Designation: B807/B807M – 13

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) processing and equipment calibration shall meet the practice and requirements of Practice B918/B918M.

1.3 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The 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 and health practices and determine the applicability of regulatory limitations prior to use.*

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 and Measurement Capability Indices

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

3. Terminology

3.1 *Definitions*—Refer to Terminology B881 for definitions of product terms used in this specification.

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

3.1.2 *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.

[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, Arlington, VA 22209, 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

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

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

3.1.4 *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.

3.1.5 *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 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 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:*

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].

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

TABLE 2 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]
6105	950 [510]	825 [440]	300 [165]
6005A	950 [510]	825 [440]	360 [200]
6061, 6262, 6041, 6064	930 [500]	850 [455]	600 [335]
6351, 6082	950 [510]	900 [480]	600 [335]
6060, 6063, 6101, 6360, 6463, 6560	930 [500]	825 [440]	150 [85]
6066, 6070	970 [520]	910 [490]	900 [500]
7004, 7005	750 to 1000 max/ [400 to 540] max	725 [385]	120 [65][C]
7029, 7046, 7116, 7129, 7146	900 to 1000 max/ [480 to 540 max]	750 [400]	600 [335]

[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], forced cooling allowed at a reduced rate down to 350°F [175°C], and cooling continuing to ambient.

[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.

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

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 (SAT) for Contact Systems* (systems other than remote sensing systems)—The accuracy of temperature measuring 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 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 Note 2). The sensors must agree within ±2°F [±1°C]; 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.

5.4 *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 mechanical property survey of the limiting product sizes to verify conformance to the specified mechanical properties for such products.

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):

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,

6.1.4 Container Temperature,

6.1.5 Ram Speed,

6.1.6 Profile configuration,

6.1.7 Extrudate temperature upon exiting the press platen (6.4),

6.1.8 Time between extrudate exit from the extrusion die and entry into the quench zone,

6.1.9 Extrudate temperature at quench entry (6.5),

6.1.10 Extrudate temperature at completion of quench,

6.1.11 Quench media temperature,

6.1.12 Quench rate (6.6),

6.1.13 System operation during normal press dead cycle, and

6.1.14 System reaction to unplanned interruptions (warning lights/audibles, system interlocks, records, billet not charged to container within time limits).

NOTE 3—Some of these time or temperature measurements may be omitted if it has been demonstrated that they are not essential to achieving an appropriate degree of process control.

6.2 Billets shall be heated to a temperature appropriate for the alloy and not to exceed the maximum temperatures listed in Table 1 (see Note 4). If a remote temperature sensing system is used and has a known error which exceeds ±2°F, then the permitted upper limits shown in Table 1 shall be adjusted by an amount to ensure that the true metal temperature does not exceed the upper limit shown, or the instrument shall be re-calibrated in accordance with 5.1.

NOTE 4—The surface temperature of a billet or log may differ significantly from its interior temperature. Temperature sensing devices may give instantaneous values at a specific point, or give average values over time or over an area. Note that gradients differ between induction and gas fired billet heaters.

6.3 When continuous monitoring of extrusion temperatures, with appropriate controls, is in place, minimum starting billet temperature is at the producer's option. Some production methods may not require or depend on uniform billet temperature. This is due to state of the art in variable ram speed controls and temperature profiling of billets. Work Instructions shall be developed for each product class with documentation.

6.4 The minimum extrudate temperature upon exiting the extrusion die shall not be less than the temperature shown for the alloy in Table 2.

6.5 The minimum temperature upon entering the quench zone shall not be less than the temperature shown for the alloy in Table 2.

6.6 The minimum cooling rate of the extrusion in the quench zone shall conform to Table 2. The cooling equipment shall be operated in a manner to preclude reheating.

6.7 For precipitation hardening (aging) and equipment calibration thereof, the requirements of Practice B918/B918M shall be met.

7. Process Capability and Quality Assurance

7.1 *Capability*—The producer's process shall have been proven capable per Practice E2281, with documented evidence of statistically verified capability, to produce product in various product classes which conforms to required mechanical property minimums. Methods to establish capability are defined in

Practice E2281. Appropriate models shall be used for representation of the data as well as the generation of control charts. For further information see ASTM MNL 7.

7.1.1 Mechanical Properties shall be determined in accordance with Test Methods B557 and B557M.

7.2 *Quality Assurance*—Heating, extrusion, and quenching facilities operated in accordance with documented procedures shall have a demonstrated capability for producing material meeting applicable material specification requirements for each product type and alloy and temper produced.

7.2.1 *Mechanical Properties*—Mechanical Properties shall conform to the requirements of the applicable material specifications.

7.2.2 *Non-Destructive Testing*—For documentation of process capability, and as part of process qualification, hardness test values and/or eddy current test values may be used as supplemental indicators of mechanical properties, and, as such, may be used as non-destructive screening methods in process surveillance checks, which may be complimentary to, but shall not be substituted for tensile test minimum requirements. Such non-destructive testing may be included in lot release criteria, but must be in conjunction with Tensile property testing.

7.2.3 *Hardness Inspection*—As part of Quality Assurance, the producer may include a sampling plan for hardness testing. The specific type of hardness tester used shall be the producer's choice. The tests shall be conducted in accordance with the applicable test standard, such as Test Method B647 for Webster hardness, Test Method B648 for Barcol hardness, Test Method E10 for Brinell hardness or Test Methods E18 for Rockwell hardness (see Note 5).

NOTE 5—While hardness tests are a good indicator of tensile properties and an appropriate screening method, hardness values do not guarantee conformance to tensile property requirements. It is the responsibility of the producer to establish the relationship, if any, between hardness values and tensile properties.

7.2.4 *Statistical Significance of Material Property Data*—Though different statistical techniques may be found useful in the analysis of mechanical property data, sufficient mechanical property test data should be accumulated to adequately determine the statistical characteristics of the process using accepted conventions.

7.2.5 *Eutectic Melting and Subsurface Porosity (applicable to 7xxx alloys only)*—Metallographic examination shall be performed to confirm the absence of eutectic melting and subsurface porosity from hydrogen diffusion. Examinations shall be performed at a minimum frequency of one sample per alloy per every three months for each press/quench facility producing that alloy.

7.2.6 *Use of Production Test Results*—The results of tests to determine conformance of heat-treated material to the requirements of the respective material specification are acceptable as evidence of process surveillance of the equipment and procedure employed.

7.2.7 *Process/Equipment Change Requalification:*

7.2.7.1 *Equipment Requalification*—Whenever any qualified equipment is changed or reworked, it shall be re-qualified unless it is known that the change or rework will not have a detrimental effect upon the properties of products. Examples of changes requiring requalification are:

(1) Change in quench nozzle type, design, or orientation,

(2) Change in quench flow rates of greater than ±5 % of rate previously qualified,

(3) Change in documented process minimum temperature allowed for material entering quench,

(4) Change in quenchant material or specified solution range, and

(5) Change in preheat or homogenizing process/ equipment.

7.2.7.2 *Process Requalification*—Substantial changes to the process shall be confirmed by requalification of the affected products with documentation of continuing capability for those products.

7.2.8 *Process Disqualification*—Inability to conform to 7.2.1 or 7.2.5 shall result in process disqualification. The process shall remain disqualified until corrective action is taken and its effectiveness is substantiated through conformance to those sections.

7.2.9 *Records*—Records shall be maintained for each extrusion press/quenching facility involved in the production and sale of extrusion press solution heat treated material to show compliance with this practice. The records shall include identification of the specific press and associated equipment involved, which includes metal heating and quenching equipment, the frequency and results of each calibration of measurement equipment or instrument used for control, and the dates and description of equipment repairs or alteration. Records shall be maintained for a minimum of three years after the inspection or test.

8. Keywords

8.1 aluminum alloys; extrusions; extrusion press solution heat treatments; solution heat treatments

SUMMARY OF CHANGES

Committee B07 has identified the location of selected changes to this standard since the last issue (B807/B807M-06) that may impact the use of this standard. (Approved June 1, 2013)

(1) Added 6360, 6041 and 6064 alloys.

(2) Deleted 6005 alloy.