TITLE: SUPPLIER QUALITY FLOWDOWN DOCUMENT

1. GENERAL REQUIREMENTS:

This document establishes the minimum quality system requirements for external providers (suppliers) to ensure that purchased products, materials and services meet the required quality level for the Howmet business.

When Howmet purchase order requirements differ from those defined herein, the purchase order requirements shall prevail. The order of precedence shall be:

1.1 Purchase order or contractual agreement (excluding this document).
1.2 Applicable purchaser's drawing.
1.3 Specifications referenced on drawings.
1.4 This document.
1.5 Specifications referenced in this document.

The requirements of this document are generic and are intended to be applicable to all organizations doing business with Howmet operations, regardless of the type, size, or product provided.

Exclusions or Exceptions - Exclusions or exceptions to these requirements **shall** be submitted in writing and accepted in writing by the Howmet Procurement and Supplier Quality Assurance organizations. Verbal authorizations shall not be permitted. Requirements that cannot be applied due to the nature of an organization and its product will be considered for exclusion, providing such exclusions do not affect the organization's ability or responsibility to provide product that meets Howmet and regulatory requirements. Suppliers **shall** contact Howmet Procurement to obtain Supplier Exception Request form 700.004.001F04 to formally submit any exception requests.

Notification of Changes - The Supplier **shall** notify the Howmet facility procurement representative of changes that affect the operational proficiency of a facility; alterations in upper management or organization restructuring; alterations in the business name, location or ownership; processing capabilities, and any other pertinent changes that could hinder the capacity to conduct customary business activities or the quality of products and services. The Supplier **shall** immediately notify Howmet when the status of their required approvals and/or certifications, or the approvals or certifications of their sub-tiers have changed or been revoked. (Also, see Change Management under 8. Process Control, below.)

Confidentiality - The supplier **shall** treat all product(s), material, and specification(s) received from Howmet as confidential in nature. Depending on the type of product or process, suppliers may be required to sign a nondisclosure agreement prior to doing business with Howmet. No Howmet or Howmet customer material is to be viewed or provided to subcontractors without prior written authorization from Howmet.

Right of Entry - Howmet, Howmet customers, and regulatory authorities reserve the right of access to all the applicable areas of the facility, at any level of the supply chain involved in the order, and to all applicable records, and to perform audits and/or inspections at the Supplier's and/or supplier's subcontractor's facility, when necessary to determine and verify the quality of contracted work, records, and product. All supplier material, records, routers, inspection, and test facilities shall be subject to review. Suppliers **shall** provide equipment, facility and necessary personnel for all on-site verifications of contract/purchase order compliance. (Also, see Right of Entry in 6. Control of Purchases below.)

Howmet Plant to Howmet Plant Orders – The supplying facility **shall** process product and /or material in accordance with their own Quality System and internal procedures, which have been assessed for compliance to Howmet requirements through the Howmet internal audit process.

2. SPECIFICATIONS:

Supplier **shall** reference the Howmet Supplier Website: https://www.howmet.com/bu-supplier-information/ for a listing of applicable internal and external specifications, forms, and pertinent documents. Requirements for Certificate of Conformance or Analysis will be as noted in the specification unless otherwise directed by the purchase order.

3. QUALITY MANAGEMENT SYSTEM REQUIREMENTS:

All suppliers that provide product, materials and services shall be responsible for maintaining quality system compliance to the applicable quality system requirements defined below in Table A. An additional explanation of Type of Suppliers can be found in Table B at the end of this document.

Suppliers **shall** be certified/registered and receive routine system evaluations by their certification body or be subject to periodic compliance audits by Howmet or a Howmet-approved 3rd party at the supplier's expense.

Table A

Supplier Type (see Appendix B for definition of supplier types)	**Certification Required**
Brokers / Traders, Component Suppliers, and Pass-Thru Distributors	ISO 9001 or completion of General Assessment Checklist 710.006.001F01, at a minimum.
Distributors	AS/EN/JISQ, ISO 9001 or completion of General Assessment Checklist 710.006.001F01, at a minimum
Laboratory / Test Facility	ISO/IEC 17025 and/or AC7101 (Nadcap) (AC7004) **3D Structured Light: NADCAP AC7130/4**
Out-Plant Services	For Aerospace products: Certification to AS/EN/JISQ 9100 & **Compliance to AS13100** as applicable: ○ Measurement System Analysis – Paragraph 7.1.5.1 ○ Control Plan – Paragraph 8.5.1.4.3 ○ Process Monitoring Measurement – Paragraph 9.1.1.1 ○ Process FMEA – Paragraph 21.4 Non-Aerospace products: ISO 9001 or completion of General Assessment Checklist 710.006.001F01, at a minimum
Quality Support Services	ISO 9001, completion of General Assessment Checklist 710.006.001F01, or an industry equivalent standard
Raw Materials & Process Materials suppliers	ISO 9001 or an industry equivalent standard
Special Process suppliers (See section 6.0 for definition of a Special Process supplier and additional requirements)	For Aerospace products: AS/EN/JISQ 9100 or meet the requirements of SAE AS9003. Compliance to AS9003 is demonstrated by satisfactory audit to National Aerospace and Defense Contractors Accreditation Program (Nadcap) AC7004. **Compliance to AS13100** as applicable: ○ Measurement System Analysis – Paragraph 7.1.5.1 ○ Control Plan – Paragraph 8.5.1.4.3

	○ Process Monitoring Measurement – Paragraph 9.1.1.1 ○ Process FMEA – Paragraph 21.4 Non-Aerospace products: ISO 9001 or completion of General Assessment Checklist 710.006.001F01, at a minimum
Tooling Suppliers	ISO 9001 or completion of General Assessment Checklist 710.006.001F01, at a minimum.

Suppliers are required to provide evidence of a certificate of registration from an IAF accredited Certification Registration Body to the industry standard listed above. Suppliers are required to notify Howmet Supplier Quality Assurance (SQA) of any changes regarding quality system certification(s). This includes additional certifications awarded, certification suspensions, and mergers and acquisitions. Quality Certifications include, but are not limited to, AS 9100, ISO 9001, ISO/IEC 17025, AS 9003 and TS 16949. Suppliers must submit to Howmet Supplier Quality a copy of the renewed certificate within 60 days of the certification expiration date. Suppliers that have not submitted a renewed certificate within 60 days of expiration date will be temporarily removed from the Howmet Approved Supplier List and will not receive new Purchase Orders until a renewed certificate has been submitted. If a renewed certificate is not available at the time of expiration Suppliers can submit a letter from their registrar or a copy of the audit report indicating certification requirements have been met. For AS9100 certified suppliers Howmet Supplier Quality may request access to suppliers OASIS AS9100 audit results. To submit Quality Certifications or provide notification of changes, e-mail all documentation to Howmet SQA at mailto:APPSupplierQuality@howmet.com

4. DRAWING AND SPECIFICATION CONTROL:

It is the supplier's responsibility to conduct timely reviews and incorporate the latest engineering specifications and drawings, including end customer specifications.

The appropriate revision level of the Howmet technical specification(s) stipulated in the Howmet purchase order shall be incorporated within 30 days, or as otherwise specified, from the "Issued" date of the related "Table of Contents" in which the specification(s) is listed. (Refer to Note 1 below). All product and material arriving at the Howmet purchasing facility immediately following incorporation of the specification and the supplier/ Howmet agreed upon effectivity date shall be configured to the appropriate specification revision level. Select specifications and the "Table of Contents" with specification revision levels are located on the Supplier Quality Website at https://www.howmet.com/bu-supplier-information/. **The supplier shall be responsible for verifying that all specifications are current prior to use and the latest revision level of the specification is noted on the certificate of conformance or analysis supplied as directed.**

Table B

Specification Type	Specification Name	Specification Type	Specification Name
AC Specifications	Advanced Core Manual	MS Specification	Mono-Shell Manual
CM Specifications	Cleaning Manual	PM Specifications	Process Materials Manual
CD Specifications	Coating Manual	SR Specifications	Shell Room Manual
CP Specifications	Core Manual	TB Specifications	Test Bar Manual
MC Specifications	Crucible Manual	WM Specifications	Wax Manual
DS Specifications	DS Manual	TM Specifications	Tooling Manual

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HAA Specifications	***Aluminum Alloy Manual***
HA Specifications	***Alloy Manual***
MP Specifications	***Ti-Ingot Technical Manual***
Various	Customer Specifications

PC	Product Criteria
AI	Activity Instructions
Various	***Customer B/Ps and Drawings***

Note 1: For the current revision level/date of a Howmet specification, refer to the appropriate Table of Contents (referenced above) on the Supplier Quality Website. Locate a specification by associating the first two digits of the specification number to the appropriate Howmet specification manual, i.e., specification AC 1100 would be found in the Advanced Core manual. This web page does not contain copies of any of the specifications listed on Howmet's website, as many are deemed proprietary and require non-disclosure agreements (NDA) prior to release. Contact the Procurement representative listed on the Howmet purchase order to obtain a copy of a Howmet specification.

Note 2: For those specifications and/or manuals in table B that are in bold italics, Howmet will continue to list the revision level and/or revision date on the purchase order.

5. ETHICS:

Howmet is committed to dealing fairly with its suppliers. Howmet will emphasize competition, without discrimination or deception, in a manner consistent with long-lasting relationships. Howmet will purchase all equipment, supplies, and services based on merit. Howmet suppliers and subcontractors will be treated with fairness and integrity. It is important that every supplier implement these same ethical standards within their company and shall make employees aware of the importance of ethical behavior.

Suppliers and subcontractors are expected to adhere to the same high standards of behavior and excellence consistent with Howmet's Code of Ethics and Standards of Business Conduct, policies, or any applicable laws or regulations. Only suppliers or subcontractors providing products or services to Howmet tied to US Government or Defense programs that exceed $5.5M annually and last more than 120 days **shall** have a documented ethics program in place and implemented within their company in compliance with FAR clause 52.203-13. Typically, an ethics program is only required for tooling, core or special alloy suppliers meeting the minimum annual sales and duration criteria. This requirement is found in "Howmet PURCHASE ORDER SUPPLEMENTAL TERMS & CONDTIONS FOR ORDERS UNDER U.S. GOVERNMENT PRIME CONTRACTORS".

When an ethics program is required, it should contain commitment from top management, a formal ethics training program and a method to report unethical issues anonymously and without consequences. This method may, at supplier discretion, be set up through an independent agency, through calls to a Howmet representative, or through an internal system. Suppliers **shall** submit a copy of their company's ethics policy to Howmet procurement for review and approval. New suppliers have 90 days to develop their ethics policy.

6. CONTROL OF PURCHASES:

Flow down of Requirements –The supplier **shall** have a process in place to flow down Howmet requirements to sub-tier suppliers. When applicable, the supplier **shall** ensure that any Howmet requirements that are associated

to items that are procured or outsourced in order to meet a Howmet purchase order are flowed down to the applicable sub-tier suppliers.

Special Processes - When special processes are outsourced, the supplier **shall** only utilize Howmet and Howmet's customer-designated Approved Suppliers. If the purchase order does not specify the sub-tier supplier to be used, the Howmet Procurement or site Quality representative shall be contacted to obtain a list of approved sources, including Howmet customer approved sources.

Special Processes are those processes and services that have the potential to directly influence the quality of products manufactured by Howmet and whose conformance to contract requirements cannot be fully determined upon receiving inspection. These processes may require a demonstration of operator or equipment capability or proficiency, and require special controls for monitoring, per specifications. Special Processes include the following:

6.1 Chemical Processing (including core/shell removal and grain etching)
6.2 Coatings
6.3 Composites
6.4 Thermal Processing (including heat treatment, brazing, and HIP)
6.5 Materials Testing Laboratory Services
6.6 Non-Destructive Testing
6.7 Non-conventional Machining and Surface Enhancement
6.8 Welding
6.9 Conventional Machining as a Special Process

Note: Exception to Nadcap certification requirements may be granted for special processes of non-aerospace parts.

Right of Entry – The supplier **shall** include right-of-entry provision in any subcontract. These provisions **shall** allow the supplier, its customers, and regulatory agencies to determine and verify the quality of work, records, and material at any place, including the plant of the subcontractor. (Also, see Right of Entry in 1. General Requirements above.)

Control of Confidential Information – The supplier **shall** establish nondisclosure agreements with subcontractors that receive or process Howmet product, blueprints or specifications, confidential proprietary technical data or other Howmet intellectual property prior to doing business with them.

Control of sub-suppliers – The supplier **shall** apply appropriate controls to its direct and sub-tier suppliers (external providers) to ensure that requirements are met.

➢ **Counterfeit Parts** – It is expected that suppliers maintain an effective Prevention and Control of Counterfeit Parts program and may use AS6174 or other applicable prevention and control of counterfeit parts program standard/ specifications as information and guidelines. The program should include the training of appropriate persons in the awareness and prevention of counterfeit parts. If potential latent counterfeit parts are determined, a written notice to Howmet Quality Management and Procurement Representative is required within 24 hours of discovery.

7. QUALITY ASSURANCE PLANNING:

Quality Planning – For new projects and/or programs with Howmet, the supplier **shall** engage in effective quality planning that embodies critical concepts of defect prevention and continuous improvement, i.e., contract review, resource planning, training, change management, cost reduction, Process Failure Modes Effects Analysis (FMEA), Production Control Plans, Measurement Systems Analysis (MSA), etc. Project/program management timelines **shall** be used to track critical project/program events, key dates, and assigned responsibilities.

Advance Product Quality Planning (APQP) - When invoked by the Purchase Order, APQP activities will be planned and carried out in accordance with industry standards (AIAG / AESQ) or Howmet APQP procedures (as specified in the Purchase Order.)

Key Product and Process Characteristics – A key characteristic is an attribute or output of a product or manufacturing process that has a significant influence on product fit, performance, service life, or manufacturability. At a minimum, the supplier shall identify the characteristics defined in Appendix A as key for those products / processes they supply and/or perform. These key characteristics **shall** be flowed down to sub-tier supplier(s). Suppliers **shall** identify these characteristics as key in the control plan. (See Appendix A - Preliminary Key Process Characteristics Index.). The use of statistical techniques may be required for identified critical key product characteristics. Howmet specifications will determine when statistical techniques are required.

Control Plans – A detailed control plan (or equivalent method) shall be documented to record the 1) inspection plan for a part to ensure that all engineering drawing characteristics and notes are subject to inspection or control, 2) controls used within a process to ensure process parameters and process related characteristics are maintained within Appropriate limits and 3) the ongoing inspection frequency (independent of the FAI) for each characteristic, for example 100% inspection, sampling plan, product of the die, etc.

Fixed Process Control Plans – Products or processes requiring fixed process control plans will be defined as such in the Howmet purchase order. A fixed process control plan requires the supplier manufacturing process to be approved by Howmet, in writing, prior to processing or production of Howmet products or materials. The designated fixed process **shall** be documented with methods of control in a technical plan format. The control plan **shall** be submitted with First Article parts for approval by Howmet prior to submitting the first production order. Once approved by Howmet, revisions or variations to this fixed process **shall** not occur unless Howmet has approved the revisions in writing.

Sampling – Ongoing product acceptance inspection **shall** be performed on specified characteristics per an agreed upon inspection plan with Howmet. This plan **shall** be defined in the detailed control plan.

When using sampling plans:

7.1 Inspection personnel **shall** be trained in the application of sampling methods.

7.2 All plans **shall** have a “zero acceptance” number.

7.3 The lot **shall** be rejected if a nonconformance is discovered in the sample. If a nonconformance is found in the sample, inspect all pieces in the lot for the nonconformance that had been noted and remove all nonconforming pieces from the lot.

7.4 Sampling plans **shall** be an industry approved C=0 plan or an alternate plan approved by Howmet SQA.

7.5 Sampling inspection is not permitted for characteristics that are affected by repair and rework Material Review Board (MRB) dispositions.

7.6 Sample(s) **shall** be randomly selected and representative of the population.

7.7 Additions or exchanges **shall** not be made to the original sample.

First Article Inspection Requirements – If required by the Howmet purchase order, the supplier **shall** submit a first article sample(s) with report for first build, revisions, and after a two (2) year lapse in production. AS9102 First Article Inspection (FAI) is the required format unless another format is agreed to in writing by the purchasing facility. The supplier **shall** furnish a first article sample(s) produced using the material, tooling, processes, and planning to be used for subsequent deliveries. The first article samples(s) **shall** be identified and submitted with a FAI report. The FAI report **shall** include the Howmet drawing with numbered characteristics corresponding to an itemized layout reflecting actual readings, and **shall** show compliance with all drawing characteristics, blueprint notes, and specifications. A photograph of the required part/item marking **shall** be included in the package. The method of measurement for dimensional characteristics shall be included with gauge identity. A photograph of the gauge(s) that were used may be requested. For subsequent revisions to the drawing, only those characteristics, notes, or specifications affected by the revision are required to be reported. A copy of the raw material C of C (or C of A) is required for an initial build first article, and a first article submitted after a two-year lapse in production (see section 11.0- Certificates).

8. PROCESS CONTROL:

Product or Service Acceptance – Product **shall** be inspected per the inspection plan or specification. Records that the product meets the defined requirements **shall** be maintained including the identity of the equipment or gage that was used to inspect each characteristic.

Control of Howmet Owned / Supplied Equipment and Tooling – Howmet owned/supplied equipment and tooling includes gages, test equipment, and tooling supplied by Howmet for use in production or maintenance or made by the Supplier and paid for by Howmet.

Supplier shall:

8.1 Use Howmet Supplied Gages, Special Test Equipment, and Special Tooling on Howmet purchase orders only and for only those purchase orders for which the items were supplied.

8.2 Identify all tools and test equipment, unless size or use prohibits, with an identification tag(s) ensuring legibility and permanency, which states the ownership designation as “Property of Howmet” upon receipt or fabrication.

8.3 Obtain written approval from Howmet prior to making modifications or changes to gages, test equipment or tooling.

8.4 Maintain, protect and preserve tooling, test equipment, and gages. Tooling and gauging **shall** be maintained for 3 years after the Howmet purchase order is complete unless Howmet directs otherwise.

8.5 Contact the Howmet Buyer before the transfer of gages, test equipment, or tooling among supplier facilities (address location) or to other suppliers.

8.6 Supplied gages, test equipment, or tooling that become excess to the needs of the purchase order **shall** be reported to Howmet.

8.7 Obtain written approval from Howmet before the disposal or destruction of Howmet-supplied gages, test equipment, or tooling.

8.8 Report all cases of loss, damage or destruction of Howmet's property in possession or control or property located at Supplier's second-tier suppliers to the Howmet Buyer within 72 hours as such facts become known.

8.9 Maintain a record (Tool List) of all Howmet supplied gages, test equipment, or tooling. The list **shall** be traceable back to the Howmet tooling purchase order and job number.

8.10 Suppliers that utilize dies in an injection process used to produce ceramic cores and wax patterns **shall** provide to Howmet a Die Life Reports at minimum every 6 months and upon request. The Die Life Reports **shall** be sent to the Howmet Business Unit Tooling Process Owner and Howmet Business Supplier Quality representative. The reports **shall** contain:

- Supplier Job Number
- Howmet Job Number
- Howmet Plant
- Quoted Life
- Total Shots
- Tool Health status

Verification of Tooling - The supplier **shall** ensure that the condition of all tooling is verified prior to use.

U.S. Government Contracts Tooling - for Howmet Purchase Orders

U.S. Government owned gages and tooling supplied by Howmet are Government Property and are subject to the provisions of the Federal Acquisition Regulation (FAR) 52.245-2 (FP) or 52.245-5 (CP), or 52.245-1. U.S. Government owned gages shall be clearly identified with a tag that states the ownership.

U.S. Government-owned gages/tooling/test equipment **shall** be treated as Howmet owned and follow the same requirements identified above.

The Supplier shall keep property records as shown in Federal Acquisition Regulation (FAR) 45.505-5 or 52.245-1.

Calibration – You must have in place a system to control, calibrate, and maintain all inspection, measuring and test equipment that has the potential to affect Howmet product quality. These items include testing software, personally owned equipment, company-owned equipment and any Howmet supplied equipment.

Where applicable, Measurement Systems Analysis (MSA) **shall** be conducted to understand and ensure accuracy, precision and uncertainty of measurement equipment. (Reference AESQ RM 13003)

All calibration must be traceable to a recognized standard such as the National Institute of Standards Technology (NIST). If your company performs calibration internally, the master gauges used to perform calibration (i.e., gauge blocks) must be sent out for calibration to either the Original Equipment Manufacturer (OEM) or an ISO/IEC 17025 accredited laboratory whose Scope of Accreditation shows that they are accredited to perform calibration of your master gauges.

All items calibrated must be identified in such a say that indicates the calibration date and due date. If any gauge or equipment is found to be out of tolerance during a normal scheduled calibration, your company must determine if any Howmet in-process product or any product built and delivered, has been negatively impacted. If so, your company must inform Howmet immediately of the potential for a dimensionally nonconforming tool, fixture, or gauge.

You must maintain a list of inspection equipment which shows the calibration due date and location of each piece of equipment.

For suppliers of calibration services, the supplier **shall** provide a certificate that states the accuracy of the subject item(s), the source performing the calibration, traceability of calibration to NIST, date of last calibration, test or report number(s), calibration method (ANSI, federal standard, etc.) and the environmental conditions during the calibration actions. In addition, documentation must show the “as received” condition of subject devices prior to adjustment.

Control of Software – The supplier **shall** have a process in place which includes Software Development and Validation Plan that are approved by the facility cognizant engineering organization and quality assurance representative. To control software that is used in design, manufacturing, inspection, test acceptance or calibration, which may have product impact.

The Software Development Plan should include the following items:

- Identification of software
- Organization structure and responsibilities
- Software development process
- Software development schedule and metrics
- Quality and project records, including retention
- Project review schedule
- Resources and resource utilization
- Corrective Action process
- Risk management
- Subcontractor management
- Security and safety, including disaster recovery
- Data management
- Programming languages
- Standards
- Storage requirements
- Version control

- Access control
- Deployment methodology
- Data migration, if required
- User training
- Hardware requirements

The Software Validation Plan **shall** include the following items:

- Software testing environment, including hardware and software elements.
- Control of installation and test activities
- Configuration and change control
- Data analysis and retention
- Method of formally documenting results
- Signature of individual(s) who performed validation and approver (validation and approval shall be performed by different personnel)

The Software Control Process should include, at a minimum:

- Objective evidence that the software performs the required function;
- A defined method to maintain version control;
- Change control process that includes re-verification and re-validation to ensure the modified software meets the requirements and/or function;
- Limited access to software masters and edit functions;
- A method to archive, backup and recovery software programs;
- An internal audit or review process to ensure compliance to maintained.

Note: Supplier(s) are not permitted to Update or Revise any Executable Program without notification and written approval from the cognizant engineering organization, designated information systems and quality systems representatives.

Product Serialization – If required by the product drawing and/or specification, product **shal**l be serialized with unique serial numbers or number series for the product and shall be referenced on the C of C form (see section 11.- Certificates).

Product Traceability - Traceability **shall** be maintained from receipt of raw material through finished product. Records and material **shall** be identified by lot number, material type, specification and applicable revision identifier or date of issue, heat number, serial number, etc., as required to maintain traceability. Records **shall** be maintained at the supplier's facility, or a storage facility approved by Howmet, and shall be available upon request within two business days.

Marking Requirements - Marking **shall** not be applied directly to any product manufactured for Howmet, or any investment cast consigned components(s) unless contractually authorized and approved in writing by the procuring Howmet facility. This includes marking materials such as ink, wax, pencil, pen, etchants, etc., and methods such as vibropeen, laser marking, etch marking, etc. All marking materials and methods **shall** be approved by the procuring Howmet facility. Once approved, changes to marking material source and/or method require written approval of Howmet.

Product Acceptance Media - When product acceptance authority media are used (e.g., stamps, electronic signatures, passwords), the supplier **shall** establish controls for the media appropriate to:

- Avoid misuse.
- Establish traceability to the authorized user.
- Avoid duplication.
- Align to responsibilities and authorities defined within the quality system.
- Maintain good condition and legibility

Change Management - In addition to change management requirements in the Howmet product specification(s) Applicable to the product being supplied, the supplier shall complete the Supplier Change Request form 700.004.001F03 and receive approval prior to making a change in the:

Process materials critical to the chemical and physical characteristics of the applicable product;
Manufacturing process that may affect the chemical or physical characteristics of the product;
Changes in manufacturing location, subcontractors, or significant process flow of the product;
Changes in product verification sampling plan and/or test methods

The Supplier Change Request form **shall** be submitted to the plant Howmet Procurement representative. The form can be found at https://www.howmet.com/bu-supplier-information/.

9. CONTAMINATION CONTROL:

Foreign Object Contamination Control and Detection - Processors performing primary or secondary manufacturing or non-destructive testing (NDT) operations on Howmet product **shall** ensure all open cavities subject to ingestion of foreign objects and debris are free of any foreign matter (e.g., machining chips and dust particles, blasting materials, shot, weld and braze splatter, coatings, process solutions, maskants, trash, food, etc.). Prior to the return of all cast components to Howmet, the processor **shall** confirm the absence of foreign matter, objects, and debris and process solutions.

A Foreign Object Damage (FOD) program **shall** be introduced to all employees performing work directly or indirectly affecting conformity to Howmet product requirements. This training **shall** increase employee awareness on the causes and effects of FOD, along with emphasis on good work habits. This training **shall** be part of employee orientation, job activity assignment, and/or reassignment, and shall be reviewed on an annual basis to ensure employee-continued awareness.
This training program **shall** include, at a minimum, the following topics:

Causes and effects of Foreign Object Damage (FOD);
Methods for protection of product;
General and location-specific housekeeping requirements;
applying business unit clean-as-you-go principles (Don't Take It, Don't Make It and Don't Pass It On);
Equipment and hardware control and accountability;
Incoming (consumable) material control and accountability;
Storage and shelf-life control for processing materials; and
Location-specific preservation and packaging controls.

Cross Contamination – All products (including raw materials) must be kept safe from any potential cross-contamination that may occur when processing similar or dissimilar products on the same manufacturing equipment. When switching from one manufacturing process or product to another, the entire relevant

manufacturing system must be purged as necessary to prevent material(s) from the previous production run to enter into the next production run.

Lot Control – In a continuous manufacturing system lot control must be maintained to a level that a nonconformance can be traced back to additional material that could be affected, including adjacent lots.

Prohibited Materials - Unless otherwise specified on the contract or Howmet technical specification, the use of any silicon carbide materials is strictly prohibited for use in the manufacturing processes of superalloy investment castings.

Materials known to contain greater than trace levels of lead, bismuth, silver, antimony, zinc, tin, iron, arsenic, and selenium and/or other harmful impurities such as tellurium, thallium, indium, sulfur, boron, and cadmium should not be utilized in product for Howmet. The supplier **shall** also preclude contamination, contact, or processing Howmet product in the same equipment as other product(s) that contains greater than trace elements of these materials, unless authorized by Howmet SQA.

Suppliers **shall** notify the Howmet facility Procurement and Quality representatives, immediately, if contamination with any of the materials listed above is suspected.

Howmet product **shall** not be processed in thermal treatment equipment or with fixtures that are used to process materials that exceed the above contaminant limits or are used for processing braze materials.

10. INSPECTION AND TEST:

Eye Examinations -

Employees performing visual inspection and/or other product acceptance activities that require visual acuity **shall** receive eye examinations, including visual acuity and color vision, as applicable, administered by medically qualified personnel or performed by personnel who have been trained by a medical professional, according to the following:

Intervals shall not exceed one year.

Individuals must meet the minimum standards in one eye, either corrected or uncorrected; ensuring that the optical aids used during the vision assessment are also used during product verification / inspection activities.

Color perception testing is required one time only. Individuals shall be capable of adequately distinguishing and differentiating colors used in the method for which certification is required, the process being performed, or inspection activity.

Records of vision testing **shall** be retained for the period that the relevant employee remains within the supplier's organization, plus three 3 years.

Individuals performing.....	**Shall be compliant with.....**
Visual Inspection (i.e., calibration, non-weld, in-process, layout, dimensional)	Near vision requirements of Jaeger 1 at 12 to 14 inches
Visual Inspection on Welds	American Welding Society Standard (AWS) D17.1
Nondestructive Testing (NDT)	Aerospace Industries Association / National Aerospace Standard AIA/NAS 410
NOTE: Vision tests may be substituted for the options listed above providing the equivalence is verified and documented by a licensed optometrist.	

11. CERTIFICATES:

Where specified on PO or by Howmet drawing or specification, product shipment **shall** be accompanied by an appropriate Certificate of Conformance (C of C), Certificate of Analysis (C of A), Certificate of Test or Certificate of Calibration, etc. The supplier **shall** be responsible for maintaining and supplying this certification documentation as objective evidence of meeting purchase order and drawing/specification requirements. The supplier **shall** provide an appropriate certificate for each lot (shipment) of product supplied to Howmet to the latest revision of the specification/drawing. Failure to provide proper certification may result in payment being withheld until proper certification has been received.

Certificates ***must*** contain the following data at a minimum unless otherwise noted:

11.1 Data defined in the applicable Howmet technical specification; or data approved or required by the applicable Howmet location
11.2 Supplier's name and address or location
11.3 If applicable, supplier's product identification (i.e., serial numbers, lot number and/or batch number)
11.4 The Howmet product identification as defined on the Purchase Order, and the drawing number with revision level or the specification with revision level, as applicable.
11.5 Statement of conformance to the purchase order
11.6 Suppliers providing calibration, dimensional inspection, material testing or Special Process services shall provide Company authorized person signature, printed name, and date.

If applicable and/or required by the receiving plant, the certificate **shall** also contain:
11.7 Verifiable results (usually numerical results or observed visual criteria) of all testing/inspections required by PO, drawing or specifications for raw materials, special processes and other applicable products;
11.8 Certification of 100 % inspection or Cpk data when required on the PO;
11.9 If outsourced processes are performed on Howmet product, the subcontractor's name, location and the specific process(es) that were subcontracted.

Distributors – When specified, material/product supplied by a distributor requires a copy of the original manufacturer's certification to be supplied with each lot/shipment. If additional verification testing is performed by the distributor, copies of both certifications are required and **shall** accompany each lot/shipment. Minimum information required on certificates per 11.1, 11.2, 11.3, 11.4.

The Purchase Order (PO) Number and Quantity Supplied/Shipped **shall** either be stated on the certificate or on the shipping documents for that shipment (i.e., Shipping Manifest or Bill of Lading). **The physical product *must* be traceable through a Certificate of Analysis or Certificate of Conformance through a batch number, lot number, or purchase order (PO) number.**

Consignment related suppliers – Howmet sites may give authorization to the suppliers not to include the Purchase Order Number into the shipping document. Traceability requirements must be defined and agreed.

Shelf Life - For limited shelf life (age/environmental sensitive materials) items, the certificate **shal**l contain the specification number, if applicable, lot or batch number of the material, date of manufacture and/or cure date (month/year or quarter/year), the shelf-life expiration date and any environmental storage conditions that apply **shall** be stated on the certificate as well as the container. Materials **shall** not be shipped with less than 75% of the required remaining shelf life to Howmet facilities unless approved in writing by the Howmet facility or as otherwise stipulated in the Purchase Order.

Chemical and Metallurgical Analysis - For Chemical and Metallurgical Analysis, the material certification (i.e., Certificate of Analysis) **shall** contain the specification number of the material being supplied as it appears on the purchase order, revision letter, lot code of heat number, and shelf life if applicable. Actual test results that are required by the specification, such as mechanical test data, chemical properties, hardness, etc., **shall** be included on the certification.

Howmet Supplied Raw Material - For Howmet Supplied Material, a certification **shall** be provided with the shipment stating the material type, the material heat/lot number, and the quantity received as it appears on the purchase order. Material substitutions are prohibited without written approval by Howmet.

Catalog Items - For standard “off-the-shelf” (catalog) items, a packing list is acceptable provided a signed statement is included. A reference to the Howmet purchase order number, manufacturer name and product number (no revision level required) is required for each item listed.

Qualified Products List - For Qualified Products List (QPL) items, the supplier **shall** state the manufacturer of items ordered and certify that the manufacturer is on the U.S. Government Qualified Products List.

12. PREPARATION FOR SHIPMENT:

Source Inspection and Surveillance - When specified on the Howmet purchase order, Howmet source inspection and system surveillance of procedures, facilities, and products covered by the purchase order are mandatory prior to shipment of purchased items. Use of supplier’s equipment, gages and measuring and testing devices **shall** be made available at the supplier’s facility for the Howmet designated Source Inspectors, when required, to determine conformance to contractual requirements. The supplier’s personnel **shall** be made available for operation of such devices and for verification of their accuracy and condition. Product acceptance does not imply supplier’s product will not be rejected upon receipt at Howmet, should a deviation be found.

Government Source Quality Assurance Inspection - When specified on the Howmet purchase order, Government Source Quality Assurance Inspection is required prior to shipment from the supplier's plant. Upon receipt of the purchase order or a letter of delegation, the supplier **shall** promptly furnish a copy to the Government Inspector who services the supplier's plant. In the event delivery of the items will be delayed due to inspection requirements, the supplier shall contact the Howmet buyer immediately. Evidence of the inspection **shall** be indicated on all shipping documents.

Packaging and Crating - Material packaging **shall** be properly identified to include the name of the manufacturer; product nomenclature, commercial and/or Howmet specification product designation identification; lot or batch designation number; gross and tare or net weight, and shelf-life expiration date. In situations where returnable packaging or carts are in place, the supplier **shall** label containers as defined by the procuring Howmet facility. If applicable, regional requirements for hazardous material shipments shall apply. When stipulated in the Howmet purchase order, all wood products used in packaging, crating and pallets **shall** be in compliance with the International Standard for Phytosanitary Measure (ISPM15) guide for regulatory wood and wood packaging in international trade. All products **shall** be labeled with the applicable Country of Origin.

Delivery - The supplier **shall** ensure that the accompanying shipping documents are protected from damage, i.e., enclosed in a weather-protected envelope and marked "Shipping Documents" or facsimile.

Contractually Provided Technical Data - Suppliers to Howmet **shall** be responsible for obtaining all necessary International Traffic in Arms Regulations (ITAR) or Export Administration Regulations (EAR) export approvals and for maintaining compliance with all export control requirements. If it is not clear whether this provision applies, contact the Howmet Procurement representative. All Howmet documents and / or technical data, electronic or otherwise, furnished by Howmet as a provision of the purchase order shall be returned to the appropriate Howmet facility upon completion or termination of the purchase order, or at the purchaser's discretion.

13. DOCUMENTED INFORMATION / RECORDS AND RETENTION:

Part, material, product and service-related tooling records, purchase orders, and amendments are to be maintained for the length of time that the contract is active plus one calendar year. Product related manufacturing and inspection records are required to be maintained for 10 years unless otherwise specified in the contract. Records shall be maintained in an appropriate environment and **shall** be available upon request within two business days.

For *ceramic core dies and wax pattern* dies, all electronic tooling models, tool drawings, die cavity component material certifications, and die cavity component heat treatment records **shall** be maintained a minimum of 10 years past the tooling ship date unless otherwise specified. All information **shall** be available upon request within two business days.

Quality system administrative records, such as internal audits and nonconformance's, **shall** be retained for seven years unless otherwise stated in the contract.

External suppliers that generate X-Ray, N-Ray and other NDT records on product purchased by Howmet, are required to provide those records to the procuring Howmet facility with shipment of the product.

14. NONCONFORMING MATERIAL:

Products and services provided from suppliers made and provided to specifications is important in Howmet ability to produce conforming product for our customers. Material that departs from drawing, specification, or maintenance requirements **shall** be properly identified, segregated, and controlled to prevent unauthorized use or delivery to Howmet or other designated destinations.

Material Review Authority - The Supplier **shall** not use dispositions of 'use as is or 'repair' without written approval by Howmet's Quality organization. Action **shall** not be taken on any nonconformance which could affect safety of personnel; adversely affect performance durability, interchangeability or reliability, materially affect weight; or otherwise result in failure of the end article to perform its intended function. All doubtful cases **shall** be submitted to Howmet for review. Howmet reserves the right to reject the decision of the Supplier's Material Review Board.

Concessions - The Supplier may request concession consideration for nonconforming material that cannot be reworked to fully conform to drawing or purchase order requirements. Suppliers **shall** use the Supplier Discrepancy Action Request (SDAR) form to obtain disposition from the applicable Howmet location quality representative. If unsure who the applicable quality representative is, the supplier should submit the request to procurement. The SDAR form **shall** be complete and concise and accompanied with supporting information such as: dimension(s) affected, drawing locations(s), photographs, sketches, chemistry, or physical analysis for material deviations, etc. The SDAR form can be located from the following website: (https://www.howmet.com/bu-supplier-information/).

Escapes to Howmet - The supplier **shall** provide prompt notification to both the Howmet Buyer and the site Supplier Quality Representative if nonconforming product or process escapes are identified after shipment to Howmet has taken place. The notification **shall** include part numbers, traceability (lot, serial, and manufacturer numbers), ship dates, quantities, and a description of the nonconformance. This applies to any nonconformance that departs from the drawing, specifications, purchase order requirements, etc. Once the initial notification is complete, the supplier **shall** initiate the corrective action process per section 14.0- Corrective Action.

Containment of Nonconforming Material - When a nonconformance is discovered or the Supplier is notified of a discrepancy, the Supplier **shall** take immediate action to determine if the condition exists on any other work in process, in Stores at the Supplier's facility, or in prior shipments. Containment action **shall** be taken and documented prior to the next shipment of the part number involved. Product identified on a Partial Shipment as source inspection accepted **shall** be re-inspected prior to shipment. The Supplier **shall** not wait for the discrepant product to be returned to begin an investigation.

Return Purchase Orders for Replacement, Reworked or Repaired Product - Product that is supplied to Howmet on a return purchase order **shall** either fully comply with all drawing requirements or have Howmet MRB approval through a signed Return Material Authorization for any repairs. Product that cannot be reworked to full drawing compliance, or where repair authorization will not be granted, **shall** be dispositioned as defined by the purchasing facility. Product that is dispositioned to scrap at the supplier's facility **shall** be mutilated prior to disposal

Return of Howmet Consigned Material - Howmet may supply material or component product for inclusion in product manufacturing. If the material or component product that were supplied by Howmet are discrepant, or in excess quantity, they **shall** be returned by the Supplier. The Supplier **shall** not return component product without

authorization from the Howmet Buyer. The Supplier **shall** clearly identify the reason for the return on the packing slip.
Cost Recovery – Howmet reserves the right to recover all incurred costs related to nonconforming product produced from the responsible supplier(s).

15. CORRECTIVE ACTION:

If nonconforming product escapes to Howmet, the supplier **shall** take corrective action immediately regardless of where the nonconformance was identified, i.e., the supplier's facility, at Howmet, in transit, at a Howmet customer, etc. This is to ensure nonconforming product is contained, root cause of the problem is identified, including, as applicable, those related to human factors and proper actions are put in place to prevent the recurrence in the process.

If nonconforming product has been identified, the supplier **shall** place their operations on immediate containment to protect Howmet from receiving additional defective material. Incidents of defective material may also require supplier containment at the Howmet facility. In such cases, the supplier shall be responsible for performing the sort inspection on-site (if possible). Some supplier related problems may require the use of a 3rd party source inspection at the cost of the supplier to ensure containment of the problem.

When performing a corrective action investigation, at a minimum, the supplier **shall** perform the following actions:

Identify the problem
Quarantine all suspect material, including raw material
Establish a clear break point for the nonconforming material
Review all suspect product to determine a disposition
Identify root cause of the nonconformance
Implement appropriate corrective actions
Validate the effectiveness of the implemented corrective actions
Update all appropriate documents to include the new controls implemented
Apply corrective actions to all like and similar processes to prevent a recurrence of the issue

Corrective action plans **shall** be reviewed with the Howmet facility SQA. Initial supplier response shall be submitted in writing within 48 hours of problem notification to the facility SQA or as directed on the Supplier Corrective Action Request (SCAR). Suppliers will be measured on the timeliness of their response. An adequate corrective action plan **shall** be submitted to Howmet within 10 business days, including responsibilities and planned completion dates. Howmet will track completion of the action plan with the supplier.

If required, the 3rd party inspection **shall** remain in place until the root cause of the problem has been identified and Howmet SQA is satisfied that the corrective action has been implemented and verified that it eliminates the problem.

Preventive actions shall be implemented to protect Howmet from receiving nonconforming product. If an escape to an Howmet facility is identified, the supplier **shall** not only correct the issue as identified above and provide Howmet with acceptable product, but also identify the deficiency in the quality planning process that allowed the nonconformance to occur and escape to Howmet.

16. DPD: Digital Product Definition:

Definitions:

Authority - Undisputed source of Howmet approved dataset for product manufacture and quality assurance acceptance.

CAD - Computer Aided Design; any computer(s), system(s), program(s) that assist engineering in the design, development, production and evaluation of design, data and drawings.

CAE - Computer Aided Engineering; the use of computers to develop engineering data to supplement engineering designs for use in production and inspection.
CAI/CMS - Computer Aided Inspection/Coordinate Measuring Systems; measurement equipment such as a CMM (Coordinate Measuring Machine), Laser Tracker, and numerical controlled machinery with inspection probe capability used to support inspection activities.

CAM/NC - Computer Aided Manufacturing/Numerical Control – manufacturing machines using computer(s) and computer data in the development and production of all parts, development and production and includes fabrication, assembly, and installation.

Dataset - Information/data prepared and maintained by electronic means (CAD/CAM) and provided by electronic data access.
Derivative - A reproduction of all or part of an authority dataset. Derivatives include paper and Mylar plots, tool designs, inspection datasets created to analyze as-built designs, check templates, numerical control datasets/media, dataset with nominal values for CMS use, QA inspection plans and other extractions for inspection/measurement use.

DPD - Digital Product Definition; the electronic data elements that specify the 3D CAD geometry and all design requirements for a product including notation and parts list, etc.

Feature - any part/product design attribute or characteristic. This includes physical portions such as a surface, face, edge, radius, hole, tab, slot, pin, etc. and requirements of NDI (nondestructive inspection). All features require validation of conformance to the design authority.

IGES - Initial Graphics Exchange Specification; the American National Standards Institute (ANSI) data standard for the exchange of computer graphics generated product definition (no solids) between different manufacturers.

MBD - Model Based Definition – a dataset containing the exact solid, its associated 3D geometry and 3D annotation of the product's dimensions and tolerances (and may include parts list/notes) to specify a complete product definition. This does not include a conventional 2D drawing. MBD is one possible format of DPD.

PAS - Product Acceptance Software; any software that performs product or tooling acceptance without subsequent inspection. Common applications include CMM, Laser Trackers, Laser Radar, CAD translators and CAD analysis software.

PTF - Program Temporary Files-software changes or additions released by the software manufacturer to correct user application problems before the next major software version is available.

Reduced Content Drawings/Minimal Definition Drawings - Any DPD dataset without full dimensioning of product features on a 2D sheet/drawing. These contain reference to a 3D surface definition of CAD geometry.

Special Tooling - Tools of such a specialized nature that without modification or alteration, their use is limited to the development and/or manufacture of production parts and assemblies. Examples of these tools include jigs, fixtures, molds, patterns, and gages identified by site specific documentation.
Translation - the resulting file/definition that occurs when a digital dataset is changed from its original CAD system format to another CAD, CAM and CAI application format and require verification.

Documented Processes
The Supplier **shall** develop and maintain comprehensive, documented DPD processes and procedures that address the integrity of engineering, tooling and configuration is maintained from receipt of Howmet data through the creation of derivatives to product acceptance and process improvement.

The documented procedures shall include;
Flow diagram (see below);

Change control and notifications (see below);

Configuration management and media security, including storage, archiving, encryption, backup and access Control;

Configuration management and traceability, including a formal release process, supplier planning/traveler traceability to current dataset, change control, and control of obsolete datasets;

Engineering Design, including customer (Howmet) approval, addressing critical and/or key characteristics and design traceability to drawings, parts lists and specifications required to define the configuration;

Product Acceptance Software (PAS)/Commercial Off the Shelf Software including identification of PAS by application (including version identification and obsoleting), limited access, prevention of unauthorized changes and verification prior to use;

Computer Aided Manufacturing (CAM) Software including configuration identification and control, verification of numerically controlled software and verification prior to use;

Supplier Developed Software;

Training – inclusive of all elements **shall** include competence evaluation, records, on-the-job training, and evaluations for all functions e.g., quality, IT, engineering, manufacturing, inspection, contract review, planning, and purchasing. All training will be updated to remain current with changes to hardware, software, and program requirements;

Coordinate Measuring Systems, including Optical Lay-up Templates. These procedures must address environmental deviations and coefficient of thermal expansion when/if used in a non-controlled environment. See Below;

Inspection Media, including method of inspection and instructions for validation of each digitally defined product feature (for first article inspection and production inspections), traceability to authority dataset, configuration control, testing or validation process, inclusion of sufficient graphics and qualified personnel.

Use of Plots for Inspection Media including ordering, storage and verification of customer supplied plots and calibration, verification of engineering definition and acceptance criteria of plot accuracy and quality inspection stamping of supplier created plots.
Note: FLOW DIAGRAM: The flow diagram **shall** graphically depict the flow of data through the DPD system from receipt of Howmet data. The diagram shall specify all segregated, secure storage locations of authority and derivative media. The diagram **shall** specify all departmental organizations responsible for the delivery of Howmet data or supplier derived data to sub-tier suppliers. The diagram **shall** also identify the documented DPD processes and work instructions associated with control of the datasets and derivatives.

Note: CHANGE CONTROL: The DPD documentation **shall** include the current level of hardware configuration, software, software revisions and other digital system information (e.g., PTF(s), project files) required to maintain compatibility with Howmet supplied datasets and/or data exchange formats.

Note: COORDINATE MEASURING SYSTEMS: CMS procedures must also address purpose for each type of equipment, calibration, testing of PAS, field checks (if applicable), drift point/stability, temperature compensation/scale factors, establishment of a coordinate system, multiple station set-up criteria, data analysis, data reports and record retention.

The supplier **shall** update their data system profile and notify their Howmet customer and Howmet SQA with 30 days of any changes to:
The documented DPD processes;
CAD, CAM, CAI software;
Addition of new DPD equipment and/or measurement equipment;

When requested suppliers must submit annually the Supplier Digital Data Self-Assessment Survey, including any updates to their data system profile.

Supplier's quality system must also include DPD requirements in the internal audit program, problem reporting, corrective and preventative action programs and Procurement activities (including sub-tier control, export control, right of access for survey and review and flow down of all Howmet requirements).

Control of Measuring Equipment
All Coordinate Measurement Systems (CMS) will be included in the Calibration Recall system and subject to all the same requirements, record keeping, and identification. The calibration standards of the CMS equipment **shall** be traceable to NIST or equivalent international standards and **shall** meet original equipment manufacturer requirements.

Reduced Content Drawing

If reduced content drawings are involved the supplier must be able to receive any associated 3D models and extract sufficient information from it for manufacturing and inspection, in addition to the 2D drawing. Suppliers must be able to identify, and document all features on the 2D drawing and features on the 3D model that are not on the 2D drawing, flag notes, parts list, and other specifications, and develop process specifications/procedures for fabrication and manufacturing processes.

Model Based Definition

Suppliers receiving engineering and/or tooling MBD datasets must be able to extract sufficient information for manufacturing and inspection activities. Suppliers QA must be able to verify all features and design requirements including control frames, specifications, notes, etc. are identified and planned for in validation and inspection activities.

First Article Inspection

All features must be reported for First Article Inspections per BOP 630.000.001, First Article Inspection Procedure.

Data Exchange Methods

Suppliers **shall** maintain the current level of hardware, software, software revisions, and other required digital system elements necessary to maintain compatibility with Howmet supplied datasets and/or data exchange formats. Suppliers must be able to receive, validate, and store all authority datasets without changing the data integrity.

Translations

Suppliers are responsible for all dataset translations used in manufacturing and inspection. A clearly documented process must exist and include a method to verify the accuracy of translations and ensure the acceptance criteria of the translated surface is within engineering/specification tolerances. Objective evidence of the translation validation must be retained. Typical allowable deviation tolerance is 0.0001 to 0.001 inch. The verification process must ensure all intended entities are accounted for in the translation. The supplier must be able to demonstrate the CAD translation process including verification/interrogation methods used and the ability to identify known discrepancies.

Special Tooling

Documented procedures **shall** exist to describe the processes for release, acceptance, identification, security, access and change control of tool design and tool inspections datasets. Tooling datasets will have traceability to current authority engineering and derivative tooling dataset sources. The engineering authority dataset(s) will be identified on the tool design when applicable. All digitally defined tooling and inspection media will be identified and traceable to the authority tool design dataset and any tool inspections datasets. Tools and tooling media will be accepted and periodically validated to the authority design to ensure accuracy and repeatability of the tool prior to use.

17. GENERAL:

Supplier Performance Reviews - Active and approved organizations that supply critical product, materials and services that directly influence the quality of Howmet manufactured products are subject to periodic performance reviews and may receive a Supplier Scorecard. Organizations with less than adequate performance will be

required to take immediate corrective and preventive action. A failure to adequately address Howmet performance issues in a timely manner may result in disqualification and loss of business.

Preference for Domestic Specialty Materials - Supplier **shall** agree to comply with Defense Federal Acquisition Regulation Supplement DFAR 252.225-7014 and Alternate I, Preference for Domestic Specialty Metals when this clause is specified in the purchase order. Use of foreign specialty metals may only be used with written authorization from Howmet Corporate Procurement. Material substitutions are prohibited without formal approval by Howmet.

Product Conformity - Suppliers **shall** ensure that their employees are aware of their contribution to product or service conformity.

PRODUCT SAFETY - Suppliers **shall** control the processes to assure the product safety, when the product can perform to its designed or intended purpose without causing unacceptable risk of harm to persons or damage to property. Suppliers **shall** make employees aware of their contribution to product safety**.**

SDS - Safety Data Sheets are required for all raw materials and chemicals.

Appendix A

PRELIMINARY KEY PROCESS CHARACTERISTICS INDEX

The processes and subsequent process key characteristics contained in this directory are the process variables (input variables) that have a cause-and-effect relationship with one or more Howmet Castings product characteristics. As such, each of these special process characteristics must be listed in the control plan and routinely monitored to ensure control of the process.

1. Abrasive Blasting
   a) Pressure (air or liquid)
   b) Nozzle distance from part
   c) Nozzle angle to the surface of the part
   d) Blasting cycle
   e) Range of rotational speed if a worktable is used
   f) Abrasive material, size, and type
   g) Masking material and procedure
   h) Pre- and post-cleaning procedure
2. Furnace Brazing
   a) Heat rate(s) (e.g., power percentages, ramp rates, degrees F/min.)
   b) Hold time(s) and temperature(s) for out-gassing, stabilization and time at established braze temperature.
   c) Chart speed(s)

d) Cooling rate(s) - include all times and temperatures for stepped cooling cycles

2.1 Furnace Atmosphere
- a) Inert gas and dew point
- b) Vacuum pressure
- c) Quenching method (vacuum cool, gas cool, fan cool, argon, backfill)
- d) Quenching gas
- e) Furnace manufacturer, type, and serial number
- f) Stacking and number of parts per load
- g) Sketch of location and orientation of parts and thermocouples in the furnace
- h) Number and type of thermocouples and method of attachment

2.2 Alloying
- a) Specification of alloying material
- b) Form of alloy (paste, tape, foil, etc.)
- c) Application method and quantity of alloy (e.g., alloy bead size, width, thickness of tape, etc.)
- d) Stop-off location, application method, and type.

2.3 Plating
- a) Plating procedure prior to brazing (if applicable)
- b) Pre- and post-cleaning procedures

3. Casting Process
   a) Melting practice used
   b) Mold or investment constituents used
   c) Number and positions of parts per mold
   d) Pre-Heat practice used
   e) Pouring temperature used
   f) Mold cooling technique used
   g) Gating and riser location used
   h) Casting method used (permanent mold, sand mold, centrifugal, etc.)
   i) Mold temperature and control used
   j) Melting and casting atmospheres used (vacuum, inert gas, etc.)
   k) Number and location of chilled bars used
   l) Source and kind of raw materials used
   m) Post-casting treatment used (chemical, mechanical, etc.)

4. Chemical Milling
   a) Temperature of chemical solution
   b) Concentration of chemical solution
   c) Etch rate (mils/min/surface)
   d) Time in solution
   e) Chemical agents (type and grade)
   f) Masking material
   g) Materials used for cleaning and benching (if required)
   h) Methods of agitation (air, mechanical, etc.)

5. Ceramic Core Manufacturing (Refer to Specification PM 301)

6. Diffusion Coating
   a) Materials:
      1. Source
      2. Type of wax
      3. Type of masking
      4. Material preparation
   b) Part cleaning
   c) Retort design
   d) Coating procedure:
      1. Packing (parts per retort, retorts per level, etc.)
      2. Furnace loading diagram
      3. Furnace design
      4. Thermocouple type and location
      5. Atmosphere
      6. Time at temperature
   e) Post-coating heat treat
   f) Post-coating cleaning

7. E B (Electron Beam) Welding
   a) Base filler and metal name(s) and specification
   b) Material and position of run-off and run-on tabs
   c) Method of joint tracking (manual or computer)
   d) Computer tracking parameters
   e) E B tack weld parameters
   f) E B welding parameters
   g) Beam stopper material and placement
   h) Weld joint configuration
   i) Maximum allowable gap

8. ECM (Electrochemical Machining)
   a) Machining voltage range
   b) Electrode feed rate
   c) Electrolyte temperature range (at tool inlet or electrolyte supply)
   d) Electrolyte concentration, pH, and conductivity range
   e) Electrolyte pressure range at tool inlet and outlet (if closed flow)
   f) Maximum amperage
   g) Electrolyte flow direction
   h) Starting gap
   i) Post-ECM cleaning procedure

9. EDM (Electro-Discharge Machining)
   a) On time
   b) Dielectric used (type/mfr. of oil)
   c) Average time
   d) Electrode material
   e) Peak current
   f) Power supply (solid state or tube type)
   g) Voltage
   h) Wave form (sine or square)
   i) Voltage type (std, hi-pol, lo-pol)
   j) Dielectric flushing method
   k) Microfarads
   l) Post-EDM cleaning procedure

10. Forging Processes
    a) Forging temperature used
    b) Number and temperature of reheats used during forging
    c) Number of strikes or amount of reduction per strike and reheats
    d) Total percentage of reduction during the forging process
    e) Type of forging die used
    f) Forging method used (drop forge, pressure forge, ring rolling, etc.)
    g) Cropping method used
    h) Billet size and shape used
    i) Source and process of ingot to billet conversion process used

j) Die insulation and lubricant used
k) Post-forging treatment used
l) Forging press rate

11. Heat Treatment
    a) Cycle description, including time (ramp, hold, etc.) temperature, atmosphere and cooling medium
    b) Furnace description (type, manufacturer, serial number)
    c) Assembly and racking instructions, including part orientation if this is controlled (sketches may be used)
    d) Materials that contact parts (e.g., fixturing, supports, protective wraps, etc.)
    e) Location and type of work load thermocouples and the methods used to attach the T/C's to the part
    f) The criteria for when parts are considered at temperature and for start or stop of the time at temperature cycle.
    g) Pre- or post-heat treat cleaning instructions
    h) Location and type of test samples (if applicable)

12. HIP (Hot Isostatic Pressing)
    a) Cycle description including time (ramp, hold, etc.) temperatures, pressures, and pressure media
    b) Pressure vessel description including autoclave mfr., model number, serial number, and capacity
    c) Part positioning in the pressure vessel
    d) Materials coming in contact with the parts (fixtures, supports, etc.)
    e) The maximum number of parts in the pressure vessel
    f) Location and type of thermocouples
    g) The criteria for start and stop of the time at temperature and pressure cycle
    h) Pre- or post-HIP cleaning procedures
    i) Location and type of getter material (if used)

13. Hot Forming
    a) Ram force (pressure)
    b) Temperature of the hot form press
    c) Time at temperature and alarm set point
    d) Tooling
    e) Die and part lubricant
    f) Die material

14. Laser Drilling, cutting and marking
    a) CNC program number and revision date
    b) Number of shots
    c) Power, energy or voltage
    d) Pulse rate and length
    e) Nozzle air or gas type
    f) Laser type (mfr., model, and serial number)
    g) Fixturing

15. Laser Joining
    a) Laser type (manufacturer and serial number)
    b) Microprocessor type
    c) Pulse rate and length
    d) Fixturing
    e) Program number and revision date
    f) Power, energy or voltage
    g) Mirror or lens focal length
    h) Mirror or lens focal length to part
    i) Traverse speed
    j) Distance between passes
    k) Number of layers
    l) Beam angle to part
    m) Beam mode
    n) Wire filler (size and feed rate

16. Plasma Arc Welding
    a) Automatic or semi-automatic processes
        1. Distance from orifice to work piece
        2. Current
        3. Arc voltage
        4. Orifice diameter
        5. Travel speed
        6. Sequence of welding
    b) Manual Processes
        1. Sequence of welding

17. Plating
    a) Type of bath
    b) Constituent composition
    c) Plating solution pH
    d) Solution temperature
    e) Current density
    f) Plating time
    g) Voltage
    h) Part cleaning and activation procedure
    i) Masking procedure
    j) Strip and replate procedure
    k Post-plating baking process

18. Resistance (spot or seam) Welding
    a) Welding current
    b) Welding time
    c) Spacing between welds
    d) Electrode design and dimensions
    e) Electrode material
    f) Weld equipment (manufacturer, model, and serial number)

19. Shot Peening
    a) Equipment type
    b) Nozzle size
    c) Nozzle angle and distance from part
    d) Number of nozzles used
    e) Air jet and size
    f) Air pressure
    g) Shot size, hardness and specification
    h) Cycle time
    i) Number of cycles
    j) Almen strip location
    k) Table rotation and oscillation speed and distance
    l) Nozzle oscillation speed and distance
20. STEM Drilling
    a) Electrolyte concentration
    b Cleaning procedure following stem drilling
    c) Acid used (name and specification)

21. Stress Free Grinding
    a) Speeds and feeds used
    b) Manufacturer of and type of abrasive wheels used
    c) Type and control of coolant used

22. Thermal Spray
    a) Thermal spray parameters
    b) Spray set-up
    c) Masking
    d) Spray gun to part angle orientation
    e) Relative motion of gun to part
    f) Location of cooling air jets
    g) Location of test panels

23. Titanium Chemical Cleaning
    a) Alkaline Cleaning
        1. Alkaline material (specification and mfr.)
        2. Concentration (oz./gal)
        3. Water Temperature
        4. Time

b) Descaling / Cleaning
   1. Descaling compound (specification and mfr.)
   2. Temperature
   3. Concentration
   4. Time

c) Acid Etch
   1. Nitric acid concentration
   2. Hydrofluoric acid concentration
   3. Water percentage
   4. Temperature

d) Rinse Cycle
   1. Water and air pressure
   2. Time
   3. Temperature

e) Minimum resistance in ohms/cm for deionized water

f) Marking material (if used)

24. <u>TIG (Tungsten Inert Gas) Welding</u>

a) Automatic or Semiautomatic processes
   1. Current
   2. Polarity
   3. Power supply type
   4. Arc voltage
   5. Travel speed (automatic TIG weld operation)
   6. Electrode type and size
   7. Filler material, size and type
   8. Sequence of welding

b) Manual TIG Welding
   1. Sequence of welding

Appendix B

SUPPLIER TYPES and PRODUCTS AND SERVICES DESCRIPTIONS

Brokers / Traders	- Base Transition Metals - Earth and Rare Earth Metals - Recycled and Re-Processed Scrap Metals
Component Supplier or Outside Processor	- Ceramic Core Manufacturing Services - Wax Pattern Production and Assembly Services - Hot Isostatic Pressing (HIP) - Casting Services - Impregnation Services - Machining Services - All types - Mechanical Finishing Services - Metal Fabrication - Airfoils
Laboratory / Test Facility	- Calibration Services - non-OEM calibration services - Dimensional Measurement Services - Laboratory Testing Services
Quality Support Svs	- Assessment Services (3rd party) - Imaging Services - document imaging, record retention, etc. - Laboratory Proficiency Testing Admin. Services - Round Robin Testing - Records Retention / Retrieval - full-service supplier
Pass-Through Distributor	- Product Manufactured to Howmet Specifications, but are not physically processed, tested, or repackaged before they are shipped to Howmet.
Raw Material and Process Material Supplier	- Abrasive Products - Adhesives - Alloy - Alloy Services - bar peeling, centerless grinding, drawing, ingot to billet conversion, rolling, shearing, and straightening - Braze materials - powders, alloy, fillers, etc. - Ceramic Core Materials - Ceramic Crucibles and Materials - Ceramic Products - (Non-Spec'd; Crucibles, Cups, Blankets, Dies, etc.) - Chemicals - (Non-Spec'd; Acetone, Chloride Solutions, Hydrogen Peroxide, etc.) - Cleaning Materials - Fasteners - screws, rivets, nuts, helicoils, pins, etc. - Forging Services - Gas Products - Hot Forming Services - Lubricants - Metals

	- Mono-Shell Materials - NDT Materials Supplier - X-ray film, solutions, etc. - SLA Prototypes - Thermocouple Manufacture - Wax Materials - Wrought Products
Special Process Supplier	- Heat Treat and Brazing Services - Chemical Processing - anodizing, cleaning, milling, plating, stripping, surface treatment, etching - Coating (of parts) - coating, plating, thermal spray, prime/painting, etc. - Non-Destructive Testing Services - Liquid Penetrant, Magnetic Particle, Ultrasonic, Radiographic (X-Ray and N-Ray_ - Surface Enhancement Services - shot peening, peen forming, glass bead peening - Materials Testing Services - including Test Bar Machining - Welding Services - Non-Conventional Machining - EDM, ECM, ECG, and LBM
Tooling Suppliers	- Manufacturers of production dies, fixtures, gages, and design services. - Die Coating and Plating - Pressure Testing Services

End of Document.