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Statistical Review of Tank 29 Ultrasonic Inspection Data

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U.S. Department of Energy

Non-Destructive Examination Independent Review

August 26, 2009

Atlanta, Georgia

Data Summary

- 93 Pit Depth 2009 Measurements from 18 strips 15 mils or Greater
- 52 Pit Depth Paired Measurements from 4 Strips: Years 2006 & 2009 for strips beneath P-2, P-5, P-9 and P-12
- 486 Wall Thickness Measurements from 18 strips (27 per strip)
- 108 Wall Thickness Paired Measurements from 4 strips: Years 2006 & 2009 for strips beneath risers P-2, P-5, P-9 and P-12

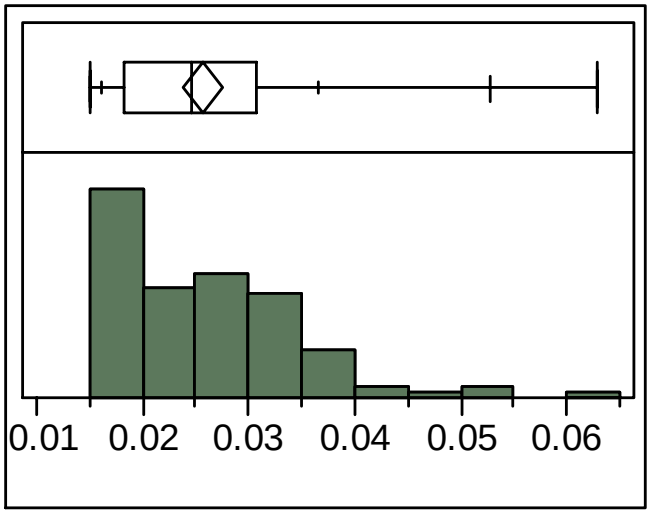
Statistical Procedures

- ANOVA: Differences in Means
- Tests for Equal Variances
- Variance Component Analysis
- Distributional Fitting: LogNormal, Extreme Value, etc.
- Statistical Tolerance Limits

  99% (Coverage) of the distribution is less than the estimated tolerance limit with 95% Confidence

- Software Used: JMP and Distribution Analyzer

Pit Depth Data for Tank 29 from Year 2009



Mean	0.026
Std Dev	0.009
Std Err Mean	0.001
upper 95% Mean	0.028
lower 95% Mean	0.024
N	93

Pit Depth > 0.015 Considered

Percentile		Pit Depth (in.)
100.0%	maximum	0.063
99.5%		0.063
97.5%		0.053
90.0%		0.037
75.0%	quartile	0.031
50.0%	median	0.024
25.0%	quartile	0.018
10.0%		0.016
2.5%		0.015
0.5%		0.015
0.0%	minimum	0.015

Summary Statistics for Tank 29 "A" Riser Strip Pit Depths

(2009 Data, Depth>0.015 included)

Riser	Location	N	Min Tank Elevation (in.)	Max Tank Elevation (in.)	Mean Pit Depth (in.)	Std Dev Pit Depth (in.)
A-01	LP	1	50	50	0.018	n/a
A-02	LP	2	111	122	0.020	0.007
A-02	MP	4	208	214	0.018	0.004
A-03	LP	2	n/a	n/a	0.031	0.001
A-03	MP	2	216	218	0.020	0.004
A-04	LP	9	41	70	0.025	0.007

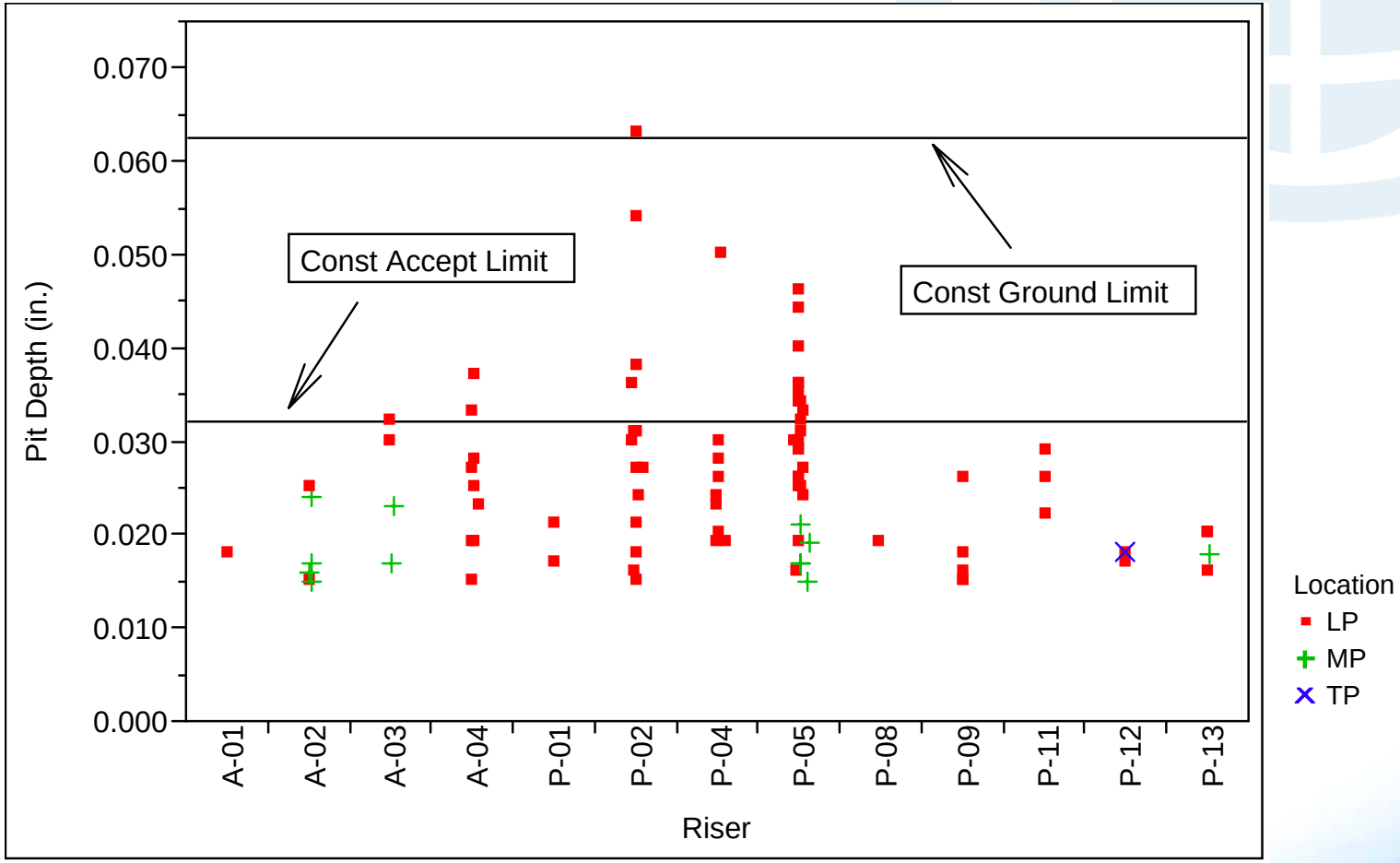
Summary Statistics for Tank 29 "P" Riser Strip Pit Depths

(2009 Data, Depth>0.015 included)

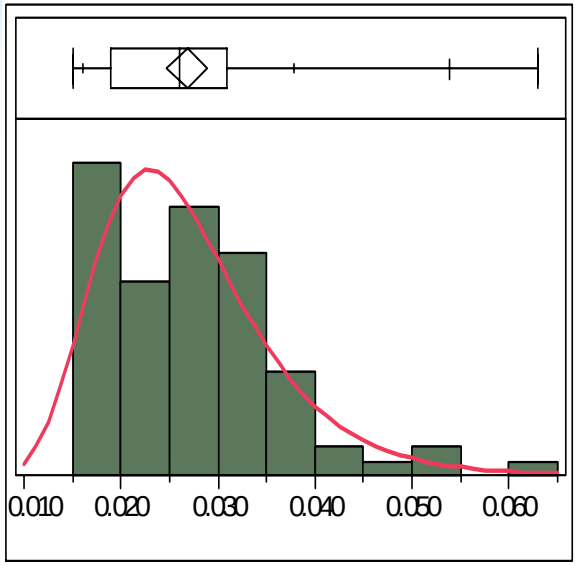
Riser	Location	N	Min Tank Elevation (in.)	Max Tank Elevation (in.)	Mean Pit Depth (in.)	Std Dev Pit Depth (in.)
P-01	LP	2	36	41	0.019	0.003
P-02	LP	16	41	78	0.031	0.013
P-04	LP	9	84	119	0.027	0.010
P-05	LP	23	99	133	0.031	0.007
P-05	MP	5	166	208	0.018	0.002
P-08	LP	1	56	56	0.019	n/a
P-09	LP	5	97	128	0.018	0.005
P-11	LP	3	27	33	0.026	0.004
P-12	LP	2	37	120	0.018	0.001
P-12	TP	1	268	268	0.018	n/a
P-13	LP	5	90	96	0.019	0.002
P-13	MP	1	172	172	0.018	n/a

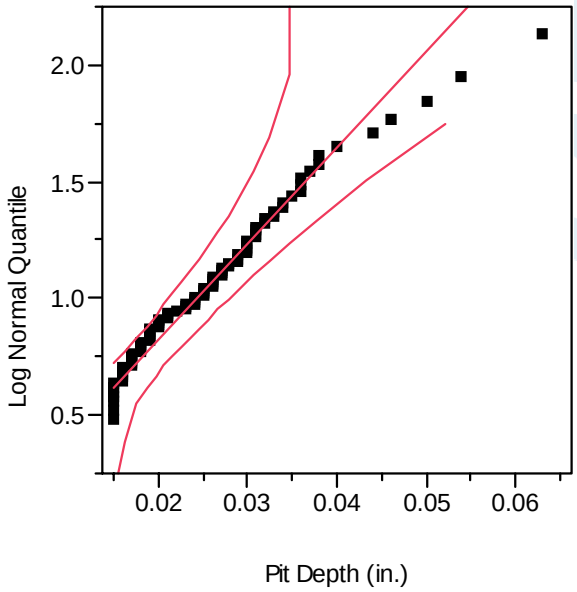
Dot Plot of 2009 Pit Depths by Riser Strip

Reportable Pit Depth 0.187 in. for Lower Plate (LP)



2009 LP Pit Depths (in.): Lognormal Distribution





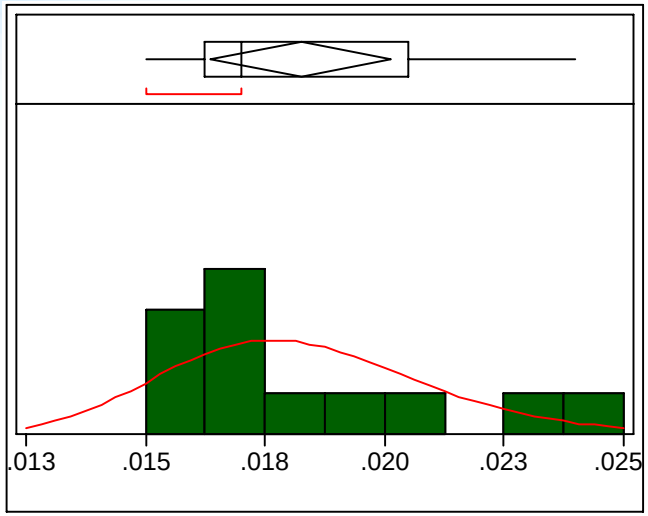
LogNormal Estimates

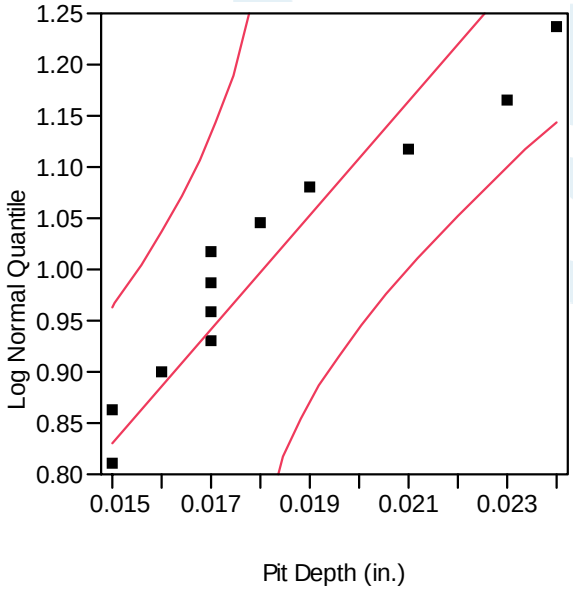
Type		Estimate
Scale	μ	-3.672
Shape	σ	0.324

Goodness-of-Fit Test
K-D Statistic

D	Prob > D
0.095576	0.0711

2009 MP Pit Depths (in.): Lognormal Distribution





LogNormal Estimates

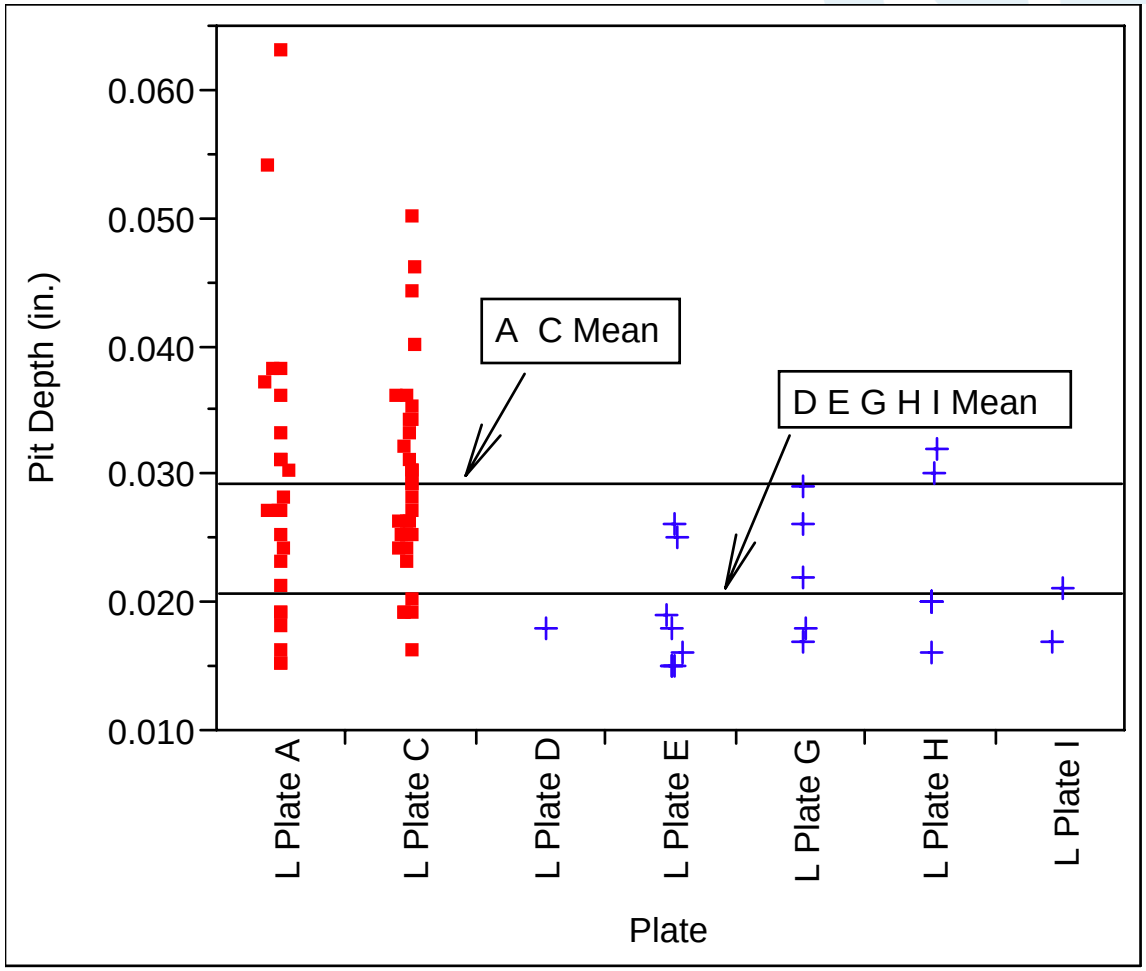
Type		Estimate
Scale	μ	-4.015
Shape	σ	0.148

Goodness-of-Fit Test

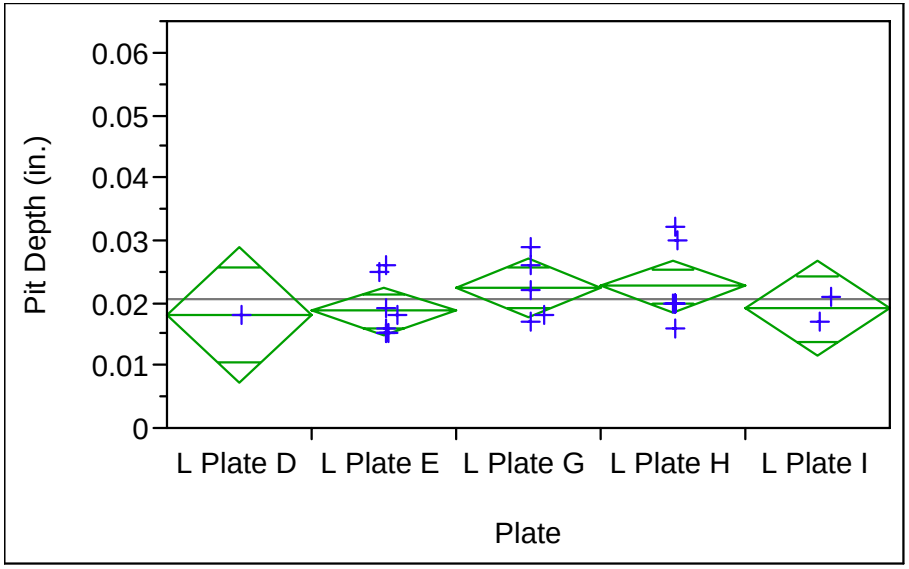
K-D

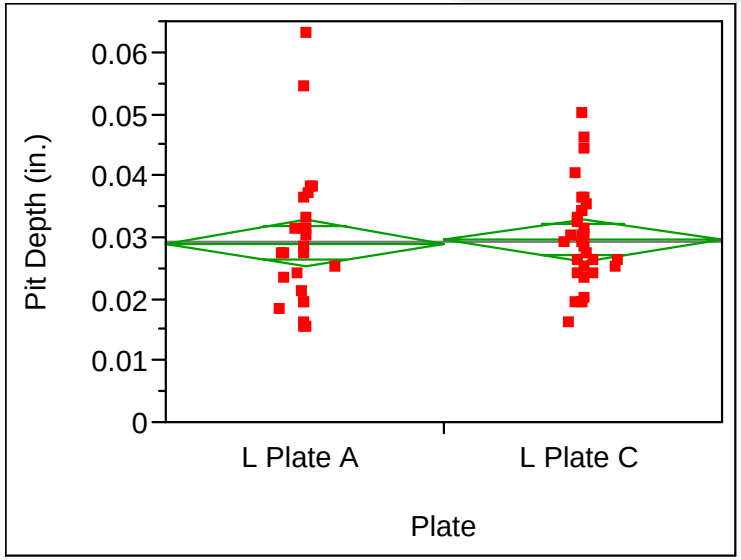
D	Prob>D
0.240	0.055

Dot Plot of 2009 LP Pit Depths by Plate

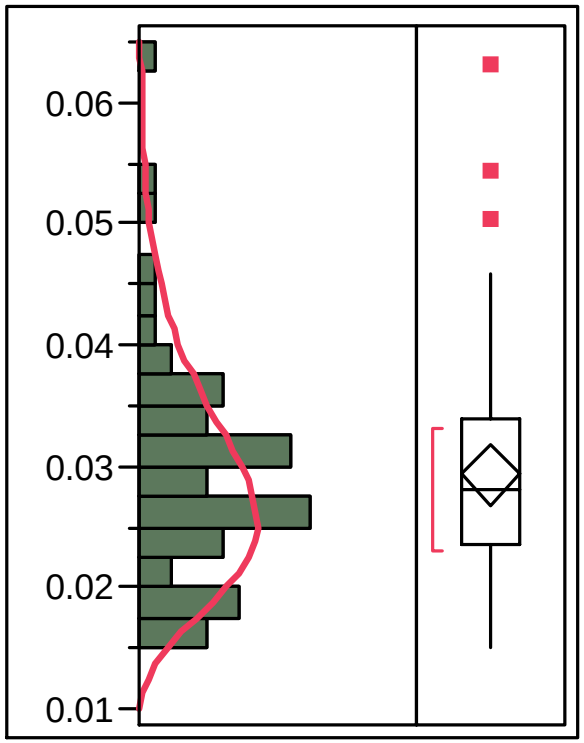


Mean Diamonds for 2009 LP Pit Depths by Plate

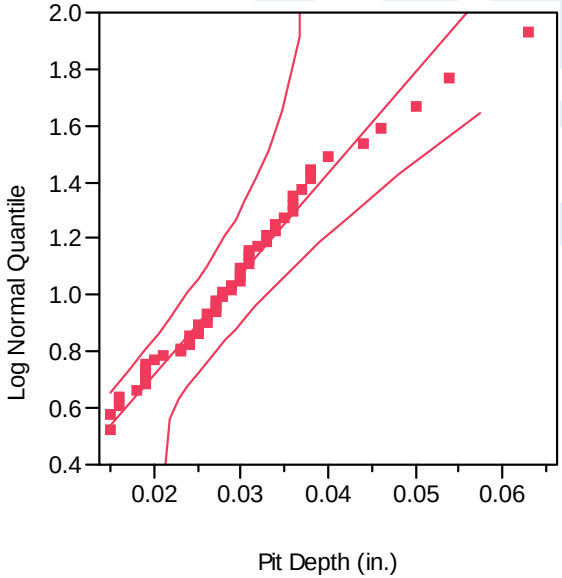




Tolerance Limit with 95% Confidence for 99% Coverage using Lower Plate A, C Pit Depth Data



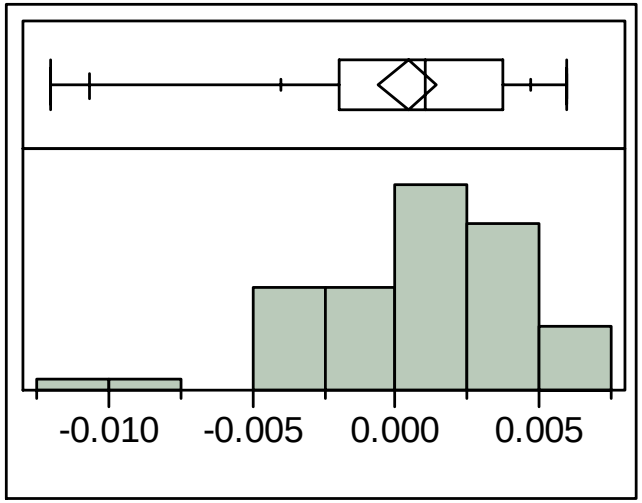
Log Normal



Distribution	Upper Limit (in.)
Lognormal (2 Parm)	0.068
Largest Extreme Value	0.070
Lognormal (3 Parm)	0.070
Gamma	0.068

Difference Between 2009 and 2006 Depths

$Depth_{2009}$ - $Depth_{2006}$ (in.)

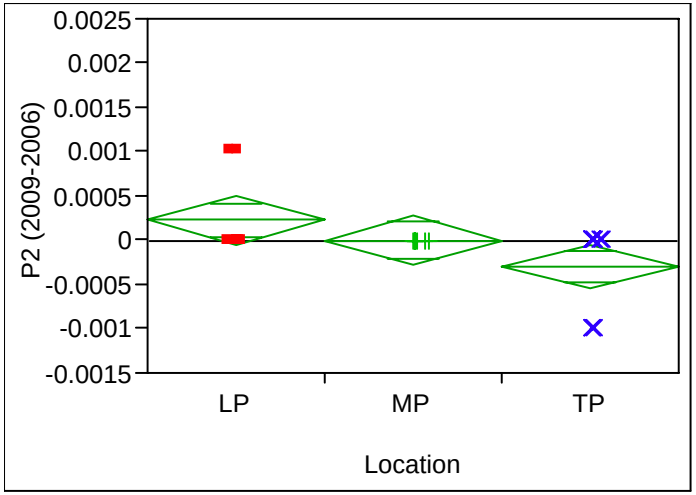


Statistic	in.
Mean	0.0004
Std Dev	0.0037
Std Err Mean	0.0005
upper 95% Mean	0.0015
lower 95% Mean	-0.0006
N	52

Percentile		Difference (in.)
100.0%	maximum	0.0060
99.5%		0.0060
97.5%		0.0060
90.0%		0.0047
75.0%	quartile	0.0037
50.0%	median	0.0010
25.0%	quartile	-0.0020
10.0%		-0.0040
2.5%		-0.0107
0.5%		-0.0120
0.0%	minimum	-0.0120

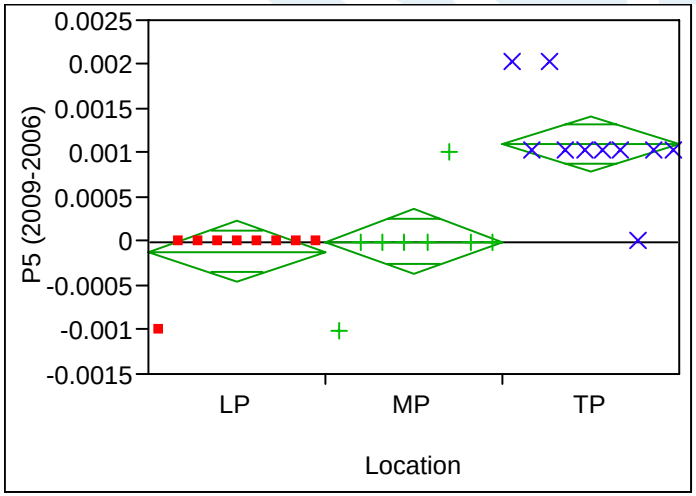
Tank 29 Wall Thickness: Year 2006 vs. 2009 by Location using Strips Beneath Risers P-02 and P-05

P-02 (2009-2006) (in.)



P-Value = 0.03

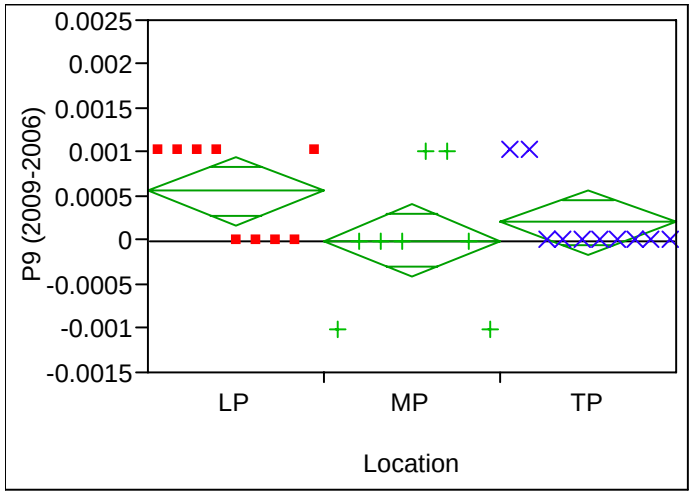
P-05 (2009-2006) (in.)



P-Value < 0.0001

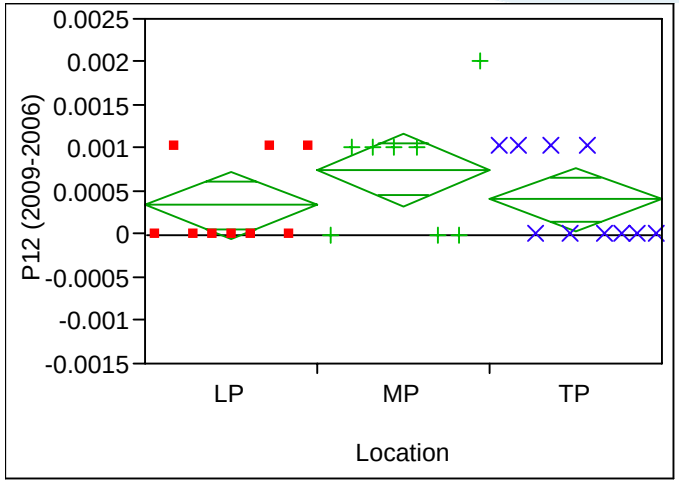
Tank 29 Wall Thickness: Year 2006 vs. 2009 by Location using Strips Beneath Risers P-09 and P-12

P-09 (2009-2006) (in.)



P-Value = 0.15

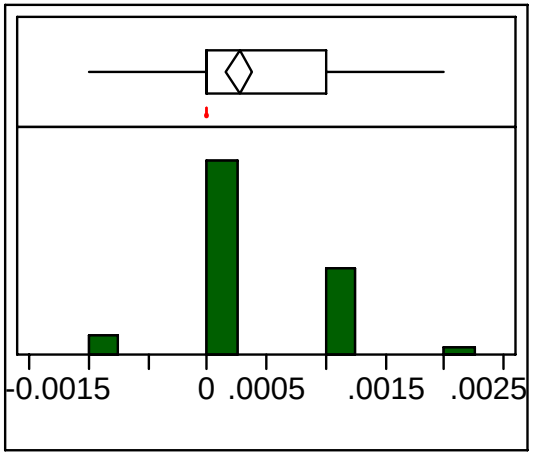
P-12 (2009-2006) (in.)



P-Value = 0.30

Wall Thickness Comparison

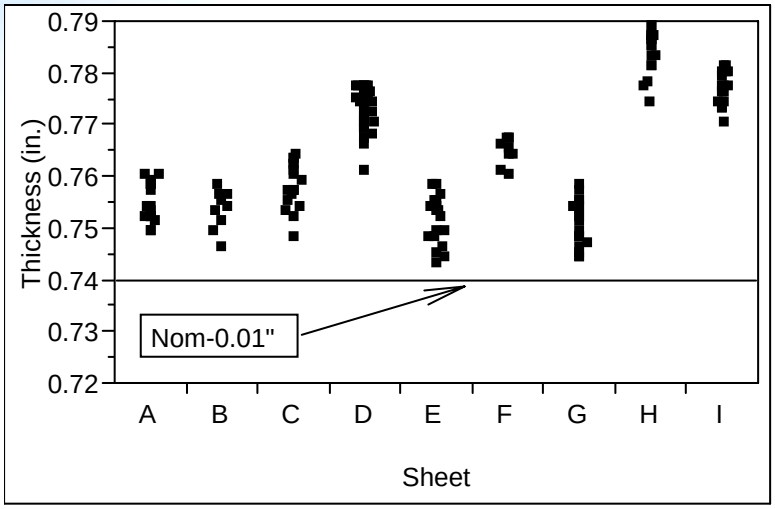
Combined Differences for Strips Beneath Risers P-02, P-05, P-09 and P-12



Statistic	(in.)
Mean	0.00027
Std Dev	0.00062
Std Err Mean	0.00006
upper 95% Mean	0.00039
lower 95% Mean	0.00015
N	108

Percentile		Difference (in.)
100.0%	maximum	0.002
99.5%		0.002
97.5%		0.002
90.0%		0.001
75.0%	quartile	0.001
50.0%	median	0
25.0%	quartile	0
10.0%		0
2.5%		-0.001
0.5%		-0.001
0.0%	minimum	-0.001

2009 LP Wall Thickness (in.) by Sheet

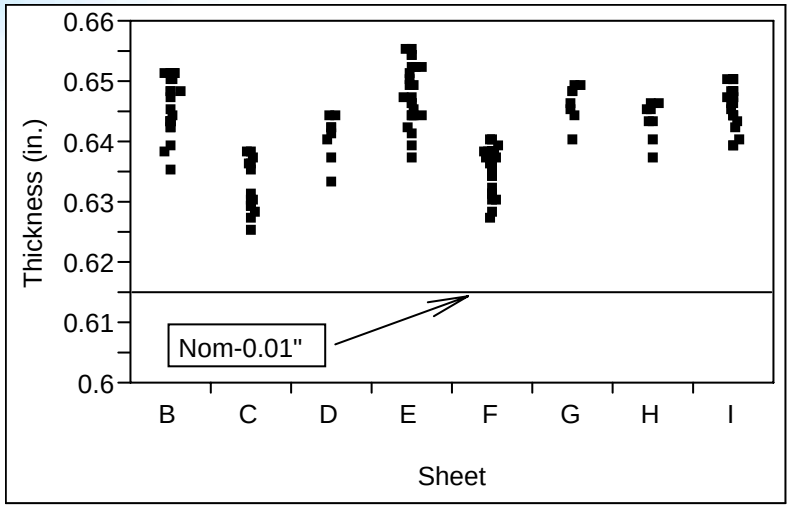


Sheet	N	Mean Thickness (in.)	Std Dev Thickness (in.)
A	18	0.755	0.0036
B	9	0.753	0.0038
C	18	0.758	0.0044
D	36	0.773	0.0038
E	18	0.751	0.0047
F	9	0.765	0.0026
G	18	0.751	0.0045
H	18	0.784	0.0043
I	18	0.777	0.0031

Variance Component Estimates

Component	Estimate	%
Sheet	0.00016	**90.8**
Residual	1.58E-05	**9.2**
Total	0.00017	**100**

2009 MP Wall Thickness (in.) by Sheet

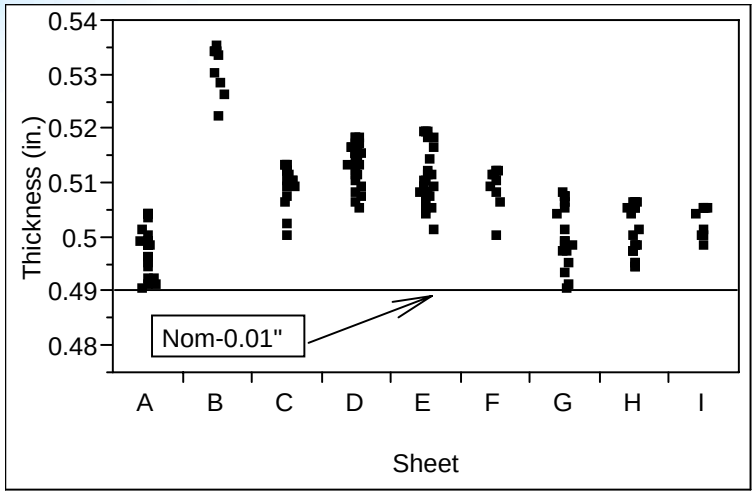


Sheet	N	Mean Thickness (in.)	Std Dev Thickness (in.)
B	24	0.646	0.0047
C	16	0.632	0.0042
D	8	0.640	0.0037
E	24	0.647	0.0051
F	32	0.635	0.0034
G	8	0.646	0.0031
H	8	0.643	0.0032
I	24	0.646	0.0034

Variance Component Estimates

Component	Estimate	%
Sheet	3.73E-05	**69.4**
Residual	1.64E-05	**30.6**
Total	5.37E-05	**100**

2009 TP Wall Thickness (in.) by Sheet



Variance Component Estimates

Component	Estimate	%
Sheet	7.57E-05	**80.1**
Residual	1.88E-05	**19.9**
Total	9.45E-05	**100**

Sheet	N	Mean Thickness (in.)	Std Dev Thickness (in.)
A	30	0.498	0.0040
B	10	0.531	0.0044
C	20	0.510	0.0036
D	30	0.513	0.0036
E	30	0.510	0.0051
F	10	0.509	0.0038
G	20	0.500	0.0057
H	20	0.500	0.0046
I	10	0.503	0.0027

Conclusions

- The 99% upper tolerance limit for pit depth is 70 mils with 95% confidence.
- 86% of pit measurements 15 mils or greater are from the lower plate.
- Mean difference in pit depths between 2006 and 2009 is less than 1 mil.
- Mean thinning from 2006 to 2009 is less than 1 mil.
- Wall thickness variability within a sheet is minor in comparison to the differences between sheets. (Horizontal Profile)