SAE The Engineering Society For Advancing Mobility Land Sea Air and Space®
INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

AEROSPACE STANDARD

SAE AS7102

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Submitted for recognition as an American National Standard

NADCAP
REQUIREMENTS FOR HEAT TREATING
ACCREDITATION PROGRAMS

1. SCOPE:

This Aerospace Standard (AS) establishes the minimum requirements for suppliers of heat treat services to be accredited by the National Aerospace and Defense Contractors Accreditation Program (NADCAP). These requirements may be supplemented by additional requirements as determined by NADCAP, but the audit checklist shall, at a minimum, assure that NADCAP Accredited Heat Treat Suppliers meet all of the requirements contained in this standard.

2. APPLICABLE DOCUMENTS:

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AS7001 National Aerospace and Defense Contractors Accreditation Program (NADCAP) - Program Description
AS7002 National Aerospace and Defense Contractors Accreditation Program (NADCAP) - Rules for Implementation
AS7003 National Aerospace and Defense Contractors Accreditation Program (NADCAP) - Program Operation
AMS2750 Pyrometry
AS7101 NADCAP - Requirements for Accreditation of Materials Test Laboratories

2.2 PRI Publications:

Available from the Performance Review Institute, 402 Commonwealth Drive, Warrendale, PA 15086-7511.

AC7102 NADCAP - Audit Criteria for Heat Treating
AC7101/3 NADCAP - Material Test Laboratories, Mechanical Testing

2.2 (Continued):

AC7101/4 NADCAP - Material Test Laboratories, Metallography and Microhardness
AC7101/5 NADCAP - Material Test Laboratories, Hardness
AC7101/7 NADCAP - Material Test Laboratories, Mechanical Test Specimens

3. GENERAL QUALITY SYSTEM:

3.1 Quality Policy:

3.1.1 There shall be a clear system in place regarding management's establishment of a comprehensive quality policy.

3.1.2 There shall be indications that the quality policy has been clearly communicated throughout the organization.

3.1.3 The quality policy shall be reviewed at least annually by the President or other top location manager and actions shall be made to assure compliance with the policy.

3.2 Organization:

3.2.1 A formal organizational chart shall exist that defines the responsibility authority and interrelation of all personnel.

3.2.2 The Quality Organization shall be well defined, established, and functioning without longstanding vacancies.

3.2.3 Audits of the quality system, processes and/or product shall be carried out by personnel independent of those having direct responsibility for the work being performed.

3.2.4 There shall be evidence that employees perform their jobs in relation to procedures.

3.3 Quality System:

3.3.1 A documented quality system, endorsed by top management, shall be established as a means of assuring that processes conform to specified requirements.

3.3.2 Documentation shall support that the policies embodied in the quality system are thoroughly implemented.

3.3.3 The quality system shall foster continuous improvement by reduction of the variation of applicable heat treat processes.

3.3.4 Procedures and other instruction documents shall be controlled under a written system of formal revision control.

3.4 Communications:

3.4.1 There shall be a system of two-way employee communications in place.

3.4.2 Records shall support that employee comments and suggestions are solicited, reviewed and acknowledged.

3.4.3 Company plans, goals, objectives and customer performance shall be made known to all employees.

3.5 Contract Review:

3.5.1 Written procedures shall exist describing purchase order/contract review and the coordination of these activities by all affected organizations.

3.5.2 Records shall support that contracts are appropriately reviewed in a timely fashion.

3.5.3 Quality and technical requirements shall be adequately defined and documented.

3.6 Internal Procedure Planning:

3.6.1 There shall be a formal, written system of procedure planning by metal system and/or equipment systems.

3.6.2 There shall be planning in use on the floor that conforms to the system.

3.6.3 This planning shall conform to customer requirements.

3.7 Purchasing - Sourcing:

3.7.1 There shall be procedures established and implemented to provide for the selection of suppliers on the basis of their ability to meet requirements.

3.7.2 A summary of in-plant and service quality performance data shall be the basis for the selection of sources and corrective action.

3.8 Purchasing - Incoming QA:

3.8.1 There shall be procedures established to afford the purchaser access to verify, at source or delivery, the quality of purchased products.

3.8.2 Documentation to support that the verifications are regularly performed and acted on shall be available.

3.8.3 Verification data shall be used in a program to prevent nonconforming purchases.

3.9 Product Identification and Traceability:

3.9.1 Procedures shall be established and maintained for identifying the product from applicable drawings, specifications or other documents, during all stages of processing and delivery.

3.9.2 Examination of in-process parts shall indicate compliance with the procedure.

3.9.3 Test and/or examination samples shall be clearly marked to maintain traceability to parent parts.

3.10 Stamp and Signature Control:

3.10.1 A written procedure for stamp control shall be established.

3.10.2 There shall be a record maintained showing stamps issued, date of issue and to whom issued.

3.10.3 Appropriate actions shall be included in the stamp/signature control system to deal with lost stamps, reassigned stamps, and removal of stamp authority.

3.11 Control of Nonconforming Parts:

3.11.1 Procedures shall be established to control identification, documentation, evaluation, segregation and disposition of nonconforming product including notification of the internal organizations and the customer concerned.

3.11.2 Documentation shall support that nonconforming material is disposed of per the procedure, and that visual inspection verifies proper segregation.

3.11.3 There shall be a procedure for timely recall of nonconforming material that is inadvertently shipped (i.e., nonconformance is discovered after shipment).

3.12 Corrective Action:

3.12.1 There shall be procedures established and maintained for investigating the cause of nonconforming parts and the corrective action needed to prevent recurrence.

3.12.2 Records shall clearly support that all nonconforming parts are handled by the corrective action system and corrective actions are implemented.

3.12.3 Analytical methods shall be used to focus corrective action efforts with the goal of preventing recurrence.

3.13 Delivery and Service:

3.13.1 There shall be a procedure established to provide for the protection of the quality of the parts after final inspection and during shipment.

3.13.2 There shall be evidence that indicates compliance with this procedure.

3.13.3 Shipping document lists shall comply with all provisions required by the P.O. or contract.

3.14 Customer Service and Satisfaction:

3.14.1 Procedures shall be established to monitor customers' satisfaction and provide customer data (e.g., a quality rating or frequency of defects) that are analyzed and communicated internally.

3.14.2 There shall be documents to support that the procedure is complied with on a timely basis.

3.14.3 There shall be a written procedure to assure customer involvement with out-of-tolerance or out-of-control conditions, inspection failures, rework, and customer engineering changes.

3.14.4 Records shall support that no unauthorized rework is performed without customer permission.

3.15 Statistical Methods - Process Integrity:

3.15.1 There shall be a system for identifying critical heat treat process variables and determining their capability (i.e., Cp, Cpk).

3.15.2 Records shall support that the variables are processes, not results, and that capability is statistically measured.

3.15.3 Analytical methods shall be used to determine critical process characteristics.

3.16 Statistical Methods - Process Control:

3.16.1 There shall be a documented system of statistical monitoring of critical heat treat processing variables.

3.16.2 There shall be documented reactions and corrections to out-of-control conditions that were statistically identified.

3.16.3 There shall be evidence of improved process variable performance over time.

3.17 Internal Quality Audits:

3.17.1 Procedures and documentation shall exist for the performance of internal audits that survey company compliance with all pertinent procedures.

3.17.2 Records shall support that internal audits are completed in a timely fashion and reviewed and acted upon by appropriate management.

3.17.3 The use of internal audits shall be an integral part of the management system and a factor in the planning process.

4. TEST & INSPECTION:

4.1 Hardness Testing:

4.1.1 The Test & Inspection requirements contained in SAE AS7101 and the audit criteria PRI AC7101/5 shall apply to Heat Treat Suppliers.

4.1.1.1 Written procedure(s) shall cover the following items:

a. Anvils have no indentations
b. Test blocks are available for values recorded
c. Log or record is up-to-date and complete
d. Test blocks do not have indentations in both sides
e. Test block indentations are not too close together
f. Daily test sample is three or more indentations
g. Test blocks have indentations greater than the number of daily readings
h. Penetrators are not chipped or otherwise damaged
i. Periodic calibration records are current and complete

4.1.1.2 Are the hardness testers part of a program of gage repeatability and reproducibility studies.

4.2 Metallography/Microhardness :

The Metallography/Microhardness requirements contained in SAE AS7101 and the audit criteria PRI AC7101/4 shall apply to Heat Treat Suppliers.

4.2.1 Surface Contamination Testing of Alloy Steel

4.2.1.1 There shall be a written procedure covering:

a. Partial decarburization for steel < 220 ksi
b. Partial decarburization for steel > 220 ksi
c. Test for < 220 ksi done monthly
d. Test for > 220 ksi done per load
e. IGO for < 220 ksi

4.2.1.2 Test records shall confirm no total decarburization, carburization or nitriding has occurred.

4.2.1.3 Test procedures shall be in accord with requirements.

4.3 Survey of Mechanical Testing Lab :

The Mechanical Testing Lab requirements contained in SAE AS7101 and the audit criteria PRI AC7101/3 shall apply to Heat Treat Suppliers.

4.4 Survey for Nonconventional and Engineering Tests :

The Nonconventional and Engineering Tests contained in SAE AS7101 and the audit criteria PRI AC7101/10 shall apply to Heat Treat Suppliers.

4.5 Preparation of Mechanical Test Specimens:

The preparation of Mechanical Test Specimens requirements contained in SAE AS7101 and the audit criteria PRI AC7101/7 shall apply to Heat Treat Suppliers.

4.6 Conductivity Testing:

4.6.1 Calibration:

4.6.1.1 There shall be a written procedure for the periodic calibration of conductivity testing devices.

4.6.1.2 Standards used for calibration shall be properly maintained and protected from damage.

4.6.1.3 The standard used for calibration shall be a primary standard with values assigned according to Test method B 193, or values shall be assigned by an agency traceable to NIST standards.

4.6.1.4 Records shall document the adequacy of the calibration system.

4.6.2 Applicability and Location of Test:

4.6.2.1 There shall be documentation specifying the location of the test on the part.

4.6.2.2 The specified location shall account for the degree of coupling between metal and coil, nearness to any edge or discontinuity, and the thickness of the tested area.

4.6.2.3 There shall be evidence that tests are performed in the correct location on the part.

4.6.3 Periodic Maintenance:

4.6.3.1 There shall be a written procedure for determining when maintenance is needed and when periodic maintenance is to be performed.

4.6.3.2 Procedures shall exist to ensure the qualification of outside firms performing maintenance and to ensure that all maintenance is performed to the required specifications.

4.6.3.3 Records shall indicate that maintenance is performed when required and in accordance with appropriate standards.

4.7 Test Coupons:

4.7.1 General:

4.7.1.1 If test coupons are used or required, there shall be a system in place to control their use.

4.7.1.2 Documentation shall support that the test coupons are used per the procedure.

4.7.1.3 Data from test programs shall be used in a statistical program of process improvement or by some other recognized method.

4.7.2 Titanium:

4.7.2.1 If AMS 2801 or MIL-H-81200 is required, there shall be a system in place to control test coupons and their use.

4.7.2.2 Documentation shall support that the test coupons are used per the procedure.

4.8 Dimensional Testing:

4.8.1 Calibration:

4.8.1.1 There shall be a written procedure for the periodic calibration of dimensional measurement devices.

4.8.1.2 Standards, gage blocks, or other devices used for calibration shall be properly maintained and protected from damage.

4.8.1.3 The standard used for calibration shall be a primary standard with values assigned by an agency traceable to NIST standards.

4.8.1.4 Records shall document the adequacy of the calibration system.

4.8.2 Applicability and Location of Test:

4.8.2.1 There shall be documentation to specify the appropriate measurement and the location of the measurement on the part.

4.8.2.2 There shall be evidence that tests are performed with the appropriate test and in the correct location on the part.

4.9 Sampling Plans:

4.9.1 Sample Size:

4.9.1.1 There shall be a written procedure to select the appropriate sample size for a given test or inspection.

4.9.1.2 Records shall support that the correct/appropriate sample was tested.

4.9.1.3 Sample sizes shall be statistically significant to support the conclusions drawn.

4.9.2 Sample Frequency:

4.9.2.1 There shall be a written sampling plan that specifies the frequency and method of sampling.

4.9.2.2 Records shall support that samples are taken in accordance with the specified sampling frequency.

4.9.2.3 The sampling frequency shall be sufficient to capture relevant process variations.

4.10 Procedures/Training:

4.10.1 A written set of procedures shall assure that operators are competent to perform an assigned operation.

4.10.2 The system shall assure that only trained operators perform assigned tasks.

4.10.3 Training procedures shall conform to recognized industry or other recognized standard, e.g., ARP1962.

4.11 Acceptance/Rejection Standards:

4.11.1 There shall be a written set of acceptance/rejection standards for tests in Sections 4.1 through 4.7.

4.11.2 Actual acceptances shall be based on the written criteria.

4.11.3 Acceptance criteria shall be sufficient to assure that no defective material is accepted without at least 95% confidence.

4.12 Test Reports:

4.12.1 Test results shall be recorded on or traceable to job work documents.

4.12.2 Both individual datum and test statistics (e.g., average, range or standard deviation) shall be reported. Where applicable, test statistics shall be correct.

4.12.3 Recorded test results shall be complete and adequate.

4.12.4 There shall be a written system to use the test data in a continuing program to improve product quality.

5. FURNACE CONTROL AND MAINTENANCE:

5.1 Furnace Document Control:

5.1.1 Operating Instructions:

5.1.1.1 There shall be a system of providing current operating manuals or instructions to furnace operators and maintenance personnel.

5.1.1.2 Manuals or instructions shall be accessible and usable at all times.

5.1.1.3 Manuals or instructions shall be clear, current, and available to all relevant personnel.

5.1.2 Heating Times:

5.1.2.1 There shall be written systems for determining heat-up time (i.e., start of soak), soak time, and cooling rate.

5.1.2.2 Process records shall support the functioning of this system.

5.1.2.3 The system shall adequately describe the actual heat profile of the load.

5.1.2.4 When metal temperature is required, shop records shall demonstrate conformance to specification.

5.1.3 Maintenance Schedules/Procedures:

5.1.3.1 Furnace maintenance schedules shall be prepared for each furnace.

5.1.3.2 Records shall support that maintenance has been performed per schedule.

5.1.3.3 Maintenance schedules shall be prepared with preventative maintenance as a goal based on prior maintenance records.

5.2 Furnace Condition:

5.2.1 External Furnace Condition -- For each furnace:

5.2.1.1 There shall be no evidence of leaking atmosphere around doors, fans, etc.

5.2.1.2 On compressed air activators, lubricator sets shall be operational.

5.2.1.3 All safety interlocks, flame curtains, burn offs, and other safety items shall be operational.

5.2.1.4 Circulation fans shall run smoothly and be in good operating condition.

5.2.1.5 There shall be proper coolant flow to circulation fans.

5.2.1.6 If gear drives are used, the drive trains/sprockets shall be in good condition.

5.2.1.7 The furnace and its surroundings shall be clean and well lighted.

5.2.1.8 All plumbing, conduit and other functional apparatus shall be clearly marked and color coded.

5.2.2 Internal Furnace Components -- For each furnace:

5.2.2.1 The refractory/insulation/heating elements shall be compatible with the parts/material being heat treated.

5.2.2.2 The refractory/insulation shall be in good operating condition.

5.2.2.3 There shall be no evidence of soot on the furnace lining.

5.2.2.4 The grade of internal alloy shall be adequate to the furnace application.

5.2.2.5 The internal alloy shall be in good condition.

5.2.2.6 If electrically heated, element insulators shall be in good condition.

5.2.2.7 If electrically heated, amp draw on heaters shall not exceed amp rating.

5.3 Atmosphere Control:

5.3.1 Metering:

5.3.1.1 Flowmeters shall be in good operating condition and appropriate to the gas they are metering.

5.3.1.2 Regular checks shall be made to assure the accuracy of flowmeters.

5.3.1.3 There shall be proper safety shut-off valves and nitrogen purges and they shall be in good operating condition.

5.3.2 Atmosphere Purging:

5.3.2.1 When atmosphere is changed, there shall be a written procedure to assure adequate purges of previous atmosphere.

5.3.2.2 The purge time for this atmosphere change shall be adequate to its application.

5.3.2.3 The procedure for an atmosphere change shall include a well defined system of ammonia cut-off and purge.

5.3.2.4 Production records shall support that the procedure is followed.

5.3.3 Salt:

5.3.3.1 If a salt bath is used, there shall be a system in place to test the salt per the applicable specification requirements.

5.3.3.2 Documentation shall support that the testing program is current.

5.3.3.3 The salt bath tests shall assure conformance to corrosion, decarburization, and intergranular attack requirements.

5.3.4 Dew Point - Titanium:

5.3.4.1 There shall be a written procedure to monitor the inlet dew point of an Argon or Helium atmosphere to the requirements.

5.3.4.2 Production records shall support that the procedure is followed.

5.3.5 Atmospheres - Aluminum:

5.3.5.1 There shall be a written procedure to assure that detrimental water and/or products of combustion do not enter the heat zone.

5.3.5.2 There shall be a procedure that includes a well defined system of protective compounds where needed.

5.3.5.3 Production records shall support that the procedure is followed.

5.4 Carbon Control:

5.4.1 Carbon System Maintenance and Calibration:

5.4.1.1 There shall be a system of maintenance and calibration of carbon controls and indicators.

5.4.1.2 Records shall support that the calibrations were performed as required by applicable specifications.

5.4.1.3 The calibration and accuracy of the carbon system shall be confirmed through analytical gauge studies or other recognized statistical measurement system evaluation method.

5.5 Quench Systems:

5.5.1 The quench mechanism shall be in good operating condition.

5.5.2 Quenchant Control:

5.5.2.1 The system of quench temperature control shall be in good operating condition.

5.5.2.2 Quench temperature measuring systems shall be calibrated and regularly maintained.

5.5.2.3 Records shall document that parts are quenched at proper temperatures.

5.5.2.4 A visual examination of the quench tank shall indicate good agitation where access to the quench tank is available.

5.5.3 Quench Properties:

5.5.3.1 There shall be a written system in place to assure proper quench integrity.

5.5.3.2 Records shall support that quenchent properties are within specified limits.

5.5.3.3 The actual quench parameters shall be recorded and traceable to the work order.

5.5.4 Press Quench Checklist:

5.5.4.1 The press quench shall be in close proximity to the furnace and temperature control during transfer shall be maintained.

5.5.4.2 Expander pressure, cylinder pressure, number, length and strength of hold down springs shall be documented for each job when applicable.

5.5.4.3 Handling procedures during transfer shall assure that the part is not locally cooled due to contact with tongs, etc., to reduce a localized area below the transformation temperature.

5.5.4.4 Dies and tooling shall be inspected between every set-up for wear, nicks, burrs, etc., and when required, repairs shall be made.

5.5.4.5 The customer shall be informed of repairs.

5.6 Fixtures, Racking and Batching:

5.6.1 Rack/Fixture Control:

5.6.1.1 There shall be a written system in place to assure that racks are matched to parts they are designed for.

5.6.1.2 Observation shall support that parts are placed in planned racks.

5.6.1.3 A certified heat treater, metallurgical engineer, or other qualified person shall design racks and match parts to them.

5.6.2 Rack Condition:

5.6.2.1 Racks shall be regularly examined for integrity and repaired or scrapped as necessary.

5.6.2.2 Visual examination shall confirm that racks are in good operating condition.

5.7 Pyrometry Testing:

5.7.1 Temperature Uniformity Surveys:

5.7.1.1 Uniformity surveys shall be performed at the frequency required by applicable specifications.

5.7.1.2 The thermocouple correction factors shall be used correctly.

5.7.1.3 Approach readings shall be taken at the frequency required by applicable specifications.

5.7.1.4 After furnace has stabilized, 30 min of readings (i.e., 7) shall be taken.

5.7.1.5 The recurrent temperature pattern shall be taken by cycling the highest and lowest reading thermocouple through a complete cycle.

5.7.1.6 There shall be written procedures to cover 5.7.1.1 through 5.7.1.5.

5.7.1.7 Temperature uniformity surveys shall conform to the specification requirements.

5.7.2 System Accuracy (Probe) Checks:

5.7.2.1 System accuracy (probe) checks shall be performed at the required frequency

5.7.2.2 The thermocouple correction factors shall be used correctly.

5.7.2.3 The temperature recorded during the probe check shall agree with the actual recorder chart temperature.

5.7.2.4 If the control thermocouple is outside the work zone, off-setting shall be used to compensate.

5.7.2.5 If probe checks exceed requirements, appropriate corrective action shall be taken and documented.

5.7.2.6 Written procedures shall cover 5.7.2.1 through 5.7.2.5.

5.7.2.7 The probe checks shall conform to applicable specification requirements.

5.7.3 Instrument Calibration:

5.7.3.1 For controllers for furnaces requiring ±5°F or ±10°F uniformity and for all aluminum furnaces:

a. Accuracy shall be within 0.3% of range.
b. Shall be capable of returning to set point within ±2°F after being driven 50°F above and 50°F below set point.
c. Shall be sensitive to an EMF equivalent change of 2°F, i.e., dead band max. of 2°F.

5.7.3.2 Controllers for furnaces requiring ±15°F uniformity shall meet 0.3% of range and the requirements for b and c above.

5.7.3.3 Controllers for furnaces requiring ±25°F uniformity shall meet 0.3% of range and the requirements for b and c above.

5.7.3.4 All controllers shall be zeroed out at low, medium, and high temperature (i.e., spanned) or offsetting of calibration shall be used at the extremes. If it can't be zeroed out (spanned) at high, medium, and low, what is done regarding the instrument shall be in accordance with applicable requirements and clearly documented.

5.7.3.5 For recorders:

a. Accuracy shall be within 0.3% of range.
b. Dead band max shall be ±2°F.
c. It shall return within ±2°F after being driven 50°F above and below.

5.7.3.6 Paragraphs 5.7.3.1 through 5.7.3.5 shall be covered by a written procedure.

5.7.3.7 All instrument calibration shall conform to the requirements.

5.7.4 Protection of Aluminum:

5.7.4.1 There shall be a system to prevent radiation sources from striking aluminum parts.

5.7.4.2 An inspection of treated parts shall reveal no evidence of direct thermal radiation.

5.8 Vacuum Equipment Qualification:

5.8.1 The heat treater shall have procedures for qualifying:

a. Vacuum system integrity (leak-up rate, etc.)
b. Traceable calibration of vacuum instruments, recorders, and sensors.
c. Does the heat treater follow these procedures.

5.8.2 These vacuum system qualification procedures shall be in accordance with customer requirements.

5.8.3 The heat treater shall have procedures for qualifying:

a. Quench gas purity.
b. Gas Quench system integrity (dew point, etc.)
c. Traceable calibration of dew point, or other gas contaminant measuring instruments.
d. Quench effectiveness of other quench media used with vacuum type systems.

5.9 Vacuum Procedures:

5.9.1 The heat treater's documented procedures require cleaning of parts and tooling with methods/materials that are compatible to the parts and tooling used in vacuum heat treating and there will be evidence that these procedures are followed.

5.9.2 Cleaning procedures shall be in accordance with customer requirements.

5.9.3 The heat treater's documented procedures shall account for furnace loading to preclude shielding and uneven heating/cooling encountered in vacuum heat treating. There shall be evidence that the heat treater follows these procedures.

5.9.4 Loading procedures shall be in accordance with customer requirements.

5.9.5 Documented procedures shall account for the required temperature, heating/cooling, and pressure parameters, as well as use of the proper measurement method for these parameters. There shall be evidence that the heat treater follows these procedures.

5.9.6 These procedures shall be in accordance with customer requirements.

6. PERSONNEL:

6.1 Qualification System:

6.1.1 There shall be a written procedure of continuing approval testing.

6.1.2 Inspection of personnel records shall confirm that tests are administered and reviewed with employees.

6.1.3 The results of testing shall be used in a continuing program of operator/supervisor improvement and development.

6.2 Training:

6.2.1 There shall be a written procedure for operator/manager training in heat treating sciences.

6.2.2 Records shall support that training is regularly scheduled and attended.

6.2.3 Only approved operators shall perform trained-operator necessary functions.

7. PROCESS PLANNING AND CONTROL:

7.1 Advance Process Planning:

7.1.1 New/Old Job Flows:

7.1.1.1 There shall be a procedure for reviewing orders for assessing the heat treater's ability to conform to requirements.

7.1.1.2 There shall be a written procedure that specifies the documentation requirements of jobs that enter the production system.

7.1.1.3 The procedure shall provide for separate flows and separate engineering responsibilities for new vs. continuing jobs.

7.1.1.4 Records shall support that proper job flows are being followed.

7.1.2 Advance Quality Planning:

7.1.2.1 There shall be a system of quality planning for each job in advance of actual processing.

7.1.2.2 The quality plan shall be evident on job travelers and conformance to it shall be demonstrated.

7.1.2.3 The quality plan shall address processing issues, not inspection data.

7.1.3 Job Documentation:

7.1.3.1 There shall be a written procedure of assigning job documentation/travelers to each job.

7.1.3.2 The procedure shall provide unambiguous traceability from the documentation to the job/parts.

7.1.3.3 The documentation shall include process status, inspection status, engineering change notices and all other relevant information.

7.1.4 Process Change System:

7.1.4.1 There shall be a documented system of altering processing or quality documents in a systematic fashion.

7.1.4.2 There shall be records that document engineering changes and their effects.

7.1.4.3 When fixed or customer agreed processes are in place, process changes shall be made only after experimental study of main and interactive effects. Customers shall be fully informed if directly involved.

7.2 Customer Specification Update System:

7.2.1 There shall be a documented system to assure that revisions to specifications in use are integrated into the production system.

7.2.2 Records shall support that new revisions to specifications were put in use promptly and older revisions are used only when specified.

7.2.3 Records shall support that parts are not processed under old specifications after new specifications are required by purchase order.

7.3 Process Control:

7.3.1 There shall be a written system to assure process conformance to process documentation.

7.3.2 The system shall include a clear method of recording actual process data for comparison to planned.

7.3.3 Audit of records shall assure conformance to process plans.

7.4 In-Process Inspections:

7.4.1 There shall be a documented system of process inspections to assure all equipment is functioning within established criteria.

7.4.2 This information recorded on the job traveller or other documentation traceable to the job in-process when the inspection was made.

7.4.3 In-process inspections shall be made in accordance with established statistical methods.

7.5 Verification of Automated Process:

7.5.1 There shall be a written procedure in effect where automated heat treating processes and/or record-keeping are used to assure the integrity of the process and records.

7.5.2 The procedure shall include a positive method of assuring electronic records cannot be altered.

7.5.3 Electronic data shall be backed-up and retained for a period at least as long as required for paper records.

8. MATERIAL HANDLING AND PROTECTION:

8.1 Receiving Procedure:

8.1.1 Count/Quality Integrity:

8.1.1.1 There shall be a written procedure for receiving, counting and inspecting inbound material.

8.1.1.2 There shall be adequate records to support conformance with this system.

8.1.1.3 Count and quality discrepancies shall be immediately brought to the customer's attention with written records.

8.1.2 Customer Documents:

8.1.2.1 There shall be a written procedure to assure that inbound customer documents attached to jobs remain traceable to those specific jobs throughout the processing cycle.

8.1.2.2 An audit of jobs shall assure conformance with this system.

8.2 Corrosion Mechanical Damage Protection:

8.2.1 There shall be a documented system in place to prescribe handling, packaging and corrosion protection of customer material.

8.2.2 An inspection of the company's facility shall confirm adherence to the system.

8.2.3 There shall be no evidence of rust, overloaded containers, uncovered storage areas, or stacks of dissimilar material and containers.

8.3 Lot Integrity:

8.3.1 There shall be a written procedure to assure lot and part integrity.

8.3.2 An inspection of the company's facility shall confirm adherence to the system.

8.3.3 The system shall logically preclude the possibility of unintentionally mixing or confusing parts.

8.4 Housekeeping:

8.4.1 There shall be a system to assure plant cleanliness and assignment of the responsibilities for housekeeping.

8.4.2 The company's facilities shall be clean, well lighted and properly marked.

8.5 Plant Space Control:

8.5.1 There shall be a written plan of functional areas in the plant specifying where in-process, defective and staged material are to be placed.

8.5.2 The plant floor shall be clearly marked to conform with the written plan.

8.5.3 The plan shall provide for complete and unambiguous separation of work-in-process, finished, and defective material.

8.6 Titanium Cleaning and Protection:

8.6.1 There shall be a system for cleaning titanium surfaces that precludes using halogenated substances.

8.6.2 There shall be evidence that the system is being complied with.

8.6.3 The system shall provide for handling of clean parts with clean, white gloves.

8.7 Copper, Nickel, Bronze Plating:

8.7.1 There shall be a documented system for controlling the following:

a. Chemical composition
b. Current density
c. Temperature
d. Agitation

8.7.2 There shall be evidence of compliance with the system.

8.7.3 Periodic tests shall indicate that applicable specifications are being met.

9. GENERAL FURNACE CHECKLIST:

9.1 There shall be a written procedure for control of heating media to preclude detrimental reactions with part surfaces. This procedure shall meet contractual requirements, and there shall be evidence that the procedure has been implemented.

9.2 There shall be a written procedure for testing consistency of circulation of furnaces heated by convection. This procedure shall meet contractual requirements, and there shall be evidence that the procedure has been implemented.

9.3 There shall be a written procedure for servicing of instrument(s). This procedure shall meet contractual requirements, and there shall be evidence that the procedure has been implemented.

9.4 There shall be a written procedure for use of offset temperatures. This procedure shall meet contractual requirements, and there shall be evidence that the procedure has been implemented.

9.5 There shall be a written procedure for system accuracy tests. This procedure shall meet contractual requirements, and there shall be evidence that the procedure has been implemented.

9.6 The procedure shall control the proximity of test and working sensors. This procedure shall meet contractual requirements, and there shall be evidence that the procedure has been implemented.

9.7 There shall be a written procedure for racking and spacing which takes the heating and cooling patterns into account. This procedure shall meet contractual requirements, and there shall be evidence that the procedure has been implemented.

9.8 There shall be a written procedure for quench transfer, agitation, and temperature. This procedure shall meet contractual requirements, and there shall be evidence that the procedure has been implemented.

9.9 There shall be a written procedure for quench severity control. This procedure shall meet contractual requirements, and there shall be evidence that the procedure has been implemented.

9.10 There shall be a written procedure for temperature uniformity tests. This procedure shall meet contractual requirements, and there shall be evidence that the procedure has been implemented.

9.11 This procedure shall specify test frequency. This procedure shall meet contractual requirements, and there shall be evidence that the procedure has been implemented.

9.12 This procedure shall specify test temperature(s) and range(s). This procedure shall meet contractual requirements, and there shall be evidence that the procedure has been implemented.

9.13 This procedure shall specify how beginning and end of test is determined. This procedure shall meet contractual requirements, and there shall be evidence that the procedure has been implemented.

10. AUDIT OF A HEAT TREATING JOB (COMPLETED OR IN-PROCESS)

Heat Treat supplier shall demonstrate compliance to all relevant and applicable specifications in two complete audits of a completed or an in-process job. Conformance to all requirements of this standard shall be demonstrated throughout the entire heat treat process.

The audits shall include information as follows:

10.1 Job identity:

a. Purchase order number: _____

b. Customer (and prime, if known): _____

c. Part number: _____

d. Part description: _____

e. Quantity: _____

f. Date of job and job number: _____

g. Material/alloy: _____

h. Material specification (if available): _____

i. Heat treat specification: _____

j. Latest specification was used (if known) Yes____No____Unknown____

k. Heat treat and other process and test requirements specified:

_____

_____

l. Part received by heat treater

- Is finish machined? Yes____No____
- Is rough machined? Yes____No____
- Has both rough and finished surfaces? Yes____No____
- Has mill surface? Yes____No____
- Other or unknown surface? Yes____No____

Describe _____

m. As-received condition: _____

n. Part size: _____

o. Part thickness: _____

10.4 Prior condition:

a. Is a prior thermal or thermo-mechanical condition required? Yes_____No___

- Required by drawing? Yes_____No___
- Required by purchase order? Yes_____No___
- Required by specification? Yes_____No___

b. What prior condition is required: _____

c. Are parts in this prior condition before heat treating? Yes____No____NA___

10.5 Shop Paperwork:

10.5.1 Basis for determining shop paper instructions:

a. Job previously run? Yes_____No_____Unknown____

b. How is this verified or determined?

_____

c. Has customer controlled instructions? Yes_____No_____

d. Does the engineering drawing revision in use match purchase order drawing revision? Yes_____No_____NA_____

List drawing revision: _____

e. Describe how job instructions are obtained, from whom, and how customer information is translated to the shop paper:

_____

_____

_____

f. Does the process procedure require customer approval? Yes_____No_____

g. Has it been obtained? Yes_____No_____NA_____

h. Is the process frozen by the customer? Yes_____No_____

i. How is the shop paper controlled so as not to be revised without proper internal approval and customer approval, when required?

_____

_____

_____

10.6 Precleaning:

10.6.1 Cleaning before heat treat:

a. Is cleaning specified? Yes_____No___

b. Cleaning on purchase order? Yes_____No___

Method:_____

c. Cleaning on drawing? Yes_____No_____NA_____

Method:_____

d. Cleaning on specification? Yes_____No_____

Method:_____

e. Parts are cleaned and protected as received and therefore require no precleaning? Yes_____No_____

f. Cleaning specified in shop paper: _____

_____

g. Actual cleaning performed: _____

_____

_____

h. Is cleanliness verified or inspected? Yes_____No_____

i. Method of inspection or manufacturing documentation of cleanliness:

_____

j. What tests are required and how is this cleaning process controlled?

_____

_____

_____

k. List test results:

_____

_____

l. Did all precleaning meet the requirements? Yes_____No_____

Describe:_____

_____

_____

10.7 Preheating/Pre-Stress Relieving:

10.7.1 a. Is preheating specified? Yes_____No_____

b. Specified on drawing? Yes_____No_____

c. Specified on purchase order? Yes_____No_____

d. Specified in specification? Yes_____No_____

e. Preheating specified:

Temp.:_____

Time:_____

Heating:_____

f. Preheating on shop paper:

Temp.:_____

Time:_____

Heating:_____

g. Actual preheating from recorder charts:

Temp.:_____

Time:_____

Heating:_____

h. Record furnace number used: _____

i. Did preheating conform to requirements? Yes_____No_____

10.7.2 a. Is pre-stress relieving specified? Yes_____No_____

b. Specified on drawing? Yes_____No_____

c. Specified on purchase order? Yes_____No_____

d. Specified in specification? Yes_____No_____

e. Pre-stress relieving specified:

Temp.: _____

Time:_____

Heating:_____

Cooling:_____

f. Pre-stress relieving on shop paper: Temp.:_____

Time:_____

Heating:_____

Cooling:_____

g. Actual preheating from recorder charts: Temp.:_____

Time:_____

Heating:_____

Cooling:_____

h. Record furnace number used:_____

i. Did pre-stress relieving conform to requirements? Yes_____No_____

10.8 Atmosphere/Surface Protection

10.8.1 Atmosphere(s) required by specification, drawing, or purchase orders:

_____

a. Atmosphere specified on shop paper:_____

b. Atmosphere used:_____

c. Does the atmosphere previously used create the need for purging prior to the job. Yes_____No_____NA____

List previous atmosphere:_____

d. How is purging done, controlled, and tested for effectiveness?

_____

e. What are the shop practices for atmosphere control, and how is the atmosphere controlled?

_____

_____

f. What are the documented atmosphere results?

_____

Does this control meet the requirements? Yes_____No_____

10.8.2 Is protective coating required? Yes_____No_____

a. Describe protective coating requirement:

_____

_____

b. Is protective coating on shop paper? Yes_____No_____

Describe:

_____

_____

c. How is protective coating controlled?

_____

d. How is the quality of the protective coating verified/inspected and documented?

_____

e. Did protective coating meet requirements? Yes_____No_____

10.9 Racking:

10.9.1 a. Customer racking or batching requirements specified:

_____

b. Is racking or batching specified on shop paper? Yes_____No_____
Describe:

_____

c. Did the operator determine racking or batching? Yes_____No_____

d. How does operator determine racking or batching?

_____

_____

e. If not operator, who determines and how?

_____

_____

f. Describe racking or batching used:

_____

_____

g. Did racking ensure that air is not entrapped detrimentally on quench? Yes_____No_____NA_____

h. Did racking ensure that salt (if applicable) is not entrapped? Yes_____No_____NA_____

_____

_____

i. How was racking verified and documented?

_____

_____

j. Did racking conform to requirements? Yes_____No____

10.10 Thermal Treatment:

10.10.1 Heat treating operations:

a. Requirement specified on drawings or purchase order:_____

_____

b. Temperature:

Heating temperature specified:_____

c. Heating, i.e., rate, step up, ramp, etc.:

_____

d. Set temperature on shop paper: _____ to _____

e. Actual temperature on recorder: _____ to _____

including multipoints: _____ to _____

or load thermocouple: _____ to _____

f. Was furnace stabilized or below the set temperature before loading parts? Yes____ No____

Describe_____

_____

_____

g. Verify no overshoot of set temperature on charts: Yes____ No____

If yes, what caused it?

_____

_____

_____

h. Is offsetting permitted? Yes____ No____

i. Is offsetting done? Yes____ No____

j. What offset is made?

_____

k. Describe method of making, controlling, and assuring correctness of offset:

_____

_____

l. What is the amount of cycling on the recorder charts?

_____

m. Is it equal to or less than the cycling during the latest temperature uniformity survey? Yes____ No____

n. If not, does this cycle preclude excursions outside the temperature uniformity limits.? Yes_____No_____

Describe: _____

_____

o. Temperature uniformity requirement: _____

_____

Is uniformity specified on shop paper? Yes_____No_____

Is furnace number specified on shop paper? Yes_____No_____

List specified furnace number(s):

_____

p. How does operator determine correct furnace(s) to use?

_____

_____

q. Record furnace number identified on the shop paper being used: _____

_____

r. Does recorder chart furnace traceability match the furnace number on shop paper? Yes_____No_____

s. Does this furnace meet the uniformity requirements? Yes_____No_____

t. Are furnace system accuracy checks and calibrations up to date and meet (sac)? Yes_____No_____

Specification requirements? (Cal) Yes_____No_____

List date(s) of calibration: _____

_____

List date of latest system accuracy check: _____

Time: _____

u. What is the part thickness?

_____

v. Soak time required by specification: _____

w. Soak time on shop paper:_____

How does operator determine soak time?

_____

_____

_____

y. How is start of soak specified?

_____

_____

_____

z. What is the basis for determining the start of soak?

_____

_____

_____

_____

_____

_____

aa. If heat time is specified or used to determine start of soak, describe here:

_____

_____

_____

ab. Record:

Date and time loaded in furnace: _____

Time instrument recovers to set point:_____

Time of start of soak: _____

Time, completion of soak: _____

ac. Time from loading to commencing soak: _____

ad: Soak time on chart (s): _____

ae: Cooling requirements specified: (excl. Quench)_____

af: Cooling on shop paper: _____

ag: Cooling method used:_____

ah: How is this cooling controlled:_____

_____

_____

_____

ai: Did cooling meet requirements? Yes____No____

aj: Does all thermal treatment meet specified requirements? Yes____No____

10.11 QUENCH:

10.11.1 Quenching:

a. Quenchant specified on shop paper: _____

b. Does this quenchant conform to requirements? Yes____No____

c. Quenchant used: _____

d. Size of bath: _____

e. Is size of bath adequate? Yes____No____

f. Agitation or circulation method: _____

_____

g. Temperature and tolerance required: _____

h. Temperature and tolerance on shop paper: _____

i. Temperature of bath at start of quench: _____

j. Temperature of bath at end of quench: _____

k. Date of calibration of temp. Gage: _____

l. Quench bath cleanliness: _____

m. Quench mechanics (hand, automatic, pressure quench from vacuum, etc.): _____

n. Amount of backfill pressure (from vacuum): _____

o. Quench delay required in specification: _____

p. Quench delay on shop paper: _____

q. Quench delay actual: _____

r. How was quench delay determined: _____

_____

s. Time in quench bath before removal: _____

t. Delay requirements between quench and next operation: _____

u. Delay requirements on shop paper: _____

v. Actual delay between end of quench and start of next operation: _____

_____

List next operation:

_____

w. Cleaning method used to remove quenchant:_____
Required:_____
Shop paper: _____
Actual: _____

x. Did all quenching meet requirements? Yes_____No_____

10.12 TEMPER:

10.12.1 Tempering (steel only):

a. Requirement on drawing or purchase order: _____
_____

b. Tempering temperature specified in specification:_____

c. Was double or multiple temper required? _____

d. Was it done? Yes_____No____
Describe:
_____
_____
_____

e. Is the tempering temperature specified contractually? Yes_____No____

f. If not, what is basis for determining tempering temperature?
_____
Use specified temperature? Yes_____No____

Specified in shop order? Yes_____No____
Record temperature: _____
Based on as-quenched hardness? Yes_____No____

g. As-quenched hardness:_____

h. Tempering temperature operator selected:_____

i. Actual tempering temperature on chart: _____to_____
Including multipoints: _____to_____
Load thermocouples: _____to_____

j. Verify no overshoot on charts: _____

k. Operators hardness check: _____

l. Was additional temper required because hardness too high? Yes_____No____
Record hardness: _____

m. How is the additional tempering documented as shop paper?

_____

_____

n. How is additional temper temperature selected?

_____

_____

o. Actual additional tempering temperature

on chart: _____ to _____

Including multipoint: _____ to _____

or Load thermocouple: _____ to _____

p. In-process hardness check results: _____

q. Additional tempering (describe as per above) and record results of all tempers: _____

r. Time at tempering specified: _____

s. Time at tempering on shop paper: _____

t. Time of tempering on charts: _____

u. Basis for operators starting tempering time:

_____

v. Times for each retemper:

_____

w. Cooling from tempering specified: _____

x. Cooling from tempering on shop paper: _____

y. Cooling from tempering used: _____

z. Final operator hardness: _____

aa. Final inspector hardness: _____

ab. Did all tempering meet requirements? Yes_____No_____

10.13 Load Thermocouples:

10.13.1 Load thermocouple requirements:

a. Are load thermocouple requirements specified? Yes_____No_____

b. What requirements are specified:

_____

c. How many are used? _____

d. What kind/type: _____

e. Where located or attached:_____

_____

_____

f. Did load thermocoupling conform to requirements? Yes_____No____

10.14 Special Treatments:

10.14.1 a. Are any cold temperature treatments required? Yes_____No____

b. Treatment specified: _____

_____

_____

c. Treatment on shop paper:_____

_____

_____

d. Treatment performed and documented: _____

_____

_____

e. Temperature on chart, if required: _____

f. Time on chart, if required: _____

g. Calibration date of recorder: _____

h. Does cold treatment conform. Yes_____No_____

10.14.2 a. Reheat treatment performed: _____

_____

_____

_____

b. Is it permitted by specification?
(Use new audit form for each reheat treatment.) Yes_____No____

c. What is the approval system for reheat treatment?

_____

1. Who approves and how?

_____

_____

2. Does customer have to approve? Yes_____No_____
If yes, was customer approval obtained? Yes_____No_____

d. Does the reheat treatment maintain the starting and ending condition of the parts?

_____

_____

_____

_____

10.15 Strighten/Stress Relieve:

10.15.1 a. Was straightening/stress relieving done? Yes_____No_____

b. Straightening and stress relief methods permitted by specification:

_____

_____

c. Method on shop paper (press, hammer, furnace, fixture, etc.):

_____

_____

d. If hot or warm, specified temperature: _____

Temperature on shop paper: _____

Temperature used: _____

Time on shop paper, if applicable: _____

Time used, if applicable: _____

e. If warm or cold, is stress relief required. Yes_____No_____

Stress relief temperature specified in specification: _____

Stress relief time specified in specification: _____

Stress relief temperature on shop paper: _____

Stress relief time on shop paper: _____

f. Temperature on charts: _____ to _____

g. Time on chart: _____ to _____

h. Inspection required by specification: _____

i. Inspection specified on shop paper: _____

j. Inspection performed:

_____

k. (Restraightening use another form per the above)

l. NDT inspection required after straighten:

_____

_____

m. NDT on shop paper:

_____

n. NDT results:_____

_____

o. NDT is performed by an approved source? Yes_____No____

List approved source: _____

p. Did straightening, stress relieving, and inspection conform to specification? Yes_____No_____

10.16 Post Cleaning:

10.16.1 Post heat treat cleaning (including sand and metal blast):

a. Is cleaning specified? Yes_____No____

b. Cleaning method on drawing or purchase order:

_____

_____

c. Cleaning methods in specification:

_____

d. Cleaning on shop paper:

_____

e. Actual cleaning performed: _____

_____

_____

f. Is cleanliness verified or inspected? Yes_____No_____

g. Methods of inspection or manufacturing documentation:

_____

_____

h. What tests are required and how is this cleaning process controlled?

_____

_____

_____

_____

i. List test results:_____

_____

_____

j. Do all post heat treat cleaning operations and controls meet requirements? Yes_____No_____