DCMA NSEO MANUFACTURING PROCESS REVIEW (MPR) CHECKLIST #39

FORGING OPERATIONS

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| **SUPPLIER & CAGE:**  |  |
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| **LOCATION:** |  |
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| **PROCESS REVIEWED:** |  |

**Program Type:**

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|  | Level I/SUSBAFE (LI/SS) |  | Navy Propulsion Program (NPP) |  | Deep Submergence Systems/Scope of Certification Program (DSS-SOC) |
|  | Nuclear Plant Material (NPM) |  | Naval Nuclear Propulsion Program (NNPP) |  | Aircraft Launch & Recovery Equipment (ALRE) |
|  | Fly By Wire Ships Control Systems (FBWSCS) |  | Ships Critical Safety Items (SCSIs) |  | Other: |

**Contractual Requirement(s) for this Process:**

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**Supplier Procedure Number(s), Title(s) & Revision Level(s)/Date(s):**

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| **Process Reviewed By:**  |  |
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| **Date(s) of Review:** |  |

**Process Concerns and Guidance:**

* The molten metal for the starting material for forgings can be cast into ingots or continuous cast into strands. The non-homogeneous dendritic grains in the cast material normally have poor mechanical properties and may also contain voids or porosity. The cast ingot must be hot worked enough to break up the grain structure, close voids and, if annealed, effect complete re-crystallization.
* Inadequate procedures for chemical check analysis prior to pouring a melt can result in unacceptable material being processed.
* Holding the material at too high a temperature or too long at proper temperature will cause grain growth. This can adversely affect mechanical properties and limit ability of the ultrasonic waves to penetrate the forging. Forgings that did not receive enough hot working between heating cycles or were heated too high or for too long had large grains and could not be ultrasonically tested.
* Cooling rate and test specimen orientation with respect to the principal direction of metal flow can affect the mechanical test results. The intent is to have test specimen properties representative of the properties achieved during the production forging process.
* Improper thermal-mechanical processing can adversely affect corrosion resistance properties which are necessary for satisfactory service. Corrosion resistance properties are rarely checked by specified lot acceptance tests.
* For commercial specifications, some forging vendors have different opinions about what is considered a representative test specimen. This has resulted in retesting or scrapping of parts when the test specimens were not considered representative by the customer.
* Insufficient hot working has resulted in forgings that could not pass Charpy V-notch impact tests. Improper forging or other metal forming techniques may cause voids and excessive pitting.
* Mechanical tensile tests have been performed properly, but calculations performed incorrectly, resulting in “acceptable” test values reported for unacceptable material.
* Samples taken from areas of forgings that received more hot work or were cooled more rapidly than the remainder of the forging they represented had mechanical properties that satisfied specification minimum requirements. However, samples taken from other areas of the forging did not meet the specified requirements.
* Forgings that had the direction of metal flow incorrectly oriented with respect to the way the forging was stressed have failed due to poor mechanical properties or leaks.
* Test material has been taken from incorrect locations or separate test coupons that did not represent the final forging in the amount of work, cross section, or heat treatment. This has occurred primarily with new vendors or with commercial specifications that do not require the vendor to provide a forging drawing.
* Vendors have used marking materials and forging lubricants that did not meet contract requirements for detrimental materials.
* There have been deviations from customer approved product qualification or 1st Article test reports. Weld repair of forgings was performed without the welding procedure being approved.
* There have been failures to obtain forging sketch and test specimen location approvals when required by contract.
* Failure to maintain material control can result in the use of incorrect raw materials and additives which can affect the mechanical properties of the material produced. Improper marking of rejected material has resulted in comingling with acceptable product.
* Non-Destructive Testing has not been performed according to procedure or has been performed using improper calibration techniques.
* Inadequate control of alloys materials, and additives has resulted in scrapped heats.

**A**. **MANPOWER:**

1. Are the personnel performing the manufacturing, testing and quality assurance functions of the appropriate skill/experience level and/or properly trained/certified to produce conforming product? Are the employees of the forging facility trained and familiar with portions of the system applicable to their position – receiving inspection, forging process, heat treatment, laboratory testing, etc. – including governing work instructions and procedures? (NAV30-24(5)/30(4)/33(1b)/33(2c)/33(4))

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1. Is there a documented training plan, and are these recorded as part of employees’ files? Identify any applicable procedural training and procedure number. (NAV30-36(2d)/39(2)(2a))

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1. What type of training/certification is required for the work performed at this facility? Are training records available (review sample) and are they accurate and complete? Are any personnel certifications expired and are the personnel still working in the process?

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1. Is there a system in place for remedial training when errors occur? Is the system documented, and are records of remedial training available?

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1. Are the credentials of the training/certification official in accordance with specification requirements? What are the requirements?

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1. Is inspection data reviewed and accepted by qualified personnel? Which personnel perform the receiving inspection, including OQE verification, of ingots/billets/bars, and to what procedure? Is the personnel identification recorded? (name, badge number, clock, shift, etc.) (NAV30-12(1a)/12(4a))

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1. Does the forge use documented, qualified procedures for performing welding repair on their forgings? Are the welders trained and qualified to the welding procedures they are asked to perform to? Does the forge maintain records showing the training and qualification of the welders?

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1. Does the forge facility have personnel assigned to observe or provide a Quality Control over check of the forging operation, heat control during forging, and heat treatment control processes, including associated documentation? If so, describe the function and authority of each. (NAV30-21(1a)/24(8)/31(1))

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1. Which personnel at the facility are responsible for incorporating customer contract requirements into shop work instructions? Which are responsible for determining the amount of ingot reduction during the forging process? Which are responsible for preparing and approving forging instructions? Which personnel prepare and/or sign final inspection/review documents and test reports attesting to product conformance (when required)? What procedures apply? (NAV30-9(1)/9(1a)/15(1)/16(2)/38(1b & c)

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1. Does the forge use documented, qualified personnel and procedures for performing non-destructive testing (NDT) and inspection of their forgings? Are the NDT personnel trained and qualified to the NDT performance and acceptance procedures/standards they are asked to perform to? Does the forge maintain records showing the training and qualification of the NDT personnel?

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**B. MATERIALS**:

1. Are procedures/work instructions adequate for control of materials? Identify processes being observed. What is being processed? (list) For Level I material, is the product controlled and traceable throughout the process?

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1. During receipt inspection of ingots/billets/bars to be used in the forging process, are inspections for physical markings, heat identification, visual and dimensional inspection performed? Does the forge verify the chemistry of the material (alloy verification test, independent testing, MTR review, etc.) to ensure compliance of the material with specification requirements? Is the verification documented? (Review OQE of prior material receipts.) What actions are taken when defects are found? (NAV30-12(2 & 2a)/12(3)/12(4b)

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1. Are certifications for raw materials used in the forging process, which have been reviewed for acceptance, maintained on file for review?

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1. Do the raw materials comply with contract/specification and/or supplier-imposed technical requirements? What were the materials reviewed?

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1. Is a particular melt type (EAF, VAR, ESR, VIM, etc.) and grade of material used to make forgings? How is type and grade determined? (NAV30-10/10(1))

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1. Is the original mill traceability identification maintained during the forging operation on the traveler or on the work piece? Is the forging unique identification physically applied to provide traceability to the modified mechanical properties? How is the physical identification marking applied and who verifies proper marking? (NAV30-19(1-3))

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1. When a surface treatment of the material is required, is the physical forging identification marking verified after surface treatment? If so, who verifies proper marking? (NAV30-20(7a))

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1. After heat treatment, are the forgings and test specimen uniquely re-identified to provide necessary traceability to the final heat treated condition for mechanical properties verification? Can each forging be traced back to a particular heat treat furnace load? Is the unique heat treat physical identification marking applied? Is the unique identification marking verified? If yes, who verifies? If the heat treated forgings are cleaned, is the physical identification marking verified after surface cleaning/conditioning? Who verifies proper marking? (NAV30-32(1-3)/35(5))

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1. Are raw materials traceable/identified, as required, and within shelf life, if applicable? (There are shelf lives for various materials. Check the manufacturer’s certification or appropriate data for this information.)

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1. Is the ingot/billet/bar (including “drops” and “cutoffs”) identification and traceability maintained during storage? If an ingot is to be cropped top and/or bottom, is a sufficient amount of metal removed? How is this verified? (NAV30-13/14/14(1))

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1. Are MILSPEC welding consumables **used** when required by the welding procedure, contract or governing specification? Are the welding consumables used to perform weld repairs **certified** to the applicable MILSPEC, AWS, or other commercial specification?

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**C. MACHINERY**:

1. Is **manufacturing equipment** adequate to produce/assess conforming supplies in compliance with contractual specifications and drawing(s)? *What Items were sampled and were they part of the supplier’s calibration program and within the calibration/check cycle?*

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1. Is **inspection and testing equipment** of the required adequacy, accuracy, precision, and range to assure supplies produced comply with specifications and drawings? *What Items were sampled and were they part of the supplier’s calibration program and within the calibration/check cycle?*

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1. Is Government owned equipment adequately protected/maintained in accordance with a documented process?

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1. Is the forging press or hammer size controlled by forging work instructions and procedures? (NAV30-16(5))

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1. Is the heating equipment (forge furnaces) satisfactory for the forging operation? How many furnaces are there? What size are the furnaces? What type of fuel (natural gas, propane, butane, etc.) and atmosphere (vacuum, inert gas, etc.) do the furnaces utilize? What are the operating temperature ranges of the furnaces? (NAV30-23(1)/23(1a-d))

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1. Is the condition of the forging furnaces, including bottoms, burners and seals, satisfactory for the operation being performed? (NAV30-23(2 & 2a))

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1. Does the instrumentation and controls for the forging furnaces include thermocouples? If so, how many and what is there location? Are controllers and recording instruments used? Is a calibration program in place for these devices, with NIST traceable standards? Are instrumentation and gauging within the calibration period? Are calibration procedures and records available? (NAV30-26(1-5))

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1. What is the allowed temperature deviation (+/- \_\_\_\_\_\_\_ degrees) from the set point of the forging furnaces? (NAV30-27(1))

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1. Does the instrumentation and controls for the heat treat furnaces include thermocouples? If so, how many and what is there location? Are controllers and recording instruments used? Is a calibration program in place for these devices, with NIST traceable standards? Are recording and sensing instruments within the calibration period? (NAV30-29(1-4))

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1. Is a temperature uniformity survey performed on the heat treat furnaces? What is the allowed temperature deviation (+/- \_\_\_\_\_\_\_ degrees) from the set point of the heat treat furnaces? Are deviations from set point addressed/evaluated? What is the procedure for performing surveys, if applicable? Is a survey frequency specified? If applicable, who reviews and approves the survey? (NAV30-29(5-10a))

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1. For mechanical testing and disposition of test specimens which is performed in-house, is the mechanical test equipment calibrated? (NAV30-33(1c))

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1. List the type, brand, and model of equipment used for mechanical properties analysis. Is the equipment used calibrated in accordance with the applicable specification (ANSI Z-540.1) or manufacturer’s recommendations? Are the standards used to calibrate the test equipment traceable to a NIST standard or other recognized organization, and are they representative of the full range of alloys produced by the facility? Does a procedure define the rounding and use of significant digits when reporting the results the mechanical properties analysis?

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**D**. **METHODS**:

1. Does the forge have a documented quality system? What specification requirements (MIL-I, ISO, etc.) does the quality system meet? What specification requirements (MIL-STD, ISO, ANZI, etc.) does the calibration system meet? (NAV30-7)

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1. Do any of the procedures in use at the facility or in use by one of the facility’s subcontractors require review/approval by the government? Have these procedures been approved by the Navy/customer? If applicable, list the Reference Approval Number.

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1. Does the forge conduct internal assessments or audits when required by contract or internal quality system requirements? If so, does the forge maintain records of internal reviews such as schedule, results, and corrective actions? Has the forge and operation been audited by a third party for compliance with the quality system requirements and process controls? If so, what date was the audit performed and by whom? (NAV30-8)

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1. Does the forge have a documented process/procedure for evaluation, review and selection of suppliers for their raw material? Are specification requirements and effective revision communicated and controlled in the purchase order to the supplier/melt source for the forging ingots/billets/bars? Are material reduction and reduction ratios addressed in material purchase orders to the supplier/melt source for the forging ingots/billets/bars? Are all applicable customer requirements (e.g., DFAR requirements) passed down in purchase orders to suppliers/melt sources for the forging ingots/billets/bars? (NAV30-11(1-2)/NAV30-11(4))

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1. If a sub-tier melter is used as the source for the forging ingots/billets/bars, is performance by that sub-tier evaluated (receiving inspection results, on-site audit, mail-in survey, positive material inspection, alloy identity verification, source inspection, etc.)? Does the forge have a documented process/procedure for evaluation, review and selection of the sub-tier supplier? Are all applicable customer requirements (e.g., DFAR requirements) passed down in purchase orders to sub-tier suppliers/melt sources for the forging ingots/billets/bars? (NAV30-11(3-4)

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1. Are work instructions, test procedures, travelers, etc. being used adequate, clear, and up to date (latest revision)? Are customer contract requirements flowed down into shop work instructions after order entry? What documents and procedures (identifying number & revision) were reviewed? (NAV30-9(1a))

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1. Is there a documented procedure/process to determine the acceptability of raw materials (ingots, billets, bars, etc.)? If so, does it include reviewing material certifications to confirm material meets specification requirements and reviewing the traceability of certified material to the paperwork? Are inspections for physical markings, heat identification, visual and dimensional inspection of ingots/billets/bars performed? Is the chemistry of the ingots/billets/bars starting material verified (alloy verification test, independent testing, MTR review, etc.)? Is this verification to ensure compliance with the specification requirements documented? (NAV30-12(2-4)

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1. Does the forge have a documented procedure for controlling, storing, and issuing ingots/billets/bars to be utilized in the production of forged products?

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1. Is there a procedure for determining the amount of ingot reduction to be performed during the forging operation? What factors are considered in making these decisions? Is a calculation performed and recorded? Are the starting material condition, size, and reduction taken into consideration in making the determination? What procedure is used? (NAV30-15(2-5a))

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1. Does the forge have procedures/ instructions for the forging process? What form are the instructions and procedures in (i.e., paper traveler, on-line (computer-based), etc.)? Do the procedures implement controls for the issuing of starting material for production, such as heat, size, etc.? Is weight and starting material size controlled? Is the forging press or hammer size controlled by the procedure? (NAV30-16(1 & 3-6))

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1. Are applicable procedures and instructions located/available at the forge work stations? Do the procedures/instructions reference processing steps and control identification traceability? (Review a sampling of in-process or completed work instructions. Does the information appear sufficient and correct? Check for operator signatures and dates.) Are corrections or revisions to work instructions controlled by procedure and correctly documented? (Line out, initialed and dated by an authorized person, etc.) List the applicable instructions/procedures reviewed. (NAV30-17(1-5a))

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1. During the forging (reduction) process, what are the actual hammer or press steps (approximate number of blows or strokes) in the process? Is the percent reduction controlled for each step? When a minimum reduction is required by the customer, is the minimum reduction that is required measured and ensured? How? Is it necessary to control the primary working direction (grain flow) of the final product? If yes, how? Is there heat conditioning (re-heating) between forging cycles? If Yes, how is temperature controlled? Do the operating instructions and procedures address these issues? (NAV30-18(1-6))

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1. Does the forge have instructions/procedures for surface preparation/cleaning, such as de-scaling, when the forging requires heat treatment or further processing? Do the cleaning methods include shot blasting? If so, does the procedure address the type of shot medium to be used? If steel shot is used, does the procedure state how iron contamination of nonferrous forgings is to be prevented? What procedure governs surface preparation? (NAV30-20(1-3a))

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1. Does the procedure for surface preparation allow for the recycling of shot blast, and is the same shot blast used on all alloys? If/When shot blast is not used for surface preparation, how are forgings cleaned after removal from the die or hammer? What other methods for cleaning, such as pickling, are used? (NAV30-20(4-6)

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1. Does the forge perform and document internal audits to verify the various processes are in control and compliant with the applicable procedures? How are deviations from procedural requirements handled? (Review a sample of records to verify compliance. List the records reviewed.) (NAV30-21(1b & c))

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1. Does the forge have a specific procedure for mechanical testing of forged products? Does the procedure require a forging drawing to identify the test specimen location? If so, does the procedure require customer approval of the drawing be obtained? Is there a process to verify the test samples conform to the forging drawing? (NAV30-22(1-3))

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1. Do mechanical test samples conform to the forging drawing? Was a production forging or prolongation used to obtain the test specimen? Was the test sample location and orientation correct per the applicable specification, forging drawing, or specific customer requirement? Was a separate specimen forged specifically for the mechanical testing? If so, was it from the same heat of material, produced from the same process steps (as closely as possible), of the same size (cross section), and representative of the actual forging? (Identify records sampled to verify test specimen compliance.) (NAV30-22(4-6d)

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1. Are the number of samples required by the specification for testing (tensile tests, elevated tensile, charpy, hardness, grain size, micro cleanliness, corrosion, etc.) controlled? Is the identification and traceability of test samples controlled? Is the method for obtaining mechanical test specimens representative of the hammer operation(s) or press operation(s)? (NAV30-22(7-9))

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1. Does the forge have a procedure for the control of the forging furnace heating process, including heating rates, temperatures, hold times, and specified tolerances? What procedure governs this, and is it readily available to forging crew personnel? If no procedure, how are these areas controlled? (NAV30-24(1-4a))

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1. Are records maintained as objective evidence for completion of the forging furnace heating process? (Check dates and signatures of process instructions/records.) Is a heat log or chart maintained to demonstrate compliance with specified requirements? Who reviews the log or chart Is there an observer or QC over check of the process and documentation? Are deviations identified and segregated? Is identification maintained, including identification of material in the oven (location layout/map within the oven) if necessary? (NAV30-24(5-10))

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1. Do forging furnace process procedures specify limitations on heating cycles during forging operations (number of cycles and temperature)? What are the heating cycles? Is there a working temperature range for a given work piece? How is the temperature range controlled, and what is the Objective Quality Evidence? Are precautions in place to avoid coarse grains (temperature too high)? Describe the precaution(s). (NAV30-25(1-3a))

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1. Does the forge have a process for controlling forging heat treatment, when heat treating is required? If heat treatment is out-sourced/sub-contracted, who performs the heat treatment for the forge? What controls are in place for outsourcing? (NAV30-28(1-1b))

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1. Do the heat treat parameters and operation meet specification or customer requirements for at least the following: a) Atmosphere; b) Temperature, hold time, and tolerances; c) Type of quench; d) Maximum furnace to quench time; e) Furnace controls (surveys, thermocouples, calibration, etc.); f) Map identifying location of forgings within the furnace, if necessary? (NAV30-28(2-2f))

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1. Does the forge have written procedures/instructions governing the heat treat process and furnace controls? Do the procedures/instructions include controls for heating rates, temperatures, hold times, and specified tolerances? What objective quality evidence is available to support this? Are specification and customer required records maintained as evidence for process description and completion? What procedure governs these areas, and is it readily available to heat treating crew personnel? (NAV30-30(1-5))

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1. Is there a process at the forge for heat treatment control? Does it include addressing/evaluating deviations? Is identification maintained, including identification of material in the furnace (location layout/map within the oven)? (NAV30-31(1-3))

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1. Does the forge conduct the mechanical testing and disposition of the test specimen? What procedures or work instructions apply, and are they available to test personnel? If testing is out-sourced, does the forge adequately describe in the purchase order the required testing and documentation required (material specification, customer requirements, etc.)? Does the forge exercise controls for selecting and maintaining the test lab provider (audits, source inspections, etc.)? What procedure(s) apply? (NAV30-33(1-2b))

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1. Does the forge verify that all mechanical testing results meet specification and customer requirements? What method of verification is used? Are the capabilities of the testing facility/analyst, and the test result dispositions, audited and/or validated periodically? Is there a procedure for evaluating acceptability of test results? Does the procedure prevent release of material until mechanical test reports are approved? Is the mechanical test specimen retained? If so, for how long? What procedure(s) apply? (NAV30-33(3-4d))

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1. Are certified material test reports generated for the mechanical properties upon completion of the mechanical testing of the test specimen? Does a review of the certified material test reports take place to verify/indicate they meet the specification and/or customer requirements? (NAV30-34(1-2))

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1. Does the forge have instructions/procedures for surface cleaning, such as de-scaling, after the forging has undergone heat treatment? Do the cleaning methods include shot blasting? If so, does the procedure address the type of shot medium to be used? If steel shot is used, does the procedure state how iron contamination of nonferrous forgings is to be prevented? What procedure governs post-heat treatment surface cleaning? (NAV30-35(1-3a))

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1. Does the procedure for surface cleaning after heat treatment allow for the recycling of shot blast, and is the same shot blast used on all alloys? If/When shot blast is not used for surface cleaning, how are forgings cleaned after final heat treatment? (NAV30-35(3b-4a))

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1. Does the forge have a process/procedure for conducting NDT on the forgings when required by the governing specification(s) or specific customer requirements? Is objective quality evidence generated and available to indicate the NDT requirements have been satisfied and the material is acceptable? Is a properly completed test report issued, including the specification of acceptance? (Review and record records sampled for verification.) (NAV30-36(1-2a)/36(2c))

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1. Does the NDT procedure in use at the forge require review/approval by the government? Has the procedure been approved by the customer? If applicable, list the Reference Approval Number. (NAV30-36(2b))

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1. If non-destructive testing is out-sourced, does the forge adequately describe in the purchase order the required testing and documentation required (material specification, customer requirements, test reports, etc.)? Does the forge exercise controls for selecting and maintaining the NDT inspection provider (audits, source inspections, etc.)? What procedure(s) apply?

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1. Are records maintained when welding repairs are performed at the forge facility? Are the correct weld procedures identified in work instructions? Are customer approved weld procedures required and available? Is filler material certified and controlled in storage, at issue, and during use? Do the records contain the information required by the applicable welding or forging specification, such as location of the repair, welder performing the repair, welding procedure used, welding consumables used, and the results of follow-up NDT? (NAV30-37(1)/37(3-5))

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1. If weld repair is out-sourced, does the forge adequately describe in the purchase order the requirements and documentation required in support of the repair (weld record/report, weld consumables, etc.)? Who performs the weld repair? What procedure(s) apply? (NAV30-37(2))

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1. When weld repair is not allowed, how is this enforced? (NAV30-37(6))

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1. Does the forge perform a final inspection/review to verify the forging conforms to the customer contract requirements prior to shipment? What items are included in the review? What instruction/procedure, if any, controls final inspection? (NAV30-38(1 & 1a))

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1. Does the forge have a documented preventive maintenance program? Are there controls to prevent contact with detrimental elements such as marking materials, forging lubricants, or other potentially detrimental materials that may come in contact with the forgings? (NAV30-39(1)/(3a-3c))

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1. Does the forge routinely evaluate forging dies to ensure compliance with dimensional and configuration requirements, even after extensive wear from the forging process?

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**E.** **ENVIRONMENT**:

1. Are any processes (chemical/mechanical testing, NDT, etc.) conducted under controlled environmental conditions (clean room, humidity/temperature, etc.) as required by contractual and/or supplier-imposed technical requirements? ***What are the environmental conditions and are they monitored (charts, gages, etc., within calibration)?***

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1. Are the work areas where the work is being performed clean and free from dirt and debris, beyond that common for this facility type?

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1. Are there an adequate number of fire protection devices maintained and readily available for use? Are eye-wash stations and other safety-related resources located in the work area, and are they easily accessible?

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1. Is the necessary personal protective equipment (hearing and eye protection, heat-resistant gloves/clothing, safety shoes, etc.) available to personnel performing forging and heat treatment operations?

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**F. PRODUCT EXAMINATION:**

***The QAR must perform a product examination in order to verify the output of the process being reviewed and document the results below. If at all possible the QAR should witness performance of the process by the supplier to verify competency of the supplier personnel.***

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| Date(s) Conducted: |  |
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| Product Examination Performed By: |  |
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| Contract Number(s): |  |
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| Part Number(s)/Serial number(s): |  |
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| Part Nomenclature(s): |  |
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| Supplier Personnel Contacted and Titles: |  |
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| Drawing Number & Revision: |  |
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| Lot Size and Sample Size: |  |

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| Characteristics Examined: | # Observations |
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1. Identify the inspection methods (W, I, T, V) used to verify conformance with procedures and standards:

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **W** |  |  | **I** |  |  | **T** |  |  | **V** |  |

**PE Comments/Concerns**

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| --- |
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|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Overall MPR Results:** | **SATISFACTORY** |  | **UNSATISFACTORY** |  |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Corrective Action Generated?** | **No** |  |  | **Yes** |  |  | **CAR#** |  |

FOLLOW-UP ACTION REQUIRED?

|  |
| --- |
|  |

**SUMMARY/NOTES/COMMENTS/CONCERNS**:

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