APPENDIX B.3

SPT ENERGY MEASUREMENT REPORTS

NORTH ANNA COL

DATA REPORT REV. 0
JANUARY 23, 2007

MACTEC PROJECT NO. 6468-06-1472

October 2, 2006

Memorandum to File DCN SC159
From: Steve Kiser SK 10-2-06
Reviewed By: Clay Sams CS 10-13-06

Subject: **Report of SPT Energy – MACTEC Raleigh CME 55LC Truck Rig (Serial No. 331145) Automatic Hammer**
WORK INSTRUCTION DCN SC159
VC Summer COL Site
South Carolina Electric and Gas (SCE&G)
Jenkinsville, South Carolina
MACTEC Project No. 6234-06-3534S

Steve Kiser, P.E. of MACTEC Engineering and Consulting, Inc. (MACTEC), performed energy measurements on the drill rig at the subject site per the referenced Work Instruction. This memorandum summarizes the field testing activities and presents the results of the energy measurements.

SPT Energy Field Measurements

SPT energy measurements were made on June 5, 2006, during drilling of Boring B-304 at the referenced site. The testing was performed from approximately 3:25 PM to 5:15 PM under partly cloudy skies and a temperature of about 84 degrees Fahrenheit. The boring was drilled with personnel and equipment from the MACTEC office in Raleigh, North Carolina. The drilling equipment consisted of a CME 55LC model track-mounted drill rig with an SPT automatic hammer. The drilling tools consisted of AW-J-sized drilling rods and a 2-foot long split tube sampler. Mud rotary drilling techniques were used to advance the boring. The drill rig operator during sampling was Mr. David White. Energy measurements were recorded during sampling at the depth intervals shown in Table 1. The length of the drill rod string (including the instrumented drill rod insert described below) for each sample was generally 4 feet longer than the depth of the sample being collected.

The energy measurements were performed with a Pile Driving Analyzer (PDA) model PAK (Serial No. 1430), and calibrated accelerometers (Serial Nos. P5953 and P104) and strain gages (Serial Nos. AW #75/1 and AW#75/2). An AW-sized steel drill rod, 2 feet long and instrumented with dedicated strain gages, was inserted at the top of the drill rod string immediately below the SPT hammer. The inserted rod was also instrumented with two piezoresistive accelerometers that were bolted to the outside of the rod. The instrumented rod insert had a cross-sectional area of approximately 1.19 square inches at the gage location.

Calibration Records

The calibration records for all the above are filed in DCN SC 102, Rev. 2. The confirmation certificate for the SPT hammer weight is contained in DCN SC4.

Calculations for EFV

The work was done in general accordance with ASTM D 4633-05. The strain and acceleration signals were converted to force and velocity by the PDA, and the data was interpreted by the PDA according to the Case Method equation. The maximum energy transmitted to the drill rod string (as measured at the location of the strain gages and accelerometers) was calculated by the PDA using the EFV method equation, as shown below:

$$EFV = \int F(t) * V(t) * dt$$

Where: EFV = Transferred energy (EFV equation), or Energy of FV
F(t) = Calculated force at time t
V(t) = Calculated velocity at time t

The EFV method of energy calculation is recommended in ASTM Standard D4633-05. The EFV equation, integrated over the complete wave event, measures the total energy content of the event using both force and velocity measurements. The EFV values associated with each blow analyzed are tabulated in the attached PDIPLOT tables and are also shown graphically in the PDIPLOT charts.

Calculations for ETR

The ratio of the measured transferred energy (EFV) to the theoretical potential energy of the SPT system (140 lb weight with the specified 30 inch fall) is the ETR. The ETR values (as percent of the theoretical value) are shown in Table 1.

Comparison of ETR to Typical Energy Transfer Ratio Range

Based on a research report published by the Florida Department of Transportation (FDOT) (Report WPI No. 0510859, 1999), the average ETR measured for automatic hammers is 79.6%. The standard deviation was 7.9%; therefore, the range of ETRs within one standard deviation of the average was reported to be 71.7% to 87.5%. This range of ETRs was also consistent with other research that was cited in the FDOT research paper. The ETR values shown in Table 1 are within the range of typical values for automatic hammers as reported in the literature.

Discussion

Based on the field testing results, observations from the SPT energy measurements are summarized below:

- The data obtained by the PDA are consistent between individual hammer blows and between the sample depths tested. In general, the first one (and sometimes two) hammer blow records recorded by the PDA produced poor quality data (which is relatively common) and, as such, the record(s) was(were) not used in the data reduction.

- The average energy transferred from the hammer to the drill rods for each individual depth interval using the EFV method ranged from 287 foot-pounds to

293 foot-pounds. These average energy transfers correspond to energy transfer ratios (ETR) of 82% to 84% of the theoretical energy (350 foot-pounds) of the SPT hammer.

- The average at each depth interval was calculated as the transferred energy for each analyzed blow of the depth intervals divided by the total number of hammer blows analyzed. The overall average energy transfer of the SPT system (for all the depth intervals tested) was 289.6 foot-pounds, with an average ETR of 82.8%.

Attachments:
Page 4 Table 1 - Summary of SPT Energy Measurements – 1 Page
Page 5 Work Instructions – SPT Energy MACTEC Raleigh CME-55LC (Hammer #331145) – 1 Page
Page 6 Record of SPT Energy Measurement – 1 Page
Pages 7-16 PDIPLOT Output – 10 Pages

TABLE 1
SUMMARY OF SPT ENERGY MEASUREMENTS (ASTM D4633-05)
VC Summer COL Site
Jenkinsville, South Carolina
MACTEC Project No. 6234-06-3534, Task 18

Rig Serial No.	Rig Owner	Rig Operator	Boring No. Tested	Date Tested	Sample Depth (feet)	SPT Blow Count (blows per six inches)	No. of Blows Analyzed	Average Measured Energy (Average EFV) (ft-lbs)[a]	Energy Transfer Ratio (%)[b] (Average ETR)
331145 (CME 55LC Truck)	MACTEC (Raleigh Office)	David White	B-304	6/5/2006	11.0 - 12.5	4 - 5 - 7	16	293	83.7%
					13.5 - 15.0	4 - 6 - 8	18	290	82.9%
					18.5 - 20.0	4 - 6 - 7	17	288	82.3%
					23.5 - 25.0	5 - 7 - 10	22	287	82.0%
					28.5 - 30.0	5 - 7 - 7	19	291	83.1%
							Average for Rig:	**289.6**	**82.8%**

[a]Measured Energy is energy based on the EFV method, as outlined in ASTM D4633-05, for each blow recorded by the PDA. In some cases, the initial one to two blows produced poor quality data, and were not used to calculate the Average Measured Energy.

[b]Energy Transfer Ratio is the Measured Energy divided by the theoretical SPT energy of 350 foot-pounds (140 pound hammer falling 2.5 feet). The average ETR values may differ slightly and insignificantly from those in the PDIPLOT tables due to roundoff.

Prepared By: [illegible] Date: 10-2-06	Checked By: Clay Estam Date: 10-23-06

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02NSC159

Work Instructions – SPT Energy MACTEC Raleigh CME-55LC (Hammer #331145)
SCE&G COL Project

Issued To: Steve Kiser

Location: SCE&G COL Project Field Office Date: June 5, 2006

Issued By: Matthew F. Cooke, Site Coordinator

Valid From: June 5, 2006 To: June 5, 2007

Task Description: Measurement of energy transferred to the drill string rods from a Standard Penetration Test (SPT) automatic hammer mounted on a drill rig. Testing will be performed using a Pile Driving Analyzer (PDA) model PAK at various depth intervals from approximately 10 to 50 feet below the ground surface for each rig drilling SPT borings at the SCE&G COL Site.

Applicable Technical Procedures or Plans, or other reference: ASTM D4633-05 Standard Test Method for Energy Measurement for Dynamic Penetrometers.

Specific Instructions (note attachments where necessary): Obtain energy measurements with the PDA at depth intervals in the range of about 10 to ~~50~~ 30 feet below the ground surface in general accordance with ASTM D4633-05. Perform energy measurement testing for MACTEC Raleigh CME-55LC #331145.

Report Format: Written report documenting results of field testing in general accordance with ASTM D4633-05, to include completed Summary of Daily Observations and Testing, Record of SPT Energy Measurement sheet(s), and PDIPLOT output data.

Specific Quality Assurance Procedures Applicable: None

Hold Points or Witness Points: Direction to perform energy measurements received from the Site Coordinator.

Records: All records generated shall be considered QA Records.

Reviewed and Approved By (Note: Only One Signature is Required to Issue):

Project Manager: Date:

Project Principal: Date:

Site Coordinator: Date: 6/5/06

No. of Pages: 1 DCN: SC159

2 PAGES + FLOPPY DISC

MACTEC

2801 YORKMONT ROAD, SUITE 100 □ CHARLOTTE, NC 28208
Telephone: (704) 357-8600 / Facsimile: (704) 357-8638

RECORD OF SPT ENERGY MEASUREMENT

GENERAL INFORMATION		DRILL RIG DATA	
PROJECT:	SCE&G VC Summer COL	MAKE:	CME 55 LC
LOCATION:	Jenkinsville, South Carolina	MODEL:	TRACK RIG
PROJECT NO.:	6234-06-3534	SERIAL NO.:	331145
DATE:	6-5-06	HAMMER TYPE:	AUTO
WEATHER:	PARTLY CLOUDY - WARM 84°	ROPE CONDITION:	N/A
INSPECTOR:	Steve Kiser	ROD SIZE:	AW-J
DRILLING COMPANY:	MACTEC - RALEIGH	NO. OF SHEAVES:	N/A

BORING DATA

BORING NUMBER:	B-304		
DEPTH DRILLED:	150' PLANNED		
TIME DRIVEN:	3:30 PM		
RIG OPERATOR:	DAVID WHITE		
HAMMER OPERATOR:	N.R.	SK 6-5-06	SK 6-5-06
PDA PAK SERIAL NO.:	1430	1430	1430
INSTR. ROD AREA:	1.19 in²		
ACCEL. SERIAL NOS.:	P104 / P5953		
STRAIN SERIAL NOS.:	#75 AW 1/2		

SAMPLE DEPTH (feet)	SPT N-VALUE (bpf)	DEPTH cont. (feet)	SPT N-VALUE (bpf)	SAMPLE DEPTH (feet)	SPT N-VALUE (bpf)	DEPTH cont. (feet)	SPT N-VALUE (bpf)	SAMPLE DEPTH (feet)	SPT N-VALUE (bpf)	DEPTH cont. (feet)	SPT N-VALUE (bpf)
11-12.5	4-5-7										
13.5-15.0	4-6-8										
18.5-20.0	4-6-7										
23.5-25	5-7-10										
28.5-30	5-7-7										
					SK 6-5-06				SK 6-5-06		

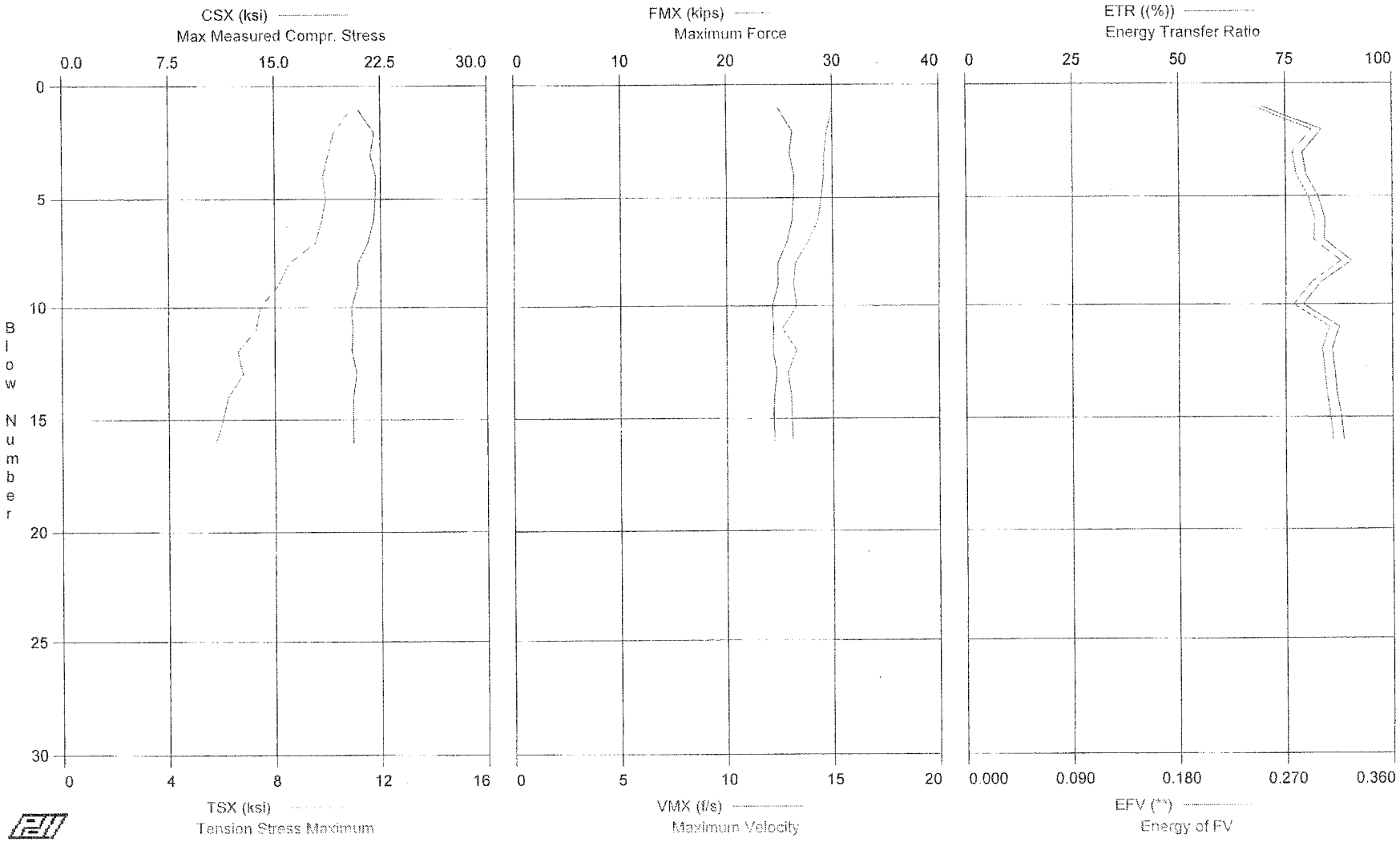
REMARKS:

MACTEC Engineering and Consulting, Inc. - Case Method Results

PDIPLOT Ver. 2005.2 - Printed: 21-Aug-2006

Test date: 5-Jun-2006

VC Summer SC&G COL Site - Boring B-304; 11' - 12.5' Sample



MACTEC Engineering and Consulting, Inc.
Case Method Results

PDIPLOT Ver. 2005.2 - Printed: 21-Aug-2006

VC Summer SC&G COL Site - Boring B-304; 11' - 12.5' Sample
OP: SEK

Rig Serial No. 331145 (MACTEC Raleigh CME 55LC)
Test date: 5-Jun-2006

AR: 1.19 in^2
LE: 19.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.50

CSX: Max Measured Compr. Stress
TSX: Tension Stress Maximum
FMX: Maximum Force
VMX: Maximum Velocity
FVP: Force/Velocity proportionality

BPM: Blows per Minute
ETR: Energy Transfer Ratio
EMX: Max Transferred Energy
EFV: Energy of FV

BL#	depth	CSX	TSX	FMX	VMX	FVP	BPM	ETR	EMX	EFV
	ft	ksi	ksi	kips	f/s	[]	**	(%)	k-ft	**
1	0.00	20.9	10.9	25	15.0	0.91	0.0	69.7	0.244	0.244
2	0.00	22.0	10.2	26	14.7	1.09	50.6	83.5	0.292	0.292
3	0.00	21.8	10.0	26	14.6	1.04	50.8	79.0	0.276	0.276
4	0.00	22.2	9.8	26	14.6	1.11	50.6	79.8	0.279	0.279
5	0.00	22.1	9.9	26	14.5	1.12	50.9	82.7	0.289	0.289
6	0.00	22.0	9.8	26	14.3	0.84	50.7	84.2	0.295	0.295
7	0.00	21.6	9.6	26	13.9	1.02	50.8	84.1	0.294	0.294
8	0.00	20.9	8.5	25	13.2	1.11	50.7	90.6	0.317	0.317
9	0.00	20.9	8.1	25	13.2	1.04	50.7	83.3	0.292	0.292
10	0.00	20.4	7.4	24	13.3	0.82	51.0	79.2	0.277	0.277
11	0.00	20.5	7.3	24	12.6	1.03	50.7	87.6	0.307	0.307
12	0.00	20.5	6.6	24	13.3	0.81	50.9	85.9	0.301	0.301
13	0.00	20.8	6.8	25	12.9	1.01	50.5	86.5	0.303	0.303
14	0.00	20.6	6.2	24	13.0	1.00	50.9	87.1	0.305	0.305
15	0.00	20.5	6.0	24	13.1	1.05	50.6	88.1	0.308	0.308
16	0.00	20.6	5.8	24	13.1	1.05	50.8	88.6	0.310	0.310
	Average	21.1	8.3	25	13.7	1.00	50.7	83.7	0.293	0.293

Total number of blows analyzed: 16

Time Summary

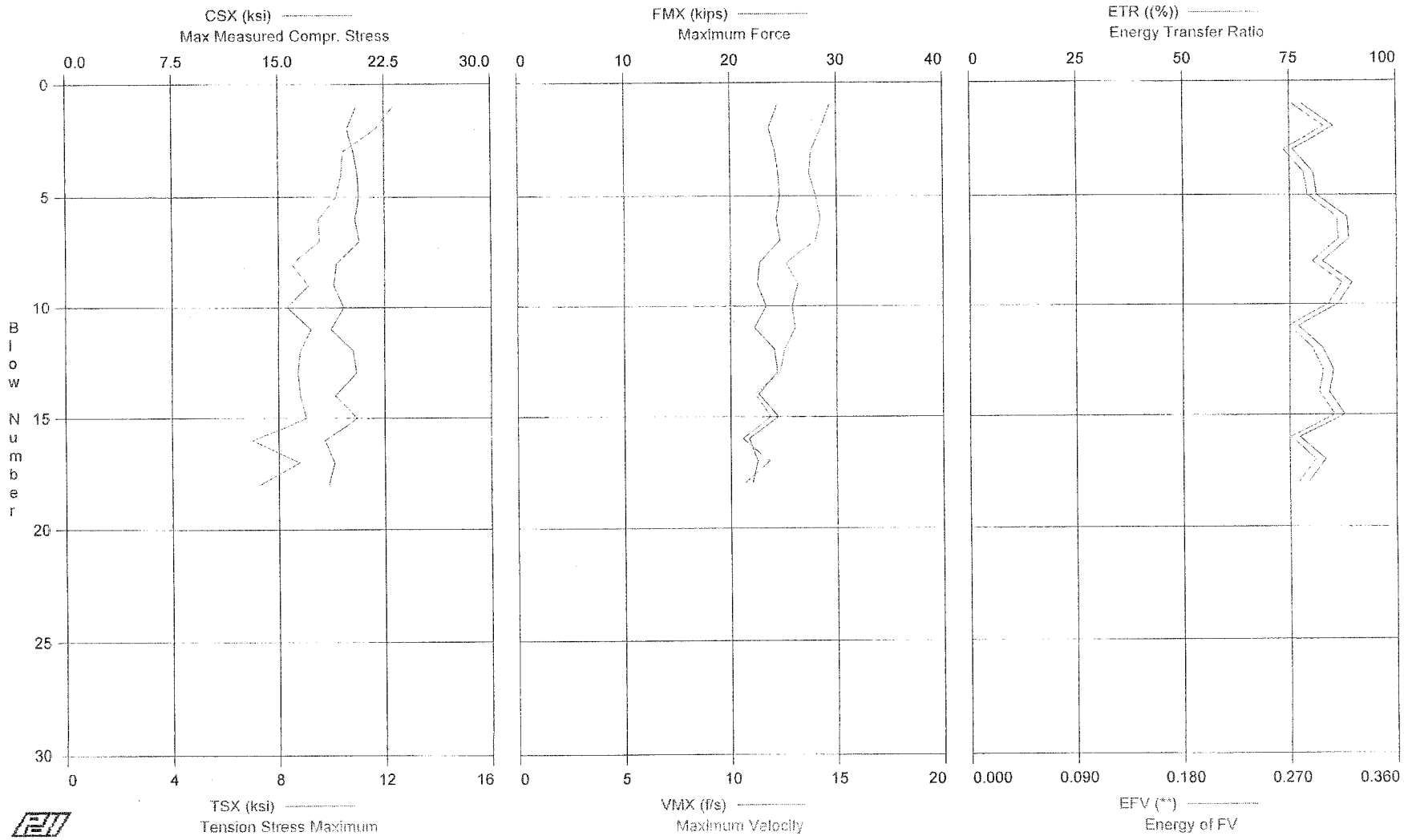
Drive 18 seconds 3:24:26 PM - 3:24:44 PM (6/5/2006) BN 1 - 16

MACTEC Engineering and Consulting, Inc. - Case Method Results

PDIPLOT Ver. 2005.2 - Printed: 21-Aug-2006

Test date: 5-Jun-2006

VC Summer SC&G COL Site - Boring B-304; 13.5' - 15' Sample



MACTEC Engineering and Consulting, Inc.
Case Method Results

PDIPLOT Ver. 2005.2 - Printed: 21-Aug-2006

VC Summer SC&G COL Site - Boring B-304; 13.5' - 15' Sample

Rig Serial No. 331145 (MACTEC Raleigh CME 55LC)

OP: SEK

Test date: 5-Jun-2006

AR: 1.19 in^2
LE: 19.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.50

CSX: Max Measured Compr. Stress
TSX: Tension Stress Maximum
FMX: Maximum Force
VMX: Maximum Velocity
FVP: Force/Velocity proportionality

BPM: Blows per Minute
ETR: Energy Transfer Ratio
EMX: Max Transferred Energy
EFV: Energy of FV

BL#	depth	CSX	TSX	FMX	VMX	FVP	BPM	ETR	EMX	EFV
	ft	ksi	ksi	kips	f/s	[]	**	(%)	k-ft	**
1	0.00	20.6	12.4	24	14.7	1.10	0.0	77.8	0.272	0.272
2	0.00	19.9	11.7	24	14.3	0.96	50.9	85.3	0.299	0.299
3	0.00	20.4	10.4	24	13.8	1.02	51.4	75.8	0.265	0.265
4	0.00	20.6	10.4	25	13.7	1.03	51.1	80.6	0.282	0.282
5	0.00	20.7	10.2	25	14.0	1.09	51.3	81.4	0.285	0.285
6	0.00	20.4	9.5	24	14.2	1.01	51.0	88.5	0.310	0.310
7	0.00	20.7	9.6	25	14.0	1.03	51.1	88.9	0.311	0.311
8	0.00	19.1	8.5	23	12.6	1.03	51.1	82.6	0.289	0.289
9	0.00	18.9	9.1	23	13.2	1.02	51.0	89.6	0.314	0.314
10	0.00	19.6	8.3	23	12.9	1.00	51.0	86.3	0.302	0.302
11	0.00	18.7	9.2	22	13.1	1.02	51.0	77.0	0.269	0.269
12	0.00	20.3	8.8	24	12.5	1.02	51.2	82.7	0.289	0.289
13	0.00	20.5	8.7	24	12.3	1.03	50.9	85.3	0.298	0.298
14	0.00	19.0	8.8	23	11.2	1.02	51.1	84.2	0.295	0.295
15	0.00	20.5	9.1	24	11.9	1.07	51.2	87.9	0.308	0.308
16	0.00	18.3	7.0	22	10.6	1.01	51.2	77.3	0.271	0.271
17	0.00	18.9	8.8	23	11.8	0.97	51.0	83.4	0.292	0.292
18	0.00	18.5	7.3	22	10.6	1.01	51.1	79.5	0.278	0.278
	Average	19.8	9.3	24	12.9	1.02	51.1	83.0	0.290	0.290

Total number of blows analyzed: 18

Time Summary

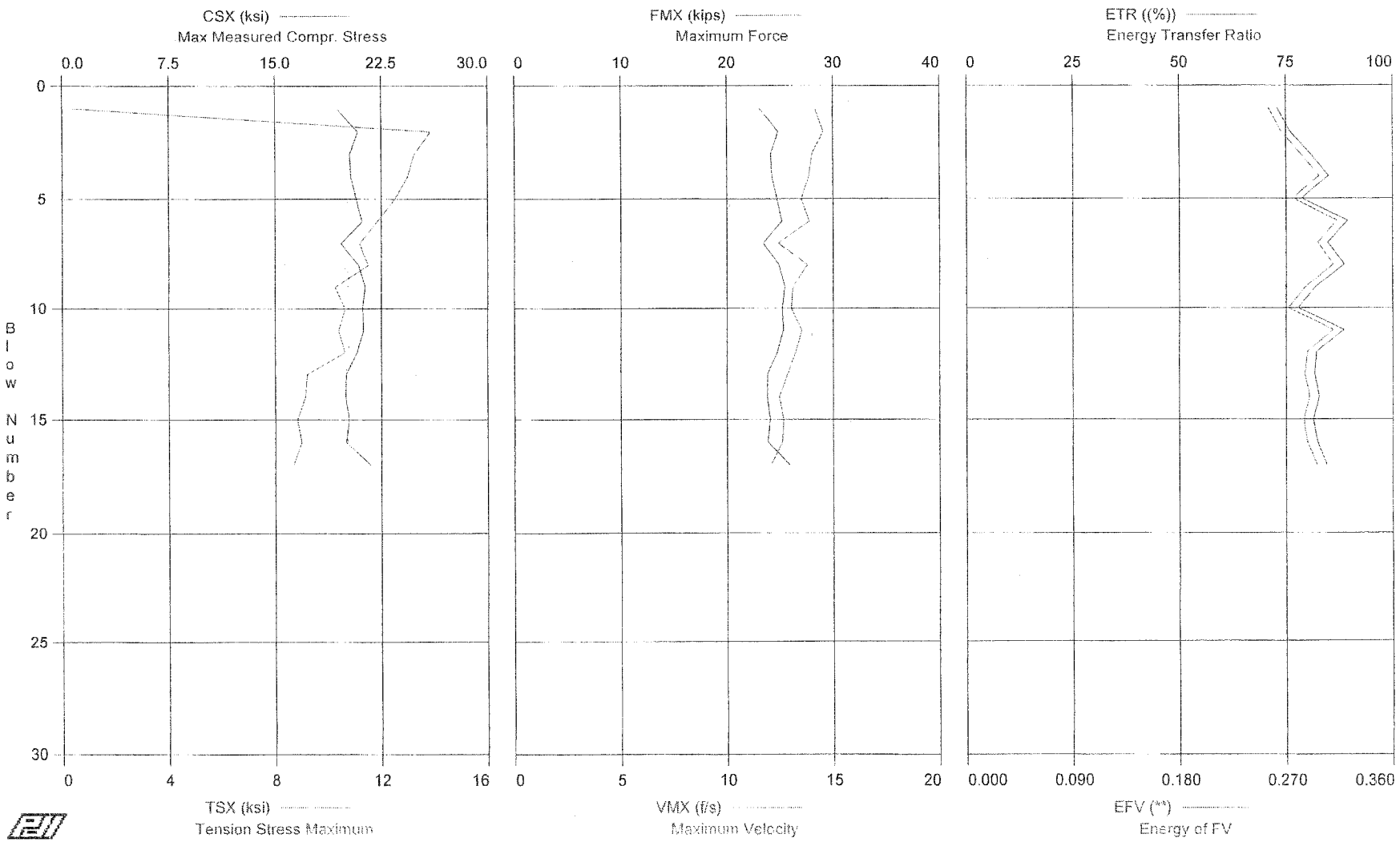
Drive 20 seconds 3:33:16 PM - 3:33:36 PM (6/5/2006) BN 1 - 18

MACTEC Engineering and Consulting, Inc. - Case Method Results

PDIPLOT Ver. 2005.2 - Printed: 21-Aug-2006

Test date: 5-Jun-2006

VC Summer SC&G COL Site - Boring B-304; 18.5' - 20' Sample



MACTEC Engineering and Consulting, Inc.
Case Method Results

PDIPLOT Ver. 2005.2 - Printed: 21-Aug-2006

VC Summer SC&G COL Site - Boring B-304; 18.5' - 20' Sample

Rig Serial No. 331145 (MACTEC Raleigh CME 55LC)
Test date: 5-Jun-2006

OP: SEK

AR: 1.19 in^2
LE: 24.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.50

CSX: Max Measured Compr. Stress
TSX: Tension Stress Maximum
FMX: Maximum Force
VMX: Maximum Velocity
FVP: Force/Velocity proportionality

BPM: Blows per Minute
ETR: Energy Transfer Ratio
EMX: Max Transferred Energy
EFV: Energy of FV

BL#	depth ft	CSX ksi	TSX ksi	FMX kips	VMX f/s	FVP []	BPM **	ETR (%)	EMX k-ft	EFV **
1	0.00	19.4	0.4	23	14.2	0.10	0.0	73.1	0.256	0.256
2	0.00	20.9	13.9	25	14.5	1.03	50.5	76.0	0.266	0.266
3	0.00	20.3	13.3	24	14.0	0.98	51.1	80.7	0.282	0.282
4	0.00	20.4	13.0	24	13.9	0.97	50.8	85.0	0.298	0.298
5	0.00	20.8	12.5	25	13.5	1.01	50.7	78.7	0.276	0.276
6	0.00	21.2	11.8	25	13.9	1.06	50.9	89.5	0.313	0.313
7	0.00	19.7	11.2	23	12.4	1.00	50.9	84.8	0.297	0.297
8	0.00	20.9	11.5	25	13.8	1.06	50.8	88.7	0.310	0.310
9	0.00	21.4	10.3	25	13.1	0.83	50.8	82.1	0.287	0.287
10	0.00	21.2	10.6	25	13.0	1.11	50.8	77.9	0.272	0.272
11	0.00	21.3	10.4	25	13.5	1.13	50.7	88.6	0.310	0.310
12	0.00	20.8	10.6	25	13.2	1.04	50.6	82.1	0.288	0.288
13	0.00	20.0	9.2	24	12.8	0.99	50.8	81.7	0.286	0.286
14	0.00	20.0	9.1	24	12.5	1.00	50.7	82.8	0.290	0.290
15	0.00	20.2	8.8	24	12.7	1.05	50.9	81.4	0.285	0.285
16	0.00	20.0	9.0	24	12.6	1.05	50.8	82.4	0.288	0.288
17	0.00	21.7	8.7	26	12.1	0.93	50.6	84.6	0.296	0.296
	Average	20.6	10.3	24	13.3	0.96	50.8	82.3	0.288	0.288

Total number of blows analyzed: 17

Time Summary

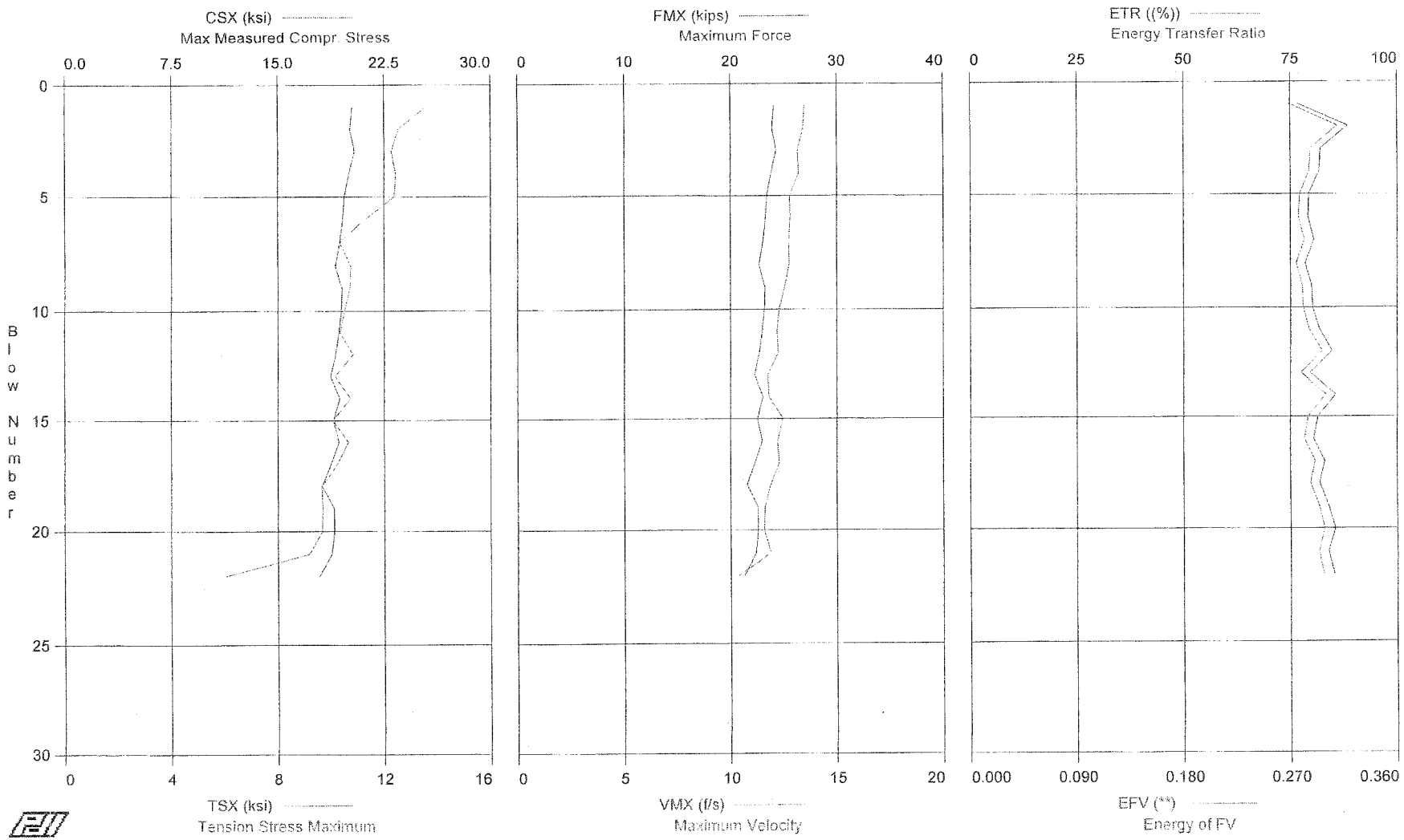
Drive 19 seconds 3:42:07 PM - 3:42:26 PM (6/5/2006) BN 1 - 17

MACTEC Engineering and Consulting, Inc. - Case Method Results

PDIPLOT Ver. 2005.2 - Printed: 21-Aug-2006

Test date: 5-Jun-2006

VC Summer SC&G COL Site - Boring B-304; 23.5' - 25' Sample



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MACTEC Engineering and Consulting, Inc.
Case Method Results

PDIPLOT Ver. 2005.2 - Printed: 21-Aug-2006

VC Summer SC&G COL Site - Boring B-304; 23.5' - 25' Sample
OP: SEK

Rig Serial No. 331145 (MACTEC Raleigh CME 55LC)
Test date: 5-Jun-2006

AR: 1.19 in^2
LE: 29.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
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CSX: Max Measured Compr. Stress
TSX: Tension Stress Maximum
FMX: Maximum Force
VMX: Maximum Velocity
FVP: Force/Velocity proportionality

BPM: Blows per Minute
ETR: Energy Transfer Ratio
EMX: Max Transferred Energy
EFV: Energy of FV

BL#	depth	CSX	TSX	FMX	VMX	FVP	BPM	ETR	EMX	EFV
	ft	ksi	ksi	kips	f/s	[]	**	(%)	k-ft	**
1	0.00	20.3	13.6	24	13.5	0.83	0.0	76.8	0.269	0.269
2	0.00	20.1	12.5	24	13.4	0.95	50.8	88.5	0.310	0.310
3	0.00	20.4	12.3	24	13.2	1.00	50.9	82.1	0.287	0.287
4	0.00	20.0	12.4	24	13.2	0.78	51.0	81.7	0.286	0.286
5	0.00	19.7	12.4	23	12.8	1.01	50.8	79.3	0.278	0.278
6	0.00	19.6	11.3	23	12.8	1.05	50.9	79.2	0.277	0.277
7	0.00	19.4	10.3	23	12.8	1.04	50.8	80.6	0.282	0.282
8	0.00	19.1	10.7	23	12.8	1.00	50.9	78.5	0.275	0.275
9	0.00	19.5	10.7	23	12.5	0.80	50.7	80.0	0.280	0.280
10	0.00	19.5	10.5	23	12.3	1.02	50.9	80.3	0.281	0.281
11	0.00	19.3	10.3	23	12.2	0.99	50.8	81.8	0.286	0.286
12	0.00	19.1	10.8	23	12.2	0.98	50.7	84.8	0.297	0.297
13	0.00	18.7	10.2	22	11.7	0.96	51.0	79.7	0.279	0.279
14	0.00	19.4	10.7	23	11.8	0.97	50.8	85.6	0.300	0.300
15	0.00	18.9	10.1	23	12.5	0.75	50.9	81.5	0.285	0.285
16	0.00	19.3	10.7	23	12.2	0.75	50.7	80.5	0.282	0.282
17	0.00	18.7	10.2	22	12.3	0.73	50.8	83.1	0.291	0.291
18	0.00	18.1	9.6	22	11.9	0.87	50.6	81.9	0.287	0.287
19	0.00	19.0	9.7	23	11.6	0.74	50.9	83.9	0.294	0.294
20	0.00	19.0	9.7	23	11.6	0.73	50.9	85.5	0.299	0.299
21	0.00	18.8	9.2	22	11.9	0.90	50.7	83.9	0.294	0.294
22	0.00	17.9	5.9	21	10.4	0.75	51.1	85.3	0.298	0.298
	Average	19.3	10.6	23	12.3	0.89	50.8	82.0	0.287	0.287

Total number of blows analyzed: 22

Time Summary

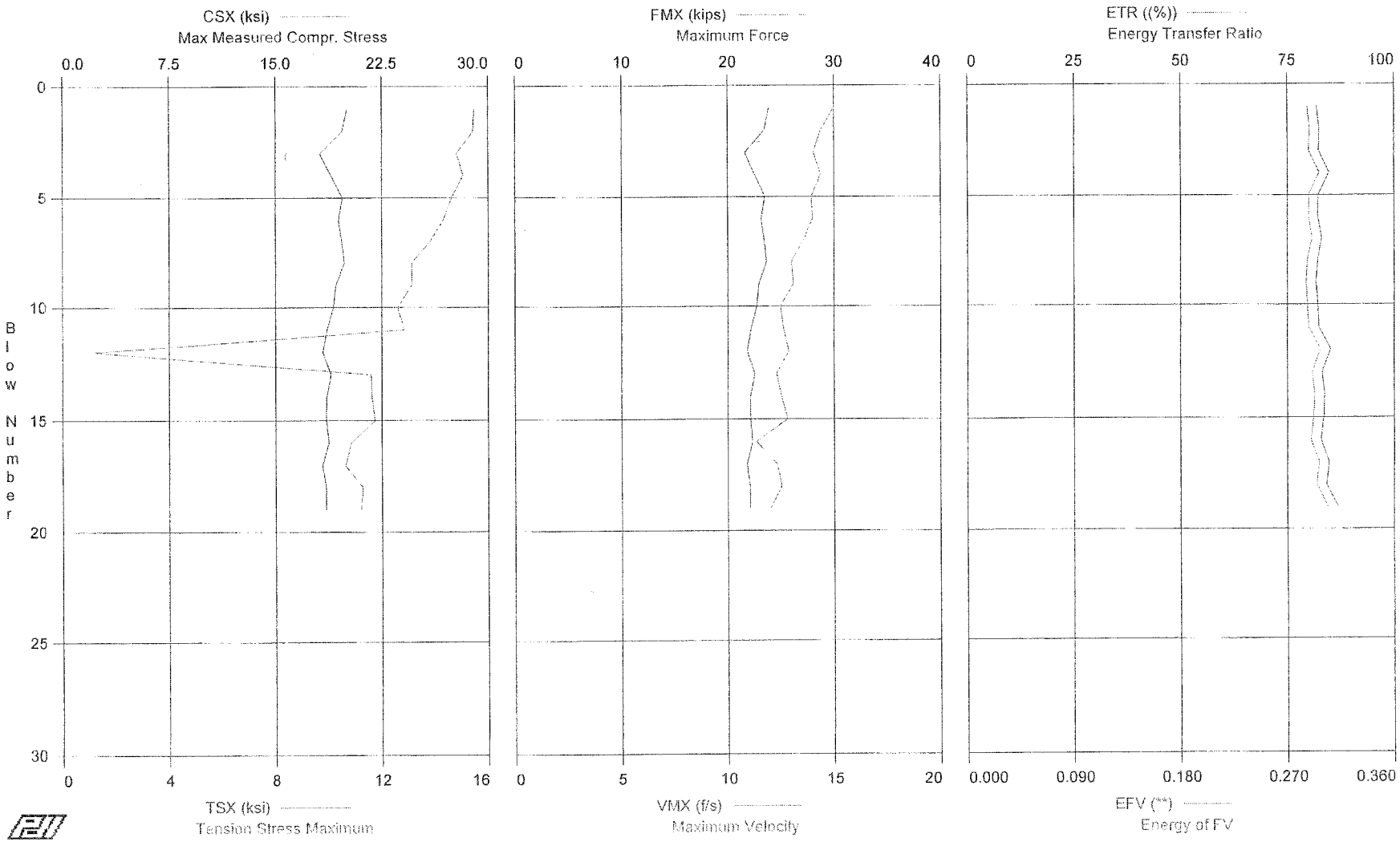
Drive 25 seconds 3:59:07 PM - 3:59:32 PM (6/5/2006) BN 1 - 22

MACTEC Engineering and Consulting, Inc. - Case Method Results

PDIPLOT Ver. 2005.2 - Printed: 21-Aug-2006

Test date: 5-Jun-2006

VC Summer SC&G COL Site - Boring B-304; 28.5' - 30' Sample



MACTEC Engineering and Consulting, Inc.
Case Method Results

PDIPLOT Ver. 2005.2 - Printed: 21-Aug-2006

VC Summer SC&G COL Site - Boring B-304; 28.5' - 30' Sample
OP: SEK

Rig Serial No. 331145 (MACTEC Raleigh CME 55LC)
Test date: 5-Jun-2006

AR: 1.19 in^2
LE: 34.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.50

CSX: Max Measured Compr. Stress
TSX: Tension Stress Maximum
FMX: Maximum Force
VMX: Maximum Velocity
FVP: Force/Velocity proportionality

BPM: Blows per Minute
ETR: Energy Transfer Ratio
EMX: Max Transferred Energy
EFV: Energy of FV

BL#	depth	CSX	TSX	FMX	VMX	FVP	BPM	ETR	EMX	EFV
	ft	ksi	ksi	kips	f/s	[]	**	(%)	k-ft	**
1	0.00	20.1	15.5	24	15.0	0.83	0.0	82.0	0.287	0.287
2	0.00	19.7	15.4	23	14.4	0.76	50.9	82.5	0.289	0.289
3	0.00	18.1	14.8	22	14.0	0.96	50.6	82.3	0.288	0.288
4	0.00	18.9	15.1	23	14.4	0.97	51.0	84.8	0.297	0.297
5	0.00	19.7	14.6	23	13.9	0.77	50.6	82.2	0.288	0.288
6	0.00	19.5	14.3	23	14.0	1.00	50.9	82.1	0.288	0.288
7	0.00	19.7	13.8	23	13.6	1.02	50.8	83.1	0.291	0.291
8	0.00	19.9	13.1	24	13.0	0.77	50.8	82.1	0.287	0.287
9	0.00	19.3	13.1	23	13.1	0.77	50.8	81.7	0.286	0.286
10	0.00	19.1	12.6	23	12.5	0.98	50.6	82.1	0.287	0.287
11	0.00	18.7	12.9	22	12.6	0.93	50.8	82.3	0.288	0.288
12	0.00	18.3	1.2 *	22	12.9	0.23	50.4	85.2	0.298	0.298
13	0.00	18.9	11.6	23	12.3	0.95	50.9	83.1	0.291	0.291
14	0.00	18.6	11.6	22	12.5	0.91	50.5	83.7	0.293	0.293
15	0.00	18.6	11.7	22	12.8	0.94	50.7	83.5	0.292	0.292
16	0.00	18.8	10.8	22	11.4	1.02	50.7	82.9	0.290	0.290
17	0.00	18.3	10.6	22	12.3	0.89	50.8	84.8	0.297	0.297
18	0.00	18.6	11.3	22	12.5	0.87	50.9	84.2	0.295	0.295
19	0.00	18.6	11.2	22	12.0	0.88	50.8	86.9	0.304	0.304
	Average	19.0	12.4	23	13.1	0.87	50.8	83.2	0.291	0.291

Total number of blows analyzed: 19

Time Summary

Drive 21 seconds 4:10:35 PM - 4:10:56 PM (6/5/2006) BN 1 - 19

* DATA FOR BL# 12 reviewed in response to Bechtel comment and found acceptable per attached e-mail.

MACTEC
1-8-07

Tice, Al

From: Kiser, Steven
Sent: Monday, January 08, 2007 3:41 PM
To: Tice, Al
Subject: RE: Bechtel comment for you

Al
I have reviewed the attached document and revisited the raw data in question. My comments are as follows:
- The circled tension stress for Blow #12 is not a typo. The printout you sent me is pulled directly from the raw data into a data manipulation software program, and does not (cannot) get changed by me.
- The reason the tension appears to be different from the rest of the blows is somewhat of a technical explanation, but I'll try it. When collecting field data, the PDA program automatically places time markers at two points based on the shape and slope of the wave traces recorded by the gages (it looks for sudden, drastic changes in slope to indicate impact). The first time marker is placed at the time of initial impact (t1), and the second marker at a time designated as t2, or 2L/c (the time it takes for the impact wave to travel down the length of the drill rods and back up to the surface; "L" is the length of rods, "c" is the wavespeed in steel). On occasion, the computer places the time markers at the wrong points, which can affect such calculations as tension stress. It appears that the time markers in the raw data were in the wrong location for this particular blow, which affected the tension stress shown. However, since the energy of the blow is calculated along the entire length of the wave trace, the location of the time markers does not affect the measured energy.
- The data (wave shape, magnitude) is consistent with the rest of the blows in the series, and the force-velocity proportionality (a key component of the testing) also looks OK. Therefore, I decided to include the blow as "good data" and left it in the calculation. That being said, however, if the blow was removed from consideration in the calculation, it should not affect the results signficantly. The energy calculated for that particular blow (298 foot-pounds) is close to the overall average for the entire series (291 foot-pounds).

I hope this explanation makes sense - please feel free to call me if you have further questions.

Steve

Steven E. Kiser, P.E.
Senior Engineer
MACTEC Engineering and Consulting, Inc.
2801 Yorkmont Road, Suite 100
Charlotte, NC 28208
Phone: (704) 357-8600 (main); (704) 357-5568 (direct)
Fax: (704) 357-8638; Cell: (704) 400-5660
Email: sekiser@mactec.com

From: Tice, Al
Sent: Friday, January 05, 2007 2:34 PM
To: Kiser, Steven
Subject: Bechtel comment for you

Steve – see attached comment from Bechtel on one of the STP energy measurement reports. Please review data and see if a typo. << File: SPT energy measurement comment.pdf >>

J. Allan Tice, P. E.
Senior Principal/Assistant Vice President

J. Allan Tice, P.E.
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ATTACHMENT ADDED 1-23-07 JAT
FOR FINAL DATA REPORT, REV. 0

October 2, 2006

Memorandum to File DCN SC53
From: Steve Kiser SK 10-2-06
Reviewed By: Clay Sams CES 10-23-06

Subject: **Report of SPT Energy – MACTEC Ashburn CME 55 Truck Rig (Serial No. 209195) Automatic Hammer**
WORK INSTRUCTION DCN SC53
VC Summer COL Site
South Carolina Electric and Gas (SCE&G)
Jenkinsville, South Carolina
MACTEC Project No. 6234-06-3534S

Steve Kiser, P.E. of MACTEC Engineering and Consulting, Inc. (MACTEC), performed energy measurements on the drill rig at the subject site per the referenced Work Instruction. This memorandum summarizes the field testing activities and presents the results of the energy measurements.

SPT Energy Field Measurements

SPT energy measurements were made on April 28, 2006, during drilling of Boring B-323 at the referenced site. The testing was performed from approximately 2:15 PM to 5:15 PM under clear sunny skies and a temperature of about 75 degrees Fahrenheit. The boring was drilled with personnel and equipment from the MACTEC office in Ashburn, Virginia. The drilling equipment consisted of a CME 55 model truck-mounted drill rig with an SPT automatic hammer. The drilling tools consisted of AW-J-sized drilling rods and a 2-foot long split tube sampler. Mud rotary drilling techniques were used to advance the boring. The drill rig operator during sampling was Mr. Hank Meyerson. Energy measurements were recorded during sampling at the depth intervals shown in Table 1. The length of the drill rod string (including the instrumented drill rod insert described below) for each sample was generally 4 feet longer than the depth of the sample being collected.

The energy measurements were performed with a Pile Driving Analyzer (PDA) model PAK (Serial No. 1430), and calibrated accelerometers (Serial Nos. P5953 and P104) and strain gages (Serial Nos. AW #75/1 and AW#75/2). An AW-sized steel drill rod, 2 feet long and instrumented with dedicated strain gages, was inserted at the top of the drill rod string immediately below the SPT hammer. The inserted rod was also instrumented with two piezoresistive accelerometers that were bolted to the outside of the rod. The instrumented rod insert had a cross-sectional area of approximately 1.19 square inches at the gage location.

Calibration Records

The calibration records for all the above are filed in DCN SC 102, Rev. 2. The confirmation certificate for the SPT hammer weight is contained in DCN SC4.

Calculations for EFV

The work was done in general accordance with ASTM D 4633-05. The strain and acceleration signals were converted to force and velocity by the PDA, and the data was interpreted by the PDA according to the Case Method equation. The maximum energy transmitted to the drill rod string (as measured at the location of the strain gages and accelerometers) was calculated by the PDA using the EFV method equation, as shown below:

$$EFV = \int F(t) * V(t) * dt$$

Where: EFV = Transferred energy (EFV equation), or Energy of FV
F(t) = Calculated force at time t
V(t) = Calculated velocity at time t

The EFV method of energy calculation is recommended in ASTM Standard D4633-05. The EFV equation, integrated over the complete wave event, measures the total energy content of the event using both force and velocity measurements. The EFV values associated with each blow analyzed are tabulated in the attached PDIPLOT tables and are also shown graphically in the PDIPLOT charts.

Calculations for ETR

The ratio of the measured transferred energy (EFV) to the theoretical potential energy of the SPT system (140 lb weight with the specified 30 inch fall) is the ETR. The ETR values (as percent of the theoretical value) are shown in Table 1.

Comparison of ETR to Typical Energy Transfer Ratio Range

Based on a research report published by the Florida Department of Transportation (FDOT) (Report WPI No. 0510859, 1999), the average ETR measured for automatic hammers is 79.6%. The standard deviation was 7.9%; therefore, the range of ETRs within one standard deviation of the average was reported to be 71.7% to 87.5%. This range of ETRs was also consistent with other research that was cited in the FDOT research paper. The ETR values shown in Table 1 are within the range of typical values for automatic hammers as reported in the literature.

Discussion

Based on the field testing results, observations from the SPT energy measurements are summarized below:

- The data obtained by the PDA are consistent between individual hammer blows and between the sample depths tested. In general, the first one (and sometimes two) hammer blow records recorded by the PDA produced poor quality data (which is relatively common) and, as such, the record(s) was(were) not used in the data reduction.

- The average energy transferred from the hammer to the drill rods for each individual depth interval using the EFV method ranged from 255 foot-pounds to

273 foot-pounds. These average energy transfers correspond to energy transfer ratios (ETR) of 73% to 78% of the theoretical energy (350 foot-pounds) of the SPT hammer.

- The average at each depth interval was calculated as the transferred energy for each analyzed blow of the depth intervals divided by the total number of hammer blows analyzed. The overall average energy transfer of the SPT system (for all the depth intervals tested) was 263.1 foot-pounds, with an average ETR of 75.2%.

Attachments:
Page 4 Table 1 - Summary of SPT Energy Measurements – 1 Page
Page 5 Work Instructions – SPT Energy MACTEC Ashburn CME-55 (Hammer #209195) – 1 Page
Page 6 Record of SPT Energy Measurement – 1 Page
Pages 7-18 PDIPLOT Output – 12 Pages

TABLE 1
SUMMARY OF SPT ENERGY MEASUREMENTS (ASTM D4633-05)
VC Summer COL Site
Jenkinsville, South Carolina
MACTEC Project No. 6234-06-3534, Task 18

Rig Serial No.	Rig Owner	Rig Operator	Boring No. Tested	Date Tested	Sample Depth (feet)	SPT Blow Count (blows per six inches)	No. of Blows Analyzed	Average Measured Energy (Average EFV) (ft-lbs)[a]	Energy Transfer Ratio (%)[b] (Average ETR)
209195 (CME 55 Truck)	MACTEC (Ashburn Office)	Hank Meyerson	B-323	4/28/2006	11.0 - 12.5	2 - 4 - 6	13	260	74.3%
					13.5 - 15.0	3 - 5 - 6	14	256	73.1%
					18.5 - 20.0	3 - 4 - 6	12	259	74.0%
					23.5 - 25.0	4 - 4 - 6	14	255	72.9%
					28.5 - 30.0	4 - 4 - 5	13	263	75.1%
					33.5 - 35.0	10 - 15 - 10	31	273	78.0%
							Average for Rig:	**263.1**	**75.2%**

[a]Measured Energy is energy based on the EFV method, as outlined in ASTM D4633-05, for each blow recorded by the PDA. In some cases, the initial one to two blows produced poor quality data, and were not used to calculate the Average Measured Energy.

[b]Energy Transfer Ratio is the Measured Energy divided by the theoretical SPT energy of 350 foot-pounds (140 pound hammer falling 2.5 feet). The average ETR values may differ slightly and insignificantly from those in the PDIPLOT tables due to roundoff.

Prepared By: [illegible]	Date: 10-2-06	Checked By: [illegible]	Date: 10-23-06

3535 N70

Work Instructions – SPT Energy MACTEC DC CME-55 (Hammer #209195)

SCE&G COL Project

Issued To: Steve Kiser

Location: SCE&G COL Project Field Office Date: April 28, 2006

Issued By: Matthew F. Cooke, Site Coordinator

Valid From: 4/28/06 To: 4/28/07

Task Description: Measurement of energy transferred to the drill string rods from a Standard Penetration Test (SPT) automatic hammer mounted on a drill rig. Testing will be performed using a Pile Driving Analyzer (PDA) model PAK at various depth intervals from approximately 10 to 50 feet below the ground surface for each rig drilling SPT borings at the SCE&G COL Site.

Applicable Technical Procedures or Plans, or other reference: ASTM D4633-05 Standard Test Method for Energy Measurement for Dynamic Penetrometers.

Specific Instructions (note attachments where necessary): Obtain energy measurements with the PDA at depth intervals in the range of 10 to 50 feet below the ground surface in general accordance with ASTM D4633-05. Perform energy measurement testing for MACTEC DC CME-55 Automatic Hammer #209195.

Report Format: Written report documenting results of field testing in general accordance with ASTM D4633-05, to include completed Summary of Daily Observations and Testing, Record of SPT Energy Measurement sheet(s), and PDIPLOT output data.

Specific Quality Assurance Procedures Applicable: None

Hold Points or Witness Points: Direction to perform energy measurements received from the Site Coordinator.

Records: All records generated shall be considered QA Records.

Reviewed and Approved By (Note: Only One Signature is Required to Issue):

Project Manager: Date:

Project Principal: Date:

Site Coordinator: Date: 4/28/06

No. of Pages: 1 DCN: SC53

2 PAGES + DISKETTE

4/28/06

1/2

MACTEC

2801 YORKMONT ROAD, SUITE 100 □ CHARLOTTE, NC 28208
Telephone: (704) 357-8600 / Facsimile: (704) 357-8638

RECORD OF SPT ENERGY MEASUREMENT

GENERAL INFORMATION		DRILL RIG DATA	
PROJECT:	SCE&G VC Summer COL	MAKE:	CME 55
LOCATION:	Jenkinsville, South Carolina	MODEL:	TRUCK RIG
PROJECT NO.:	6234-06-3534	SERIAL NO.:	209195
DATE:	4-28-06	HAMMER TYPE:	AUTOMATIC
WEATHER:	SUNNY, CLEAR, WARM 75°	ROPE CONDITION:	N/A
INSPECTOR:	Steve Kiser	ROD SIZE:	AW-J
DRILLING COMPANY:	MACTEC - ASHBURN	NO. OF SHEAVES:	N/A

BORING DATA

BORING NUMBER:	B-323		
DEPTH DRILLED:	85' PLANNED		
TIME DRIVEN:	1:40 PM START		
RIG OPERATOR:	HANK MEYERSON		
HAMMER OPERATOR:	N/A		
PDA PAK SERIAL NO.:	1430	1430	1430
INSTR. ROD AREA:	1.19 in²		
ACCEL. SERIAL NOS.:	P104 / P5953		
STRAIN SERIAL NOS.:	AW #75 1/2		

SAMPLE DEPTH (feet)	SPT N-VALUE (bpf)	DEPTH cont. (feet)	SPT N-VALUE (bpf)	SAMPLE DEPTH (feet)	SPT N-VALUE (bpf)	DEPTH cont. (feet)	SPT N-VALUE (bpf)	SAMPLE DEPTH (feet)	SPT N-VALUE (bpf)	DEPTH cont. (feet)	SPT N-VALUE (bpf)
11/12.5	2-4-6										
13.5/15	3-5-6										
18.5/20	3-4-6										
23.5/25	4-4-6										
28.5/30	4-4-5										
33.5/35	10-15-10										

MGC 4/28/06

MGC 4/28/06

REMARKS: NA

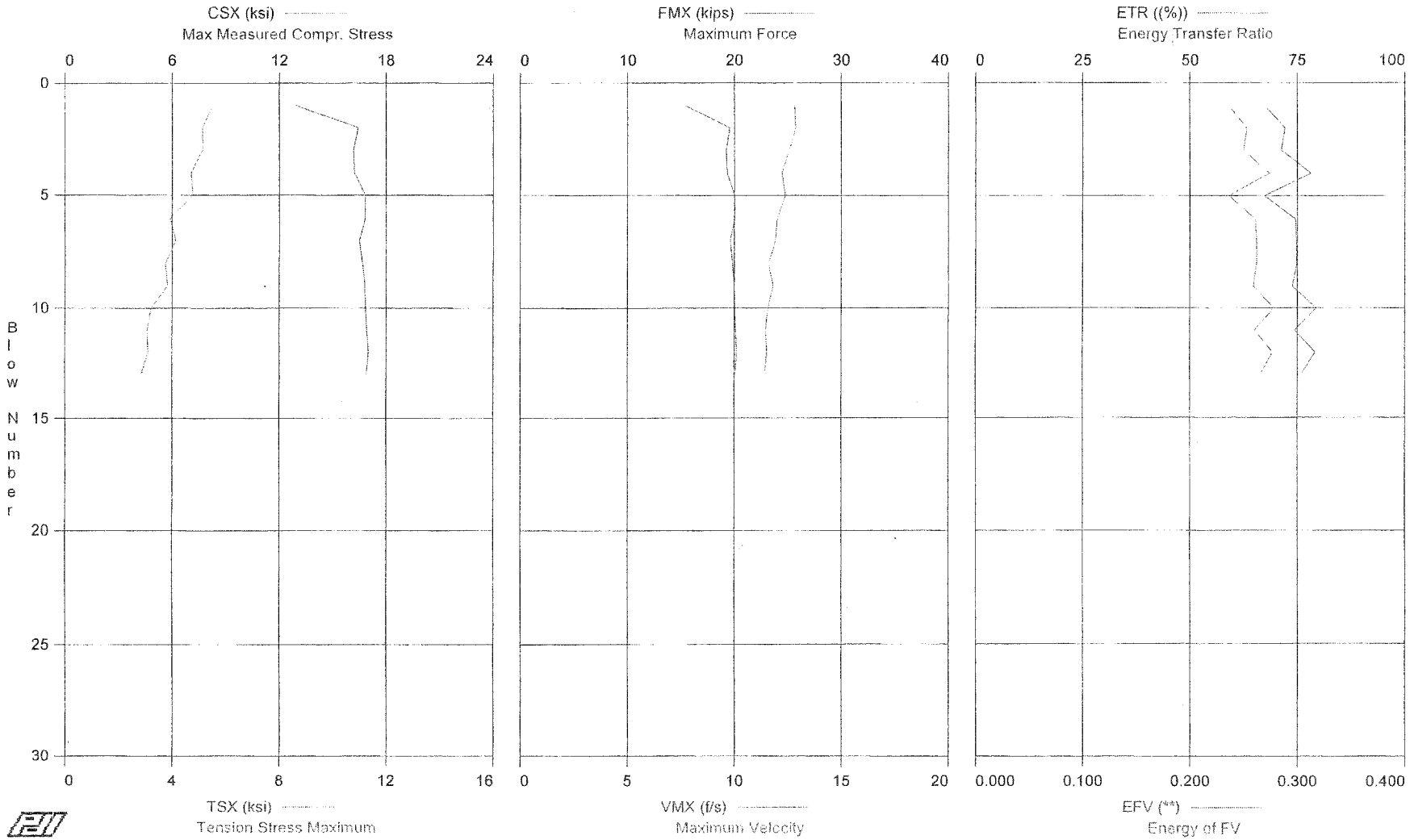
2/2

MACTEC Engineering and Consulting, Inc. - Case Method Results

PDIPLOT Ver. 2005.2 - Printed: 2-May-2006

Test date: 28-Apr-2006

VC Summer COL Site - Boring B-323; 11' - 12.5' Sample



MACTEC Engineering and Consulting, Inc.
Case Method Results

PDIPLOT Ver. 2005.2 - Printed: 2-May-2006

VC Summer COL Site - Boring B-323; 11' - 12.5' Sample
OP: SEK

Rig Serial No. 209195 CME 55 Ashburn Truck Rig
Test date: 28-Apr-2006

AR: 1.19 in^2
LE: 16.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000.0 ksi
JC: 0.70

CSX: Max Measured Compr. Stress
TSX: Tension Stress Maximum
FMX: Maximum Force
VMX: Maximum Velocity
DMX: Maximum Displacement

BPM: Blows per Minute
ETR: Energy Transfer Ratio
EMX: Max Transferred Energy
EFV: Energy of FV

BL#	depth ft	BLC bl/ft	CSX ksi	TSX ksi	FMX kips	VMX f/s	DMX in	BPM **	ETR (%)	EMX k-ft	EFV **
1	11.17	6	13.0	5.5	15	12.8	2.83	0.0	67.5	0.236	0.236
2	11.33	6	16.4	5.1	20	12.9	2.82	54.8	72.2	0.253	0.253
3	11.50	6	16.2	5.1	19	12.6	2.84	54.8	71.3	0.250	0.250
4	11.63	8	16.2	4.7	19	12.2	2.44	54.7	78.2	0.274	0.274
5	11.75	8	16.8	4.8	20	12.4	2.43	54.3	67.3	0.236	0.236
6	11.88	8	16.8	3.9	20	12.0	1.67	54.5	74.6	0.261	0.261
7	12.00	8	16.5	4.1	20	11.9	2.32	54.3	74.8	0.262	0.262
8	12.08	12	16.7	3.7	20	11.6	1.76	54.5	74.9	0.262	0.262
9	12.17	12	16.8	3.8	20	11.8	1.99	54.3	73.9	0.259	0.259
10	12.25	12	16.8	3.2	20	11.6	1.96	54.3	79.4	0.278	0.278
11	12.33	12	16.9	3.1	20	11.5	1.79	54.3	74.3	0.260	0.260
12	12.42	12	17.0	3.1	20	11.5	2.64	54.3	79.2	0.277	0.277
13	12.50	12	16.9	2.8	20	11.4	1.74	54.5	76.0	0.266	0.266
		Average	16.4	4.1	20	12.0	2.25	54.5	74.1	0.260	0.260

Total number of blows analyzed: 13

Time Summary

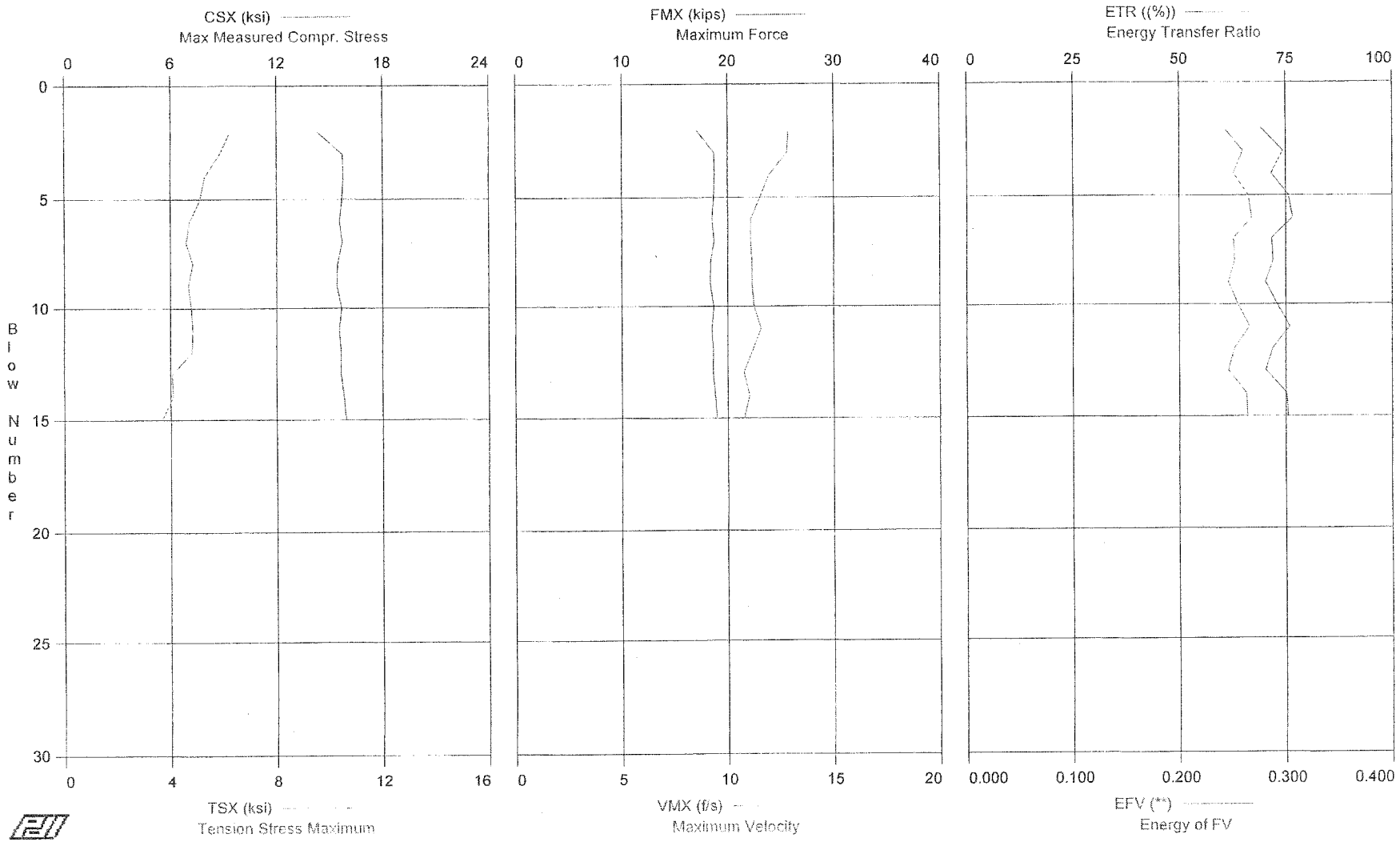
Drive 13 seconds 2:11:33 PM - 2:11:46 PM (4/28/2006) BN 1 - 13

MACTEC Engineering and Consulting, Inc. - Case Method Results

PDIPLOT Ver. 2005.2 - Printed: 2-May-2006

Test date: 28-Apr-2006

VC Summer COL Site - Boring B-323; 13.5' - 15' Sample



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MACTEC Engineering and Consulting, Inc.
Case Method Results

PDIPLOT Ver. 2005.2 - Printed: 2-May-2006

VC Summer COL Site - Boring B-323; 13.5' - 15' Sample
OP: SEK

Rig Serial No. 209195 CME 55 Ashburn Truck Rig
Test date: 28-Apr-2006

AR: 1.19 in^2
LE: 19.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000.0 ksi
JC: 0.70

CSX: Max Measured Compr. Stress
TSX: Tension Stress Maximum
FMX: Maximum Force
VMX: Maximum Velocity
DMX: Maximum Displacement

BPM: Blows per Minute
ETR: Energy Transfer Ratio
EMX: Max Transferred Energy
EFV: Energy of FV

BL#	depth ft	BLC bl/ft	CSX ksi	TSX ksi	FMX kips	VMX f/s	DMX in	BPM **	ETR (%)	EMX k-ft	EFV **
2	13.75	8	14.3	6.3	17	12.9	2.24	55.0	69.2	0.242	0.242
3	13.88	8	15.7	5.8	19	12.8	2.37	54.7	74.4	0.260	0.260
4	14.00	8	15.8	5.3	19	12.0	1.79	54.5	71.6	0.251	0.251
5	14.10	10	15.7	5.1	19	11.5	1.92	54.4	75.7	0.265	0.265
6	14.20	10	15.6	4.7	19	11.1	1.70	54.4	76.7	0.268	0.268
7	14.30	10	15.7	4.6	19	11.1	1.38	54.3	71.7	0.251	0.251
8	14.40	10	15.5	4.8	18	11.2	1.43	54.3	72.0	0.252	0.252
9	14.50	10	15.4	4.7	18	11.1	1.91	54.5	70.3	0.246	0.246
10	14.58	12	15.7	4.8	19	11.2	1.15	54.2	73.0	0.255	0.255
11	14.67	12	15.5	4.8	19	11.6	1.79	54.5	76.0	0.266	0.266
12	14.75	12	15.7	4.8	19	11.2	1.55	54.1	72.0	0.252	0.252
13	14.83	12	15.6	4.1	19	10.8	1.41	54.4	70.3	0.246	0.246
14	14.92	12	15.8	4.1	19	11.0	1.42	54.3	75.2	0.263	0.263
15	15.00	12	15.9	3.7	19	10.8	1.41	54.3	75.5	0.264	0.264
		Average	15.6	4.8	19	11.4	1.68	54.4	73.1	0.256	0.256

Total number of blows analyzed: 14

Time Summary

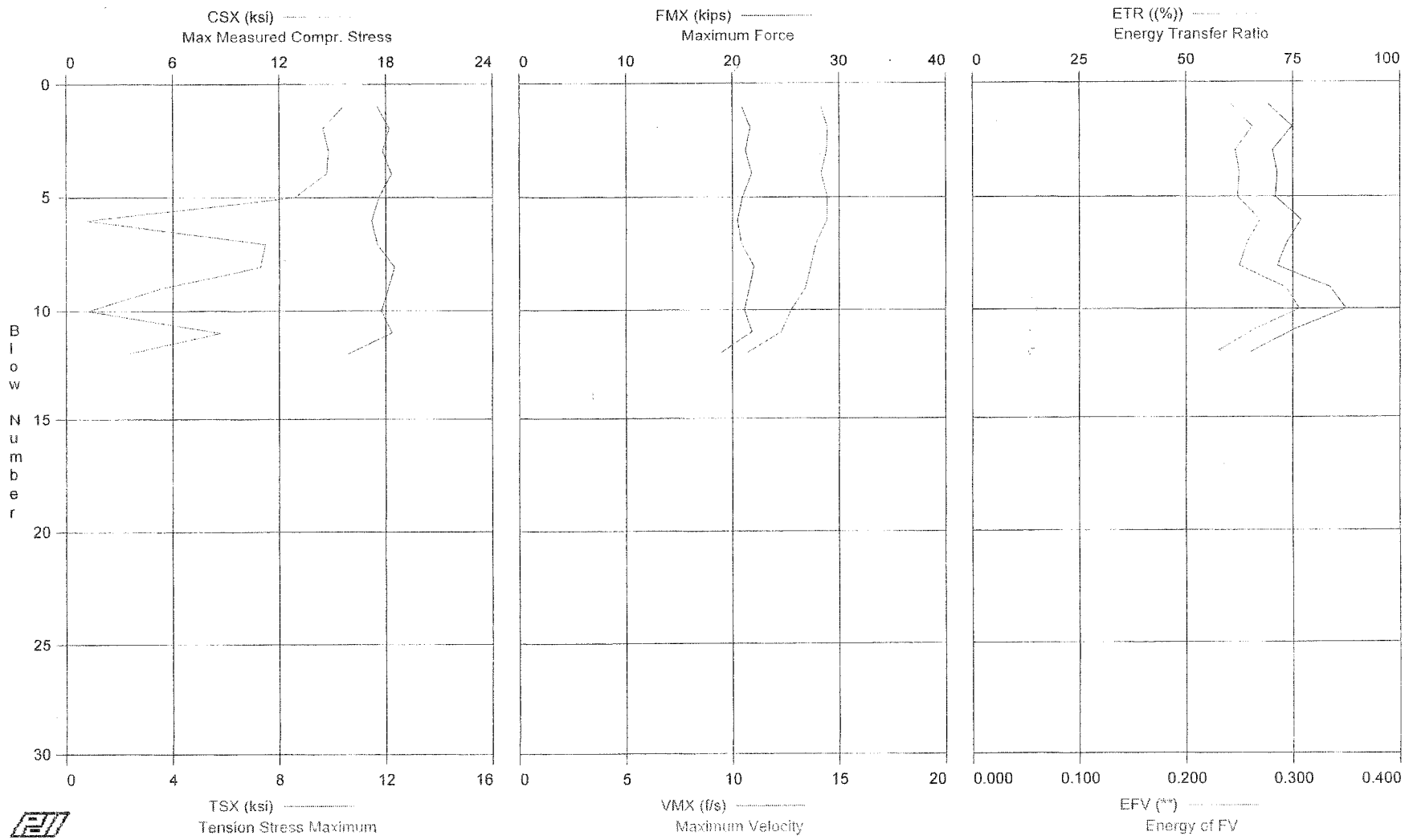
Drive 16 seconds 2:39:00 PM - 2:39:16 PM (4/28/2006) BN 1 - 15

MACTEC Engineering and Consulting, Inc. - Case Method Results

PDIPLOT Ver. 2005.2 - Printed: 2-May-2006

Test date: 28-Apr-2006

VC Summer COL Site - Boring B-323; 18.5' - 20' Sample



MACTEC Engineering and Consulting, Inc.
Case Method Results

PDIPLOT Ver. 2005.2 - Printed: 2-May-2006

VC Summer COL Site - Boring B-323; 18.5' - 20' Sample
OP: SEK

Rig Serial No. 209195 CME 55 Ashburn Truck Rig
Test date: 28-Apr-2006

AR: 1.19 in^2
LE: 24.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000.0 ksi
JC: 0.70

CSX: Max Measured Compr. Stress
TSX: Tension Stress Maximum
FMX: Maximum Force
VMX: Maximum Velocity
DMX: Maximum Displacement

BPM: Blows per Minute
ETR: Energy Transfer Ratio
EMX: Max Transferred Energy
EFV: Energy of FV

BL#	depth ft	BLC bl/ft	CSX ksi	TSX ksi	FMX kips	VMX f/s	DMX in	BPM **	ETR (%)	EMX k-ft	EFV **
1	18.75	4	17.5	10.4	21	14.1	3.72	0.0	69.2	0.242	0.242
2	19.00	4	18.2	9.6	22	14.5	3.50	54.7	74.9	0.262	0.262
3	19.13	8	17.8	9.9	21	14.4	2.91	54.3	70.3	0.246	0.246
4	19.25	8	18.3	9.8	22	14.2	2.71	54.2	71.3	0.250	0.250
5	19.38	8	17.6	8.6	21	14.5	3.56	54.3	70.8	0.248	0.248
6	19.50	8	17.2	0.7	20	14.4	2.82	54.1	76.9	0.269	0.269
7	19.58	12	17.5	7.5	21	13.9	2.61	54.2	73.5	0.257	0.257
8	19.67	12	18.5	7.3	22	13.7	3.03	54.2	71.4	0.250	0.250
9	19.75	12	18.1	3.4	22	13.4	2.67	54.2	83.6	0.293	0.293
10	19.83	12	17.8	0.8	21	12.8	2.56	54.3	87.4	0.306	0.306
11	19.92	12	18.4	5.8	22	12.3	1.56	54.2	74.8	0.262	0.262
12	20.00	12	15.9	2.2	19	10.7	1.78	46.8	65.2	0.228	0.228
		Average	17.7	6.3	21	13.6	2.79	53.6	74.1	0.259	0.259

Total number of blows analyzed: 12

Time Summary

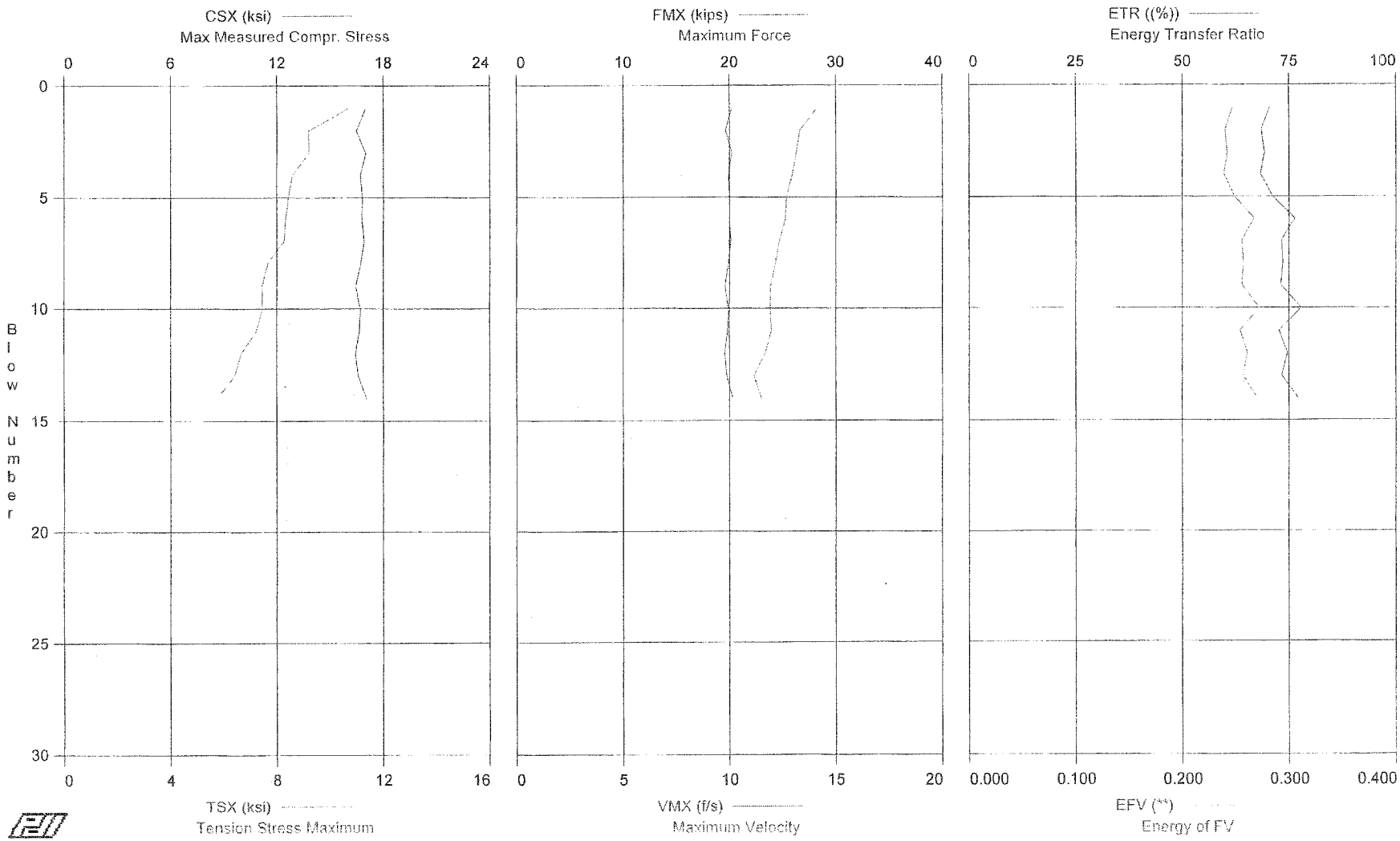
Drive 12 seconds 3:24:09 PM - 3:24:21 PM (4/28/2006) BN 1 - 12

MACTEC Engineering and Consulting, Inc. - Case Method Results

PDIPLOT Ver. 2005.2 - Printed: 2-May-2006

Test date: 28-Apr-2006

VC Summer COL Site - Boring B-323; 23.5' - 25' Sample



13

MACTEC Engineering and Consulting, Inc.
Case Method Results

PDIPLOT Ver. 2005.2 - Printed: 2-May-2006

VC Summer COL Site - Boring B-323; 23.5' - 25' Sample
OP: SEK

Rig Serial No. 209195 CME 55 Ashburn Truck Rig
Test date: 28-Apr-2006

AR: 1.19 in^2
LE: 29.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000.0 ksi
JC: 0.70

CSX: Max Measured Compr. Stress
TSX: Tension Stress Maximum
FMX: Maximum Force
VMX: Maximum Velocity
DMX: Maximum Displacement

BPM: Blows per Minute
ETR: Energy Transfer Ratio
EMX: Max Transferred Energy
EFV: Energy of FV

BL#	depth ft	BLC bl/ft	CSX ksi	TSX ksi	FMX kips	VMX f/s	DMX in	BPM **	ETR (%)	EMX k-ft	EFV **
1	23.63	8	17.0	10.7	20	14.1	2.85	0.0	70.5	0.247	0.247
2	23.75	8	16.5	9.2	20	13.3	2.57	54.2	68.5	0.240	0.240
3	23.88	8	17.0	9.2	20	13.1	2.20	53.9	69.3	0.242	0.242
4	24.00	8	16.7	8.6	20	13.0	2.26	53.9	68.3	0.239	0.239
5	24.13	8	16.8	8.4	20	12.7	2.08	53.8	71.1	0.249	0.249
6	24.25	8	16.8	8.3	20	12.6	2.30	53.8	76.3	0.267	0.267
7	24.38	8	16.9	8.3	20	12.4	2.06	53.8	73.3	0.256	0.256
8	24.50	8	16.7	7.6	20	12.2	1.76	54.0	73.6	0.257	0.257
9	24.58	12	16.4	7.4	20	11.9	1.72	53.9	73.0	0.256	0.256
10	24.67	12	16.7	7.5	20	11.9	1.82	53.9	77.8	0.272	0.272
11	24.75	12	16.7	7.2	20	12.0	1.62	53.9	72.7	0.254	0.254
12	24.83	12	16.4	6.6	20	11.7	2.20	53.6	74.6	0.261	0.261
13	24.92	12	16.6	6.4	20	11.2	1.42	53.8	73.4	0.257	0.257
14	25.00	12	17.1	5.7	20	11.5	1.51	53.8	77.1	0.270	0.270
		Average	16.7	7.9	20	12.4	2.03	53.9	72.8	0.255	0.255

Total number of blows analyzed: 14

Time Summary

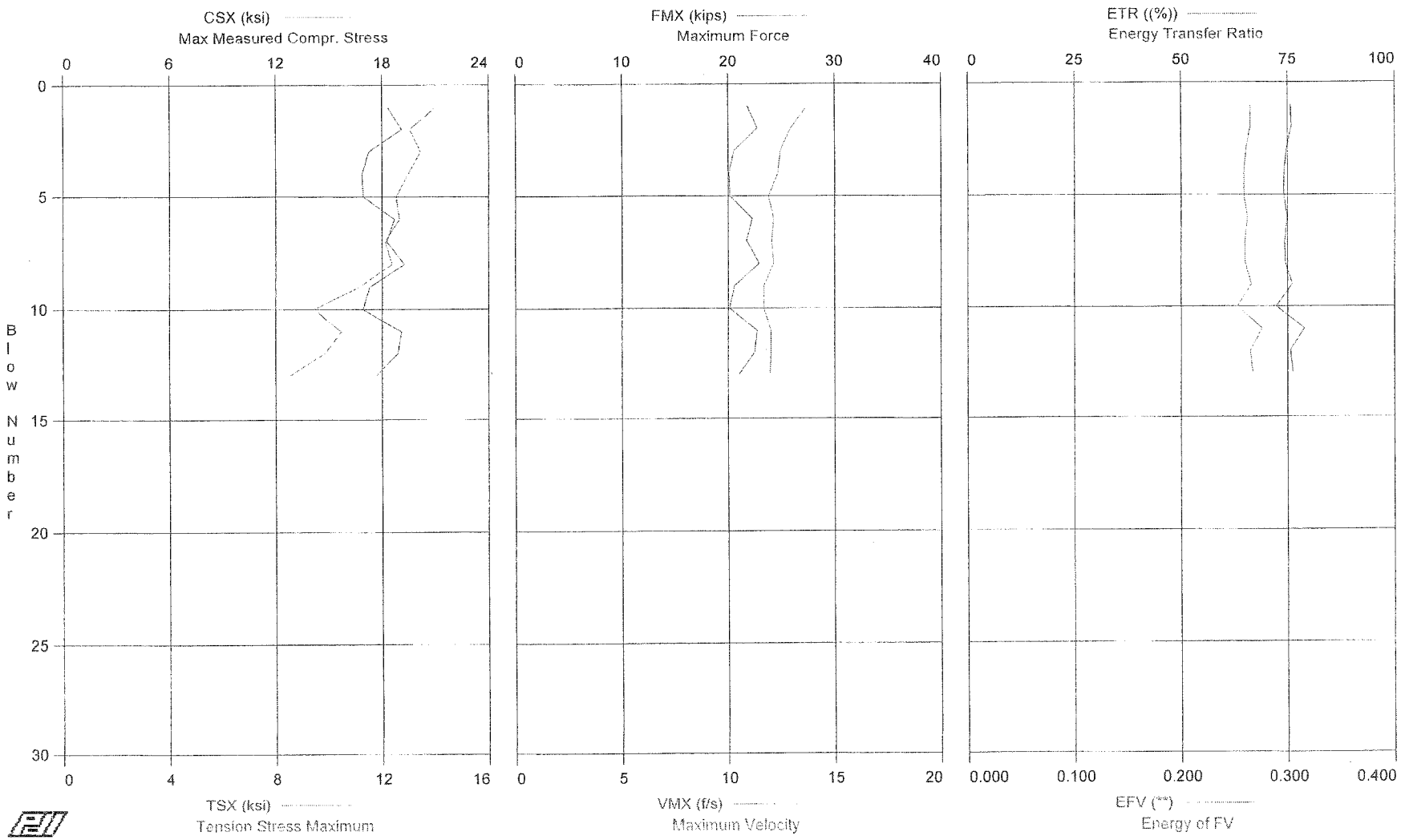
Drive 14 seconds 3:55:26 PM - 3:55:40 PM (4/28/2006) BN 1 - 14

MACTEC Engineering and Consulting, Inc. - Case Method Results

PDIPLOT Ver. 2005.2 - Printed: 2-May-2006

Test date: 28-Apr-2006

VC Summer COL Site - Boring B-323; 28.5' - 30' Sample



15

MACTEC Engineering and Consulting, Inc.
Case Method Results

PDIPLOT Ver. 2005.2 - Printed: 2-May-2006

VC Summer COL Site - Boring B-323; 28.5' - 30' Sample
OP: SEK

Rig Serial No. 209195 CME 55 Ashburn Truck Rig
Test date: 28-Apr-2006

AR: 1.19 in^2
LE: 34.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000.0 ksi
JC: 0.70

CSX: Max Measured Compr. Stress
TSX: Tension Stress Maximum
FMX: Maximum Force
VMX: Maximum Velocity
DMX: Maximum Displacement

BPM: Blows per Minute
ETR: Energy Transfer Ratio
EMX: Max Transferred Energy
EFV: Energy of FV

BL#	depth ft	BLC bl/ft	CSX ksi	TSX ksi	FMX kips	VMX f/s	DMX in	BPM **	ETR (%)	EMX k-ft	EFV **
1	28.63	8	18.3	14.0	22	13.7	2.91	0.0	75.7	0.265	0.265
2	28.75	8	19.1	13.0	23	12.9	2.50	54.5	75.8	0.265	0.265
3	28.88	8	17.3	13.5	21	12.5	2.09	54.2	74.7	0.261	0.261
4	29.00	8	16.9	13.0	20	12.3	2.24	54.3	74.1	0.259	0.259
5	29.13	8	16.9	12.5	20	11.9	2.07	53.9	74.1	0.259	0.259
6	29.25	8	18.7	12.7	22	12.1	2.12	54.3	74.9	0.262	0.262
7	29.38	8	18.3	12.1	22	12.0	2.08	54.2	74.3	0.260	0.260
8	29.50	8	19.3	12.4	23	12.1	2.07	54.2	74.4	0.260	0.260
9	29.60	10	17.3	11.1	21	11.7	2.20	54.1	76.1	0.266	0.266
10	29.70	10	16.9	9.5	20	11.7	1.93	54.3	72.3	0.253	0.253
11	29.80	10	19.1	10.5	23	12.0	2.91	54.2	78.9	0.276	0.276
12	29.90	10	18.9	9.8	22	12.0	2.16	54.1	75.7	0.265	0.265
13	30.00	10	17.7	8.5	21	12.0	2.32	54.2	76.2	0.267	0.267
		Average	18.0	11.7	21	12.2	2.28	54.2	75.2	0.263	0.263

Total number of blows analyzed: 13

Time Summary

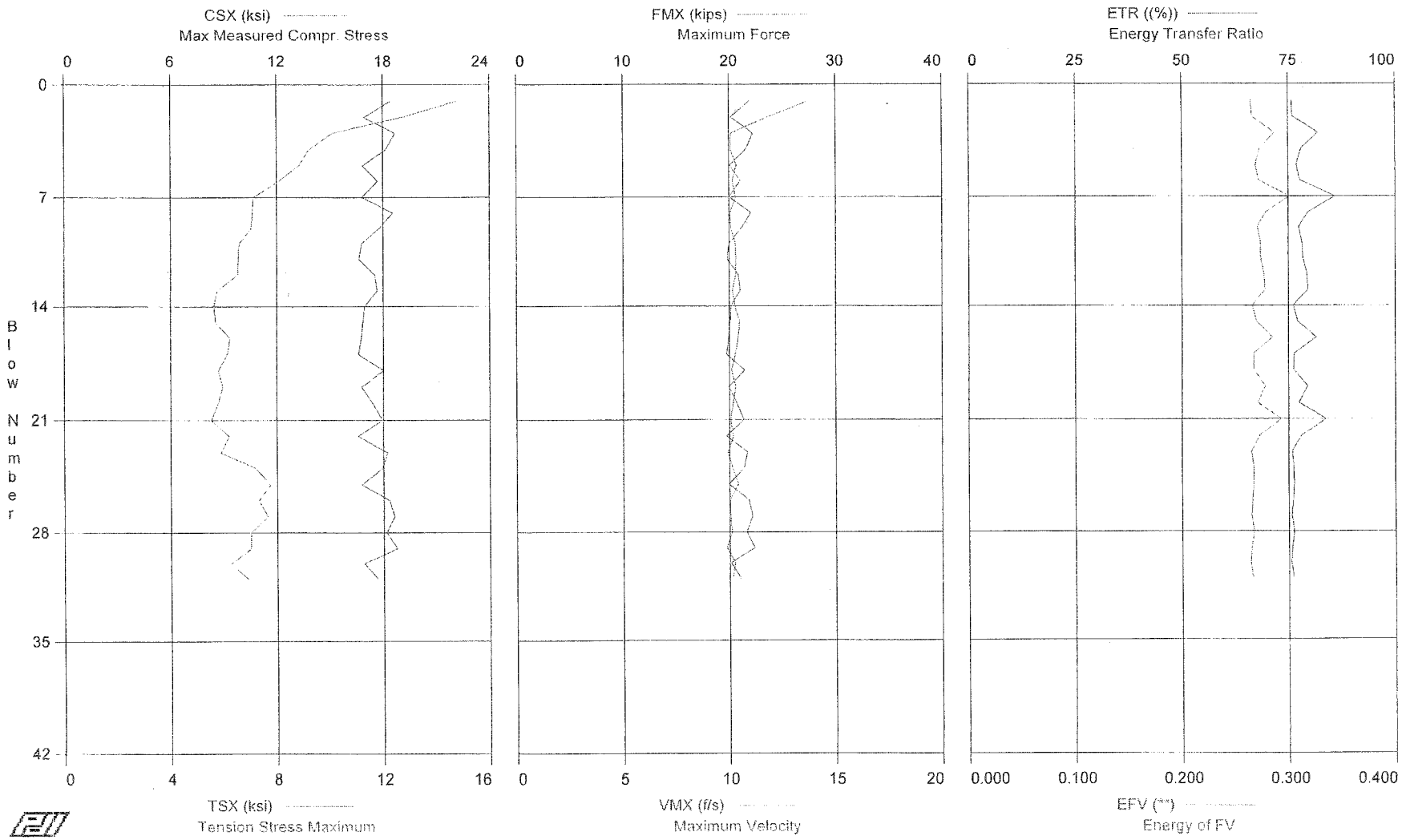
Drive 13 seconds 4:20:26 PM - 4:20:39 PM (4/28/2006) BN 1 - 13

MACTEC Engineering and Consulting, Inc. - Case Method Results

PDIPLOT Ver. 2005.2 - Printed: 2-May-2006

Test date: 28-Apr-2006

VC Summer COL Site - Boring B-323; 33.5' - 35' Sample



MACTEC Engineering and Consulting, Inc.
Case Method Results

PDIPLOT Ver. 2005.2 - Printed: 2-May-2006

VC Summer COL Site - Boring B-323; 33.5' - 35' Sample
OP: SEK

Rig Serial No. 209195 CME 55 Ashburn Truck Rig
Test date: 28-Apr-2006

AR: 1.19 in^2
LE: 39.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000.0 ksi
JC: 0.70

CSX: Max Measured Compr. Stress
TSX: Tension Stress Maximum
FMX: Maximum Force
VMX: Maximum Velocity
DMX: Maximum Displacement

BPM: Blows per Minute
ETR: Energy Transfer Ratio
EMX: Max Transferred Energy
EFV: Energy of FV

BL#	depth ft	BLC bl/ft	CSX ksi	TSX ksi	FMX kips	VMX f/s	DMX in	BPM **	ETR (%)	EMX k-ft	EFV **
1	33.58	12	18.4	14.8	22	13.8	2.91	0.0	75.8	0.265	0.265
2	33.67	12	16.9	12.7	20	11.8	1.77	55.9	76.1	0.266	0.266
3	33.75	12	18.7	10.1	22	10.1	0.99	54.6	81.9	0.287	0.287
4	33.83	12	18.1	9.2	22	10.1	1.09	54.9	78.0	0.273	0.273
5	33.92	12	16.9	8.8	20	10.4	1.07	54.5	76.8	0.269	0.269
6	34.00	12	17.7	8.1	21	10.2	1.28	54.6	77.6	0.272	0.272
7	34.03	30	16.8	7.1	20	10.3	1.31	54.6	85.9	0.301	0.301
8	34.07	30	18.6	7.1	22	10.0	0.92	54.6	79.7	0.279	0.279
9	34.10	30	17.8	7.0	21	10.1	1.25	54.5	77.4	0.271	0.271
10	34.13	30	16.8	6.6	20	10.3	1.16	54.4	78.2	0.274	0.274
11	34.17	30	16.6	6.5	20	10.3	1.09	54.7	78.4	0.274	0.274
12	34.20	30	17.5	6.5	21	10.3	1.04	54.4	79.3	0.277	0.277
13	34.23	30	17.7	5.8	21	10.1	1.05	54.6	79.5	0.278	0.278
14	34.27	30	17.0	5.6	20	10.3	0.52	54.6	76.1	0.266	0.266
15	34.30	30	16.9	5.7	20	10.5	1.13	54.5	77.1	0.270	0.270
16	34.33	30	16.8	6.2	20	10.4	1.40	54.5	81.5	0.285	0.285
17	34.37	30	16.6	6.1	20	10.3	0.99	54.5	76.3	0.267	0.267
18	34.40	30	18.0	5.8	21	10.1	0.87	54.4	76.2	0.267	0.267
19	34.43	30	16.8	6.0	20	10.3	1.41	54.4	79.4	0.278	0.278
20	34.47	30	17.4	5.8	21	10.2	0.77	54.4	77.4	0.271	0.271
21	34.50	30	18.0	5.5	21	10.1	1.40	54.3	83.7	0.293	0.293
22	34.55	20	16.6	6.2	20	10.2	1.11	54.6	78.0	0.273	0.273
23	34.60	20	18.2	5.9	22	9.9	1.34	54.4	75.8	0.265	0.265
24	34.65	20	18.0	7.2	21	10.1	1.27	54.5	76.2	0.267	0.267
25	34.70	20	16.8	7.7	20	10.4	1.06	54.3	76.3	0.267	0.267
26	34.75	20	18.3	7.3	22	10.0	1.86	54.5	76.1	0.266	0.266
27	34.80	20	18.6	7.7	22	10.0	1.38	54.3	75.6	0.265	0.265
28	34.85	20	18.2	7.0	22	10.1	1.73	54.3	76.2	0.267	0.267
29	34.90	20	18.8	7.0	22	9.9	1.14	54.4	75.8	0.265	0.265
30	34.95	20	16.9	6.2	20	10.3	1.52	54.3	75.5	0.264	0.264
31	35.00	20	17.7	6.9	21	10.1	1.83	54.4	76.0	0.266	0.266
		Average	17.5	7.3	21	10.4	1.28	54.5	77.9	0.273	0.273

Total number of blows analyzed: 31

Time Summary

Drive 33 seconds 5:11:29 PM - 5:12:02 PM (4/28/2006) BN 1 - 31

November 21, 2006

Memorandum to File DCN SC137
From: Steve Kiser SK 11-21-06
Reviewed By: Clay Sams CES 11-21-06

Subject: **Report of SPT Energy – MACTEC Knoxville CME 55 Rig (Serial No. 212393) Automatic Hammer**
WORK INSTRUCTION DCN SC137
VC Summer COL Site
South Carolina Electric and Gas (SCE&G)
Jenkinsville, South Carolina
MACTEC Project No. 6234-06-3534S

Steve Kiser, P.E. of MACTEC Engineering and Consulting, Inc. (MACTEC), performed energy measurements on the drill rig at the Fairfield Resort site per the referenced Work Instruction. This memorandum summarizes the field testing activities and presents the results of the energy measurements.

SPT Energy Field Measurements

SPT energy measurements were made on November 20, 2006, during drilling of Boring B-7 at the Fairfield Resort site in Sevierville, Tennessee. The testing was performed from approximately 8:00 AM to 9:00 AM under cloudy skies with intermittent rain and snow and a temperature of about 35 degrees Fahrenheit. The boring was drilled with personnel and equipment from the Knoxville, Tennessee office of MACTEC. The drilling equipment and tools were the same as used at the SCE&G COL site and consisted of a CME 55 model ATV-mounted drill rig with an SPT automatic hammer. The drilling tools consisted of AW-J-sized drilling rods and a 2-foot long split tube sampler. Hollow-stem auger drilling techniques were used to advance the boring. The drill rig operator during sampling was Mr. George Akins. Energy measurements were recorded during sampling at the depth intervals shown in Table 1. The length of the drill rod string (including the instrumented drill rod insert described below) for each sample was generally 4 feet longer than the depth of the sample being collected.

The energy measurements were performed with a Pile Driving Analyzer (PDA) model PAK (Serial No. 1430), and calibrated accelerometers (Serial Nos. P5953 and P5094) and strain gages (Serial Nos. AW #144/1 and AW#144/2). An AW-sized steel drill rod, 2 feet long and instrumented with dedicated strain gages, was inserted at the top of the drill rod string immediately below the SPT hammer. The inserted rod was also instrumented with two piezoresistive accelerometers that were bolted to the outside of the rod. The instrumented rod insert had a cross-sectional area of approximately 1.19 square inches at the gage location.

Calibration Records

The calibration records for all the above are filed in DCN SC 102, Rev. 2. The confirmation certificate for the SPT hammer weight is contained in DCN SC4.

Calculations for EFV

The work was done in general accordance with ASTM D 4633-05. The strain and acceleration signals were converted to force and velocity by the PDA, and the data was interpreted by the PDA according to the Case Method equation. The maximum energy transmitted to the drill rod string (as measured at the location of the strain gages and accelerometers) was calculated by the PDA using the EFV method equation, as shown below:

$$EFV = \int F(t) * V(t) * dt$$

Where: EFV = Transferred energy (EFV equation), or Energy of FV
F(t) = Calculated force at time t
V(t) = Calculated velocity at time t

The EFV method of energy calculation is recommended in ASTM Standard D4633-05. The EFV equation, integrated over the complete wave event, measures the total energy content of the event using both force and velocity measurements. The EFV values associated with each blow analyzed are tabulated in the attached PDIPLOT tables and are also shown graphically in the PDIPLOT charts.

Calculations for ETR

The ratio of the measured transferred energy (EFV) to the theoretical potential energy of the SPT system (140 lb weight with the specified 30 inch fall) is the ETR. The ETR values (as percent of the theoretical value) are shown in Table 1.

Comparison of ETR to Typical Energy Transfer Ratio Range

Based on a research report published by the Florida Department of Transportation (FDOT) (Report WPI No. 0510859, 1999), the average ETR measured for automatic hammers is 79.6%. The standard deviation was 7.9%; therefore, the range of ETRs within one standard deviation of the average was reported to be 71.7% to 87.5%. This range of ETRs was also consistent with other research that was cited in the FDOT research paper. The ETR values shown in Table 1 are within the range of typical values for automatic hammers as reported in the literature.

Discussion

Based on the field testing results, observations from the SPT energy measurements are summarized below:

- The data obtained by the PDA are consistent between individual hammer blows and between the sample depths tested. In general, the first one (and sometimes two) hammer blow records recorded by the PDA produced poor quality data (which is relatively common) and, as such, the record(s) was(were) not used in the data reduction.

- The average energy transferred from the hammer to the drill rods for each individual depth interval using the EFV method ranged from 262 foot-pounds to

280 foot-pounds. These average energy transfers correspond to energy transfer ratios (ETR) of 75% to 80% of the theoretical energy (350 foot-pounds) of the SPT hammer.

- The average at each depth interval was calculated as the transferred energy for each analyzed blow of the depth intervals divided by the total number of hammer blows analyzed. The overall average energy transfer of the SPT system (for all the depth intervals tested) was 268.1 foot-pounds, with an average ETR of 76.6%.

Attachments:
Page 4 Table 1 - Summary of SPT Energy Measurements – 1 Page
Page 5 Work Instructions – SPT Energy MACTEC Knoxville CME-550 (Hammer #212393) – 1 Page
Page 6 Record of SPT Energy Measurement – 1 Page
Pages 7-~~18~~ 16 PDIPLOT Output – 10 Pages
CEI

TABLE 1
SUMMARY OF SPT ENERGY MEASUREMENTS (ASTM D4633-05)
VC Summer COL Site
Jenkinsville, South Carolina
MACTEC Project No. 6234-06-3534, Task 18

Rig Serial No.	Rig Owner	Rig Operator	Boring No. Tested	Date Tested	Sample Depth (feet)	SPT Blow Count (blows per six inches)	No. of Blows Analyzed	Average Measured Energy (Average EFV) (ft-lbs)[a]	Energy Transfer Ratio (%)[b] (Average ETR)
212393 (CME 55 ATV)[c]	MACTEC (Knoxville Office)	George Akins	B-7	11/20/2006	13.5 - 15.0	11 - 7 - 12	26	262	74.9%
					18.5 - 20.0	9 - 6 - 11	17	280	80.0%
					23.5 - 25.0	12 - 14 - 12	41	270	77.1%
					28.5 - 30.0	9 - 10 - 12	32	267	76.3%
					33.5 - 35.0	4 - 50/4"	44	266	76.0%
							Average for Rig:	**268.1**	**76.6%**

[a]Measured Energy is energy based on the EFV method, as outlined in ASTM D4633-05, for each blow recorded by the PDA. In some cases, the initial one to two blows produced poor quality data, and were not used to calculate the Average Measured Energy.

[b]Energy Transfer Ratio is the Measured Energy divided by the theoretical SPT energy of 350 foot-pounds (140 pound hammer falling 2.5 feet). The average ETR values may differ slightly and insignificantly from those in the PDIPLOT tables due to roundoff.

[c]Rig was tested on Boring B-7 at the Fairfield Resort site in Sevierville, Tennessee

Prepared By: [illegible]	Date: 11-21-06	Checked By: Clay Adams	Date: 11-21-06

4

Work Instructions – SPT Energy MACTEC Knoxville CME-550 (Hammer #212393)

SCE&G COL Project

Issued To: Steve Kiser

Location: MACTEC Columbia Office Date: October 23, 2006

Issued By: Matthew F. Cooke, Site Coordinator

Valid From: October 23, 2006 To: October 23, 2007

Task Description: Measurement of energy transferred to the drill string rods from a Standard Penetration Test (SPT) automatic hammer mounted on a drill rig. Testing will be performed using a Pile Driving Analyzer (PDA) model PAK at various depth intervals from approximately 10 to 50 feet below the ground surface for each rig drilling SPT borings at the SCE&G COL Site.

Applicable Technical Procedures or Plans, or other reference: ASTM D4633-05 Standard Test Method for Energy Measurement for Dynamic Penetrometers.

Specific Instructions (note attachments where necessary): Obtain energy measurements with the PDA at depth intervals in the range of about 10 to 50 feet below the ground surface in general accordance with ASTM D4633-05. Perform energy measurement testing for MACTEC CME-550 Automatic Hammer #212393.

Report Format: Written report documenting results of field testing in general accordance with ASTM D4633-05, to include completed Summary of Daily Observations and Testing, Record of SPT Energy Measurement sheet(s), and PDIPLOT output data.

Specific Quality Assurance Procedures Applicable: None

Hold Points or Witness Points: Direction to perform energy measurements received from the Site Coordinator.

Records: All records generated shall be considered QA Records.

Reviewed and Approved By (Note: Only One Signature is Required to Issue):

Project Manager: Date:

Project Principal: Date:

Site Coordinator: Date: 10/23/06

No. of Pages: 1 DCN: SC137

MACTEC

2801 YORKMONT ROAD, SUITE 100 . CHARLOTTE, NC 28208
Telephone: (704) 357-8600 / Facsimile: (704) 357-8638

RECORD OF SPT ENERGY MEASUREMENT

GENERAL INFORMATION		DRILL RIG DATA	
PROJECT:	FAIRFIELD RESORT	MAKE:	CME
LOCATION:	SEVIERVILLE, TENN.	MODEL:	55 ATV
PROJECT NO.:	6382-06-0116	SERIAL NO.:	212393
DATE:	11-20-06	HAMMER TYPE:	AUTOMATIC
WEATHER:	CLOUDY, COLD, SNOWY; 35°	ROPE CONDITION:	N/A
INSPECTOR:	Steve Kiser	ROD SIZE:	AW-J
DRILLING COMPANY:	MACTEC KNOXVILLE	NO. OF SHEAVES:	N/A

BORING DATA			
BORING NUMBER:	B-7		
DEPTH DRILLED:	35'		
TIME DRIVEN:	8:45 AM		
RIG OPERATOR:	GEORGE AKINS		
HAMMER OPERATOR:	N.R.		
PDA PAK SERIAL NO.:	1430	1430	1430
INSTR. ROD AREA:	1.19 in²		
ACCEL. SERIAL NOS.:	P5953 P5094		
STRAIN SERIAL NOS.:	144 AW 1/2		

SAMPLE DEPTH (feet)	SPT N-VALUE (bpf)	DEPTH cont. (feet)	SPT N-VALUE (bpf)	SAMPLE DEPTH (feet)	SPT N-VALUE (bpf)	DEPTH cont. (feet)	SPT N-VALUE (bpf)	SAMPLE DEPTH (feet)	SPT N-VALUE (bpf)	DEPTH cont. (feet)	SPT N-VALUE (bpf)
13.5/15	11-7-12										
18.5/20	9-6-11										
23.5/25	12-14-12										
28.5/30	9-10-12										
33.5/35	4-50/5"										

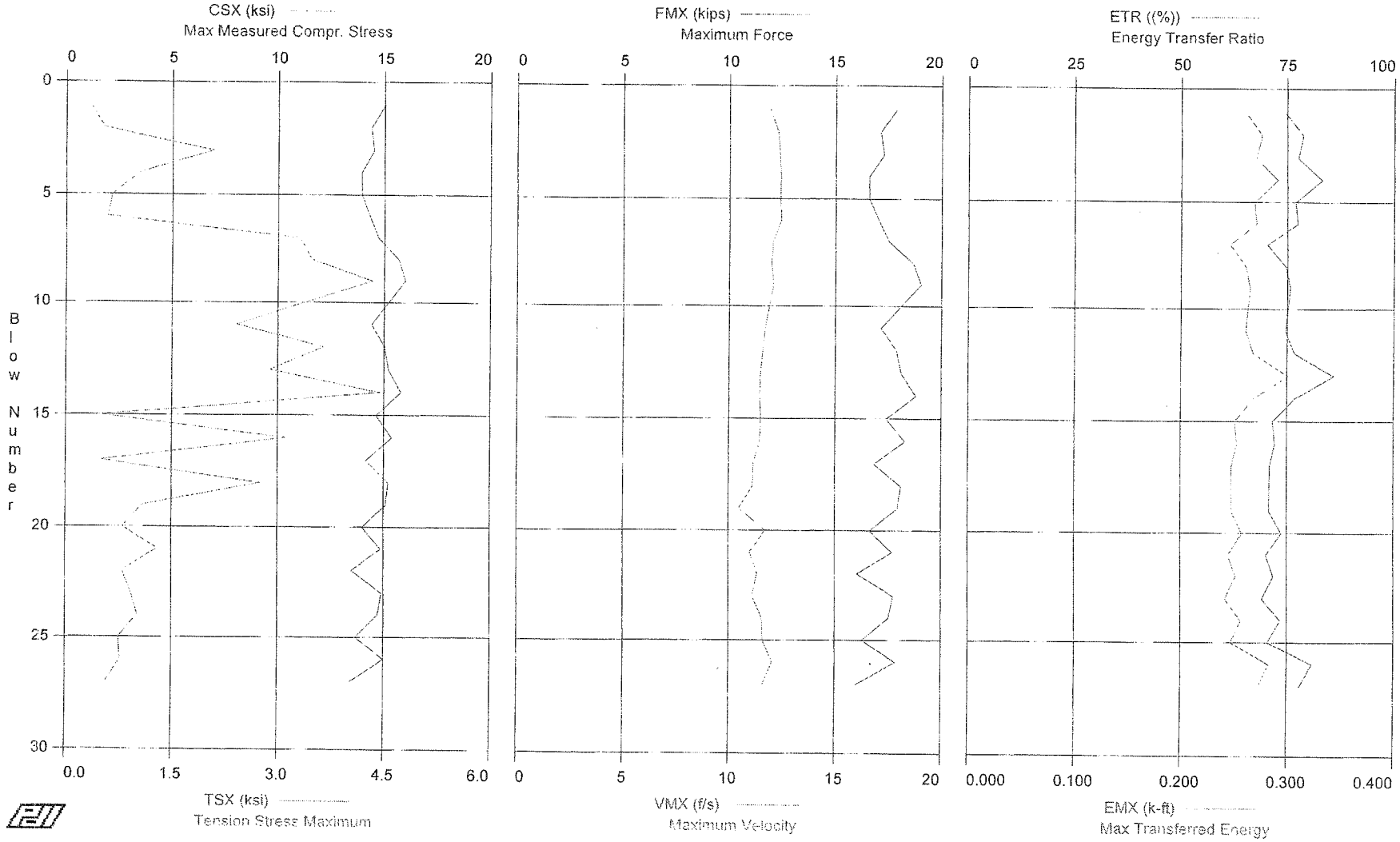
REMARKS:

PDIPLOT Ver. 2005.2 - Printed: 20-Nov-2006

MACTEC Engineering and Consulting, Inc. - Case Method Results

Test date: 20-Nov-2006

North Anna COL Project - Boring B-7; 13.5' - 15' Sample



MACTEC Engineering and Consulting, Inc.
Case Method Results

PDIPLOT Ver. 2005.2 - Printed: 20-Nov-2006

North Anna COL Project - Boring B-7; 13.5' - 15' Sample
OP: SEK

Rig Serial No. 212393 (MACTEC Knoxville CME 55)
Test date: 20-Nov-2006

AR: 1.19 in^2
LE: 19.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.60

CSX: Max Measured Compr. Stress
TSX: Tension Stress Maximum
FMX: Maximum Force
VMX: Maximum Velocity
DFN: Final Displacement

BPM: Blows per Minute
EFV: Energy of FV
ETR: Energy Transfer Ratio
EMX: Max Transferred Energy

BL#	depth ft	CSX ksi	TSX ksi	FMX kips	VMX f/s	DFN in	BPM **	EFV **	ETR (%)	EMX k-ft
1	0.00	15.03	0.34	18	11.9	0.63	0.0	0.3	74.5	0.261
2	0.00	14.37	0.54	17	12.3	0.82	55.6	0.3	78.8	0.276
3	0.00	14.51	2.09	17	12.4	0.74	53.6	0.3	77.5	0.271
4	0.00	13.93	1.05	17	12.4	1.36	54.8	0.3	83.1	0.291
5	0.00	13.94	0.65	17	12.4	0.24	54.3	0.3	76.9	0.269
6	0.00	14.32	0.58	17	12.4	0.36	54.7	0.3	77.4	0.271
7	0.00	14.72	3.31	18	12.1	0.78	27.4	0.2	70.2	0.246
8	0.00	15.69	3.48	19	12.0	0.40	54.0	0.3	74.6	0.261
9	0.00	16.00	4.34	19	12.1	1.04	56.1	0.3	75.7	0.265
11	0.00	14.42	2.41	17	11.7	1.19	42.7	0.3	74.6	0.261
12	0.00	15.03	3.65	18	11.6	1.44	55.4	0.3	76.7	0.268
13	0.00	15.22	2.88	18	11.5	1.72	54.7	0.3	86.0	0.301
14	0.00	15.81	4.45	19	11.4	1.54	54.6	0.3	76.7	0.268
15	0.00	14.64	0.48	17	11.5	1.66	53.6	0.3	71.7	0.251
16	0.00	15.38	3.12	18	11.5	1.52	56.3	0.3	72.2	0.253
17	0.00	14.16	0.50	17	11.2	1.15	56.3	0.2	71.0	0.248
18	0.00	15.23	2.75	18	11.1	0.57	53.6	0.2	70.9	0.248
19	0.00	15.10	1.09	18	10.5	0.61	27.4	0.2	70.8	0.248
20	0.00	14.00	0.81	17	11.7	0.61	55.0	0.3	73.7	0.258
21	0.00	14.88	1.31	18	11.0	0.37	55.1	0.2	70.1	0.245
22	0.00	13.49	0.80	16	11.3	0.79	27.4	0.3	71.9	0.252
23	0.00	14.91	0.93	18	11.1	0.02	55.1	0.2	69.2	0.242
24	0.00	14.73	1.02	18	11.6	0.83	53.7	0.3	73.5	0.257
25	0.00	13.67	0.76	16	11.6	0.48	54.3	0.2	70.5	0.247
26	0.00	14.99	0.78	18	12.0	1.03	54.8	0.3	80.9	0.283
27	0.00	13.43	0.57	16	11.6	1.06	55.6	0.3	78.0	0.273
	Average	14.68	1.72	17	11.7	0.88	51.0	0.3	74.9	0.262

Total number of blows analyzed: 26

Time Summary

Drive 33 seconds 7:59:24 AM - 7:59:57 AM (11/20/2006) BN 1 - 27

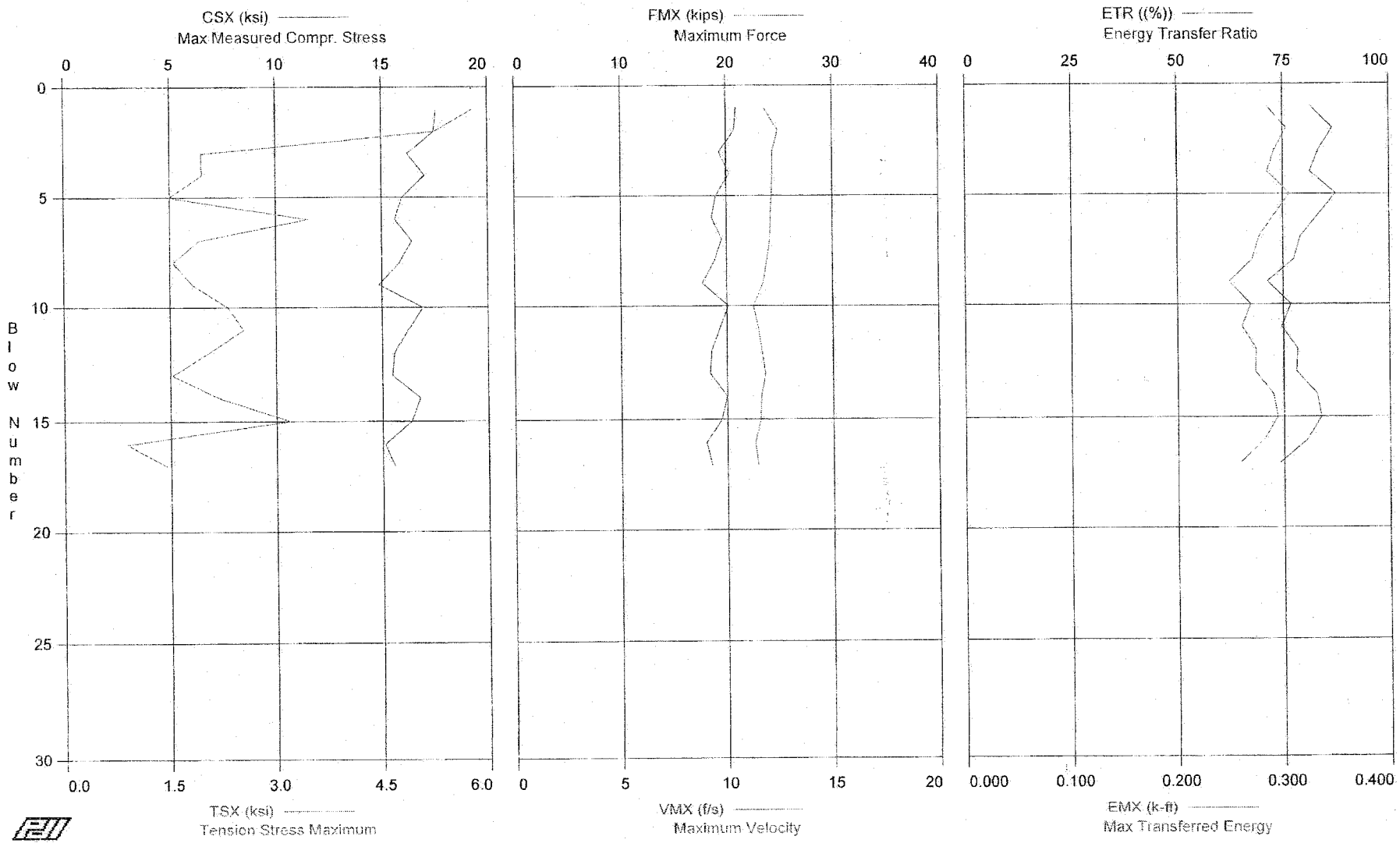
8

MACTEC Engineering and Consulting, Inc. - Case Method Results

PDIPLOT Ver. 2005.2 - Printed: 20-Nov-2006

Test date: 20-Nov-2006

North Anna COL Project - Boring B-7; 18.5' - 20' Sample



MACTEC Engineering and Consulting, Inc.
Case Method Results

PDIPLOT Ver. 2005.2 - Printed: 20-Nov-2006

North Anna COL Project - Boring B-7; 18.5' - 20' Sample
OP: SEK

Rig Serial No. 212393 (MACTEC Knoxville CME 55)
Test date: 20-Nov-2006

AR: 1.19 in^2
LE: 24.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.60

CSX: Max Measured Compr. Stress
TSX: Tension Stress Maximum
FMX: Maximum Force
VMX: Maximum Velocity
DFN: Final Displacement

BPM: Blows per Minute
EFV: Energy of FV
ETR: Energy Transfer Ratio
EMX: Max Transferred Energy

BL#	depth ft	CSX ksi	TSX ksi	FMX kips	VMX f/s	DFN in	BPM **	EFV **	ETR (%)	EMX k-ft
1	0.00	17.61	5.79	21	11.8	0.97	0.0	0.3	81.5	0.285
2	0.00	17.46	5.25	21	12.4	1.02	53.5	0.3	86.7	0.303
3	0.00	16.22	1.95	19	12.2	0.97	55.2	0.3	83.4	0.292
4	0.00	17.04	1.96	20	12.2	1.12	54.9	0.3	81.4	0.285
5	0.00	15.97	1.49	19	12.1	1.30	54.9	0.3	87.4	0.306
6	0.00	15.63	3.46	19	12.1	0.92	54.8	0.3	83.0	0.291
7	0.00	16.42	1.91	20	12.0	0.67	55.1	0.3	79.0	0.277
8	0.00	15.83	1.55	19	11.9	0.11	55.2	0.3	77.5	0.271
9	0.00	14.86	1.82	18	11.7	0.75	55.5	0.2	71.2	0.249
10	0.00	16.95	2.32	20	11.3	0.61	54.6	0.3	76.7	0.269
11	0.00	16.23	2.54	19	11.5	0.60	54.5	0.3	74.6	0.261
12	0.00	15.58	2.05	19	11.7	0.95	55.5	0.3	78.3	0.274
13	0.00	15.48	1.53	18	11.8	1.17	54.3	0.3	78.0	0.273
14	0.00	16.78	2.19	20	11.6	1.13	53.7	0.3	82.8	0.290
15	0.00	16.37	3.19	19	11.6	1.25	55.9	0.3	83.9	0.294
16	0.00	15.12	0.89	18	11.3	1.44	53.5	0.3	80.4	0.281
17	0.00	15.57	1.45	19	11.4	0.84	55.8	0.3	74.1	0.259
	Average	16.18	2.43	19	11.8	0.93	54.8	0.3	80.0	0.280

Total number of blows analyzed: 17

Time Summary

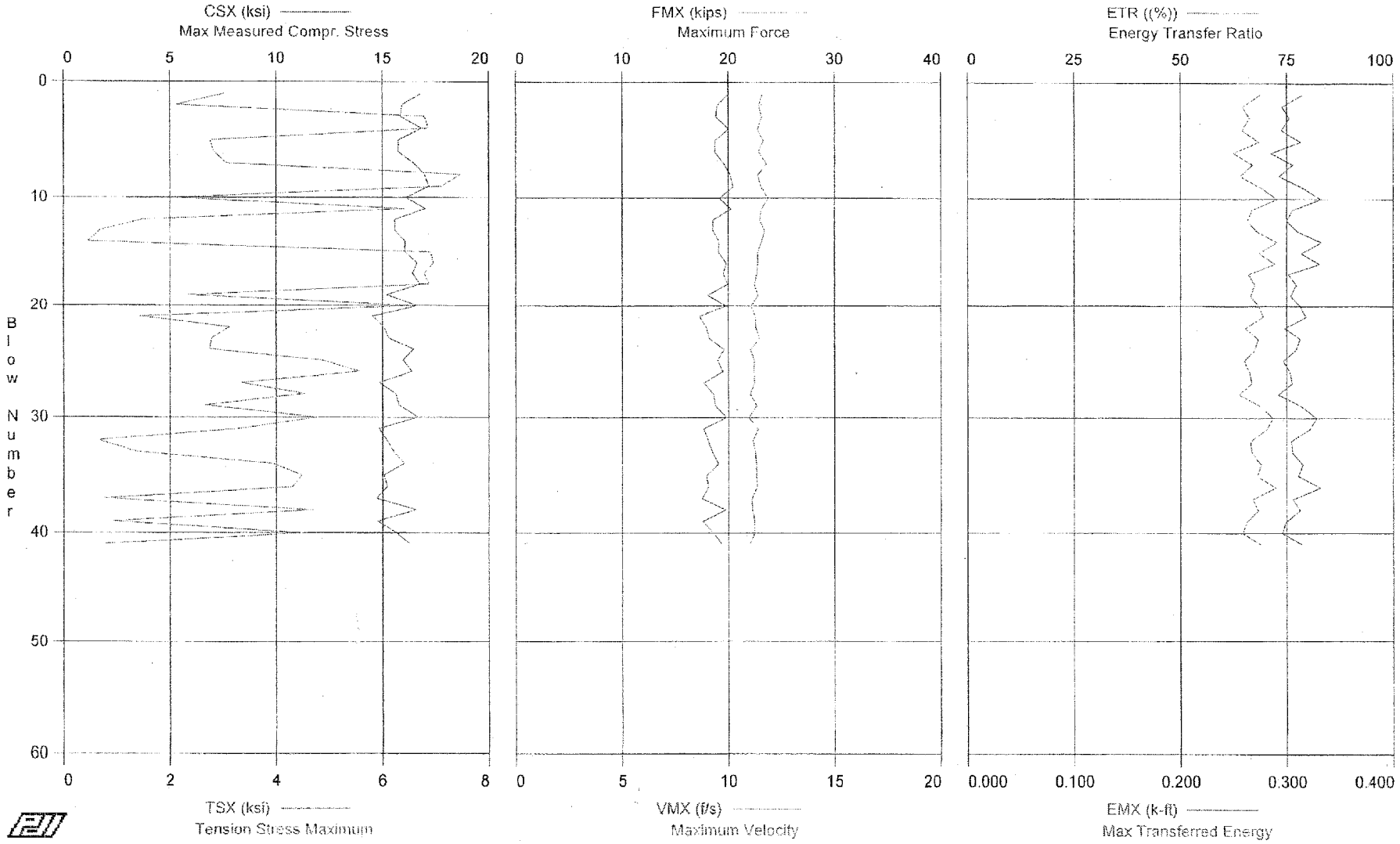
Drive 17 seconds 8:18:08 AM - 8:18:25 AM (11/20/2006) BN 1 - 17

PDIPLOT Ver. 2005.2 - Printed: 20-Nov-2006

MACTEC Engineering and Consulting, Inc. - Case Method Results

Test date: 20-Nov-2006

North Anna COL Project - Boring B-7; 23.5' - 25' Sample



MACTEC Engineering and Consulting, Inc.
Case Method Results

PDIPLOT Ver. 2005.2 - Printed: 20-Nov-2006

North Anna COL Project - Boring B-7; 23.5' - 25' Sample
OP: SEK

Rig Serial No. 212393 (MACTEC Knoxville CME 55)
Test date: 20-Nov-2006

AR: 1.19 in^2
LE: 29.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.60

CSX: Max Measured Compr. Stress
TSX: Tension Stress Maximum
FMX: Maximum Force
VMX: Maximum Velocity
DFN: Final Displacement

BPM: Blows per Minute
EFV: Energy of FV
ETR: Energy Transfer Ratio
EMX: Max Transferred Energy

BL#	depth ft	CSX ksi	TSX ksi	FMX kips	VMX f/s	DFN in	BPM **	EFV **	ETR (%)	EMX k-ft
1	0.00	16.84	3.04	20	11.6	0.41	0.0	0.3	78.6	0.275
2	0.00	15.93	2.13	19	11.5	0.51	58.0	0.3	74.0	0.259
3	0.00	15.84	6.80	19	11.6	0.79	53.5	0.3	75.7	0.265
4	0.00	16.85	6.86	20	11.4	0.44	55.2	0.3	73.7	0.258
5	0.00	15.75	2.75	19	11.6	1.03	52.5	0.3	78.3	0.274
6	0.00	15.75	2.83	19	11.4	0.97	27.1	0.3	71.3	0.250
7	0.00	16.47	3.07	20	11.8	0.57	55.2	0.3	76.5	0.268
8	0.00	16.97	7.47	20	11.4	0.47	53.7	0.3	73.2	0.256
9	0.00	17.19	7.12	20	11.5	1.61	27.3	0.3	78.8	0.276
10	0.00	16.11	2.06	19	11.9	1.21	53.2	0.3	83.1	0.291
11	0.00	17.03	6.42	20	11.6	0.56	55.5	0.3	76.4	0.267
12	0.00	15.58	1.49	19	11.5	1.34	53.0	0.3	75.1	0.263
13	0.00	15.59	0.69	19	11.7	1.23	27.2	0.3	77.6	0.272
14	0.00	16.07	0.46	19	11.6	1.34	54.7	0.3	83.2	0.291
15	0.00	16.06	6.91	19	11.4	1.26	53.8	0.3	78.4	0.274
16	0.00	16.64	6.96	20	11.4	1.54	54.4	0.3	82.7	0.289
17	0.00	16.42	6.79	20	11.3	0.10	53.6	0.3	75.4	0.264
18	0.00	16.76	6.88	20	11.2	0.18	54.7	0.3	77.2	0.270
19	0.00	15.19	2.35	18	11.4	0.68	53.6	0.3	75.9	0.266
20	0.00	16.64	6.56	20	11.1	-0.06	54.7	0.3	78.2	0.274
21	0.00	14.53	1.42	17	11.3	1.27	55.2	0.3	79.5	0.278
22	0.00	15.08	3.12	18	11.3	1.07	54.3	0.3	74.6	0.261
23	0.00	15.29	2.78	18	11.5	0.85	52.2	0.3	78.1	0.273
24	0.00	16.46	2.75	20	11.1	0.55	55.0	0.3	77.1	0.270
25	0.00	15.96	4.87	19	11.2	0.83	54.1	0.3	74.2	0.260
26	0.00	16.39	5.56	19	11.2	1.21	53.3	0.3	75.8	0.265
27	0.00	14.85	3.33	18	11.2	0.39	54.9	0.3	76.3	0.267
28	0.00	15.64	4.55	19	11.0	0.62	54.3	0.3	73.0	0.255
29	0.00	15.77	2.66	19	11.3	0.74	53.0	0.3	78.4	0.275
30	0.00	16.69	4.78	20	11.0	0.96	54.5	0.3	82.0	0.287
31	0.00	14.85	3.30	18	11.4	1.15	54.6	0.3	80.3	0.281
32	0.00	15.20	0.65	18	11.2	0.59	55.0	0.3	76.1	0.266
33	0.00	15.53	1.36	18	11.3	0.66	53.5	0.3	76.3	0.267
34	0.00	16.03	3.92	19	11.3	1.11	52.9	0.3	78.8	0.276
35	0.00	15.07	4.49	18	11.3	1.02	55.0	0.3	77.7	0.272
36	0.00	15.23	4.31	18	11.4	1.62	53.6	0.3	83.0	0.290
37	0.00	14.71	0.76	18	11.1	0.72	54.4	0.3	76.5	0.268
38	0.00	16.58	4.69	20	11.1	0.71	53.9	0.3	78.1	0.273
39	0.00	14.76	0.93	18	11.2	0.82	55.0	0.3	74.7	0.262
40	0.00	15.66	4.49	19	11.2	0.82	53.1	0.3	73.9	0.259
41	0.00	16.28	0.74	19	11.0	0.57	54.0	0.3	78.6	0.275
	Average	15.91	3.78	19	11.4	0.84	52.2	0.3	77.2	0.270

Total number of blows analyzed: 41

Time Summary

Drive 47 seconds 8:29:34 AM - 8:30:21 AM (11/20/2006) BN 1 - 41

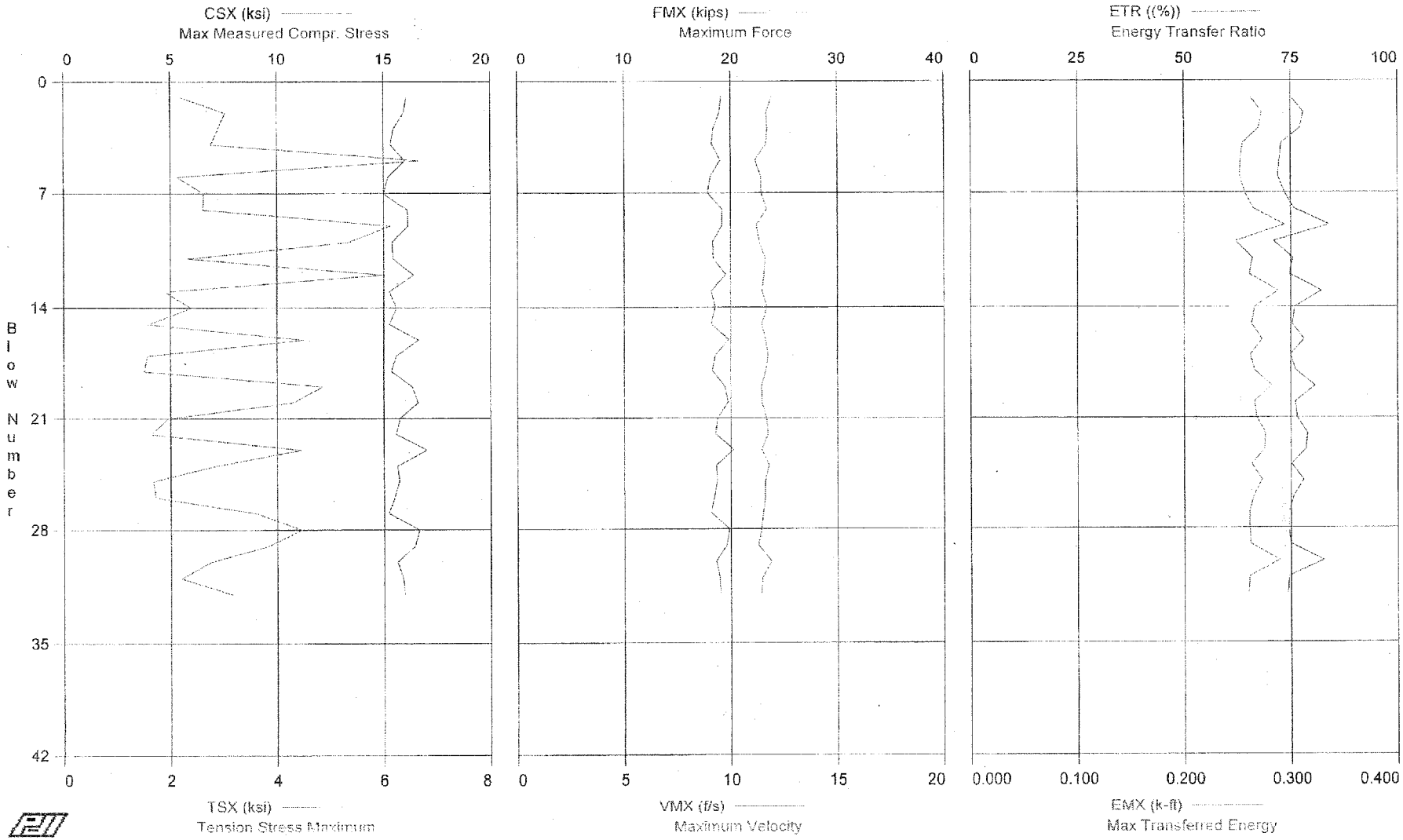
12

MACTEC Engineering and Consulting, Inc. - Case Method Results

PDIPLOT Ver. 2005.2 - Printed: 20-Nov-2006

Test date: 20-Nov-2006

North Anna COL Project - Boring B-7; 28.5' - 30' Sample



32

MACTEC Engineering and Consulting, Inc.
Case Method Results

PDIPLOT Ver. 2005.2 - Printed: 20-Nov-2006

North Anna COL Project - Boring B-7; 28.5' - 30' Sample
OP: SEK

Rig Serial No. 212393 (MACTEC Knoxville CME 55)
Test date: 20-Nov-2006

AR: 1.19 in^2
LE: 34.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.60

CSX: Max Measured Compr. Stress
TSX: Tension Stress Maximum
FMX: Maximum Force
VMX: Maximum Velocity
DFN: Final Displacement

BPM: Blows per Minute
EFV: Energy of FV
ETR: Energy Transfer Ratio
EMX: Max Transferred Energy

BL#	depth ft	CSX ksi	TSX ksi	FMX kips	VMX f/s	DFN in	BPM **	EFV **	ETR (%)	EMX k-ft
1	0.00	16.08	2.21	19	11.9	0.10	0.0	0.3	75.0	0.262
2	0.00	15.95	3.03	19	11.7	1.17	56.0	0.3	78.0	0.273
3	0.00	15.47	2.89	18	11.7	0.91	53.9	0.3	77.2	0.270
4	0.00	15.32	2.76	18	11.7	0.91	53.0	0.3	72.8	0.255
5	0.00	15.99	6.64	19	11.2	0.96	56.2	0.3	72.3	0.253
6	0.00	15.21	2.13	18	11.4	0.75	53.3	0.3	71.9	0.252
7	0.00	15.00	2.62	18	11.4	1.02	53.6	0.3	73.5	0.257
8	0.00	16.12	2.61	19	11.7	0.89	52.8	0.3	75.7	0.265
9	0.00	16.13	6.13	19	11.2	1.58	54.1	0.3	84.0	0.294
10	0.00	15.40	5.34	18	11.4	0.51	54.8	0.2	71.0	0.248
11	0.00	15.45	2.33	18	11.6	1.13	52.6	0.3	75.4	0.264
12	0.00	16.40	6.01	20	11.6	0.67	56.0	0.3	74.7	0.261
13	0.00	15.26	1.89	18	11.5	1.10	53.2	0.3	82.2	0.288
14	0.00	15.59	2.38	19	11.7	1.16	53.7	0.3	75.9	0.266
15	0.00	15.26	1.58	18	11.5	0.79	54.0	0.3	75.3	0.263
16	0.00	16.64	4.52	20	11.6	0.92	53.9	0.3	78.0	0.273
17	0.00	15.59	1.56	19	11.7	0.68	53.7	0.3	74.9	0.262
18	0.00	15.36	1.51	18	11.6	0.63	53.7	0.3	76.1	0.266
19	0.00	16.32	4.85	19	11.4	0.91	55.6	0.3	80.7	0.282
20	0.00	16.61	4.30	20	11.5	1.07	54.3	0.3	76.0	0.266
21	0.00	15.76	1.96	19	11.7	0.78	53.2	0.3	76.4	0.268
22	0.00	15.58	1.63	19	11.7	0.83	53.0	0.3	78.8	0.276
23	0.00	17.02	4.46	20	11.5	0.65	54.1	0.3	78.5	0.275
24	0.00	15.64	2.84	19	11.8	0.38	53.7	0.3	75.1	0.263
25	0.00	15.72	1.67	19	11.6	1.23	53.3	0.3	78.0	0.273
26	0.00	15.51	1.72	18	11.6	0.61	54.0	0.3	75.6	0.265
27	0.00	15.23	3.62	18	11.5	0.43	54.3	0.3	74.6	0.261
28	0.00	16.66	4.45	20	11.4	0.80	53.7	0.3	74.4	0.261
29	0.00	16.46	3.84	20	11.3	0.62	54.2	0.3	74.9	0.262
30	0.00	15.64	2.74	19	11.9	1.55	53.6	0.3	82.7	0.289
31	0.00	15.90	2.20	19	11.5	0.86	53.4	0.3	74.5	0.261
32	0.00	15.97	3.17	19	11.4	0.99	54.1	0.3	74.2	0.260
	Average	15.82	3.18	19	11.6	0.86	54.0	0.3	76.2	0.267

Total number of blows analyzed: 32

Time Summary

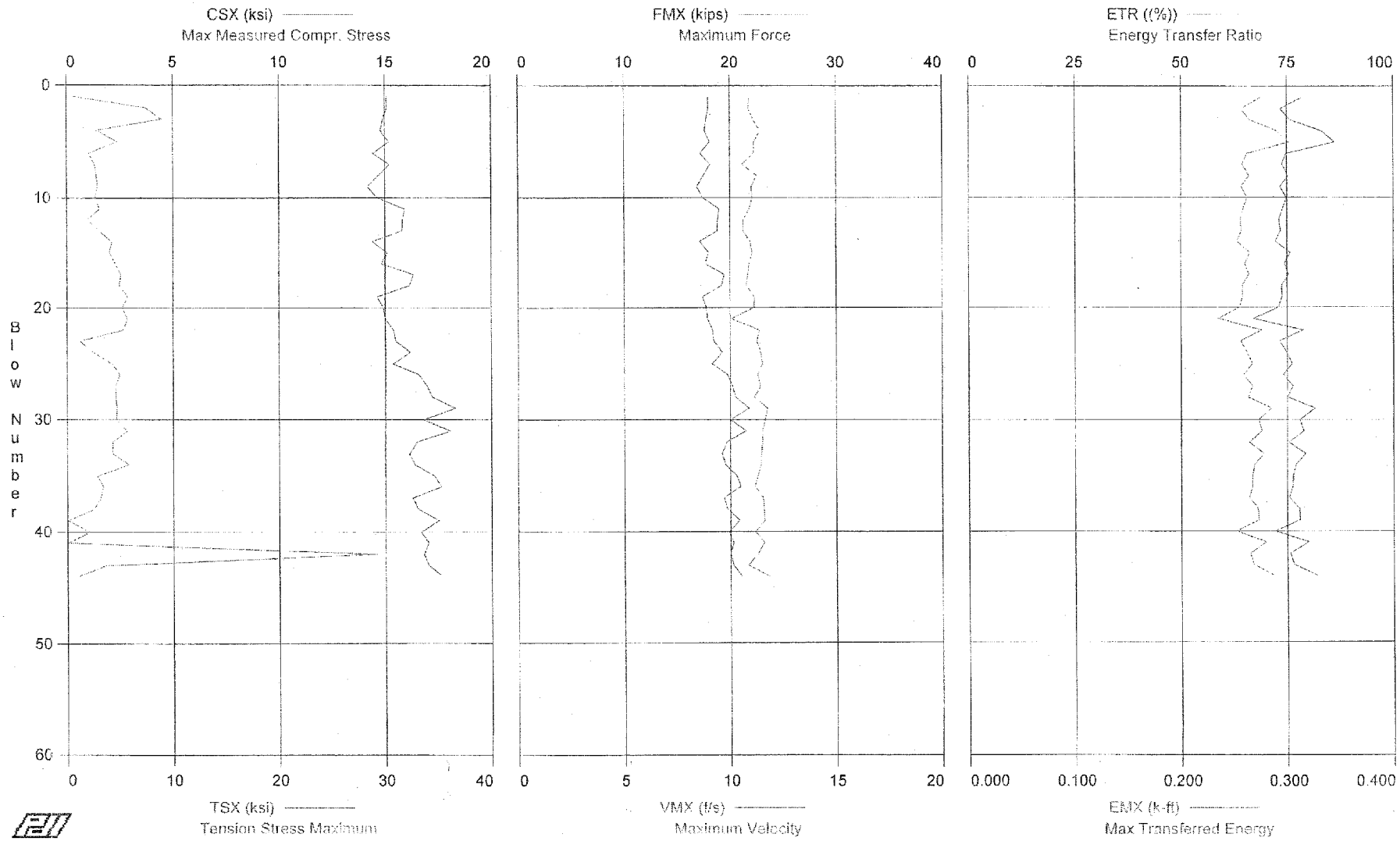
Drive 34 seconds 8:41:06 AM - 8:41:40 AM (11/20/2006) BN 1 - 32

MACTEC Engineering and Consulting, Inc. - Case Method Results

PDIPLOT Ver. 2005.2 - Printed: 20-Nov-2006

Test date: 20-Nov-2006

North Anna COL Project - Boring B-7; 33.5' - 35' Sample



MACTEC Engineering and Consulting, Inc.
Case Method Results

PDIPLOT Ver. 2005.2 - Printed: 20-Nov-2006

North Anna COL Project - Boring B-7; 33.5' - 35' Sample
OP: SEK

Rig Serial No. 212393 (MACTEC Knoxville CME 55)
Test date: 20-Nov-2006

AR: 1.19 in^2
LE: 39.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.60

CSX: Max Measured Compr. Stress
TSX: Tension Stress Maximum
FMX: Maximum Force
VMX: Maximum Velocity
DFN: Final Displacement

BPM: Blows per Minute
EFV: Energy of FV
ETR: Energy Transfer Ratio
EMX: Max Transferred Energy

BL#	depth	CSX	TSX	FMX	VMX	DFN	BPM	EFV	ETR	EMX
	ft	ksi	ksi	kips	f/s	in	**	**	(%)	k-ft
1	0.00	15.09	0.68	18	10.9	1.28	0.0	0.3	78.5	0.275
2	0.00	15.10	7.45	18	10.9	1.53	53.7	0.3	73.5	0.257
3	0.00	14.91	8.96	18	11.1	2.12	54.2	0.3	75.7	0.265
4	0.00	14.80	2.83	18	11.4	2.23	53.2	0.3	83.2	0.291
5	0.00	15.19	4.75	18	11.1	1.77	55.6	0.3	86.3	0.302
6	0.00	14.44	2.10	17	11.1	0.40	53.6	0.3	74.8	0.262
7	0.00	15.22	2.65	18	10.6	1.18	55.4	0.3	73.8	0.258
8	0.00	14.70	2.83	17	11.3	0.87	52.5	0.3	75.3	0.264
9	0.00	14.18	2.89	17	11.0	0.61	54.0	0.3	73.3	0.257
10	0.00	14.65	2.71	17	11.1	0.61	53.7	0.3	74.8	0.262
11	0.00	15.94	3.09	19	10.9	0.69	52.7	0.3	74.0	0.259
12	0.00	15.83	1.91	19	10.6	0.50	54.1	0.3	73.1	0.256
13	0.00	15.80	3.01	19	10.6	1.06	55.1	0.3	73.4	0.257
14	0.00	14.40	4.25	17	11.0	0.16	53.5	0.3	72.3	0.253
15	0.00	15.11	4.03	18	11.0	0.52	26.7	0.3	75.7	0.265
16	0.00	14.81	4.57	18	10.9	0.69	53.9	0.3	74.4	0.260
17	0.00	16.34	5.09	19	10.8	0.34	53.4	0.3	75.4	0.264
18	0.00	16.15	4.94	19	10.8	0.17	53.9	0.3	73.7	0.258
19	0.00	14.62	5.72	17	11.1	0.39	53.1	0.3	73.8	0.258
20	0.00	14.92	5.22	18	11.1	0.26	54.4	0.3	73.0	0.255
21	0.00	15.02	5.70	18	10.1	-0.32	52.2	0.2	67.1	0.235
22	0.00	15.41	5.27	18	11.4	0.31	55.4	0.3	78.8	0.276
23	0.00	15.51	1.22	18	11.3	-0.67	53.2	0.3	73.2	0.256
24	0.00	16.18	2.47	19	11.4	0.28	54.5	0.3	74.8	0.262
25	0.00	15.37	4.25	18	11.5	-0.24	52.8	0.3	76.2	0.267
26	0.00	16.59	4.96	20	11.3	-0.17	55.8	0.3	74.0	0.259
27	0.00	16.98	4.57	20	11.4	0.21	52.7	0.3	76.4	0.267
28	0.00	17.22	4.60	20	11.1	0.07	53.1	0.3	75.0	0.263
29	0.00	18.30	4.71	22	11.8	-0.10	53.5	0.3	81.6	0.285
30	0.00	16.80	4.64	20	11.6	0.50	27.2	0.3	77.9	0.273
31	0.00	18.08	5.65	22	11.5	0.04	52.8	0.3	78.9	0.276
32	0.00	16.50	4.30	20	11.5	0.55	54.9	0.3	75.4	0.264
33	0.00	16.14	4.27	19	11.5	0.36	53.7	0.3	79.3	0.278
34	0.00	16.40	5.82	20	11.4	-0.34	53.7	0.3	77.0	0.269
35	0.00	17.32	2.85	21	11.3	-0.64	53.2	0.3	76.3	0.267
36	0.00	17.63	3.42	21	11.2	0.34	54.8	0.3	76.3	0.267
37	0.00	16.29	3.13	19	11.5	0.20	53.9	0.3	75.4	0.264
38	0.00	16.54	2.54	20	11.6	0.49	53.4	0.3	77.8	0.272
39	0.00	17.52	0.08	21	11.6	0.37	54.3	0.3	77.9	0.273
40	0.00	16.67	2.13	20	11.2	-0.09	54.5	0.3	72.1	0.252
41	0.00	17.03	0.05	20	11.6	-0.40	52.1	0.3	80.0	0.280
42	0.00	16.82	29.19	20	11.3	-32.18	54.0	0.3	75.6	0.265
43	0.00	17.04	3.61	20	10.8	0.64	52.1	0.3	76.5	0.268
44	0.00	17.67	1.02	21	11.8	-0.37	27.0	0.3	81.9	0.287
	Average	15.98	4.32	19	11.2	-0.31	51.9	0.3	76.0	0.266

Total number of blows analyzed: 44

Time Summary

Drive 55 seconds 8:58:00 AM - 8:58:55 AM (11/20/2006) BN 1 - 47

December 15, 2006

Memorandum to File DCN STP644
From: Steve Kiser
Reviewed By: Kathryn White

Subject: **Report of SPT Energy – MACTEC Raleigh CME 45 Trailer Rig (Serial No. 04) Automatic Hammer**
WORK INSTRUCTION DCN STP644
South Texas Project (STP) COL Site
Wadsworth, Texas
MACTEC Project No. 5050-06-0496

Steve Kiser, of MACTEC Engineering and Consulting, Inc. (MACTEC), performed energy measurements on the drill rig at the subject site per the referenced Work Instruction. This memorandum summarizes the field testing activities and presents the results of the energy measurements.

SPT Energy Field Measurements

SPT energy measurements were made on November 29, 2006, during drilling of Boring B-333 at the referenced site. The testing was performed from approximately 2:15 to 3:45 PM under cloudy skies and a temperature of about 70 degrees Fahrenheit. The boring was drilled with personnel and equipment from the MACTEC office in Raleigh, North Carolina. The drilling equipment consisted of a CME 45 model trailer-mounted drill rig with an SPT automatic hammer. The drilling tools consisted of AW-J-sized drilling rods and a 2-foot long split tube sampler. Mud rotary drilling techniques were used to advance the boring. The drill rig operator during sampling was Mr. Danny Rhodes. Energy measurements were recorded during sampling at the depth intervals shown in Table 1. The length of the drill rod string (including the instrumented drill rod insert described below) for each sample was generally 4 foot longer than the depth of the sample being collected.

The energy measurements were performed with a Pile Driving Analyzer (PDA) model PAK (Serial No. 1430), and calibrated accelerometers (Serial Nos. P5953 and P5094) and strain gages (Serial Nos. AW #144/1 and AW#144/2). An AW-sized steel drill rod, 2 feet long and instrumented with dedicated strain gages, was inserted at the top of the drill rod string immediately below the SPT hammer. The inserted rod was also instrumented with two piezoresistive accelerometers that were bolted to the outside of the rod. The instrumented rod insert had a cross-sectional area of approximately 1.19 square inches at the gage location.

Calibration Records

The calibration records for all the above are filed in DCN SC 102, Rev. 2. The confirmation certificate for the SPT hammer weight is contained in DCN SC4.

Calculations for EFV

The work was done in general accordance with ASTM D 4633-05. The strain and acceleration signals were converted to force and velocity by the PDA, and the data was interpreted by the PDA according to the Case Method equation. The maximum energy transmitted to the drill rod string (as measured at the location of the strain gages and accelerometers) was calculated by the PDA using the EFV method equation, as shown below:

$$EFV = \int F(t) * V(t) * dt$$

Where: EFV = Transferred energy (EFV equation), or Energy of FV
F(t) = Calculated force at time t
V(t) = Calculated velocity at time t

The EFV method of energy calculation is recommended in ASTM Standard D4633-05. The EFV equation, integrated over the complete wave event, measures the total energy content of the event using both force and velocity measurements. The EFV values associated with each blow analyzed are tabulated in the attached PDIPLOT tables and are also shown graphically in the PDIPLOT charts.

Calculations for ETR

The ratio of the measured transferred energy (EFV) to the theoretical potential energy of the SPT system (140 lb weight with the specified 30 inch fall) is the ETR. The ETR values (as percent of the theoretical value) are shown in Table 1.

Comparison of ETR to Typical Energy Transfer Ratio Range

Based on a research report published by the Florida Department of Transportation (FDOT) (Report WPI No. 0510859, 1999), the average ETR measured for automatic hammers is 79.6%. The standard deviation was 7.9%; therefore, the range of ETRs within one standard deviation of the average was reported to be 71.7% to 87.5%. This range of ETRs was also consistent with other research that was cited in the FDOT research paper. The ETR values shown in Table 1 are generally within the range of typical values for automatic hammers as reported in the literature.

Discussion

Based on the field testing results, observations from the SPT energy measurements are summarized below:

- The data obtained by the PDA are consistent between individual hammer blows and between the sample depths tested. In general, the first and last one (and sometimes two) hammer blow records recorded by the PDA produced poor quality data (which is relatively common) and, as such, the record(s) was(were) not used in the data reduction.

- The average energy transferred from the hammer to the drill rods for each individual depth interval using the EFV method ranged from 258 foot-pounds to

295 foot-pounds. These average energy transfers correspond to energy transfer ratios (ETR) of 74% to 84% of the theoretical energy (350 foot-pounds) of the SPT hammer.

- The average at each depth interval was calculated as the transferred energy for each analyzed blow of the depth intervals divided by the total number of hammer blows analyzed. The overall average energy transfer of the SPT system (for all the depth intervals tested) was 288.4 foot-pounds, with an average ETR of 82.4%.

Attachments:
Page 4 Table 1 - Summary of SPT Energy Measurements – 1 Page
Page 5 Work Instructions – SPT-Energy #04 – 1 Page
Page 6 Record of SPT Energy Measurement – 1 Page
Pages 7-18 PDIPLOT Output – 12 Pages

TABLE 1
SUMMARY OF SPT ENERGY MEASUREMENTS (ASTM D4633-05)
South Texas Project (STP) COL Site
Wadsworth, Texas
MACTEC Project No. 5050-06-0496

Rig Serial No.	Rig Owner	Rig Operator	Boring No. Tested	Date Tested	Sample Depth (feet)	SPT Blow Count (blows per six inches)	No. of Blows Analyzed	Average Measured Energy (Average EFV) (ft-lbs)[a]	Energy Transfer Ratio (%)[b] (Average ETR)
04 (CME 45 Trailer)	MACTEC (Raleigh Office)	Danny Rhodes	B-333	11/29/2006	13.5 - 15.0	6 - 7 - 9	22	258	73.7%
					23.5 - 25.0	3 - 5 - 5	13	279	79.7%
					28.5 - 30.0	7 - 11 - 12	30	288	82.3%
					33.5 - 35.0	16 - 24 - 23	63	287	82.0%
					38.5 - 40.0	15 - 41 - 68	134	295	84.3%
							Average for Rig:	**288.4**	**82.4%**

[a]Measured Energy is energy based on the EFV method, as outlined in ASTM D4633-05, for each blow recorded by the PDA. In some cases, the initial and final one to two blows produced poor quality data, and were not used to calculate the Average Measured Energy.

[b]Energy Transfer Ratio is the Measured Energy divided by the theoretical SPT energy of 350 foot-pounds (140 pound hammer falling 2.5 feet). The average ETR values may differ slightly and insignificantly from those in the PDIPLOT tables due to roundoff.

Prepared By:	Date:	Checked By:	Date:

Work Instruction SPT-ENERGY #04

South Texas COL Project
MACTEC Engineering and Consulting, Inc.

Issued To: Steve Kiser
Location: STP Field Office Date: November 28, 2006
Issued By: Jay Cerceo, Site Coordinator MACTEC Project No.: 5050-06-0496
Valid Thru: 11/28/2006 To 11/28/2007 Rev. No. 0

Task Description: Perform SPT Energy measurements of drill rigs at the South Texas COL Project.

Applicable Technical Procedures or Plans, or other reference: ASTM (D4633), South Texas COL Geotechnical Work Plan Attachment 3, Bechtel's Engineering Specification for Subsurface Investigation and Laboratory Testing for South Texas Project Units 3 & 4 (Specification).

Specific Instructions (*note attachments where necessary*): Follow guidelines in South Texas COL Work Plan, Attachment 3. Energy measurements to be performed on drill rigs while performing SPT sampling. Obtain energy measurements with the PDA at depth intervals in the range of **15 to 100 feet** below the ground surface in general accordance with ASTM D4633-05. Perform energy measurement for SPT automatic hammer number **04**. The hammer number is stamped on the hammer.

Special Instructions: **Complete all field forms in ink.**

Report Format: Completed Field Forms As Follows: Daily Field Report, Record of SPT Energy Measurement and PDIPLOT output data, Photographs (rig and equipment setup, energy measurement equipment).

Specific Quality Assurance Procedures Applicable: None

Hold Points or Witness Points: None

Records: All records generated shall be considered QA Records.

Reviewed and Approved By: (*Note: Only one signature is required to issue*)
Project Manager (MACTEC): _____ Date: _____
Project Principal (MACTEC): _____ Date: _____
Site Coordinator (MACTEC): _____ Date: 11/28/2006

No. of Pages: 1 DCN: STP644

C:\06-0496 STP COL\Work Instructions\work instructions for SPT Energy #04 MACTEC - Raleigh.doc

MACTEC

2801 YORKMONT ROAD, SUITE 100 □ CHARLOTTE, NC 28208
Telephone: (704) 357-8600 / Facsimile: (704) 357-8638

RECORD OF SPT ENERGY MEASUREMENT

GENERAL INFORMATION		DRILL RIG DATA	
PROJECT:	South Texas Project	MAKE:	CME
LOCATION:	Wadsworth, Texas	MODEL:	45 TRAILER
PROJECT NO.:	5050-06-0496	SERIAL NO.:	# 04
DATE:	11-29-06	HAMMER TYPE:	AUTO MATIC
WEATHER:	CLOUDY; 70°	ROPE CONDITION:	N/A
INSPECTOR:	Steve Kiser	ROD SIZE:	AW-J
DRILLING COMPANY:	MACTEC - RALEIGH	NO. OF SHEAVES:	N/A

BORING DATA			
BORING NUMBER:	B-333		
DEPTH DRILLED:	100' PLANNED		
TIME DRIVEN:	1:45 PM		
RIG OPERATOR:	DONNY RHODES		
HAMMER OPERATOR:	N.R.		
PDA PAK SERIAL NO.:	1430	1430	1430
INSTR. ROD AREA:	1.19 in²		
ACCEL. SERIAL NOS.:	5094 / 5753		
STRAIN SERIAL NOS.:	144 AW 1/2		

SAMPLE DEPTH (feet)	SPT N-VALUE (bpf)	DEPTH cont. (feet)	SPT N-VALUE (bpf)	SAMPLE DEPTH (feet)	SPT N-VALUE (bpf)	DEPTH cont. (feet)	SPT N-VALUE (bpf)	SAMPLE DEPTH (feet)	SPT N-VALUE (bpf)	DEPTH cont. (feet)	SPT N-VALUE (bpf)
13.5/15	6-7-9										
23.5/25	3-5-5										
28.5/30	7-11-12										
33.5/35	10-24-23										
38.5/40	15-41-68										

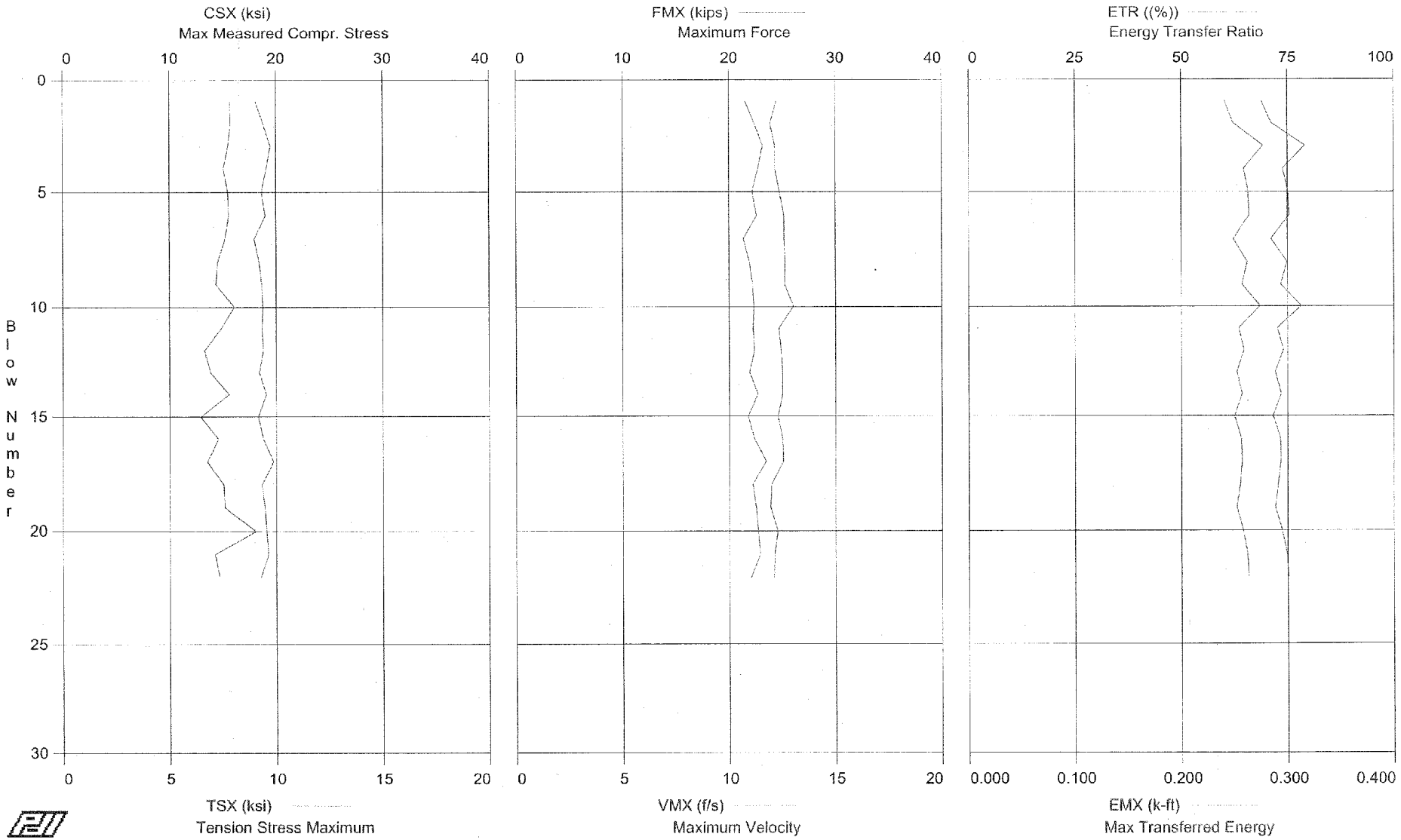
REMARKS:

MACTEC Engineering and Consulting, Inc. - Case Method Results

PDIPLOT Ver. 2005.2 - Printed: 30-Nov-2006

Test date: 29-Nov-2006

STP COL Project - Boring B-333; 13.5' - 15' Sample



MACTEC Engineering and Consulting, Inc.
Case Method Results

PDIPLOT Ver. 2005.2 - Printed: 30-Nov-2006

STP COL Project - Boring B-333; 13.5' - 15' Sample
OP: SEK

Rig Serial No. 04 (MACTEC Raleigh CME 45 Trailer)
Test date: 29-Nov-2006

AR: 1.19 in^2
LE: 19.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.60

CSX: Max Measured Compr. Stress
TSX: Tension Stress Maximum
FMX: Maximum Force
VMX: Maximum Velocity
DFN: Final Displacement

BPM: Blows per Minute
EFV: Energy of FV
ETR: Energy Transfer Ratio
EMX: Max Transferred Energy

BL#	depth	CSX	TSX	FMX	VMX	DFN	BPM	EFV	ETR	EMX
	ft	ksi	ksi	kips	f/s	in	**	**	(%)	k-ft
1	0.00	18.09	7.84	22	12.2	1.10	0.0	0.2	68.9	0.241
2	0.00	18.81	7.86	22	11.9	1.17	36.3	0.2	71.2	0.249
3	0.00	19.47	7.74	23	12.2	1.28	36.4	0.3	79.2	0.277
4	0.00	19.10	7.53	23	12.2	1.27	36.4	0.3	73.9	0.259
5	0.00	18.64	7.73	22	12.4	1.24	36.5	0.3	75.2	0.263
6	0.00	18.99	7.77	23	12.6	1.28	36.5	0.3	75.4	0.264
7	0.00	17.94	7.60	21	12.6	1.64	36.5	0.2	71.1	0.249
8	0.00	18.41	7.25	22	12.6	2.21	36.4	0.3	74.9	0.262
9	0.00	18.67	7.17	22	12.6	1.31	36.5	0.3	73.4	0.257
10	0.00	18.76	8.04	22	13.0	2.18	36.5	0.3	78.2	0.274
11	0.00	18.70	7.41	22	12.3	1.74	36.5	0.3	72.6	0.254
12	0.00	18.81	6.64	22	12.4	1.71	36.6	0.3	74.0	0.259
13	0.00	18.42	6.92	22	12.5	1.60	36.5	0.3	72.1	0.252
14	0.00	19.08	7.78	23	12.5	1.74	36.5	0.3	73.5	0.257
15	0.00	18.30	6.44	22	12.3	1.40	36.5	0.3	71.6	0.250
16	0.00	18.79	7.28	22	12.5	1.88	36.5	0.3	73.3	0.256
17	0.00	19.72	6.75	23	12.5	1.89	36.5	0.3	73.4	0.257
18	0.00	18.66	7.52	22	12.0	1.58	36.4	0.3	72.7	0.255
19	0.00	18.93	7.58	23	11.9	1.40	36.6	0.3	72.1	0.252
20	0.00	19.09	9.02	23	12.3	1.35	36.4	0.3	73.7	0.258
21	0.00	19.25	7.11	23	12.1	1.52	36.5	0.3	74.8	0.262
22	0.00	18.52	7.32	22	12.1	1.28	36.5	0.3	75.2	0.263
	Average	18.78	7.47	22	12.4	1.53	36.5	0.3	73.7	0.258

Total number of blows analyzed: 22

Time Summary

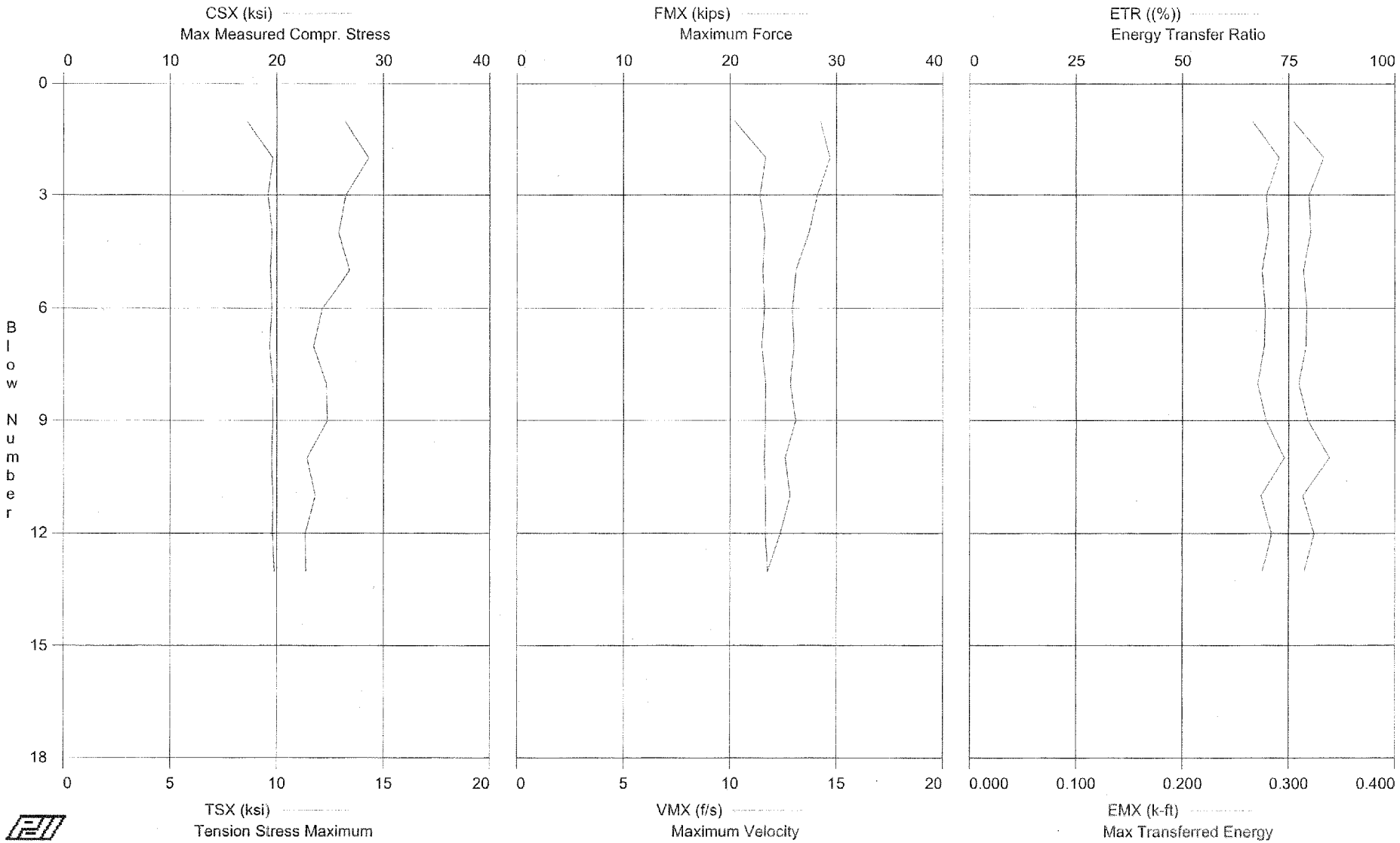
Drive 35 seconds 2:13:34 PM - 2:14:09 PM (11/29/2006) BN 1 - 22

MACTEC Engineering and Consulting, Inc. - Case Method Results

PDIPLOT Ver. 2005.2 - Printed: 30-Nov-2006

Test date: 29-Nov-2006

STP COL Project - Boring B-333; 23.5' - 25' Sample



MACTEC Engineering and Consulting, Inc.
Case Method Results

PDIPLOT Ver. 2005.2 - Printed: 30-Nov-2006

STP COL Project - Boring B-333; 23.5' - 25' Sample
OP: SEK

Rig Serial No. 04 (MACTEC Raleigh CME 45 Trailer)
Test date: 29-Nov-2006

AR: 1.19 in^2
LE: 29.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.60

CSX: Max Measured Compr. Stress
TSX: Tension Stress Maximum
FMX: Maximum Force
VMX: Maximum Velocity
DFN: Final Displacement

BPM: Blows per Minute
EFV: Energy of FV
ETR: Energy Transfer Ratio
EMX: Max Transferred Energy

BL#	depth ft	CSX ksi	TSX ksi	FMX kips	VMX f/s	DFN in	BPM **	EFV **	ETR (%)	EMX k-ft
1	0.00	17.19	13.19	20	14.2	2.23	0.0	0.3	76.1	0.266
2	0.00	19.63	14.31	23	14.7	2.85	48.6	0.3	83.2	0.291
3	0.00	19.16	13.23	23	14.1	2.65	48.6	0.3	79.8	0.279
4	0.00	19.57	12.90	23	13.7	2.18	48.8	0.3	80.3	0.281
5	0.00	19.38	13.41	23	13.1	2.21	48.8	0.3	78.5	0.275
6	0.00	19.54	12.13	23	12.9	2.33	48.7	0.3	79.3	0.278
7	0.00	19.31	11.72	23	13.0	2.37	48.8	0.3	79.1	0.277
8	0.00	19.63	12.31	23	12.8	2.41	48.9	0.3	77.4	0.271
9	0.00	19.61	12.37	23	13.1	1.73	48.7	0.3	79.6	0.279
10	0.00	19.52	11.41	23	12.6	1.74	48.9	0.3	84.6	0.296
11	0.00	19.63	11.80	23	12.8	1.61	48.7	0.3	78.4	0.274
12	0.00	19.61	11.33	23	12.4	1.34	48.9	0.3	81.0	0.284
13	0.00	19.78	11.36	24	11.8	1.48	49.0	0.3	78.7	0.275
	Average	19.35	12.42	23	13.2	2.09	48.8	0.3	79.7	0.279

Total number of blows analyzed: 13

Time Summary

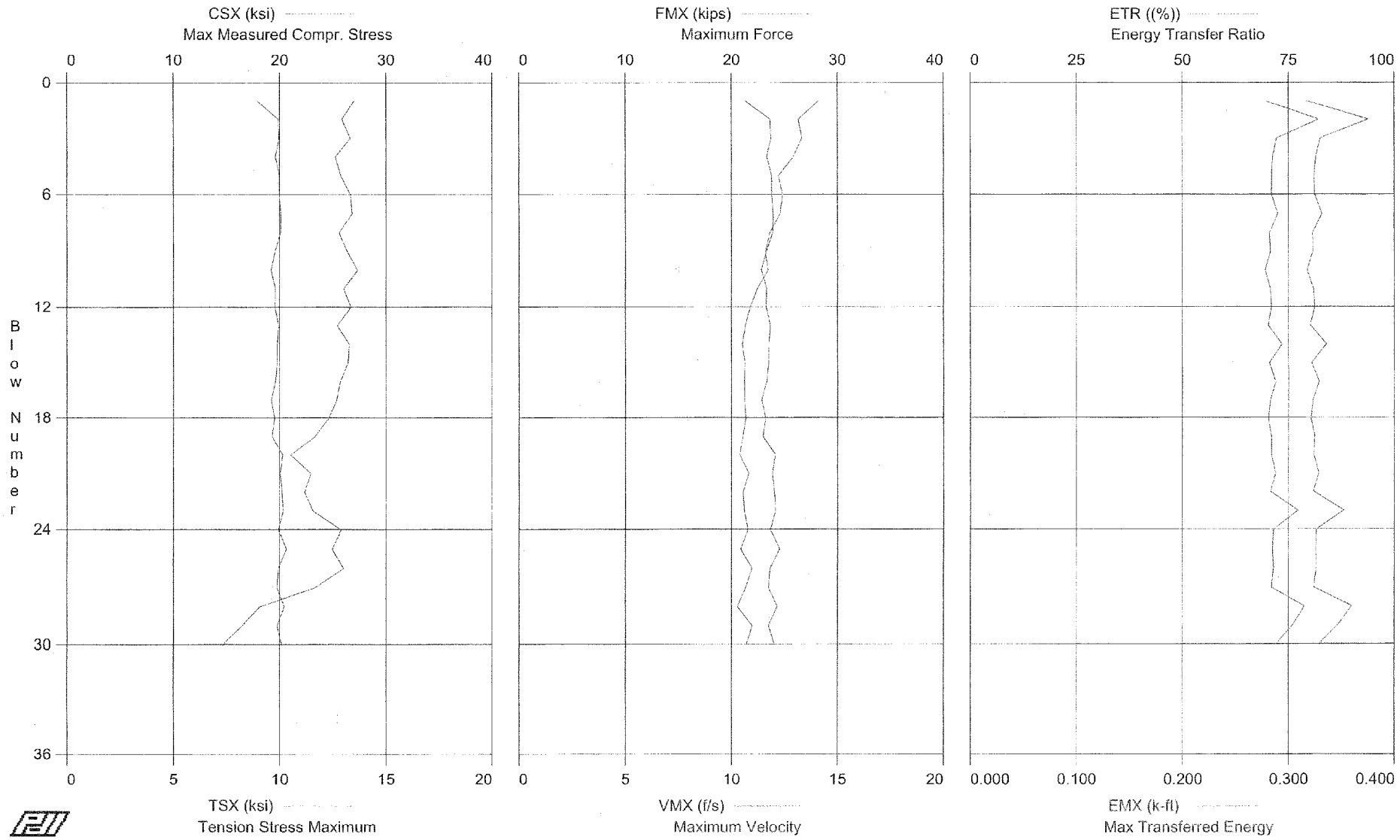
Drive 16 seconds 3:13:34 PM - 3:13:50 PM (11/29/2006) BN 1 - 14

MACTEC Engineering and Consulting, Inc. - Case Method Results

PDIPLOT Ver. 2005.2 - Printed: 30-Nov-2006

Test date: 29-Nov-2006

STP COL Project - Boring B-333; 28.5' - 30' Sample



MACTEC Engineering and Consulting, Inc.
Case Method Results

PDIPLOT Ver. 2005.2 - Printed: 30-Nov-2006

STP COL Project - Boring B-333; 28.5' - 30' Sample
OP: SEK

Rig Serial No. 04 (MACTEC Raleigh CME 45 Trailer)
Test date: 29-Nov-2006

AR: 1.19 in^2
LE: 34.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.60

CSX: Max Measured Compr. Stress
TSX: Tension Stress Maximum
FMX: Maximum Force
VMX: Maximum Velocity
DFN: Final Displacement

BPM: Blows per Minute
EFV: Energy of FV
ETR: Energy Transfer Ratio
EMX: Max Transferred Energy

BL#	depth ft	CSX ksi	TSX ksi	FMX kips	VMX f/s	DFN in	BPM **	EFV **	ETR (%)	EMX k-ft
1	0.00	17.90	13.49	21	14.1	1.36	0.0	0.3	79.3	0.278
2	0.00	19.87	12.92	24	13.2	1.74	48.9	0.3	93.9	0.329
3	0.00	19.95	13.32	24	13.3	1.22	48.7	0.3	82.6	0.289
4	0.00	19.60	12.61	23	12.9	1.49	48.9	0.3	81.5	0.285
5	0.00	20.00	12.88	24	12.2	1.10	49.0	0.3	81.1	0.284
6	0.00	20.00	13.33	24	12.4	1.51	48.9	0.3	81.2	0.284
7	0.00	20.13	13.41	24	12.3	0.82	48.9	0.3	82.9	0.290
8	0.00	20.09	12.79	24	11.8	1.23	48.9	0.3	80.7	0.282
9	0.00	19.56	13.19	23	11.6	0.81	48.8	0.3	80.8	0.283
10	0.00	19.17	13.66	23	11.7	1.29	48.9	0.3	79.4	0.278
11	0.00	19.60	13.01	23	11.2	0.95	48.8	0.3	80.9	0.283
12	0.00	19.56	13.36	23	10.9	0.71	48.7	0.3	81.3	0.284
13	0.00	19.91	12.70	24	10.7	0.67	49.0	0.3	80.2	0.281
14	0.00	19.78	13.27	24	10.5	1.04	49.0	0.3	84.0	0.294
15	0.00	19.76	13.21	24	10.6	1.21	48.9	0.3	80.5	0.282
16	0.00	19.60	12.83	23	10.6	0.75	48.8	0.3	82.3	0.288
17	0.00	19.20	12.67	23	10.6	1.64	49.0	0.3	80.8	0.283
18	0.00	19.53	12.30	23	10.7	1.08	49.0	0.3	80.4	0.281
19	0.00	19.29	11.65	23	10.5	0.60	48.9	0.3	81.3	0.284
20	0.00	20.29	10.52	24	10.4	0.84	48.9	0.3	81.1	0.284
21	0.00	20.05	11.46	24	10.8	1.11	48.9	0.3	82.2	0.288
22	0.00	20.22	11.16	24	10.6	0.94	48.9	0.3	81.0	0.283
23	0.00	20.31	11.56	24	10.6	1.00	48.9	0.3	88.1	0.309
24	0.00	19.90	12.89	24	10.8	1.07	49.0	0.3	81.6	0.286
25	0.00	20.64	12.46	25	10.4	1.04	48.9	0.3	81.5	0.285
26	0.00	19.88	13.00	24	11.0	1.02	48.9	0.3	81.6	0.286
27	0.00	19.75	11.64	23	10.7	0.99	49.0	0.3	81.1	0.284
28	0.00	20.44	9.05	24	10.3	1.63	48.9	0.3	90.0	0.315
29	0.00	19.75	8.21	23	11.0	0.99	48.9	0.3	86.7	0.304
30	0.00	20.18	7.29	24	10.7	0.99	48.9	0.3	82.2	0.288
	Average	19.80	12.19	24	11.3	1.09	48.9	0.3	82.4	0.288

Total number of blows analyzed: 30

Time Summary

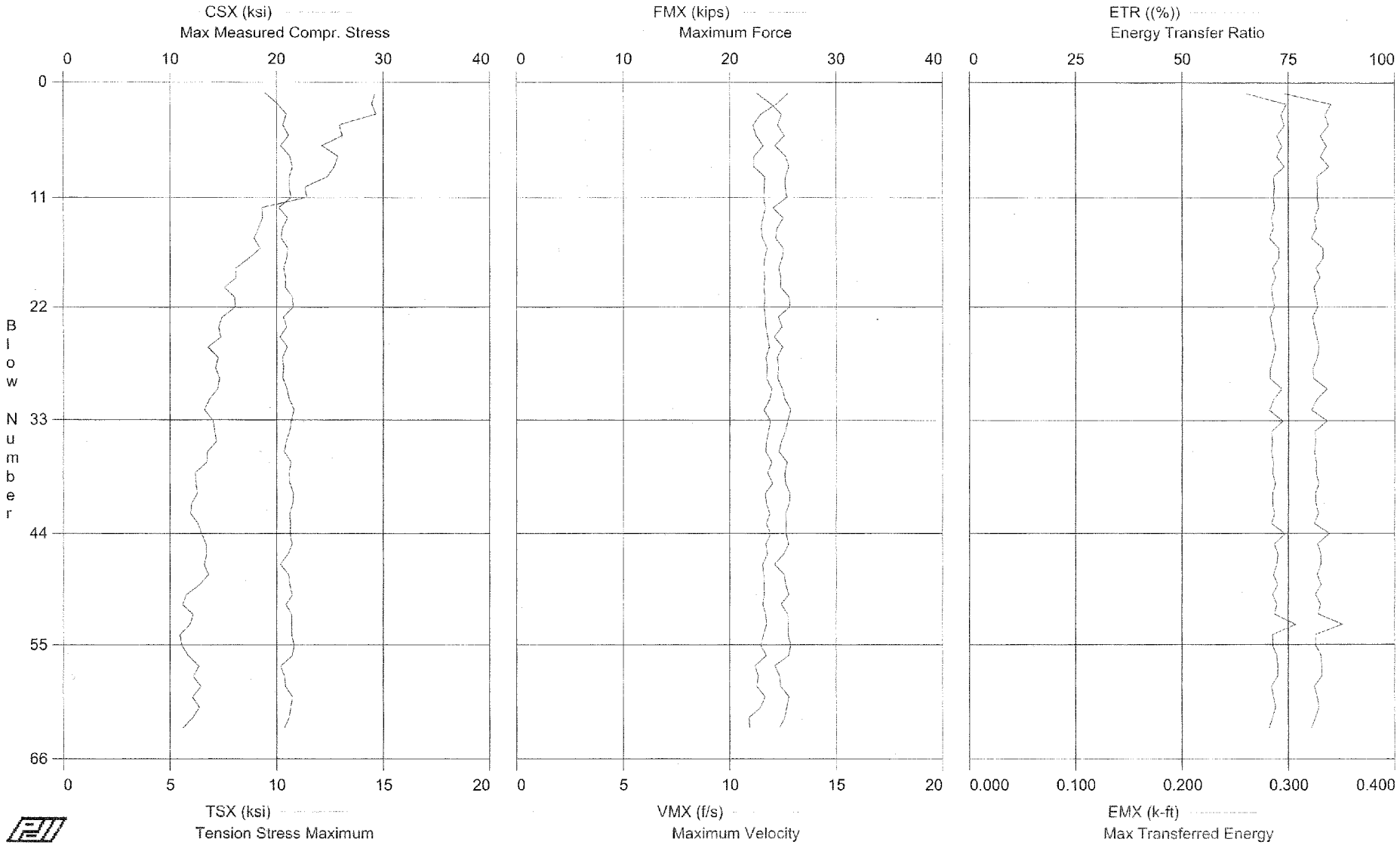
Drive 35 seconds 3:22:19 PM - 3:22:54 PM (11/29/2006) BN 1 - 30

MACTEC Engineering and Consulting, Inc. - Case Method Results

PDIPLOT Ver. 2005.2 - Printed: 30-Nov-2006

Test date: 29-Nov-2006

STP COL Project - Boring B-333; 33.5' - 35' Sample



MACTEC Engineering and Consulting, Inc.
Case Method Results

PDIPLOT Ver. 2005.2 - Printed: 30-Nov-2006

STP COL Project - Boring B-333; 33.5' - 35' Sample
OP: SEK

Rig Serial No. 04 (MACTEC Raleigh CME 45 Trailer)
Test date: 29-Nov-2006

AR: 1.19 in^2
LE: 39.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.60

CSX: Max Measured Compr. Stress
TSX: Tension Stress Maximum
FMX: Maximum Force
VMX: Maximum Velocity
DFN: Final Displacement

BPM: Blows per Minute
EFV: Energy of FV
ETR: Energy Transfer Ratio
EMX: Max Transferred Energy

BL#	depth ft	CSX ksi	TSX ksi	FMX kips	VMX f/s	DFN in	BPM **	EFV **	ETR (%)	EMX k-ft
1	0.00	18.93	14.63	23	12.8	1.35	0.0	0.3	74.2	0.260
2	0.00	20.07	14.46	24	12.2	1.50	45.8	0.3	85.1	0.298
3	0.00	20.90	14.66	25	11.4	1.13	48.8	0.3	83.6	0.293
4	0.00	20.59	12.93	24	11.1	1.08	48.9	0.3	84.5	0.296
5	0.00	21.12	13.08	25	11.2	0.88	48.9	0.3	82.6	0.289
6	0.00	20.37	12.12	24	11.6	0.86	48.9	0.3	84.0	0.294
7	0.00	21.25	12.88	25	11.1	0.80	49.0	0.3	82.6	0.289
8	0.00	21.49	12.70	26	11.1	0.12	48.8	0.3	84.6	0.296
9	0.00	21.20	12.36	25	11.6	0.41	48.9	0.3	81.7	0.286
10	0.00	21.20	11.33	25	11.6	0.14	49.0	0.3	82.0	0.287
11	0.00	21.33	11.41	25	11.6	0.60	48.9	0.3	81.8	0.286
12	0.00	20.22	9.30	24	11.7	0.77	49.0	0.3	82.1	0.287
13	0.00	21.04	9.33	25	11.6	0.57	48.9	0.3	81.1	0.284
14	0.00	20.55	9.14	24	11.5	0.66	49.0	0.3	81.6	0.286
15	0.00	20.43	8.94	24	11.5	0.57	49.1	0.3	80.4	0.282
16	0.00	21.04	9.22	25	11.8	0.25	48.9	0.3	83.1	0.291
17	0.00	20.94	8.69	25	11.6	0.90	48.8	0.3	83.2	0.291
18	0.00	20.65	8.07	25	11.6	0.92	48.9	0.3	81.5	0.285
19	0.00	20.83	8.09	25	11.6	0.67	49.0	0.3	82.4	0.288
20	0.00	20.81	7.54	25	11.6	0.70	48.9	0.3	81.0	0.284
21	0.00	21.50	8.03	26	11.7	0.89	48.8	0.3	81.5	0.285
22	0.00	21.57	8.06	26	11.6	0.81	48.9	0.3	82.0	0.287
23	0.00	20.64	7.45	25	11.7	0.97	48.9	0.3	80.7	0.283
24	0.00	20.94	7.27	25	11.7	0.96	48.8	0.3	81.1	0.284
25	0.00	20.32	7.37	24	11.8	0.82	48.9	0.3	81.8	0.286
26	0.00	20.99	6.77	25	11.9	1.46	48.8	0.3	82.2	0.288
27	0.00	20.55	7.25	24	11.7	1.17	49.0	0.3	81.8	0.286
28	0.00	20.65	7.13	25	11.8	1.17	48.9	0.3	80.8	0.283
29	0.00	20.59	7.32	25	11.7	1.24	49.0	0.3	81.0	0.283
30	0.00	20.98	7.22	25	12.0	0.98	48.8	0.3	84.1	0.294
31	0.00	21.16	6.84	25	11.9	0.75	48.8	0.3	81.7	0.286
32	0.00	21.63	6.61	26	11.6	0.68	48.9	0.3	80.5	0.282
33	0.00	21.39	7.00	25	11.9	0.84	48.9	0.3	84.2	0.295
34	0.00	21.22	7.08	25	11.8	0.65	49.0	0.3	81.3	0.284
35	0.00	20.89	7.18	25	11.7	0.55	48.7	0.3	81.4	0.285
36	0.00	20.71	6.74	25	11.7	1.24	48.9	0.3	81.2	0.284
37	0.00	21.35	6.71	25	12.0	1.16	48.9	0.3	81.6	0.286
38	0.00	21.16	6.18	25	11.8	0.91	49.0	0.3	81.6	0.285
39	0.00	21.21	6.21	25	12.0	0.72	48.9	0.3	82.2	0.288
40	0.00	21.57	6.26	26	11.7	0.58	49.0	0.3	81.4	0.285
41	0.00	21.51	5.99	26	11.7	1.27	48.9	0.3	81.5	0.285
42	0.00	21.22	5.95	25	11.9	0.95	49.1	0.3	82.1	0.287
43	0.00	21.28	6.30	25	11.7	1.31	48.9	0.3	81.1	0.284
44	0.00	21.27	6.48	25	11.9	1.24	48.9	0.3	84.7	0.297
45	0.00	21.46	6.68	26	11.7	0.70	48.9	0.3	81.9	0.287
46	0.00	21.05	6.71	25	11.8	1.22	48.9	0.3	82.7	0.290
47	0.00	20.33	6.59	24	11.5	1.03	48.9	0.3	82.7	0.289
48	0.00	21.13	6.79	25	11.6	1.40	48.9	0.3	81.8	0.286
49	0.00	21.22	6.37	25	11.6	1.65	49.0	0.3	82.7	0.290
50	0.00	21.47	5.75	26	11.6	1.03	49.0	0.3	81.4	0.285
51	0.00	20.86	5.58	25	11.6	1.49	48.9	0.3	82.6	0.289
52	0.00	21.41	6.08	25	11.7	1.13	48.9	0.3	82.0	0.287
53	0.00	21.42	5.92	25	11.7	2.05	48.9	0.3	87.8	0.307
54	0.00	21.42	5.45	25	11.6	1.22	48.9	0.3	81.4	0.285
55	0.00	21.63	5.54	26	11.4	1.35	48.9	0.3	81.4	0.285
56	0.00	21.46	5.84	26	11.7	1.07	48.9	0.3	82.7	0.289
57	0.00	20.37	6.35	24	11.2	1.24	48.9	0.3	82.9	0.290
58	0.00	20.75	6.08	25	11.3	1.02	48.7	0.3	83.0	0.290
59	0.00	20.83	6.44	25	11.3	1.32	48.9	0.3	81.1	0.284
60	0.00	21.49	6.03	26	11.6	0.95	48.9	0.3	81.8	0.286
61	0.00	21.31	6.37	25	11.5	1.51	49.0	0.3	82.2	0.288
62	0.00	21.15	6.05	25	10.9	1.20	48.9	0.3	81.4	0.285
63	0.00	20.72	5.58	25	10.9	1.34	48.9	0.3	80.4	0.282

STP COL Project - Boring B-333; 33.5' - 35' Sample
OP: SEK

Rig Serial No. 04 (MACTEC Raleigh CME 45 Trailer)
Test date: 29-Nov-2006

	CSX	TSX	FMX	VMX	DFN	BPM	EFV	ETR	EMX
	ksi	ksi	kips	f/s	in	**	**	(%)	k-ft
Average	21.00	7.98	25	11.6	0.99	48.9	0.3	82.1	0.287

Total number of blows analyzed: 63

Time Summary

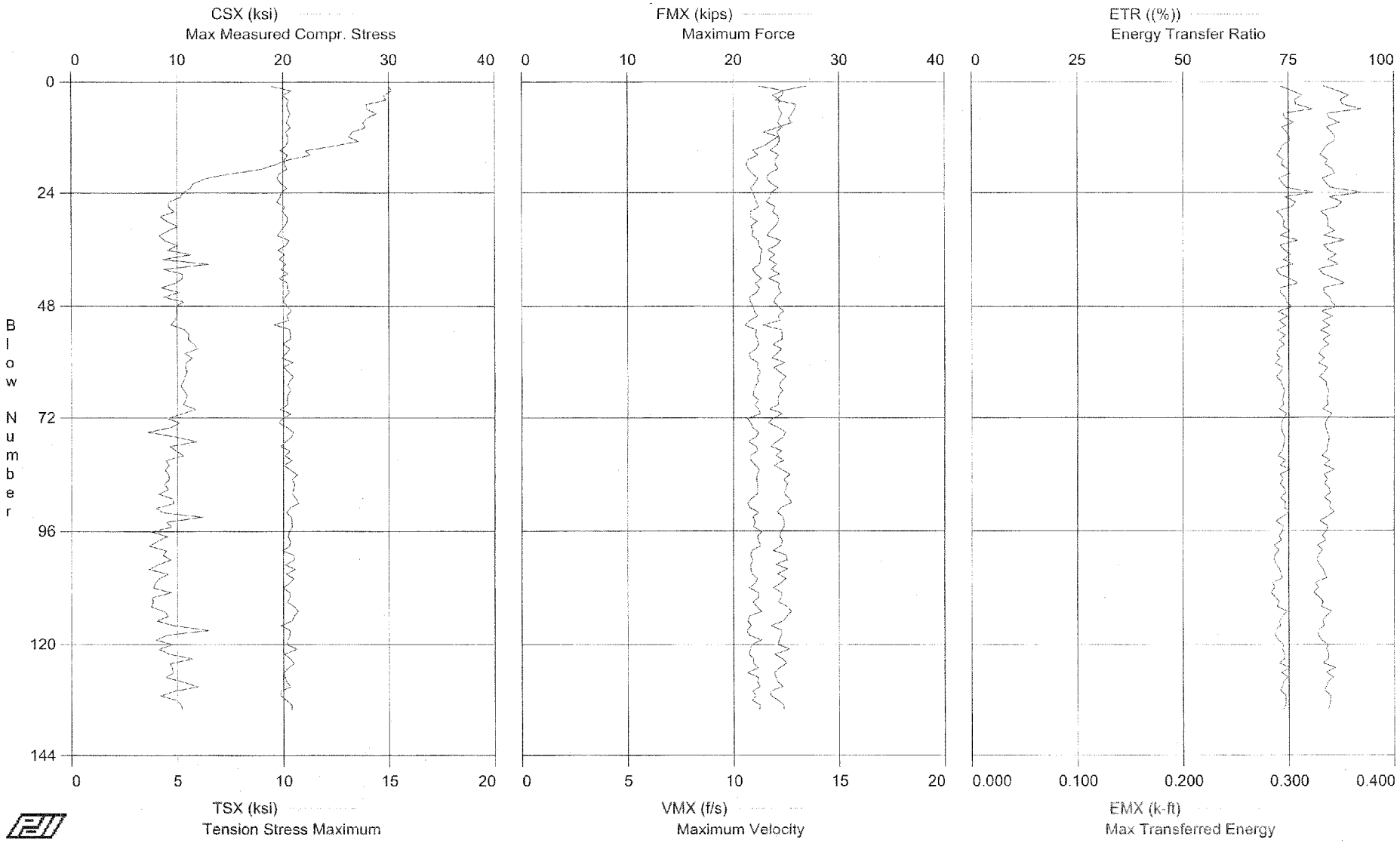
Drive 1 minute 17 seconds 3:35:31 PM - 3:36:48 PM (11/29/2006) BN 1 - 64

MACTEC Engineering and Consulting, Inc. - Case Method Results

PDIPLOT Ver. 2005.2 - Printed: 30-Nov-2006

Test date: 29-Nov-2006

STP COL Project - Boring B-333; 38.5' - 40' Sample



MACTEC Engineering and Consulting, Inc.
Case Method Results

PDIPLOT Ver. 2005.2 - Printed: 30-Nov-2006

STP COL Project - Boring B-333; 38.5' - 40' Sample
OP: SEK

Rig Serial No. 04 (MACTEC Raleigh CME 45 Trailer)
Test date: 29-Nov-2006

AR: 1.19 in^2
LE: 44.00 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft3
EM: 30,000 ksi
JC: 0.60

CSX: Max Measured Compr. Stress
TSX: Tension Stress Maximum
FMX: Maximum Force
VMX: Maximum Velocity
DFN: Final Displacement

BPM: Blows per Minute
EFV: Energy of FV
ETR: Energy Transfer Ratio
EMX: Max Transferred Energy

BL#	depth	CSX	TSX	FMX	VMX	DFN	BPM	EFV	ETR	EMX
	ft	ksi	ksi	kips	f/s	in	**	**	(%)	k-ft
1	0.00	18.86	14.99	22	13.5	1.92	0.0	0.3	83.3	0.292
3	0.00	19.96	14.77	24	12.3	1.41	48.7	0.3	89.3	0.313
5	0.00	20.38	13.94	24	13.0	2.10	48.9	0.3	87.8	0.307
7	0.00	20.68	14.40	25	12.8	1.76	48.8	0.3	84.1	0.295
9	0.00	20.35	13.78	24	12.8	2.27	48.8	0.3	87.1	0.305
11	0.00	20.27	13.27	24	11.4	0.57	48.9	0.3	85.2	0.298
13	0.00	20.48	13.58	24	11.8	1.33	48.9	0.3	86.0	0.301
15	0.00	19.74	11.06	23	10.9	1.60	48.9	0.3	83.3	0.292
17	0.00	20.13	10.20	24	10.7	1.65	48.7	0.3	84.3	0.295
19	0.00	20.38	8.95	24	10.7	1.48	49.0	0.3	85.4	0.299
21	0.00	19.46	6.33	23	11.2	1.60	48.9	0.3	83.1	0.291
23	0.00	20.37	5.61	24	10.8	2.06	48.9	0.3	85.0	0.298
25	0.00	19.72	5.15	23	11.0	1.98	48.9	0.3	84.7	0.297
27	0.00	20.16	4.60	24	11.2	1.54	48.9	0.3	86.5	0.303
29	0.00	20.39	4.21	24	10.8	1.63	49.0	0.3	84.1	0.294
31	0.00	20.16	5.02	24	10.8	2.55	48.8	0.3	84.4	0.295
33	0.00	19.48	4.15	23	10.9	1.49	48.9	0.3	83.4	0.292
35	0.00	20.28	5.01	24	11.2	2.13	48.8	0.3	83.3	0.292
37	0.00	20.11	5.65	24	11.3	2.96	48.8	0.3	86.3	0.302
39	0.00	20.26	6.47	24	11.2	1.46	48.7	0.3	86.9	0.304
41	0.00	20.46	5.23	24	11.1	1.81	48.7	0.3	83.2	0.291
43	0.00	20.45	4.90	24	11.0	1.88	48.7	0.3	88.3	0.309
45	0.00	20.58	5.08	24	11.1	1.41	48.5	0.3	83.4	0.292
47	0.00	20.03	5.29	24	10.8	1.10	48.5	0.3	85.2	0.298
49	0.00	20.80	4.97	25	11.0	0.97	49.0	0.3	82.8	0.290
51	0.00	20.52	4.87	24	10.8	2.13	48.7	0.3	83.1	0.291
53	0.00	20.61	5.32	25	11.1	1.47	48.5	0.3	82.5	0.289
55	0.00	20.67	5.51	25	11.1	2.58	48.7	0.3	83.1	0.291
57	0.00	20.64	5.97	25	11.1	1.55	48.7	0.3	82.8	0.290
59	0.00	19.86	5.69	24	10.8	1.93	48.8	0.3	83.5	0.292
61	0.00	20.00	5.36	24	11.1	1.34	48.7	0.3	84.3	0.295
63	0.00	20.96	5.34	25	11.1	1.52	48.7	0.3	82.3	0.288
65	0.00	20.42	5.16	24	11.0	1.75	48.7	0.3	84.0	0.294
67	0.00	20.38	5.45	24	10.9	1.26	48.7	0.3	84.3	0.295
69	0.00	20.39	5.28	24	11.0	1.66	48.7	0.3	84.4	0.295
71	0.00	20.70	5.22	25	11.3	0.96	48.6	0.3	85.3	0.298
73	0.00	19.58	5.08	23	10.8	1.99	48.7	0.3	83.8	0.293
75	0.00	20.93	3.60	25	11.2	1.44	48.9	0.3	84.1	0.294
77	0.00	20.24	5.91	24	10.7	1.34	48.7	0.3	84.5	0.296
79	0.00	20.64	4.96	25	11.1	1.47	48.7	0.3	84.1	0.294
81	0.00	20.81	4.45	25	10.8	1.78	48.7	0.3	84.8	0.297
83	0.00	20.71	4.42	25	11.2	1.55	48.5	0.3	85.9	0.301
85	0.00	20.82	4.60	25	11.1	1.88	48.6	0.3	84.2	0.295
87	0.00	20.97	4.57	25	11.1	1.68	48.8	0.3	84.6	0.296
89	0.00	21.21	4.77	25	10.8	1.43	48.7	0.3	83.5	0.292
91	0.00	20.60	3.99	25	10.8	1.44	48.7	0.3	84.7	0.296
93	0.00	20.75	6.20	25	10.9	1.29	48.7	0.3	84.3	0.295
95	0.00	20.83	4.71	25	10.9	1.21	48.5	0.3	84.4	0.295
97	0.00	20.47	4.53	24	11.1	1.42	48.7	0.3	83.0	0.291
99	0.00	20.59	3.69	25	11.3	1.63	48.6	0.3	81.8	0.286
101	0.00	20.99	4.32	25	10.8	1.42	48.6	0.3	82.1	0.287
103	0.00	20.18	4.08	24	10.8	1.10	48.5	0.3	82.2	0.288
105	0.00	20.29	4.56	24	10.9	1.33	48.4	0.3	83.6	0.293
107	0.00	20.58	3.95	24	11.0	0.77	48.6	0.3	81.3	0.285
109	0.00	20.63	4.71	25	11.2	1.25	48.7	0.3	80.9	0.283
111	0.00	20.38	3.85	24	10.9	1.21	48.6	0.3	83.2	0.291
113	0.00	21.38	4.38	25	11.3	1.09	48.6	0.3	85.2	0.298
115	0.00	20.77	4.01	25	10.7	1.13	48.6	0.3	83.0	0.291
117	0.00	20.61	6.47	25	10.6	1.79	48.6	0.3	82.1	0.287
119	0.00	20.42	3.98	24	11.3	1.56	48.5	0.3	82.8	0.290
121	0.00	21.26	4.12	25	10.8	1.86	48.7	0.3	83.9	0.294
123	0.00	20.67	5.73	25	10.9	1.64	48.7	0.3	84.4	0.296
125	0.00	20.44	4.75	24	11.2	1.33	48.7	0.3	86.1	0.301
127	0.00	20.16	4.43	24	11.2	1.64	48.7	0.3	85.6	0.299
129	0.00	20.72	5.96	25	11.2	0.71	48.6	0.3	83.9	0.294

STP COL Project - Boring B-333; 38.5' - 40' Sample
OP: SEK

Rig Serial No. 04 (MACTEC Raleigh CME 45 Trailer)
Test date: 29-Nov-2006

BL#	depth ft	CSX ksi	TSX ksi	FMX kips	VMX f/s	DFN in	BPM **	EFV **	ETR (%)	EMX k-ft
131	0.00	19.74	4.19	23	11.1	1.61	48.6	0.3	84.9	0.297
133	0.00	20.77	5.17	25	11.2	1.95	48.8	0.3	84.7	0.297
	Average	20.38	6.01	24	11.1	1.51	48.7	0.3	84.3	0.295

Total number of blows analyzed: 134

Time Summary

Drive 2 minutes 44 seconds 3:45:22 PM - 3:48:06 PM (11/29/2006) BN 1 - 134