

Appendix XIII – SPT Energy Testing Results

CME 750X ATV - SN322938 (R-58)

S&ME Annual Testing

H. Forbes

Test date: 8/7/2017

AR: 1.20 in²

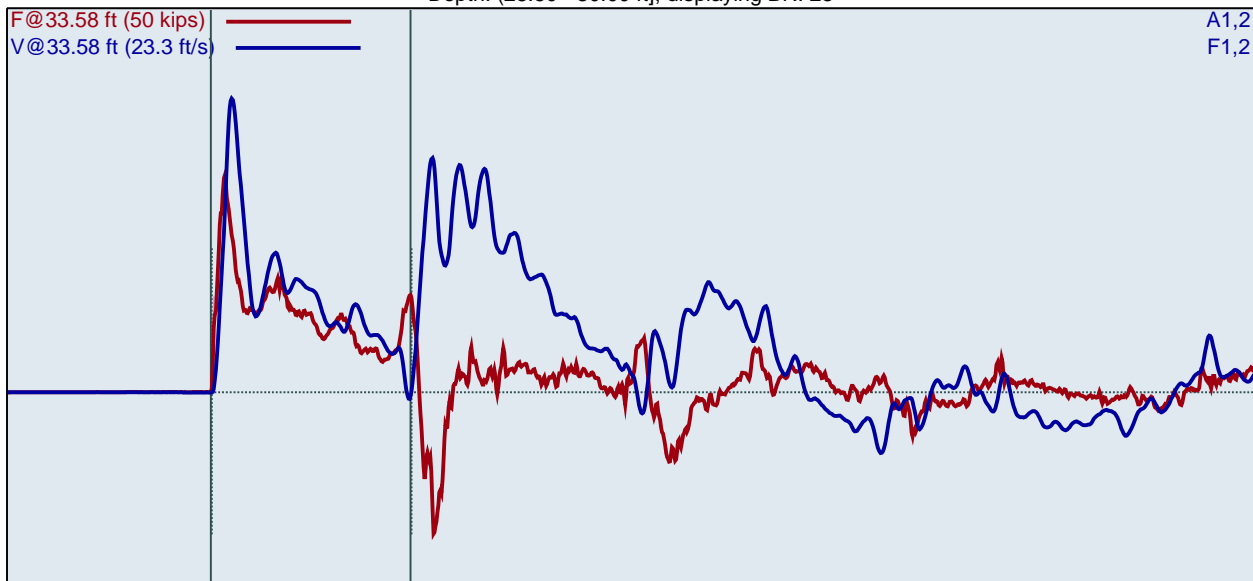
SP: 0.492 k/ft³

LE: 33.58 ft

EM: 30000 ksi

WS: 16807.9 ft/s

Depth: (28.50 - 30.00 ft], displaying BN: 23



BPM: Blows/Minute

CSX: Compression Stress Maximum

FMX: Maximum Force

DFN: Final Displacement

VMX: Maximum Velocity

EFV: Maximum Energy

DMX: Maximum Displacement

ETR: Energy Transfer Ratio - Rated

BL#	LP ft	BC /6"	BPM bpm	FMX kips	VMX ft/s	DMX in	CSX ksi	DFN in	EFV ft-lb	ETR (%)
1	28.60	5	1.9	28	17.5	1.20	23.5	1.20	288.9	82.6
2	28.70	5	50.3	29	17.6	1.20	24.1	1.20	286.6	81.9
3	28.80	5	50.3	29	17.8	1.20	24.6	1.20	289.0	82.6
4	28.90	5	50.4	27	17.2	1.20	22.4	1.20	290.4	83.0
5	29.00	5	50.3	29	18.1	1.20	24.0	1.20	290.3	82.9
6	29.06	8	50.4	29	18.1	0.84	24.5	0.75	291.6	83.3
7	29.13	8	50.4	28	17.6	0.83	23.4	0.75	289.2	82.6
8	29.19	8	50.5	28	16.6	0.81	23.2	0.75	287.1	82.0
9	29.25	8	50.4	28	17.9	0.80	23.0	0.75	290.6	83.0
10	29.31	8	50.5	28	17.5	0.81	23.0	0.75	285.5	81.6
11	29.38	8	50.3	28	17.6	0.83	23.6	0.75	287.7	82.2
12	29.44	8	50.4	29	17.8	0.85	24.2	0.75	283.7	81.1
13	29.50	8	50.4	28	17.8	0.90	23.3	0.75	290.0	82.9
14	29.54	12	50.4	29	17.6	0.95	24.3	0.50	286.2	81.8
15	29.58	12	50.6	30	18.1	0.91	25.1	0.50	289.9	82.8
16	29.63	12	50.3	30	18.1	0.84	24.6	0.50	289.8	82.8
17	29.67	12	50.5	29	18.3	0.81	24.0	0.50	291.2	83.2
18	29.71	12	50.2	30	18.2	0.82	24.7	0.50	293.3	83.8
19	29.75	12	50.3	28	18.3	0.80	23.2	0.50	291.2	83.2
20	29.79	12	50.3	30	17.6	0.79	24.6	0.50	289.4	82.7
21	29.83	12	50.4	29	18.0	0.79	24.4	0.50	292.0	83.4
22	29.88	12	50.4	28	18.1	0.83	23.7	0.50	294.1	84.0
23	29.92	12	50.4	28	17.9	0.80	23.6	0.50	292.2	83.5
24	29.96	12	50.4	29	18.1	0.81	24.2	0.50	292.9	83.7
25	30.00	12	50.4	29	17.8	0.80	24.1	0.50	296.0	84.6

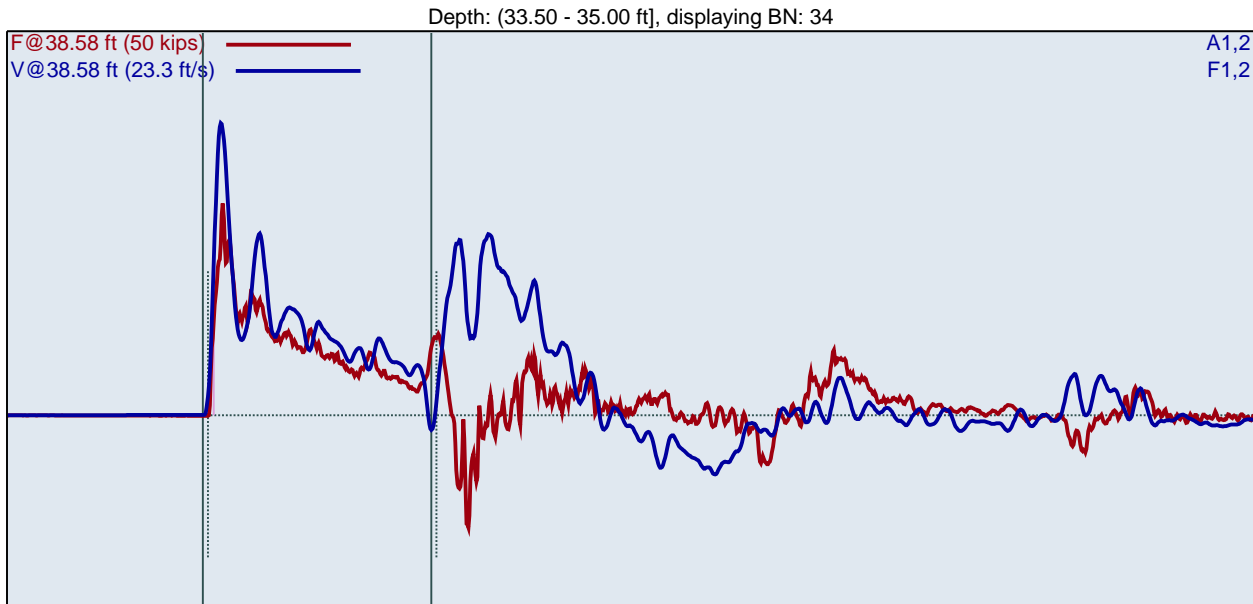
Average	50.4	29	17.8	0.83	23.9	0.60	290.2	82.9
Std Dev	0.1	1	0.4	0.04	0.6	0.12	3.0	0.8
Maximum	50.6	30	18.3	0.95	25.1	0.75	296.0	84.6
Minimum	50.2	28	16.6	0.79	23.0	0.50	283.7	81.1

N-value: 20

Sample Interval Time: 28.54 seconds.

CME 750X ATV - SN322938 (R-58)
H. Forbes
AR: 1.20 in²
LE: 38.58 ft
WS: 16807.9 ft/s

S&ME Annual Testing
Test date: 8/7/2017
SP: 0.492 k/ft³
EM: 30000 ksi



BPM: Blows/Minute
FMX: Maximum Force
VMX: Maximum Velocity
DMX: Maximum Displacement

CSX: Compression Stress Maximum
DFN: Final Displacement
EFV: Maximum Energy
ETR: Energy Transfer Ratio - Rated

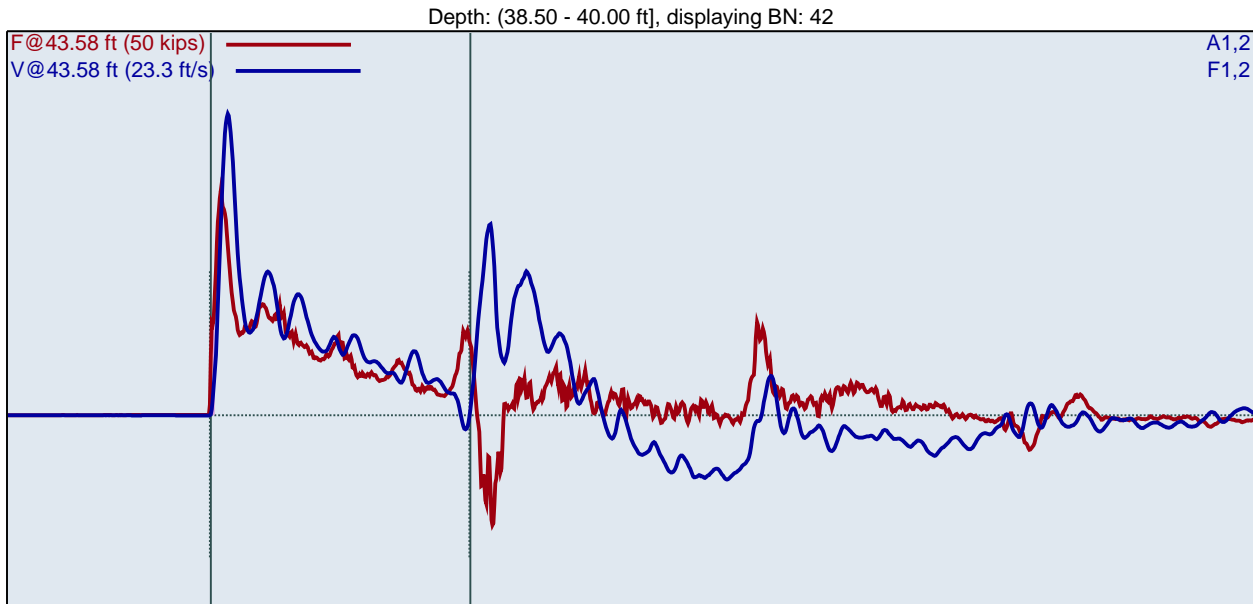
BL#	LP ft	BC /6"	BPM bpm	FMX kips	VMX ft/s	DMX in	CSX ksi	DFN in	EFV ft-lb	ETR (%)
1	33.55	11	56.3	29	16.4	1.09	23.9	0.55	296.5	84.7
2	33.59	11	51.7	29	16.8	0.77	24.4	0.55	303.4	86.7
3	33.64	11	52.0	28	17.1	0.68	23.7	0.55	302.0	86.3
4	33.68	11	51.7	28	17.6	0.66	23.7	0.55	304.4	87.0
5	33.73	11	52.0	29	17.0	0.64	23.8	0.55	301.2	86.1
6	33.77	11	51.6	29	17.7	0.63	24.3	0.55	307.0	87.7
7	33.82	11	51.8	27	17.0	0.61	22.8	0.55	295.1	84.3
8	33.86	11	51.9	28	16.6	0.61	23.5	0.55	302.0	86.3
9	33.91	11	51.9	29	17.2	0.61	24.3	0.55	304.6	87.0
10	33.95	11	51.9	29	17.5	0.60	23.8	0.55	302.9	86.6
11	34.00	11	51.8	28	16.7	0.59	23.5	0.55	300.3	85.8
12	34.04	12	51.9	28	17.5	0.57	23.3	0.50	297.2	84.9
13	34.08	12	51.7	28	17.3	0.58	23.1	0.50	304.7	87.1
14	34.13	12	52.1	28	17.7	0.59	23.1	0.50	304.3	87.0
15	34.17	12	51.7	29	17.4	0.57	23.8	0.50	304.2	86.9
16	34.21	12	51.9	29	17.3	0.56	24.0	0.50	304.2	86.9
17	34.25	12	51.9	28	16.6	0.54	23.6	0.50	298.8	85.4
18	34.29	12	51.8	29	16.7	0.53	23.8	0.50	298.8	85.4
19	34.33	12	51.9	28	17.0	0.54	23.4	0.50	300.8	85.9
20	34.38	12	51.8	28	17.0	0.52	23.7	0.50	299.1	85.5
21	34.42	12	51.8	28	17.3	0.52	23.1	0.50	299.0	85.4
22	34.46	12	51.7	28	17.5	0.53	23.7	0.50	301.5	86.1
23	34.50	12	52.0	28	17.6	0.53	23.5	0.50	301.1	86.0
24	34.54	13	51.6	28	17.7	0.53	23.1	0.46	304.2	86.9
25	34.58	13	52.0	29	17.6	0.53	23.8	0.46	301.4	86.1

26	34.62	13	51.6	28	17.8	0.52	23.1	0.46	300.3	85.8
27	34.65	13	52.0	27	17.9	0.51	22.8	0.46	301.3	86.1
28	34.69	13	51.8	28	17.8	0.52	22.9	0.46	299.5	85.6
29	34.73	13	51.7	27	18.0	0.52	22.8	0.46	302.9	86.6
30	34.77	13	52.0	28	17.8	0.51	23.1	0.46	298.1	85.2
31	34.81	13	51.6	26	17.0	0.52	21.7	0.46	297.8	85.1
32	34.85	13	51.9	26	17.7	0.52	21.4	0.46	297.4	85.0
33	34.88	13	51.8	26	16.5	0.53	21.3	0.46	296.5	84.7
34	34.92	13	51.8	28	17.8	0.53	23.0	0.46	302.7	86.5
35	34.96	13	51.7	26	17.9	0.51	21.6	0.46	299.8	85.6
36	35.00	13	51.9	25	17.7	0.50	21.1	0.46	302.3	86.4
Average			51.8	28	17.4	0.53	22.9	0.48	300.7	85.9
Std Dev			0.1	1	0.4	0.02	0.8	0.02	2.5	0.7
Maximum			52.1	29	18.0	0.59	24.0	0.50	304.7	87.1
Minimum			51.6	25	16.5	0.50	21.1	0.46	296.5	84.7
N-value: 25										

Sample Interval Time: 40.46 seconds.

CME 750X ATV - SN322938 (R-58)
H. Forbes
AR: 1.20 in²
LE: 43.58 ft
WS: 16807.9 ft/s

S&ME Annual Testing
Test date: 8/7/2017
SP: 0.492 k/ft³
EM: 30000 ksi



BPM: Blows/Minute
FMX: Maximum Force
VMX: Maximum Velocity
DMX: Maximum Displacement

CSX: Compression Stress Maximum
DFN: Final Displacement
EFV: Maximum Energy
ETR: Energy Transfer Ratio - Rated

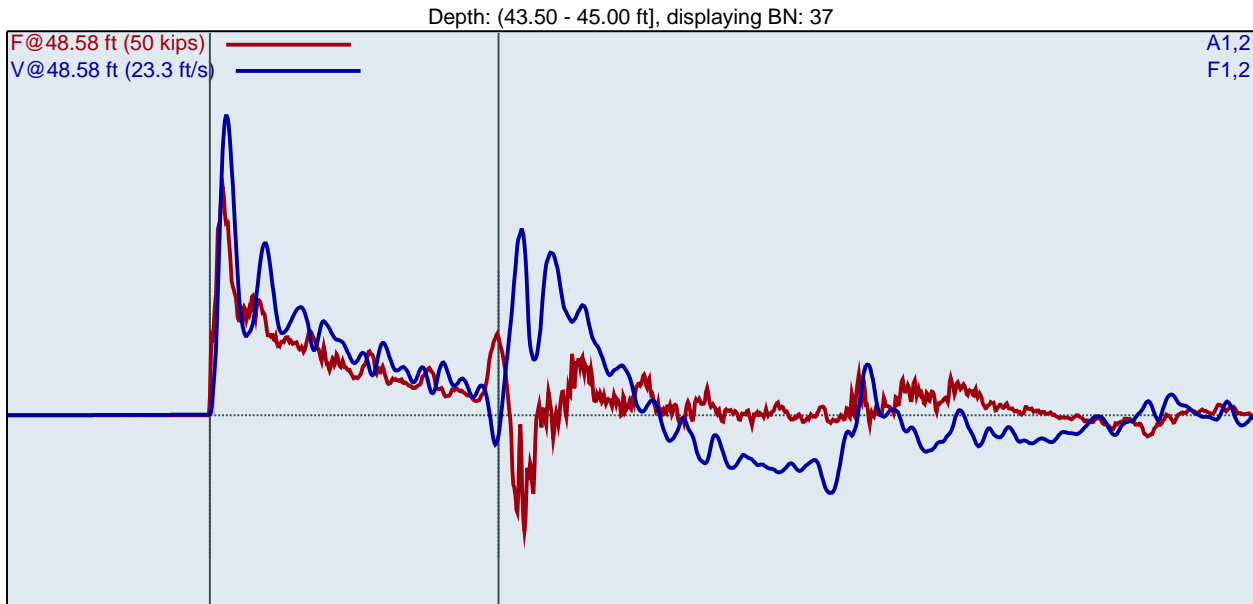
BL#	LP ft	BC /6"	BPM bpm	FMX kips	VMX ft/s	DMX in	CSX ksi	DFN in	EFV ft-lb	ETR (%)
1	38.54	13	59.6	28	18.3	0.97	23.7	0.46	296.6	84.7
2	38.58	13	51.2	28	18.2	0.80	23.0	0.46	299.5	85.6
3	38.62	13	51.5	28	17.9	0.76	22.9	0.46	295.4	84.4
4	38.65	13	51.1	28	18.2	0.74	23.4	0.46	298.5	85.3
5	38.69	13	51.3	28	18.4	0.72	23.2	0.46	297.5	85.0
6	38.73	13	51.3	28	17.4	0.70	23.3	0.46	295.4	84.4
7	38.77	13	51.3	27	18.2	0.68	22.9	0.46	294.9	84.3
8	38.81	13	51.5	29	18.0	0.66	24.5	0.46	297.0	84.9
9	38.85	13	51.7	29	18.2	0.64	24.3	0.46	298.7	85.3
10	38.88	13	51.7	27	17.9	0.62	22.9	0.46	297.2	84.9
11	38.92	13	51.7	29	18.1	0.61	23.8	0.46	297.1	84.9
12	38.96	13	51.7	29	18.2	0.59	24.3	0.46	295.6	84.5
13	39.00	13	51.5	29	18.3	0.59	23.9	0.46	297.1	84.9
14	39.04	14	51.8	29	17.9	0.57	24.1	0.43	297.1	84.9
15	39.07	14	51.5	29	18.4	0.56	24.3	0.43	297.6	85.0
16	39.11	14	51.7	28	18.2	0.56	23.6	0.43	297.2	84.9
17	39.14	14	51.5	28	18.1	0.55	23.6	0.43	295.0	84.3
18	39.18	14	51.6	28	17.8	0.55	23.7	0.43	297.3	85.0
19	39.21	14	51.7	28	18.1	0.54	23.3	0.43	294.4	84.1
20	39.25	14	51.6	29	18.1	0.54	24.2	0.43	296.3	84.7
21	39.29	14	51.6	28	18.0	0.53	23.0	0.43	294.3	84.1
22	39.32	14	51.5	30	17.8	0.53	25.1	0.43	296.6	84.7
23	39.36	14	51.8	28	17.8	0.52	23.1	0.42	293.8	84.0
24	39.39	14	51.5	30	17.8	0.52	24.7	0.43	298.5	85.3
25	39.43	14	51.7	27	17.7	0.52	22.7	0.43	295.1	84.3

26	39.46	14	51.5	29	17.7	0.51	24.1	0.43	295.8	84.5
27	39.50	14	51.7	28	18.0	0.51	22.9	0.43	296.6	84.7
28	39.53	17	51.6	30	17.8	0.51	24.8	0.35	295.8	84.5
29	39.56	17	51.5	27	17.5	0.50	22.4	0.35	295.9	84.6
30	39.59	17	51.7	29	17.9	0.50	24.0	0.35	294.0	84.0
31	39.62	17	51.4	28	18.1	0.50	23.5	0.35	297.6	85.0
32	39.65	17	51.8	26	17.2	0.49	21.9	0.35	292.2	83.5
33	39.68	17	51.5	29	17.8	0.49	23.9	0.35	293.9	84.0
34	39.71	17	51.5	28	17.7	0.49	23.3	0.35	295.9	84.5
35	39.74	17	51.6	30	17.7	0.49	25.0	0.35	295.7	84.5
36	39.76	17	51.5	27	17.8	0.48	22.8	0.35	294.0	84.0
37	39.79	17	51.7	30	17.7	0.48	25.2	0.35	296.7	84.8
38	39.82	17	51.6	28	17.9	0.47	23.7	0.35	296.8	84.8
39	39.85	17	51.7	29	17.9	0.47	24.5	0.35	295.7	84.5
40	39.88	17	51.5	29	18.0	0.47	24.3	0.35	296.8	84.8
41	39.91	17	51.8	28	17.9	0.46	23.6	0.35	296.0	84.6
42	39.94	17	51.6	29	18.3	0.46	24.3	0.35	295.4	84.4
43	39.97	17	51.7	28	17.2	0.46	23.0	0.35	293.6	83.9
44	40.00	17	51.5	29	17.5	0.45	24.1	0.35	297.9	85.1
Average			51.6	29	17.8	0.51	23.8	0.39	295.8	84.5
Std Dev			0.1	1	0.3	0.03	0.8	0.04	1.5	0.4
Maximum			51.8	30	18.4	0.57	25.2	0.43	298.5	85.3
Minimum			51.4	26	17.2	0.45	21.9	0.35	292.2	83.5
N-value: 31										

Sample Interval Time: 49.95 seconds.

CME 750X ATV - SN322938 (R-58)
H. Forbes
AR: 1.20 in²
LE: 48.58 ft
WS: 16807.9 ft/s

S&ME Annual Testing
Test date: 8/7/2017
SP: 0.492 k/ft³
EM: 30000 ksi



BPM: Blows/Minute
FMX: Maximum Force
VMX: Maximum Velocity
DMX: Maximum Displacement

CSX: Compression Stress Maximum
DFN: Final Displacement
EFV: Maximum Energy
ETR: Energy Transfer Ratio - Rated

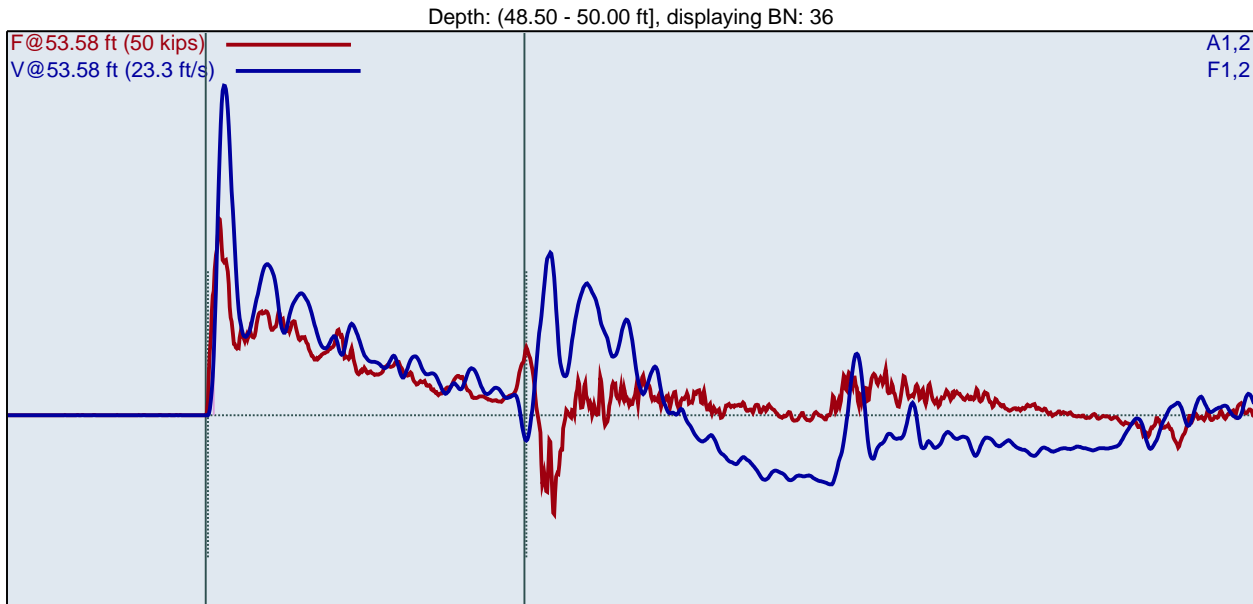
BL#	LP ft	BC /6"	BPM bpm	FMX kips	VMX ft/s	DMX in	CSX ksi	DFN in	EFV ft-lb	ETR (%)
1	43.55	10	59.9	29	17.7	1.08	24.5	0.60	304.6	87.0
2	43.60	10	51.9	28	17.5	0.78	23.7	0.60	298.4	85.2
3	43.65	10	51.8	30	17.9	0.77	24.7	0.60	302.6	86.4
4	43.70	10	52.0	29	18.4	0.77	24.3	0.60	308.2	88.1
5	43.75	10	51.8	30	18.4	0.71	25.2	0.60	305.0	87.1
6	43.80	10	51.9	29	18.1	0.71	24.4	0.60	303.5	86.7
7	43.85	10	51.9	30	18.4	0.70	24.9	0.60	310.5	88.7
8	43.90	10	52.0	30	18.2	0.68	24.6	0.60	305.7	87.3
9	43.95	10	51.5	29	17.8	0.67	24.5	0.60	309.1	88.3
10	44.00	10	51.9	31	18.4	0.67	26.0	0.60	312.2	89.2
11	44.04	12	51.9	30	18.1	0.64	25.3	0.50	306.2	87.5
12	44.08	12	51.7	29	17.9	0.62	24.0	0.50	309.0	88.3
13	44.13	12	51.9	30	18.0	0.59	24.8	0.50	301.6	86.2
14	44.17	12	51.6	31	18.3	0.60	25.5	0.50	313.4	89.5
15	44.21	12	52.0	30	18.2	0.58	24.9	0.50	302.7	86.5
16	44.25	12	51.7	30	17.9	0.59	24.9	0.50	311.4	89.0
17	44.29	12	51.8	30	18.3	0.59	25.2	0.50	309.4	88.4
18	44.33	12	51.8	30	17.9	0.59	25.2	0.50	312.3	89.2
19	44.38	12	51.8	29	17.9	0.57	24.4	0.50	303.9	86.8
20	44.42	12	51.7	30	17.8	0.56	24.9	0.50	305.4	87.3
21	44.46	12	51.7	29	17.9	0.56	24.3	0.50	304.9	87.1
22	44.50	12	52.1	29	17.7	0.56	24.3	0.50	305.3	87.2
23	44.53	17	51.7	31	18.1	0.56	25.7	0.35	306.8	87.7
24	44.56	17	52.1	29	17.8	0.55	24.6	0.35	305.1	87.2
25	44.59	17	51.4	30	18.3	0.56	24.8	0.35	311.8	89.1

26	44.62	17	52.1	29	17.6	0.54	24.2	0.35	300.3	85.8
27	44.65	17	51.7	29	17.6	0.53	24.1	0.35	306.0	87.4
28	44.68	17	51.9	29	17.9	0.53	24.0	0.35	303.5	86.7
29	44.71	17	51.7	29	16.9	0.53	24.0	0.35	301.9	86.3
30	44.74	17	51.6	27	17.1	0.52	22.1	0.35	302.1	86.3
31	44.76	17	52.0	29	17.7	0.49	23.9	0.35	297.0	84.8
32	44.79	17	51.7	28	18.0	0.49	23.6	0.35	297.5	85.0
33	44.82	17	51.9	29	17.7	0.50	24.0	0.35	301.9	86.3
34	44.85	17	51.6	29	18.0	0.50	23.9	0.35	302.8	86.5
35	44.88	17	51.7	29	17.8	0.51	24.5	0.35	306.2	87.5
36	44.91	17	51.6	29	17.8	0.51	24.1	0.35	306.3	87.5
37	44.94	17	51.9	30	18.2	0.50	24.8	0.35	307.4	87.8
38	44.97	17	52.0	29	17.8	0.50	24.5	0.35	304.8	87.1
39	45.00	17	51.7	28	17.3	0.49	23.3	0.35	305.2	87.2
Average			51.8	29	17.8	0.55	24.4	0.41	305.2	87.2
Std Dev			0.2	1	0.3	0.04	0.7	0.07	4.0	1.1
Maximum			52.1	31	18.3	0.64	25.7	0.50	313.4	89.5
Minimum			51.4	27	16.9	0.49	22.1	0.35	297.0	84.8
N-value: 29										

Sample Interval Time: 43.93 seconds.

CME 750X ATV - SN322938 (R-58)
H. Forbes
AR: 1.20 in²
LE: 53.58 ft
WS: 16807.9 ft/s

S&ME Annual Testing
Test date: 8/7/2017
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BPM: Blows/Minute
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DMX: Maximum Displacement

CSX: Compression Stress Maximum
DFN: Final Displacement
EFV: Maximum Energy
ETR: Energy Transfer Ratio - Rated

BL#	LP ft	BC /6"	BPM bpm	FMX kips	VMX ft/s	DMX in	CSX ksi	DFN in	EFV ft-lb	ETR (%)
1	48.56	8	52.4	27	19.9	1.03	22.4	0.75	312.1	89.2
2	48.63	8	52.1	26	19.2	0.92	21.7	0.75	309.0	88.3
3	48.69	8	51.8	27	20.0	0.89	22.5	0.75	316.4	90.4
4	48.75	8	52.0	27	19.6	0.82	22.6	0.75	309.3	88.4
5	48.81	8	51.9	27	19.9	0.81	22.7	0.75	314.9	90.0
6	48.88	8	51.9	27	19.7	0.77	22.5	0.75	310.8	88.8
7	48.94	8	52.1	27	19.9	0.77	22.6	0.75	314.0	89.7
8	49.00	8	52.0	27	19.8	0.76	22.8	0.75	313.9	89.7
9	49.04	12	52.2	27	19.6	0.67	22.7	0.50	309.4	88.4
10	49.08	12	51.9	28	19.6	0.65	23.2	0.50	309.7	88.5
11	49.13	12	52.0	28	19.4	0.64	23.3	0.50	311.6	89.0
12	49.17	12	51.9	27	19.3	0.64	22.7	0.50	311.2	88.9
13	49.21	12	52.0	27	19.4	0.63	22.5	0.50	309.2	88.3
14	49.25	12	51.8	28	19.4	0.62	23.2	0.50	310.9	88.8
15	49.29	12	51.9	27	19.3	0.62	22.8	0.50	310.3	88.7
16	49.33	12	52.0	28	19.6	0.61	23.0	0.50	310.0	88.6
17	49.38	12	51.8	27	19.6	0.60	22.5	0.50	306.8	87.7
18	49.42	12	52.0	26	20.0	0.60	21.5	0.50	310.1	88.6
19	49.46	12	51.8	26	19.1	0.59	21.9	0.50	309.8	88.5
20	49.50	12	52.0	26	19.9	0.58	21.8	0.50	309.4	88.4
21	49.53	18	51.8	27	19.9	0.60	22.1	0.33	318.1	90.9
22	49.56	18	52.0	27	19.8	0.56	22.3	0.33	306.3	87.5
23	49.58	18	51.9	27	18.7	0.59	22.9	0.33	317.4	90.7
24	49.61	18	51.9	26	19.7	0.56	22.0	0.33	305.1	87.2
25	49.64	18	51.9	26	19.5	0.57	21.7	0.33	312.1	89.2

26	49.67	18	51.5	24	19.1	0.55	20.2	0.33	303.5	86.7
27	49.69	18	52.1	26	19.9	0.56	21.8	0.33	311.5	89.0
28	49.72	18	51.7	25	20.0	0.55	21.2	0.33	311.9	89.1
29	49.75	18	52.0	26	20.3	0.54	21.8	0.33	310.6	88.7
30	49.78	18	51.8	26	19.5	0.53	21.7	0.33	304.6	87.0
31	49.81	18	52.0	24	20.4	0.53	20.4	0.33	312.1	89.2
32	49.83	18	51.9	26	20.1	0.53	22.1	0.33	311.7	89.1
33	49.86	18	52.2	26	19.2	0.51	21.4	0.33	302.3	86.4
34	49.89	18	51.8	25	20.3	0.51	21.0	0.33	310.3	88.6
35	49.92	18	51.7	25	20.1	0.50	21.2	0.33	308.1	88.0
36	49.94	18	51.9	26	20.0	0.50	21.4	0.33	309.2	88.4
37	49.97	18	51.5	26	20.6	0.51	21.5	0.33	313.8	89.6
38	50.00	18	51.9	25	19.9	0.49	21.0	0.33	303.3	86.7
Average			51.9	26	19.7	0.57	22.0	0.40	309.7	88.5
Std Dev			0.2	1	0.4	0.05	0.8	0.08	3.6	1.0
Maximum			52.2	28	20.6	0.67	23.3	0.50	318.1	90.9
Minimum			51.5	24	18.7	0.49	20.2	0.33	302.3	86.4
N-value: 30										

Sample Interval Time: 42.70 seconds.

Summary of SPT Test Results

Project: CME 750X ATV - SN322938 (R-58), Test Date: 8/7/2017

BPM: Blows/Minute						CSX: Compression Stress Maximum							
FMX: Maximum Force						DFN: Final Displacement							
VMX: Maximum Velocity						EFV: Maximum Energy							
DMX: Maximum Displacement						ETR: Energy Transfer Ratio - Rated							
Instr. Length ft	Start Depth ft	Final Depth ft	Blows Applied /6"	N Value	N60 Value	Average BPM bpm	Average FMX kips	Average VMX ft/s	Average DMX in	Average CSX ksi	Average DFN in	Average EFV ft-lb	Average ETR (%)
33.58	28.50	30.00	5-8-12	20	28	50.4	29	17.8	0.83	23.9	0.60	290.2	82.9
38.58	33.50	35.00	11-12-13	25	35	51.8	28	17.4	0.53	22.9	0.48	300.7	85.9
43.58	38.50	40.00	13-14-17	31	44	51.6	29	17.8	0.51	23.8	0.39	295.8	84.5
48.58	43.50	45.00	10-12-17	29	41	51.8	29	17.8	0.55	24.4	0.41	305.2	87.2
53.58	48.50	50.00	8-12-18	30	42	51.9	26	19.7	0.57	22.0	0.40	309.7	88.5
Overall Average Values:						51.6	28	18.2	0.58	23.4	0.44	301.0	86.0
Standard Deviation:						0.5	1	0.9	0.11	1.2	0.10	7.3	2.1
Overall Maximum Value:						52.2	31	20.6	0.95	25.7	0.75	318.1	90.9
Overall Minimum Value:						50.2	24	16.5	0.45	20.2	0.33	283.7	81.1

**Report of SPT Energy Measurements
S&ME CME-55 Truck (SN 328245)
Fayetteville, North Carolina
S&ME Project No. 6235-17-009**



Prepared for:
**North Carolina Department of Transportation
Geotechnical Engineering Unit
1589 Mail Service Center
Raleigh, North Carolina 27699**

Prepared by:
**S&ME, Inc.
9751 Southern Pine Boulevard
Charlotte, NC 28273**

May 1, 2017



May 1, 2017

North Carolina Department of Transportation
Geotechnical Engineering Unit
1589 Mail Service Center
Raleigh, North Carolina 27699

Attention: Mr. Shunyi (Chris) Chen, Ph.D., P.E.

cc: Ms. Cheryl A. Youngblood, L.G.

Reference: **Report of SPT Energy Measurements**
S&ME CME-55 Truck (SN 328245)
Fayetteville, North Carolina
S&ME Project No. 6235-17-009

Dear Mr. Chen:

We have completed the Standard Penetration Test (SPT) energy measurements on the automatic hammer mounted on our CME-55 Truck drill rig with a serial number of 328245. This service was performed by our Mr. Robert E. Kral on April 4, 2017 between the times of 11:39 AM and 12:40 PM. SPT energy testing was performed in general accordance with ASTM D4633 and the most recent revision of the North Carolina Department of Transportation, Geotechnical Engineering Unit's requirements. The testing procedures, equipment used during testing, and detailed results are presented in this report.

1.0 Dynamic Testing Methodology

Testing was performed using a model PAX (Serial No. 3733L) Pile Driving Analyzer™ (PDA) manufactured by Pile Dynamics, Inc. The PDA records and interprets data from two piezoresistive accelerometers (Serial Nos. K5641 and K5642) bolted to a 2-foot long AWJ drill rod (SN203) internally instrumented with two strain transducers. The instrumented AWJ drill rod has a cross-sectional area of 1.20 square inches, an outside diameter of approximately 1.75 inches, and an inside diameter of 1.375 inches at the gage location. Calibration sheets for the accelerometers and the instrumented rod are included in the Appendix. The accelerometers and strain gages, which are mounted on opposing axes near the middle of the instrumented rod, monitor acceleration and strain for each hammer blow. The analyzer converts the data to velocities and forces, computing the maximum transferred hammer energies with the "EFV" method described in ASTM D4633. All results are recorded and displayed in real time for each blow.



2.0 Testing and Observations

S&ME personnel were on site on April 4, 2017 to observe and perform testing during SPT sampling on the CME-55 truck mounted rig operated by Ted Miller of S&ME. The measurements were taken during drilling operations at the Fayetteville Outer Loop (TIP U-2519AA) project in Fayetteville, North Carolina. The measurements were obtained during the SPT sampling of Soil Test Boring Y2_2800. SPT energy measurements were recorded during four intervals at depths of approximately 57.6, 62.6, 67.6, and 72.6 ft below the existing ground surface. The information presented in the tables below summarizes the equipment tested and tooling used for this Report of SPT Energy Measurements.

Table 2-1: Drill Rig Information

Manufacturer	CME
Model	55
Serial Number	328245
Operator	Ted Miller
Carrier	Truck

Table 2-2: Hammer Information

Model / Type	CME / Auto
Serial Number	N/A
Anvil Height (inches)	11.5
Anvil Diameter (inches)	2.5
Drop Height (inches)	30
Ram Weight (pounds)	140
Ram Serial Number	N/A

Table 2-3: Drilling and Instrumented Rod Information

Drill Rod Type	AWJ
OD (inches)	1.75
ID (inches)	1.25
Cross-Sectional Area (in ²)	1.20
Typical Length (feet)	5 and 10
Instrumented Rod Type	AWJ (SN 203)
OD (inches)	1.75
ID (inches)	1.25
Cross-Sectional Area (in ²)	1.20
Total Instrumented Rod Length (feet)	2.0
Length Below Gages (feet)	0.88
Split Spoon Length (feet)	2.88

The reported blow counts, obtained by the drill rig personnel, are presented with the energy data in Table 3-1 and on the Field and Boring Logs in the Appendix. A representative graph of force and normalized velocity vs. time for a typical blow and the following list of plots and tables are incorporated into the Appendix.

3.0 Dynamic Testing Results

Based on the test data, the automatic hammer on the CME-55 truck mounted rig operated at a rate of about 51.6 to 52.2 blows per minute (bpm) during dynamic testing. The measured transferred hammer energy (EFV) was generally in the range of about 267.1 to 307.3 ft-lbs, which corresponds to Energy Transfer Ratio (ETR) values of about 76.3% to 87.8%, respectively. The SPT Energy Measurement Data Summary tables in the Appendix present the test data from every hammer blow at each sampling interval along with representative force and velocity traces for each test interval. The reported blow counts, obtained by the drill rig personnel, and a summary of the test data and average computed hammer energy and transfer ratio values are provided in Table 3-1. Plots and tables of the following are also included in the Appendix and present the test data with depth for each test interval:

- ◆ Penetration vs. BLC
- ◆ Penetration vs. CSX
- ◆ Average ETR vs. Rod Length
- ◆ Penetration vs. FMX
- ◆ Penetration vs. VMX
- ◆ ETR vs. Rod Length
- ◆ Penetration vs. EFV
- ◆ Penetration vs. ETR

Table 3-1: Summary of Dynamic Testing Results

Data Set ID	Instrumentation to Sampler Tip Length (ft)	Sample Depth (ft)	Blows per 6" Increment / N-value	Soil Sample Description (Residual)	Avg. BPM	Avg. EFV (ft-lbs)	Avg. ETR (percent)
1	63.76	57.6 - 59.1	7-10-9 / 19	SAND	51.9	286.9	82.0
2	68.76	62.6 - 64.1	9-10-12 / 22	SAND	52.0	298.6	85.3
3	73.76	67.6 - 69.1	6-13-17 / 30	SAND	51.9	295.9	84.5
4	78.76	72.6 - 74.1	6-11-10 / 21	SAND	51.9	294.8	84.2
Overall Average					51.9	294.4	84.1

The average hammer rate, transferred energy, and transfer ratio were calculated for each depth interval. Per ASTM D4633, only the blows from the final foot of each sample interval (i.e. the blows that determine the N-value) were included when computing these average values. **The overall average transferred hammer energy for the automatic hammer on the CME-55 truck mounted rig (for all the depth intervals tested) was 294.4 foot-pounds, with an average ETR of 84.1%.**

4.0 Limitations of Report

This report has been prepared in accordance with generally accepted geotechnical engineering practice for specific application to this project. The conclusions contained in this report were based on the applicable standards of our profession in this geographic area at the time this report was prepared. No other warranty, express or implied, is made.

5.0 Closing

S&ME appreciates the opportunity to provide this report to the North Carolina Department of Transportation Geotechnical Engineering Unit. Please let us know if you have any questions concerning this report.

Sincerely,

S&ME, Inc.



R. Heath Forbes, P.E. (SC)
Geotechnical Project Manager



Robert E. Kral, P.E.
Transportation Services Project Manager
N.C. Registration No. 042642



Senior Reviewed By: Kristen H. Hill, L.G., P.E.

Appendices:

- ◆ Appendix I - CME 55 (SN 328245) SPT Energy Measurements Summary Plots and Tables
- ◆ Appendix II - Field Log and Boring Log
- ◆ Appendix III - Instrumented Rod and Accelerometer Calibration Sheets
- ◆ Appendix IV - Certificate of Proficiency

Appendix I

CME55 Truck (SN 328245)

28+00, 20LT

R. Kral

Test date: 4/4/2017

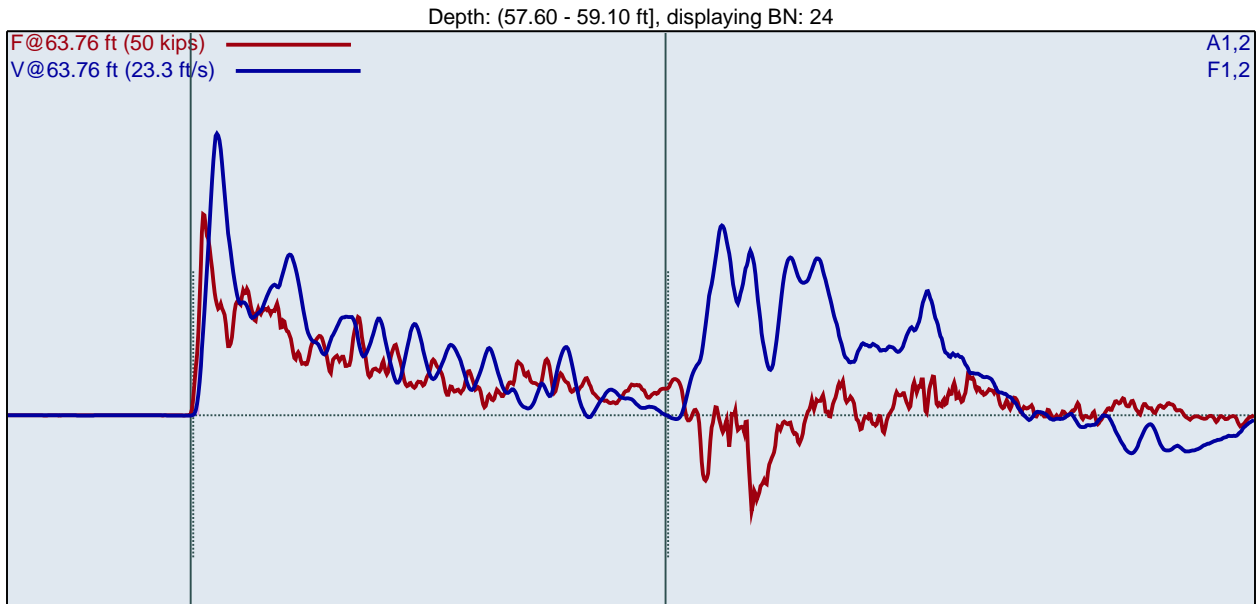
AR: 1.20 in²

SP: 0.492 k/ft³

LE: 63.76 ft

EM: 30000 ksi

WS: 16807.9 ft/s



BPM: Blows/Minute

CSX: Compression Stress Maximum

FMX: Maximum Force

DFN: Final Displacement

VMX: Maximum Velocity

EFV: Maximum Energy

DMX: Maximum Displacement

ETR: Energy Transfer Ratio - Rated

BL#	LP ft	BC /6"	BPM bpm	FMX kips	VMX ft/s	DMX in	CSX ksi	DFN in	EFV ft-lb	ETR (%)
1	57.67	7	60.7	27	14.5	1.02	22.9	0.78	247.9	70.8
2	57.74	7	52.7	27	14.5	1.03	22.2	0.82	266.7	76.2
3	57.81	7	52.0	27	14.5	0.84	22.7	0.81	255.9	73.1
4	57.89	7	51.8	27	14.6	0.82	22.7	0.81	266.4	76.1
5	57.96	7	52.2	27	14.9	0.81	22.6	0.81	264.2	75.5
6	58.03	7	52.0	27	15.1	0.83	22.8	0.82	275.9	78.8
7	58.10	7	52.1	27	15.5	0.86	22.7	0.83	286.6	81.9
8	58.15	10	51.9	27	15.9	0.70	22.9	0.57	280.6	80.2
9	58.20	10	51.9	27	15.8	0.67	22.5	0.56	275.1	78.6
10	58.25	10	52.0	27	15.9	0.67	22.6	0.56	273.4	78.1
11	58.30	10	51.9	28	16.0	0.68	23.0	0.57	275.0	78.6
12	58.35	10	52.0	28	16.3	0.78	23.2	0.56	290.9	83.1
13	58.40	10	51.7	28	16.5	0.69	23.1	0.57	279.9	80.0
14	58.45	10	52.2	28	16.5	0.67	23.5	0.57	274.3	78.4
15	58.50	10	51.7	27	16.6	0.77	22.8	0.57	292.7	83.6
16	58.55	10	52.1	27	16.5	0.75	22.5	0.57	290.2	82.9
17	58.60	10	52.2	27	16.3	0.74	22.6	0.57	287.9	82.3
18	58.66	9	51.7	27	16.3	0.76	22.2	0.63	294.5	84.2
19	58.71	9	52.0	27	16.3	0.73	22.2	0.65	289.5	82.7
20	58.77	9	51.9	25	16.5	0.74	20.8	0.64	292.3	83.5
21	58.82	9	51.9	27	16.2	0.72	22.3	0.64	290.6	83.0
22	58.88	9	51.9	26	17.3	0.71	21.9	0.64	295.6	84.5
23	58.93	9	52.2	27	16.8	0.71	22.3	0.64	290.4	83.0
24	58.99	9	51.9	26	17.1	0.71	21.8	0.64	291.7	83.4
25	59.04	9	52.0	25	16.9	0.71	21.1	0.64	293.0	83.7

26	59.10	9	51.9	25	16.1	0.70	20.6	0.64	293.7	83.9
Average			51.9	27	16.4	0.72	22.3	0.60	286.9	82.0
Std Dev			0.1	1	0.4	0.03	0.8	0.04	7.5	2.1
Maximum			52.2	28	17.3	0.78	23.5	0.65	295.6	84.5
Minimum			51.7	25	15.8	0.67	20.6	0.56	273.4	78.1
N-value: 19										

Sample Interval Time: 28.81 seconds.

CME55 Truck (SN 328245)

28+00, 20LT

R. Kral

Test date: 4/4/2017

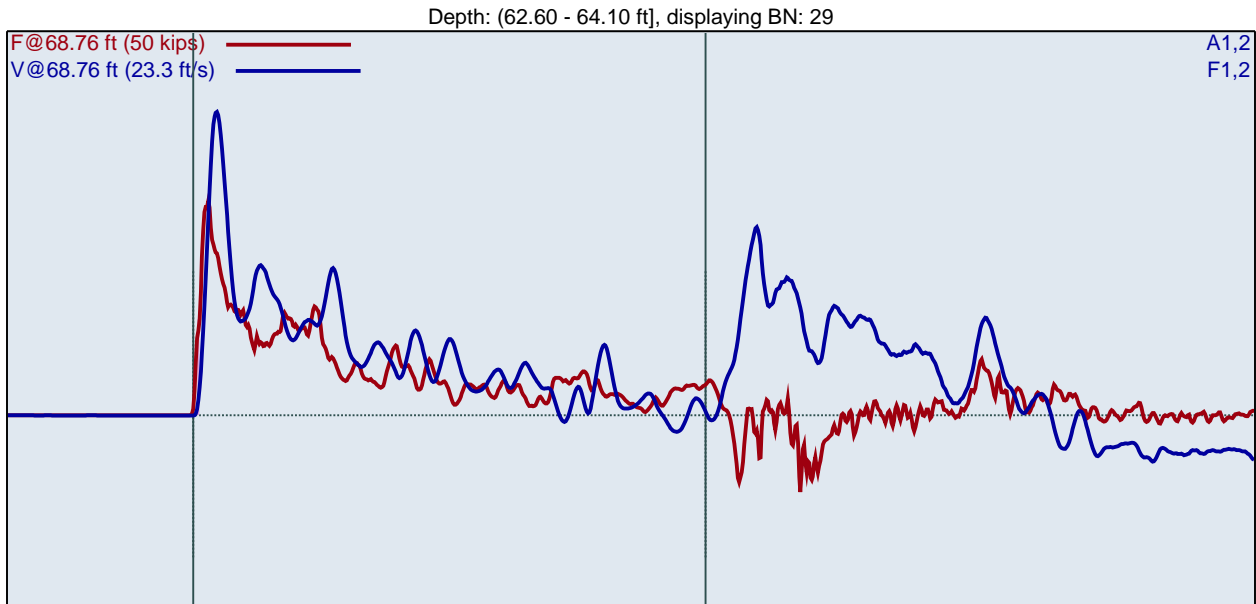
AR: 1.20 in²

SP: 0.492 k/ft³

LE: 68.76 ft

EM: 30000 ksi

WS: 16807.9 ft/s



BPM: Blows/Minute

CSX: Compression Stress Maximum

FMX: Maximum Force

DFN: Final Displacement

VMX: Maximum Velocity

EFV: Maximum Energy

DMX: Maximum Displacement

ETR: Energy Transfer Ratio - Rated

BL#	LP ft	BC /6"	BPM bpm	FMX kips	VMX ft/s	DMX in	CSX ksi	DFN in	EFV ft-lb	ETR (%)
1	62.66	9	61.1	27	16.9	0.69	22.6	0.61	261.9	74.8
2	62.71	9	52.2	27	17.0	0.69	22.8	0.62	269.8	77.1
3	62.77	9	52.1	28	17.2	0.70	23.0	0.63	277.9	79.4
4	62.82	9	51.7	28	17.1	0.67	23.7	0.63	275.2	78.6
5	62.88	9	52.1	30	17.7	0.67	24.6	0.63	280.4	80.1
6	62.93	9	51.9	29	18.1	0.73	24.2	0.64	295.0	84.3
7	62.99	9	52.1	27	18.1	0.68	22.7	0.63	289.4	82.7
8	63.04	9	52.0	28	17.9	0.68	23.6	0.63	284.1	81.2
9	63.10	9	51.8	27	17.8	0.72	22.1	0.64	291.3	83.2
10	63.15	10	52.1	26	17.7	0.68	22.1	0.57	288.0	82.3
11	63.20	10	51.8	27	17.9	0.64	22.6	0.56	281.8	80.5
12	63.25	10	52.0	26	17.5	0.72	21.9	0.56	297.4	85.0
13	63.30	10	51.7	26	17.7	0.73	21.9	0.56	296.1	84.6
14	63.35	10	52.1	26	17.4	0.67	21.6	0.57	291.3	83.2
15	63.40	10	51.8	27	17.8	0.67	22.4	0.57	291.6	83.3
16	63.45	10	52.1	27	17.9	0.71	22.4	0.57	299.7	85.6
17	63.50	10	52.0	27	18.0	0.62	22.7	0.57	286.6	81.9
18	63.55	10	51.9	28	18.1	0.67	23.0	0.58	300.7	85.9
19	63.60	10	52.0	27	17.9	0.68	22.5	0.57	297.1	84.9
20	63.64	12	51.8	28	18.5	0.68	23.5	0.48	300.2	85.8
21	63.68	12	51.9	28	18.5	0.68	23.6	0.48	304.5	87.0
22	63.73	12	51.9	28	18.6	0.67	23.3	0.48	305.1	87.2
23	63.77	12	52.2	28	18.3	0.67	23.4	0.47	304.9	87.1
24	63.81	12	51.8	28	18.4	0.67	23.1	0.47	306.8	87.7
25	63.85	12	52.2	28	18.2	0.64	23.0	0.47	301.2	86.1

26	63.89	12	51.8	28	18.2	0.64	23.1	0.47	300.9	86.0
27	63.93	12	52.0	28	18.3	0.64	23.1	0.47	301.1	86.0
28	63.98	12	51.9	28	18.4	0.65	23.0	0.47	306.1	87.4
29	64.02	12	51.9	28	18.4	0.64	23.3	0.47	304.6	87.0
30	64.06	12	52.1	28	18.4	0.64	23.0	0.47	303.1	86.6
31	64.10	12	51.9	27	18.2	0.63	22.9	0.47	301.4	86.1
Average			52.0	27	18.1	0.67	22.8	0.52	298.6	85.3
Std Dev			0.1	1	0.3	0.03	0.5	0.05	6.7	1.9
Maximum			52.2	28	18.6	0.73	23.6	0.58	306.8	87.7
Minimum			51.7	26	17.4	0.62	21.6	0.47	281.8	80.5
N-value: 22										

Sample Interval Time: 34.59 seconds.

CME55 Truck (SN 328245)

28+00, 20LT

R. Kral

Test date: 4/4/2017

AR: 1.20 in²

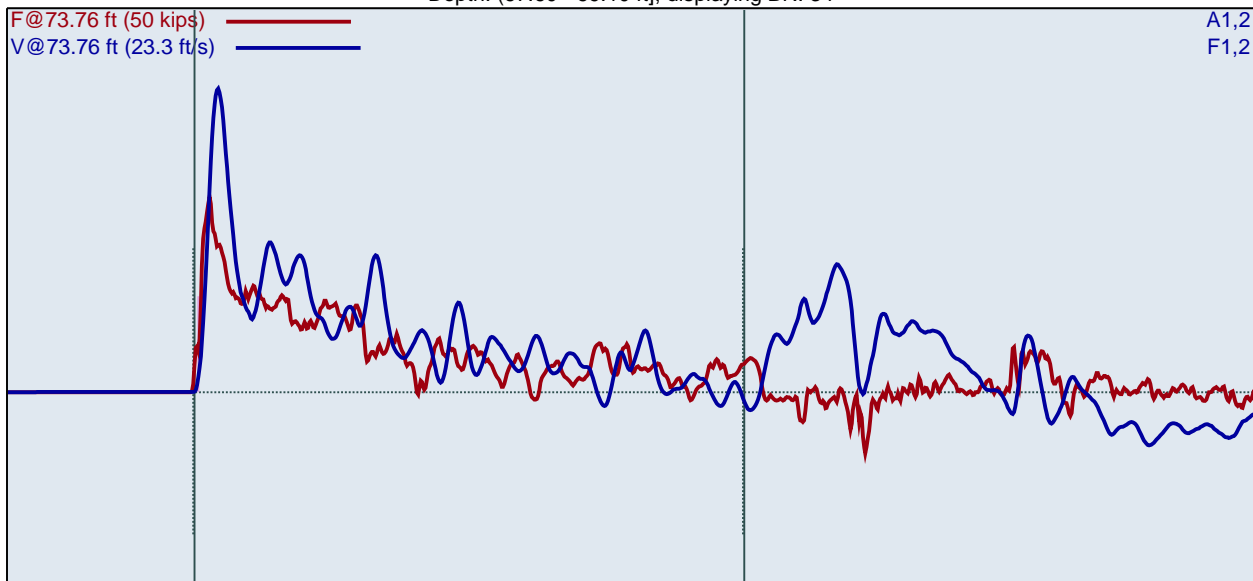
SP: 0.492 k/ft³

LE: 73.76 ft

EM: 30000 ksi

WS: 16807.9 ft/s

Depth: (67.60 - 69.10 ft), displaying BN: 34



BPM: Blows/Minute

CSX: Compression Stress Maximum

FMX: Maximum Force

DFN: Final Displacement

VMX: Maximum Velocity

EFV: Maximum Energy

DMX: Maximum Displacement

ETR: Energy Transfer Ratio - Rated

BL#	LP ft	BC /6"	BPM bpm	FMX kips	VMX ft/s	DMX in	CSX ksi	DFN in	EFV ft-lb	ETR (%)
1	67.68	6	107.6	26	17.9	1.46	22.0	0.93	302.9	86.5
2	67.77	6	52.5	27	18.4	1.25	22.6	0.94	298.6	85.3
3	67.85	6	51.6	26	17.8	1.10	22.0	0.95	295.1	84.3
4	67.93	6	52.1	27	18.0	1.00	22.3	0.97	297.0	84.8
5	68.02	6	52.0	27	18.1	0.96	22.3	0.96	298.5	85.3
6	68.10	6	51.7	27	18.2	0.97	22.3	0.97	297.2	84.9
7	68.14	13	52.0	26	17.9	0.81	21.8	0.43	296.1	84.6
8	68.18	13	52.0	26	18.3	0.62	21.4	0.42	274.8	78.5
9	68.22	13	51.8	26	18.2	0.59	22.1	0.42	274.6	78.5
10	68.25	13	52.2	25	18.2	0.55	20.8	0.42	267.1	76.3
11	68.29	13	52.0	25	18.3	0.57	21.0	0.42	271.7	77.6
12	68.33	13	51.9	26	18.1	0.59	21.4	0.43	282.2	80.6
13	68.37	13	51.8	25	17.7	0.61	20.6	0.44	291.8	83.4
14	68.41	13	51.7	25	17.5	0.54	20.8	0.44	289.3	82.7
15	68.45	13	52.1	26	18.2	0.53	21.4	0.44	298.8	85.4
16	68.48	13	51.9	24	17.6	0.53	19.7	0.44	294.4	84.1
17	68.52	13	51.9	25	18.0	0.52	20.5	0.44	296.4	84.7
18	68.56	13	51.6	24	17.8	0.52	20.2	0.44	300.1	85.7
19	68.60	13	52.1	24	17.4	0.51	20.3	0.44	298.5	85.3
20	68.63	17	51.8	24	17.3	0.51	19.7	0.33	299.4	85.5
21	68.66	17	52.1	24	17.5	0.52	20.1	0.34	298.9	85.4
22	68.69	17	51.8	26	18.3	0.49	21.3	0.33	296.4	84.7
23	68.72	17	51.9	24	17.7	0.53	20.2	0.33	302.2	86.3
24	68.75	17	51.9	25	17.7	0.54	20.7	0.33	302.7	86.5
25	68.78	17	51.9	23	17.3	0.54	19.5	0.33	300.3	85.8

26	68.81	17	51.8	25	17.6	0.54	20.7	0.33	302.2	86.3
27	68.84	17	52.0	26	18.3	0.53	21.8	0.33	305.8	87.4
28	68.86	17	52.1	24	17.8	0.55	20.0	0.33	302.1	86.3
29	68.89	17	51.9	26	18.4	0.54	21.5	0.33	305.1	87.2
30	68.92	17	52.1	26	17.8	0.54	21.5	0.33	298.9	85.4
31	68.95	17	51.8	26	18.6	0.53	21.6	0.33	301.3	86.1
32	68.98	17	51.8	25	18.2	0.54	21.2	0.33	301.2	86.1
33	69.01	17	51.6	25	18.1	0.54	20.8	0.33	304.1	86.9
34	69.04	17	51.9	25	18.5	0.54	21.2	0.33	305.7	87.3
35	69.07	17	51.6	25	17.9	0.55	20.8	0.33	306.3	87.5
36	69.10	17	51.7	26	18.1	0.54	21.3	0.33	307.3	87.8
Average			51.9	25	17.9	0.55	20.9	0.38	295.9	84.5
Std Dev			0.2	1	0.4	0.06	0.7	0.05	10.7	3.1
Maximum			52.2	26	18.6	0.81	22.1	0.44	307.3	87.8
Minimum			51.6	23	17.3	0.49	19.5	0.33	267.1	76.3
N-value: 30										

Sample Interval Time: 40.39 seconds.

CME55 Truck (SN 328245)

28+00, 20LT

R. Kral

Test date: 4/4/2017

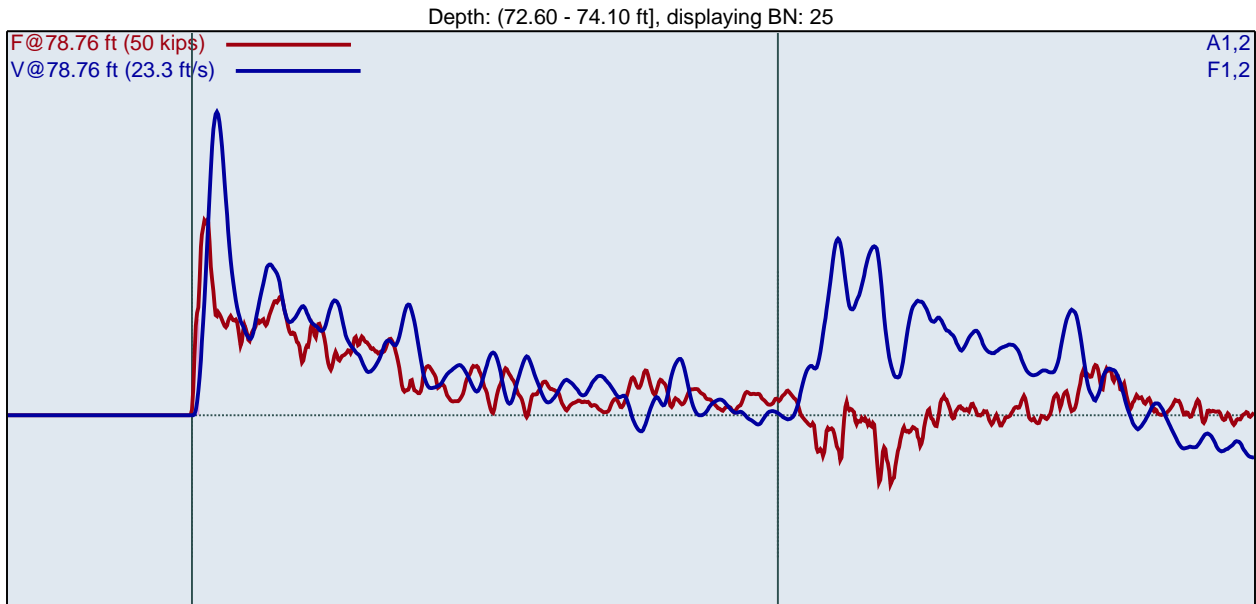
AR: 1.20 in²

SP: 0.492 k/ft³

LE: 78.76 ft

EM: 30000 ksi

WS: 16807.9 ft/s



BPM: Blows/Minute

CSX: Compression Stress Maximum

FMX: Maximum Force

DFN: Final Displacement

VMX: Maximum Velocity

EFV: Maximum Energy

DMX: Maximum Displacement

ETR: Energy Transfer Ratio - Rated

BL#	LP ft	BC /6"	BPM bpm	FMX kips	VMX ft/s	DMX in	CSX ksi	DFN in	EFV ft-lb	ETR (%)
1	72.68	6	60.7	26	18.7	1.34	21.6	0.94	303.1	86.6
2	72.77	6	52.6	25	17.9	1.18	20.9	0.95	297.0	84.9
3	72.85	6	52.2	27	17.8	1.01	22.1	0.96	292.2	83.5
4	72.93	6	52.0	24	17.9	1.00	19.9	0.96	290.9	83.1
5	73.02	6	51.9	23	18.0	0.96	19.2	0.96	297.6	85.0
6	73.10	6	52.1	24	18.4	0.96	20.0	0.96	296.8	84.8
7	73.15	11	51.8	23	18.1	0.76	19.4	0.50	296.0	84.6
8	73.19	11	52.1	24	18.6	0.76	20.2	0.50	297.6	85.0
9	73.24	11	51.7	25	18.9	0.74	20.8	0.51	298.2	85.2
10	73.28	11	52.2	24	18.3	0.72	19.8	0.51	297.6	85.0
11	73.33	11	52.0	24	19.1	0.71	20.1	0.51	297.5	85.0
12	73.37	11	52.2	25	19.4	0.71	21.1	0.51	296.2	84.6
13	73.42	11	51.7	23	18.5	0.72	19.5	0.51	295.7	84.5
14	73.46	11	51.9	26	18.9	0.72	21.9	0.51	298.1	85.2
15	73.51	11	52.1	25	19.6	0.72	20.8	0.51	297.2	84.9
16	73.55	11	51.8	26	19.0	0.71	21.7	0.51	294.0	84.0
17	73.60	11	52.0	26	20.0	0.72	21.8	0.51	299.1	85.5
18	73.65	10	52.0	26	19.3	0.71	21.4	0.57	294.4	84.1
19	73.70	10	52.1	25	19.1	0.70	20.6	0.57	290.9	83.1
20	73.75	10	51.7	25	20.2	0.70	21.0	0.57	297.5	85.0
21	73.80	10	52.0	27	19.1	0.69	22.3	0.58	290.9	83.1
22	73.85	10	52.0	25	18.9	0.70	21.2	0.58	293.6	83.9
23	73.90	10	52.0	26	18.8	0.69	21.4	0.58	292.7	83.6
24	73.95	10	52.1	25	18.9	0.68	20.9	0.58	288.9	82.5
25	74.00	10	51.6	25	18.4	0.68	21.1	0.58	288.7	82.5

26	74.05	10	52.1	25	18.9	0.69	21.0	0.57	294.1	84.0
27	74.10	10	51.8	25	19.2	0.68	20.7	0.58	291.6	83.3
Average			51.9	25	19.0	0.71	20.9	0.54	294.8	84.2
Std Dev			0.2	1	0.5	0.02	0.7	0.03	3.1	0.9
Maximum			52.2	27	20.2	0.76	22.3	0.58	299.1	85.5
Minimum			51.6	23	18.1	0.68	19.4	0.50	288.7	82.5
N-value: 21										

Sample Interval Time: 29.95 seconds.

Summary of SPT Test Results

Project: CME55 Truck (SN 328245), Test Date: 4/4/2017

BPM: Blows/Minute											CSX: Compression Stress Maximum		
FMX: Maximum Force											DFN: Final Displacement		
VMX: Maximum Velocity											EFV: Maximum Energy		
DMX: Maximum Displacement											ETR: Energy Transfer Ratio - Rated		
Instr. Length ft	Start Depth ft	Final Depth ft	Blows Applied /6"	N Value	N60 Value	Average BPM bpm	Average FMX kips	Average VMX ft/s	Average DMX in	Average CSX ksi	Average DFN in	Average EFV ft-lb	Average ETR (%)
63.76	57.60	59.10	7-10-9	19	26	51.9	27	16.4	0.72	22.3	0.60	286.9	82.0
68.76	62.60	64.10	9-10-12	22	30	52.0	27	18.1	0.67	22.8	0.52	298.6	85.3
73.76	67.60	69.10	6-13-17	30	42	51.9	25	17.9	0.55	20.9	0.38	295.9	84.5
78.76	72.60	74.10	6-11-10	21	29	51.9	25	19.0	0.71	20.9	0.54	294.8	84.2
Overall Average Values:						51.9	26	17.9	0.65	21.6	0.49	294.4	84.1
Standard Deviation:						0.2	1	1.0	0.08	1.1	0.10	8.9	2.5
Overall Maximum Value:						52.2	28	20.2	0.81	23.6	0.65	307.3	87.8
Overall Minimum Value:						51.6	23	15.8	0.49	19.4	0.33	267.1	76.3



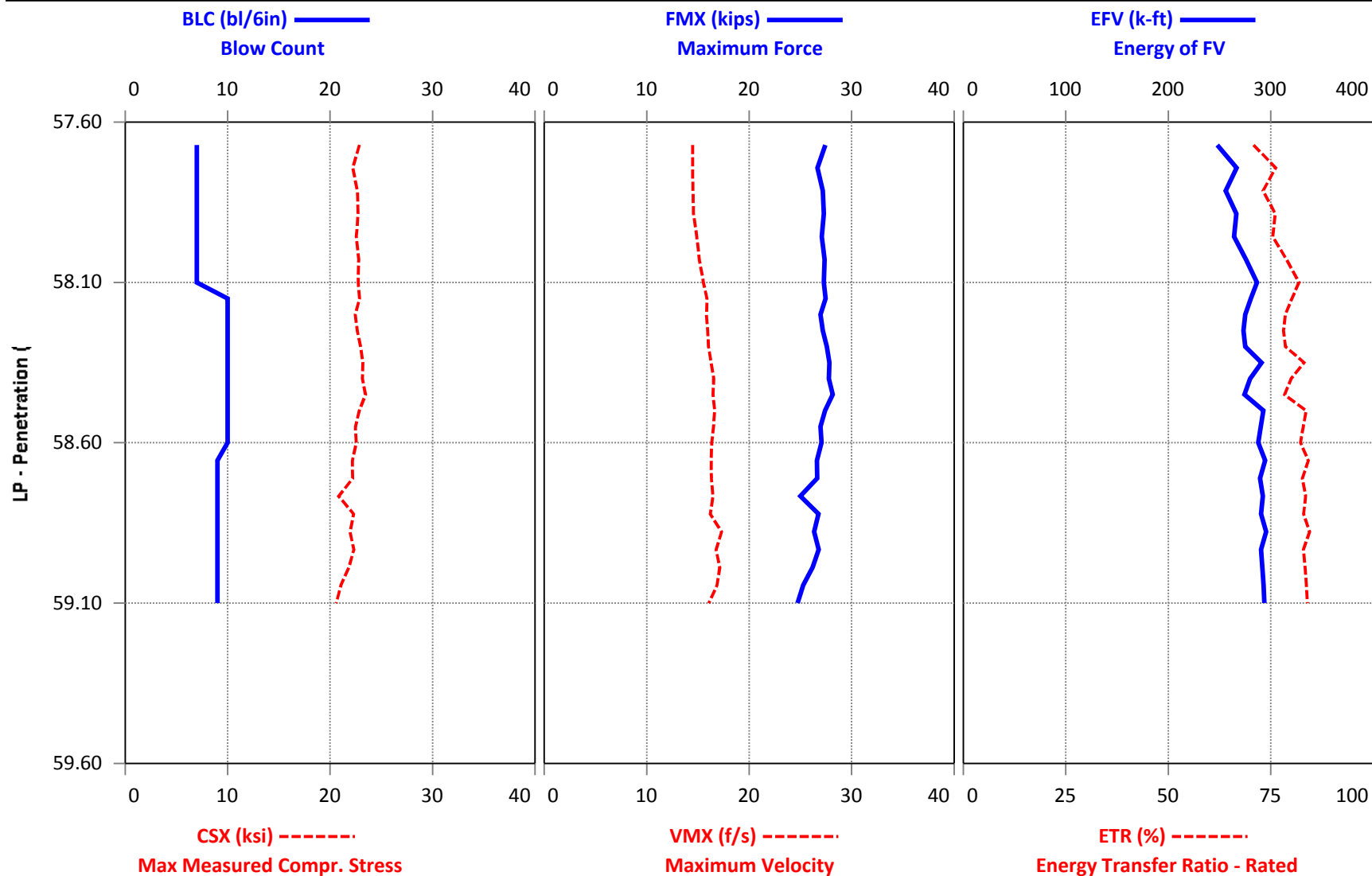
Printed: 25-April-2017

Pile Dynamics, Inc. - PDILOT2 Ver 2016.2.57.6 - Case Method & iCAP® Results

Test started: 04-April-2017



CME55 Truck (SN 328245) - 57.6 to 59.1 ft
28+00, 20LT





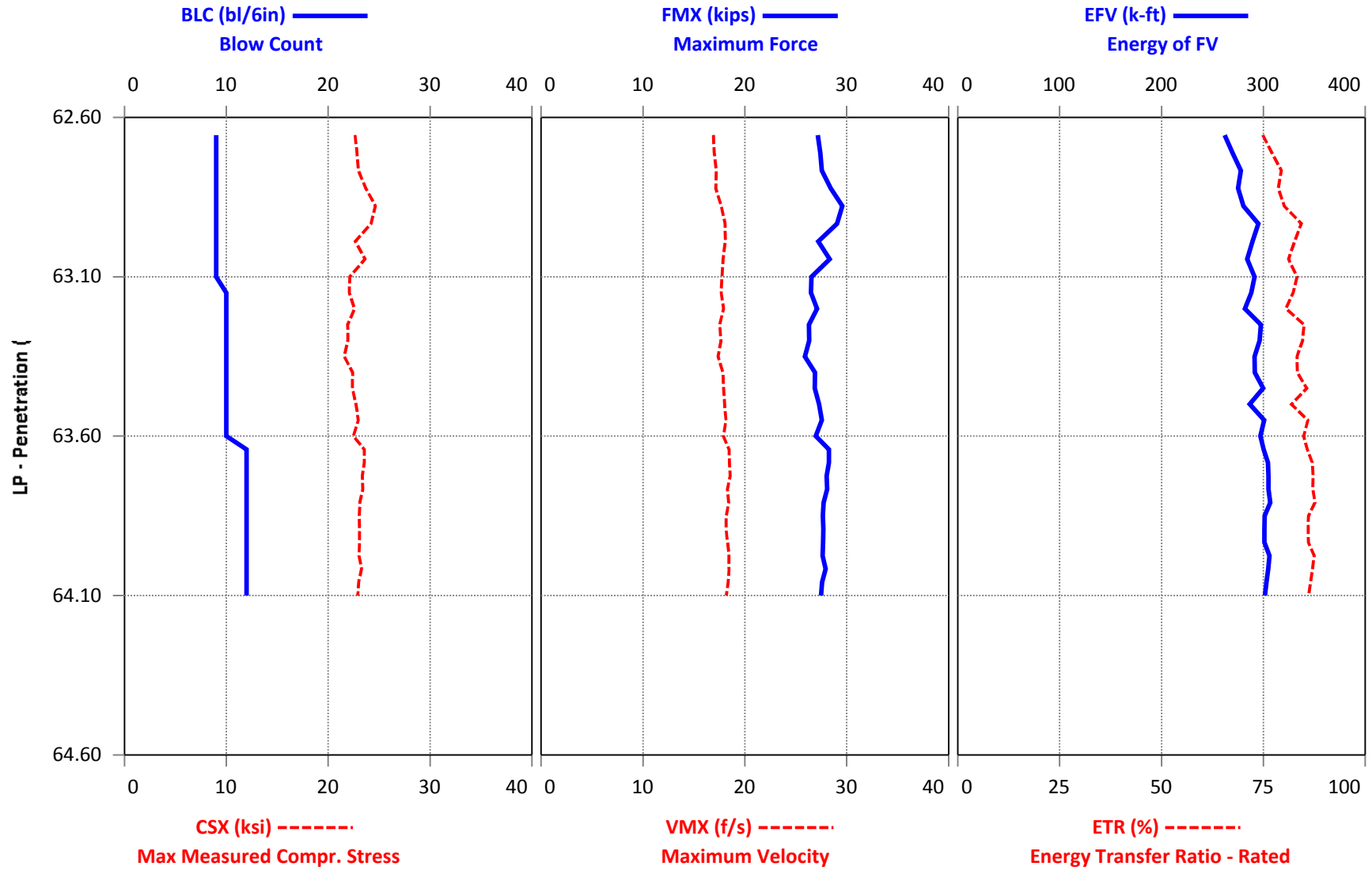
Printed: 25-April-2017

Pile Dynamics, Inc. - PDILOT2 Ver 2016.2.57.6 - Case Method & iCAP® Results

Test started: 04-April-2017



CME55 Truck (SN 328245) - 62.6 to 64.1 ft
28+00, 20LT





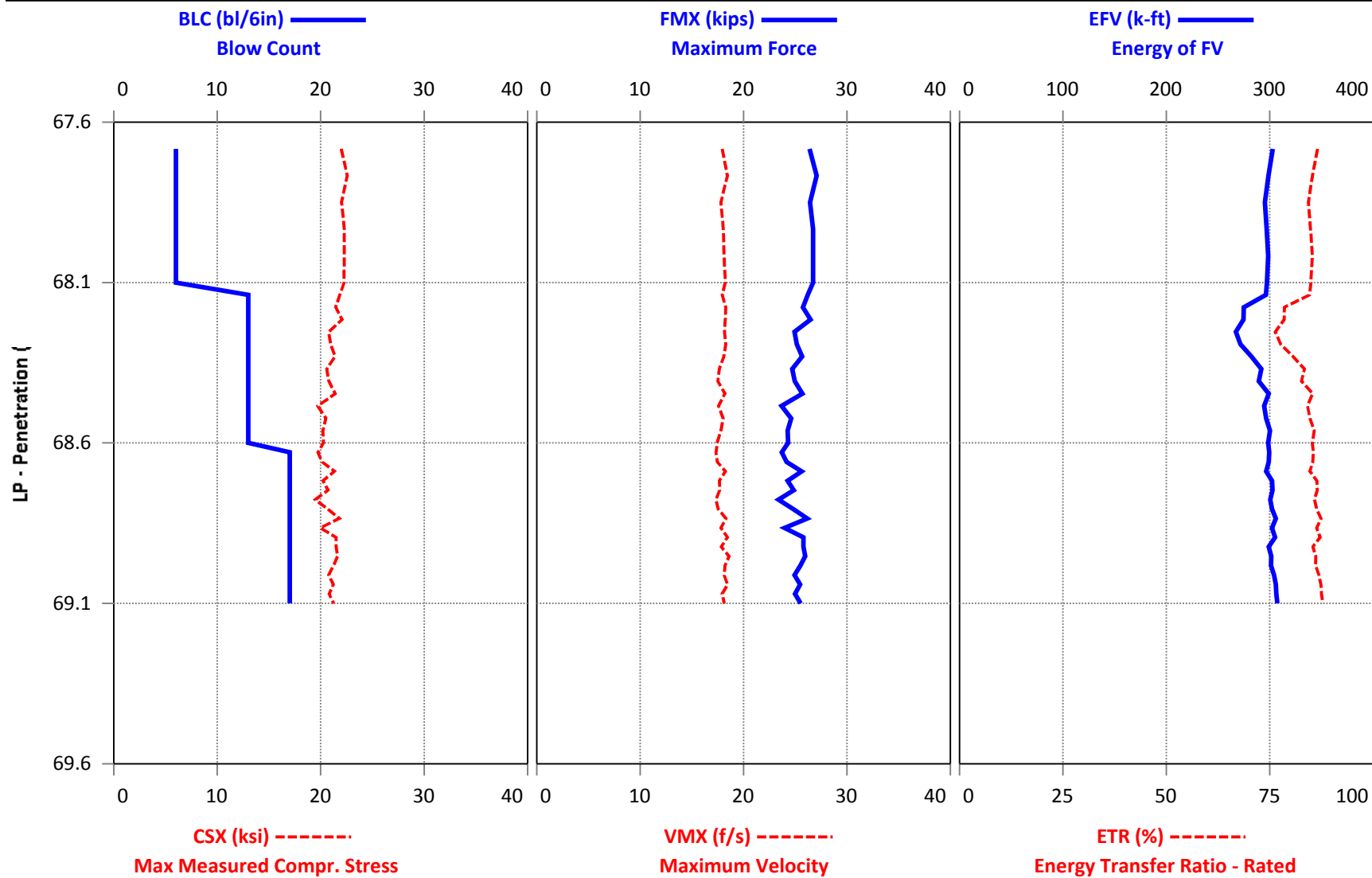
Printed: 25-April-2017

Pile Dynamics, Inc. - PDILOT2 Ver 2016.2.57.6 - Case Method & iCAP® Results

Test started: 04-April-2017



**CME55 Truck (SN 328245) - 67.6 to 69.1 ft
28+00, 20LT**





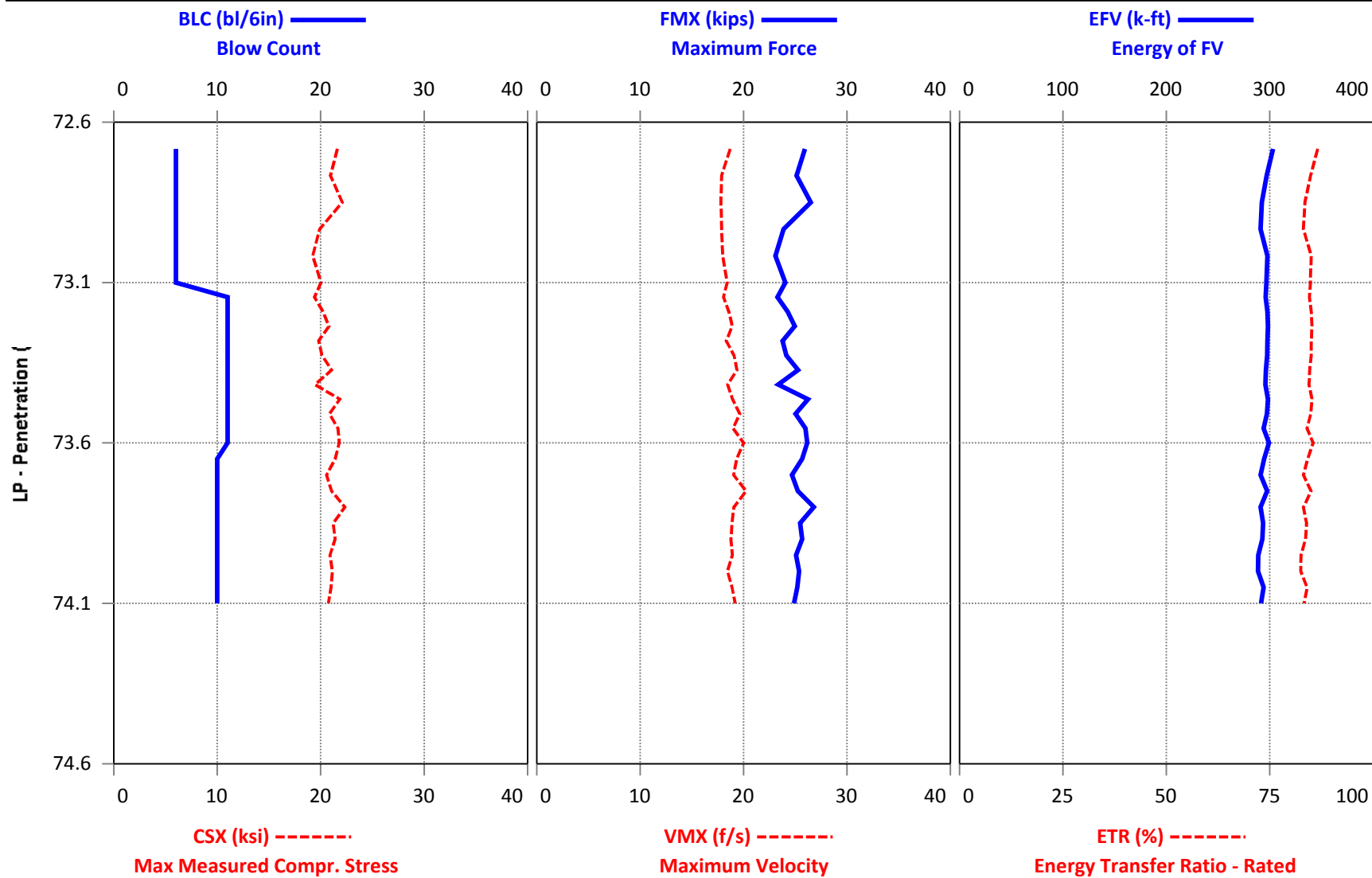
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Pile Dynamics, Inc. - PDILOT2 Ver 2016.2.57.6 - Case Method & iCAP® Results

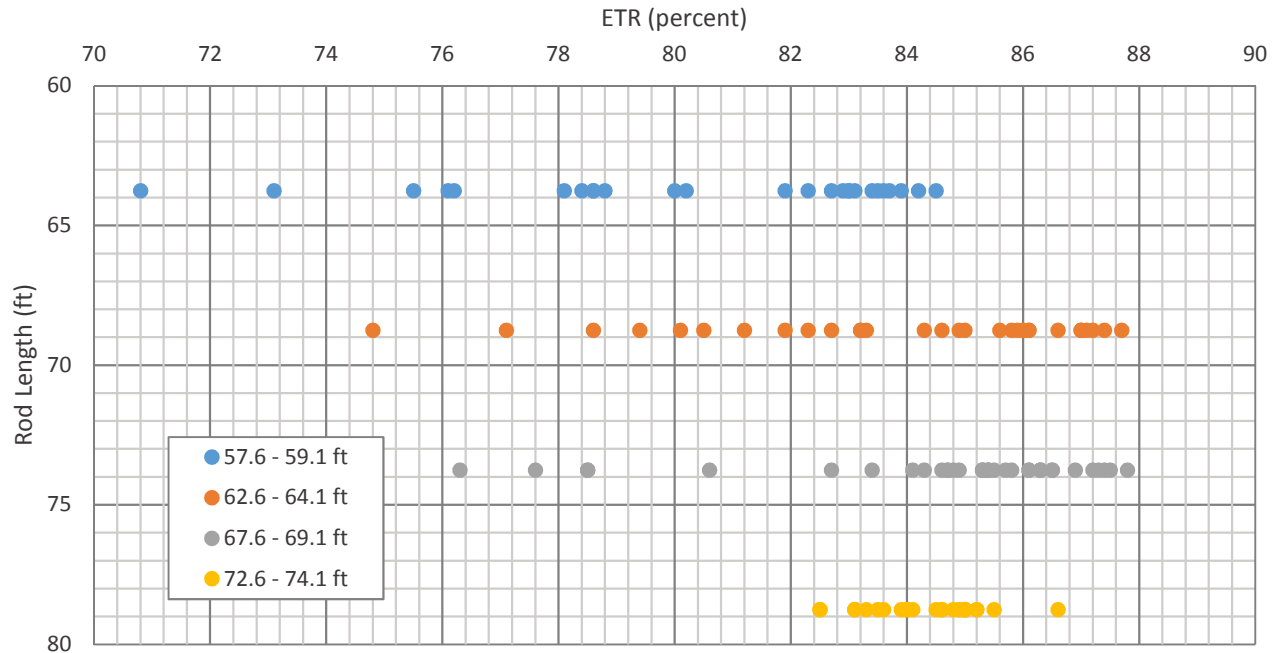
Test started: 04-April-2017



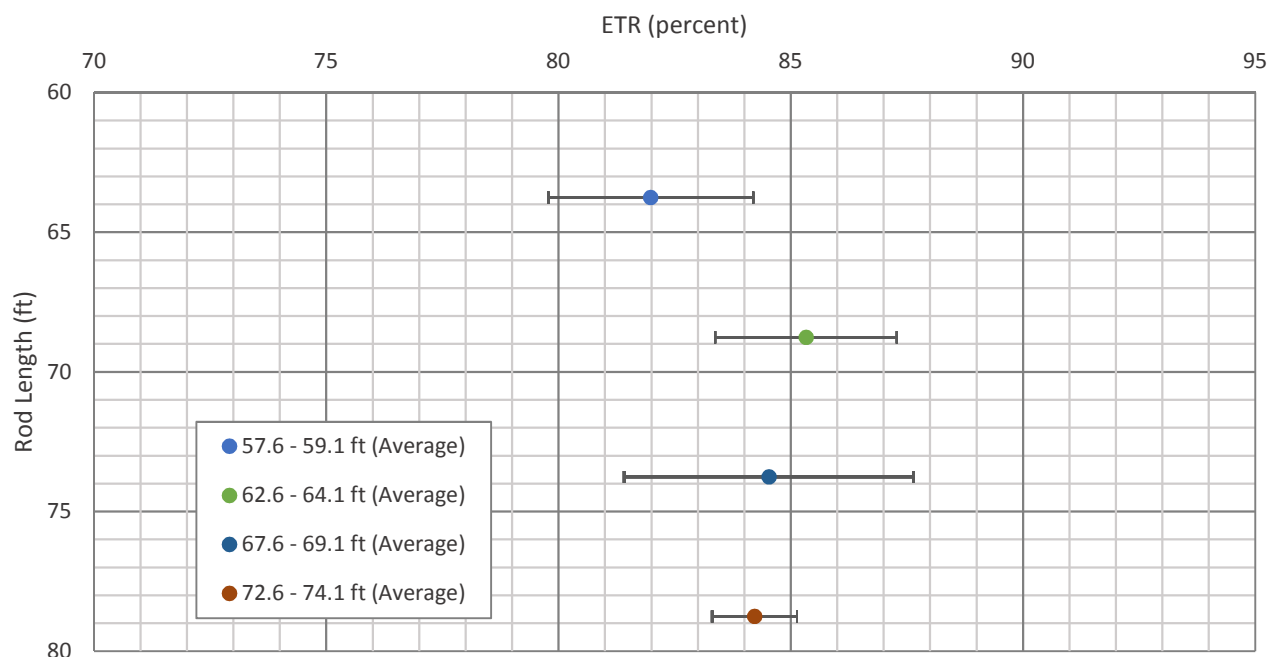
**CME55 Truck (SN 328245) - 72.6 to 74.1 ft
28+00, 20LT**



ETR versus Rod Length
CME55 Truck Rig (SN 328245)
Fayetteville Outer Loop
S&ME Project No. 6235-17-009



Average ETR versus Rod Length with ± 1 Standard Deviation
CME55 Truck Rig (SN 328245)
Fayetteville Outer Loop
S&ME Project No. 6235-17-009



Appendix II

SPT Energy Evaluation Form



Project: FAYETTEVILLE OUTER LOOP
 Project No.: 6235-17-009
 Boring No.: 28+00 20 LEFT -12-

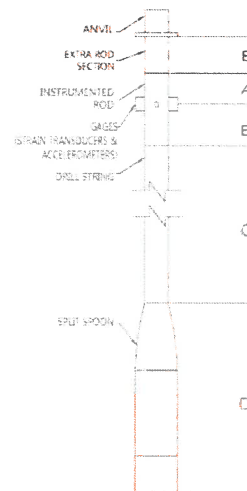
Date (s): 4/4/17
 Weather: PARTLY CLOUDY / 70°F
 Drill Rod Type: AWS

On-site Personnel

Drilling Company: S&ME
 Rig Oper./Helper: T. MILLER / A. PLATTENBURG
 Rig Engr/Geologist: J. SWARTLEY
 Analyzer Oper.: R. KRAL

Rod Info

(A + E) Impact Surface
 to Gages Length: 1.5 ft
 (B) Instr. Rod Length
 below Gages: 0.88 ft
 (A) + (B) Instr. Rod Length: 2 ft
 (D) Spoon Length: 2.68 ft
 (E) Rod Length Above
 Instr. Rod (if applicable): 0.38 ft
 Instr. Rod S/N: 203 AWS
 Instr. Rod Outside Dia.: 1.75 in.
 Instr. Rod Area: 1.20 in²
 PDA Make/Model: PAX
 PDA Serial No.: 3733L
 Calib. Pulse Test (y/n): Y



Rig/Hammer Info

Drill Rig Make/Model: CME 55
 Carrier Type: TRUCK
 Rig Serial No.: 328245
 Hammer Type/Model: CME-AUTO
 Hammer Serial No.: 328245
 Hammer Drop System: AUTOMATIC
 Lubrication Condition: REL. MANUFACTURED
 Manufacturer Recommended
 Operation Rate (bpm): 50
 Drop Height from
 Calibration Record (in.): 30
 Hammer Weight from
 Calibration Record (lbs): 140
 Anvil Dimension (in.): 11.5
 Drilling Method: MUD ROTARY

Gage Information

Gage	Serial No.	Calibration No.
Accel.	A3	K5641 358 376
	A4	K5642 314 324
Strain	F3	203 AWS 1 211.46 212.63
	F4	203 AWS 2 210.87 212.32

Date of Test	Test Depth Increment (ft to ft)	Test Time Start / Stop (Military)	Length of Drill String (ft) (C)	(LE) Length Below Gages (ft) (B)+(C)+(D)	Avg. Meas. Hammer Rate (BPM)	SPT Blow Counts				Drop Height In Tolerance (y/n)
						6"	12"	18"	N Value	
4/4	32.6 To 34.1	10:38/1041	35	38.76		60H	60H	60H	0	N/A
4/4	38.5 To 40.0	1050/1051	40	43.76		3	3	1	3	Y
	37.6 To 39.1	1137/1138								
4/4	57.6 To 59.6	1139/1140	60	63.76	52	7	10	9	19	Y
4/4	62.6 To 64.1	1157/1158	65	68.76	52	9	10	12	22	Y
4/4	67.6 To 69.1	1218/1219	70	73.76	52	6	13	17	30	Y
4/4	72.6 To 74.1	1239/1240	75	78.76	52	6	11	10	21	Y

Comments: (1) If there are any nonconformances or deficiencies identified during the testing, immediately pause the drilling and testing activities and notify the Site Manager and describe them in the space below; (2) Note any unusual hammer operating conditions that affect the hammer performance, or changes in operating conditions (e.g. verticality, weather, or lubrication between trials). Drop height tolerance is ± 1 inch. Drop height verified by Rig Geologist/Engineer at time of SPT Energy measurement for CME hammers and at the beginning of the day for Diedrich hammers; (3) Note any changes in rod diameter along drill string and record locations of short rod sections; (4) Prepare a sketch or take a picture of the instrumented drill rod assembly and indicate the approximate relative location and orientation of the strain gauges, accelerometers, and LE Datum; (5) Note: Identify all attached pages, including photographs, with the Project No., Boring No., and date.

Prepared By (print/signature)
 SPT Energy Lead

Date
 4/4/17

Reviewed By (print/signature)
 Site Manager

Date



NCDOT GEOTECHNICAL ENGINEERING UNIT BORELOG REPORT

SHEET

WBS 34817.1.S5			TIP U-2519AA		COUNTY CUMBERLAND		GEOLOGIST Contract Geologist							
SITE DESCRIPTION FAYETTEVILLE OUTER LOOP FROM I-95 TO SOUTH OF SR 1118 (PARKTON RD.)								GROUND WTR (ft)						
BORING NO. Y2_2800			STATION 28+00		OFFSET 20 ft LT		ALIGNMENT -Y2-		0 HR. N/A					
COLLAR ELEV. 184.7 ft			TOTAL DEPTH 104.1 ft		NORTHING 421,505		EASTING 2,013,281		24 HR. 23.0					
DRILL RIG/HAMMER EFF./DATE SME275 CME-55 89% 01/15/2016					DRILL METHOD Mud Rotary			HAMMER TYPE Automatic						
DRILLER Contract Driller			START DATE 04/04/17		COMP. DATE 04/04/17		SURFACE WATER DEPTH N/A							
ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT			BLOWS PER FOOT					SAMP. NO.	LOG MOI	SOIL AND ROCK DESCRIPTION	
			0.5ft	0.5ft	0.5ft	0	25	50	75	100			ELEV. (ft)	DEPTH (ft)
185														
	184.1	0.6	7	5	4	9							184.7	0.0
	182.1	2.6	3	4	4	8							184.1	0.6
180														
	177.1	7.6	7	6	8	14								
175														
	172.1	12.6	6	3	5	8								
170														
	167.1	17.6	9	8	3	11								
165													164.7	20.0
	162.1	22.6	3	3	4	7					SS-78	W		
160														
	157.1	27.6	9	10	10	20						Sat.	158.7	26.0
155														
	152.1	32.6	WOR	WOR	WOH	0					SS-79	W	153.7	31.0
150														
	147.1	37.6	3	2	1	3					SS-80	Sat.	148.7	36.0
145														
	142.1	42.6	1	1	2	3						Sat.		
140													138.7	46.0
	137.1	47.6	5	9	11	20						W		
135													133.7	51.0
	132.1	52.6	7	8	17	25						Sat.	131.7	53.0
130														
	127.1	57.6	7	10	9	19						Sat.	128.7	56.0
125														
	122.1	62.6	9	10	12	22						Sat.		
120														
	117.1	67.6	6	13	17	30						Sat.		
115														
	112.1	72.6	6	11	10	21						Sat.		
110														
	107.1	77.6	6	9	9	18						Sat.	108.7	76.0

NCDOT BORE SINGLE U2519AA_GEO_RDWY_BP.GPJ NC_DOT.GDT 4/26/17



NCDOT GEOTECHNICAL ENGINEERING UNIT BORELOG REPORT

SHEET

WBS 34817.1.S5		TIP U-2519AA		COUNTY CUMBERLAND		GEOLOGIST Contract Geologist										
SITE DESCRIPTION FAYETTEVILLE OUTER LOOP FROM I-95 TO SOUTH OF SR 1118 (PARKTON RD.)						GROUND WTR (ft)										
BORING NO. Y2_2800		STATION 28+00		OFFSET 20 ft LT		ALIGNMENT -Y2-										
COLLAR ELEV. 184.7 ft		TOTAL DEPTH 104.1 ft		NORTHING 421,505		EASTING 2,013,281										
DRILL RIG/HAMMER EFF./DATE SME275 CME-55 89% 01/15/2016				DRILL METHOD Mud Rotary		HAMMER TYPE Automatic										
DRILLER Contract Driller		START DATE 04/04/17		COMP. DATE 04/04/17		SURFACE WATER DEPTH N/A										
ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT			BLOWS PER FOOT					SAMP. NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION	DEPTH (ft)	
			0.5ft	0.5ft	0.5ft	0	25	50	75	100						ELEV. (ft)
105						Match Line										
100	102.1	82.6	6	10	10	20							Sat.	98.7	86.0	
	97.1	87.6	5	8	14	22							W			
95													W			
90	92.1	92.6	5	12	14	26							W			
	87.1	97.6	7	8	9	17							W			
85													W			
	82.1	102.6	8	13	15	28							W	80.6	104.1	
Boring Terminated at Elevation 80.6 ft IN VERY STIFF CLAY (COASTAL PLAIN)																

Appendix III



Quality Assurance for Deep Foundations

PDI Certificate of Calibration

PDI Accelerometer Calibration

Model PR-KICHER Serial # K5641

Cal Date: 27 FEB 17

Cal Due: 27 FEB 19

Temperature: 64.5 deg. F

Humidity 30 %

Calibrated at
Pile Dynamics, Inc.
30725 Aurora Road
Cleveland, OH 44139

Manufactured by Pile Dynamics, Inc.

Procedure used: PDA Accelerometer Calibration Procedure 2016-6, Revision 20160422

Equipment was found to be

☒ in tolerance As Received

☐ out of tolerance As Received

☒ in tolerance As Returned

☐ out of tolerance As Returned

PDI Calibration: 0.0752 mv/5000g

Calibration Standards Utilized

Hopkinson Bar Force Calibration F2, verified on 25 APRIL 16

PDI HopBar DOS PAK, serial number 1273K, verified on 25 APRIL 16

Calibration performed by: Laine Wright
Laine Wright, Technician

Reviewed by: Robert Sprenger
Robert Sprenger, Production Manager

Accelerometer CC-5 Issued 20160426

QBTA: ON [ALT-F1/BB=60]

Pile Dynamics, Inc.

TG F2 DPF

File Dynamics 25-Feb-17 23:18	FS — 10	BN 62 SL 408/ 3440/ 99	PJ: PN: HOPBAR	A 4 -- US F 2 3.3
LE 39.6 ft AR 1.7 in2 EM 30000 Ksi SP 0.492 K/ft3 WS 16810 ft/s WC 17043 ft/s				
JC 0.40 FM 1.00 UM 1.00				
EA/C 30.3 Ks/ft UN KIPS*0.1 FR 20000 MB 30				
DL -40 UT -1 PK 1 TM-PEAK				
F1/2 500/ 213 F3/4 213/ 213 A1/2 999/ 999 A3/4 999/ 376	TS 12 TB 8.0	E B PD: k5641 T1 9.6 2L/C 4.7	VA 1000 UE 1022	LP 0.00 ft LI 1.0
ACCEPT SQ-OFF FL-OFF PR-OFF		UMX= 4.3 FMX= 66 AMX= 129 EMX= 0.3 MEX= 129 FUP= 1.00		
		ACCELEROMETER CALIBRATION N.I.S.T. Traceable SERIAL NUMBER: K5641 CALIBRATION FACTOR: .0752 MV/G PAK (*5000): 376 DATE: 27Feb17 PDA OPERATOR: [Signature]		
contact Pile Dynamics USA with your questions tel USA - 216 - 831- 6131 fax USA - 216 - 831- 0916		OP: laine [ver:4.05]		

Smart Sensor

Smart Chip Programmed By SMW on 27Feb17 CRC Value 3C62



Quality Assurance for Deep Foundations

PDI Certificate of Calibration

PDI Accelerometer Calibration

Model PR-KICHER Serial # K5642

Cal Date: 27 FEB 17

Cal Due: 27 FEB 19

Temperature: 64.5 deg. F

Humidity 30 %

Calibrated at
Pile Dynamics, Inc.
30725 Aurora Road
Cleveland, OH 44139

Manufactured by Pile Dynamics, Inc.

Procedure used: PDA Accelerometer Calibration Procedure 2016-6, Revision 20160422

Equipment was found to be

☒ in tolerance As Received

☐ out of tolerance As Received

☒ in tolerance As Returned

☐ out of tolerance As Returned

PDI Calibration: .0648 mv/5000g

Calibration Standards Utilized

Hopkinson Bar Force Calibration F2, verified on 25 APRIL 16

PDI HopBar DOS PAK, serial number 1273K, verified on 25 APRIL 16

Calibration performed by: *Laine Wright*
Laine Wright, Technician

Reviewed by: *Robert Sprenger*
Robert Sprenger, Production Manager

Accelerometer CC-5 Issued 20160426

QBTA: ON [ALT-F1/BB=60]

Pile Dynamics, Inc.

TG F2 DPF

Pile Dynamics 25-Feb-17 23:16		FS — 10	BN 59 SL 406/ 3440/ 2	PJ: PN: HOPBAR	A 4 -- US F 2 3.3
LE 39.6 ft AR 1.7 in2 EM 30000 Ksi SP 0.492 K/ft3 WS 16810 ft/s WC 17043 ft/s					
JC 0.40 FM 1.00 UM 1.00					
EA/C 30.3 Ks/ft UN KIPS*0.1 FR 20000 MB 30					
DL -40 UT -1 PK 1 TM-PEAK					
F1/2 500/ 213 F3/4 213/ 213 A1/2 999/ 999 A3/4 999/ 324					
TS 12 TB 8.0		E B PD: k5642 T1 9.6 2L/C 4.7	VA 1000	UE 1022	LP 0.00 ft LI 1.0
ACCEPT SQ-OFF FL-OFF PR-OFF		VMX= 4.4 FMX= 67 AMX= 139 EMX= 0.3 MEX= 131 FUP= 0.99			
		ACCELEROMETER CALIBRATION N.I.S.T. Traceable			
contact Pile Dynamics USA with your questions tel USA - 216 - 831- 6131 fax USA - 216 - 831- 0916		SERIAL NUMBER: K5642 CALIBRATION FACTOR: .0648 mV/g PAK (*5000): 324 DATE: 27Feb17 PDA OPERATOR: [Signature]			
<-AT:PIEZORESISTIVE		OP: laine [ver:4.05]		AT:PIEZOELECTRIC->	

Smart Sensor

Smart Chip Programmed By J.M.W. on 27 CRC Value 4A8A



Quality Assurance for Deep Foundations

PDI Certificate of Calibration

PDI SPT Drill Rod Serial # 203 AWJ

Cal Date: 3-6-17

Cal Due: 3-6-19

Temperature: 69.2 deg. F

Humidity 42 %

Manufactured by Pile Dynamics, Inc.

Calibrated at: Pile Dynamics, Inc., 30725 Aurora Road, Cleveland, OH 44139

Procedure used: SPT Drill Rod Calibration Procedure 2016-4, Revision 20160422

Calibration Data: Attach SPT Rod Data Sheet DS-17

Equipment was found to be

☒ in tolerance As Received

_____ out of tolerance As Received

☒ in tolerance As Returned

_____ out of tolerance As Returned

Calibration Standards Utilized

1. PDI SPT Calibration Signal Conditioning Unit #000001, verified on 20160302
2. PDI Load Cell #75, Certificate #3482090006
3. Capacitec Displacement Sensor #2034, Certificate #3482090004
4. Capacitec Displacement Sensor #2040, Certificate #3482090004
5. Capacitec Displacement Mainframe #4004-671, Certificate #3482090004
6. Brown & Sharpe Digital Caliper #8G028506, Certificate #3482090001
7. National Instruments USB-6210 DAQ serial number 159AFDE, Certificate #3482090002

Calibration performed by:

David Burrell Technician

Reviewed by:

Robert Sprenger, Production Manager

SPT CC-16 Issued 20160425



Quality Assurance for Deep Foundations

SPT Calibration Data Sheet Revision number 20160426
Use Calibration Procedure Number 2016-8, Revision 20160422

SPT Drill Rod Data

Serial Number: 203 Awd Calibration Date: 3-6-17

Temperature: 69.2 °F Humidity: 42%

Calibration performed in accordance with PDI SPT Calibration Procedure 2016-4, Revision 20160422

As Received (circle one): Operational - Malfunctioning - Damaged

Calibration data

Pre-Load: 1. 8152 2. 8045 3. 8081

Total Load: 1. 18645 2. 17966 3. 9859

Common typical theoretical EA values based on SPT Rod Type:

AW: 35400 NW: 43100 or 68100 N3: 70800 BW: 52344

EA Theoretical 35,400 EA Measured 36076.68 Error 1.91 %
Within 4% Tolerance Y / N

Alternative EA verification: Measure wall thickness, calculate area and multiply by 30000. (use spreadsheet for calculation)

Calibration values

Channel 1: As Found: (last cal): 215.76 As Left: 212.63 Within 5% Tolerance: Y / N

Channel 2: As Found: (last cal): 215.53 As Left: 212.32 Within 5% Tolerance: Y / N

EA: As Found: (last cal): 35465 As Left: 36076.68 Difference: 1.2 %

Calibration performed by:

David Burrell, Technician

Reviewed by:

Robert Sprenger, Production Manager

SPT DS-17 Issued 20160426

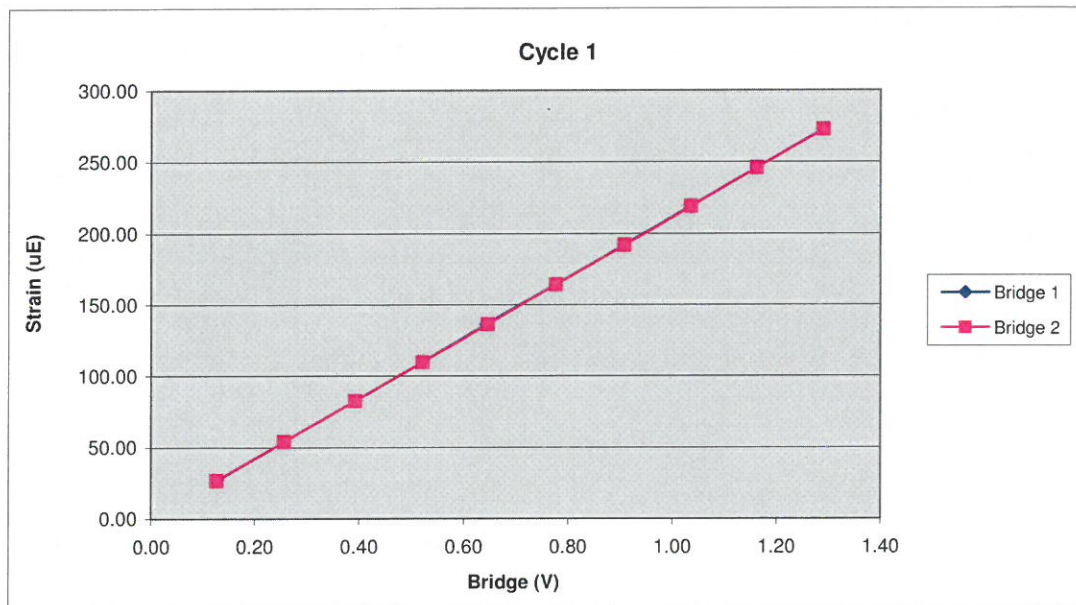
30725 Aurora Road • Cleveland, Ohio 44139 USA • +1-216-831-6131 • Fax +1-216-831-0916

E-mail: info@pile.com • www.pile.com

203AWJ		Cycle 1		
Sample	Force (lb)	Strain (μ E)	Bridge 1 (V)	Bridge 2 (V)
1	0.00	0.00	0.00	0.00
2	980.36	26.90	0.13	0.13
3	1968.60	54.22	0.26	0.26
4	3007.18	82.91	0.39	0.39
5	3992.07	109.88	0.52	0.52
6	4933.68	136.53	0.64	0.65
7	5952.40	164.15	0.78	0.78
8	6953.03	191.85	0.91	0.91
9	7927.29	218.90	1.04	1.04
10	8900.18	245.69	1.16	1.16
11	9893.92	272.74	1.29	1.29

Bridge 1		Bridge 2	
Force Calibration (lb/V)	7662.50	Force Calibration (lb/V)	7652.99
Offset	-1.78	Offset	1.71
Correlation	0.999999	Correlation	0.999997
Strain Calibration (μ E/V)	211.52	Strain Calibration (μ E/V)	211.26
Offset	-0.14	Offset	-0.05
Correlation	0.999998	Correlation	0.999999

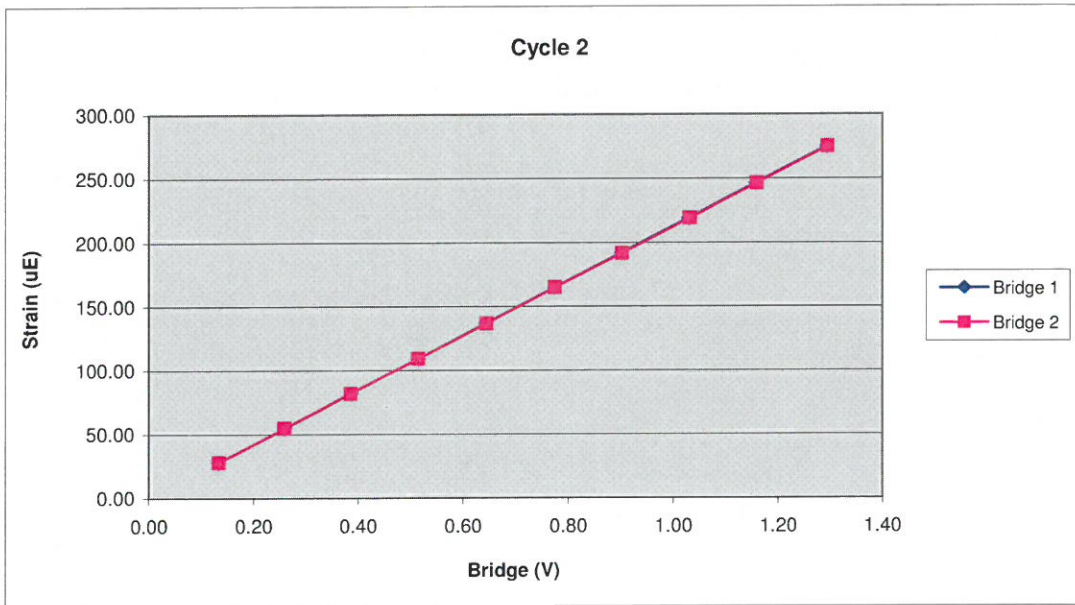
Force Strain Calibration	
EA (Kips)	36225.50
Offset	3.39
Correlation	0.999997



203AWJ		Cycle 2		
Sample	Force (lb)	Strain (μE)	Bridge 1 (V)	Bridge 2 (V)
1	0.00	0.00	0.00	0.00
2	1014.59	28.23	0.13	0.13
3	1983.94	54.87	0.26	0.26
4	2963.12	81.94	0.39	0.39
5	3939.16	109.15	0.51	0.51
6	4924.05	136.83	0.64	0.64
7	5932.34	164.92	0.77	0.78
8	6919.00	191.62	0.90	0.90
9	7908.80	219.00	1.03	1.03
10	8881.89	246.36	1.16	1.16
11	9921.85	274.90	1.29	1.29

Bridge 1		Bridge 2	
Force Calibration (lb/V)	7681.97	Force Calibration (lb/V)	7665.41
Offset	-11.43	Offset	-6.15
Correlation	0.999999	Correlation	0.999998
Strain Calibration ($\mu\text{E}/\text{V}$)	212.92	Strain Calibration ($\mu\text{E}/\text{V}$)	212.46
Offset	-0.28	Offset	-0.14
Correlation	0.999998	Correlation	0.999998

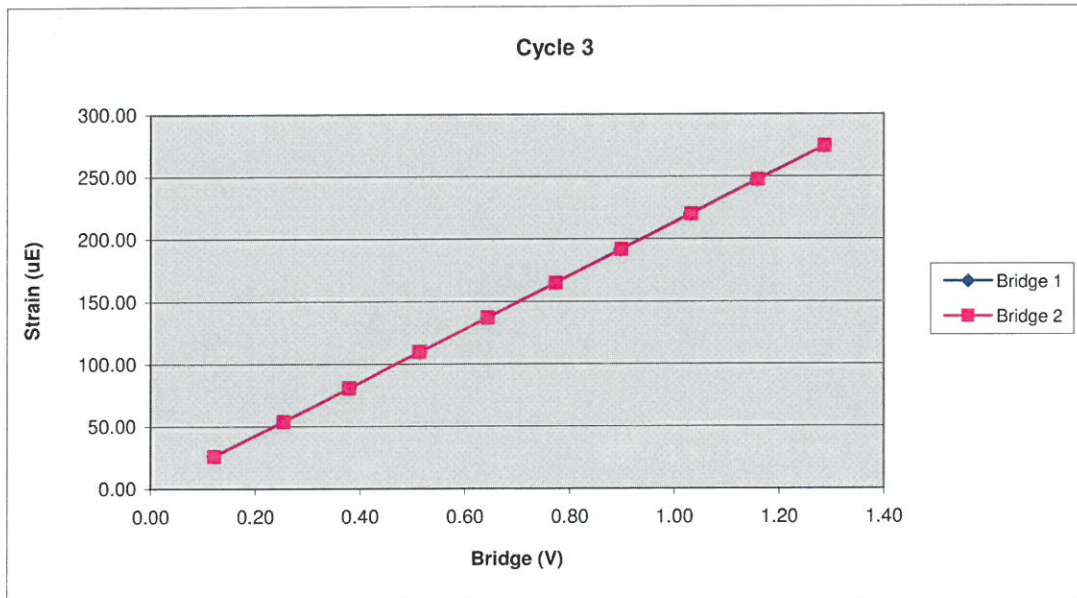
Force Strain Calibration	
EA (Kips)	36079.71
Offset	-1.25
Correlation	0.999996



203AWJ		Cycle 3		
Sample	Force (lb)	Strain (μ E)	Bridge 1 (V)	Bridge 2 (V)
1	0.00	0.00	0.00	0.00
2	931.98	26.11	0.12	0.12
3	1944.40	53.79	0.25	0.25
4	2911.39	80.73	0.38	0.38
5	3940.93	109.71	0.51	0.51
6	4935.26	137.15	0.64	0.64
7	5929.39	164.84	0.77	0.77
8	6888.90	191.71	0.90	0.90
9	7914.90	219.99	1.03	1.03
10	8887.40	247.28	1.16	1.16
11	9859.30	274.46	1.29	1.29

Bridge 1		Bridge 2	
Force Calibration (lb/V)	7667.78	Force Calibration (lb/V)	7660.59
Offset	2.72	Offset	1.09
Correlation	0.999999	Correlation	1.000000
Strain Calibration (μ E/V)	213.44	Strain Calibration (μ E/V)	213.24
Offset	-0.06	Offset	-0.11
Correlation	0.999998	Correlation	0.999997

Force Strain Calibration	
EA (Kips)	35924.82
Offset	4.97
Correlation	0.999998



Bridge Excitation (V) 5
Shunt Resistor (ohm) 60.4k

Calibration Factors	203AWJ		
Bridge 1 ($\mu\text{E/V}$)	212.63	Bridge 2 ($\mu\text{E/V}$)	212.32
EA Factor (Kips)	36076.68	Area (in^2)	1.20

Calibrated by:

Calibrated Date:

2/24/2017

Pile Dynamics Inc
30725 Aurora Rd
Solon, OH 44139

Traceable to N.I.S.T.

Appendix IV



This documents that
Robert E. Kral
AMEC Foster Wheeler

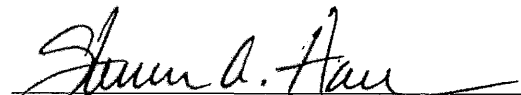
has on May 20, 2016 achieved the rank of

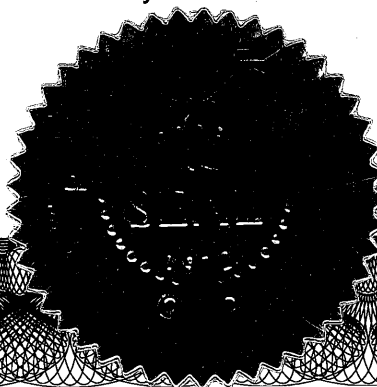
ADVANCED


on the **Dynamic Measurement and Analysis Proficiency Test.**

The individual identified on this document demonstrated to the degree granted above an understanding of theory, data quality evaluation, interpretation and signal matching for high strain dynamic testing of deep foundations. ***It is recommended that individuals at the Advanced level seek Master or Expert levels through additional study within four years of the date of this document.***

The ability of the individual named to provide appropriate knowledge and advice on a specific project is not implied or warranted by the Pile Driving Contractors Association or Pile Dynamics, Inc. **This certificate can be verified at www.PDAproficiencytest.com.** The Pile Driving Contractors Association or Pile Dynamics, Inc. assumes no liability for foundation testing and analysis work performed by the bearer of this certificate.


Steven A. Hall, Executive Director
Pile Driving Contractors Association




Garland Likins, Senior Partner
Pile Dynamics, Inc.

No. 2072



**Report of SPT Energy Measurements
S&ME Diedrich D-50 Track (SN 382)
Winston-Salem, North Carolina
S&ME Project No. 6235-17-020**

PREPARED FOR:

**North Carolina Department of Transportation
Geotechnical Engineering Unit
1589 Mail Service Center
Raleigh, North Carolina 27699**

PREPARED BY:

**S&ME, Inc.
9751 Southern Pine Boulevard
Charlotte, NC 28273**

September 1, 2017



September 1, 2017

North Carolina Department of Transportation
Geotechnical Engineering Unit
1589 Mail Service Center
Raleigh, North Carolina 27699

Attention: Dr. Shunyi (Chris) Chen, Ph.D., P.E.

Cc: Ms. Cheryl A. Youngblood, L.G.

Reference: **Report of SPT Energy Measurements**
S&ME Diedrich D-50 Track (SN 382)
Winston-Salem, North Carolina
S&ME Project No. 6235-17-020

Dear Dr. Chen:

We have completed the Standard Penetration Test (SPT) energy measurements on the automatic hammer mounted on our Diedrich D-50 track-mounted drill rig with a serial number of 382. This service was performed by our Mr. Robert E. Kral, P.E. on August 22, 2017. SPT energy testing was performed in general accordance with ASTM D4633 and the most recent revision of the North Carolina Department of Transportation, Geotechnical Engineering Unit's requirements. The testing procedures, equipment used during testing, and detailed results are presented in this report.

1.0 Dynamic Testing Methodology

Testing was performed using a model PAX (Serial No. 3733L) Pile Driving Analyzer™ (PDA) manufactured by Pile Dynamics, Inc. The PDA records and interprets data from two piezoresistive accelerometers (Serial Nos. K5641 and K5642) bolted to a 2.67-foot long BW drill rod (SN102) internally instrumented with two strain transducers. The BW instrumented drill rod length included one BW box to BWJ pin and one BWJ box to BW pin sub. The instrumented BW drill rod has a cross-sectional area of 1.80 square inches, an outside diameter of approximately 2.125 inches, and an inside diameter of 1.75 inches at the gage location. The accelerometers and strain gages, which are mounted on opposing axis near the middle of the instrumented rod, monitor acceleration and strain for each hammer blow. The analyzer converts the data to velocities and forces, computing the maximum transferred hammer energies with the "EFV" method described in ASTM D4633. All results are recorded and displayed in real-time for each blow. Calibration sheets for the accelerometers and the instrumented rod are included in the Appendix.



2.0 Testing and Observations

S&ME personnel were on site on August 22, 2017, to observe and perform testing during SPT sampling on the Diedrich D-50 track-mounted rig operated by Justin Millwood of S&ME. The measurements were taken during drilling operations for the NCDOT R-2247CD Winston-Salem Northern Beltway Design-Build project in Winston-Salem, North Carolina. The measurements were obtained during the SPT sampling of Soil Test Boring Y25ARPB_2200. SPT energy measurements were recorded during four intervals at depths of approximately 33½, 38½, 43½, and 48½ ft below the existing ground surface. The information presented in the tables below summarizes the equipment tested and tooling used during the SPT Energy Measurements.

Table 2-1: Drill Rig Information

Manufacturer	Diedrich
Model	D-50
Serial Number	382
Operator	Justin Millwood
Carrier	Track

Table 2-2: Hammer Information

Model / Type	CME / Auto
Serial Number	382
Anvil Height (inches)	11.5
Anvil Diameter (inches)	2.5
Drop Height (inches)	30
Ram Weight (pounds)	140
Ram Serial Number	N/A

Table 2-3: Drilling and Instrumented Rod Information

Drill Rod Type	BWJ
OD (inches)	2.125
ID (inches)	1.75
Cross-Sectional Area (in ²)	1.80
Typical Lengths (feet)	5 and 10
Instrumented Rod Type	BW (SN 102)
OD (inches)	2.125
ID (inches)	1.75
Cross-Sectional Area (in ²)	1.80
Total Instrumented Rod Length (feet)	2.67
Length Below Gages (feet)	1.42
Split-Spoon Length (feet)	2.95



3.0 Dynamic Testing Results

The total rod length from the instrumentation to the tip of the split-spoon sampler was determined by adding 4.62 ft to the required drill rod length at each sample depth. Based on the test data, the automatic hammer on the Diedrich D-50 track-mounted rig operated at a rate of about 41.1 to 41.9 blows per minute (bpm) during dynamic testing. The measured transferred hammer energy (EFV) was generally in the range of about 282.2 to 320.4 ft-lbs, which corresponds to Energy Transfer Ratio (ETR) values of about 80.6% to 91.5%, respectively. The SPT Energy Measurement Data Summary tables in the Appendix present the test data from every hammer blow at each sampling interval along with representative force and velocity traces for each test interval. The reported blow counts, obtained by the drill rig personnel, and a summary of the test data and average computed hammer energy and transfer ratio values are provided in Table 3-1. Plots and tables of the following are also included in the Appendix and present the test data with depth for each test interval:

- Penetration vs. BLC
- Penetration vs. CSX
- Average ETR vs. Rod Length
- Penetration vs. FMX
- Penetration vs. VMX
- ETR vs. Rod Length
- Penetration vs. EFV
- Penetration vs. ETR

Table 3-1: Summary of Dynamic Testing Results

Data Set ID	Sample Depth (ft)	Drill Rod Length (ft)	Instrumentation to Sampler Tip Length (ft)	Blows per 6" Increment / N-value	Soil Sample Description (Coastal Plain)	Avg. BPM	Avg. EFV (ft-lbs)	Avg. ETR (%)
1	33½ - 35	34	38.62	3-3-4 / 7	Sandy CLAY	41.5	297.2	84.9
2	38½ - 40	39	43.62	3-4-4 / 8	Sandy SILT	41.6	297.0	84.9
3	43½ - 45	44	48.62	4-6-11 / 17	Sandy SILT	41.5	303.8	86.8
4	48½ - 50	49	53.62	4-7-10 / 17	Sandy SILT	41.6	307.0	87.7
Overall Average						41.6	302.9	86.5

The average hammer rate, transferred energy, and transfer ratio were calculated for each depth interval. Per ASTM D4633, only the blows from the final foot of each sample interval (i.e. the blows that determine the N-value) were included when computing the average values shown in Table 3-1. The overall average transferred hammer energy for the automatic hammer on the Diedrich D-50 track-mounted rig (for all the depth intervals tested) was 302.9 foot-pounds, with an average ETR of 86.5%.



4.0 Limitations of Report

This report has been prepared in accordance with generally accepted geotechnical engineering practice for specific application to this project. The conclusions contained in this report were based on the applicable standards of our profession in this geographic area at the time this report was prepared. No other warranty, express or implied, is made.

5.0 Closing

S&ME appreciates the opportunity to provide this report to the North Carolina Department of Transportation Geotechnical Engineering Unit. Please let us know if you have any questions concerning this report.

Sincerely,

S&ME, Inc.

A handwritten signature in black ink, appearing to read 'G. Canivan'.

Gregory J. Canivan, P.E.
Technical Principal

A handwritten signature in black ink, appearing to read 'Robert E. Kral'.

Robert E. Kral, P.E.
Transportation Services Project Manager
N.C. Registration No. 042642



Appendices:

- Appendix I - Diedrich D-50 (SN 382) SPT Energy Measurements Summary Plots and Tables
- Appendix II - Field Log and Borelog Report
- Appendix III - Instrumented Rod and Accelerometer Calibration Sheets
- Appendix IV - Certificate of Proficiency

Appendices

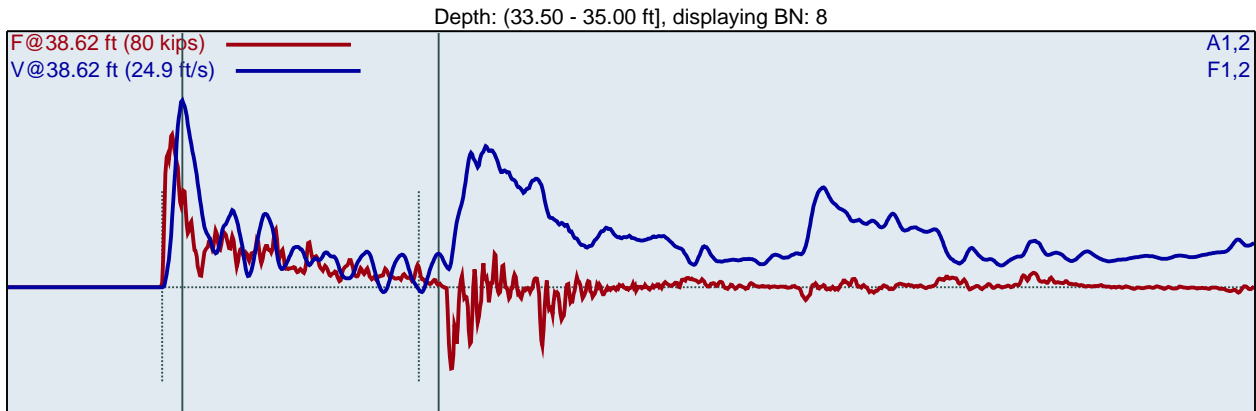
Appendix I

DIEDRICH D50 (SN382)
R. KRAL

Y25ARPB_2200
Test date: 8/22/2017

AR: 1.80 in²
LE: 38.62 ft
WS: 16807.9 ft/s

SP: 0.492 k/ft³
EM: 30000 ksi



BPM: Blows/Minute
FMX: Maximum Force
VMX: Maximum Velocity
DMX: Maximum Displacement

CSX: Compression Stress Maximum
DFN: Final Displacement
EFV: Maximum Energy
ETR: Energy Transfer Ratio - Rated

BL#	LP ft	BC /6"	BPM bpm	FMX kips	VMX ft/s	DMX in	CSX ksi	DFN in	EFV ft-lb	ETR (%)
1	33.67	3	1.9	45	14.5	2.25	24.9	2.00	261.5	74.7
2	33.83	3	41.1	46	16.5	2.26	25.8	2.00	301.0	86.0
3	34.00	3	41.9	46	18.1	2.17	25.5	2.00	312.3	89.2
4	34.17	3	41.5	46	17.0	2.00	25.3	2.00	298.7	85.3
5	34.33	3	41.4	49	18.1	2.00	27.2	2.00	304.9	87.1
6	34.50	3	41.6	48	16.9	2.00	26.5	2.00	288.7	82.5
7	34.63	4	41.5	48	17.5	1.51	26.5	1.50	295.4	84.4
8	34.75	4	41.6	48	18.2	1.50	26.5	1.50	299.8	85.7
9	34.88	4	41.1	48	17.3	1.50	26.8	1.50	295.9	84.5
10	35.00	4	41.8	49	18.1	1.50	27.2	1.50	297.0	84.9
Average			41.5	48	17.6	1.72	26.6	1.71	297.2	84.9
Std Dev			0.2	1	0.5	0.25	0.6	0.25	4.5	1.3
Maximum			41.8	49	18.2	2.00	27.2	2.00	304.9	87.1
Minimum			41.1	46	16.9	1.50	25.3	1.50	288.7	82.5

N-value: 7

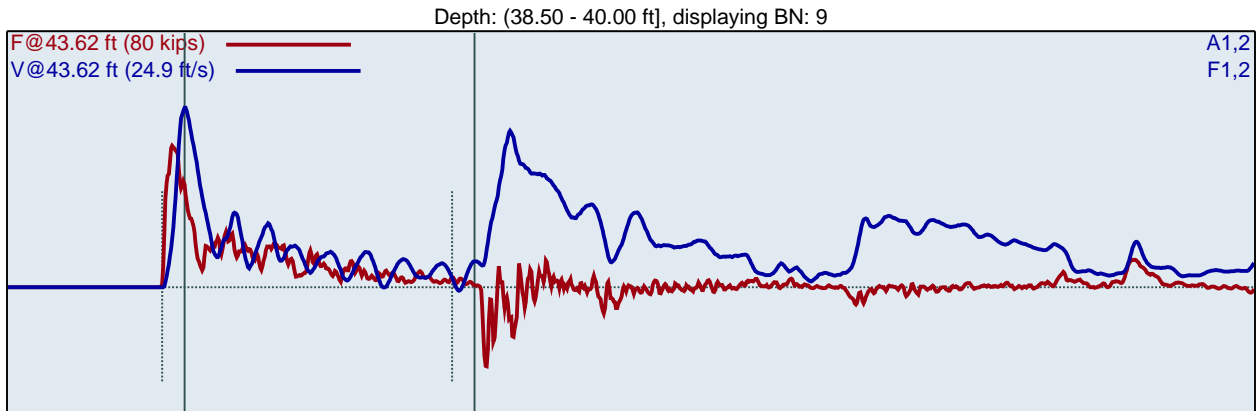
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DIEDRICH D50 (SN382)
R. KRAL

Y25ARPB_2200
Test date: 8/22/2017

AR: 1.80 in²
LE: 43.62 ft
WS: 16807.9 ft/s

SP: 0.492 k/ft³
EM: 30000 ksi



BL#	LP ft	BC /6"	BPM bpm	FMX kips	VMX ft/s	DMX in	CSX ksi	DFN in	EFV ft-lb	ETR (%)
1	38.67	3	1.9	49	19.1	2.24	27.1	2.00	303.1	86.6
2	38.83	3	41.6	49	18.1	2.24	27.2	2.00	294.2	84.1
3	39.00	3	41.5	49	18.0	2.00	27.2	2.00	305.3	87.2
4	39.13	4	41.8	49	17.6	1.62	27.2	1.50	288.4	82.4
5	39.25	4	41.2	49	16.9	1.52	27.2	1.50	282.2	80.6
6	39.38	4	41.7	46	17.4	1.50	25.4	1.50	298.0	85.1
7	39.50	4	41.7	48	18.0	1.50	26.6	1.50	295.8	84.5
8	39.63	4	41.5	44	17.4	1.50	24.7	1.50	300.4	85.8
9	39.75	4	41.5	44	17.5	1.50	24.6	1.50	301.5	86.2
10	39.88	4	41.5	45	17.9	1.50	25.1	1.50	305.1	87.2
11	40.00	4	41.5	44	18.1	1.50	24.6	1.50	304.7	87.1
Average			41.6	46	17.6	1.52	25.7	1.50	297.0	84.9
Std Dev			0.2	2	0.4	0.04	1.1	0.00	7.5	2.1
Maximum			41.8	49	18.1	1.62	27.2	1.50	305.1	87.2
Minimum			41.2	44	16.9	1.50	24.6	1.50	282.2	80.6
N-value: 8										

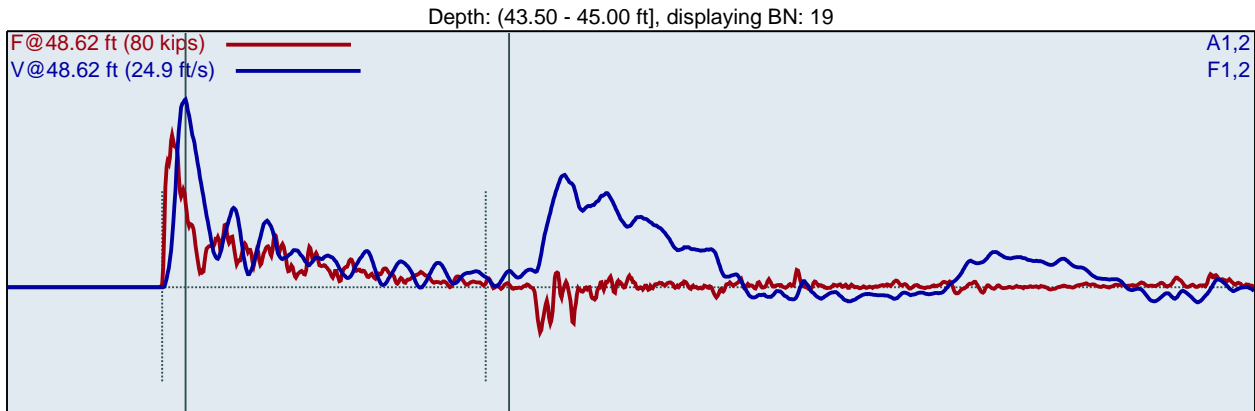
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DIEDRICH D50 (SN382)
R. KRAL

Y25ARPB_2200
Test date: 8/22/2017

AR: 1.80 in²
LE: 48.62 ft
WS: 16807.9 ft/s

SP: 0.492 k/ft³
EM: 30000 ksi



BL#	LP ft	BC /6"	BPM bpm	FMX kips	VMX ft/s	DMX in	CSX ksi	DFN in	EFV ft-lb	ETR (%)
1	43.63	4	1.9	48	17.5	1.50	26.8	1.50	290.4	83.0
2	43.75	4	41.5	46	16.8	1.56	25.4	1.50	291.6	83.3
3	43.88	4	41.7	43	17.0	1.78	23.7	1.50	301.8	86.2
4	44.00	4	41.7	45	18.2	1.55	24.9	1.50	315.4	90.1
5	44.08	6	41.8	43	17.5	1.29	24.0	1.00	307.6	87.9
6	44.17	6	41.4	44	17.6	1.14	24.3	1.00	311.0	88.9
7	44.25	6	41.5	46	18.3	1.08	25.5	1.00	314.4	89.8
8	44.33	6	41.7	43	17.5	1.09	24.1	1.00	308.2	88.1
9	44.42	6	41.4	44	18.1	1.07	24.4	1.00	314.7	89.9
10	44.50	6	41.6	43	18.0	1.06	23.8	1.00	313.5	89.6
11	44.55	11	41.9	45	18.3	0.90	24.8	0.55	303.9	86.8
12	44.59	11	41.3	43	17.4	0.84	24.0	0.55	307.3	87.8
13	44.64	11	41.7	43	17.5	0.74	24.1	0.55	296.0	84.6
14	44.68	11	41.4	45	17.9	0.69	24.7	0.55	296.1	84.6
15	44.73	11	41.4	45	17.4	0.66	24.9	0.55	291.2	83.2
16	44.77	11	41.4	45	18.2	0.65	25.1	0.55	304.5	87.0
17	44.82	11	41.7	44	17.7	0.62	24.4	0.55	304.3	86.9
18	44.86	11	41.4	43	17.4	0.59	24.0	0.55	299.6	85.6
19	44.91	11	41.4	47	18.3	0.59	26.4	0.55	302.2	86.3
20	44.95	11	41.7	47	18.0	0.56	26.3	0.55	290.0	82.9
21	45.00	11	41.3	46	17.8	0.56	25.4	0.55	301.0	86.0
Average			41.5	44	17.8	0.83	24.7	0.71	303.8	86.8
Std Dev			0.2	1	0.3	0.24	0.8	0.22	7.4	2.1
Maximum			41.9	47	18.3	1.29	26.4	1.00	314.7	89.9
Minimum			41.3	43	17.4	0.56	23.8	0.55	290.0	82.9
N-value: 17										

Sample Interval Time: 28.83 seconds.

DIEDRICH D50 (SN382)

Y25ARPB_2200

R. KRAL

Test date: 8/22/2017

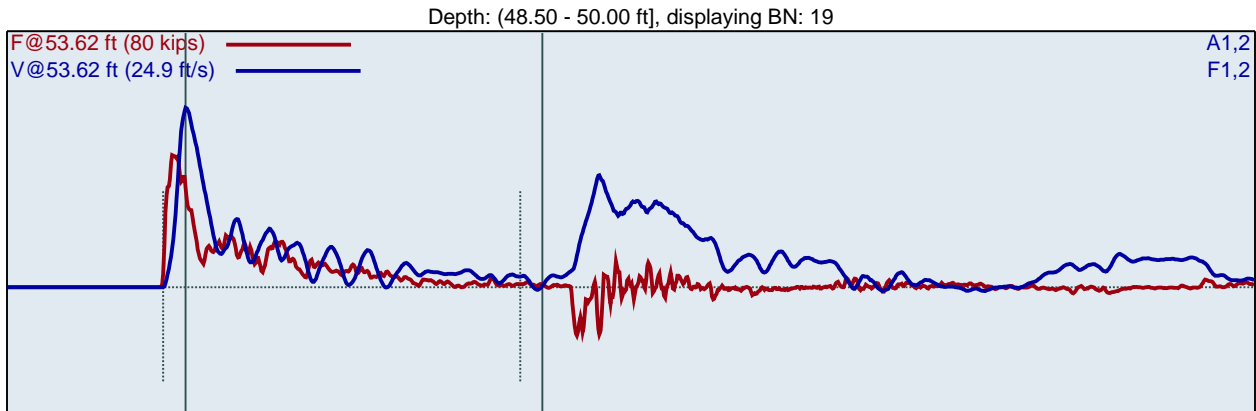
AR: 1.80 in²

SP: 0.492 k/ft³

LE: 53.62 ft

EM: 30000 ksi

WS: 16807.9 ft/s



BL#	LP ft	BC /6"	BPM bpm	FMX kips	VMX ft/s	DMX in	CSX ksi	DFN in	EFV ft-lb	ETR (%)
1	48.63	4	1.9	44	15.2	1.70	24.5	1.50	263.8	75.4
2	48.75	4	41.7	41	16.6	1.64	22.9	1.50	302.0	86.3
3	48.88	4	41.5	41	16.9	1.54	22.7	1.50	307.1	87.7
4	49.00	4	41.4	42	16.4	1.50	23.1	1.50	303.6	86.8
5	49.07	7	41.6	42	16.6	1.10	23.5	0.86	302.3	86.4
6	49.14	7	41.8	41	16.9	1.03	23.0	0.86	303.8	86.8
7	49.21	7	41.7	42	16.6	0.98	23.2	0.86	295.3	84.4
8	49.29	7	41.3	42	17.2	0.99	23.5	0.86	312.3	89.2
9	49.36	7	41.7	43	17.6	0.94	23.8	0.86	311.4	89.0
10	49.43	7	41.9	42	17.3	0.91	23.4	0.86	308.2	88.1
11	49.50	7	41.3	42	17.6	0.89	23.4	0.86	319.1	91.2
12	49.55	10	41.9	41	17.5	0.73	22.7	0.60	314.7	89.9
13	49.60	10	41.6	42	17.1	0.70	23.3	0.60	302.7	86.5
14	49.65	10	41.5	43	18.3	0.73	23.7	0.60	320.4	91.5
15	49.70	10	41.5	42	17.0	0.70	23.1	0.60	305.3	87.2
16	49.75	10	41.8	41	17.5	0.71	22.7	0.60	309.9	88.6
17	49.80	10	41.6	41	17.1	0.69	22.8	0.60	298.7	85.4
18	49.85	10	41.5	42	17.8	0.68	23.1	0.60	305.8	87.4
19	49.90	10	41.6	41	17.5	0.67	22.9	0.60	303.0	86.6
20	49.95	10	41.5	42	17.2	0.67	23.5	0.60	300.2	85.8
21	50.00	10	41.5	42	17.5	0.66	23.6	0.60	306.3	87.5
Average			41.6	42	17.3	0.81	23.2	0.71	307.0	87.7
Std Dev			0.2	1	0.4	0.15	0.3	0.13	6.7	1.9
Maximum			41.9	43	18.3	1.10	23.8	0.86	320.4	91.5
Minimum			41.3	41	16.6	0.66	22.7	0.60	295.3	84.4
N-value: 17										

Sample Interval Time: 28.80 seconds.

Summary of SPT Test Results

Project: DIEDRICH D50 (SN382), Test Date: 8/22/2017

BPM: Blows/Minute											CSX: Compression Stress Maximum		
FMX: Maximum Force											DFN: Final Displacement		
VMX: Maximum Velocity											EFV: Maximum Energy		
DMX: Maximum Displacement											ETR: Energy Transfer Ratio - Rated		
Instr. Length ft	Start Depth ft	Final Depth ft	Blows Applied /6"	N Value	N60 Value	Average BPM bpm	Average FMX kips	Average VMX ft/s	Average DMX in	Average CSX ksi	Average DFN in	Average EFV ft-lb	Average ETR (%)
38.62	33.50	35.00	3-3-4	7	10	41.5	48	17.6	1.72	26.6	1.71	297.2	84.9
43.62	38.50	40.00	3-4-4	8	11	41.6	46	17.6	1.52	25.7	1.50	297.0	84.9
48.62	43.50	45.00	4-6-11	17	24	41.5	44	17.8	0.83	24.7	0.71	303.8	86.8
53.62	48.50	50.00	4-7-10	17	24	41.6	42	17.3	0.81	23.2	0.71	307.0	87.7
Overall Average Values:						41.6	44	17.6	1.06	24.6	0.98	302.9	86.5
Standard Deviation:						0.2	2	0.4	0.41	1.4	0.45	7.9	2.3
Overall Maximum Value:						41.9	49	18.3	2.00	27.2	2.00	320.4	91.5
Overall Minimum Value:						41.1	41	16.6	0.56	22.7	0.55	282.2	80.6



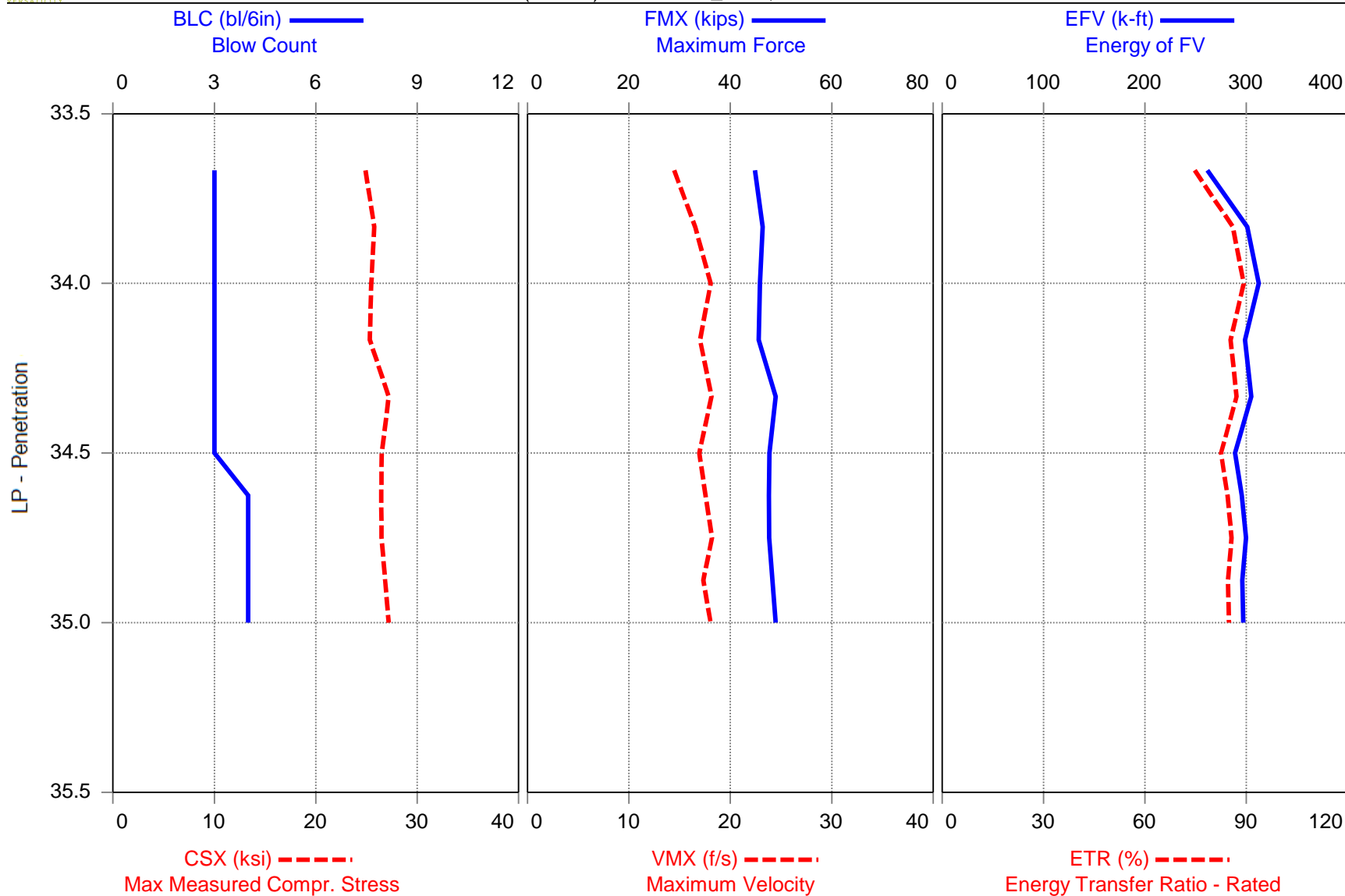
Pile Dynamics, Inc. - PDILOT2 Ver 2016.2.57.6 - Case Method & iCAP® Results

Printed: 31-August-2017

Test started: 22-August-2017



DIEDRICH D50 (SN382) - Y25ARPB_2200, 33.5 to 35





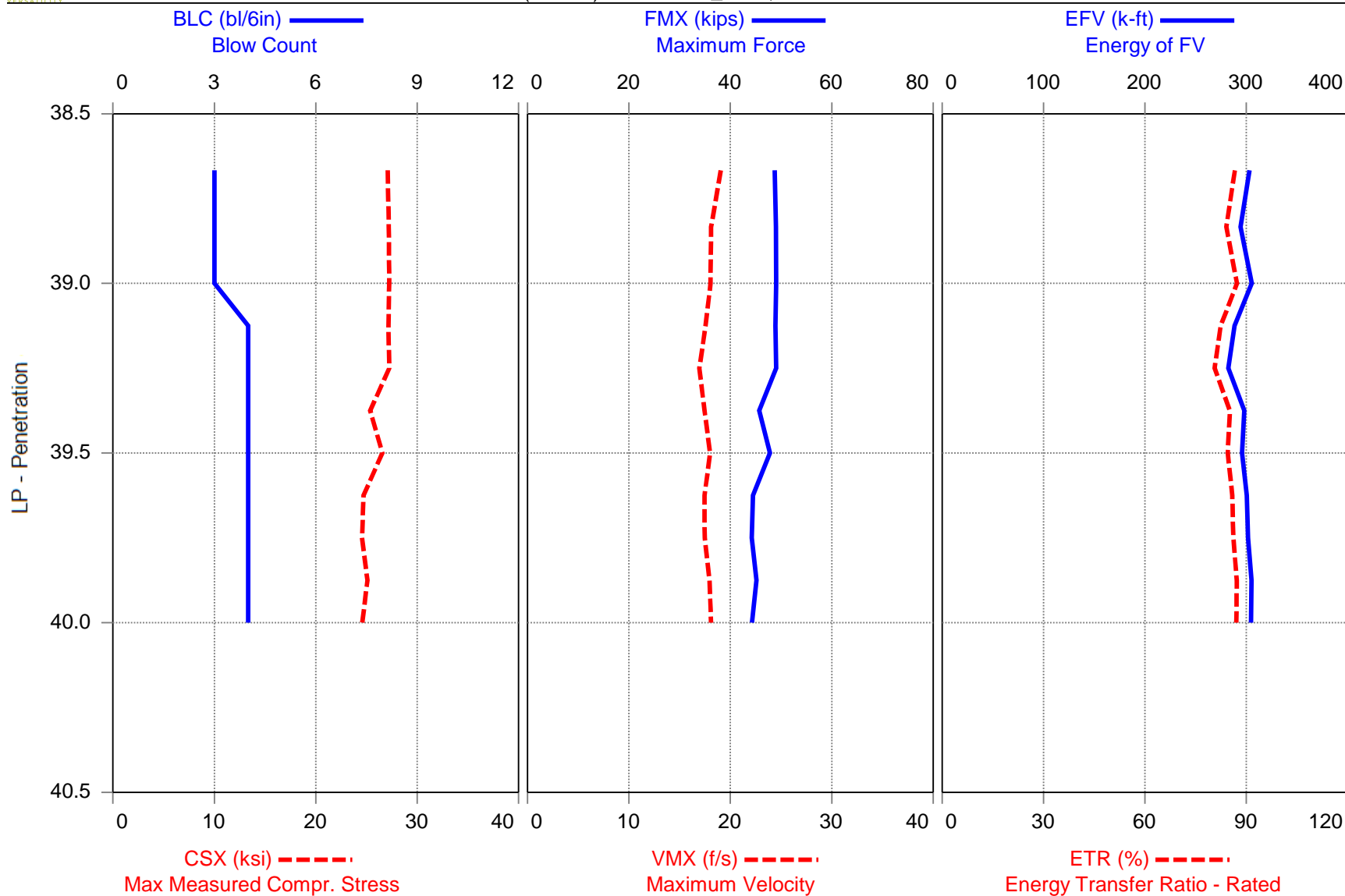
Pile Dynamics, Inc. - PDILOT2 Ver 2016.2.57.6 - Case Method & iCAP® Results

Printed: 31-August-2017

Test started: 22-August-2017

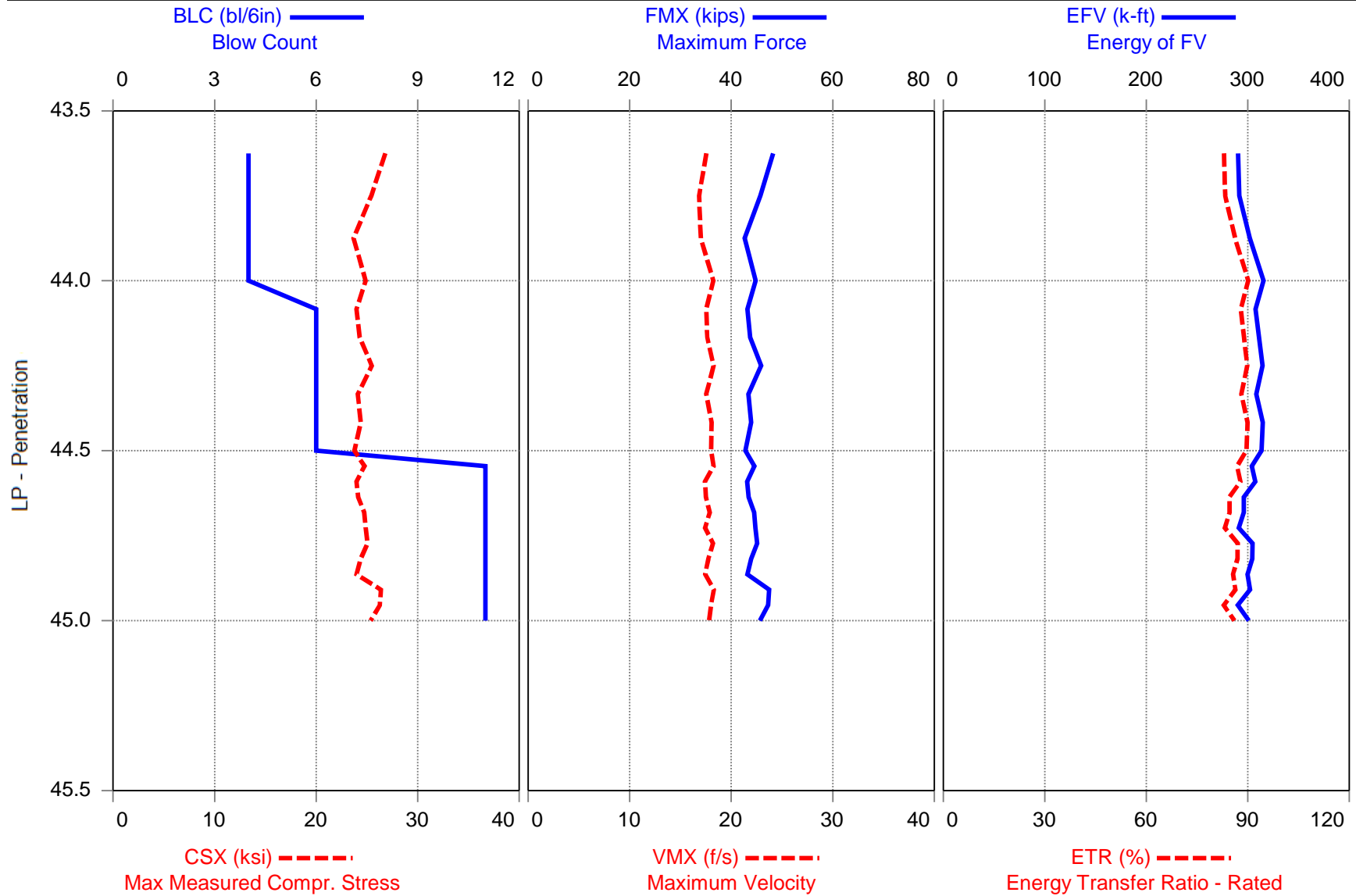


DIEDRICH D50 (SN382) - Y25ARPB_2200, 38.5 to 40



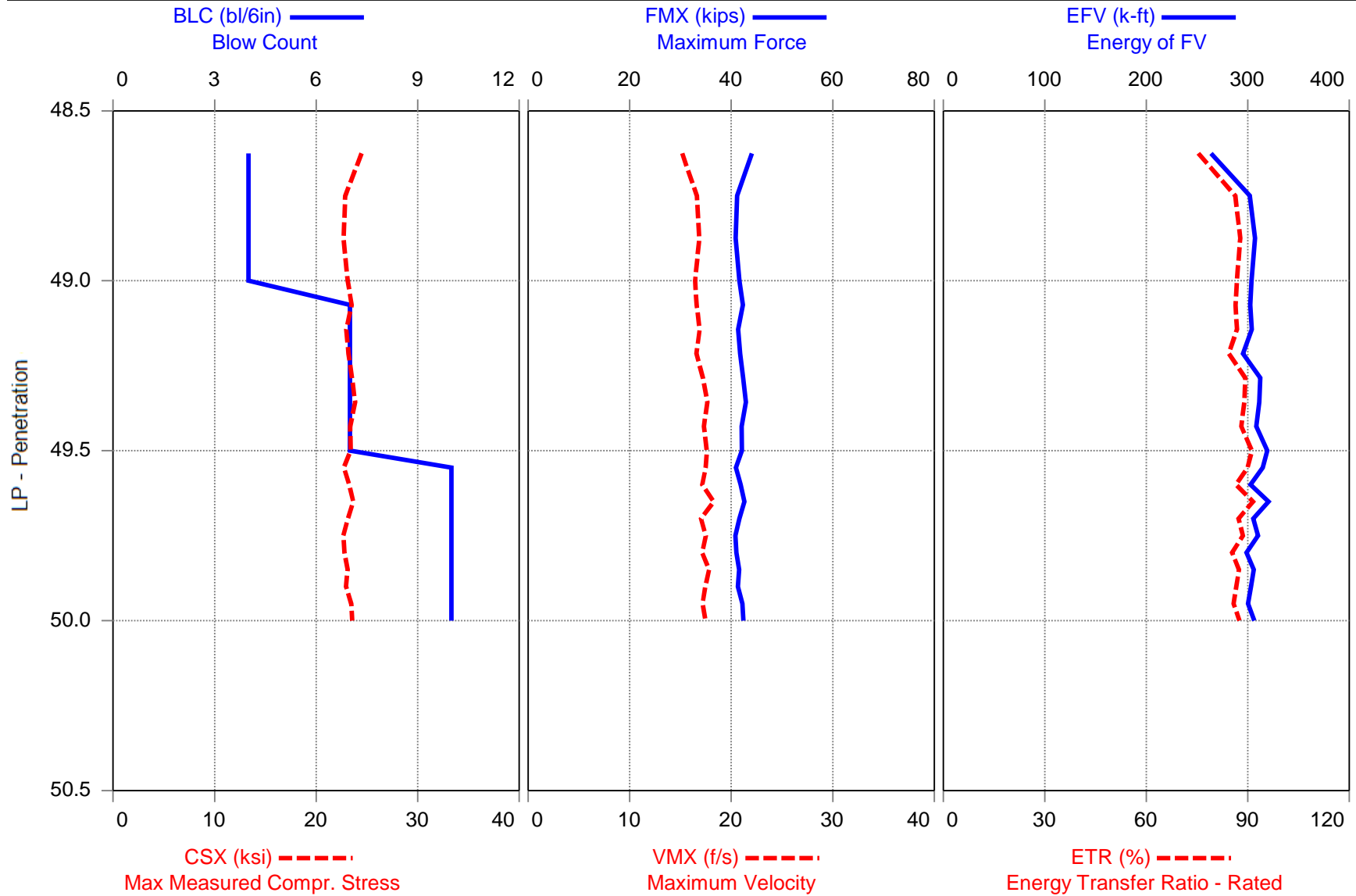


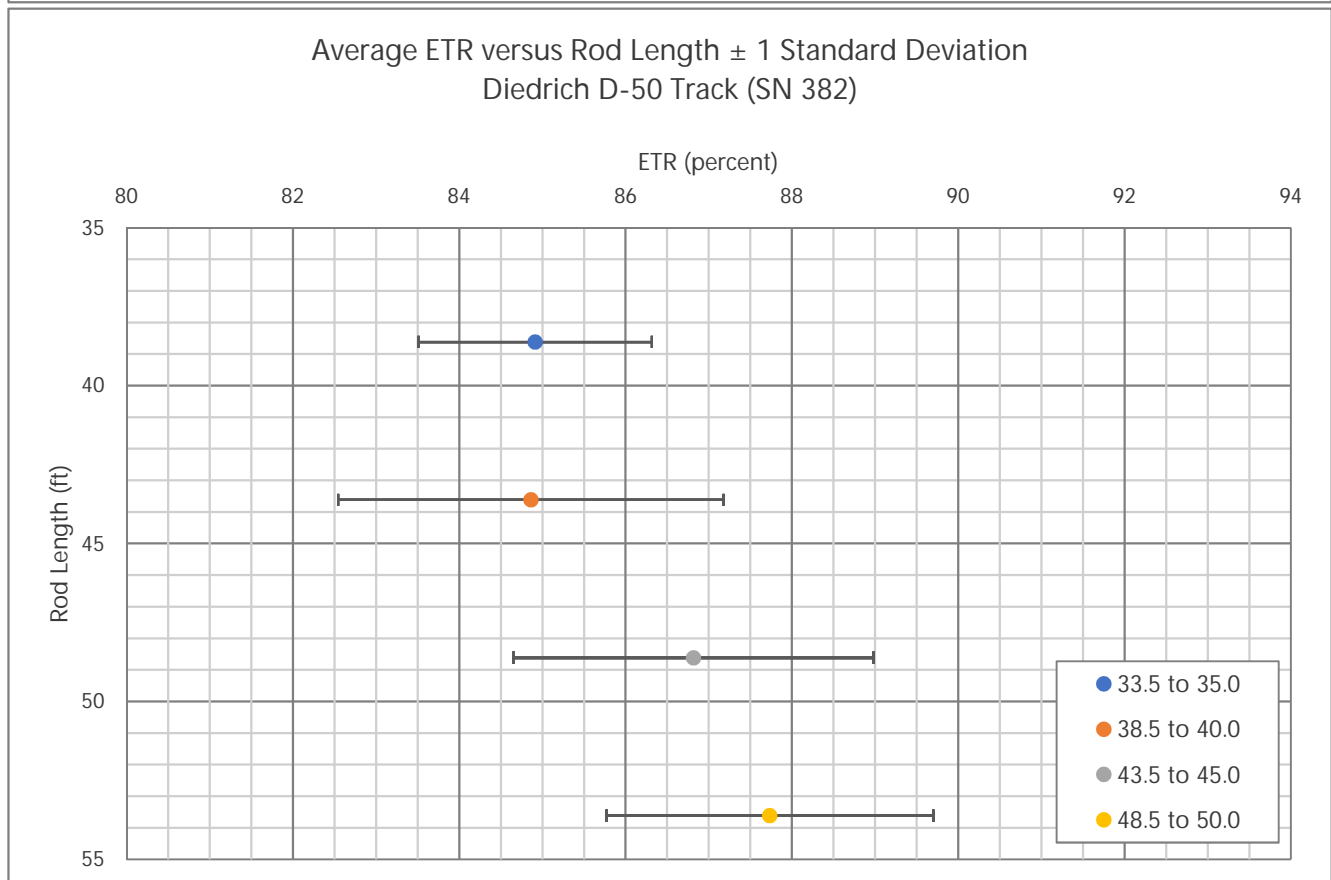
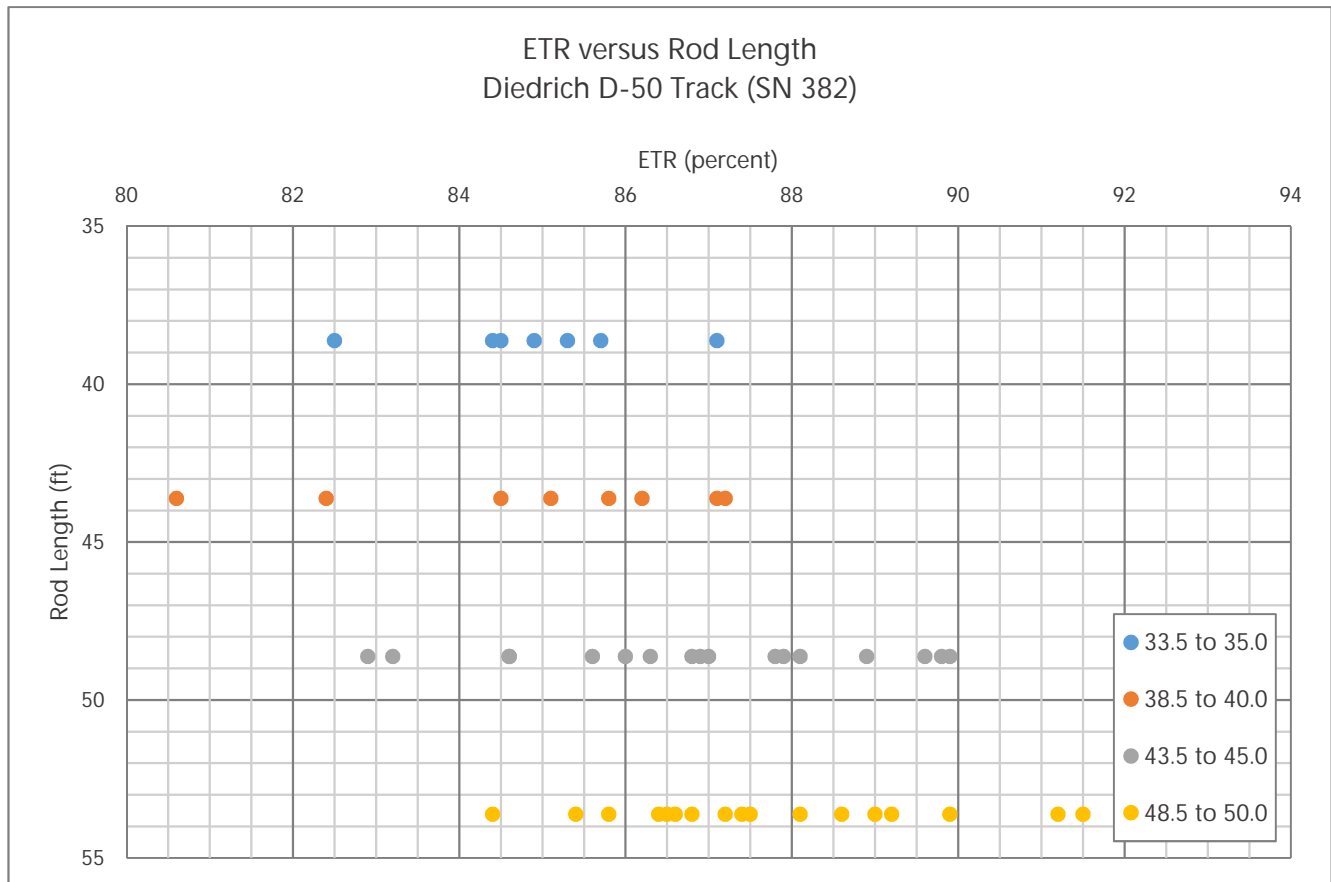
DIEDRICH D50 (SN382) - Y25ARPB_2200, 43.5 to 45





DIEDRICH D50 (SN382) - Y25ARPB_2200, 48.5 to 50





Appendix II

SPT Energy Evaluation Form



Project: R-2247
 Project No.: 6235-17-020
 Boring No.: Y25AR7B-2200

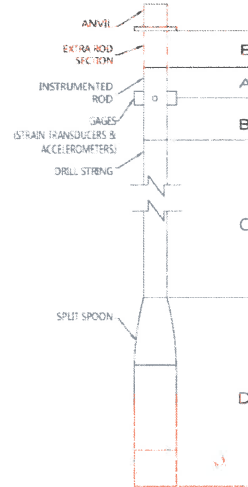
Date (s): 8/22/17
 Weather: 90° SUNNY
 Drill Rod Type: BW5

On-site Personnel

Drilling Company: S&ME, INC.
 Rig Oper./Helper: JUSTIN MILLWOOD
 Rig Engr/Geologist: FINLEY LLOYD
 Analyzer Oper.: BOB KRAL

Rod Info

(A + E) Impact Surface
 to Gages Length: 1.67 ft
 (B) Instr. Rod Length
 below Gages: 1.42 ft
 (A) + (B) Instr. Rod Length: 2.67 ft
 (D) Spoon Length: 2.95 ft
 (E) Rod Length Above
 Instr. Rod (if applicable): 0.42 ft
 Instr. Rod S/N: 102BW-2
 Instr. Rod Outside Dia.: 2.125 in.
 Instr. Rod Area: 1.80 in²
 PDA Make/Model: PA2
 PDA Serial No.: 3733L
 Calib. Pulse Test (y/n): Y



Rig/Hammer Info

Drill Rig Make/Model: DIEDRICH D-50
 Carrier Type: TRACK (MST-8000A)
 Rig Serial No.: 387
 Hammer Type/Model: DIEDRICH
 Hammer Serial No.: 382
 Hammer Drop System: AUTO
 Lubrication Condition: PER MANUFACTURER
 Manufacturer Recommended
 Operation Rate (bpm): 45
 Drop Height from
 Calibration Record (in.): 30
 Hammer Weight from
 Calibration Record (lbs): 140
 Anvil Dimension (in.): 30
 Drilling Method: HSA

Gage Information

Gage	Serial No.	Calibration No.
Accel.	A3	5641
	A4	5642
Strain	F3	102BW-1
	F4	102BW-2

Date of Test	Test Depth Increment (ft to ft)	Test Time Start / Stop (Military)	Length of Drill String (ft) (C)	(LE) Length Below Gages (ft) (B)+(C)+(D)	Avg. Meas. Hammer Rate (BPM)	SPT Blow Counts				Drop Height In Tolerance (y/n)
						6"	12"	18"	N Value	
8/22	33.5 To 35.0	11:35 / 11:35	34	38.62	41	3	3	4	7	Y
8/22	38.5 To 40.0	11:44 / 11:44	39	43.62	41	3	4	4	8	Y
8/22	42.5 To 45.0	11:53 / 11:53	44	48.62	41	4	6	11	17	Y
8/22	46.5 To 50.0	12:00 / 12:01	49	53.62	41	4	7	10	17	Y

SA-CL
 SA-SI
 SA-SI
 SA-SI

Comments: (1) If there are any nonconformances or deficiencies identified during the testing, immediately pause the drilling and testing activities and notify the Site Manager and describe them in the space below; (2) Note any unusual hammer operating conditions that affect the hammer performance, or changes in operating conditions (e.g. verticality, weather, or lubrication between trials). Drop height tolerance is ± 1 inch. Drop height verified by Rig Geologist/Engineer at time of SPT Energy measurement for CME hammers and at the beginning of the day for Diedrich hammers; (3) Note any changes in rod diameter along drill string and record locations of short rod sections; (4) Prepare a sketch or take a picture of the instrumented drill rod assembly and indicate the approximate relative location and orientation of the strain gauges, accelerometers, and LE Datum; (5) Note: Identify all attached pages, including photographs, with the Project No., Boring No., and date.

[Signature]
 Prepared By (print/signature)
 SPT Energy Lead

8/22/17
 Date

SHEET

NC DOT BORE SINGLE 623516009 R2247_CD_GEO.GPJ NC_DOT.GDT 8/31/17

Appendix III



Quality Assurance for Deep Foundations

PDI Certificate of Calibration

PDI Accelerometer Calibration

Model PR-KICHER Serial # K5641

Cal Date: 27 FEB 17

Cal Due: 27 FEB 19

Temperature: 64.5 deg. F

Humidity 30 %

Calibrated at
Pile Dynamics, Inc.
30725 Aurora Road
Cleveland, OH 44139

Manufactured by Pile Dynamics, Inc.

Procedure used: PDA Accelerometer Calibration Procedure 2016-6, Revision 20160422

Equipment was found to be

☒ in tolerance As Received

☐ out of tolerance As Received

☒ in tolerance As Returned

☐ out of tolerance As Returned

PDI Calibration: 0.0752 mv/5000g

Calibration Standards Utilized

Hopkinson Bar Force Calibration F2, verified on 25 APRIL 16

PDI HopBar DOS PAK, serial number 1273K, verified on 25 APRIL 16

Calibration performed by: Laine Wright

Laine Wright, Technician

Reviewed by: Robert Sprenger

Robert Sprenger, Production Manager

Accelerometer CC-5 Issued 20160426

QBTA: ON [ALT-F1/BB=60]

Pile Dynamics, Inc.

TG F2 DPF

File Dynamics 25-Feb-17 23:18	FS — 10	BN 62 SL 408/ 3440/ 99	PJ: PN: HOPBAR	A 4 -- US F 2 3.3			
LE 39.6 ft AR 1.7 in2 EM 30000 Ksi SP 0.492 K/ft3 WS 16810 ft/s WC 17043 ft/s							
JC 0.40 FM 1.00 UM 1.00							
EA/C 30.3 Ks/ft UN KIPS*0.1 FR 20000 MB 30							
DL -40 UT -1 PK 1 TM-PEAK							
F1/2 500/ 213 F3/4 213/ 213 A1/2 999/ 999 A3/4 999/ 376							
TS 12 TB 8.0					E B PD: k5641 T1 9.6 2L/C 4.7	VA 1000 UE 1022	LP 0.00 ft LI 1.0
UMX= 4.3 FMX= 66 AMX= 129 EMX= 0.3 MEX= 129 FUP= 1.00							
ACCEPT SQ-OFF FL-OFF PR-OFF							
ACCELEROMETER CALIBRATION N.I.S.T. Traceable SERIAL NUMBER: K5641 CALIBRATION FACTOR: .0752 mV/g PAK (*5000): 376 DATE: 27Feb17 PDA OPERATOR: [Signature]							
OP: laine [ver:4.05]							

contact Pile Dynamics USA
with your questions
tel USA - 216 - 831- 6131
fax USA - 216 - 831- 0916

Smart Sensor

Smart Chip Programmed By SMW on 27Feb17 CRC Value 3C62

QBTA: ON [ALT-F1/BB=60]

Pile Dynamics, Inc.

TG F2 DPF

Pile Dynamics 17-Jul-17 21:04	FS — BN 460 10 SL 515/ 3440/ 99	PJ: PN: HOPBAR	A 4 -- US F 2 3.3
LE 39.6 ft AR 1.7 in2 EM 30000 Ksi SP 0.492 K/ft3 WS 16810 ft/s WC 17043 ft/s			
JC 0.40 FM 1.00 VM 1.00			
EA/C 30.3 Ks/ft UN KIPS±0.1 FR 20000 MB 30			
DL -35 UT -1 PK 1 TM-PEAK			
F1/2 500/ 213 F3/4 213/ 213 A1/2 999/ 999 A3/4 999/ 320	TS 12 TB 8.0	E B PD: k5642 T1 9.6 2L/C 4.7	VA 1000 VE 1022 LP 0.00 ft LI 1.0

ACCEPT SQ-OFF FL-OFF PR-OFF	VMX= 4.5 FMX= 68 AMX= 149 EMX= 0.3 MEX= 133 FVP= 1.00
	ACCELEROMETER CALIBRATION N.I.S.T. Traceable
	SERIAL NUMBER: <u>K5642</u>
	CALIBRATION FACTOR: <u>.064 mV/g</u>
	PAK (*5000): <u>320</u> DATE: <u>19JULY17</u>
contact Pile Dynamics USA with your questions tel USA - 216 - 831- 6131 fax USA - 216 - 831- 0916	PDA OPERATOR: <u>[Signature]</u> OP: laine [ver:4.05]
<-AT:PIEZORESISTIVE	AT:PIEZOELECTRIC->

Smart Sensor

Smart Chip Programmed By A.M.W. on 19JULY17 CRC Value 73CE



Quality Assurance for Deep Foundations

PDI Certificate of Calibration

PDI SPT Drill Rod Serial # 102 BW

Cal Date: 2-27-17

Cal Due: 2-27-19

Temperature: 69.2 deg. F

Humidity 42 %

Manufactured by Pile Dynamics, Inc.

Calibrated at: Pile Dynamics, Inc., 30725 Aurora Road, Cleveland, OH 44139

Procedure used: SPT Drill Rod Calibration Procedure 2016-4, Revision 20160422

Calibration Data: Attach SPT Rod Data Sheet DS-17

Equipment was found to be

☒ in tolerance As Received

☐ out of tolerance As Received

☒ in tolerance As Returned

☐ out of tolerance As Returned

Calibration Standards Utilized

1. PDI SPT Calibration Signal Conditioning Unit #000001, verified on 20160302
2. PDI Load Cell #75, Certificate #3482090006
3. Capacitec Displacement Sensor #2034, Certificate #3482090004
4. Capacitec Displacement Sensor #2040, Certificate #3482090004
5. Capacitec Displacement Mainframe #4004-671, Certificate #3482090004
6. Brown & Sharpe Digital Caliper #8G028506, Certificate #3482090001
7. National Instruments USB-6210 DAQ serial number 159AFDE, Certificate #3482090002

Calibration performed by:

David Burrell Technician

Reviewed by:

Robert Sprenger, Production Manager

SPT CC-16 Issued 20160425



Quality Assurance for Deep Foundations

SPT Calibration Data Sheet Revision number 20160426
Use Calibration Procedure Number 2016-8, Revision 20160422

SPT Drill Rod Data

Serial Number: 102 BW Calibration Date: 2-27-17

Temperature: 69.2 °F Humidity: 42%

Calibration performed in accordance with PDI SPT Calibration Procedure 2016-4, Revision 20160422

As Received (circle one): Operational - Malfunctioning - Damaged

Calibration data

Pre-Load: 1. 8032 2. 8103 3. 8051

Total Load: 1. 17944 2. 18025 3. 17918

Common typical theoretical EA values based on SPT Rod Type:

AW: 35400 NW: 43100 or 68100 N3: 70800 BW: 52344

EA Theoretical 52344 EA Measured 53973.2 Error 3.11 %

Within 4% Tolerance: Y N

Alternative EA verification: Measure wall thickness, calculate area and multiply by 30000. (use spreadsheet for calculation)

Calibration values

Channel 1: As Found: (last cal): 218.03 As Left: 211.49 Within 5% Tolerance: Y / N

Channel 2: As Found: (last cal): 216.99 As Left: 211.97 Within 5% Tolerance: Y / N

EA: As Found: (last cal): 52603.80 As Left: 53973.2 Difference: 2.6 %

Calibration performed by:

David Burrell
David Burrell, Technician

Reviewed by:

Robert Sprenger
Robert Sprenger, Production Manager

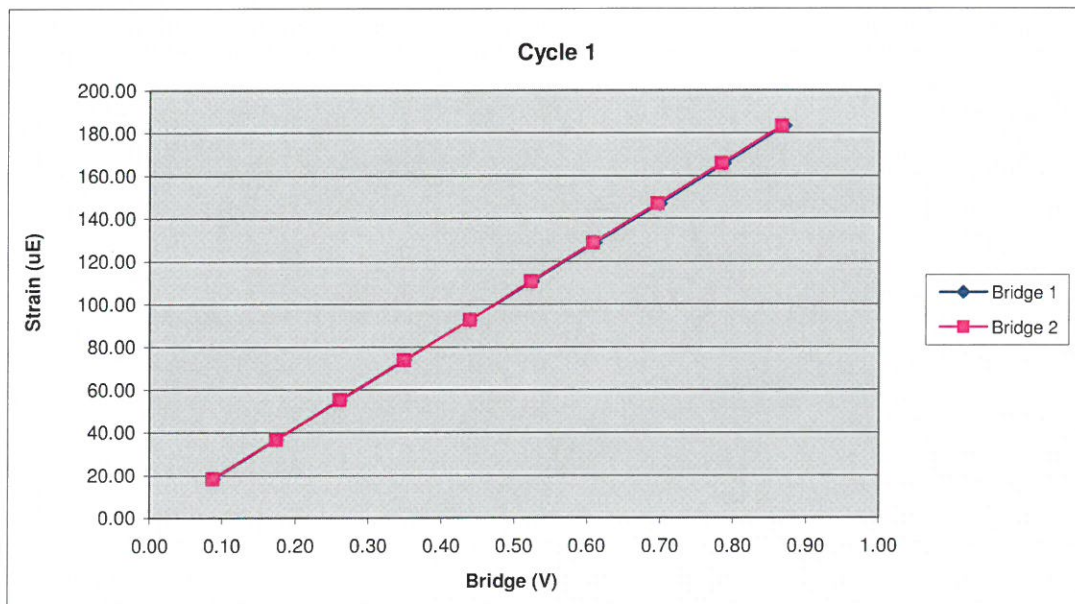
SPT DS-17 Issued 20160426

30725 Aurora Road • Cleveland, Ohio 44139 USA • +1-216-831-6131 • Fax +1-216-831-0916
E-mail: info@pile.com • www.pile.com

102BW		Cycle 1		
Sample	Force (lb)	Strain (μ E)	Bridge 1 (V)	Bridge 2 (V)
1	0.00	0.00	0.00	0.00
2	994.33	18.41	0.09	0.09
3	1984.92	36.66	0.17	0.17
4	2976.10	55.17	0.26	0.26
5	3978.50	73.79	0.35	0.35
6	4997.02	92.56	0.44	0.44
7	5967.75	110.67	0.52	0.52
8	6936.11	128.65	0.61	0.61
9	7949.72	147.12	0.70	0.70
10	8958.80	165.80	0.79	0.78
11	9912.81	183.41	0.87	0.87

Bridge 1		Bridge 2	
Force Calibration (lb/V)	11383.56	Force Calibration (lb/V)	11443.76
Offset	-3.84	Offset	-11.61
Correlation	0.999997	Correlation	0.999997
Strain Calibration (μ E/V)	210.68	Strain Calibration (μ E/V)	211.79
Offset	0.00	Offset	-0.14
Correlation	0.999996	Correlation	0.999998

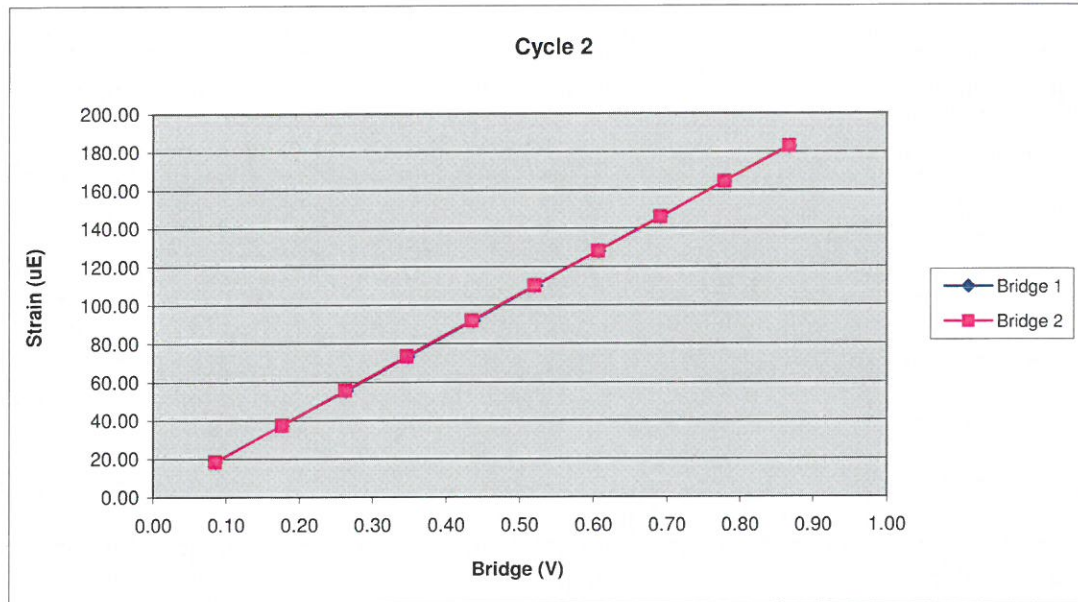
Force Strain Calibration	
EA (Kips)	54033.05
Offset	-3.88
Correlation	0.999998



102BW		Cycle 2		
Sample	Force (lb)	Strain (μ E)	Bridge 1 (V)	Bridge 2 (V)
1	0.00	0.00	0.00	0.00
2	990.79	18.37	0.09	0.09
3	2024.07	37.45	0.18	0.18
4	3007.38	55.54	0.26	0.26
5	3968.86	73.37	0.35	0.35
6	4989.55	92.06	0.44	0.43
7	5960.67	110.16	0.52	0.52
8	6939.65	128.18	0.61	0.61
9	7913.13	145.93	0.69	0.69
10	8905.30	164.37	0.78	0.78
11	9922.44	182.88	0.87	0.87

Bridge 1		Bridge 2	
Force Calibration (lb/V)	11435.73	Force Calibration (lb/V)	11435.98
Offset	0.17	Offset	9.08
Correlation	0.999999	Correlation	0.999999
Strain Calibration (μ E/V)	210.77	Strain Calibration (μ E/V)	210.77
Offset	0.16	Offset	0.33
Correlation	0.999997	Correlation	0.999998

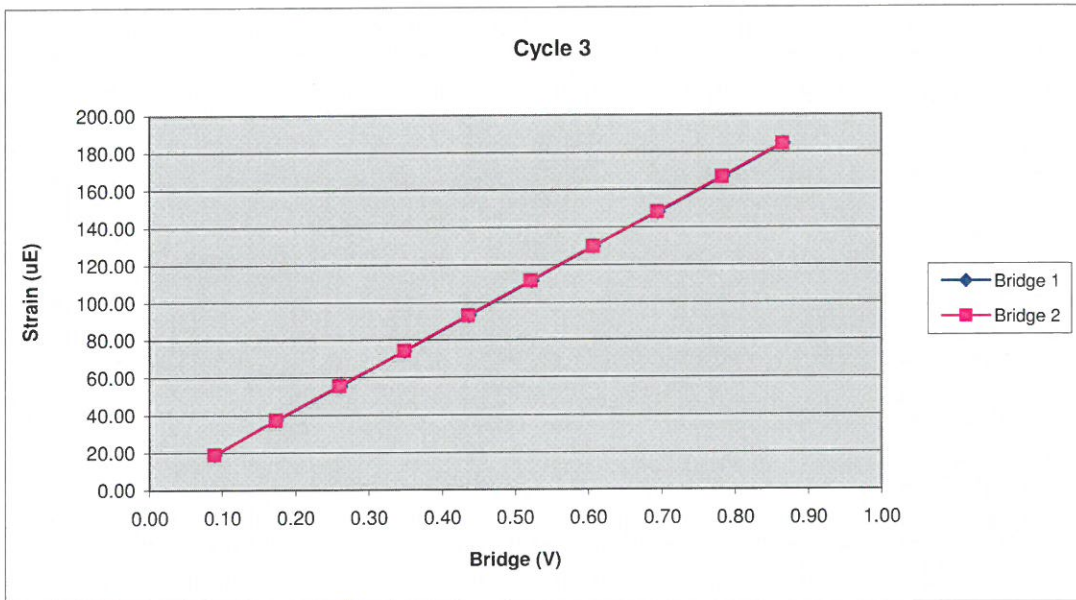
Force Strain Calibration	
EA (Kips)	54256.99
Offset	-8.56
Correlation	0.999999



102BW		Cycle 3		
Sample	Force (lb)	Strain (μ E)	Bridge 1 (V)	Bridge 2 (V)
1	0.00	0.00	0.00	0.00
2	996.69	18.87	0.09	0.09
3	1961.32	37.18	0.17	0.17
4	2957.81	55.62	0.26	0.26
5	3966.89	74.24	0.35	0.35
6	4987.58	93.01	0.44	0.44
7	5947.49	111.39	0.52	0.52
8	6915.46	129.65	0.61	0.61
9	7914.71	148.00	0.70	0.69
10	8927.52	166.74	0.78	0.78
11	9867.37	184.37	0.87	0.86

Bridge 1		Bridge 2	
Force Calibration (lb/V)	11424.35	Force Calibration (lb/V)	11442.09
Offset	-20.96	Offset	-14.35
Correlation	0.999998	Correlation	0.999997
Strain Calibration (μ E/V)	213.02	Strain Calibration (μ E/V)	213.35
Offset	0.00	Offset	0.12
Correlation	0.999995	Correlation	0.999996

Force Strain Calibration	
EA (Kips)	53629.74
Offset	-20.93
Correlation	0.999994



Bridge Excitation (V) 5
Shunt Resistor (ohm) 60.4k

Calibration Factors	102BW		
Bridge 1 ($\mu\text{E}/\text{V}$)	211.49	Bridge 2 ($\mu\text{E}/\text{V}$)	211.97
EA Factor (Kips)	53973.26	Area (in^2)	1.80

Calibrated by:



Calibrated Date:

2/27/2017

Pile Dynamics Inc
30725 Aurora Rd
Solon, OH 44139

Traceable to N.I.S.T.

Appendix IV



This documents that

Robert E. Kral
S&ME, Inc.

has on May 20, 2016 achieved the rank of

ADVANCED


on the **Dynamic Measurement and Analysis Proficiency Test.**

The individual identified on this document demonstrated to the degree granted above an understanding of theory, data quality evaluation, interpretation and signal matching for high strain dynamic testing of deep foundations. ***It is recommended that Individuals at the Advanced level seek Master or Expert levels through additional study within six years of the date of this document.***

The ability of the individual named to provide appropriate knowledge and advice on a specific project is not implied or warranted by the Pile Driving Contractors Association or Pile Dynamics, Inc. **This certificate can be verified at www.PDAproficiencytest.com.** The Pile Driving Contractors Association or Pile Dynamics, Inc. assumes no liability for foundation testing and analysis work performed by the bearer of this certificate.


Steven A. Hall, Executive Director
Pile Driving Contractors Association




Garland Likins, Senior Partner
Pile Dynamics, Inc.

No. 2072