AEROSPACE RECOMMENDED PRACTICE

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ARP 891

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Revised

DETERMINATION OF ALUMINUM ALLOY TEMPERS THROUGH ELECTRICAL CONDUCTIVITY MEASUREMENT (EDDY CURRENT)

1. SCOPE - This recommended practice establishes a procedure for checking the tempers of aluminum alloys through eddy current conductivity measurements and defines criteria for acceptance or rejection.

2. APPLICABLE SPECIFICATIONS AND STANDARDS

Military

MIL-F-5509 Fittings, Flared Tube, Fluid Connection
MIL-F-18280 Fittings, Flareless Tube, Fluid Connection

Other

AS 915 Conductivity Standard - Eddy Current; Type of Aluminum Alloy Temper Testing Equipment
ASTM B193-57 Standard Method of Test for Resistivity of Electrical Conductor Materials.

3. REQUIREMENTS

3.1 Environment - The tests shall be conducted at room temperature, i.e. 70 ± 10 F. No special arrangements are required to control the humidity in the test area.

3.2 Standards and Test Parts - The temperature of the AS 915 standard plates and the test parts shall be maintained uniform within ± 3 F, provided aluminum standards are used.

The test can be conducted on as-forged or rough machined surfaces not exceeding a roughness of 200 RHR.

Surfaces with identification stamps or similar irregularities should be avoided. Such irregular or rough surfaces should be checked by moving the probe slowly along the surface until an area with maximum meter deflection is found. The test parts shall have a minimum thickness as shown in Table II.

3.3 Area of Test Parts - For direct (uncompensated) readings the part to be inspected must have a flat area at least as large as shown in Table II. Conductivity measurements on parts with cylindrical surfaces or flat areas smaller than the probe face require correction per 4.1.16.

3.4 Electrical Conductivity - Acceptable electrical conductivity values and corresponding indicated hardness shall be as specified in Table I.

4. RECOMMENDED PROCEDURES

4.1 Procedure for Magnaflux ED 500 Instrument with Flex-ECII Probe*

4.1.1 Attach the probe to the instrument.

4.1.2 Switch the instrument on, leave the sensitivity knob at a low setting.

4.1.3 Rotate the balance control so that the meter reads between 100 and 200 μ A.

*Or other test equipment which meets the requirements set forth in paragraph 5.2.

TABLE I

THE VALUES LISTED ARE % I. A. C. S. * AND CORRESPONDING INDICATED ROCKWELL HARDNESS BAR STOCK AND FORGINGS

ALLOY \ TEMPER	0 **	T351	T4	T851	T6	T73
2014	48.6 - 50.7% H 95 Max		31.5 - 34.8% B 65 - 80		35.2 - 39.7% B 78 Min	
2024	46.8 - 48.5% H 90 Max	28.8 - 31% E 95 Min		38 - 42%	34 - 40% B 69 Min	
6061	42.3 - 48.5% H 75 Max		37.6 - 40.5% E 70 Min		40 - 44.8% E 85 Min	
7075	44.5 - 47.8% H 95 Max				31.4 - 34.8% B 82 Min	38 - 42% B 79 Min

Note: Sheet and Plate 2014 T4 32.5 - 34%
2014 T6 37 - 39%

* I. A. C. S. - International Annealed Copper Standard

**0 - Indicates Annealed Condition

Note: The hardness values in this table are not intended as an option to or replacement for conventional Brinell hardness and tensile tests. They apply to hardness testing of finished or semi-finished parts where Brinell or tensile testing is not feasible.

4.1.4 Allow 20 minutes for warm-up.

4.1.5 Set the frequency control to 5 and rotate the lift-off knob clockwise to stop.

4.1.6 Place the probe on standard #1 and note the direction of meter deflection.

NOTE: The standards #1 and #2 referred to in this procedure show readings of 210 and 440 µ A. The standards #1 and #2 are conductivity coupons per AS 915. They were selected to calibrate for a conductivity range to check 2024 T6 temper. If other standards are being used, their values must be substituted for 210 and 440.

4.1.7 Reduce the frequency setting to the next lower number (in this case from 5 to 4) and repeat step 4.1.6. Keep the needle on the scale by adjusting the balance control.

4.1.8 Repeat 4.1.6 and 4.1.7 until the direction of meter deflection reverses.

4.1.9 At this frequency rotate the lift-off control connecter clockwise to stop and repeat step 4.1.6. The meter should now deflect in the opposite direction from the deflection obtained before rotating the lift-off control. If not, move the frequency control one step back.

4.1.10 Rotate the lift-off control gradually until the meter reads the same (within 20 µ A or less) with the probe firmly against standard #1 and for the probe 5 in. or higher over the standard.

NOTE: It is normal that the meter needle deflects when the probe is put on and removed from the standard.

4.1.11 Increase the sensitivity slightly and repeat step 4.1.10. This is to be repeated until the sensitivity dial reaches the stop in the clockwise direction. If necessary, the balance has to be corrected to keep the meter needle on scale.

NOTE: The lift-off control is the fine adjustment of the operating frequency, while the frequency control is the coarse adjustment. During step 4.1.11 the lift-off control may reach the stop in clockwise direction without the sensitivity reaching maximum in the clockwise direction. If this happens, the frequency control has to be rotated to the next lower number and the lift-off control rotated counter-clockwise to stop. Then step 4.1.11 can be completed to the requirement above.

4.1.12 Complete balancing for lift-off as follows: Place a nonconductive shim on the standard, then place the probe on the shim.

The shim is to be approximately .001 in. thick. Plastic film such as mylar, polyethylene, or cellophane as used for normal wrapping is recommended. Slide the shim out and note the amount and direction of meter deflection. Rotate the lift-off control slightly in clockwise direction and check for the amount and direction of the meter deflection for the probe on shim and on bare standard. Repeat this until there is no change in readings for the probe on the bare standard and on the standard with shim.

NOTE: If necessary, switch per Note, step 4.1.11.

When the probe is removed from the standard, the meter will read below zero. This is of no importance; however, if the machine is idle for a period of one hour or more, it is advisable to bring the needle on scale (with the balance control only).

The machine is now operating at a frequency between 110 and 120 kc. Effects on the conductivity readings due to coating, drilube, and irregularities of the surface are negligible.

4.1.13 Place the probe on standard #1 and rotate the balance control until the meter reads 210 microamps.

4.1.14 Place the probe on standard #2 and note the reading. If it reads higher than 440 μ A, reduce the sensitivity. Then place the probe on standard #1 and readjust the meter to 210 with the balance control. Repeat this until standard #1 reads 210 and standard #2 reads 440 on the meter.

4.1.15 <u>Procedure for Normal Test Procedure with Magnaflux ED 500*</u>

For normal day to day operation, steps 4.1.3 and 4.1.5 through 4.1.11 do not have to be followed if the machine setting is not disturbed. Step 4.1.12 shall be done once a day after warm-up. Step 4.1.13 shall be done when evaluating or testing borderline material and before testing a new lot.

4.1.16 <u>Correction for Insufficient Area and Curvature</u>

4.1.16.1 Correction for insufficient area: Fig. 1.

4.1.16.2 Correction for curvature: Fig. 2.

4.1.17 Conversion from ED 500 reading in μ A to % I.A.C.S.: Fig. 3.

4.2 <u>Procedure for the Magnaflux FM 110 and FM 120 Instrument*</u>

4.2.1 Turn the switch to position 2.

4.2.2 Set the index on the conductivity dial to the red line at the high end of the scale. Press the probe firmly against the high conductivity calibration sample. Adjust the "Cal-High" knob so that the meter reads zero.

*Or other test equipment which meets the requirements set forth in paragraph 5.2.

4.2.3 Set the index of the conductivity dial on the red mark at the low end of the scale. Press the probe firmly against the low conductivity calibration sample, adjust the "Cal-Low" knob so that the meter reads zero.

4.2.4 Repeat the steps 4.1.3 and 4.1.4 until no adjustments are necessary.

4.3 Procedure for the Magnaflux FM 100 Instrument*

4.3.1 At the beginning of each week the instrument shall be adjusted as follows:

4.3.1.1 With the "power" switch turned off, adjust the meter mechanically to zero by turning the small screw on the meter face.

4.3.1.2 Turn the "power" switch on and allow the instrument to warm up for at least one hour.

4.3.1.3 Balance the meter.

NOTE: For this and all of the following adjustments, the sensitivity control should be set in its full clockwise position.

Push in and adjust the "BAL-Output" knob so that the meter reads zero.

4.3.2 Calibration at High End of Dial

4.3.2.1 Adjust the index on the "conductivity" dial to read line at the high end of the scale.

4.3.2.2 Press the probe firmly against the "High" calibration sample.

4.3.2.3 Adjust the "Cal-High" knob so that the meter reads zero.

4.3.3 Calibration at the Low End of the Dial

4.3.3.1 Adjust the index of the "conductivity" dial to the red mark at the low end of the scale.

4.3.3.2 Press the probe firmly against the "Low" calibration sample.

4.3.3.3 Adjust the "Cal-Low" knob so that the meter reads zero.

4.3.3.4 Repeat steps 4.3.2 through 4.3.3 until the meter reads zero for both the high and low calibration points.

4.3.4 Calibration Over Mid-Range

4.3.4.1 Press the probe firmly against the "Medium" calibration sample and adjust the "conductivity" dial until the meter reads zero. If the index on the "conductivity" dial indicates the proper value of conductivity, the instrument is calibrated. Proceed with step number 4.3.6.

NOTE: The calibration of the FM 100 requires three standard coupons for a low, medium, and high conductivity.

4.3.4.2 If the reading in paragraph 4.3.4.1 is too high, set the conductivity dial to read a value slightly less than that of the standard block used for the Mid Range Calibration. If the reading is too low, set the "conductivity" dial to read slightly higher than that of the standard block used for the Mid Range Calibration.

4.3.4.3 With the probe pressed firmly against the "Medium" sample, adjust the "Medium Adj" control unit the meter reads zero.

*Or other test equipment which meets the requirements set forth in paragraph 5.2.

4.3.4.4 Insert a .004 in. thick paper between the probe and the "Medium" sample. The meter will normally deflect from zero.

4.3.4.5 With the probe pressed firmly against the paper, adjust the "Lift-Off Adj" control so that the meter deflection is equal to the figure supplied by the manufacturer of the probe. A plus (+) sign indicates a deflection to the right of the zero mark on the meter; a minus (-) sign, a deflection to the left of zero.

4.3.4.6 Repeat steps 4.3.4.3 through 4.3.4.5 until zero is obtained with the probe on the bare metal and the deflection given in step 4.3.4.5 obtained with the probe on .004 in. paper.

4.3.5 Repeat steps 4.3.4.4 through 4.3.4.6 until the instrument reads the proper value at all three calibration points.

4.3.6 Compensation for Intermediate Layers

4.3.6.1 With the probe pressed firmly on the "Medium" sample, adjust the "conductivity" dial so that the meter reads zero.

4.3.6.2 Place a .004 in. thick paper between the probe and sample. If the meter deflects to the figure supplied in 4.3.4.5, the instrument is compensated for thin intermediate layers of insulating material.

4.3.6.3 If there is a deflection greater than or less than that indicated in 4.3.4.5, repeat steps 4.3.4.4 through 4.3.5.

The instrument should be checked against the mid-range standard at least twice each day and any time that borderline readings are encountered.

5. USE AND APPARATUS

5.1 Intended Use

This recommended practice is intended to be used as a non-destructive test to verify the heat treatment of aluminum alloys. It is particularly applicable to fluid system connection fittings manufactured in accordance with specification MIL-F-5509 and MIL-F-18280. It is to be used in conjunction with hardness testing of sample parts from the lot to be inspected (see Table I).

5.2 Apparatus

Any alternative procedure or equipment may be used and specified here if its characteristics compare with those outlined in Table II or if it is suitable for other reasons, and provided it is acceptable to the purchaser or other agency requiring use of this practice.

5.2.1 Instruments

This recommended practice refers to the use of the following or equivalent instruments:

Magnaflux ED 500 with detachable Magnaflux or Flex EC II probe
Magnaflux FM 110
Magnaflux FM 120
Magnaflux FM 100

5.2.2 Standards

Adjustment and calibration of the instruments used require standard coupons with conductivities approximating #1 the minimum and #2 the maximum values of the expected conductivity range of the parts to be tested. Conductivity standard coupons shall be per standard AS 915. As an alternate method, master standard bars fabricated per ASTM B193-57 may be used.

5.2.3 Characteristics of Test Apparatus

Table II

Characteristics	Magnaflux ED 500*		Magnaflux FM 110* FM 120	Magnaflux FM 100* Series
	Probe #62743	Flex-ECII Probe		
Accuracy (% of scale)	± 3%	± 1%	± 3%	± 1%
Min required flat area, square or round, for direct reading (in.)	.50	.34	.50	.50
Min required diameter of curvature for direct reading. Correction per Fig. 2 for smaller diameters.	8	3	8	8
Adjustment chart for below min flat area	Not prepared	Fig. 1	Not prepared	Not prepared
Adjustment chart for below min diameter	Not prepared	Fig. 2	Not prepared	Not prepared
Approx readings per minute	15 - 20	30 - 40	3 - 10	3 - 10
Effects of coating or packaging up to .005 in. thick	None	None	Affected	None
Min recommended part thickness (in.)	.03	.03	.07	.07
Read-Out	Convertible to % I.A.C.S. if required		% I.A.C.S.	% I.A.C.S.
Powered by	110V AC	110V AC	Battery portable	110V AC

*Or other test equipment which meets the requirements set forth in paragraph 5.2.

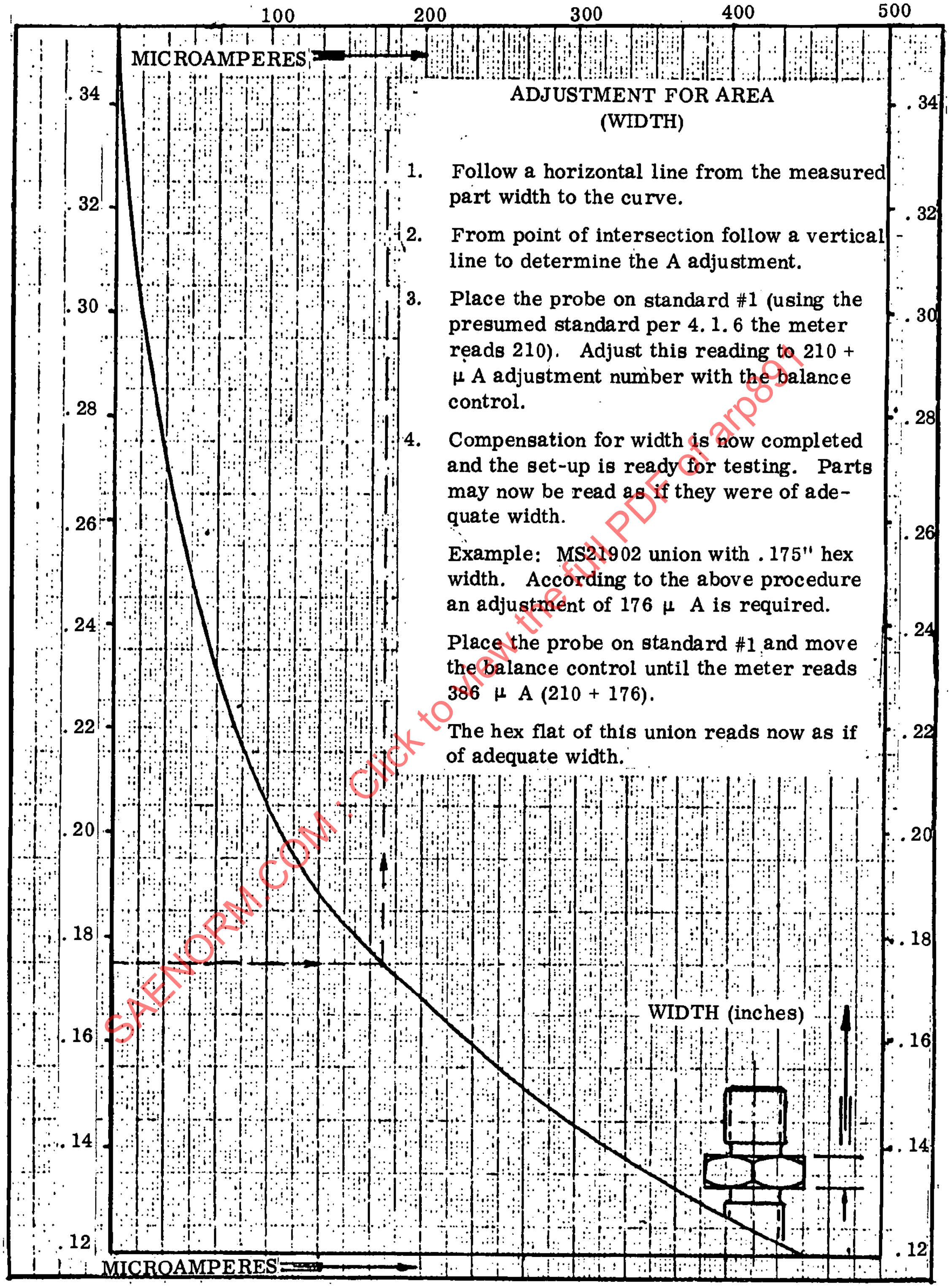

FIGURE 1

COMPENSATION CURVE FOR WIDTH
FOR ED 500 WITH FLEX-EC II PROBE