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Program Document HTBOK

PD 6103

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BODY OF KNOWLEDGE

ROLE DESCRIPTION: Planner
SPECIAL PROCESS: Heat Treatment
METHOD: Performance of Carbon and Alloy Steel Requirements

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

All eQuaLified BoKs are created by subject matter experts who participate in the eQuaLified Body of Knowledge Review Boards. All eQuaLified BoKs are updated periodically according to the latest revision of eQuaLified PD6100 to ensure consistency with current industry practice.

1. INTRODUCTION

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

This document consitutes the eQuaLified BoK for Carbon and Alloy Steel Planner. It defines the baseline knowledge and experience required to be considered competent to perform this role.

Unless otherwise stated, the HT BoKRB has followed guidelines as detailed in the current revision 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 eQuaLified examination candidate preparation
- Heat Treat Examination Review Board (HT-ERB) for the development of eQuaLified examinations
- Candidates taking eQuaLified examinations who wish to prepare in advance

2. REFERENCES

eQuaLified documents:

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

IAQG documents:

IAQG Guidance PCAP 001 Competence Management Guideline

3. DEFINITIONS

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

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

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

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

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

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

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

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

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

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

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

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

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

4. GUIDANCE TO EXAMINATION CANDIDATES

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

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

Re-assessment of candidates to this BoK is required every at least every **5 years**, unless otherwise specified.

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

- Self-study
- Completion of internal training
- Completion of external training (a list of eQuaLified Approved Providers can be found at www.eQuaLified.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

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***
Heat Treat Specific Criteria	Basic understanding of the process for heat treatment of carbon and alloy steel including cleaning, loading, start and end of soak, atmospheres, quenching tempering, refrigeration, testing, and documentation. .	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 who perform the work and who evaluate and review 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
METHOD: Carbon and Alloy Steel
REFERENCE GUIDELINES: ***Addendum 1 is a list of the International Standards and Reference Documents applicable to carbon and alloy steel heat treatment processes.***
NOTE: The term "planning" as used in the following Table is meant to include any combination of company-wide procedures, local department resident work instructions, part specific routers or travelers, and documented training that has been determined to provide complete instructions to operators. It should not be implied that all necessary information will be found in a single document.

Row #	COMPETENCE.	Weight (1,3,7,10)	Exam Type Written/ Practical	Reference Guidelines
	KNOWLEDGE: The basic knowledge of the special processes, methods and tools			
1	**GENERAL QUALITY SYSTEMS KNOWLEDGE:**			
2	Aerospace Quality Systems and compliance.	7	W	AS9100
3	Internal work instructions as well as industry standards. (see Addendum -1 of this document).	7	W	AS9100
4	How non-conformance is addressed using tools such as Root Cause Corrective Action and 5 Why's.	7	W	AS9100
5	The need to meet safety compliance requirements as applicable.	10	W	AS9100
6	The requirements for traceability of calibration to NIST or equivalent national agencies.	7	W	AS9100
7	The responsibility for Inspection lies with the special process provider and includes the verification and control of activities carried out by authorized third party contractors or approved suppliers.	7	W	AS9100
8	The responsibility for compliance lies with the special process provider.	7	W	AS9100
9	Records of System Accuracy Tests, Temperature Uniformity Surveys, Calibration, and of Initial, Periodic and Acceptance Tests, of test results on product and of all related process parameters and controls must be maintained and available for inspection for a period specified by regulating bodies or customers whichever is the greatest..	7	W	AS9100
10	**Parts and Raw Material**			
11	Parts as covered here by AMS2759/1 and AMS2759/2 are usually identified by a customer Part Number and are heat treated, usually to the end use condition to meet the requirements of a drawing, contract, purchase order, or heat treatment specification. At the time of heat treatment they may resemble Raw Material.	7	W	AMS2759/1 AMS2759/2
12	Raw Material as covered here by AMS-H-6875 includes but is not limited to items such as Sheet, Plate, Wire, Rod, Bar, Forgings or Extrusions. It is usually identified by a Heat, Charge, Batch, or Lot number. It may or may not have been heat treated by the producer	7	W	AMS-H-6875
13	**Caution:** The primary difference in interpretation of parts versus raw material focuses on Castings and Forgings. Some Primes consider Castings and Forgings as Parts, while others consider them as Raw Material. It is the responsibility of the Supplier to know and demonstrate compliance with the policy of each individual Prime Customer. See the Nadcap Heat Treat Audit Handbook for specific information by Prime			
14	**PYROMETRY**			
15	The importance of compliance with all Pyrometry requirements including temperature sensors, instrumentation, classification of thermal processing equipment, system accuracy tests, and temperature uniformity surveys and including reporting of any non-conformances.	7	W	AMS2750
16	The importance of producing Work Instructions which are in compliance with customer requirements and AMS2750 as related to Pyrometry including sensors (thermocouples) and instrument calibration, and furnace class (uniformity) and instrumentation type, Temperature Uniformity Surveys and System Accuracy Tests.	7	W	AMS2750
17	**Caution:** Heat Treatment of carbon and alloy steels shall not be implemented without a prerequisite understanding of the Pyrometry requirements which affect these materials types.	10	W	AMS2750
18	**GENERAL METALLURGICAL KNOWLEDGE RELATED TO HEAT TREATING CARBON AND ALLOY STEELS (Applicable to all specifications referencing AMS2759 and AMS2769)**			
19	The metallurgy of carbon and alloy steels and the effect this must have on planning.	7	W	
20	The ability to clearly plan Heat Treatment instructions applied to Carbon and Alloy Steels including the following: • Annealing • Subcritical Annealing • Stress Relieving • Preheating	7	W	AMS2759, AMS2769, AMS2759/1, AMS2759/2 & AMS-H-6875

	• Hardening (Austenitizing and Quenching) • Tempering • Snap Tempering • Low Temperature / Cryogenic treatments			
21	The definitions and importance of terms applicable to Heat Treatment of Carbon and Alloy Steels: • Set temperature (Set Point) • Heating • Start of soak • Soak time • End of soak • Interruptions • Temper / Cryogenic delay • Protective Coatings • Cleaning • Homogenization (effects on Heat treatment response)	**10**	**W**	**AMS2759, AMS2769 AMS2759/1, AMS2759/2 & AMS-H-6875**
22	The need to effectively plan and control the use and application of protective compounds to minimize possible contamination from furnace atmospheres. Coatings must be applied according to Customer / Prime requirements, which must be reflected on Work Instructions.	**7**	**W**	**AMS2759, AMS2759/1, AMS2759/2 & AMS-H-6875**
23	That planning must reflect the use of equipment and instruments for the heat treatment of carbon and alloy steels which must be in accordance with AMS2750 and all customer requirements.	**10**	**W**	**AMS2759, AMS2759/1, AMS2759/2 & AMS-H-6875**
24	**Equipment**			
25	That thermal processing equipment must meet the requirements of AMS2750. Furnaces shall have a minimum of Type D instrumentation.	**7**	**W**	**AMS2759 3.1**
26	That quench baths specified in planning must permit complete immersion of parts, provide for agitation of the quench media or the parts, be of sufficient volume to absorb the heat rejected by the most massive part to be quenched, and have a temperature indicator with a sensor in the quench media. **NOTE:** As of July 2015, AMS 2750 requires that quench systems used for heat treatments that include a quenchant temperature requirement (minimum, maximum or both) shall be equipped with a recording instrument	**7**	**W**	**AMS2759 3.1.1 AMS2750 3.3.3.2**
27	That planning must provide that quenching baths are free from visible contamination that could detrimentally affect the process.	**5**	**W**	**AMS2759 3.1.1**
28	That planning must provide that a system check shall be made, prior to production use to ensure the adequacy of the agitation system and that the system is designed to minimize susceptibility to agitation variations.	**5**	**W**	**AMS2759 3.1.1**
29	That bath maintenance programs shall be established, and when using polymers, a concentration control system shall be established prior to production use.	**5**	**W**	**AMS2759 3.1.1**
30	That fixtures and fixture materials specified in planning must not cause contamination of parts and must not reduce the heating, cooling, or quenching rates to less than required for correct hardening of parts.	**7**	**W**	**AMS2759 3.1.2**
31	That cleaning equipment shall be provided to clean parts before heat treatment, to remove oil from parts quenched in oil baths, and salt residue from parts heated or quenched in salt baths. When using polymer quenchants, a rinsing system shall be in place to remove quenchant from the parts.	**5**	**W**	**AMS2759 3.1.3**
32	That vacuum furnaces specified in planning must meet the requirements of AMS2769.	**10**	**W**	**AMS2759 3.1.4**
33	That instrumentation used to control furnace atmosphere shall be calibrated and serviced according to manufacturer's recommendations.	**7**	**W**	**AMS2759 3.1.5**
34	**Quenching Media**			
35	That when liquid quenching is required, planning may only specify oil, water, or polymer/water solutions as specified for the alloy and temper indicated.	**7**	**W**	**AMS2759 3.2.1**
36	That procedures must exist to determine the consistency of quench effectiveness for each tank by testing initially and quarterly thereafter and comparing the results with those obtained previously by the same method.	**5**	**W**	**AMS2759 3.2.1**
37	That procedures must exist to establish control limits for each quenching system. If results indicate that a quenchant is outside the established limits, corrective action shall be taken and the tests repeated to verify restoration of the prior condition.	**5**	**W**	**AMS2759 3.2.1**
38	That planning must avoid inappropriate quenchants or improperly designed systems that are not appropriate for a particular alloy and configuration to prevent problems, such as cracking and high residual stresses.	**7**	**W**	**AMS2759 3.2.2**
39	That because of wide differences in quenching characteristics of different quenchants in different quenching systems, a quenchant validation procedure must exist and must be followed when initially establishing the quenching procedure or when changing from one quenchant to another.	**5**	**W**	**AMS2759 3.2.2**
40	That procedures must ensure when substituting a polymer/concentration for an existing oil quenchant, there is quenchant validation that the polymer and concentration being substituted achieves cooling characteristics that are similar to the existing oil quenchant and that the properties being produced are equivalent to those for oil quenched parts	**5**	**W**	**AMS2759 3.2.2.1**
41	That except when marquenching, the temperature of the quenchant shall be in the range 60 to 160 °F (16 to 71 °C) at the initiation of the quenching operation, and shall not exceed 200 °F (93	**10**	**W**	**AMS2759 3.2.3**

	°C) at any time during the quenching operation, unless otherwise approved by the cognizant engineering organization.			
42	That planning must control that oil and polymer quenchants are only used within the temperature range recommended by the product manufacturer.	**7**	**W**	**AMS2759 3.2.3**
43	That procedures must exist so that quench oil used in integral quench vacuum furnaces, where the quench chamber is below atmospheric pressure, shall be vacuum degassed at approximately the maximum recommended temperature for the oil initially and after each addition of oil.	**7**	**W**	**AMS2759 3.2.4**
44	**Quench Effectiveness** That procedures must specify the frequency and methods for the testing of oil quenchants in accordance with all customer requirements and the records indicate that quenchant effectiveness is consistent and meets specification requirements.	**7**	**W**	**AC7102 9.12**
45	**Polymer Quenchants**			
46	That polymer quenching may be used only when permitted by the particular specification for the alloy and metal thickness and that planning and records must indicate compliance	**7**	**W**	**AC7102 9.11.1, 9.11.3**
47	That procedures must specify the frequency and methods for determining the polymer concentration in accordance with specification and customer requirements.	**5**	**W**	**AC7102 9.11.4**
48	**Salt Baths**			
49	That planning must ensure that composition and maintenance of salt baths shall be such as to prevent contamination of the parts including carburization, decarburization, nitriding, and intergranular attack requirements. Salt baths shall be tested in accordance with AMS2759	**10**	**W**	**AMS2759 3.3.8** **AC7102 9.6.2**
50	**Quenching from Salt Bath Furnaces** That procedures must specify that water shall be monitored weekly to ensure salt content does not exceed 2% by weight and that polymers shall be monitored weekly to ensure salt content does not exceed 6% by weight.	**5**	**W**	**AMS2759 3.2.5**
51	**Salt Removal** That planning must allow for the fact that salt residues must be removed immediately after quenching and before any following process.	**5**	**W**	**AMS2759 3.2.6**
52	**Cleaning**			
53	That prior to heat treatment, planning must provide that parts be clean and visually free of contaminants such as dirt, metal residues, lubricants and solvent residues. This is particularly important in relation to vacuum heat treatment and treatment of parts with less than 0.200 inch (0.51 mm) machining after treatment. Where cleaning is required completion of this process must be documented.	**7**	**W**	**AMS2759 3.3.2** **AMS2769 3.3.4** **AC7102 5.2.1**
54	**Corrosion Protection** That planning must provide that parts be protected from corrosion during processing and storage.	**5**	**W**	**AMS2759 3.3.3**
55	**Racking, Fixturing and Spacing**			
56	That planning must provide that parts be racked and supported, or otherwise oriented, primarily to ensure access of the heating, cooling, and quenching media to all surfaces of all parts and secondarily to minimize warpage.	**7**	**W**	**AMS2759 3.3.4**
57	That planning of certain parts must allow for parts to be spaced far enough apart to ensure uniform heating and cooling and not impede circulation of the heating medium and quenchant.	**7**	**W**	**AC7102 9.14**
58	That there must be internal procedures, racking sketches, or other means to ensure that spacing between the parts is adequate for circulation of the heating medium and coolant/quenchant as required by the specifications and records to indicate that these procedures are followed	**7**	**W**	**AC7102 9.14**
59	That planning must identify any specially designed racks and fixtures and monitor and document their condition. Planning must reflect that specific jigs be required for the specific parts for which they are designed for.	**5**	**W**	**AMS2759 3.3.4** **AC7102 9.14**
60	That racks, fixtures and/or baskets must be free from residues from salt baths and other contamination. Planning must ensure that there is time allowed for this inspection and cleaning process.	**5**	**W**	**AMS2759 3.2.5/3.2.6**
61	That internal procedures must require that racks/fixtures/baskets are examined for integrity, and repaired or scrapped as necessary and records indicate that the procedures are followed	**5**	**W**	**AC7102 9.14**
62	**Purging**			
63	That planning must provide that whenever the atmosphere type (e.g., neutral, carburizing, nitriding) is changed, and prior to heating of parts, remnants of the previous atmosphere shall be removed from the furnace or retort and from gas supply lines. **NOTE:** This requirement does not apply if there is documented confirmation that material removal after heat treatment will ensure that all surfaces of finished parts will be free from contamination.	**10**	**W**	**AMS2759 3.3.5** **AC7102 9.5.1**
64	That planning must include that removal of the previous atmosphere shall be accomplished by purging with the replacement atmosphere at the highest temperature at which it will be used.	**7**	**W**	**AMS2759 3.3.5.1**
65	That planning must establish that purging be performed in accordance with a procedure that has been proved effective previously, by sensors (e.g., oxygen probe) or tests (e.g., microhardness) that are capable of detecting the presence of the previous atmosphere or the resulting contaminant.	**5**	**W**	**AMS2759 3.3.5.2**
66	That procedures must include that the efficacy of the purge is confirmed, in conjunction with the first heat treatment load employing the new atmosphere, by the sensors or tests used to establish the procedure.	**7**	**W**	**AMS2759 3.3.5.3**
67	**Loading** That procedures must not allow parts to be loaded into a furnace with the temperature higher than the set temperature, unless load sensors (number, location, and method of attachment to be	**7**	**W**	**AMS2759 3.3.6**

	approved by the cognizant engineering organization) are attached to the part to ensure the part temperature does not exceed the set temperature.			
68	**Loading Check** That planning and work instructions must reflect the need to verify the internal condition of the furnace prior to loading to check cleanliness and freedom from mechanical damage (may be a visual only check).	**5**	**W**	
69	**Set Temperature** That planning must provide that control instrument(s) shall be set either at the temperature required by specification or at an offset temperature based on the last temperature uniformity survey or system accuracy test. Offsets, if used, shall meet the requirements of AMS2750.	**7**	**W**	**AMS2759 3.3.7**
70	**Heat Treatment in Vacuum Furnaces**			
71	That internal procedure or other documentation must specify cleaning of parts, tooling and baskets by methods and with materials that ensure freedom from contamination during vacuum heat treating	**7**	**W**	**AC7102 11.**
72	That internal procedure, photographic evidence, or other documentation specify placement of load thermocouples, racking of parts, and furnace loading	**5**	**W**	**AC7102 11.**
73	That planning must ensure that vacuum furnaces used must meet the requirements of AMS 2769 and Customer / Prime specifications and be capable of achieving the vacuum levels and leak rates specified.	**7**	**W**	**AMS2769 3.1 / 3.1.1.3**
74	That planning must take account of the requirement to carry out regular contamination checks for which representative test coupons must be available and analyzed with results being documented. Quality system requirements should the results fail to meet requirements.	**7**	**W**	**AMS2769 3.1.1.4**
75	That planning must take account of requirement to check condition of door and other seals (e.g. thermocouple entry ports) which must be clean and free from damage or tears. Also understanding of the requirements for cleaning and greasing different types of sealing material which must be documented on work instructions, the traveler / data card, or in specific internal instructions.	**5**	**W**	
76	The need for documenting repairs or changes of seals particularly on doors, thermocouple entry ports and gauges.	**5**	**W**	
77	**Soak**			
78	Why adherence to set temperatures and furnace uniformity is critical and the ability to clearly convey that through planning.	**10**	**W**	**AMS2759 3.3.7**
79	How planning must convey requirements for start and end of soak in accordance with specification requirements through clear and concise work instructions.	**10**	**W**	
80	**Quench**			
81	That planning must include that quench mechanisms (manual or automated) must be capable of meeting the maximum quench delay if required by Customer / Prime specifications and results recorded and verified for each individual load	**7**	**W**	**AC7102 9.9.1**
82	That planning must include a requirement that the temperature of quench media must be controlled and documented in accordance with Customer / Prime requirements.	**10**	**W**	**AMS2759 3.2** **AC7102 9.10.1**
83	That planning must include that records must demonstrate that quench media has been at the specified temperature before, during and after the parts were quenched.	**7**	**W**	**AMS2759 3.3.2** **AC7102 9.10**
84	That planning must include a requirement to verify that agitation of quench media or the parts during quenching conforms to applicable specifications.	**5**	**W**	**AMS2759 3.2** **AC7102 9.10**
85	**Gas Quenching in Vacuum furnaces**			
86	That planning must include requirements for selection of quench gas type (e.g. Nitrogen/Argon/Helium), gas pressure during quench, and cooling direction	**7**	**W**	**AMS2769 3.1.3.2**
87	How to check cooling rates on gas quenching when there are specific requirements.	**5**	**W**	
88	**Low Temperature Treatment when Required by Specification**			
89	That planning must take account of and convey, through concise written instructions the importance of meeting the maximum permitted process delays between Quench/Temper and Quench/Freeze/Temper, and the effect exceeding the requirement might have on the mechanical properties of the product. Planning must include that in-process delay times are recorded and subject to review if they are exceeded.	**10**	**W**	**AC7102 9.9.1**
90	That records must show that cooling after quench is in compliance with customer requirements specified in procedures or shop planning.	**7**	**W**	**AC7102 8.2**
91	That procedures and job planning must specify time/temperature limits for sub-ambient/subzero treatments	**7**	**W**	
92	The importance of recording the temperature in each refrigeration cycle to allow verification against Customer / Prime requirements	**7**	**W**	
93	**Qualification** That all facilities, including subcontractors, performing heat treatment in accordance with this specification shall be approved as specified by the cognizant quality assurance organization.	**10**	**W**	**AMS2759 3.4**
94	**Test Methods** That planning must provide for the following tests, as applicable: • Hardness in accordance with ASTM A 370, ASTM E 10, ASTM E 18, and ASTM E 384, as applicable. (NOTE: The approximate conversion of tensile strength requirements to hardness shall be in accordance with ASTM A 370. Hardness tests shall be performed on the thickest section, unless otherwise specified by the cognizant quality assurance organization.)	**5**	**W**	**AMS2759 3.5**

	Tensile Properties when required by the cognizant engineering organization, in accordance with ASTM A 370 and ASTM E 8 / 8M • Salt Bath Neutrality Test • Quench Rate Control			
95	**Additional Processes** That planning must assure that parts are not subjected to thermal operations or straightening operations other than those specified, unless permitted by the cognizant engineering organization	**10**	**W**	**AMS2759 3.6**
96	**Strength Ranges** That when only a minimum tensile strength is specified and the heat treating processor has the option of selecting the tempering or aging temperature, the planning must control the process and inspections so that maximum tensile strength (converted to hardness) shall be 20.0 ksi (138 MPa) above the specified minimum for strength levels up to and including 260 ksi (1793 MPa) minimum and 25.0 ksi (172 MPa) above minimum for strength levels over 260 ksi (1793 MPa) minimum.	**5**	**W**	**AMS2759 3.7**
97	That when both the minimum tensile strength and the tempering temperature are specified, planning must control the process and inspections so that the maximum strength shall be 30.0 ksi (207 MPa) above the specified minimum.	**5**	**W**	**AMS2759 3.7.1**
98	**PERIODIC TESTING**			
99	The need for Periodic Testing which planning must take account of when scheduling work and must provide for documentation.	**5**	**W**	**AMS2759 4.2.2** **AMS2769 4.2.2**
100	That planning must have a process to ensure that periodic testing is performed per procedures and the customer requirements and in accordance with AMS2759 and AMS2769.	**5**	**W**	**AMS2759 4.2.2** **AMS2769 4.2.2**
101	**Surface Contamination Testing**			
102	That internal testing procedures must cover the following: • Partial decarburization • Total decarburization • Carburization • IGO/IGA (Inter Granular Oxidation/Inter Granular Attack) test	**5**	**W**	**AC7102 7.8.2**
103	That there must be a system in place to ensure that decarburization tests are performed at the proper frequency, whether it is periodic or with the load	**5**	**W**	**AC7102 7.8.4**
104	**Additional Periodic Tests**			
105	**Daily Tests** • Salt bath neutrality test of baths used to heat treat steel to minimum tensile strength of 220 ksi (1517 MPa) and higher. • Check of hardness testing machines	**5**	**W**	**AMS2759 4.2.2.1**
106	**Weekly Tests** • Salt bath neutrality test for baths used to heat treat parts to a minimum tensile strength below 220 ksi (1517 MPa). • Salt content monitoring of water and polymer quenchants	**3**	**W**	**AMS2759 4.2.2.2**
107	**Quarterly Tests** • Servicing and certification or calibration of Rockwell (or similar) and of Brinell hardness test machines. • Quench rate control tests	**5**	**W**	**AMS2759 4.2.2.3**
108	**Preproduction Tests** That systems must be in place and procedures provide that preproduction tests are performed for each piece of equipment prior to any production heat treating to be used, including: • Initial temperature uniformity survey as in AMS2750. • Pyrometry system accuracy test as in AMS2750. • Instrument calibration as in AMS2750. • Certification or calibration of hardness testing machines • Certification or calibration of tensile testing machines • Salt bath neutrality test • Quench rate control test • Calibration of atmosphere control measuring equipment	**10**	**W**	**AMS2759 4.2.3**
109	**Sampling and Testing**			
110	That planning must provide that frequency of hardness testing shall be in accordance with Table 2 of AMS2759 or other applicable requirements. **NOTE**: When hardness testing would be destructive or impractical to accomplish, the method for verification of correct heat treatment shall be as specified by the cognizant engineering or quality engineering organization	**7**	**W**	**AMS2759 4.3, Table 2**
111	That planning must provide that after final operation (hardening and tempering, aging, etc.), every part must be hardness tested unless statistical sampling is authorized by the cognizant quality assurance organization or when parts are subjected to 100% testing after thermal processing subsequent to final hardening operation.	**10**	**W**	**AMS2759 4.3, Table 2**
112	That when heat treating standard components, such as nuts and bolts, for which the frequency of testing is specified, planning shall provide that the requirements of the component specifications take precedence.	**3**	**W**	**AMS2759 4.3.1.2**
113	That planning must account for selection of the test location as the thickest or heaviest section of the part that is practical to test and where the test will not be detrimental to the function of the part.	**7**	**W**	**AMS2759 4.3.1.3**
114	That planning must provide for the collection of data necessary to comply with specification and	**5**	**W**	**AMS2759 1.5, 4.6,**

	customer requirements for Logs, Records and Reports/Certification.			**4.7**
115	**PROCESS VERIFICATION** That planning must provide that each heat treatment cycle is reviewed for job traceability, correct temperature, time at temperature and all other related parameters and that this review is documented	**10**	**W**	**AC7102 6.1.1**
116	That planning must provide for this review to be performed by Quality Assurance, other designated personnel, or self-inspected by an automated computer control and monitoring system	**7**	**W**	**AC7102 6.1.2**
	REQUIREMENTS SPECIFIC TO PRODUCT PROCESSED IN ACCORDANCE WITH SPECIFIC AMS STANDARDS DESCRIBED ABOVE (Competence)			
117	**A) SPECIFIC REQUIREMENTS RELATED TO: AMS2759/1 – Heat Treatment of Carbon and Low-Alloy Steel Parts Minimum Tensile Strength Below 220 ksi (1517 MPa)**			
118	That this specification, in conjunction with the general requirements for steel heat treatment covered in AMS2759, establishes the requirements for heat treatment of carbon and low-alloy steel parts to minimum ultimate tensile strengths below 220 ksi (1517 MPa).	**7**	**W**	**1.1**
119	That heat treatment of carbon and low-alloy steel parts to minimum ultimate tensile strengths below 220 ksi (1517 MPa) shall conform to AMS2759 and the requirements specified herein.	**7**	**W**	**3.1**
120	That equipment shall conform to AMS2759..		**W**	**3.2**
121	That planning must provide that furnace temperature uniformity requirements for annealing, subcritical annealing, normalizing, hardening, straightening, stress relieving, and baking shall be ±25 °F (±14 °C), and for tempering shall be ±15 °F (±8 °C) except shall be ±10 °F (±6 °C) for H-11, D6AC, and 9Ni-4Co steels	**10**	**W**	**3.2**
122	**Heating Environment** That planning must provide that parts are controlled by type and heat treated in the class of atmosphere permitted in Table 1 for that type when heating above 1250 °F (677 °C). When heating parts at 1250 °F (677 °C) or below, Class A, B, or C atmosphere may be used.	**7**	**W**	**3.3**
123	**Types of Parts** That planning must identify the part type as follows. **Type 1:** Parts with 0.020 inch (0.51 mm) or more to be machined off all surfaces after heat treatment and parts with as-forged, as-cast, or hot-finished mill surfaces at time of heat treatment with all surfaces to be machined off. **Unless informed that all surfaces will have at least 0.020 inch (0.51 mm) machined off, the heat treating processor shall assume all surfaces will not, and shall control the part as Type 2, 3, or 4, as applicable.** **Type 2:** Forgings, castings, sheet, strip, plate, bar, rod, tubing, and extrusions with hot-finished surfaces at time of heat treatment and which will remain on the finished part. **Type 3:** Parts with finished machined surfaces or surfaces with less than 0.020 inch (0.51 mm) to be machined off any surface after heat treatment and parts with protective coating on all surfaces. **Type 4:** Parts that are partially machined with both un-machined, as-forged, as-cast, or hot-finished mill surfaces and finished machined surfaces or machined surfaces with less than 0.020 inch (0.51 mm) to be machined off after heat treatment.	**5**	**W**	**3.3.1**
124	That if part type cannot be determined, the part shall be processed as Type 3.	**7**	**W**	**3.3.1.1**
125	**Classes of Atmospheres** That planning must specify the atmosphere as follows **Class A:** Argon, hydrogen, helium, nitrogen, nitrogen-hydrogen blends, vacuum, or neutral salt. Nitrogen from dissociated ammonia is not permitted. **Class B:** Endothermic, exothermic, or carbon-containing nitrogen-base **Class C:** Air or products of combustion.	**5**	**W**	**3.3.2**
126	**Atmospheres** That procedures must provide that atmosphere furnaces be controlled to ensure that surfaces of heat treated parts meet surface contamination requirements and that salt baths must be tested in accordance with AMS2759.	**7**	**W**	**3.3.3**
127	**Protective Coatings** That a supplemental coating or plating is permitted when approved by the cognizant engineering organization. Planning may specify that fine grain copper plating in accordance with AMS2418 or nickel plating in accordance with AMS2424 may be used without approval but surface contamination test specimens shall not be plated	**5**	**W**	**3.3.4**
128	**Preheating** That preheating until furnace stabilization in the 900 to 1200 °F (482 to 649 °C) range is recommended before heating parts above 1300 °F (704 °C) if the parts have previously been heat treated to a hardness greater than 35 HRC, have abrupt changes of section thickness, have sharp reentrant angles, have finished machined surfaces, have been welded, have been cold formed or straightened, have holes, or have sharp or only slightly-rounded notches or corners.	**3**	**W**	**3.4.1**
129	**Soaking**			
130	That planning must control heating such that either the heating medium or the part temperature, as applicable, is maintained at the set temperature in Table 2, 3, or 4 for the soak time specified herein.	**10**	**W**	**3.4.2**
131	That planning must provide that soaking commence when all control, indicating, and recording thermocouples reach the specified set temperature or, if load thermocouples are used, when the part temperature reaches the minimum of the furnace uniformity tolerance at the set temperature.	**10**	**W**	**3.4.2**
132	That planning must take into account that parts coated with copper plate or similar reflective	**7**	**W**	**3.4.2.1**

	coatings that tend to reflect radiant heat shall have their soak time increased by at least 50%, unless load thermocouples are used.			
133	**Annealing**			
134	That planning for annealing must specify heating to the temperature specified in Table 2, soaking for the time specified in Table 5, and cooling to below the temperature specified in Table 2 at the rate shown in Table 2 followed by air cooling to ambient temperature.	**7**	**W**	**3.4.3**
135	That isothermal annealing treatments may be used provided equivalent hardness and microstructure are obtained. Planning for isothermal annealing must specify heating to the annealing temperature specified in Table 2, soaking for the time specified in Table 5, cooling to a temperature below the critical, holding for sufficient time to complete transformation, and air cooling to ambient temperature	**7**	**W**	**3.4.3**
136	**Subcritical Annealing** That planning for subcritical annealing prior to hardening must specify heating in the range 1150 to 1250 °F (621 to 677 °C), soaking for the time specified in Table 5, and cooling to ambient temperature. Steel parts of the 9Ni-4Co type shall be subcritical annealed as specified in Table 2.	**5**	**W**	**3.4.4**
137	**Pre-Hardening Stress Relieving** That planning for pre-hardening stress relieving must specify heating prior to hardening in the range 1000 to 1250 °F (538 to 677 °C), soaking for not less than the time specified in Table 5, and cooling to ambient temperature.	**5**	**W**	**3.4.5**
138	**Normalizing** That planning for normalizing must specify heating to the temperature specified in Table 2, soaking for the time specified in Table 5, and cooling in air or atmosphere to ambient temperature. Circulated air or atmosphere is recommended for thicknesses greater than 3 inches (76 mm). Normalizing may be followed by tempering or subcritical annealing.	**5**	**W**	**3.4.6**
139	**Hardening (Austenitizing and Quenching)**			
140	That planning for welded parts, and brazed parts with a brazing temperature above the normalizing temperature, must include that they be normalized before hardening.	**5**	**W**	**3.4.7**
141	That planning for parts identified as damage tolerant, maintenance critical, or fracture critical must include that they be normalized before hardening.	**5**	**W**	**3.4.7**
142	That planning must include that hardening be accomplished by heating to the austenitizing temperature specified in Table 2, soaking for the time specified in Table 5, and quenching as specified in Table 2. The parts shall be cooled to or below the quenchant temperature before tempering.	**10**	**W**	**3.4.7**
143	**Tempering**			
144	That planning must include that tempering be accomplished by heating quenched parts to the temperature required to produce the specified properties. Parts should be tempered within two hours of quenching. Suggested tempering temperatures for specific tensile strengths for each alloy and quenchant are given in Table 3. Alternate tempering temperatures for listed alloys, based on as-quenched hardness, are given in Table 4.	**7**	**W**	**3.4.8**
145	That planning must include that soaking time for tempering shall be not less than two hours plus one hour additional for each inch (25 mm) of thickness or fraction thereof greater than one inch (25 mm). Thickness is defined in AMS2759.	**7**	**W**	**3.4.8**
146	That when load thermocouples are used, planning must include that the soaking time be not less than one hour..	**7**	**W**	**3.4.8**
147	That multiple tempering is permitted and that when multiple tempering is used, planning must provide that parts be cooled to ambient temperature between tempering treatments.	**5**	**W**	**3.4.8**
148	That planning can include that prior to final tempering parts may be snap tempered for two hours at a temperature, usually 400 °F (204 °C), that is lower than the tempering temperature.	**3**	**W**	**3.4.8.1**
149	**Straightening**			
150	That planning may allow straightening for parts having minimum tensile strength below 180 ksi (1241 MPa) cold without stress relieving.	**5**	**W**	**3.4.9**
151	That straightening of parts hardened and tempered to minimum tensile strength of 180 ksi (1241 MPa) and higher may only be performed when approved by the cognizant engineering organization, Planning for these parts must provide that straightening be accomplished at either ambient temperature, during tempering, or by heating to not higher than 50 °F (28 °C) below the tempering temperature.	**7**	**W**	**3.4.9**
152	That planning must provide that ambient temperature straightening or hot or warm straightening after tempering shall be followed by stress relieving	**5**	**W**	**3.4.9**
153	That it is permissible to re-temper at a temperature not higher than the last tempering temperature after straightening during tempering.	**5**	**W**	**3.4.9**
154	**Post-Tempering Stress Relieving**			
155	That when required by the cognizant engineering organization planning must provide that parts shall, after operations which follow hardening and tempering, be stress relieved by heating the parts to 50 F (28 C) degrees below the tempering temperature and soaking for not less than one hour plus one hour additional for each inch (25 mm) of thickness or fraction thereof greater than one inch (25 mm).	**7**	**W**	**3.4.10**
156	That when load thermocouples are used, the soaking time for post tempering stress relief shall be not less than one hour.	**7**	**W**	**3.4.10**
157	That post tempering stress relief is prohibited on parts that have been peened or thread- or fillet-rolled after hardening and tempering.	**10**	**W**	**3.4.10**

158	**Properties** That planning shall provide that parts conform to the hardness specified by the cognizant engineering organization or to the hardness converted from the required tensile strength in accordance with AMS2759.	**7**	**W**	**3.5**
159	**Surface Contamination**			
160	That planning must provide that salt baths and the protective atmosphere in furnaces for heating parts above 1250 °F (677 °C), when less than 0.020 inch (0.51 mm) of metal is to be removed from any surface, shall be controlled to prevent carburization or nitriding and to prevent total decarburization. Partial decarburization shall not exceed 0.005 inch (0.13 mm). Intergranular attack shall not exceed 0.0007 inch (0.018 mm).	**7**	**W**	**3.5.1**
161	That planning must address that the rejection criterion for depth of decarburization shall be the microhardness reading at which there is more than a 20-point Knoop, or equivalent, decrease in hardness from the core hardness.	**7**	**W**	**3.5.1**
162	That planning must address that the rejection criterion for carburization and nitriding shall be that the microhardness shall not exceed the core hardness by 20 points Knoop or more, or equivalent, at a depth of 0.002 inch (0.05 mm).	**7**	**W**	**3.5.1**
163	That these surface contamination requirements also apply to the cumulative effects of operations such as normalizing followed by austenitizing or austenitizing followed by re-austenitizing.	**7**	**W**	**3.5.1**
164	That planning must provide that for reheat treatments, the original specimen or a portion thereof must accompany the parts and be tested after the reheat treatment.	**10**	**W**	**3.5.1**
165	That unless specifically informed that at least 0.020 inch (0.51 mm) will be removed from all surfaces of parts, the planning must provide that the parts be heat treated as if less than 0.020 inch (0.51 mm) will be removed from some surfaces and, therefore, shall use controlled atmosphere which will produce parts conforming to surface contamination requirements.	**10**	**W**	**3.5.1.1**
166	That planning may allow that parts that will be machined after heat treatment, but that will have less than 0.020 inch (0.51 mm) of metal removed from any machined surface may be reclassified as Type 1 and need not meet surface contamination requirements as heat treated, when it is demonstrated by tests on each load that all excessive surface contamination is removable from all machined surfaces, taking into account distortion after heat treatment.	**5**	**W**	**3.5.1.2**
167	That furnaces used exclusively to heat treat parts that will have all contamination removed shall not require testing.	**3**	**W**	**3.5.1.3**
168	That the heat treating planning must take into account whether cumulative heat treating operations at their facility have caused excessive surface contamination.	**7**	**W**	**3.5.1.4**
169	**Test Methods** That planning must provide for the required testing per AMS2759 and AMS2759/1	**7**	**W**	**3.6**
170	**Surface Contamination** That planning must provide that testing be performed by the microhardness method in accordance with ASTM E 384, supplemented, if necessary, by ARP1820. Test specimens shall be of the same alloy as the parts. Unless otherwise specified, test specimens shall be in the as-quenched condition except that secondary hardening steels, such as H-11, shall be tempered. In addition, the presence of total depth of decarburization, carburization, and nitriding shall be determined by etching with the appropriate etchant and examining at approximately 250X magnification. The depth of intergranular attack shall be determined on an un-etched specimen at approximately 250X magnification	**7**	**W**	**3.6.1**
171	**QUALITY ASSURANCE PROVISIONS** That planning must address inspection, classification of tests, sampling, approval, entries, records, and reports in accordance with AMS2759 and AMS2759/1.	**7**	**W**	**4.**
172	**Acceptance Tests** That planning must provide that, in addition to the tests specified in AMS2759, tests for surface contamination on damage tolerant or fracture critical parts shall be performed on each lot. It is the responsibility of purchaser to inform the heat treater on the drawing, contract, or purchase order that parts are damage tolerant or fracture critical.	**10**	**W**	**4.1.1**
173	**Periodic Tests** That planning must provide that, in addition the tests specified in AMS2759, tests for surface contamination shall be performed monthly on each furnace in service, each kind of atmosphere to be used in each furnace, and for each Class B atmosphere at two carbon potentials, up to 0.40% and over 0.40%.	**7**	**W**	**4.1.2**
174	**Preproduction Tests** That procedures must address that, in addition to the tests specified in AMS2759, tests for surface contamination shall be performed prior to any production heat treating on each furnace, each kind of atmosphere to be used in each furnace, and for each Class B atmosphere at two carbon potentials, up to 0.40% and over 0.40%.	**7**	**W**	**4.1.3**
175	That heating below 1400 °F (760 °C) with Class B atmospheres containing 5% or more of hydrogen (H2), carbon monoxide (CO), or methane (CH4), may result in explosion and fire.	**10**	**W**	**8.2**
176	That when supplemental plating or coating, such as copper plate, is used, all atmosphere controls and surface contamination tests are still required.	**5**	**W**	**8.3**
177	That use of a chromic-caustic etch to reveal intergranular attack/oxidation has been discontinued because (1) it is an environmental hazard (2) it is unnecessary for measurement of maximum depth of crevices, and (3) light etching zones extending beyond the crevices have been misinterpreted as manifestations of intergranular oxidation.	**3**	**W**	**8.4**
178	That snap tempering is an immediate low temperature treatment to relieve stresses and prevent cracking prior to the next operation. Final tempering to the specified requirements is performed	**3**	**W**	**8.5.1**

	after snap tempering.			
179	**B) SPECIFIC REQUIREMENTS RELATED TO: AMS2759/2 - Heat Treatment of Carbon and Low-Alloy Steel Parts 220 ksi (1517 MPa) Minimum Tensile Strength Or Higher**			
180	That this specification, in conjunction with the general requirements for steel heat treatment covered in AMS2759, establishes the requirements for heat treatment of low-alloy steel parts to minimum ultimate tensile strengths of 220 ksi (1517 MPa) and higher. Parts are defined in AMS2759.	**7**	**W**	**1.1**
181	That heat treatment of low-alloy steel parts to minimum ultimate tensile strengths of 220 ksi (1517 MPa) shall conform to AMS2759 and the requirements specified herein.	**7**	**W**	**3.1**
182	That equipment shall conform to AMS2759.	**7**	**W**	**3.2**
183	That planning must provide that furnace temperature uniformity requirements for annealing, subcritical annealing, normalizing, hardening, straightening, stress relieving, and baking shall be ±25 °F (±14 °C), and for tempering or aging shall be ±10 °F (±6 °C).	**10**	**W**	**3.2**
184	**Heating Environment** That planning must provide that parts are controlled by type and heat treated in the class of atmosphere permitted in Table 1 for that type when heating above 1250 °F (677 °C). When heating parts at 1250 °F (677 °C) or below, Class A, B, or C atmosphere may be used.	**7**	**W**	**3.3**
185	**Types of Parts** That planning must identify the part type as follows. **Type 1:** Parts with 0.020 inch (0.51 mm) or more to be machined off all surfaces after heat treatment and parts with as-forged, as-cast, or hot-finished mill surfaces at time of heat treatment with all surfaces to be machined off. **Unless informed that all surfaces will have at least 0.020 inch (0.51 mm) machined off, the heat treating processor shall assume all surfaces will not and shall control the part as Type 2, 3, or 4, as applicable.** **Type 2:** Forgings, castings, sheet, strip, plate, bar, rod, tubing, and extrusions with hot-finished surfaces at time of heat treatment and which will remain on the finished part. **Type 3:** Parts with finished machined surfaces or surfaces with less than 0.020 inch (0.51 mm) to be machined off any surface after heat treatment and parts with protective coating on all surfaces. **Type 4:** Parts that are partially machined with both un-machined (e.g., as-forged, as-cast, or hot-finished mill surfaces) and finished/near-finished surfaces (e.g., finished machined surfaces or machined surfaces with less than 0.020 inch (0.51 mm) to be machined off after heat treatment).	**7**	**W**	**3.3.1**
186	That if part type cannot be determined, the part shall be processed as Type 3.	**10**	**W**	**3.3.1.1**
187	**Classes of Atmospheres** That planning must specify the atmosphere as follows **Class A:** Argon, hydrogen, helium, nitrogen, nitrogen-hydrogen blends, vacuum, or neutral salt. Nitrogen from dissociated ammonia is not permitted. **Class B:** Endothermic, exothermic, or carbon-containing nitrogen-base **Class C:** Air or products of combustion.	**7**	**W**	**3.3.2**
188	**Atmospheres** That procedures must provide that atmosphere furnaces be controlled to ensure that surfaces of heat treated parts meet surface contamination requirements and that salt baths must be tested in accordance with AMS2759.	**7**	**W**	**3.3.3**
189	**Protective Coatings** That a supplemental coating or plating is permitted when approved by the cognizant engineering organization. Planning may specify that fine grain copper plating in accordance with AMS2418 or nickel plating in accordance with AMS2424 may be used without approval but surface contamination test specimens shall not be plated	**5**	**W**	**3.3.4**
190	**Preheating** That preheating until furnace stabilization in the 900 to 1200 °F (482 to 649 °C) range is recommended before heating parts above 1300 °F (704 °C) if the parts have previously been heat treated to a hardness greater than 35 HRC, have abrupt changes of section thickness, have sharp reentrant angles, have finished machined surfaces, have been welded, have been cold formed or straightened, have holes, or have sharp or only slightly-rounded notches or corners.	**3**	**W**	**3.4.1**
191	**Soaking**			
192	That planning must control heating such that either the heating medium or the part temperature, as applicable, is maintained at the set temperature in Table 2, 3, or 4 for the soak time specified herein.	**7**	**W**	**3.4.2**
193	That planning must provide that soaking commence when all control, indicating, and recording thermocouples reach the specified set temperature or, if load thermocouples are used, when the part temperature reaches the minimum of the furnace uniformity tolerance at the set temperature.	**7**	**W**	**3.4.2**
194	That planning must take into account that parts coated with copper plate or similar reflective coatings that tend to reflect radiant heat shall have their soak time increased by at least 50%, unless load thermocouples are used	**7**	**W**	**3.4.2.1**
195	**Annealing**			
196	That planning for annealing must specify heating to the temperature specified in Table 2, soaking for the time specified in Table 4, and cooling to below the temperature specified in Table 2 at the rate shown in Table 2 followed by air cooling to ambient temperature.	**7**	**W**	**3.4.3**
197	That isothermal annealing treatments may be used providing equivalent hardness and microstructure are obtained. Isothermal annealing shall be accomplished by heating to the annealing temperature specified in Table 2, soaking for the time specified in Table 4, cooling to a	**5**	**W**	**3.4.3**

	temperature below the critical, holding for sufficient time to complete transformation, and air cooling to ambient temperature.			
198	**Subcritical Annealing** That planning for subcritical annealing prior to hardening must specify heating in the range 1150 to 1250 °F (621 to 677 °C), soaking for the time specified in Table 4, and cooling to ambient temperature. Steel parts of the 9Ni - 4Co types shall be subcritical annealed as specified in Table 2.	**7**	**W**	**3.4.4**
199	**Pre-Hardening Stress Relieving** That planning for pre-hardening stress relieving must specify heating in the range 1000 to 1250 °F (538 to 677 °C), soaking for not less than the time specified in Table 4, and cooling to ambient temperature.	**5**	**W**	**3.4.5**
200	**Normalizing** That planning for normalizing must specify heating to the temperature specified in Table 2, soaking for the time specified in Table 4, and cooling in air or atmosphere to ambient temperature. Circulating air or atmosphere is recommended for thicknesses greater than 3 inches (76.2 mm). Normalizing may be followed by tempering or subcritical annealing.	**7**	**W**	**3.4.6**
201	**Hardening (Austenitizing and Quenching)**			
202	That planning must include that all parts, except those made from H-11, 52100, or M-50 steels, shall be in one of the following conditions prior to austenitizing: normalized, normalized and tempered, normalized and overaged, or hardened.	**7**	**W**	**3.4.7**
203	That planning must include that if such parts have been normalized only, without tempering or over-aging, they shall be preheated within the range of 850 to 1250 °F (454 to 677 °C) before exposure to the austenitizing temperature.	**7**	**W**	**3.4.7**
204	That planning for welded parts, and for brazed parts with a brazing temperature above the normalizing temperature, shall be normalized before hardening.	**5**	**W**	**3.4.7**
205	That planning must include that hardening shall be accomplished by heating to the austenitizing temperature specified in Table 2, soaking for the time specified in Table 4, and quenching as specified in Table 2. The parts shall be cooled to or below the quenchant temperature before tempering.	**10**	**W**	**3.4.7**
206	**Tempering**			
207	That planning must include that tempering be accomplished by heating quenched parts to the temperature required to produce the specified properties. Parts should be tempered within 2 hours of quenching. Tempering for specific tensile strengths for each alloy is shown in Table 3. Soaking time shall be not less than 2 hours plus 1 hour additional for each inch (25 mm) of thickness or fraction thereof greater than 1 inch (25 mm).	**7**	**W**	**3.4.8**
208	That when load thermocouples are used, the soaking time shall be not less than 2 hours.	**7**	**W**	**3.4.8**
209	That multiple tempering is permitted. When multiple tempering is used, parts shall be cooled to ambient temperature between tempering treatments.	**3**	**W**	**3.4.8**
210	That planning can include that prior to final tempering parts may be snap tempered for 2 hours at a temperature, usually 400 °F (204 °C), that is lower than the final tempering temperature.	**3**	**W**	**3.4.8.1**
211	**Straightening**			
212	That straightening of parts hardened and tempered to minimum tensile strength of 180 ksi (1241 MPa) and higher may only be performed when approved by the cognizant engineering organization. Planning for these parts must provide that straightening be accomplished at either ambient temperature, during tempering, or by heating to not higher than 50 °F (28 °C) below the tempering temperature.	**10**	**W**	**3.4.9**
213	That planning must provide that ambient temperature straightening or hot or warm straightening after tempering shall be followed by stress relieving.	**7**	**W**	**3.4.9**
214	That it is permissible to re-temper at a temperature not higher than the last tempering temperature after straightening during tempering	**5**	**W**	**3.4.9**
215	**Post-Tempering Stress Relieving**			
216	That when required by the cognizant engineering organization, parts shall, after operations which follow hardening and tempering, be stress relieved by heating the parts to 50 °F (28 °C) below the tempering temperature and soaking for not less than 1 hour plus 1 hour additional for each inch (25 mm) of thickness or fraction thereof greater than 1 inch (25 mm).	**5**	**W**	**3.4.10**
217	When load thermocouples are used, the soaking time for post tempering stress relief shall be not less than 1 hour.	**5**	**W**	**3.4.10**
218	That stress relief is prohibited on parts that have been peened or thread- or fillet-rolled after hardening and tempering.	**10**	**W**	**3.4.10**
219	**Properties** That planning shall provide that parts shall conform to the hardness specified by the cognizant engineering organization or to the hardness converted from the required tensile strength in accordance with AMS2759.	**7**	**W**	**3.5**
220	**Surface Contamination**			
221	That planning must provide that salt baths and the protective atmosphere in furnaces for heating parts above 1250 °F (677 °C), when less than 0.020 inch (0.51 mm) of metal is to be removed from any surface, shall be controlled to prevent carburization or nitriding and to prevent complete decarburization.	**10**	**W**	**3.5.1**
222	That planning must address that partial decarburization shall not exceed 0.006 inch (0.15 mm) and a severity of 5 points HRC converted from Knoop. Depth and severity are described in ARP1820	**10**	**W**	**3.5.1**

223	That planning must address that intergranular attack shall not exceed 0.0007 inch (0.018 mm).	**10**	**W**	**3.5.1**
224	That planning must address that the rejection criterion for total depth of decarburization shall be the microhardness reading that has more than a 20-point Knoop, or equivalent, decrease in hardness from the core hardness.	**10**	**W**	**3.5.1**
225	That planning must address that the rejection criterion for severity of decarburization is the difference between the HRC hardness (converted from Knoop) at 0.0003 inch (0.008 mm) and that of the core.	**10**	**W**	**3.5.1**
226	That planning must address that the rejection criterion for carburization and nitriding shall be that the microhardness shall not exceed the core hardness by 20 points Knoop or more, or equivalent, at a depth of 0.0003 inch (0.008 mm).	**10**	**W**	**3.5.1**
227	That these surface contamination requirements also apply to the cumulative effects of operations such as normalizing followed by austenitizing or austenitizing followed by re-austenitizing.	**7**	**W**	**3.5.1**
228	That planning must provide that for reheat treatments, the original specimen or a portion thereof shall accompany the parts and be tested after the reheat treatment.	**10**	**W**	**3.5.1**
229	That unless specifically informed that at least 0.020 inch (0.51 mm) will be removed from all surfaces of parts, the planning must provide that the parts be heat treated as if less than 0.020 inch (0.51 mm) will be removed from some surfaces and, therefore, shall use controlled atmosphere which will produce parts conforming to surface contamination requirements.	**10**	**W**	**3.5.1.1**
230	That planning may allow that parts that will be machined after heat treatment, but which will have less than 0.020 inch (0.51 mm) of metal removed from any machined surface may be reclassified as Type 1 and need not meet the surface contamination requirements as heat treated, when it is demonstrated by tests on each load that all excessive surface contamination is removable from all machined surfaces, taking into account distortion after heat treatment.	**5**	**W**	**3.5.1.2**
231	That furnaces used exclusively to heat treat parts that will have all contamination removed shall not require testing.	**3**	**W**	**3.5.1.3**
232	That the heat treating planning must take into account whether cumulative heat treating operations at that facility have caused excessive surface contamination.	**5**	**W**	**3.5.1.4**
233	**Test Methods** That planning must provide for the required testing per AMS2759 and AMS2759/2	**7**	**W**	**3.6**
234	**Surface Contamination** That planning must provide that testing be performed by the microhardness method in accordance with ASTM E 384, supplemented, if necessary, by ARP1820. Test specimens shall be of the same alloy as the parts. Unless otherwise specified, test specimens shall be in the as-quenched condition except that secondary hardening steels, such as H-11, shall be tempered. In addition, the presence of total depth of decarburization, carburization, and nitriding shall be determined by etching with the appropriate etchant and examining at approximately 250X magnification. The depth of intergranular attack shall be determined on an un-etched specimen at approximately 250X magnification.	**10**	**W**	**3.6.1**
235	**QUALITY ASSURANCE PROVISIONS** That planning must address inspection, classification of tests, sampling, approval, entries, records, and reports in accordance with AMS2759 and AMS2759/1.	**7**	**W**	**4**
236	That planning may provide that testing for reclassification of parts that will be machined after heat treatment, but which will have less than 0.020 inch (0.51 mm) of metal removed from any machined surface be by any microhardness method if more than 0.002 inch (0.05 mm) is subsequently machined off all machined surfaces.	**5**	**W**	**3.6.1.1**
237	**Acceptance Tests** That planning must provide that, in addition to the tests specified in AMS2759, tests for surface contamination shall be performed on each lot. Alternatively, if carbon potential is controlled automatically and either indicated or recorded, the frequency of surface contamination tests may be in accordance with an approved sampling plan.	**10**	**W**	**4.1.1**
238	**Preproduction Tests** That procedures must address that, in addition to the tests specified in AMS2759, tests for surface contamination shall be performed prior to any production heat treating on each furnace, each kind of atmosphere to be used in each furnace, and for each Class B atmosphere at two carbon potentials, up to 0.40% and over 0.40%.	**7**	**W**	**4.1.2**
239	That planning may provide for an Alternative Sampling Plan to meet acceptance test requirements for heat treatment processes verified by statistical process control (SPC) to be stable and capable (that is, when statistical evaluation of the product and process parameters show that all measured values fall within established control limits).	**5**	**W**	**4.2, 4.2.2**
240	That heating below 1400 °F (760 °C) with Class B atmospheres containing 5% or more of hydrogen (H2), carbon monoxide (CO), or methane (CH4), may result in explosion and fire.	**10**	**W**	**8.2**
241	That when supplemental plating or coating, such as copper plate, is used, all atmosphere controls and surface contamination tests are still required.	**5**	**W**	**8.3**
242	That use of a chromic-caustic etch to reveal intergranular attack/oxidation has been discontinued because (1) it is an environmental hazard (2) it is unnecessary for measurement of maximum depth of crevices, and (3) light etching zones extending beyond the crevices have been misinterpreted as manifestations of intergranular oxidation	**3**	**W**	**8.4**
243	That snap tempering is an immediate low temperature treatment to relieve stresses and prevent cracking prior to the next operation. It is most often used prior to a refrigeration cycle. Final tempering to the specified requirements is performed after snap tempering.	**3**	**W**	**8.5.1**
244	That Marquenching (Martempering) consists of quenching an austenitized alloy in a salt or hot oil bath at a temperature in the upper part of, or slightly above, the martensite range and holding	**3**	**W**	**8.5.2**

	until temperature uniformity throughout the part is obtained, usually followed by air cooling through the martensite range to ambient temperature.			
245	**D) SPECIFIC REQUIREMENTS RELATED TO: AMS-H-6875 Class A - Heat Treatment of Raw Material**			
246	That planning must communicate that this specification establishes requirements for the heat treatment of Raw Material .**It is not intended to be used for the treatment of parts.**	**7**	**W**	**Scope 1.1**
247	**Caution –** If this document is specified for what appear to be parts, contact the customer for clarification. There are some legacy contractual requirements where AMS-H-6875 could still be required.	**10**		
248	That this specification describes procedures that, when followed, will produce the desired properties and material qualities within the limitations of the respective alloys tabulated in Table 1A. Alloys other than those specifically covered herein may be heat treated using all applicable requirements of this specification.	**5**	**W**	**1.1**
249	That the Class A requirements of this specification apply to Carbon and Alloy Steels	**5**	**W**	**1.2**
250	**Furnace media and protective coatings**			
251	**Atmospheres**			
252	That gases used as furnace atmospheres must only be used for the appropriate Class determined from Table 1. Supplementary protective coatings may be used in accordance with the requirements of this specification.	**7**	**W**	**3.1.1.1 and 3.3.1.3**
253	That unless otherwise specified by the cognizant engineering organization , planning may permit an air/product of combustion atmosphere only for tempering, stress relieving and 1400 °F (760 °C) or below transformation treatments. An air/product of combustion atmosphere may be used for treatment above 1400 °F (760 °C) for Class A material that will have a minimum of 0.020 inch (0.51mm) metal removed from all surfaces after heat treatment or have been protected by electroplates.	**7**	**W**	**Table 1 Note 2**
254	That planning must provide that exothermic, nitrogen based or endothermic atmosphere shall be refined or blended to avoid a change in carbon content at the surface of the material. A product of combustion at -40 °F (-40 °C) maximum dew point (e.g., endothermic) may be used for class A material that allows 0.003 inch (0.08 mm) maximum partial decarburization at the surface. Exothermic atmosphere is permissible for heat treatment of class A mill products.	**7**	**W**	**Table 1 Note 4**
255	That when using nitrogen, nitrogen based or exothermic atmospheres, planning may allow Class A steels to be fine grain copper plated 0.002 to 0.005 inch (0.05 to 0.13 mm) thick in accordance with AMS2418 or nickel plated per AMS2424 or AMS-QQ-N-290 or equivalent as a supplementary surface protection. Other supplementary protective coatings may be used if approved by the cognizant engineering organization	**5**	**W**	**Table 1 Note 8**
256	That dissociated ammonia is permissible for annealing of Class A mill products providing residual ammonia at the outlet of the generator does not exceed 15 ppm.	**7**	**W**	**Table 1 Note 9**
257	That furnaces for mill products shall be supplied with a consistent atmosphere gas that meets the requirements of the material specification.	**5**	**W**	**3.1.1.2**
258	That planning must ensure that atmospheres are controlled such that they do not contaminate parts being treated including vacuum and salt baths.	**7**	**W**	**3.1.1.2**
259	That planning must take into account the need or requirement to carry out purges before treating materials in furnaces whose use is not limited solely to aerospace work.	**7**	**W**	**3.1.1.2**
260	That salt baths may be used for Class A (carbon and alloy) steels and must be tested initially and at least weekly to prevent general corrosion, carburization , decarburization and intergranular attack exceeding the limits of this specification	**7**	**W**	**3.1.1.3**
261	That procedures must control that additives used for adjustments shall be limited to salts in bath and rectifiers recommended by the salt manufacturer.	**5**	**W**	**3.1.1.3**
262	**Temperature Uniformity** That planning must be in accordance with the requirements of AMS2750 (Pyrometry) for control and testing of furnaces, ovens, salt baths, vacuum furnaces, refrigeration equipment and allied pyrometric equipment.	**10**	**W**	**3.1.1.4**
263	**Temperature Range and Set Temperature** That planning must provide that the set temperature on the furnace control instrument shall be such that the load temperature falls within the specified range, taking into account the temperature uniformity of the furnace. In continuous furnaces used to anneal and normalize mill products, a thermal head may be used. The temperature of the mill product shall not exceed the maximum processing temperature.	**10**	**W**	**3.1.1.5**
264	That furnaces must have instrumentation to a minimum of Type D per AMS2750.	**7**	**W**	**3.1.2.1**
265	That Furnace Class requirements per AMS2750 are Furnace Class 2 +/-10°F (+/- 6°C) for tempering after hardening of D6AC and 9Ni-4Co (Class A) alloy steels and other (Class A) low alloy steels - 220 ksi (1517 MPa) UTS and higher and Furnace Class 5 +/-25°F (+/-14°C) for all other processes.	**10**	**W**	**3.1.2.1**
266	**Quench Tanks**			
267	That quench tanks must permit total immersion, provide adequate circulation to produce the required properties in the largest material processed, provide a means for indicating the temperature of the media and for cooling and heating as required.	**7**	**W**	**3.1.3.1**
268	**NOTE:** As of July 2015, AMS 2750 requires that quench systems used for heat treatments that include a quenchant temperature requirement (minimum, maximum or both) shall be equipped	**5**	**W**	**AMS2750 3.3.3.2**

	with a recording instrument.			
269	That planning must provide for documentation that oil quenching medium is between 60°F and 160°F (15°/71°C) at the beginning of the quench and shall not exceed 200°F (93°C) at any time during the quenching operation, unless otherwise approved by the cognizant engineering organization	**10**	**W**	**3.1.3.1.1**
270	That procedures must ensure that the temperature of the oil quenching media shall not exceed the manufacturer's recommended operating range.	**5**	**W**	**3.1.3.1.1**
271	That procedures must ensure that quench oil used in integral quench vacuum furnace systems, where the quench chamber is below atmospheric pressure, is vacuum degassed at approximately the maximum recommended temperature for the quenchant initially and after each major addition of oil	**5**	**W**	**3.1.3.1.1**
272	That Aqueous Polymer Quenchants may be used as permitted in Table 1A for Class A Carbon and Alloy Steels. Procedures must ensure that baths have adequate circulation.	**5**	**W**	**3.1.3.1.3**
273	**Thermal Treatment**			
274	That heating rates must be controlled to prevent damage to material. Pre-heating at 1000 to 1200 °F (538 to 649 °C) is recommended before heating material above 1300 °F if the material: • Has been previously hardened above Rc 35, or is made of steel of 0.50 (nominal) percent carbon or over, or • Has abrupt changes of section, or sharp re-entrant angles, or • Has been finish machined	**5**	**W**	**3.2.1**
275	That material in Class A shall be hardened by Austenitizing, Quenching and Tempering.	**5**	**W**	**3.2.2**
276	**Prior Condition of Class A Steel Parts**			
277	That planning shall provide that parts made from H-11 steel be in the annealed condition, prior to hardening, unless it has been hot headed. Hot headed H-11 material shall be annealed, prior to hardening, by furnace cooling from 1625 °F ± 25 (885°C ± 14) to at least 1000 °F (538°C), at a maximum rate of 50 °F (28°C) per hour.	**5**	**W**	**3.2.2.1**
278	That planning shall provide that parts made of 52100 or 1095 steel be hardened from the spheroidize annealed condition	**5**	**W**	**3.2.2.1**
279	That planning shall provide that parts made from other Class A steels to be hardened and tempered to 220 ksi (1517 MPa) and above shall be either normalized, normalized and tempered, or normalized and sub-critical annealed, prior to initial austenitizing.	**7**	**W**	**3.2.2.1**
280	That planning shall provide that parts that have been welded shall be normalized, prior to hardening.	**5**	**W**	**3.2.2.1**
281	That planning shall provide that parts identified as damage tolerant, maintenance critical or fracture critical shall be normalized, normalized and tempered or normalized and subcritical annealed, regardless of the strength that they are subsequently to be heat-treated.	**7**	**W**	**3.2.2.1**
282	**Austenitizing, Quenching**			
283	That planning must provide that parts be held within the specified temperature range for sufficient time for the necessary transformation and diffusion to take place. The recommended holding times at temperature are listed in Table 2A.	**10**	**W**	**3.2.2.2**
284	That planning must provide quenching shall be carried out in the quenchant specified in Table 1A as applicable.	**7**	**W**	**3.2.2.3**
285	That planning must ensure that material be cooled to or below the quenchant temperature before tempering.	**7**	**W**	**3.2.2.3**
286	That planning allowance should be made that if hardened material cannot be tempered within 2 hours after quenching material may be Snap Tempered at 400°F +/- 25°F (204°C +/- 14°C) for 1 hour or as appropriate to prevent cracking.	**5**	**W**	**3.2.2.3**
287	**Tempering** That planning shall include that tempering be carried out in compliance with Table 3. Tempering temperatures in Table 1A are recommended unless indicated as mandatory.	**5**	**W**	**3.2.2.4**
288	**Normalizing** That planning shall include that normalizing be accomplished by cooling from Table 1A temperatures in circulated air or in a circulated protective atmosphere. The recommended minimum holding times at temperature are listed in Table 2A.	**7**	**W**	**3.2.4.1**
289	**Annealing Class A Steel** That planning shall ensure that annealing (full annealing) of Classes A material shall be accomplished in accordance with Table 1A and at suggested holding times in Table 2A. Sub-critical (partial) annealing of Class A material shall be accomplished by heating to 1200 to 1250 °F (649°C to 677°C) and holding in that temperature range for 2 hours.	**7**	**W**	**3.2.4.2**
290	**Stress Relieving**			
291	That planning must provide that stress relieving before hardening of Class A material be accomplished at any temperature between 1000 °F and 1250 °F (538°C to 677°C).	**7**	**W**	**3.2.4.4**
292	That planning must provide that stress relieving after hardening of Classes A material shall be accomplished by heating to a maximum temperature of 50 °F (28°C) below the tempering temperature. The recommended minimum holding times at temperature are listed in Table 2A..	**7**	**W**	**3.2.4.4**
293	That stress relieving after hardening is prohibited on parts that have been peened or cold deformed; e.g., roll threaded	**10**	**W**	**3.2.4.4**
294	**Process Requirements**			
295	That planning must specify equipment and processing techniques for the heat-treatment of	**7**	**W**	**3.3.1**

	material that are fully capable of providing the combination of mechanical properties, corrosion resistance and microstructure in the product as specified in the appropriate procurement document.			
296	**Cleaning** That material shall be cleaned prior to heat treatment to remove contaminants and leave no substance that could have a deleterious effect. Cleaning prior to heat treatment of mill products is not required provided no surface condition is retained that could have a deleterious effect on the product	**5**	**W**	**3.3.1.1**
297	**Spacing** That material should be racked or supported to allow circulation of heating and quenching media exposure to heating or quenching media and to minimize warpage	**7**	**W**	**3.3.1.2**
298	**Plating** That except for certain copper or nickel plating, approval from the cognizant engineering organization must be obtained prior to the use of coatings or plating for protection of surfaces during heat treatment.	**7**	**W**	**Table 1 Note 8** **3.3.1.3**
299	**Hardness Testing**			
300	That planning must provide that frequency of hardness testing for material that has been final heat-treated, shall be in accordance with the sampling requirements of AMS2759.	**7**	**W**	**3.3.2**
301	That planning must ensure that hardness testing shall be performed in the heaviest section that is suitable and not detrimental to the function of the material.	**7**	**W**	**3.3.2**
302	That when heat treating standard components such as nuts and bolts or mill products, the sampling and hardness test requirements of the applicable component and steel specifications take precedence	**5**	**W**	**3.3.2**
303	That planning must provide that hardness test data be converted to equivalent tensile strengths as specified by ASTM A 370 and the tensile strengths shall conform to the design requirements. Where a dispute exists in the hardness test, the tensile tests hall be performed in accordance with ASTM E 8 / E 8M and the test results shall conform to the design requirements	**5**	**W**	**3.3.2**
304	**Permissible Variations of Classes A Steel from Design Ultimate Strength** That when a minimum acceptable strength level and no maximum strength level is specified by design or the applicable material specification, the maximum strength shall be 20 ksi (138 MPa) above the minimum, except for Hy-Tuf and H-11 steels for which a maximum strength of 30 ksi (207 MPa) above the minimum is acceptable. For 300 M steel, a maximum strength of 30 ksi (207 MPa) above the minimum is acceptable, provided the maximum tensile strength does not exceed 305 ksi (2103 MPa).	**5**	**W**	**3.3.2.1**
305	**Surface Contamination** That planning must account for the requirements for Surface Contamination when material is hardened, normalized, or re-hardened. The requirements for decarburization, for carburization and nitriding, and for intergranular attack shall apply unless it is definitely known that sufficient material will be subsequently removed to eliminate deleterious surface conditions.	**7**	**W**	**3.3.3.1**
306	**Decarburization, Carburization and Nitriding and inter-granular attack (IGA)**			
307	That procedures must control the heating medium in furnaces used for normalizing and for hardening Classes A material so as not to produce excessive decarburization..	**7**	**W**	**3.3.3.1**
308	That procedures must provide that for furnaces used to heat-treat material whose final hardness will be HRC 46 (220 ksi/1517 MPa) and above, partial decarburization shall be judged excessive if greater than 0.003 inch (0.08 mm) deep on any finish machined surface.	**10**	**W**	**3.3.3.1**
309	That procedures must provide that for furnaces used to heat-treat material whose final hardness will be less than HRC 46 (220 ksi/1517 MPa) decarburization shall be not greater than 0.005 inch (0.13mm) deep on any finish machined surface	**7**	**W**	**3.3.3.1**
310	That total decarburization is not acceptable.	**7**	**W**	**3.3.3.1**
311	That furnaces used for Heat Treatment above 1250°F (676°C) must be controlled to preclude carburizing or nitriding.	**7**	**W**	**3.3.3.2** **4.2.3.1**
312	That furnaces used for Heat Treatment above 1250°F (676°C) shall be controlled to preclude IGA exceeding 0.0007 inch (0.018 mm) on material heat treated to <220 ksi (1517 MPa) and 0.0005 inch (0.013 mm) on other materials.	**7**	**W**	**3.3.3.3** **4.2.3.2**
313	**Quenchant effectiveness** That the consistency of quenchant effectiveness must be determined by testing each quenchant in each tank initially and quarterly thereafter by an approved test method and comparing the results with those obtained previously by the same method. Procedures must establish control limits for each quenching system. If the results indicate that a quenchant is outside the established limits, corrective action shall be taken and the test shall be repeated to verify restoration of the prior condition	**7**	**W**	**3.3.3.4**
314	**Heat Treatment of Parts** That finished or semi-finished parts shall be heat treated in accordance with AMS2759. Raw materials shall be heat treated in accordance with the requirements specified herein. Any references to parts heat treatment in this document are superseded by the requirements specified in AMS2759. **Caution –** If this document is specified for what appear to be parts, contact the customer for clarification. There are some legacy contractual requirements where AMS-H-6875 could still be required.	**5**	**W**	**3.4**
315	**Control Records**	**5**	**W**	**4.1.2**

	That records of system accuracy tests, furnace temperature surveys, calibration of control and recording instruments and date, time, temperature, and quenchant used in heat treating material shall be on file and available for review by contractors and Government representatives for 5 years. In addition heat treaters of final parts shall keep furnace recorder charts for 5 years.			
316	**Surface Contamination Tests**			
317	That procedures must ensure that each furnace used for normalizing and austenitizing of Classes A material shall be tested for conformance with surface contamination requirements. (A furnace used exclusively for heat-treatment of material where all contamination on that material will subsequently be removed need not be tested)	**7**	**W**	**4.2.1**
318	That specimens of Classes A material, except H-11, may be tested either in the tempered or in the un-tempered condition at the option of the cognizant engineering organization. However, procedures must provide that H-11 specimens be tested after completion of heat treatment.	**5**	**W**	**4.2.1.1**
319	That procedures must assure that for material made from Class A steels with a final strength of 220 ksi (1517 MPa) or hardness of HRC 46 or higher, at least one specimen of the same alloy shall be heat treated with each load.	**10**	**W**	**4.2.1.2**
320	That procedures must assure that for material that is damage tolerant or fracture critical, a minimum of one specimen of the same alloy shall be heat-treated with each load regardless of the final strength or hardness.	**10**	**W**	**4.2.1.2**
321	That if such material is reheat-treated, the original specimen, or a portion of the original specimen must accompany the material and be tested for conformance to surface contamination requirements after the reheat-treatment.	**10**	**W**	**4.2.1.2**
322	That procedures must assure that for lower strength material, under 220 ksi (1517 MPa), made from Class A steels, at least one specimen shall be tested for conformance to surface contamination requirements as follows • With the first load of each alloy group (Class A steels of 0.45 percent carbon and lower. and Class A steels of above 0.45 percent carbon are considered as separate alloy groups): • Each month for atmosphere furnaces, • Each week for salt baths	**7**	**W**	**4.2.1.2**
323	**Mechanical Properties** Planning must provide for conformance to testing requirements, including: • Hardness Test of Heat Treated Material • Tensile Tests (when specified) • Metallographic Tests	**7**	**W**	**4.2.2**
324	That procedures must address testing for Quench Rate Control using one of the following • Comparative Cooling Curve Evaluation • Magnetic Quenchometer • Hot Wire Test • Mechanical Properties Test	**7**	**W**	**4.3**
	SKILLS: Defined within these rolls describes the range of skills. The skills required to perform a particular special process task			
325	Has To be able to recognize and report in real time deviations from process parameters or other events which may have a negative impact on product quality.	**7**	**W**	
326	Capable of understanding, interpreting and complying with various customer requirements for precedence in documents.	**7**	**W**	
327	Capable of understanding interpreting and complying with various requirements for identification, review and revision of documents (Document Control).	**7**	**W**	
328	Ability to understand and interpret specification requirements and customer flow-down requirements.	**7**	**W**	
329	Has To be able to recognize conflicts within customer requirements and deviations from specifications and to ensure that they are resolved prior to final planning.	**7**	**W**	
330	Capable of generating clear and concise Work Instructions consistent with company practices and 'higher level' QMS requirements for general and specific procedures, operator training and approvals.	**7**	**W**	
331	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 • Temper delay • Heating and Cooling rates (where applicable)	**7**	**W**	
332	Capable of evaluating potential product impact of deviations from process parameters or other events which may have a negative impact on product quality	**7**	**W**	
333	The proper operation, maintenance, and calibration requirements for equipment used for testing evaluation and acceptance (e.g. Hardness)	**7**	**W**	
334	Pyrometry testing requirements including Furnace Class and Type, Calibration, Sensors	**7**	**W**	

	(thermocouples) , SAT and TUS.			
335	Capable of reviewing Calibration, SAT and TUS reports when required.	**7**	**W**	
336	Capable of documenting an on-going plan for Pyrometry compliance to AMS 2750 at shop and site level.	**7**	**W**	
337	Capable of planning, monitoring and making timely reminders/notifications of Pyrometry requirements and test frequencies.	**7**	**W**	
338	Capable of carrying out 'Self Audits.'	**7**	**W**	
339	Capable of conducting internal training and personal qualification exams to comply with Heat Treatment Body of Knowledge /Examination Review Board requirements	**7**	**W**	
340	Understanding the safety concerns involved with heat treatment including the need to include in planning instructions the need for the safe use of handling tools and personal protective equipment.	**7**	**W**	
341	The Preventive Maintenance Program.	**7**	**W**	
	PERSONAL ATTRIBUTES: Are statements that will enable judgment of the person's personal attributes			
342	Willingness to train and mentor co-workers.	**NA**	**NA**	
343	Good communicator at all levels.	**NA**	**NA**	
344	Takes responsibility to challenge unclear customer requirements or those that do not appear to conform to specification or customer requirements.	**NA**	**NA**	
345	Personal integrity.	**NA**	**NA**	
356	Attentive to details.	**NA**	**NA**	
	EXPERIENCE: Are the minimum experience requirement expected to demonstrate their competence.			
347	**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.**	**NA**	**NA**	
348	**Recommended Minimum Classroom Training** **Heat Treatment – 80 hours** **Paperwork – 40 hours** **Test, Inspection, Maintenance – 40 hours**	**NA**	**NA**	**ARP 1962 Table 1**
349	**Recommended Minimum On-the-Job-Training** **Air atmosphere–9 months** **Salt bath–9 months** **Furnace atmospheres and atmosphere control –12 months** **Inert gas atmosphere–12 months** **Vacuum–12 months** **Carbon and alloy steel hardening – 12 months** **High-strength steel (220 ksi (1515 MPa) and higher) - 24 months**	**NA**	**NA**	**ARP 1962 Table 2**
350	**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.**	**NA**	**NA**	**ARP 1962 3.3.1.4, 3.3.1.4.1, 3.3.1.4.2**
	NON-SPECIAL PROCESS RELATED REQUIREMENTS: Defined within these rolls are other general or pre-requisite needed			
351	**Must have a thorough understanding of general Quality Systems (AS9100) or equivalent.**	**7**	**W**	
352	**Must have a thorough understanding of customer specific requirements**	**7**	**W**	
353	**Must have a thorough understanding of Control of Non Conformance for equipment and product including containment, customer notification and disposition.**	**7**	**W**	

7. DOCUMENT REVISION HISTORY

REVISION DATE	SUMMARY

ADDENDUM 1

LIST OF INTERNATIONAL STANDARDS & REFERENCE DOCUMENTS FOR HEAT TREATMENT OF CARBON AND ALLOY STEELS

SPECIAL PROCESS	DOCUMENT TITLE	DOCUMENT NUMBER
Heat Treatment	Nadcap Audit Criteria For Heat Treating	AC7102
Plating	Plating, Copper	AMS2418
Plating	Plating, Nickel, Low-Stressed Deposit	AMS2424
Heat Treatment	Heat Treatment of Steel Parts, General Requirements	AMS2759
Heat Treatment	Heat Treatment of Carbon and Low-Alloy Steel Parts, Minimum Tensile Strength Below 220 ksi (1517 MPa)	AMS2759/1
Heat Treatment	Heat Treatment of Low-Alloy Steel Parts, Minimum Tensile Strength 220 ksi (1517 MPa) and Higher	AMS2759/2
Heat Treatment	Heat Treatment of Steel Raw Materials	AMS-H-6875
Plating	Nickel Plating (Electrodeposited)	AMS-QQ-N-290
Heat Treatment	Chord Method of Evaluating Surface Microstructural Characteristics	ARP1820
Heat Treatment	Training And Approval Of Heat-Treating Personnel	ARP1962
Quality	Quality Management Systems - Requirements for Aviation, Space and Defense Organizations	AS9100
Testing	Mechanical Testing of Steel Products	ASTM A 370
Testing	Tension Testing of Metallic Materials	ASTM E 8 / E 8M
Testing	Brinell Hardness of Metallic Materials	ASTM E 10
Testing	Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials	ASTM E 18
Testing	Knoop and Vickers Hardness of Materials	ASTM E 384