DCMA NSEO MANUFACTURING PROCESS REVIEW (MPR) CHECKLIST #29

CASTING (FOUNDRY) 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:**

* Castings are inherently less sound than wrought materials and products.
* Inadequate procedures for chemical check analysis prior to pouring a melt can result in unacceptable material being processed.
* Improper casting methods can result in an excessive amount of (and/or excessive size of) internal voids, which can lead to poor mechanical properties and part failure.
* Poor casting practices can result in a high inclusion count, which can result in poor mechanical properties and possible failure.
* The casting process can result in high residual stresses; some castings must be stress relieved.
* Weld repairs can result in defects which can lead to failure. Weld repairs must be carefully controlled and documented. Weld repair is not appropriate for many casting alloys.
* Mechanical tensile tests have been performed properly, but calculations performed incorrectly, resulting in “acceptable” test values reported for unacceptable material.
* Castings with large and/or excessive internal voids and /or inclusions have failed during service.
* Improper stress relief of castings has resulted in failures.
* Weld repair defects have resulted in failures.
* There have been deviations from customer approved product qualification or 1st Article test reports. Weld repair of castings was performed without the welding procedure being approved.
* 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.
* Cast valve components have cracked during welding installation due to excessive inclusions (dross) in the material, although weldability testing was acceptable.
* Weld repair of castings has been performed without the welding procedure being approved.
* Excess gas – primarily hydrogen and nitrogen – if not removed during casting solidification, can result in unwanted porosity being present in the product.
* Particular attention should be given to alloy composition, dissolved gas content, entrained solids (such as oxides and intermetallic compounds), and improper temperature, as these are the four principal factors which contribute to metallurgical defects in castings. Poor fluidity, shrinkage porosity, gas porosity, and hot cracking may result.

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

1. Are the people 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 foundry’s employees trained and familiar with portions of the system applicable to their position? (NAV29-1A)

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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. Are inspection and manufacturing personnel trained in the use of procedures? (for preparing test coupons, performing chemical analysis, performing mechanical testing, etc.) Is there a documented training plan, and are these recorded a part of employees’ files? Identify any applicable procedural training. (NAV29-23B/24B/25B)

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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? Is the operator identification recorded? (name, badge number, clock, shift, etc.)

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1. Does the foundry use documented, qualified procedures for performing welding repair on their castings? Are the welders trained and qualified to the welding procedures they are asked to perform? Does the foundry maintain records showing the training and qualification of the welders? (NAV29-18/A/B)

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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. Are certifications for raw materials used in the foundry process reviewed for acceptance and 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. 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 remaining metal after each pour (gates, risers and other scrap) labeled, sorted and stored in accordance with the foundries material control process? (NAV29-12)

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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? (NAV29-20/21)

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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. Do procedures call for the use of calibrated instrumentation to control the temperature of the melt? Are calibrated instruments being used where required by internal procedure or by the governing specifications? (NAV29-7B/I)

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1. Are procedures/work instructions adequate for control of proper equipment? Where foundry equipment is used on multiple alloy types are precautions such as “wash heats” or other cleaning processes used to prevent or limit cross contamination of different alloys? (NAV29-10)

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1. Is foundry equipment that may come in contact with molten product, such as ladles, crucibles, stirrers, skimmers and thermal blankets, controlled for use in a single alloy or family of alloys where cross contamination is not a concern? (NAV29-9)

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1. List the type, brand, and model of equipment used for chemical and for mechanical 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? Is the chemical testing equipment capable of reporting full quantitative values, including trace elements, for the alloys produced by the foundry? Does a procedure define the rounding and use of significant digits when reporting the results of the chemical and mechanical analysis? (NAV29-23C-F/24C-E)

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

1. Does the foundry have a documented quality system if so, what recognized quality management system does the foundry’s quality system comply with? (NAV29-1/B)

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1. Is a documented procedure used for preparing the test coupons and accomplishing chemical analysis, mechanical testing, and weldability testing? Are these procedures available to and in use by the personnel performing these tests (NAV29-23/A/24/A/25/A)

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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. (NAV29-14A/18C)

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1. Does the foundry conduct internal assessments or audits when required by contract or internal quality system requirements? If so, does the foundry maintain records of internal reviews such as schedule, results, and corrective actions? Has the foundry ever been subjected to a 3rd party quality audit? If so, by whom? Describe any significant findings and if they have been corrected. (NAV29-1C/I/2)

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1. Does the foundry have a documented process for evaluation, review and selection of suppliers for their raw material? (i.e., ingot, alloying additions, purchased scrap)? If so, does this process include a review for past performance and review of technical capability? Provide listing of suppliers, noting the type/alloy of material provided? (NAV29-3/A-C)

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1. Are work instructions, test procedures, travelers, etc. being used adequate, clear, and up to date (latest revision)? What documents (identifying number & rev) were reviewed?

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1. Is there a documented procedure/process to determine the acceptability of raw materials (i.e., ingot, alloying additions, purchased scrap)? If so, does it include reviewing material certifications and/or re-performing material verification testing to confirm material meets specification requirements and reviewing the traceability of certified material to the paperwork? Does this procedure/process take into account differences in the source of the material and require different levels of verification based on past supplier performance, or receiving certified and traceable material with test reports, or versus uncertified scrap (i.e. changing sample sizes or performing additional testing on material before acceptance)? (NAV29-4/A-C)

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1. Does the foundry have a documented procedure for controlling, storing, and issuing raw materials and additives? Does this procedure require raw materials to be labeled/marked and stored in a manner to preclude mix-up with other similar materials? Does the foundry control back scrap (revert), re-melt, or internal scrap material by alloy and/or heat number? Does the procedure cover the disposition of material that does not meet chemical and/or mechanical requirements? (NAV29-5/A-C)

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1. Is there a procedure for developing, documenting and controlling the entire casting process, including all foundry engineering, such as gating, risering, pattern design and pour temperature when a 1st article test is required? Does this procedure include a change control process that addresses analyzing any changes to the casting processes for their effect on the end product and whether or not validation and/or re-qualification of the 1st article test is required? Once the 1st article test is accepted by the customer, is the customer notified when there are modifications to the production of a casting that impacts the acceptability of the original 1st article test? (NAV29-6/A/B)

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1. Does the foundry have a specific melting and pouring procedure for each alloy group the foundry melts? Do these procedures define what is considered a single heat or lot, and do the heat/lot definitions comply with the applicable specifications for the alloy? Do internal procedures require a chemical check analysis prior to releasing the melt for pouring? Do these procedures identify when and how many chemical and/or mechanical test coupons are poured? Are the test coupons marked to maintain traceability to the heat/lot and to the actual production material? (NAV29-7/A/I/C/D/I/II)

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1. Do the procedures identify the size and shape of the test coupons required? Does this meet the requirements of the applicable casting specifications, including some heat treatable castings which require the test coupons to represent the thickest portion of the production castings? Do the melt procedures specifically forbid adding material to the melt after the test coupons used to certify the final product have been poured? Do the melt procedures have limits on the maximum size or weight of a pour, and are these limits within the capability of the foundry’s equipment? (NAV29-7E/I/F/G/I)

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1. Do procedures limit pour time and/or address additions of de-oxidants and other additives to maintain chemistry where applicable, and do the procedures require measurement or weighing of these additives before use? (NAV29-7H/I)

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1. Do the procedures require heat lot traceable records that record the parameters used during the casting process, such as mold #, personnel performing pour, the constituents (additives, certified ingot, backscrap/revert) used in the pour including amounts, and the melt time and temperature? Are heat/lot traceability markings cast into final product or marked immediately after cooling and removal from the molds, or is a process in place to assure traceability is maintained until markings are applied? (NAV29-7I/8)

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1. Does the foundry have any process to limit surface contamination of the final product from shot blasting or other final cleaning process? (NAV29-11)

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1. Are the chemistry and mechanical properties of each heat/pour of metal verified after melting and/or casting even where pre-certified ingot is used? (NAV29-13)

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1. Does the foundry use a documented procedure for performing and evaluating NDT on the final product? For NDT performed in house, List the NDT performed. Is NDT used as certification of the final product being performed by a NDT examiner certified in the applicable discipline? Are records kept that detail the size and location of any rejectable defects noted during the inspections? (NAV29-14/15/A-C)

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1. For sub-contracted NDT, list the NDT subcontracted and list subcontractors used. Is any oversight or evaluation performed on subcontractors performing NDT? Does the foundry receive reports detailing the size and location of any rejectable defects noted during the inspections? (NAV29-16/A-C)

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1. Does the foundry have a process for reviewing repetitive casting defects in order make improvements to their casting process and foundry engineering, which will improve the acceptability of the final product? (NAV29-17)

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1. Are records maintained when welding repairs are performed? Do the records contain the information required by the applicable welding or casting specification such as location of the repair, welder performing the repair, welding procedure used, welding consumables used, and the results of follow-up NDT? (NAV29-19/A)

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1. Does the foundry subcontract the testing of any of its material, such as chemical, mechanical or weldability testing? Does the foundry use a documented procedure to select/evaluate subcontracted test lab(s) performing mechanical and chemistry testing? Are test labs required to be certified through a 3rd party such as A2LA or NADCAP? Is a list of qualified testing labs, along with their capabilities, maintained, and does the foundry perform any oversight or confirmation testing to provide assurance that the lab is performing properly? (NAV29-22/A-D)

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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?

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

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

FOLLOW-UP ACTION REQUIRED?

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

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