

METHOD 2003.7

SOLDERABILITY

1. PURPOSE. The purpose of this test method is to evaluate the solderability of terminations (including leads up to 0.125 inch in diameter) that are normally joined by a soldering operation. This evaluation is made on the basis of the ability of these terminations to be wetted by a coating of solder, and to produce a suitable fillet when dip soldered. These procedures will test whether the treatment used in the manufacturing process to facilitate soldering is satisfactory and that it has been applied to the required portion of the part that is designed to accommodate a solder connection. An accelerated aging test is included in this test method that simulates natural aging under a combination of various storage conditions that have different deleterious effects.

1.1 Terms and definitions. The definition of terms shall be in accordance with the following:

1.1.1 Solderability. The property of a metal to be wetted by solder.

1.1.2 Wetting. The formation of a relatively uniform, smooth and unbroken film of solder, adherent to the surface tested.

1.1.3 Porosity. A condition of a solder coating with a spongy appearing, uneven surface that contains a concentration of small pinholes and pits. See figure 2003-1.

1.1.4 Nonwetting. A condition whereby a surface has contacted molten solder, but the solder has not adhered to all of the surface, and the surface tested remains exposed. See figure 2003-2.

1.1.5 Pinholes and voids. Holes occurring as imperfections that penetrate entirely through the solder layer. See figures 2003-3, 2003-4, and 2003-5.

1.1.6 Dewetting. A condition that results when molten solder has coated a surface and then receded leaving irregularly shaped mounds of solder separated by areas covered with a thin solder film, and where the base metal is not exposed. See figure 2003-6.

1.1.7 Foreign material. Particles of material located on, but different from, the lead material or coating. See figure 2003-7.

1.1.8 Solder and flux minimum application depth.

1.1.8.1 Dual-in-line packages. The location at which the termination widens to its maximum shoulder dimension, or to the package base plane, whichever is the further point from the seal.

1.1.8.2 Radial-lead packages (e.g., flatpacks, top brazed quads). A location on the lead, no greater than 0.05 inch from the package.

1.1.8.3 Axial-lead packages (e.g., TO cans, PGA, and platform packages). A location on the lead that is no greater than 0.05 inch from the body of the package, the seating plane, or the standoff, whichever is the furthest from the glass seal.

1.1.8.4 Leaded chip carriers (i.e., J bend, gull wing). A location on the leads equal to an extension of the base plane onto the leads, or the point at which the lead widens.

1.1.8.5 Leadless chip carriers. The location that provides for complete immersion of the termination.

2. APPARATUS.

2.1 Solder pot. A solder pot of sufficient size to contain at least two pounds of solder shall be used. The solder shall be static during the dipping procedure. The apparatus shall be capable of maintaining the solder at the temperature specified in 4.4.

2.2 Dipping mechanism. A dipping mechanism capable of controlling the rates of immersion and emersion of the terminations and providing a dwell time (total time at the required depth) in the solder bath as specified in 4.4 shall be used. The sample holder shall not come in contact with the solder bath and shall be designed to minimize the trapping of flux.

2.3 Optical equipment. A binocular optical system capable of providing a minimum magnification of 10X shall be used.

2.3.1 Lighting equipment. A lighting system shall be used that will provide a uniform, nonglare, nondirectional illumination of the specimen.

2.4 Steam aging equipment. A noncorrodible container and cover of sufficient size to allow the placement of specimens inside the vessel shall be used. The specimens shall be placed such that the lowest portion of the specimen is a minimum of 1.5 inches above the surface of the water (see 3.4). A suitable method of supporting the specimens shall be improvised using noncontaminating material. The apparatus shall be capable of having the specified temperature verified as required by 4.2.

2.4.1 Cleaning of the system. The apparatus shall be drained and cleaned at least once per month or prior to use. A more frequent cleaning cycle may be necessary as indicated by resistivity, visual, or general cleanliness of the water. No contaminating solvents shall be used.

3. MATERIALS

3.1 Flux. The flux shall conform to flux type symbol "A" (flux type "L0") of ANSI/J-STD-004, Requirements for Soldering Fluxes (previously designated as type "R" in MIL-F-14256) (25 percent by weight gum rosin in a 99 percent isopropyl alcohol solvent). The specific gravity of the flux shall be maintained within the range of 0.838 to 0.913 at 25°C. The customer/equipment manufacturer may, at their option, use flux type symbol "A" or "B" (flux type "L0" or "L1") flux (previously designated as "RMA" in MIL-F-14256).

3.2 Solder. The acquired solder shall conform to type Sn63A or Pb37A (previously designated as Sn63 in QQ-S-571) or Sn60A or Pb40A (previously designated as Sn60 in QQ-S-571) of ANSI/J-STD-006, Requirements for Electronic Grade Solder Alloys and Fluxed and Non-fluxed Solid Solders for Electronic Soldering Applications.

3.3 Isopropyl alcohol. Commercial grade isopropyl alcohol or better shall be used.

3.4 Water. The water to be used for steam aging purposes shall be either distilled or deionized.

WARNING: These materials may involve substances that are flammable, toxic to eyes, skin, or respiratory tract, or present a serious burn potential. Eye and skin protection should be used. Heat resistant gloves should be used when handling hot objects.

4. PROCEDURE. The test procedure shall be performed on the number of terminations specified in the acquisition document. The test may be performed just prior to packaging for storage or shipment, immediately upon removal from the manufacturer's protective packaging, or as a qualification or quality conformance test. The sample shall be selected at random. During handling, special care shall be exercised to prevent the surfaces being tested from being abraded or contaminated by grease, perspiration, or abnormal atmospheres. The test procedure shall consist of the following operations:

- a. Proper preparation of the specimens (see 4.1), if applicable.
- b. Aging of all specimens (see 4.2).
- c. Application of flux and immersion of the terminations into molten solder (see 4.3 and 4.4).
- d. Examination and evaluation of the tested portions of the terminations upon completion of the solder-dip process (see 4.5).

MIL-STD-883E
NOTICE 2

4.1 Preparation of terminations. No wiping, cleaning, scraping, or abrasive cleaning of the terminations shall be performed prior to testing. Any special preparation of the terminations, such as bending or reorientation prior to the test, shall be specified in the acquisition document. The customer/equipment manufacturer, may, at their option, clean the terminations using a nonabrasive, nonactive solvent (e.g., isopropyl alcohol).

4.2 Steam aging. Prior to the application of the flux and subsequent solder dips, all specimens assigned to this test shall be subjected to aging by exposure of the surfaces to be tested to water vapor for 8 hours ± 0.5 hour in the apparatus specified in 2.4. The water vapor temperature at the component lead level shall be in accordance with table I. Aging may be interrupted once for 10 minutes maximum. The devices shall be removed from the test apparatus upon completion of the specified test period.

4.2.1 Drying and storage procedures. Upon removing the test specimens from the apparatus, the parts may be dried using one of the following procedures:

- a. Bake at 100°C maximum for no more than 1 hour in a dry atmosphere (dry nitrogen atmosphere is recommended).
- b. Air dry at ambient temperature for a minimum of 15 minutes.

NOTE: Parts not solderability-tested within 2 hours after removal from the aging apparatus shall be stored in a desiccant jar or dry nitrogen cabinet for a maximum of 72 hours before testing. The parts shall not be used for testing if they have exceeded the storage requirements.

4.3 Application of flux. The terminations to be tested shall be immersed in flux maintained at room ambient temperature. The terminations, unless otherwise specified in the individual specification, shall be immersed according to 1.1.8. The terminations to be tested shall be immersed in the flux for 5 to 10 seconds, and shall be drained for 5 to 20 seconds prior to dipping in the solder pot. The flux shall be covered when not in use and discarded a minimum of once a day. Any obvious droplets of flux clinging to the termination may be removed by blotting.

4.4 Solder dip procedure. The dross and burned flux shall be skimmed from the surface of the molten solder prior to testing. A wave solder pot may be used for this purpose, but the solder shall be static during the dipping procedure. The molten solder shall be at a uniform temperature of 245°C $\pm 5^\circ\text{C}$ (473°F, $\pm 9^\circ\text{F}$). (Skimming may not be required in wave or flow pots). The part shall be attached to a dipping mechanism (see 2.2) and the flux covered terminations immersed once (except for the possible duplicate immersion of corner terminations on leadless packages) in the molten solder to the depth specified in 1.1.8. NOTE: The test sample shall not be suspended above the hot solder pot for longer than 7 seconds. The immersion and emersion rates shall be 1.0 inch per second $\pm .25$ inch per second. The dwell time in the solder shall be 5 seconds $\pm .5$ second. The dwell time for terminations greater than or equal to 0.040 inch in diameter shall be 7 seconds $\pm .5$ second. After the dipping process, the part shall be allowed to cool in air. Residual flux shall be removed from the terminations by dipping the parts in isopropyl alcohol or other suitable solvent. If necessary, a clean soft cloth, cotton swab, or equivalent, moistened with clean isopropyl alcohol or other suitable solvent, may be used to remove all remaining flux.

- * 4.4.1 Solder dipping of gold plated terminations. Gold plated terminations shall be cycled twice in flux and solder using one or two solder pots. The first immersion is to scavenge the gold on the terminations. It is recommended that a separate solder pot be used for gold plated devices. In any case, the user of this test should use two separate pots, a sufficiently large pot, or monitor closely the contamination level of a single small pot to assure that the test is performed as intended.

4.4.2 Immersion angle. Unless otherwise specified, the terminations shall be immersed perpendicular to the solder surface. For leaded or leadless chip carriers, the terminations shall be immersed at a 30° to 45° angle to the solder surface.

4.4.3 Solder bath contaminants. The manufacturer shall have a system to verify that the solder bath does not exceed the contaminant levels specified in table II.

Supersedes page 3 of MIL-STD-883E

METHOD 2003.7
15 November 1991

MIL-STD-883E
NOTICE 2

TABLE I. Altitude versus steam temperature (see 4.2).

Altitude (feet)	Steam temperature (°C +3, -5)
0 - 2,000	93
2,001 - 4,000	91
4,001 - 6,000	89
Greater than 6,000	87

TABLE II. Maximum limits of solder bath contaminant (see 4.4.3).

Contaminant	Contaminant percentage limit
Copper	0.300
Gold	0.200
Cadmium	0.005
Zinc	0.005
Aluminum	0.006
Antimony	0.500
Iron	0.020
Arsenic	0.030
Bismuth	0.250
Silver	0.100
Nickel	0.010

NOTE: The total copper, gold, cadmium, zinc, and aluminum
contaminants shall not exceed 0.4 percent.

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METHOD 2003.7
15 November 1991

- * 4.5 Examination of terminations. The dipped portion of the terminations shall be examined using a magnification of 10-15X. Verification of failures may be accomplished with higher magnifications up to 60X. The customer/equipment manufacturer of the component may establish a critical portion of the termination within the dipped area. The customer/equipment manufacturer has the option to accept solderability defects outside their established critical area. The customer/equipment manufacturer has the option of cleaning parts to remove carbonate/sulfate deposits caused by exposure of the parts to the steam aging or cleaning process. The customer/equipment manufacturer shall assure that the cleaning process does not adversely affect the physical, mechanical, electrical, or reliability performance of the parts. This cleaning process shall be fully documented. For leaded devices only, the cut portions of the lead which expose lead ends shall not be used for examination and evaluation of the solder coverage of the termination.

4.5.1 Criteria for acceptance. The criteria for acceptable solderability (see figures 2003-1 through 2003-7) are:

- a. The dipped portion of the terminations is at least 95 percent covered by a continuous new solder coating.
- b. Pinholes, voids, porosity, nonwetting, or dewetting do not exceed 5 percent of the total area.
- c. For leadless terminations and elements having solder attachment terminations, there shall be no solder bridging between any termination area and any other metallization not connected to it by design. In the event that the solder dipping causes bridging, the test shall not be considered a failure provided that a local application of heat (e.g., gas, soldering iron, or redipping) results in solder pullback and no wetting of the dielectric area as indicated by microscopic examination. The area of the surface to be tested shall be as specified in 1.1.8.

NOTE: The total area of the surface to be tested including all faces for rectangular leads) as specified in 4.5 shall be examined. In the case of a dispute, the percentage of coverage with pinholes or voids shall be determined by the actual measurement of those areas, compared to the total area(s).

5. SUMMARY. The following details are to be specified in the individual specifications unless otherwise noted:

- a. The number of terminations of each part to be tested (see 4).
- b. Special preparations of the terminations, if applicable (see 4.1).
- c. Depth of immersion if other than in 1.1.8.
- d. Magnification, if other than in 2.3.
- e. Solder composition, flux, and temperature if other than those specified in this document.
- f. Number of cycles, if other than one, or as noted in this test method. Where more than one cycle is specified to test the resistance of the device to heat as encountered in multiple solderings, the examinations and measurements required shall be made at the end of the first cycle and again at the end of the total number of cycles applied. Failure of the device on any examination and measurement at either the one-cycle or the end point shall constitute a failure to meet this requirement.

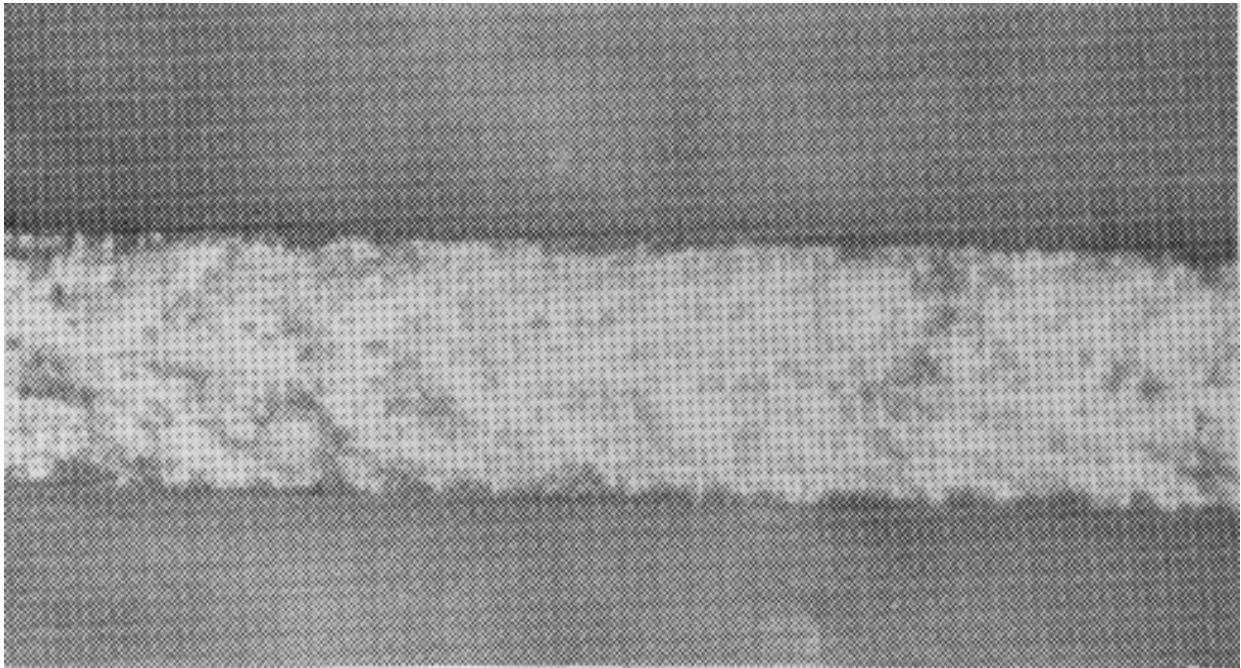


FIGURE 2003-1. Porosity.

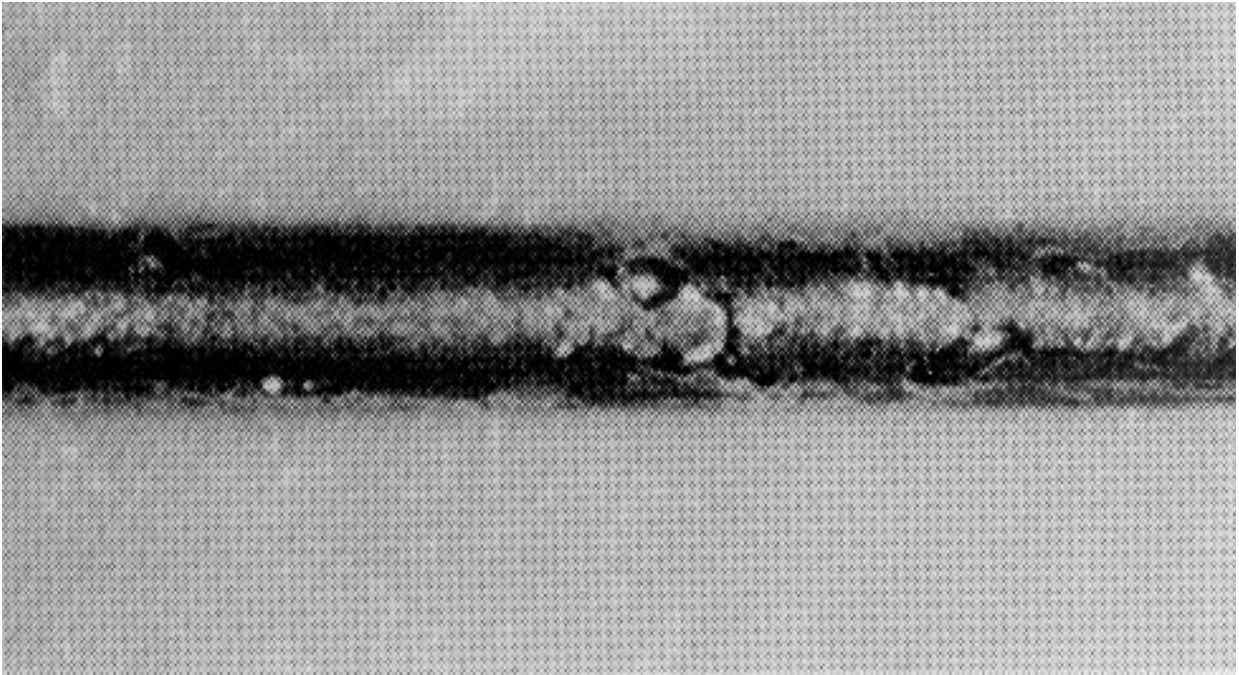


FIGURE 2003-2. Nonwetting.

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MIL-STD-883E
NOTICE 4

How to use this chart:

1. The chart is set-up for .5 inch long leads.
2. View the entire circumference of the lead.
3. Locate the lead diameter on the left side of the chart.
4. Locate the diameter of the void on the top of the chart.

	0.001	0.003	0.005	0.010	0.015	0.020	0.030	0.040
0.010	1000	111	40	10	4.4	2.5	1.10	0.62
0.015	1500	167	60	15	6.6	3.75	1.60	0.937
0.020	2000	222	80	20	8.8	5	2.22	1.25
0.030	3000	333	120	30	13.0	7.5	3.33	1.87
0.040	4000	444	160	40	17.7	10	4.44	2.50
0.050	5000	555	200	50	22.0	12.5	5.55	3.12
0.060	6000	666	240	60	26.6	15	6.66	3.75

Examples for less than .5 inch leads:

- A. Lead length = 0.350.
- B. $0.350/0.500 = 0.700$.
- C. To determine the number of acceptable voids, multiply the number of voids on the chart by 0.700.
- * D. For a .001 inch void on a 0.010 inch diameter lead = 700 voids.
- E. For leads greater than 1.0 inch in length, see 4.5.

FIGURE 2003-3. Solderability evaluation guidelines.

Supersedes page 8 of MIL-STD-883E

METHOD 2003.7
15 November 1991

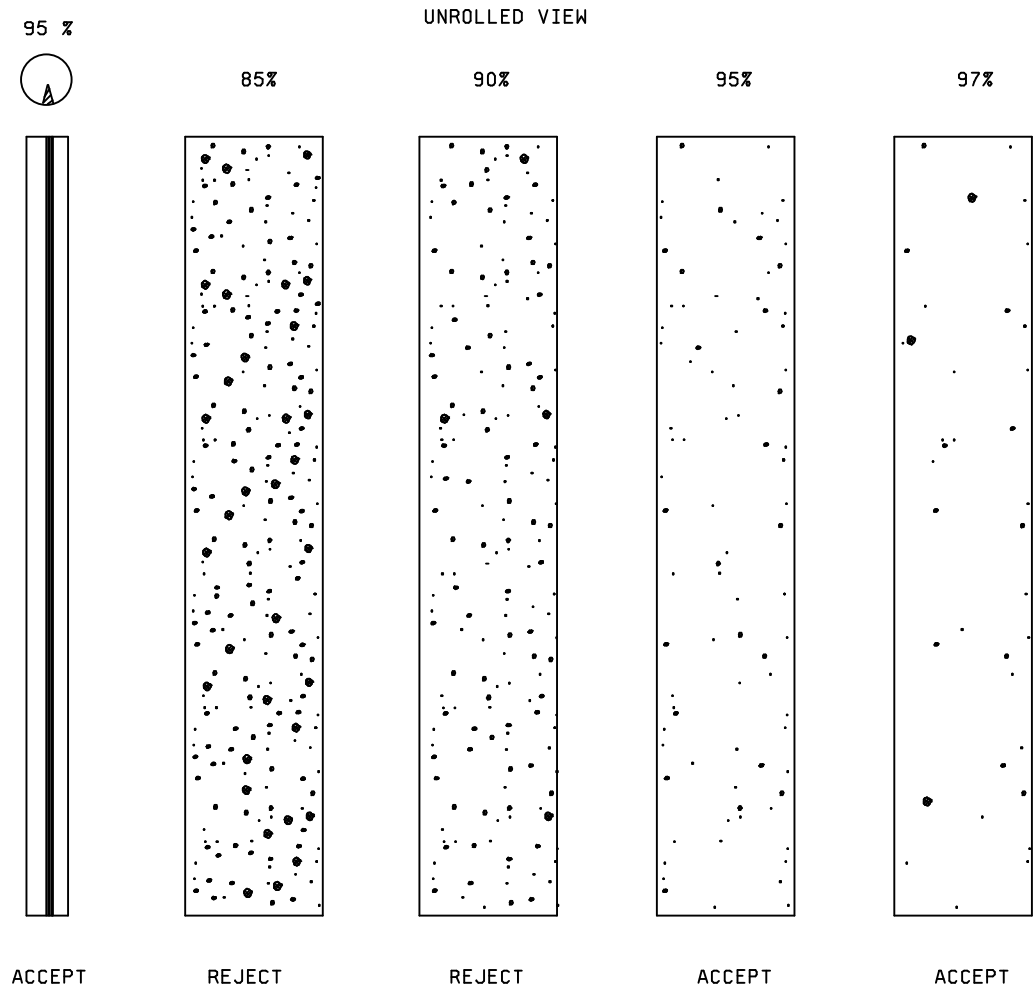


FIGURE 2003-4. Solderability coverage of a 0.5 inch, .025 diameter lead at 10X magnification.

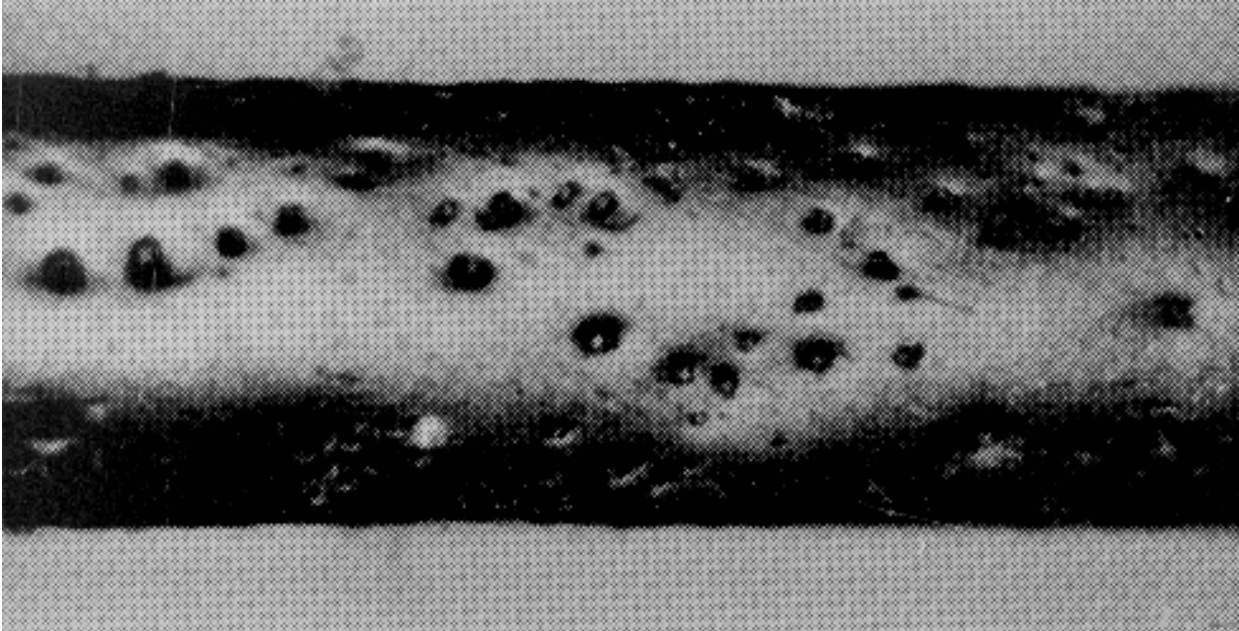


FIGURE 2003-5. Pinholes.

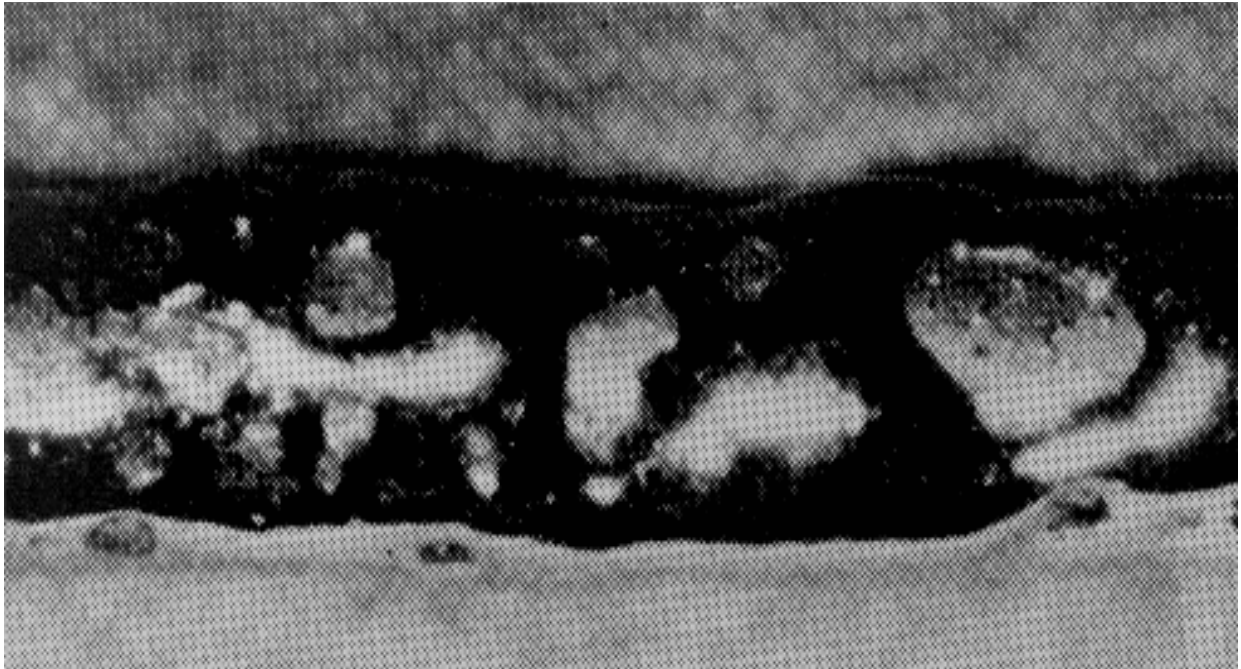


FIGURE 2003-6. Dewetting.

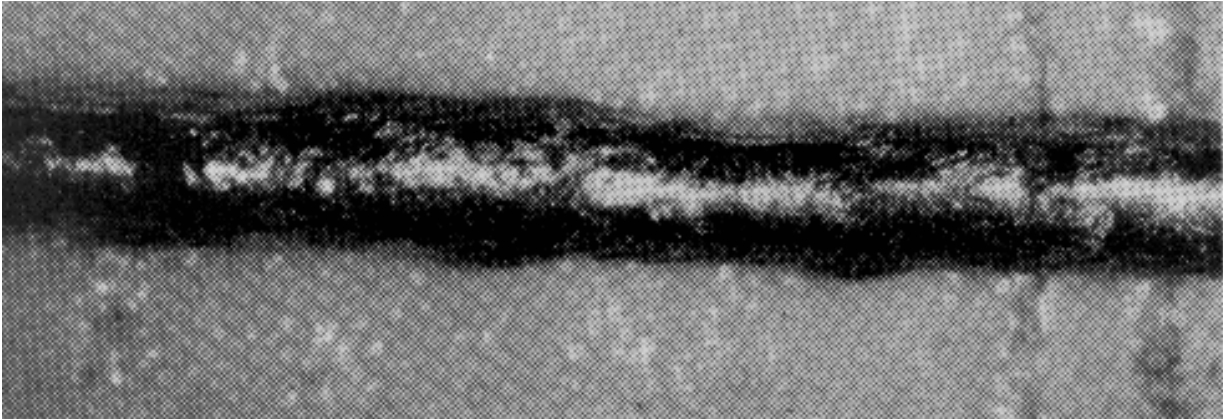


FIGURE 2003-7. Foreign material.