 minutes for thicknesses up to 0.049 inch (1.24 mm), 60 minutes for thicknesses from 0.050 to 0.101 inch (1.27 to 2.57 mm) and 120 minutes for thicker sheet or for plate. **Soaking Time** Knowledge and understanding that planning must include that to ensure all lots will develop specified properties after aging, soaking time shall be established in accordance with AMS 2772. However, the total soaking time used for any lot (single or multiple solution heat treatments) should be limited to the minimum necessary to ensure that the product will meet the specified requirements. **Re-Solution Heat Treatment of Alclad 2xxx and 7xxx Sheet and Plate** Knowledge and understanding that planning must include that product thinner than 0.020 inch (0.51 mm) shall not be re-solution heat treated. Sheet thicknesses from 0.020 to 0.125 inch (0.51 to 3.18 mm) inclusive shall not be re-solution heat treated more than once. Product thicker than 0.125 inch (3.18 mm) shall not be re-solution heat treated more than twice. NOTE These restrictions are not applicable to any lot of product which is tested to ensure conformance to the alclad thickness requirement of the material specification.	7	GEN	AMS2772
171.	**Aging** Knowledge and understanding that recommended aging temperatures and times are shown in AMS 2772. Alternate temperatures and times may be used provided the aged material meets the specified requirements.	7	GEN	AMS2772
172.	**Temper Conversion** When a warehouse, distributor or similar organization, or its vendor, converts raw material to a different temper in accordance with this specification or AMS-H-6088, the following provisions shall apply: • The heat treatment of the raw material and any heat treatment of samples for heat-treatment- response tests shall conform to the technical requirements and quality assurance provisions of AMS2770. For products not included in AMS2770, the temperatures and times of AMS2772 shall be used. • The converted product shall be tested in accordance with the requirements of the applicable material specification. • Any original mill marks shall be removed and the product shall be re-identified in accordance with ASTM B 666/B 666M; the new identification shall ensure traceability to the warehouse/ distributor's records showing the original producer, the lot number and the converting organization. • The report to the purchaser shall include certification of conversion to the new temper, the conversion heat treatment procedure, the test results for the converted product and the original mill certification	7	GEN	AMS2772
173.	**Procedure for Response-to-Heat-Treatment Tests** Knowledge and understanding that planning must include that when a material specification or other procurement document requires heat treatment of samples to demonstrate response to user heat treatment (e.g., heat treatment of -O or -F temper material to -T42 or -T62 temper), the procedure used by producers, forge shops or warehouses/distributors and their vendors shall include conformance to the mandatory set temperatures and times in AMS2772.	7	GEN	AMS2772
174.	Knowledge and understanding of Recommended Annealing Times, Temperatures and Cooling • 1xxx, 3xxx, and 5xxx Series Alloys Except 3003 - Heat to 650 °F (343 °C); cooling rate optional. • 3003 Alloy - Heat to 775 °F (413 °C); cooling rate optional. • 2xxx and 6xxx Series Alloys Except 6013 - Soak for 2 to 3 hours at 760 °F (404 °C); cool at rate of 50 °F (28 °C) per hour or slower to 500 °F (260 °C); further cooling rate optional. • 6013 Alloy -Soak for 2 to 3 hours at 775 °F (413 °C); cool at rate of 50 °F (28 °C) per hour or slower to 500 °F (260 °C); further cooling rate optional. • 7xxx Series Alloys - Soak for 2 to 3 hours at 760 °F (404 °C); cool to 400 °F (204 °C) or lower, reheat to 450 °F (232 °C), and soak for four hours; cooling rate optional.	7	GEN	AMS2772
175.	Knowledge and understanding that planning must include that processing to -O1 Temper shall consist of heating product to the temperature range shown in AMS 2772 followed by an air cool.	7	GEN	AMS2772
176.	**Record Retention** Knowledge and understanding that planning must include that records of all inspections and tests shall be kept available for review for 5 years after the inspection or test. records of	7	GEN	AMS2772

	all applicable production parameters, e.g., racking, time, temperature, quenchant temperature and pressure, and quench delay shall be kept available for review for 5 years after heat treatment. **NOTE** – Many customers have substantially longer record retention requirements which take precedence over the five-year period.			
177.	Knowledge and understanding of the extensive requirements for qualification of any equipment used for air blast, spray and immersion quenching of 2xxx and 7xxx series alloys. Any questions about the qualification status of equipment shall be brought to the attention of the process owner.	7	GEN	AMS2772
178.	**Metallurgical Testing** Knowledge and understanding that planning must include that the following tests shall be performed on production material from each solution heat treating furnace initially and periodically thereafter. The frequency of testing shall be (1) monthly until a total of 6 successful tests have been performed; then the frequency may be reduced to quarterly. However, if a failure occurs, the frequency shall revert to monthly and shall not be reduced again until a total of 6 successive successful tests have been performed. The above initial and periodic test requirements shall be applied after any modification of the equipment which could affect the metallurgical properties of the product. **Heat Treat Induced Porosity and Eutectic Melting** - A sample of 2xxx or 7xxx sheet (non-alclad shall be used for heat treat induced porosity testing) heat treated during the previous calendar month shall be tested. If sheet was not heat treated, a sample of product of an alternate form (order of preference: tube, extrusion, wire, rod, bar, plate, forging) shall be tested. The thickness of the sample shall be not more than twice the thickness of the thinnest product heat treated during the previous month. **Intergranular Corrosion Susceptibility of Sheet, Wire, or Extrusion -** A sample representative of the thickest (under 0.250 inch (6.35 mm)) product solution heat treated during the previous calendar month shall be tested. Primary order of preference shall be based on alloy/temper as follows: (1) 2xxx in -T3 or -T4 temper, (2) 7xxx in -T6 temper. Secondary order of preference shall be based on form as follows: (1) sheet, (2) extrusion, (3) wire. No test is required if 2xxx-T3 or -T4 or 7xxx-T6 in the above categories was not solution heat treated. Knowledge and understanding that planning must include the Test Methods and Acceptance Criteria for these tests as follows **Heat Treat Induced Porosity and Eutectic Melting -** One or more specimens taken from the solution heat treated sample(s) shall be sectioned, polished, and examined at 500X magnification before and after etching. The specimen(s) shall be free from (1) heat treat induced porosity, evidenced by multiple voids in grain boundaries near the surface which are visible in more than two fields of view, and (2) eutectic melting, evidenced by rosettes or eutectic structure at grain boundary triple points. **Intergranular Corrosion Susceptibility** - The sample shall be prepared and tested in accordance with ASTM G 110 modified as follows: • Specimen surface area shall be not less than 4 square inches (25.8 cm2) (sum of both sides) except, for wire, a minimum length of 4 inches (102 mm) shall suffice. • Removal of cladding may be confirmed by either examination of specimen surfaces or microscopic examination of metallographic cross sections. • After immersion in the etching cleaner and nitric acid, the specimen shall be rinsed in water and either (1) air dried or (2) immersed in the test solution. • The immersion period in the test solution shall be 6 to 7 hours. • After exposure in the test solution, corrosion products shall be removed by simultaneously rinsing in running water and brushing with a soft bristle brush. • Metallographic examination shall be between 200 and 500X magnification. • The severity of inter-granular corrosion exhibited by the major surfaces of the sample (end-grain attack shall be disregarded) shall be no greater than that normally experienced by producers when heat treating under production conditions in accordance with the requirements and recommendations of this specification. Intentional or inadvertent process changes shall not cause increased severity.	7	GEN	AMS2772
179.	**Test Failures due to Equipment Deficiency** Knowledge and understanding that planning must include that If any valid test fails to meet any requirement specified herein, or if any valid test (after retesting, if permitted) fails to meet a requirement of the material specification or the drawing, and the cause of the failure was a deficiency of the heat treating equipment (not the test procedure or test apparatus), the following measures shall be taken: • The equipment shall not be used for production until the cause of the failure has been corrected and the test has been performed successfully. • The quality assurance organization responsible for the equipment shall evaluate possible effects of the failure on product processed since the last successful test. The evaluation shall be documented and, where necessary, shall include consultation with metallurgists, engineers, and purchasers. Appropriate corrective action shall be taken and documented.	7	GEN	AMS2772

180.	Knowledge and understanding that most of the mandatory set temperatures and aging times specified for response-to-heat-treatment tests are based on those of AMS2770. For alloys/tempers not covered by AMS2770, temperatures/times are based on AMS2772. These tests are intended to demonstrate that the material, in the as-produced condition (prior to any additional processing) has the capability to respond to a heat treatment which duplicates, as closely as possible, user's test and production heat treating conditions.	7	GEN	AMS2772
181.	Knowledge and understanding that continuously quenched product traverses through a quench chamber without a pause or change of direction. Non-continuously quenched product pauses or changes direction during its traverse through a quench chamber	7	GEN	AMS2772
	SKILLS: **The skills required to perform a particular special process task**			
179.	Capable of understanding, interpreting and complying with various customer requirements for precedence of documents	7	GEN	AS9100
180.	Capable of understanding, interpreting and complying with various customer requirements for how to handle documents which have been revised, superseded or canceled	7	GEN	AS9100
181.	Ability to interpret specification requirements and customer flow-down requirements	7	GEN	AS9100
182.	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	7	GEN	AS9100
183.	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.	7	GEN	AS9100
184.	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 after quench including refrigeration temperature • Periodic and lot acceptance test requirements and results	7	GEN	AC7102
185.	Capable of evaluating the potential product impact of deviation from process parameters or other events which may have a negative impact on product quality	7	GEN	AS9100
186.	Knowledge of the proper operation, maintenance and calibration requirements for equipment used for testing, evaluation and acceptance (e.g., hardness, conductivity)	7	GEN	AS9100
187.	Basic understanding of pyrometry testing requirements including instrument calibrations, SAT and TUS testing	7	GEN	AMS2750
188.	Capable of reviewing calibration, SAT and TUS reports when required	7	GEN	AMS2750
189.	Capable of documenting an on-going plan for pyrometry compliance at site level per AMS2750	7	GEN	AMS2750
190.	Capable of providing timely notification of calibration requirements	7	GEN	AS9100
191.	Capable of conducting periodic self-audits	7	GEN	AS9100
192.	Capable of conducting internal personal qualification exam in order to comply with HT BoK ERB requirements	7	GEN	ARP1962
193.	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	7	GEN	General Industry
194.	Understands precautions to be taken when handling thermocouples to avoid damage	7	GEN	General Industry
195.	Understanding of the Preventive Maintenance Program and how it is incorporated into planning	7	GEN	AS9100
196.				
197.	**Sequencing**			
198.	Has an appropriate understanding of where this process falls in the sequence of events and how to reflect that in planning so that operators can also understand it.	10	GEN	
	PERSONAL ATTRIBUTES: ***Are statements that will enable judgment of the person's personal attributes***			
199.	Willingness to train and mentor co-workers	7	GEN	
200.	Good communicator at all levels, especially with respect to clear written instructions	7	GEN	
201.	Understands and responds positively when operators challenge work instructions that do not appear to conform to specification or customer requirements	10	GEN	
202.	Personal integrity	7	GEN	
203.	Attentive to details	7	GEN	
	EXPERIENCE: ***Are the minimum experience requirement expected to demonstrate their competence.***			
204.	**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.			
205.	**Recommended Minimum Classroom Training** Heat Treatment – 80 hours Paperwork – 40 hours Test, Inspection, Maintenance – 40 hours	10	GEN	ARP 1962
206.	**Recommended Minimum On-the-Job-Training** Air atmosphere – 9 months Sat bath – 9 months Aluminum Alloys (aging and stress relief only) – 12 months Aluminum Alloys (all other processes) – 24 months	10	GEN	ARP 1962
207.	**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 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**			
208.	Must have a thorough understanding of general Quality Systems (AS9100) or equivalent.	7	GEN	AS9100
209.	Must have a thorough understanding of customer specific requirements.	7	GEN	AS9100
210.	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
21 May 2018	Updated to new template
20 August 2018	Document reviewed and updated by content developer to ensure it is up to date
4 December 2019	Editorial revision to update program name from eQualified to PRI Qualification[SM.]

ADDENDUM 1

LIST OF INDUSTRY STANDARDS FOR ALUMINUM HEAT TREATMENT

SPECIAL PROCESS	DOCUMENT TITLE	DOCUMENT NUMBER
Heat Treating	Baseline Nadcap Audit Criteria for Aluminum Heat Treating	AC7102/2
Heat Treating	Baseline Nadcap Audit Criteria for Hardness and/or Conductivity Testing for Heat Treating	AC7102/5
Heat Treating	Nadcap Audit Criteria for Heat Treating Pyrometry	AC7102/8
Heat Treating	SAE Aerospace Materials Specification – Pyrometry	AMS 2750
Heat Treating	SAE Aerospace Materials Specification – Heat Treatment of Wrought Aluminum Alloy Parts	AMS 2770
Heat Treating	SAE Aerospace Materials Specification – Heat Treatment of Aluminum Alloy Castings	AMS 2771
Heat Treating	SAE Aerospace Materials Specification – Heat Treatment of Aluminum Alloy Raw Materials	AMS 2772
Heat Treating	SAE Aerospace Recommended Practice - Training and Approval of Heat-Treating Personnel	ARP 1962
Quality	AS9100 Quality Management Systems - Requirements for Aviation, Space and Defense Organizations	AS 9100
Quality	Quality Standards	ISO9001