



# Ball Grid Array Joint Inspection Using X-ray as it relates to voids and the IPC-7095A specification

White Paper

## Introduction

With the introduction of Lead-free solder, voiding within Ball Grid Array (BGA) joints is potentially a major issue during Printed Circuit Board Assembly (PCBA) manufacture. With BGA components sometimes costing hundreds or even thousands of US Dollars, there has to be an understanding about when voiding within the joint is excessive.

There are a number of specifications that a manufacturer can refer to but with respect to BGA joints, IPC-7095A is probably the most comprehensive. It has an entire section on voiding within the BGA ball and limits on when the void size becomes either a Process Control issue or a Corrective Action Indicator. However, some of this information seems to conflict with other IPC specifications, for example IPC-A-610D.

## IPC Specifications

IPC-7095A is the Specification for the Design and Assembly Process Implementation for BGAs. Chapter 7 deals with the Assembly of BGAs on the printed circuit board and has extensive information on voiding.

Where possible, it is important to know the location of the void within the ball. Voids at the package or PCB interfaces are more likely to cause failures or weaknesses in the joint compared with voids completed within the ball.

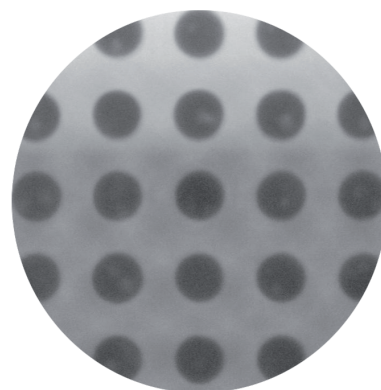







Table 7-7 Void Classification			
Void Analysis	Void Within the Ball	Void at the Package Interface	Void at the Mounting Surface Interface
Void in BGA Balls Prior to attachment to a PWB	 Type A	 Type B	N/A
Void in BGA Balls after Attachment to a PWB	 Type C	 Type D	 Type E

Figure 1: IPC-7095A Table 7-7 - Void analysis matrix

**Type A & B voids**  
 These voids occur in the ball before the component is attached to the PCB and therefore typically not tested on a production line. They are typically detected during a sample inspection of product received from the component supplier.

**Type C voids**  
 As shown in the figure above, these voids are found within the ball and not at either attachment interface. These voids may be wholly or partially contained with the ball.

**Type D voids**  
 These are voids at the interface between the ball and the package. These are typically, though not exclusively formed when the solder ball is attached to the component during the packaging process.

**Type E voids**  
 These are voids at the ball and PCB (pad) interface. These are formed during the reflow process when attaching the component to the Printed Circuit Board.

Type C voids are generally less critical as they are not on an attachment interface. However, if the void is too large, the strength integrity of the entire joint may be compromised. There is an argument that multiple microvoiding within the ball actually increases joint strength by creating a flexibly spongy structure, however, at this stage the validity of this theory is unknown. Plus it is not possible to consistently create the spongy micro void structure.

Type D and E voids being at a mounting interface have the potential of creating weaker joints due to the fact there may be less solder to lend strength to the joint. Another potential problem could be a decrease in the ability to dissipate heat due to the air gap instead of having a continuous layer of solder.

**Table 7-8 Void Size Limitation**

Void Type	Void Description	Process Control Criteria			Determine By
		Class 1	Class 2	Class 3	
A	Voids within the solder ball at incoming	36% of area = 60% of Dia	20% of area = 45% of Dia	9% of area = 30% of Dia	Transmission or cross section X-ray (sampling)
B	Voids at package interface at incoming	25% of area = 50% of Dia	12% of area = 35% of Dia	4% of area = 20% of Dia	Transmission * or cross section X-ray (sampling)
C	Voids within the ball after PCA reflow	36% of area = 60% of Dia	20% of area = 45% of Dia	9% of area = 30% of Dia	Transmission * or cross section X-ray (sampling)
D	Voids at the package interface after PCA reflow	25% of area = 50% of Dia	12% of area = 35% of Dia	4% of area = 20% of Dia	Transmission * or cross section X-ray (sampling)
E	Voids at the mounting surface/printed board after PCA reflow	25% of area = 50% of Dia	12% of area = 35% of Dia	4% of area = 20% of Dia	Transmission * or cross section X-ray (sampling)

If transmission X-ray is used to evaluate the occurrence of void the tightest criteria (% allowable at ball or interface) must be used for the evaluation since transmission X-ray cannot determine the location of the void. This would be the criteria for a type "D" void.

**Figure 2 : IPC-7095A Table 7-8**

Within IPC-7095A, Figure 2 (shown at the above) is the relevant specification as to the maximum void size permitted.

Class 1 products are high volume, very low cost and typically X-ray inspection is not carried out. If these products fail at functional test, they are typically scrapped instead of being repaired.

Computers and cell phone PC-BAs are examples of products that fall within the Class 2 rating.

Class 3 products are where high reliability is required, for example in Aerospace and Defense applications, hence the much tighter limit on allowable voids.

Using the Agilent *Medalist* 5DX Automated X-ray Inspection system, it is possible to "slice" the BGA to determine whether the void is contained within the ball or whether it is at a connecting interface. Traditional Transmission X-ray systems can only inspect the BGA from above and hence all voids need to be evaluated using the Type D void criteria irrespective of the location of the void.

**7.5.1.7 Accept/Reject Criteria**

The accept/reject criteria for BGA assemblies as being considered by the J-STD-001 and IPC-A-610 Task Groups at the time for release of this standard.

Those documents provide the final accept/reject criteria used in contractual agreements. The recommended accept/reject conditions have been supplied to those standard.

**Figure 3 : IPC-7095A Section 7.5.1.7**

*IPC-7095A does allow for the CM and the OEM to set other criteria as shown above.*

**8.2.12.4 Surface Mount Area Array - Voids**

Design induced voids. e.g. , microvia in land, are excluded from criteria. In such cases acceptance criteria will need to be established between the manufacturers and users.

Manufacturers may use test of analysis to develop alternate acceptance criteria for voiding that consider the end-use environment.

**Figure 4 : Section 8.2.12.4**

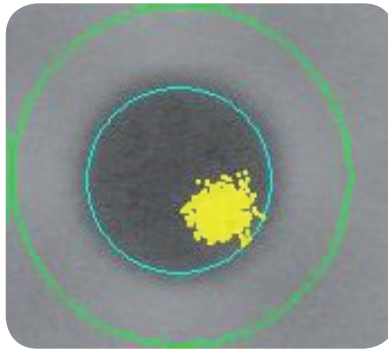
*IPC-A-610D has a different specification on allowable voids IPC-A-610D does not differentiate between the different Classes of products nor on the location of the void. And furthermore, IPC-A-610D also allows the Contract Manufacturers (CM) and the Original Equipment Manufacturers(OEM) to agree on an acceptance criteria subject to the end user environment.*

## X-ray Inspection

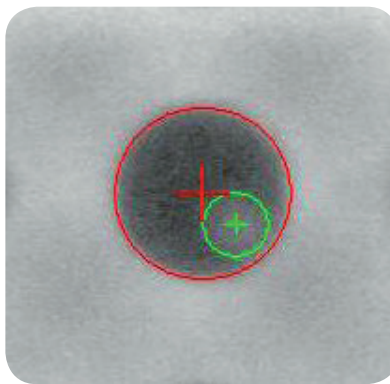
At first glance it seems that the two IPC specifications conflict, however on further study both suggest that the CM and the OEM agree to a pass/fail criteria that depends on the end customer usage and the above specs are the suggested maximum permissible voiding for each class of product.

Most X-ray inspection systems have some means of measuring voids within the BGA. It could be a manual process where an operator puts cursors over the voids and measures the diameter of the joint versus the diameter of the ball. In the case of the *Medalist 5DX*, an algorithm automatically calculates the area of the void and compares it with the area of the ball.

This automation in the *Medalist 5DX* means that the calculation of the void diameter/area is much more accurate and faster than having to rely on an Operator manually measuring the void and ball diameters.



**Figure 5 : Automatic measurement of void using algorithms**



**Figure 6 : Manual measurement of void using graphical measurement tools**

Acknowledgements  
Data from IPC7095A and IPC-A-610D for the purposes of validating the same.

FOR MORE INFORMATION ON AGILENT TECHNOLOGIES' AUTOMATED X-RAY INSPECTION SOLUTIONS, VISIT:

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Printed in the USA, December 14,  
2006  
5989-5663EN



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