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Standard Practice for Extrusion Press Solution Heat Treatment for Aluminum Alloys[1]

This standard is issued under the fixed designation B807/B807M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This practice establishes the controls required for extrusion press solution heat treatment of the 6xxx and 7xxx series aluminum alloys in Table 1 when ASTM material specifications allow use of this process in lieu of furnace solution heat treatment. For the alloys listed in Table 1, this practice is an alternate process to solution heat treatment in a furnace, such as specified in Practice B918/B918M for the attainment of T3, T4, T6, T7, T8, and T9-type tempers (see ANSI H35.1/H35.1M).

1.2 This practice applies only to extrusion press solution heat treatment for aluminum alloys. Precipitation hardening (aging) and annealing processing and equipment calibration shall meet the practice and requirements of Practice B918/B918M.

1.3 The values stated in either Metric SI units or ~~inch-pound~~ US Customary units are to be regarded separately as standard. The Metric SI units are shown in brackets or in separate tables. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.4 *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~~ safety, health, and ~~health~~environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 The following documents of the issue in effect on the date of material purchase form a part of this specification to the extent referenced herein:

2.2 *ASTM Standards:*[2]
B557 Test Methods for Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products
B557M Test Methods for Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products (Metric)
B647 Test Method for Indentation Hardness of Aluminum Alloys by Means of a Webster Hardness Gage
B648 Test Method for Indentation Hardness of Aluminum Alloys by Means of a Barcol Impressor
B881 Terminology Relating to Aluminum- and Magnesium-Alloy Products
B918/B918M Practice for Heat Treatment of Wrought Aluminum Alloys
E10 Test Method for Brinell Hardness of Metallic Materials
E18 Test Methods for Rockwell Hardness of Metallic Materials
E2281 Practice for Process Capability and Performance Measurement

2.3 *ASTM Manual:*[2]
ASTM MNL 7 ~~Manual on~~ Presentation of Data and Control Chart Analysis

2.4 *ANSI Standard:*[3]
H35.1/H35.1M Alloy and Temper Designation Systems for Aluminum

[1] This practice is under the jurisdiction of ASTM Committee B07 on Light Metals and Alloys and is the direct responsibility of Subcommittee B07.03 on Aluminum Alloy Wrought Products.

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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 Aluminum Association, ~~Inc., 1525 Wilson Blvd., Suite 600,~~1400 Crystal Dr., Suite 430, Arlington, VA ~~22209,~~22202, http://www.aluminum.org.

***A Summary of Changes section appears at the end of this standard**

~~TABLE 1 Extrusion Billet or Log Temperature High Limit~~[A]

~~Alloy~~	~~Billet or Log Temperature~~	
	~~Upper °F~~	~~[Upper °C]~~
~~6005A, 6105~~	~~1050~~	~~565~~
~~6061, 6262, 6041, 6064~~	~~1050~~	~~565~~
6060, 6063, 6101, 6463, 6360, 6560	1060	570
~~6351, 6082,~~	~~1050~~	~~565~~
~~6066, 6070~~	~~1020~~	~~550~~
~~7004, 7005~~	~~1000~~	~~540~~
~~7029, 7046, 7116, 7129, 7146~~	~~1000~~	~~540~~

TABLE 1 Extrusion Billet or Log Temperature High Limit[A]

Alloy	Billet or Log Temperature	
	Upper °F	[Upper °C]
6060, 6063, 6101, 6463, 6360, 6560	1060	570
6005A, 6005, 6105, 6008, 6061, 6262, 6064, 6351, 6082, 6040, 6041, 6042, 6064	1050	565
6066, 6070, 6010, 6013	1020	550
7004, 7005, 7046, 7146, 7046A	1000	540
7003, 7108A, 7029, 7116, 7129	980	525

[A] These upper limit temperatures ~~avoid~~reduce the possibility of eutectic melting due to overheating, and include a safety ~~factor~~margin of approximately ~~25°F [15°C] degrees.~~25 °F [15 °C].

3. Terminology

3.1 ~~*Definitions*—~~*Definitions:*

3.1.1 Refer to Terminology B881 for definitions of product terms used in this specification.~~Refer to Terminology B881 for definitions of product terms used in this specification.~~

3.1.2 *extrudate, n*—material exiting an extrusion die subject to further processing (quenching, stretching, ~~cutting),~~cutting) to become an extruded profile.

3.1.3 *extrusion billet, n*—solid or hollow form, commonly cylindrical, used as the final length of material charged into the extrusion press cylinder, and is usually a cast product, but may be a wrought product or sintered from powder compact.

3.1.4 *extrusion log, n*—starting stock for extrusion ~~billet. Extrusion~~billet; extrusion log is usually produced in lengths from which shorter extrusion billets are cut.

3.1.5 *extrusion press solution heat treatment, n*—heating an alloy to a suitable temperature and then extruding, while holding for a sufficient time to allow one or more soluble constituents to enter into solid solution, where they are retained in a supersaturated state after quenching.

3.1.6 *furnace solution heat treatment, n*—heating an alloy to a suitable temperature in a furnace and holding for a sufficient time to allow one or more soluble constituents to enter into solid solution, where they are retained in a supersaturated state after quenching.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *product class, n*—a category of extruded product, consisting of the same alloy, temper and thickness, which can be grouped for purposes of analysis of process qualification data and/or process monitoring data.

3.2.2 *product type, n*—a category of extruded product, consisting of the same alloy and product form (such as tube, pipe, rod, bar, or profile) which can be grouped for analysis of process qualification and/or process monitoring.

3.2.3 *remote temperature sensing system, n*—a system of temperature measurement of a non-contact type usually including either a single or multi-wavelength radiation sensing device.

4. Equipment

4.1 Aluminum alloy billets are preheated prior to being extruded as prescribed in 6.2. Usual heating methods include, but are not limited to, induction, flame impingement, or forced air. Controls shall be adequate to ensure that the equipment can be operated in a manner which precludes overheating of the billet or deleterious contamination of the billet by the furnace environment. Induction equipment may require measurement of thermal gradients along the billet. Flame impingement devices require assessment of thermocouple placement relative to burner location to avoid the possibility of non-uniform surface temperature. Billet temperature shall be monitored and controlled to the extent that the extrusion billet is not to exceed the maximum temperature shown in Table 1 prior to ~~extrusion (see~~ extrusion.~~Note 1).~~

~~NOTE 1—Some aspects of the metallurgical structure of the alloy after solution heat treatment are influenced by the thermal characteristics of the heating equipment used, and the starting microstructure of the billet/log. Some heating equipment achieves very rapid temperature rise and may require the metal to be soaked for a period to ensure that sufficient applicable alloying elements are taken into solid solution. This soaking stage may be eliminated if the alloying elements are substantially in solid solution prior to charging the metal to the heating equipment (this being accomplished by sufficient prior homogenization/cooling practices).~~

4.1.1 Automatic control and recording devices used to measure temperature at pertinent points in the heating equipment shall be calibrated as specified in Section 5.

4.2 The extrusion press equipment and controls shall be adequate to ensure that billets are capable of being extruded in accordance with the process requirements for the products being produced, as ~~prescribed~~specified in Section 6.

4.3 Equipment for quenching the extrudate may consist of, but is not limited to, water or water/glycol mixture in a standing wave, quench tank, spray, pressurized water device, air/water fog or air blast, or combination thereof. Controls shall be adequate to assure that the equipment is operated in a manner which achieves the required quench conditions as prescribed in 6.6 and in Table 2.

5. Equipment Calibration and Standardization

5.1 ~~*Non-Contact Sensor System (Remote Sensing System) Calibration and System Accuracy Test:*~~ Instrument and sensor calibration are defined in Table 3. System Accuracy Test (SAT) requirements are defined in Table 4.

~~5.1.1 *Initial Calibration*—Non-contact sensors shall be calibrated prior to initial use by an ISO 17025 or A2LA certified laboratory. It may also be certified by the manufacturer if their process is traceable to NIST or national equivalent. Initial calibration shall be within ±6°F [±3°C].~~

TABLE 2 Recommended Minimum Die Exit Temperature, Temperature Entering Quench, and Cooling Rate in ~~the~~ Quench Zone[A,B]

~~Alloy~~	~~Min Die Exit °F [°C]~~	~~Min Temp Entering Quench °F [°C]~~	~~Min Cooling Rate, °F/min [°C/min]~~
Alloy	Min Die Exit °F [°C]	Min Temp Entering Quench °F [°C]	Min Cooling Rate, °F/min [°C/min]
~~6105~~	~~950 [510]~~	~~825 [440]~~	~~300 [165]~~
6005, 6105, 6005A	950 [510]	860 [460]	300 [165]
~~6005A~~	~~950 [510]~~	~~825 [440]~~	~~360 [200]~~
6061	950 [510]	860 [460]	600 [335]
~~6061, 6262, 6041, 6064~~	~~930 [500]~~	~~850 [455]~~	~~600 [335]~~
6262, 6040, 6041, 6064	930 [500]	860 [460]	600 [335]
6351, 6082	950 [510]	900 [480]	600 [335]
~~6060, 6063, 6101, 6360, 6463, 6560~~	~~930 [500]~~	~~825 [440]~~	~~150 [85]~~
6060, 6063, 6101, 6360, 6463, 6560	930 [500]	840 [450]	150 [85]
~~6066, 6070~~	~~970 [520]~~	~~910 [490]~~	~~900 [500]~~
6066, 6070, 6010, 6013	970 [520]	910 [490]	900 [500]
~~7004, 7005~~	~~750 to 1000 max/ [400 to 540] max~~	~~725 [385]~~	~~120 [65]~~[C]
7004, 7005	750 [400]	725 [385]	120 [65][C]
~~7029, 7046, 7116, 7129, 7146~~	~~900 to 1000 max/ [480 to 540 max]~~	~~750 [400]~~	~~600 [335]~~
7003, 7108A, 7029, 7046, 7046A, 7116, 7129, 7146	900 [480]	750 [400]	150 [85][C]

[A] The cooling rate is defined as the average temperature drop per unit of time when subjected to a constant cooling system from initial extrudate temperature, down to ~~400°F [205°C],~~400 °F [205 °C], forced cooling allowed at a reduced rate down to ~~350°F [175°C], and cooling continuing to ambient.~~350 °F [175 °C], and still air cooling (faster is acceptable) continuing to ambient temperature.

[B] These minimum temperatures and cooling rates may be altered when statistical analysis of mechanical property test data substantiates that the material will meet the tensile property requirements of 7.1 and other required material ~~characteristics.~~characteristics as required in this specification.

[C] Air or air mist only cooling preferred, as higher cooling rates may degrade corrosion performance.

TABLE 3 Instrument and Sensor Calibration

Device	Maximum Calibration Period	Calibration Accuracy Required	Used For	Calibrated Against
Field Test Instrument	within past 12 months	±1 °F [±0.6 °C]	SAT; initial calibration of record, control or monitoring sensors	National Institute of Standards and Technology (NIST) or equivalent national standard
Field Test Sensor	within past 12 months	±2 °F [±1.1 °C]	SAT; initial calibration of record, control or monitoring sensors	
Non-contact Sensors	before first use (installation in equipment) and at least annual thereafter	±10 °F [5.5 °C]	measuring, recording or controlling the temperature of thermal processing equipment	ISO17025, A2LA or instruments manufacturer with a process traceable to the National Institute of Standards and Technology (NIST) or equivalent national standard

TABLE 4 System Accuracy Test

Method	Instrumentation Device	Calibration Accuracy (Maximum SAT Difference Allowed)	SAT Frequency
Probe	non-contact	±15 °F [±8.3 °C]	monthly [max 31 days]
Probe in conjunction with Comparative Method	contact	Comparative Method ±10 °F [±5.5 °C]	weekly [max 7 days]
		Probe ±10 °F [±5.5 °C]	quarterly [max 91 days]

~~5.1.2 *System Accuracy Tests (SAT)*—Non contact sensors must be compared weekly under operating conditions and temperature to a contact thermocouple and test instrument touching the extrusion within 3 in. [75 mm] of the focus point of the non-contact sensor (see Note 2). The non contact sensor must read within ±2°F [±1°C] of the contact pyrometry system; if not, the non-contact sensor system must be adjusted to read within the stated tolerance or an offset in operation must be used to account for the variation and may then be used for production.~~

5.2 ~~*Temperature Measuring*~~ *System Accuracy ~~Test~~Tests (SAT) ~~for Contact Systems~~ (For Contact and Non-contact Sensors)*—~~(systems other than remote sensing systems)—The accuracy of temperature measuring~~Sensors must be compared at the frequency defined in Table 4 ~~system(s) shall be tested~~ under operating conditions ~~at least once during each week that the facility is used. The test should be made by inserting a calibrated test temperature sensing element to contact~~ and temperature to a contact test sensor and test instrument in contact with the surface being measured within 3 in. [75 mm] of the ~~system's sensing element and reading the test temperature sensing element with a calibrated test potentiometer (see~~focus point of the non-contact sensor or 3 in. [75 mm] of the contact ~~Note 2). The sensors must agree within ±2°F [±1°C];~~ sensor, or as best can be practically performed. The sensor must read within the specified tolerance in Table 4 of the field test sensor and instrument; if not, the sensor system must be adjusted to read within the stated tolerance or an offset in operation must be used to account for the variation and may then be used for production. ~~When the system is equipped with dual potentiometer measuring systems which are checked daily against each other, the above checks shall be conducted at least once every three months. The dual sensors must agree within ±2°F [±1°C]; if not, the systems shall either be recalibrated or replaced. Alternatively, the sensor's reading may be compared to the test instrument/sensor and the discrepant system(s) recalibrated or replaced.~~

~~5.3 *Test Instrument/Sensor for SAT*—The contact pyrometer thermocouple (sensor) and test instrument must be calibrated to a NIST-traceable source within 3 months of use. Calibration error of the instrument shall be no more than ±1°F [±0.6°C] and the sensor shall be within ±2°F [±1°C] or 0.4 % of true temperature (whichever is greater).~~

~~NOTE 2—**Warning:** Advice should be sought from the equipment manufacturer to determine precautions necessary when inserting sensing elements to avoid incurring any safety hazards.~~

5.3 *Continuous Billet Heating Furnace Calibration*—For continuous billet heating furnaces, the type of survey and written procedures for performing the survey should be established for each particular furnace involved. The types of continuous billet heating furnaces may vary considerably, depending upon the product and sizes involved. For some types and sizes of furnaces, the only practical way to survey the furnace is to perform ~~an extensive~~ a mechanical property survey of the limiting extruded product sizes to verify conformance to the specified mechanical properties for such products. Methods to establish capability are defined in Practice E2281.

6. Extrusion Press Solution Heat Treat Procedure

6.1 Pertinent control points requiring defined written operating practices, data collection, and record keeping include, but are not limited to (see Note ~~3~~1):

6.1.1 Billet or log temperature in the heating equipment (6.2),

6.1.2 Billet temperature upon being charged into the press container (6.3),

6.1.3 Time from billet discharge from heating furnace to charging of billet into press container,