

For Diameter U42 (Sensitivity = 0.25)

One-way ANOVA: D25-1, D25-2, D25-3, D25-4, D25-5, D25-6, D25-7, D25-8, D25-9



• **Ho:** Are the average voiding diameters the same for all 9 BGA voiding measurements.

Analysis of Variance

Source	DF	SS	MS	F	P
Factor	8	3.79	0.47	0.20	0.991
Error	1566	3696.17	2.36		
Total	1574	3699.96			

• **Ha:** Are the average voiding diameters different for all 9 BGA voiding measurements.

Individual 95% CIs For Mean

Based on Pooled StDev

Level	N	Mean	StDev	CI
D25-1	175	8.380	1.511	(8.20, 8.56)
D25-2	175	8.404	1.560	(8.20, 8.61)
D25-3	175	8.277	1.509	(8.20, 8.55)
D25-4	175	8.315	1.558	(8.20, 8.59)
D25-5	175	8.371	1.578	(8.20, 8.64)
D25-6	175	8.340	1.506	(8.20, 8.58)
D25-7	175	8.308	1.592	(8.20, 8.65)
D25-8	175	8.257	1.511	(8.20, 8.56)
D25-9	175	8.391	1.499	(8.20, 8.58)

Pooled StDev = 1.536

The Null Hypothesis is represented by "Ho" and the Alternative Hypothesis is by "Ha".

Software: MINITAB

Figure 4: ANOVA shows no difference between BGA voiding diameter measurement for a BGA with sensitivity setting of 0.25.

For Diameter U42 (Sensitivity = 0.45)

One-way ANOVA: D45-1, D45-2, D45-3, D45-4, D45-5, D45-6, D45-7, D45-8, D45-9

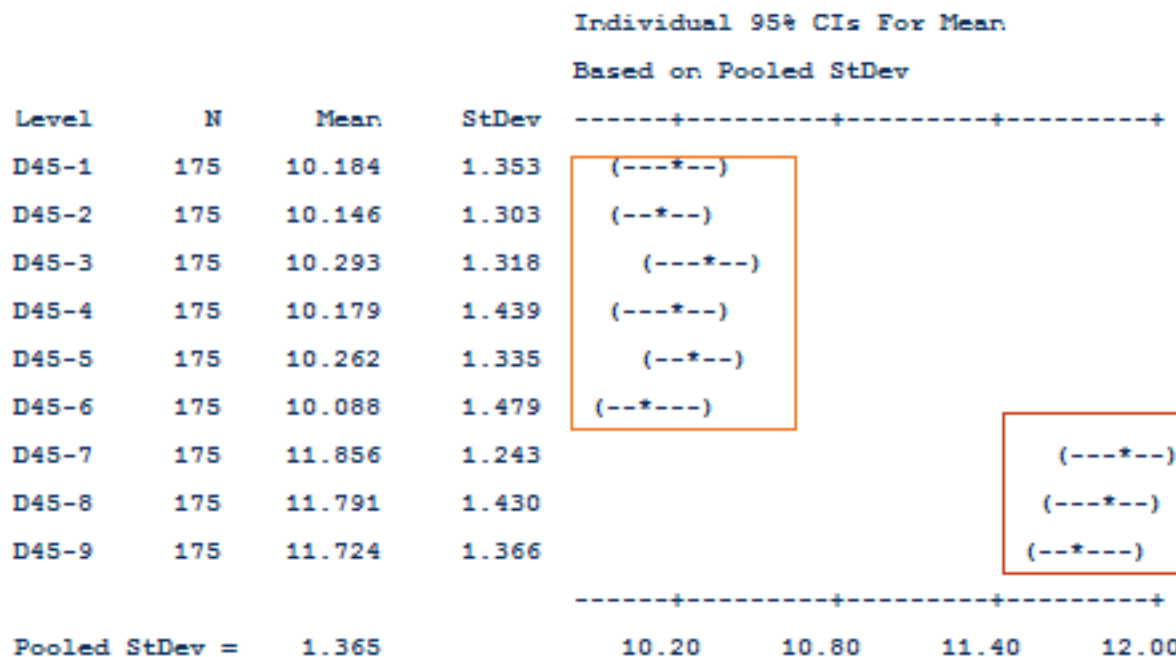
Analysis of Variance

Source	DF	SS	MS	F	P
Factor	8	900.95	112.62	60.47	0.000
Error	1566	2916.43	1.86		
Total	1574	3817.37			



• **Ho:** Are the average voiding diameters the same for all 9 BGA voiding measurements.

• **Ha:** Are the average voiding diameters different for all 9 BGA voiding measurements.



With sensitivity set at 0.45 the measurements are different between the first 6 and last 3. As we include the sensitivity the average increases and there's more variation between the same samples.

Figure 5: ANOVA shows difference between BGA voiding diameter measurement for a BGA with sensitivity setting of 0.45.

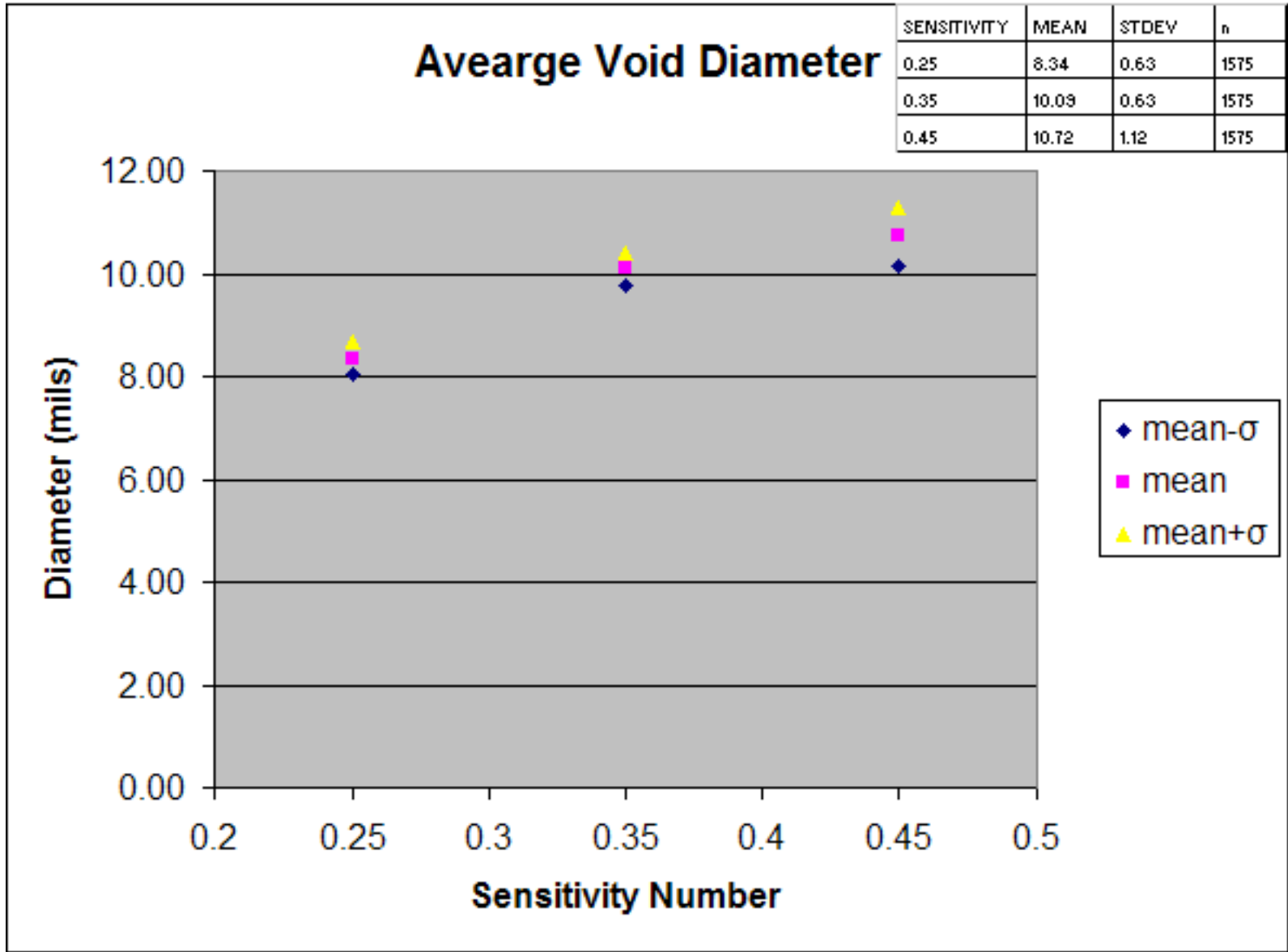


Figure 6: Mean of void diameter versus algorithm sensitivity setting.



Ho: Are all the average voiding diameters the same

Ha: Are all the average voiding diameters different

One-way ANOVA: Mean versus Sensitivity

Analysis of Variance for Mean

Source	DF	SS	MS	F	P
Sensitivity	2	534.95	267.48	176.74	0.000
Error	522	790.00	1.51		
Total	524	1324.96			

Individual 95% CIs For Mean
Based on Pooled StDev

Level	N	Mean	StDev
D25Mean	175	8.339	1.378
D35Mean	175	10.093	1.269
D45Mean	175	10.725	1.015

Pooled StDev = 1.230

Boxplots of fMean by Sensitivity

(means are indicated by solid circles)

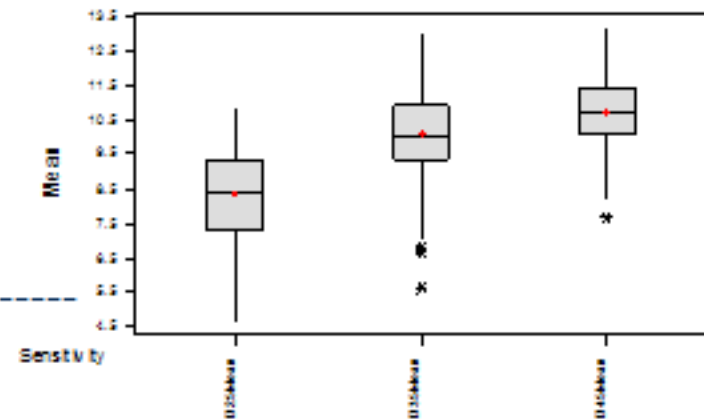


Figure 7: ANOVA for mean of void diameter.



Ho: Are all the average standard deviations the same

Ha: Are all the average standard deviations different

One-way ANOVA: STDV versus Sensitivity_1

Analysis of Variance for STDV

Source	DF	SS	MS	F	P
Sensitiv	2	27.409	13.704	55.21	0.000
Error	522	129.573	0.248		
Total	524	156.982			

Individual 95% CIs For Mean
Based on Pooled StDev

Level	N	Mean	StDev	
D25STDEV	175	0.6345	0.3418	(---+---)
D35STDEV	175	0.6273	0.5435	(---+---)
D45STDEV	175	1.1155	0.5766	(---+---)

Pooled StDev = 0.4982

Boxplots of STDV by Sensitiv
(means are indicated by solid circles)

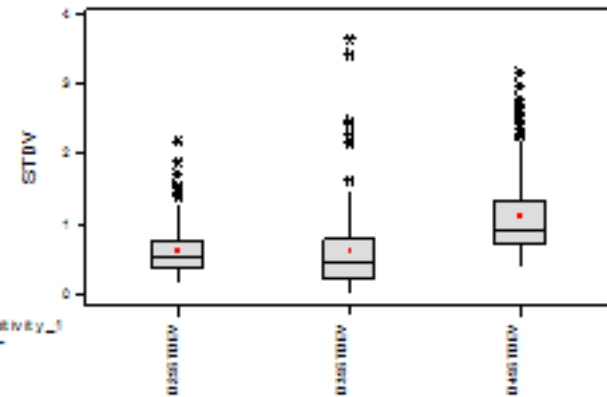


Figure 8: ANOVA for standard deviation of void diameter.

Ho: Are all the average voiding percentage the same
 Ha: Are all the average voiding percentage different

One-way ANOVA: P25Mean, P35Mean, P45Mean

Analysis of Variance

Source	DF	SS	MS	F	P
Factor	2	9025.45	4512.72	516.01	0.000
Error	489	4276.52	8.75		
Total	491	13301.97			

Individual 95% CIs For Mean
Based on Pooled StDev

Level	N	Mean	StDev	
<u>P25Mean</u>	164	16.543	2.888	(+-)
<u>P35Mean</u>	164	23.706	3.038	(-+)
<u>P45Mean</u>	164	26.763	2.944	(+-)

Pooled StDev = 2.957

17.5 21.0 24.5 28.0

Boxplots of P25Mean - P45Mean
(means are indicated by solid circles)

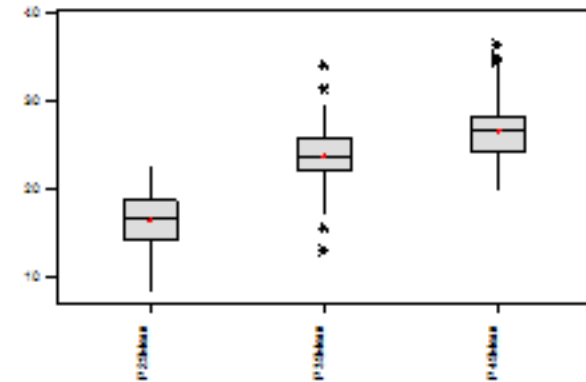


Figure 9: ANOVA for mean of void area percentage.



Ho: Are all the average standard deviations for percentage the same

Ha: Are all the average standard deviations for percentage different

One-way ANOVA: P25STDEV, P35STDEV, P45STDEV

Analysis of Variance

Source	DF	SS	MS	F	P
Factor	2	770.78	385.39	116.10	0.000
Error	489	1623.25	3.32		
Total	491	2394.03			

Individual 95% CIs For Mean
Based on Pooled StDev

Level	N	Mean	StDev	CI
P25STDEV	164	2.200	0.953	(--*--)
P35STDEV	164	2.834	1.602	(--*--)
P45STDEV	164	5.115	2.546	(--*--)

Pooled StDev = 1.822

Box plots of P25STDEV - P45STDEV
(means are indicated by solid circles)

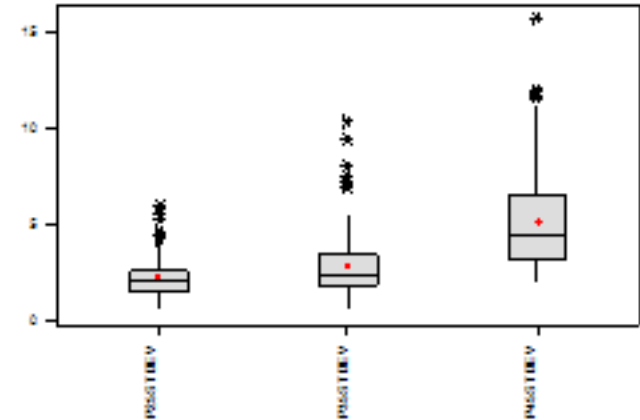


Figure 10: ANOVA for standard deviation of void area percentage.

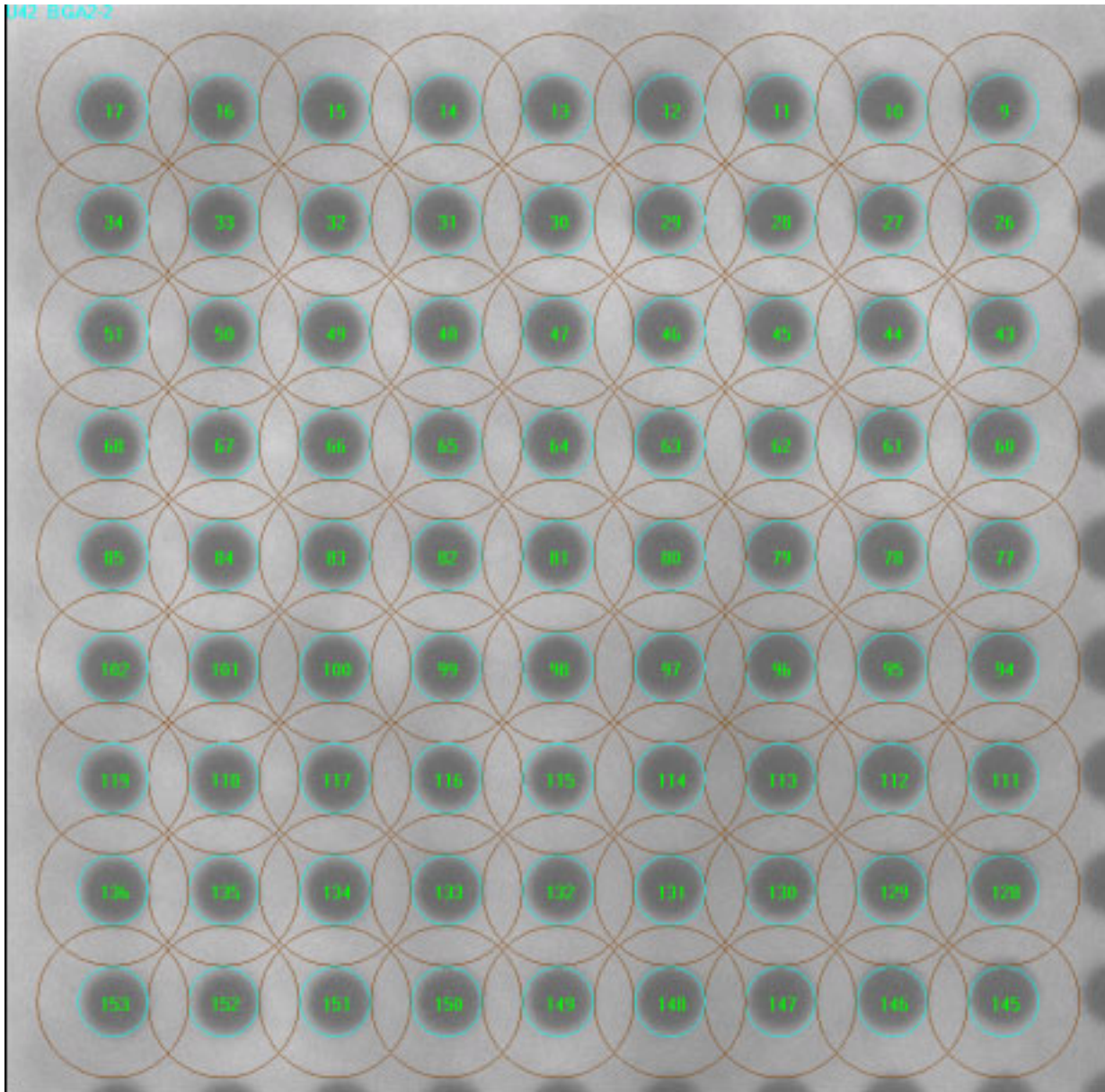


Figure 11: The image of the BGA without voiding (camera frame grabber setting of 5 using v. 8.1).

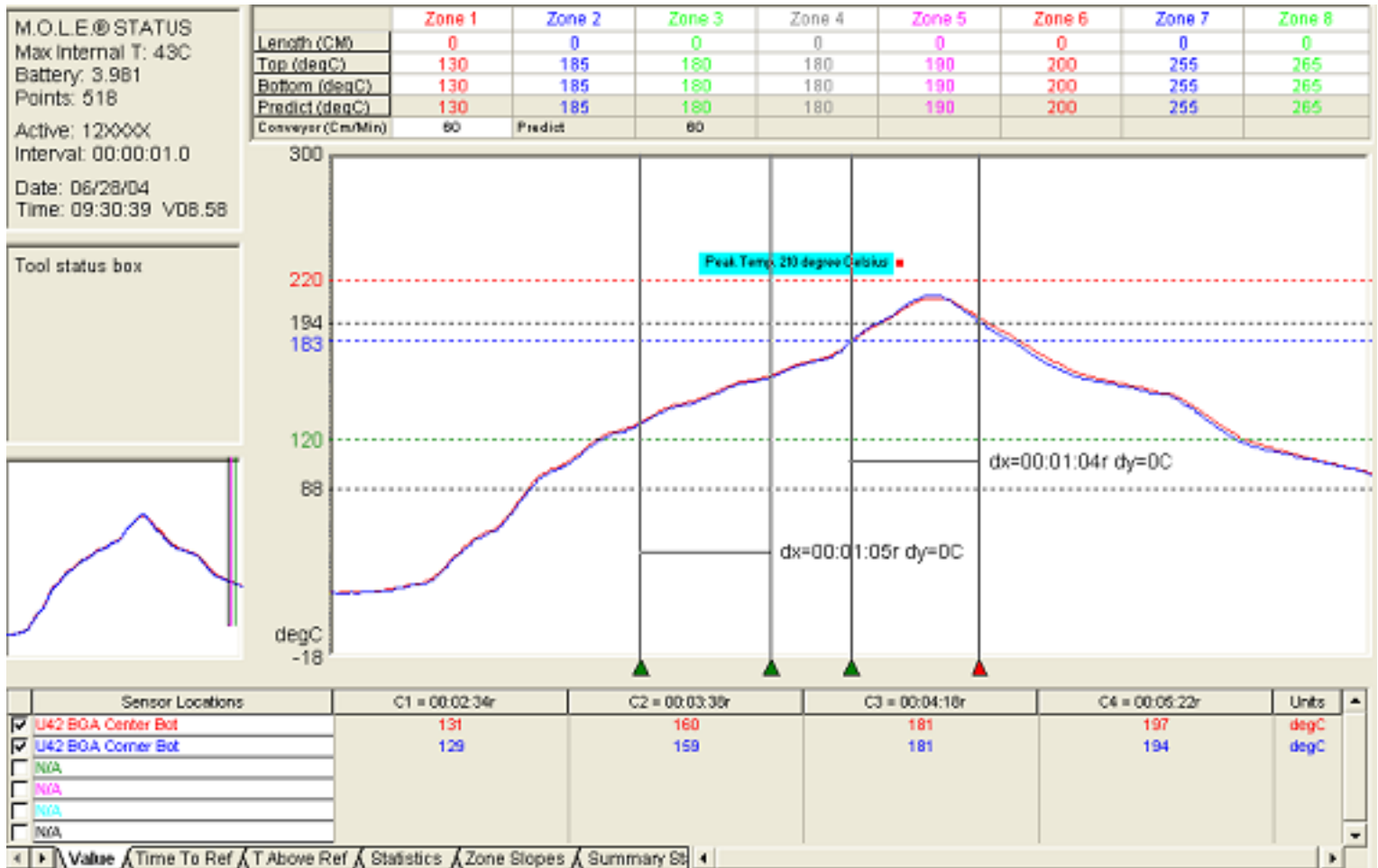


Figure 12: Non-optimized bottom reflow profile. (Peak temperature 210°C; time above 183°C is 64 sec.; soak time between 130° and 160°C is 65 sec.)

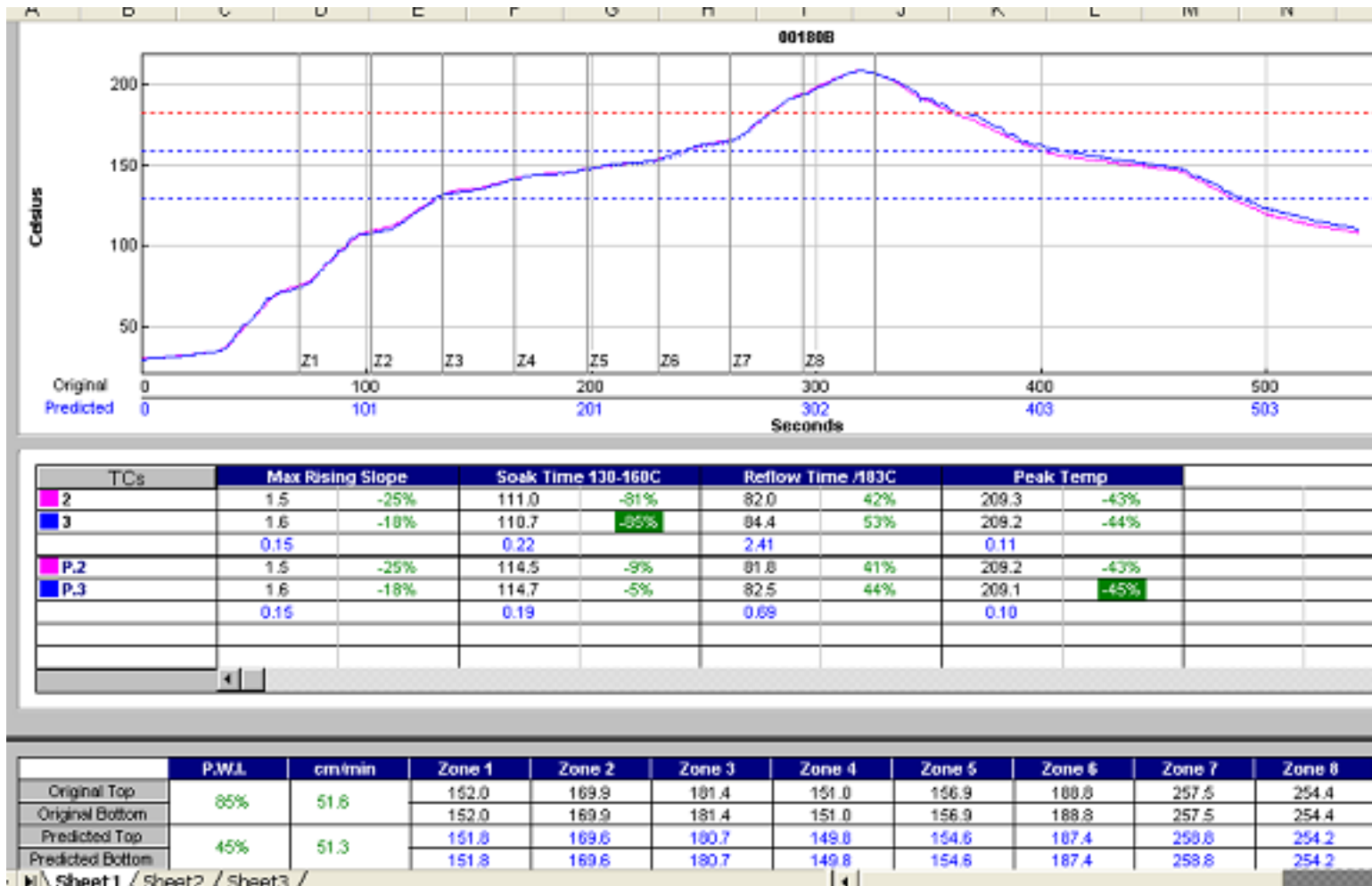


Figure 13: Optimized bottom reflow profile: (Peak temperature 209°C. Time above 183°C is 75-85 sec. Soak time between 130° and 160°C is 110 to 120 sec.)

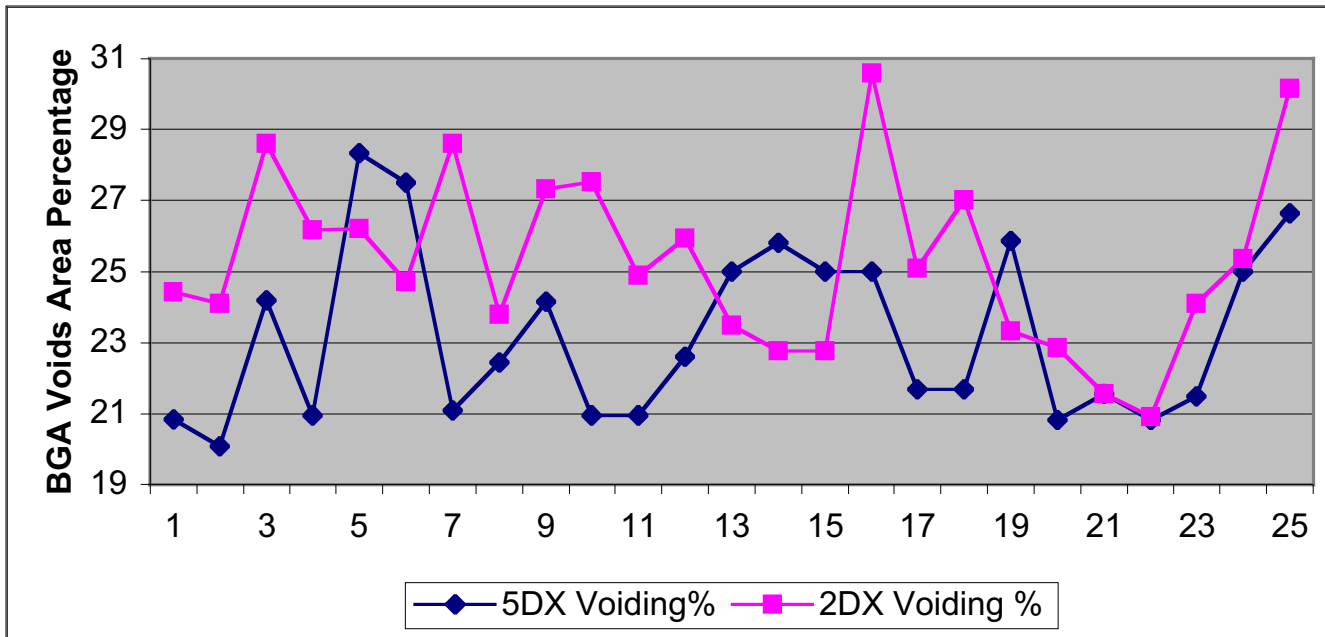


Figure 14: 5DX and 2DX measurements for the same real defect pins (void area > 20% of ball area).