Designation: B 807 – 02

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

This standard is issued under the fixed designation B 807; 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 is intended to cover the controls necessary to press solution heat treat some 6xxx and 7xxx series aluminum alloys at extrusion facilities when the alloy design permits them to be so treated; specific alloys are shown in Table 1. 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 B 918 for the attainment of T3, T4, T6, T7, T8 and T9-type tempers (See ANSI H35.1).

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:*

B 557 Test Methods of Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products[2]

B 918 Practice for Heat Treatment of Wrought Aluminum Alloys[2]

2.3 *ANSI Standard:*

H35.1 Alloy and Temper Designation Systems for Aluminum[2]

3. Terminology

3.1 *Definitions:*

3.1.1 *extrusion billet*—the starting stock for the extrusion operation. Extrusion billet is a solid or hollow form, commonly cylindrical, that is usually a cast product, but may be a wrought product or manufactured from sintered powder. Extrusion billet is termed as the final length of material charge used in the extrusion process.

3.1.2 *extrusion ingot*—a cast form that is solid or hollow, usually cylindrical, suitable for extruding.

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

3.1.4 *solution heat treatment*—heating an alloy at a suitable temperature for sufficient time to cause one or more soluble constituents to enter into solid solution, and then cooling the material rapidly enough to retain the constituents in solution. (Note 1)

NOTE 1—Metallurgical structure of the alloy is influenced by the heating equipment used. Some heating equipment achieves very rapid temperature rise and may require the metal to be soaked for a period within the temperature range noted in Table 1 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.

TABLE 1 Extrusion Billet or Log Temperature[A,B]

Alloy	Billet or Log Temperature	
	Upper °F	Lower °F
6005, 6005A, 6105	1025	800
6061, 6262	1035	850
6060, 6063, 6101, 6463	1025	800
6351	1010	875
7004, 7005	950	710
7029, 7046, 7116, 7129, 7146	1000	850

[A] The range shown may require appreciable narrowing, depending upon reduction ratio, section configuration, and other extrusion parameters.

[B] These temperatures may be altered when statistical analysis of tensile test data substantiates that the material will meet the tensile property requirements of 5.3.1 and other required material characteristics.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *potentiometer measuring system*—a means of temperature measurement which compares thermoelectric electromotive force (emf) with a reference emf (also known as a null-balance indicator).

3.2.2 *remote temperature sensing system*—a system of temperature measurement of a non-contact type usually including either a single or multi-wave length radiation sensing device.

3.2.3 *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 form of the frequency distribution curve and to provide a reliable estimate of the population mean and standard deviation. In most instances, the distribution is normal in form, and properties are based on the results of a minimum of 100 tests from at least 10 different lots of material. There should be a 95 % confidence that at least 99 % of the distribution conforms to material specifications.

[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] *Annual Book of ASTM Standards*, Vol 02.02.

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

4. Apparatus

4.1 Prior to being extruded, aluminum alloys are heated to the temperature range shown in Table 1. 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 metal overheating or deleterious contamination of the metal by the furnace environment. (Note 2)

NOTE 2—Induction equipment requires measurement of thermal gradients along the billet. Flame impingement devices require assessment of thermocouple placement relative to burner location because of the possibility of nonuniform surface temperature.

4.1.1 Metal temperature shall be monitored and controlled to the extent that the entire metal charge (Note 2) is within the required range prior to extrusion.

4.1.2 Automatic control and recording devices used to measure temperature at pertinent points in the heating equipment shall be calibrated as specified in 5.1.1.

4.1.2.1 Pertinent measuring points include, but are not limited to: (Note 3)

(1) Metal temperature in the heating equipment, and

(2) Metal temperature after heating, and before charging to the extrusion press.

NOTE 3—The intent is to minimize the time period between discharge of the metal, at the desired temperature, from the heating equipment and the initiation of the extrusion process. 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.

4.2 During extrusion, pertinent temperature measuring points include, but are not limited to (Notes 3 and 4):

4.2.1 Metal temperature at quench entry, and

4.2.2 Metal temperature at completion of quench.

NOTE 4—When the design of the quench equipment does not permit measuring the extrudate temperature at the entry to the quench zone, the quench portion of the facility may be approved if all other requirements of this practice are met when the facility is operated according to the documented procedure.

4.3 The following time measurements are pertinent (Note 3):

4.3.1 Time interval between measurement of metal temperature immediately prior to charging to the extrusion press and start of extrusion,

4.3.2 Time interval between the metal exiting from press and its entering the quench, and

4.3.3 Time interval between metal entry to and exit from, the quench.

4.4 *Quenching*—Quenching methods may consist of, but are not limited to, water or water/glycol mixture in a standing wave, a quench tank, a spray, or a pressurized water device, or a fog or an air blast, or a combination thereof. The quench equipment shall be used in a manner such that the quench parameters can be controlled, are recorded, and meet the requirements of Tables 2 and 3.

5. Calibration and Standardization

5.1 *Calibration of Equipment*:

5.1.1 *Temperature Measuring System Accuracy Test for Remote Sensing Systems*—The accuracy of remote sensing

TABLE 2 Maximum Time Interval Between Extrusion Emergence From the Extrusion Die and Entry to the Quench Zone[A]

Element Thickness Range, in.[B]	Time Interval, s[C]
Up through 0.062	45
Over 0.062 through 0.150	50
Over 0.150 through 0.250	60
Over 0.250	90

[A] The boundaries of the quench zone are the extremities over which the minimum cooling rate in Table 3 applies.

[B] The thinnest element of the extruded profile generally governs the thickness range for the maximum permitted time interval. If the thinnest element is not a main feature of the extrusion, it generally may be disregarded unless it represents the fastest cooling portion of the profile.

[C] Longer time intervals may be used only when complete extrusion press solution heat treatment documentation, including statistically supporting mechanical properties, substantiate that the increased time interval will not have a deleterious effect.

TABLE 3 Minimum Cooling Rate in the Quench Zone[A]

Alloy	Cooling Rate, °F/s[BC]
6005, 6005A, 6105	4
6061, 6262, 6351	15
6060, 6063, 6101, 6463, 7004, 7005	2
7029, 7046, 7116, 7129, 7146	10

[A] The cooling rate is defined as the average temperature drop when subjected to a constant cooling system from initial extrudate temperature, down to 400°F.

[B] Cooling with still air from 400°F to ambient temperature is permissible.

[C] A lower quench rate may be used when supported by a documented process and statistical confirmation that the material specification requirements are met.

systems shall be within ±6°F of true temperature, and calibrations shall be traceable to a National Institute of Standards and Technology reference standard. This test shall be performed under operating conditions at least once during each week that the facility is used. When the measured temperature of the system differs by more than ±2°F from that of the NIST standard, the system may be used, provided that the adjustments of 6.1 are used.

5.1.2 *Temperature Measuring System Accuracy Test 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 to within 3 in. of the system's sensing element and reading the test temperature sensing element with a calibrated test potentiometer. (**Warning**—Advice should be sought from the equipment manufacturer to determine precautions necessary when inserting sensing elements to avoid incurring any safety hazards.) 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. Test temperature sensing element, test instrument, and cold junction compensation combination shall have been calibrated and traceable to National Institute of Standards and Technology certified sensing elements within the previous three months to an accuracy of ±2°F of true temperature.

5.1.3 *Records*—Records shall be maintained for each extrusion press/quench facility involved in the production of press solution heat-treated material to show compliance with this practice. The records shall include identification of the specific press involved (which includes metal heating and quenching equipment), the frequency and results of calibration of measurement equipment used for control, and the dates and description of equipment repairs or alteration.

5.2 *Process Surveillance Tests*:

5.2.1 *Test Requirements*:

5.2.1.1 Surveillance tests of heating, extrusion, and quench facilities operated in accordance with documented procedures shall have a demonstrated capability for producing material meeting applicable material specification requirements for each type of product (shapes, tube, rod, hollow section, etc.), and alloy and temper produced. Surveillance tests shall include tensile properties and metallographic examination to confirm that the heat treatment process has not resulted in eutectic melting or subsurface porosity from hydrogen diffusion. Both tests for eutectic melting and subsurface porosity from hydrogen diffusion may be omitted for 6xxx series alloys.

5.2.1.2 *Frequency of Tests*—Mechanical property tests shall be carried out at the frequency required by the applicable material specification. When no material specification is applicable, the number of samples tested shall be not less than one per 1000 lb of product weighing less than 1 lb per ft or not less than one per 1000 ft of product for material weighing 1 lb or more per ft. *Product* is meant to include the alloy in the form being extruded, such as tube, pipe, or shape. Examination to confirm the absence of solution heat treat induced eutectic melting or subsurface porosity from hydrogen diffusion shall be performed at a minimum rate of one sample per alloy per every three months for each press/quench facility producing that alloy.

5.2.1.3 *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.

5.2.2 *Test Methods*:

5.2.2.1 Mechanical properties shall be determined in accordance with Test Methods B 557.

5.2.2.2 *Eutectic Melting*—Specimens from at least one of the heat-treated samples in 5.2.1.1 shall be sectioned in the plane perpendicular to the direction of the extrusion, polished to an appropriate fineness, mildly etched with an etchant such as Keller's reagent, to reveal any evidence of eutectic melting and examined at a magnification of 500 diameters.

5.3 *Interpretation of Results*:

5.3.1 *Mechanical Properties*—Tensile properties determined in accordance with 5.2.2.1 shall conform to the requirements of the applicable material specification(s).

5.3.2 *Eutectic Melting and Subsurface Porosity Resulting from Hydrogen Diffusion During Solution Heat Treatment*—There shall be no evidence of subsurface porosity from hydrogen diffusion during solution heat treatment or eutectic melting attributable to the extrusion press solution heat treatment process.

5.3.3 *Process Disqualification*—Inability to conform to 5.3.1 or 5.3.2 shall result in process disqualification. The process shall remain disqualified until corrective action is taken and its effectiveness substantiated through conformance to 5.3.1 and 5.3.2.

6. Extrusion Press Solution Heat Treat Procedure

6.1 Billets shall be heated to a temperature appropriate for the alloy in the range recommended in Table 1 (Note 5). If a remote temperature sensing system is used and has a known error which exceeds ±2°F, then the permitted upper and lower bounds shown in Table 1 shall be adjusted by an amount to ensure that the true metal temperature is within the limits of Table 1.

NOTE 5—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. It is important to correlate these apparent temperatures with the resultant metallurgical structure and tensile properties to ensure conformity to this practice.

6.2 The heated billet shall be loaded to the extrusion press at which time the billet temperature shall not be less than the lower value shown for the alloy in Table 1.

6.3 The maximum time interval between the emergence of the extrusion from the die and entry to the quench zone shall not exceed the value shown in Table 2.

6.4 The minimum cooling rate of the extrusion in the quench zone shall conform to Table 3. The cooling equipment shall be operated in a manner to preclude reheating.

7. Keywords

7.1 aluminum alloys; press; solution heat treatment

SUMMARY OF CHANGES

This section identifies the principal changes to this standard that have been incorporated since the last issue.

(*1*) Replaced Practice B 597 with Practice B 918 in 1.1 and 2.2.

(*2*) Moved cautionary statement from Note 5 to 5.1.2.