Designation: B947 – 14

Standard Practice for Hot Rolling Mill Solution Heat Treatment for Aluminum Alloy Plate[1]

This standard is issued under the fixed designation B947; 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 hot rolling mill solution heat treatment of the 6xxx series aluminum alloy plate in Table 1 when ASTM material specifications allow use of this process instead 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 as the preliminary step for the attainment of T651-type tempers (see ANSI H35.1/H35.1M).

1.2 This practice applies only to hot rolling mill solution heat treatment of plate for the listed aluminum alloys. Precipitation hardening (aging), processing, and equipment calibration for aging shall meet the practice and requirements of Practice B918.

1.3 The values stated in either SI units or inch-pound units are to be regarded separately as standard. 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 nonconformance 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]

B209 Specification for Aluminum and Aluminum-Alloy Sheet and Plate

B209M Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric)

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)

B881 Terminology Relating to Aluminum- and Magnesium-Alloy Products

B918 Practice for Heat Treatment of Wrought Aluminum Alloys

E2281 Practice for Process and Measurement Capability Indices

ASTM MNL7 Manual on Presentation of Data and Control Chart Analysis

2.3 *ANSI Standard:*

H35.1/H35.1M Alloy and Temper Designation Systems for Aluminum[3]

2.4 *European Standard:*

EN 485-2 Aluminium and Aluminium Alloys—Sheet, Strip And Plate—Part 2: Mechanical Properties[4]

3. Terminology

3.1 *Definitions*—For definitions of terms used in this test method, refer to Terminology B881.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *rolling slab, n*—semi-finished or intermediate product produced by hot rolling which is between ingot and plate form.

3.2.2 *load sensor or load thermocouple, n*—sensors that are attached to the production material or a representation of production material, that supply temperature data of the production material to process or test instrumentation.

4. Equipment

4.1 Aluminum alloy ingots or rolling slabs are preheated prior to being hot rolled as prescribed in 6.2. Controls shall be

[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 the Aluminum Association, Inc., 1525 Wilson Blvd. Suite 600, Arlington, VA 22209, www.aluminum.org.

[4] Available from European Committee for Standardization (CEN), 36 rue de Stassart, B-1050, Brussels, Belgium.

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

TABLE 1 Ingot High Limit Temperature[A]

Alloy	Ingot Upper Limit Temperature °F [°C]
6061	1067 [575]

[A] These upper limit temperatures avoid the possibility of eutectic melting due to overheating, and include a safety margin of approximately 13°F [7°C].

adequate to ensure that the equipment is operated in a manner which precludes overheating of the ingot or rolling slab or deleterious contamination by the furnace environment. Metal temperature shall be monitored and controlled to not exceed the maximum temperature shown in Table 1 prior to hot rolling.

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 ingot. 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 minimized 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 or manual control and recording devices used to measure temperature at pertinent points in the heating equipment shall be calibrated as specified in 5.1 and 5.2. Table 2 shows preheat/homogenizing furnace temperature tolerance.

4.2 The hot rolling and quench equipment and controls shall be adequate to ensure that ingots are capable of being hot rolled in accordance with the process requirements for the products being produced, as prescribed in 6.3 and 6.4.

4.3 Equipment for quenching the hot rolled slab may consist of, but is not limited to, water or water/glycol mixture in a standing wave, quench tank, spray, or pressurized water device. Controls shall be adequate to assure that the equipment is operated in a manner which achieves the required quench conditions in Table 3.

5. Equipment Calibration and System Accuracy Tests (SAT)

5.1 *Non-Contact Sensor System (Remote Sensing System) Calibration and SAT:*

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

5.1.2 *SAT*—Noncontact sensors must be compared weekly under operating conditions and temperature to the SAT test instrument/sensor (5.3); test sensor must be in contact with the ingot, hot rolled slab, or plate within 3 in. [75 mm] of the focus point of the noncontact sensor (see Note 2). The noncontact sensor must read within ±2°F [±1°C] of the contact pyrometry system; if not, the noncontact 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.

TABLE 2 Homogenization and Pre-heat Furnace Temperature Tolerance

Alloy	Pre-heat Oven Temperature Range °F [°C]
6061	±15 [±8]

TABLE 3 Minimum Temperature Entering Quench and Cooling Rate in Quench Zone[A,B]

Alloy	Min Temp Entering Quench °F [°C]	Min Cooling Rate °F/min [°C/min]
6061	870 [466]	600 [316]

[A] The cooling rate is defined as the average temperature drop per unit of time when subjected to a constant cooling system from initial slab 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 such as corrosion resistance.

5.2 *Temperature Measuring System Accuracy Test (SAT) for Contact Systems:*

5.2.1 *SAT*—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 placing a calibrated test temperature sensing element (5.3) to make contact with the surface (ingot, hot rolled slab, or plate) 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 contact system must read within ±2°F [±1°C] of the test instrument. If not, the contact system shall be calibrated to read within the stated tolerance or an offset in operation shall be used to account for the variation. Once the adjustment or offset is in use, the system may then be used for production. When the system is equipped with dual potentiometer measuring systems which are checked daily against each other and agree within ±2°F [±1°C], the above checks and corrections shall be conducted at least once every three months.

5.3 *Test Instrument/Sensor for SAT*—The contact pyrometer thermocouple (sensor) and test instrument must be calibrated to a NIST (or equivalent national standard) traceable source before first use and calibrated within three months of use and recalibrated every three months thereafter when used. 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 *Preheat/Slab Reheat Furnace Calibration and Temperature Uniformity Survey*—For continuous or batch furnaces, the type of survey and procedures for performing the survey shall be established and documented for each particular furnace or furnace type involved.

5.4.1 A temperature uniformity survey shall be performed before first use and at least each six months thereafter using load thermocouples in each corner that represent the ends and corners as well as the remainder of the ingot or slab. Variation