Technical Paper

Evaluation of Plated-Through-Hole Deformation in Lead-Free Press-Fit Connections

Dr. George J. S. Chou
Tyco Electronics
Harrisburg, PA

tyco | Electronics

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Introduction

IEC 60352-5 specification[1] requires the transverse sectioning of plated-through hole (PTH) in press-fit connection technology meets the following conditions: (1) the hole deformation shall be smaller than 70 μm measured by a tangential difference between the drilled hole and the deformed hole, (2) the thickness of the remaining plating thickness must be more than 8 μm, and (3) there is no cracks in the plating of the through hole, in addition to the requirement of no cracks in Cu plating in the longitudinal sectioning of PTH for double side printed board.

In the previous study entitled "Effects of Lead-Free Surface Finishes on Press-Fit Connections"[2], we have reported that all the PTHs pass the IEC requirements in both longitudinal and transverse sectioning of PTHs after the second repair in press-fit connections using different combinations of lead-free and tin-lead finishes on both compliant pins and PTHs. At the time of the study, a pass-or-fail criterion was used to check if the distortions of PTHs in the transverse cross-sections at a depth of 0.4 mm below PCB top surface met the IEC requirements. Two concentric circles of a radius in the size of drilled hole and a radius of 70 μm larger than the drilled hole were overlapped on the images of PTHs and then checked if the PTHs passed or failed the requirement of maximum tangential deformation of 70 μm. Also, a straight line of 8 μm in length was used to check if the PTHs exceeded the requirement of minimum remaining plating thickness.

In contrast to the requirement (1) of IEC specification for the transverse sectioning described in the first paragraph of this section, the R4-10 of NEBS[1] GR-78-CORE has more stringent requirements as: (1) the average plated-through hole deformation radius shall be no greater than 0.0015 inch (38 μm) when measured from the drilled hole and (2) the absolute maximum deformation radius shall be smaller than 0.002 inch (50 μm). But, other similar requirements in IEC specification are still called for by the R4-11 of NEBS GR-78-CORE that requires the

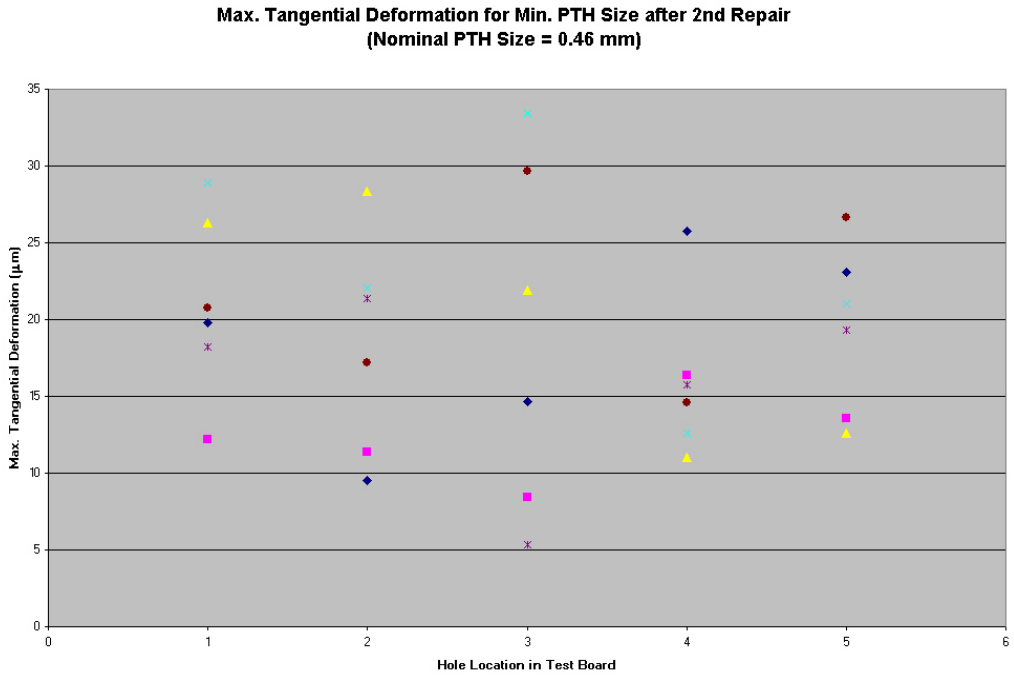
[1] Network Equipment Building System, Telcordia Specifications

minimum average copper thickness in the PTH remaining between the pin and the laminate, averaged over a 10-hole microsection sample, shall be no less than 0.0003 inch (8 μm). There shall be no copper cracks or other interplane separation from the PTH barrel or separations between the PCB laminate and the barrel.

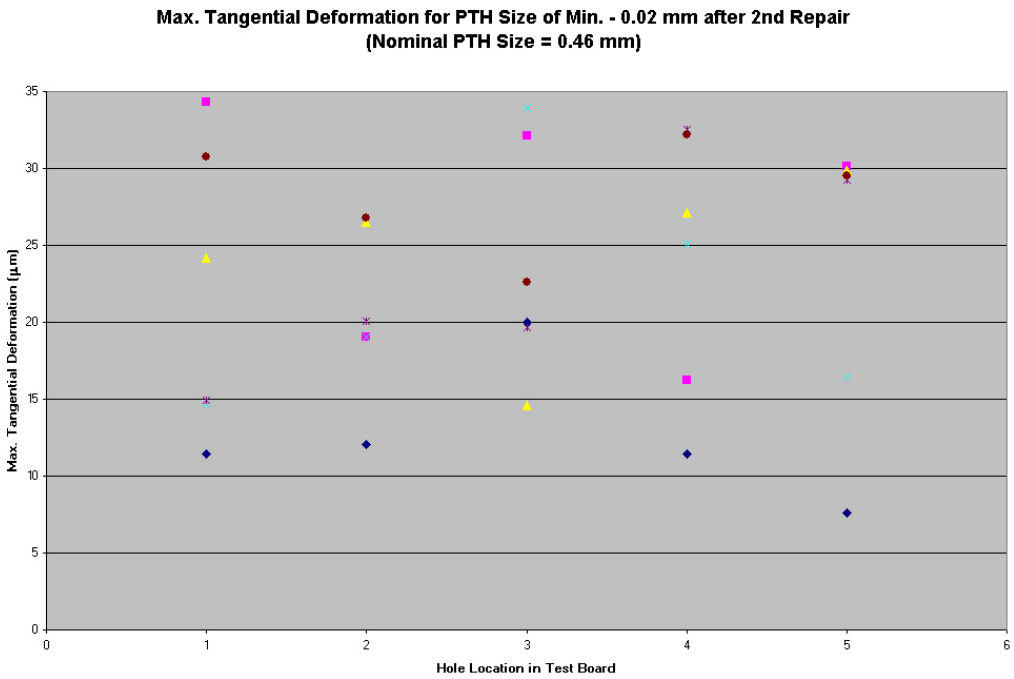
To address the more stringent R4-10 and R4-11 requirements in the NEBS GR-78-CORE compared to the IEC specification for the previous study[2], we have conducted re-evaluations on the PTHs cross-sectioned in transverse direction from the previous study. The following section lists the re-evaluation results of using image analysis technique to measure the maximum tangential deformation and the minimum plating thickness in the deformed PTHs.

PTH Evaluation Results and Discussion

In this white paper, the PTHs of minimum hole size and a size of 0.02 mm less than the minimum hole size are evaluated to present the most deformed situations in press-fit connection. Thus, the evaluation results on these PTHs should represent the extreme conditions of the deformed PTHs in the connection. Once these most deformed PTHs meet the NEBS GR-78-CORE requirements R4-10 and R4-11, the PTHs of larger sizes in the same press-fit applications should also meet the requirements. Figures 1-4 are showing the measurements of maximum tangential deformation and minimum remaining Cu thickness for the deformed PTHs of minimum hole size and a size of 0.02 mm less than the minimum hole size in press-fit applications. The different color (or marker) of each data points represent the different PTH surface finishes in the connection. Six PTH finishes evaluated in the tests are: HASL SnPb, galvanic Au, OSP, immersion Au, immersion Sn, and immersion Ag. The hole location as shown in the x-axis of the figures is related to the surface finish of compliant pin (i.e. SnPb or two lead-free pure tin finishes).

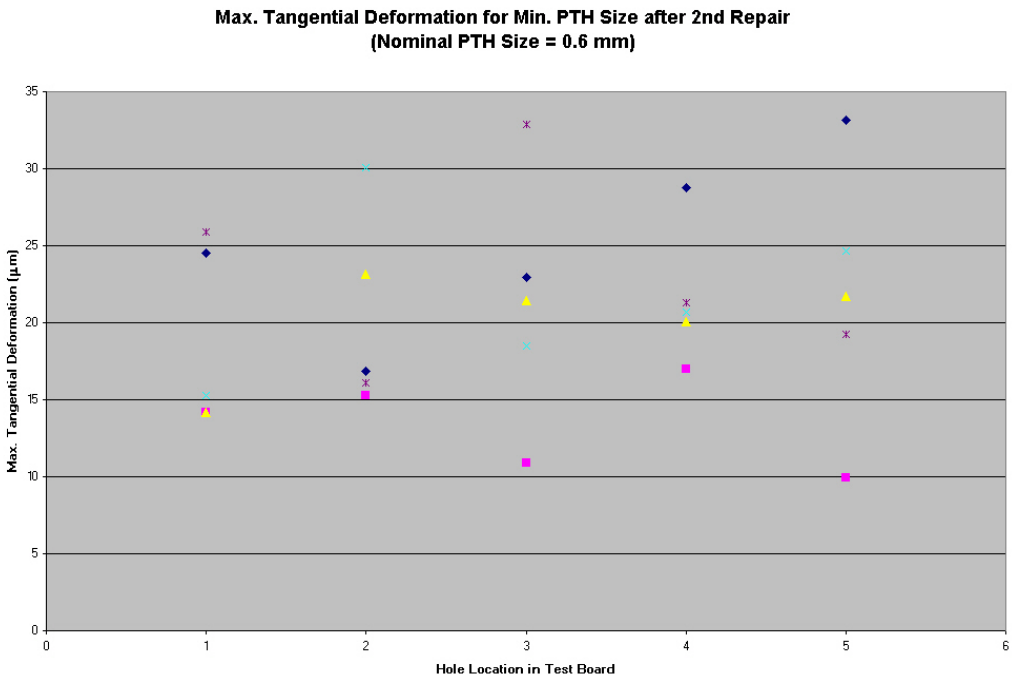


(a)

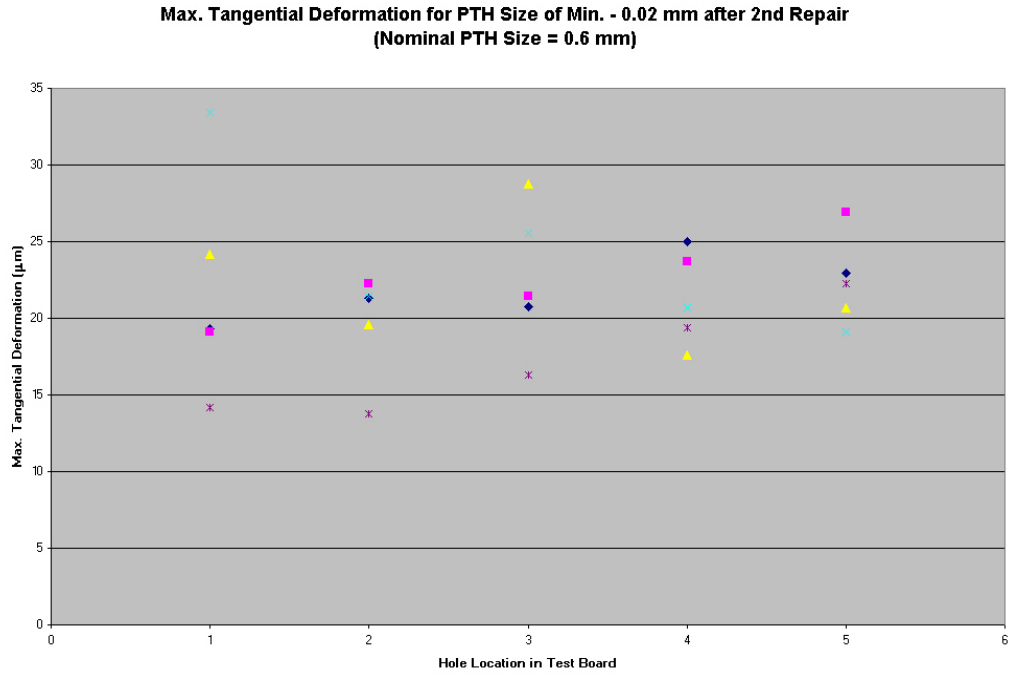


(b)

Figure 1. Measurements of maximum tangential deformation for (a) PTHs of a size of 0.02 mm less than the PTHs of a minimum size (b) in nominal 0.46 mm applications

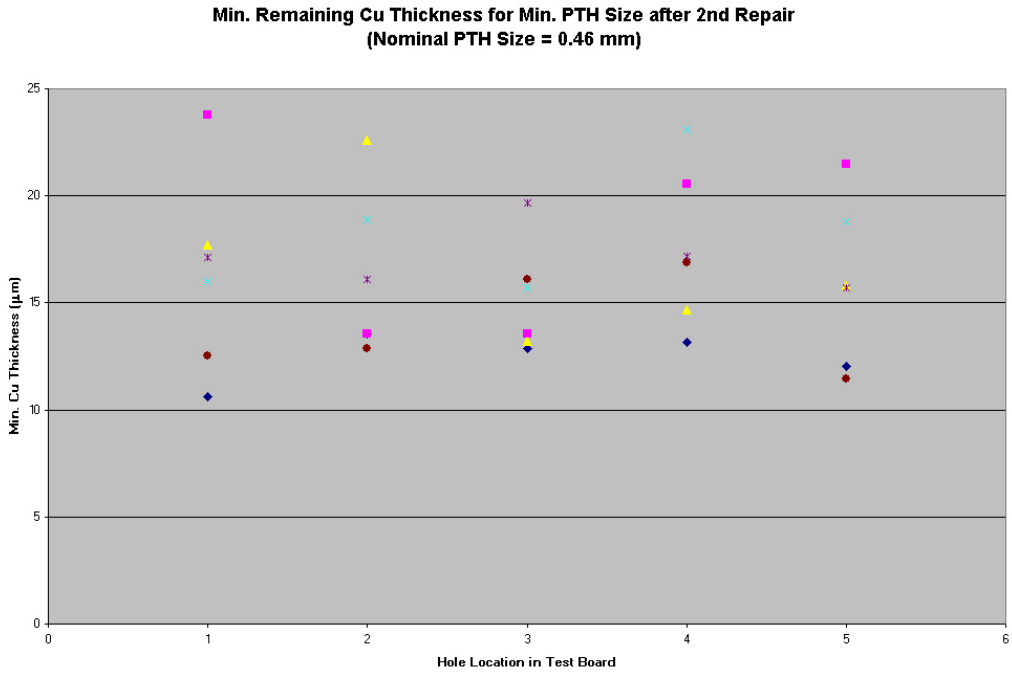


(a)

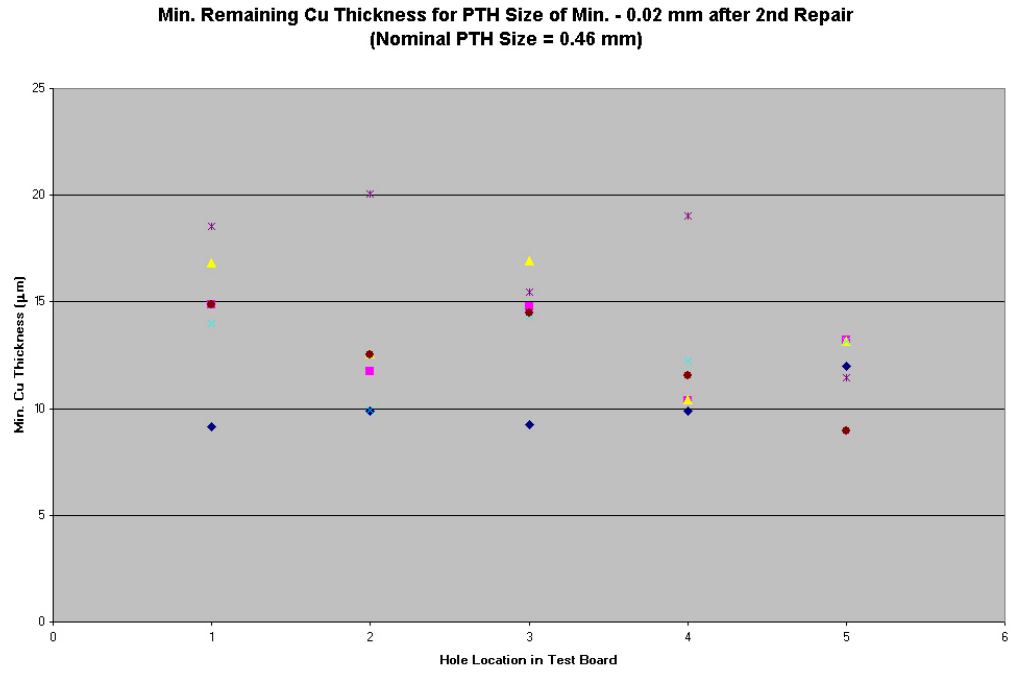


(b)

Figure 2. Measurements of maximum tangential deformation for (a) PTHs of a size of 0.02 mm less than the PTHs of a minimum size (b) in nominal 0.6 mm applications

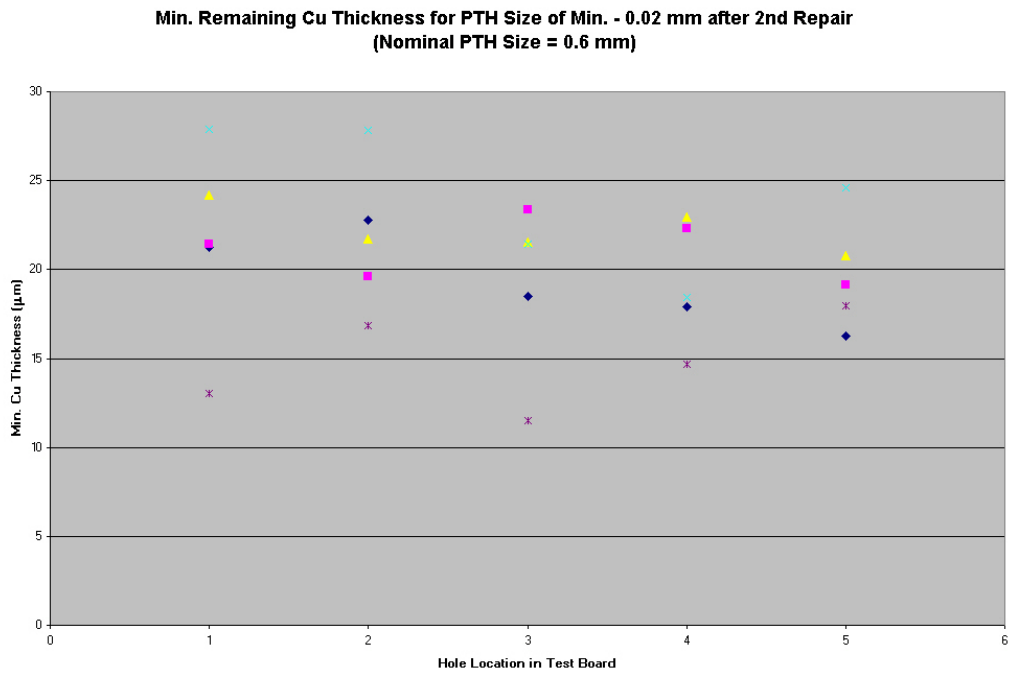


(a)

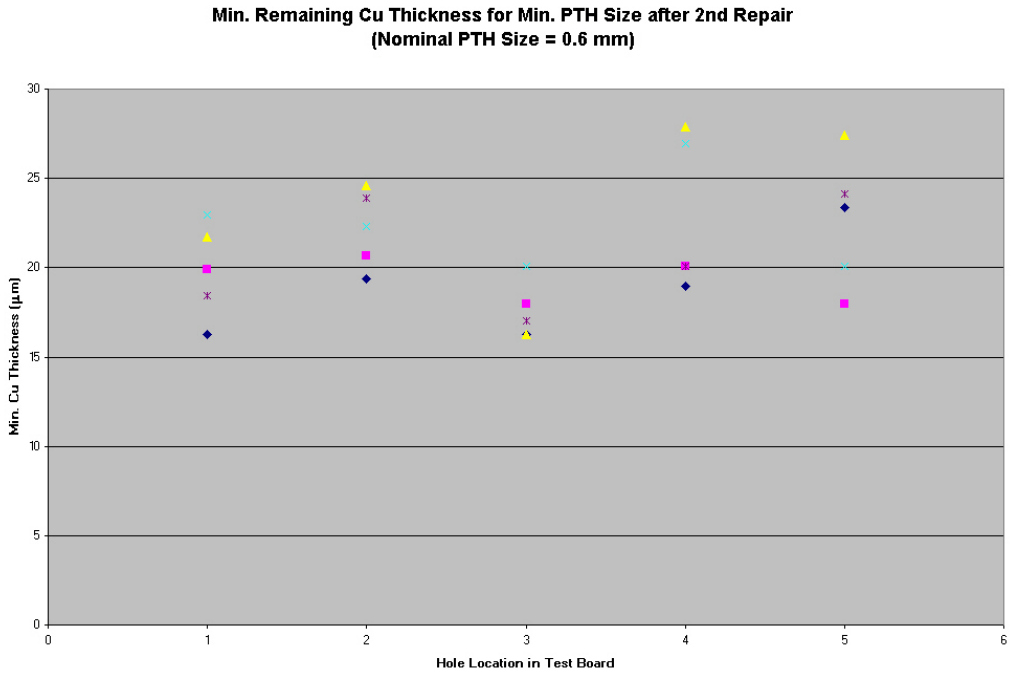


(b)

Figure 3. Measurements of minimum remaining Cu thickness for (a) PTHs of a size of 0.02 mm less than the PTHs of a minimum size (b) in nominal 0.46 mm applications



(a)



(b)

Figure 4. Measurements of minimum remaining Cu thickness for (a) PTHs of a size of 0.02 mm less than the PTHs of a minimum size (b) in nominal 0.46 mm applications

For all the combinations of different lead-free and SnPb finishes on PTHs and compliant pins in press-fit application, Figures 1-4 show the maximum tangential deformation for all the PTHs in the evaluation is less than 35 μm. Also, as presented in the previous study, there are no cracks found on any PTHs in the evaluation. The minimum remaining Cu thickness for all the PTHs is greater than 8 μm and meets the R-11 requirement of NEBS GR-78-CORE. Because the maximum tangential deformation is less than 35 μm for all the PTHs, the requirement (1) of R4-10 in NEBS GR-78-CORE for an average PTH deformation radius less than 38 μm is automatically met. The average, minimum, and maximum values of maximum tangential deformation and minimum remaining Cu thickness for the PTH measurements in Figures 1-4 are lists in Tables 1 and 2. As expected, smaller PTH size results in larger deformation for the PTH.

Table 1. Average, minimum, and maximum values of maximum tangential deformation measurements in Figures 1-2

Nominal PTH Size	0.46 mm		0.6 mm	
PTH Size for Measurements	min. – 0.02 mm	min.	min. – 0.02 mm	min.
Average (μm)	22.80	18.73	21.59	20.74
Minimum (μm)	7.59	5.36	13.77	9.95
Maximum (μm)	34.30	33.43	33.41	33.13

Table 2. Average, minimum, and maximum values of minimum remaining Cu thickness measurements in Figures 3-4

Nominal PTH Size	0.46 mm		0.6 mm	
PTH Size for Measurements	min. – 0.02 mm	min.	min. – 0.02 mm	min.
Average (μm)	13.18	16.24	20.31	20.98
Minimum (μm)	8.93	0.63	11.48	16.29
Maximum (μm)	20.04	23.78	27.87	27.88

Conclusions

The re-evaluation results of PTH damage and deformation in the lead-free press-fit study[2] show that the most distorted PTHs of minimum hole size and a size of 0.02 mm less than the minimum hole size not only pass the IEC specifications in transverse sectioning but also comply the more stringent R4-10 and R4-11 requirements in NEBS GR-78-CORE.

References

[1] IEC 60352-5: Solderless connections – Part 5: Press-in connections – General requirements, test methods and practice guidance, Second edition, 2001.

[2] George J.S. Chou and Robert D. Hilty, "Effects of Lead-Free Surface Finishes on Press-Fit Connections", *Proceedings of The IPC Annual Meeting 2003*, Minneapolis, MN, Sept. 28-Oct. 2, 2003, p. S07-2-1 to S07-2-10.