



Standard Practice for Hot Isostatic Pressing of Steel, Stainless Steel, and Related Alloy Castings¹

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1. Scope*

1.1 This practice covers general requirements for Hot Isostatic Pressing (HIP) of steel, stainless steel, and related alloy castings.

1.2 *Units*—The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:²

A703 Specification for Steel Castings, General Requirements, for Pressure-Containing Parts

A781 Specification for Castings, Steel and Alloy, Common Requirements, for General Industrial Use

A957 Specification for Investment Castings, Steel and Alloy, Common Requirements, for General Industrial Use

A985 Specification for Steel Investment Castings General Requirements, for Pressure-Containing Parts

E220 Test Method for Calibration of Thermocouples By Comparison Techniques

2.2 AMS Standards:³

AMS 2750 Pyrometry

3. Terminology

3.1 Definitions:

¹ This practice is under the jurisdiction of ASTM Committee A01 on Steel, Stainless Steel and Related Alloys and is the direct responsibility of Subcommittee A01.18 on Castings.

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

³ Available from SAE International (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001, <http://www.sae.org>.

3.1.1 *autoclave, n*—a pressure-containing vessel used in the HIP process.

3.1.2 *hot isostatic pressing (HIP), n*—a solid state process which applies heat and pressure simultaneously to objects in an autoclave via an inert gas in such a way as to eliminate internal voids and obtain desired properties.

3.1.3 *inert gas, n*—a nonoxidizing gas used for pressurizing a HIP vessel.

4. Ordering Information

4.1 The authorization or requirement for hot isostatic pressing (HIP) shall be agreed upon between purchaser and supplier and must be documented.

4.1.1 The Supplementary Requirements of the Common Requirements Specifications contain a section for authorization of hot isostatic pressing (HIP) of castings. These Common Requirements Specifications include, but are not limited to:

A703 Specification for Steel Castings, General Requirements, for Pressure-Containing Parts

A781 Specification for Castings, Steel and Alloy, Common Requirements, for General Industrial Use

A957 Specification for Investment Castings, Steel and Alloy, Common Requirements, for General Industrial Use

A985 Specification for Steel Investment Castings General Requirements, for Pressure-Containing Parts

4.2 The HIP processing parameters shall be as agreed upon between the purchaser and supplier.

5. Quality Requirements

5.1 The HIP process shall at a minimum document and have traceability for:

5.1.1 Operating parameters for each autoclave/vessel used in production.

5.1.2 Software and instrumentation used for control and documentation purposes.

5.1.3 Gas used to backfill or quench.

5.1.4 Contact fixturing within the autoclave.

5.2 Methods of gas dilution, replenishment, reuse, and purification shall be documented in a written procedure.

5.3 Fixtures, plates, trays, spacers, hangers, containers and baskets shall be made of a material compatible with the parts

to be treated or shall be adequately isolated to assure that undesirable reactions, product contamination and distortions do not occur.

5.4 Prior to pressurization, adequate care shall be taken to ensure that no product contamination occurs.

6. Autoclave Type/Qualification

6.1 Autoclave shall consist of inert gas pressurization, internally heated cold wall pressure vessel type.

6.2 Unless otherwise specified, the selection and type of inert gas shall be at the discretion of the HIP processor.

6.3 When argon is used, the gas emanating from the autoclave prior to hot isostatic pressing shall be a minimum of 99.98% by volume (200 ppm total impurities) as determined by online gas analysis and shall not exceed the requirements specified in **Table 1**.

6.4 When a gas other than argon is used, the type and purity level shall be agreed upon by the purchaser and supplier prior to processing.

7. Temperature Uniformity

7.1 A temperature uniformity survey shall be conducted at a 6 month maximum interval on each HIP unit using a typical production load of parts or material under typical operating parameters.

7.2 A minimum of two thermocouples for each heating zone in the working volume of the HIP unit shall be used for determining temperature uniformity, one positioned at the centerline and the other at the outside diameter of the heating zone. More than two thermocouples may be used if desired.

7.3 For production HIP cycles, when approaching thermal equilibrium none of the load monitoring thermocouple readings shall exceed the selected control temperature by more than the allowable tolerance as specified by the purchaser. After reaching thermal equilibrium temperature variation of any load

monitoring thermocouple shall not vary more than the allowable tolerance as specified by the purchaser.

8. Temperature Measurement and Control

8.1 Temperature measuring devices shall be provided for the autoclave. A permanent record of temperature during the entire cycle shall be maintained.

8.2 Temperature uniformity measurements shall be made using thermocouples calibrated to ASTM **E220** or AMS 2750.

8.3 The accuracy of each instrument shall be determined by using the equipment manufacturer's recommendations.

8.4 The temperature control system shall have an accuracy of ± 0.5 % of the maximum operating temperature over the entire operating temperature range.

8.5 After initial qualification, each instrument's calibration shall be verified at an interval of at least every 90 days.

9. Pressure Measurement and Control

9.1 Pressure measurement shall be made using sensors calibrated in accordance with the equipment manufacturer's recommendations.

9.2 The equipment's performance shall be within the limits supplied by the manufacturer.

9.3 After initial qualification, each instrument shall be re-qualified at a yearly interval.

9.4 Pressure levels shall be monitored and maintained as follows:

9.4.1 A minimum of one pressure sensor shall be used to monitor the pressure of the working zone.

9.4.2 Pressure readings from each sensor shall be recorded during heat-up and temperature hold at intervals not to exceed five minutes per sensor.

10. Gas Measurement

10.1 Gas purity as described in **6.3** shall be determined by use of gas chromatographic analysis or other suitable methods that have been agreed upon between the purchaser and supplier.

10.2 Frequency of gas analysis shall be performed as agreed upon between the purchaser and supplier.

11. Keywords

11.1 HIP; HIP'ing; Densification; Shrinkage; Porosity; Hot Isostatic Pressing

TABLE 1 Argon Gas Purity Requirements

Impurity Element	Maximum % by Volume	ppm (vol/vol)
Nitrogen	0.005%	50
Hydrogen	0.0125%	125
Oxygen	0.0025%	25
Hydrocarbons	0.0025%	25
(as methane, CH ₄)		
Total	0.020%	200
Dewpoint (H ₂ O)		-45°C