1. PURPOSE. The purpose of this examination is to nondestructively detect unbonded regions, delaminations and/or voids in the die attach material and at interfaces within devices through the measurement of acoustic continuity. It establishes methods and criteria for ultrasonic inspection of devices.

For certain device structures or die attach materials, a dramatic distinction between well-bonded and poorly bonded conditions may be difficult to achieve. This factor should be considered in relation to the design of each device when application of this test method is specified.

2. DEFINITIONS.

2.1 The term “die attach interface” as used in this test method refers to the entire bulk area between the die and the substrate to which it is bonded. For die attach interfaces, this includes the interface between the die attach material and the die, the interface between the die attach material and the substrate, plus the die attach material itself.

2.2 The term “bulk material” as used in this test method refers to the entire thickness within a specific layer of material. For die attach, the attachment material by itself is considered a bulk material.

2.3 The term “ultrasonic inspection” as used in this test method refers to high frequency ultrasonic visualization (imaging) which produces a gray or color scale output such as may be provided by ultrasonic scanning (US) or acoustic microscope (AM) techniques. The most common mode utilized for die attach inspection is an X-Y plane scan at specified depth(s) in Z, which is commonly referred to as C-Scan or C-mode imaging. Other ultrasonic techniques may also be utilized to obtain the die attach integrity data.

2.4 The term “reflected” as used in this test method refers to the change in direction of an ultrasound wave front at an interface between two different media so that the wave front returns via the medium from which it originated.

2.5 The term “reflection mode” as used in this test method refers to an ultrasonic scan or acoustic microscope that uses one transducer as both the pulser and receiver. (This is also known as a pulse/echo system.)

2.6 The term “transmitted” as used in this test method refers to the propagation of an ultrasound wave through a media or an interface between media that allows it to continue through the structure.

2.7 The term “transmission mode” as used in this test method refers to an ultrasonic scan or an acoustic microscope that transmits ultrasound completely through the sample from a sending transducer to a receiver on the opposite side.

3. APPARATUS. The apparatus and materials for this test shall include:

3.1 Ultrasonic inspection equipment: The ultrasonic inspection equipment shall have a test frequency sufficient to penetrate to the die attach material interface. In the case that the opening of a sealed hermetic or non-hermetic device with a known air cavity is undesirable, the ultrasonic equipment shall be capable of detecting an acoustic signal that enters the top and bottom or back of a package and is reflected by or transmitted through to the desired material interface. The test frequencies and focal distances shall be adequate to achieve a resolution capable of detecting voids as small as 0.0254 mm (0.001 inch) in diameter, when inspecting through the die is desired, but this may not be feasible due to the construction of the device. In such cases, the test frequency and focal distance shall be chosen to ensure penetration down to the desired material interface with the achievable resolution being a secondary consideration.

3.2 Output device: A hard copy gray or color scale recording unit or other direct recording device (computer storage) shall be used to produce an image for analysis (manual or automated). The dynamic range of the output image shall be at least 256 discernible colors or levels of gray scale. The appropriate gray/color scale shall be included in each image. The image, hard copy or digital, shall be large enough to achieve a resolution capable of detecting a void as small as 0.0254 mm (0.001 inches) in diameter, when inspecting through the die, or the best feasible resolution for that application.
3.3 **Holding tank**: A holding tank for containing the coupling fluid and locating fixtures (as needed) to ensure accurate and repeatable placement of the devices inspected. The holding tank, locating fixtures and any auxiliary supporting hardware shall be constructed of materials that will be unaffected by corrosion or other reactivity in the presence of the coupling fluid.

3.4 **Ultrasonic detector**: Reflection mode imaging shall be used when the opening of a sealed, hermetic device is undesirable. For inspection of the die attach interfaces within a sealed device, as an example, it shall be capable of detecting an acoustic signal which enters the back or bottom of the package and is reflected by the material interface(s). The reflection and/or transmission modes of imaging shall be used when inspecting a non-hermetic or the opening of a sealed hermetic device is allowable.

4. **PROCEDURE**. The ultrasonic inspection instrument shall be selected or adjusted as necessary to obtain satisfactory images and achieve maximum image details within the sensitivity requirements for the device or defect features the test is directed toward. In the case of reflection mode or transmission mode images, care must be exercised to insure that the ultrasound penetrates and is sensitive to the entire die attach interface or bulk material area of interest.

4.1 **Mounting and handling**. The devices shall be mounted in the holding tank so that the devices are not damaged or contaminated and are in the proper plane for inspection. The devices may be mounted in any type of fixture providing the fixtures do not block the view from the ultrasonic transducer to any portion of the body of the device in the region of interest. The coupling fluid in the holding tank shall be distilled water or other suitable noncorrosive liquid. The devices shall remain in the coupling fluid for as short a time as possible. Subsequent to the ultrasound inspection, proper cleaning and drying of the samples are required. Refer to J-STD-033 for the recommended bake out times and procedures to remove any ingressed moisture within a non-hermetic surface mount devices.

4.2 **Views**. All devices, shall have at least one image view made with the ultrasound penetrating the device in a direction perpendicular to the plane of the material interfaces, and for which there is acoustic continuity from the device exterior surface to the die attach interface(s) (Note: Generally, the Z-axis direction with the die attach parallel to the X-Y plane). For devices with no sealed air gap above the die (unlidded or non-hermetic devices), an image view made with the ultrasound directed from (reflected) or through (transmitted) the surface of the die to the material interface(s) may be specified (see figure 2030-1 for examples).

4.3 **Recording and marking**. The ultrasonic image shall be printed using paper and with at least a resolution of 300 data elements per inch nominal or stored in a digital file format by the equipment. The image shall be identified by unambiguously marking the paper on which the image is printed or stored within the digital file format with, but not limited to the following information:

4.3.1 Device manufacturer's name or code identification number.

4.3.2 Device type or part number.

4.3.3 Production lot number or date code or inspection lot number.

4.3.4 Ultrasonic image number and date.

4.3.5 Device serial or cross reference numbers, where applicable.

4.3.6 Ultrasonic laboratory identification, if other than device manufacturer.

4.3.7 Mounting material utilized for the die attachment, if known.

4.4 **Recording with nonprint techniques**. The use of documentation techniques, other than paper recording techniques is permitted (e.g., computer records, digital data files) provided that the equipment is capable of storing results of at least equal quality when compared to printed recording techniques, and all requirements specified herein, except those pertaining to the actual paper recording. If possible, the digital file name should incorporate a unique device identifier, such as a serial number, as part of the file name.

4.5 **Serialized devices**. When device serialization is required, each device shall be readily identified by a serial number.
4.6 **Set up verification.** When imaging lidded (sealed) devices, one open lid device of the same type and construction should be available to set up the equipment. The device may be a scrapped, nonoperational device or a known set up sample with known voids which will be used to identify internal landmarks and insure the equipment is properly operating.

4.7 **Tests.** Ultrasonic frequency gate settings, receiver attenuation, and other equipment settings shall be selected to achieve the resolution desired for the type of inspection being accomplished, in the example of die attach a resolution of 0.0254 mm (0.001 inch) in diameter, when inspecting through the die. Optimize the ultrasonic signal reflected from the material interface of interest, and distinguish image features with as great a contrast as possible. Ultrasonic images shall be made for each view required.

4.8 **Operating personnel.** Personnel who will perform ultrasonic inspection shall have training in ultrasonic imaging procedures and techniques so that defects revealed by this method can be validly interpreted and compared with applicable standards.

4.9 **Interpretation of ultrasonic images.** Ultrasonic images shall be inspected to determine that each device conforms to this standard and defective devices shall be rejected. Interpretation of the image shall be made under moderate light level conditions without a glare on the recording paper's surface or the display monitor. The image shall be viewed at an appropriate magnification to determine acceptance as specified herein. Automated percentage void or bond area calculations can be utilized instead of visual analysis upon confirming that the automated method is at least equal to the accuracy of the visual method (see figure 2030-2 for example of automated method).

4.10 **Reports of records.**

4.10.1 **Reports of inspection.** When specified, the manufacturer shall furnish inspection reports with each shipment of devices. The report shall describe the results of the ultrasonic inspection, and list the purchase order number or equivalent identification, the part number, the date code, the quantity inspected, the quantity rejected, and the date of test. For each rejected device, the part number, the serial number when applicable, and the cause for rejection shall be listed.

4.10.2 **Ultrasonic image and report retention.** When specified, the manufacturer shall retain a set of the ultrasonic images and a copy of the inspection report. These shall be retained for the period specified by the procuring activity in the acquisition document.

4.11 **Examination and acceptance criteria for die attach.** In the examination of devices, the following aspects shall be considered unacceptable die attach interface, and devices that exhibit any of the following defects shall be rejected. If heat transfer is a concern, defects directly under the “hot” regions of the attach interface may be an issue and should be evaluated further with reliability testing.

4.12 **Voids and Unbonded Area.** When imaging devices ultrasonically, certain types of mounting material may not give true representation of voids; therefore the mounting material shall be noted on the inspection report, when known.

4.12.1 Total of voids in excess of 50 percent of the total intended interface region (see figure 2030-3).

4.12.2 A single void in excess of 15 percent of the total intended interface region (see figure 2030-3).

4.12.3 A single corner void in excess of 10 percent of the total intended interface region (see figure 2030-3).

4.12.4 When the interface region of interest is divided into four equal quadrants by bisecting both pairs of opposite edges, any quadrant exhibiting interface region voids in excess of 70 percent of the intended interface quadrant region (see figure 2030-3).

In case of dispute, the percent of voiding shall be determined by actual measurement from the digital image using percentage void and bond image analysis functions with at least two threshold levels, i.e. B&W.
5. **SUMMARY.** The following details shall be specified in the applicable acquisition document:

5.1 Number of views, if other than indicated in 4.2.

5.2 Image marking, if other than indicated in 4.3 or marking of samples to indicate they have been ultrasonically imaged, if required.

5.3 Defects to be sought in the samples and criteria for acceptance or rejection, if other than indicated in 4.12.

5.4 Image and report retention per 4.10.2, if applicable.

5.5 Test reports, if other than indicated in 4.10.1.
Example 2030-1a: Unlidded device reflection mode image through the die to die attach interface.

Example 2030-1b: Unlidded device reflection mode image through substrate side to die attach interface.

Example 2030-1c: Non-hermetic device reflection mode image through substrate side to die attach interface (see figure 2030-2 for example automated method analysis).

FIGURE 2030-1. Example Reflection Mode Grayscale Images of Die Attach Interface
FIGURE 2030-2. Example Automated Method Analysis Report for Die Attach Interface
Typical Transmission Mode Image Analysis (Two threshold levels – B&W)

Reject: Single void larger than 15 percent (%) of total intended interface.
Reject: Corner void larger than 10 percent (%) of total intended interface.

Accept: No single void larger than 15 percent (%) of total intended interface.
Accept: Corner void of area less than 10 percent (%) of total intended interface.

Reject: Quadrant more than 70 percent (%) unbonded.

Accept: All quadrants less than 70 percent (%) unbonded.

= Void or Unbonded area

FIGURE 2030-3. Void criteria for die attach material interface inspection.