# GE Infrastructure Sensing

# Calibration Report 060915A0813

Digital Pressure Indicator

for

#### **Fugro Consultants LP**

6100 Hillcroft Houston, TX 77081

Date of Issue: September 15, 2006

Page 4 of 6

Full Scale: 500 psi gauge

#### As Found / As Left Calibration Data

Calibration Date: September 15, 2006 Calibration Standard: PC-89, and ,WS-12

Medium: nitrogen

Applied	Uncertainty	Displayed
psi	psi	psi
0.0	0.0E+00	0.0
124.6700	1.4E <b>-</b> 03	124,7
249.580	2.7E-03	249.6
374.330	4.1E-03	374.4
499.070	5.5E-03	499.2
249.580	2.7E-03	249.6
0.0	0.0E+00	0.1

Notes: The instrument was not adjusted.



General Electric Company 10311 Westpark Drive Houston, TX 77042 T 713 975 0547 F 713 975 6338

# GE Infrastructure Sensing

# Calibration Report 060915A0813

Digital Pressure Indicator

for

#### **Fugro Consultants LP**

6100 Hillcroft Houston, TX 77081

Date of Issue: September 15, 2006

Page 5 of 6

Full Scale: 250 psi gauge

#### As Left Calibration Data

Calibration Date: September 15, 2006

Calibration Standard: PC-89, WS-12, and WS-27

Medium: nitrogen

Applied	Uncertainty	Displayed
psi	psi	psi
0.00	0.0E+00	0.00
61.7960	6.8E-04	61.80
124.6680	1.4E-03	124.65
186.5430	2.1E-03	186.55
249.579	2.7E-03	249.60
124.6680	1.4E-03	124.65
0.00	0.0E+00	0.00

Notes: The instrument was adjusted prior to recording the above data.



General Electric Company 10311 Westpark Drive Houston, TX 77042 USA T 713 975 0547 F 713 975 6338

# GE Infrastructure Sensing

# Calibration Report 060915A0813

Digital Pressure Indicator

for

#### **Fugro Consultants LP**

6100 Hillcroft Houston, TX 77081

Date of Issue: September 15, 2006

Page 6 of 6

Full Scale: 100 psi gauge

#### As Left Calibration Data

Calibration Date: September 15, 2006

Calibration Standard: PC-67, WS-12, and WS-27

Medium: nitrogen

	Applied	Uncertainty	Displayed
_	psi	psi	psi
	0.00	0.0E+00	0.00
	24.86100	2.5E-04	24.84
	49.8390	5.0E-04	49.84
	74.9860	7.5E-04	74.98
	99.9310	1.0E-03	99.96
	49.8390	5.0E-04	49.82
	0.00	0.0E+00	0.00

Notes: The instrument was adjusted prior to recording the above data.



General Electric Company 10311 Westpark Drive Houston, TX 77042 USA T 713 975 0547

F 713 975 6338





#### SCOPE OF ACCREDITATION TO ISO/IEC 17025:1999

GE Infrastructure Sensing

10311 Westpark Drive Houston, TX 77042-5312 Mr. Kenneth A. Kolb

Phone: 713-975-0547 Fax: 713-975-6338

E-mail: kenneth.kolb@ge.com URL: http://www.gesening.com

#### **CALIBRATION LABORATORIES**

**NVLAP LAB CODE 200491-0** 

NVLAP Code: 20/A01

ANSI/NCSL Z540-1-1994; Part 1

Compliant

Remarks

MECHANICAL

NVLAP Code: 20/M08

Mass

Range

Calibration of Primary Piston Gauge Masses

1 mg to 17 kg I mg to 1.2 kg	$5.0 \times 10^{-6}$ but not less than 0.5 mg $5.0 \times 10^{-6}$ but not less than 0.5 mg	Substitution – Mechanical Substitution – Electronic
Calibration of Secondary Pistor	a Gauge Masses	
1 mg to 8.0 kg	$2.0 \times 10^{-5}$ but not less than $0.5 \text{ mg}$	Substitution - Electronic
1 mg to 1.2 kg 1.2 kg to 8 kg	$2.0 \times 10^{-5}$ but not less than $0.5 \text{ mg}$ $2.0 \times 10^{-5}$ but not less than 43 mg	Direct Reading - Electronic Direct Reading - Electronic

Best Uncertainty (±)

Relative to Indicated Value note 1

2006-01-01 through 2006-12-31

Effective dates

For the National Institute of Standards and Technology

Page 1 of 4

NVLAP-01S (REV. 2004-10-31)





#### **CALIBRATION LABORATORIES**

NVLAP LAB CODE 200491-0

#### THERMODYNAMICS

NVLAP Code: 20/T05

Pressure

Pneumatic Pressure using Primary Piston Gauge note 2

Range	Best Uncertainty (±) of Reading tiole 1	Remarks
-100 kPa to -1.38 kPa	1.0 x 10 <sup>-5</sup> but not less than 0.07 Pa	Negative Gauge Mode
-16 kPa to 16 kPa	$1.1 \times 10^{-5}$ but not less than 0.034 Pa	Differential Mode
1.38 kPa to 1.4 MPa 1.4 MPa to 7 MPa	$1.0 \times 10^{-5}$ but not less than 0.07 Pa $1.1 \times 10^{-5}$ but not less than 2.8 Pa	Gauge Mode note 4 Gauge Mode note 4
7 MPa to 21 MPa 21 MPa to 104 MPa	$1.1 \times 10^{-5} + 1.9 \times 10^{-7}$ per MPa $3.5 \times 10^{-5}$	Gauge Mode Gauge Mode

Pneumatic Effective Area Determination using Primary Piston Gauge note 2

Range	Best Uncertainty (±) of Reading notes 1, 7	Remarks
1.38 kPa to 345 kPa	8.8 x 10 <sup>-6</sup>	
11.72 kPa to 1.4 MPa	8.3 x 10 <sup>-6</sup>	
14 kPa to 7 MPa	$1.0 \times 10^{-5} + 2.4 \times 10^{-7} \text{ per MPa}^{note 3}$	
700 kPa to 21 MPa	$1.0 \times 10^{-5} + 4.8 \times 10^{-7} \text{ per MPa}^{note 3}$	
1.17 MPa to 104 MPa	$3.37 \times 10^{-5}$	

Pneumatic Pressure using Precision Transducer note 2

Best Uncertainty (±) of Reading	Kemarks
0.133 Pa	Absolute Mode
$5.0 \times 10^{-5}$ but not less than $0.035$ Pa	Differential Mode
$6.5 \times 10^{-5}$ but not less than $0.22$ Pa	Gauge Mode note 5
	5.0 x 10 <sup>-5</sup> but not less than 0.035 Pa

2006-01-01 through 2006-12-31

Effective dates

For the National Institute of Standards and Technology

Page 2 of 4

NVLAP-01S (REV, 2004-10-31)





#### **CALIBRATION LABORATORIES**

**NVLAP LAB CODE 200491-0** 

Pneumatic Effective Area Determination using Precision Transducer note 2

20 Pa to 17 MPa

 $7.2 \times 10^{-5}$  but not less than 0.05 Pa

Pneumatic Deadweight Tester Output Pressure Conformance using Precision Transducer note 2

Range

Best Uncertainty (±) of Reading notes 1,8

Remarks

20 Pa to 17 MPa

 $7.5 \times 10^{-5}$  but not less than 0.053 Pa

Hydraulic Pressure using Primary Piston Gauge note 1

Range	Best Uncertainty (±) of Reading notes 1, 6	Remarks
50 kPa to 7 MPa	2.5 x 10 <sup>-5</sup> but not less than 10 Pa	Gauge Mode
7 MPa to 140 MPa	$3.5 \times 10^{-5}$	Gauge Mode
14 MPa to 280 MPa	7.5 x 10 <sup>-5</sup>	Gauge Mode
280 MPa to 500 MPa	1.0 x 10 <sup>-4</sup>	Gauge Mode

Hydraulic Effective Area Determination using Primary Piston Gauge "note?

Kange	Best Uncertainty (±) of Reading	Kemarks
50 kPa to 7 MPa	2.31 x 10 <sup>-5</sup>	
7 MPa to 140 MPa	$3.34 \times 10^{-5}$	
140 MPa to 280 MPa	7.29 x 10 <sup>-5</sup>	
280 MPa to 500 MPa	9.80·x 10 <sup>-5</sup>	

Hydraulic Effective Area Determination using Secondary Piston Gauge note 2

70 kPa to 140 MPa

7.2 x 10<sup>-5</sup>

2006-01-01 through 2006-12-31

Effective dates

For the National Institute of Standards and Technology

Page 3 of 4

NVLAP-01S (REV. 2004-10-31)





#### **CALIBRATION LABORATORIES**

**NVLAP LAB CODE 200491-0** 

Hydraulic Deadweight Tester Output Pressure Conformance using Secondary Piston Gauge nate 2

70 kPa to 140 MPa

7.5 x 10<sup>-5</sup> but not less than 50 Pa

2006-01-01 through 2006-12-31

Effective dates

For the National Institute of Standards and Technology

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NVLAP-015 (REV. 2004-10-31)

<sup>1.</sup> Represents an expanded uncertainty using a coverage factor, k = 2, at an approximate level of confidence of 95 %.

<sup>2.</sup> This capability includes on-site calibration service, as limited by influences of operating environment.

<sup>3.</sup> Component uncertainties are combined in quadrature.

<sup>4.</sup> For absolute mode, uncertainties increase by 1.33E + 00 Pa, combined in quadrature with stated level.

<sup>5.</sup> For absolute mode, uncertainties increase by 1.88E + 00 Pa, combined in quadrature with stated level.

<sup>6.</sup> For absolute mode, uncertainties increase by 1.31E + 01 Pa, combined in quadrature with stated level.

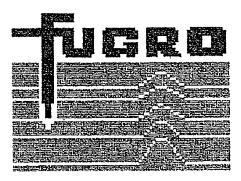
<sup>7.</sup> Calibration process may include the use of transducers to measure small differential pressures.

<sup>8.</sup> Conformance evaluation of Deadweight Tester output pressure compared to indicated pressure.

# **QUALITY SYSTEM MANUAL**

### **FOR**

# HOUSTON GEOTECHNICAL LABORATORY



#### CONTROL#: GEO-1

Fugro Consultants, Inc.

6100 Hillcroft

Houston, Texas 77081

Phone: (713) 369-5400

Fax: (713) 369-5545

Document Revised: July 07, 2007

CALIBRATION EQUIPMENT OR REFERENCE STANDARDS				
Equipment Name	Calibration	Check	Procedure	
	Interval	Interval	Used	
Digital Wickometer & Westmanical Micrometers	rear aveate -		Ouside Source	
Force Transducers	1 year	·	Outside Source	
Metal specimens	Verny Before L	se of After Repair	HGL-2655	
Pressure Gages	2 years		Outside Source	
Set of Gage Blocks	5 wears		Outside Source	
Thermometers .	1 year		Outside Source	
Torque Pransdicers	35,2years		Ourside Source	
Voltmeters/Multimeters (6.5 digit)	3 years	·.	Outside Source	

<sup>\*</sup>The term "calibration" is used to maintain consistency with ASTM D 3740. It is taken to mean "verification."

# PRE JOB CALIBRATION VERIFICATION

#### **CALIBRATION CERTIFICATE**



**APPLICANT** 

FGI HOUSTON

Certificate number

FC070040

Page 1 of 1

SUBMITTED

A Piezo Cone Penetrometer

Manufacturer

Fugro Engineers B.V.

Device type

CONE, A15F2.5CKE3SW2/ B, 50 bar

Serial number

N# TUR512

The device contains an electronic data sheet which contains, amongst others, the characteristics of all the sensors inside the device. The data acquisition system calculates the measured value from these known characteristics. All calibration results are conform the values specified below.

#### Force calibration

Calibration reference: 548 FRE.001

Procedure: FEBV.CAL.PRO.003 KALIBRATIE KRACHT <u>Title of channel(s)</u>: <u>Cone</u> and <u>Cone+Fric.</u>

Max. load

150 kN

Range	Calibration range		Sensitivity	Zero load	
	From	to		Deviation	output
1		0	25 kN	< 0.5 %	< 0.75 kN
	,				
Calibration uncertainty			0.3 %	0.008 kN	

#### Pressure test:

Deviation from specified Alpha factor at 2.5 MPa

#### Cone quality control values:

Max. deviation from reference	< 1 %
Max. Tip to Sleeve friction Crosstalk	< 1 %

#### Pressure calibration

Calibration reference: 3257-0001

Procedure: FEBV.CAL.PRO.004 KALIBRATIE DRUK

Title of channel: Pore 2

Max. load

30 Mpa

Range	Calibration range		Sensitivity	Zero load		
	From		Deviation	output		
. 1	0	2.5 MPa	< 1.0 %	< 0.002 MPa		
Calibrat	l tion uncert	ainty	0.6 %	0.003 MPa		

Pore 2 transducer: Kistler 4043A50

SN: 1233109

#### Calibration of the slope sensor

Calibration reference:

Procedure: FEBV. CAL. PRO. 006 KALIBRATIE HELLING

Title of channel: Slope x

Range	Calibration From	on range	Sensitivity Deviation	Zero load output
1	0	15 deg	< 10 %	< 1.5 deg
Calibra	tion unce	rtainty	1 %	0.5 deg

Typical values for this type of device

Cone diameter (mm)	43.7	Pore 2 position	2	Alpha factor	0.58
Cone area (square cm).	15	Sleeve length (mm)	144.7	Cone - Sleeve distance (mm)	14.4
Sleeve diameter (mm)	43.9	Sleeve area (square cm)	200	Cone - Pore 2 distance (mm)	6.0

TRACEABILITY.

The measurements have been executed using standards for which the traceability to primary and/or (inter)national standards has been demonstrated.

Calibrated by:

Hoogendoorn, Raymond

Approved by: Sinjorgo, Gerry

Calibration date: 16-1-2007

Approval date: 16-

Calibrate before: 16-1-2008

YOHIDE & . PSCKE1026 (2003 dec : 29/09/2005 3:15:00 PM Page 110 of 809

#### **Calibration Verification Certificate**



Device Type:

Piezo Cone Penetrometer

Device Number:

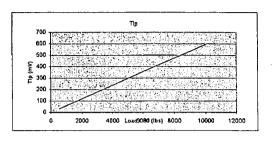
F7.5CKESW2/V 1701-1788

#### TIP CALIBRATION

Tip area = 15 cm 2 = 0.0161 ft 2

Tip readings in mV

tor
0
7963
3413
5401
8639
7269
9048

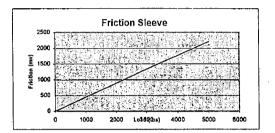


#### **FRICTION CALIBRATION**

Sleeve area = 200 cm2 = 0.2153 ft2

Friction readings in mV

				Friction
Load	Load	load/area	Friction	Cal Factor
lb	Tons	tsf	mV	Мра
0	0	0	0	0
620	0.31	1.439851	279.8	0.49278463
1990	0.995	4.621458	884.6	0.50028711
3520	1.76	8.17464	1562.3	0.50106193
5010	2.505	11.63493	2212.2	0.5036473
7510	3.755	17.44078	3308.9	0.50474203

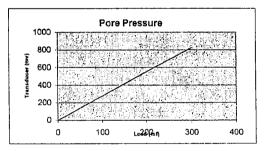


#### PORE PRESSURE TRANSDUCER CALIBRATION

Serial: 1233109

Pore Pressure readings in mV

	oure rouding	,0	
Pressure	Pressure	Transducer	P.Pres.
		readings	Cal Factor
psi	tsf	mV	Mpa
0	0	0	0
75	5.4	206.7	2.50173026
150	10.8	413.6	2.50052053
300	21.6	824.2	2.50962215



#### Temperature Calibration (30 - 115 degrees F)

remperature	. Ounbid		degicesi				
Temp (deg TI	P (mV)	FRIC (mV) F	IEZO (mV)	Deviation	mV	Мра	% Full Scale
30	-0.017	-0.198	-0.109	Tip	0.274	0.0137	0.0274
50	-0.008	-0.336	-0.067	Friction	3.185	0.001593	0.3185
75	0.011	-0.456	-0.054	Piezo	2.593	0.006483	0.2593
100	0.132	2.307	-2.192				
115	0.257	2 987	-2 647				

TIP CALIBRATED BY GEOTAC (A2LA APPROVED) LOAD CELL:

Model 560K, Serial No. 129739

FRICTION CALIBRATED BY INTERFACE (A2LA APPROVED) LOAD CELL:

Model: 1211EX-10K-B, Serial: 113655

PORE PRESSURE TRANSDUCER CALIBRATED BY GE SENSING (AANSI/NCSL APPROVED)

Pressure Indicator Model: UP\$3000CC, Serial: A0813

TEMPERATURE CALIBRATED BY HOUSTON PRECISION TYPE K THERMOCOUPLE (A2LA APPROVED)

Model # 8528-40, Serial # C95005824, ID # TD-001

Calibration Verified by: Dennis Stauffer F

Date:

11/5/2007

Checked By

: Recep Yilmaz

\_ .

Date: 11/5/2007

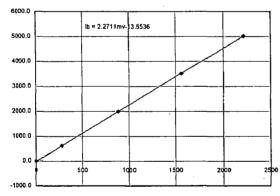
HGL	Instrumen	ŧ١	/arifica	tion

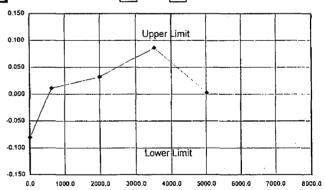
F; NonBF; X	FS; Abs.	):		louston Reading	Resolution	LVDT?: on of Instrument:	
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lb/mV							
6.4790583							
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		-0.150					- ]
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,	Uncertainity Budg	et Analysis Fo	or ft				
Value in 1b	Distribution	Divisor	Туре	Uncerta	inty (u <sub>i</sub> )	u <sub>i</sub> ²	Comment
ty	N	2.0000	В			<del></del>	1
	N	1.0000	Α	6.47	791	41.9782	
	R	3,4641	В			0.0000	
- <u>x</u>	N	1.0000	A				
<del></del>	R	3.4641	В				
				<u> </u>			
6. I C 4704	Co	verage Factor		2		for 95% confider	nce level.
ity 6.4791							
easurement Capability)3	12.9	158	lb				
easurement Capability) <sup>3</sup> A2LA, not that typically used in uncertain	12.9 ainty calculations; i.e., ST	158 DEV of the Mean.		(2) This	value is uniqu	e for type (model) of equip	oment.
easurement Capability)3	12.9 ainty calculations; i.e., ST 5% confidence level using	158 DEV of the Mean.	:=2.			e for type (model) of equip	1
	Fugro F7.5CKESW 1701-1788 ( ft  NA  33716 11/5/200 11/4/200 In Servic 0.1 X Standard Equipment Load Cell (A2AL Af Geotac 560K 129739  C = F ncertainty, & Error Sum 0.9999862 -13.453260 16.882877 16.882877 16.882877 16.892877 19/mV  Value in 1b  Value in 1b  Value in 1b	Cone Penetrometer_TIP	Cone Penetrometer_TIP	Cone Penetrometer_TIP	Cone Penetrometer_TIP	Cone   Penetrometer_TIP	Cone Penetrometer_TIP

#### HGI Instrument Verification

			ngr ment v	vernication
DATE:	11/5/2007	Instrument No.: ft100	Location:	LVDT?: Yes; X N
	Type Analysis:	X BF; NonBF;	XFS; Abs.	Reading Resolution of Instrument: 0.000001

Instrument	Identification/Data			Instrument	Standard	Prediction	Abs. Error	Full Scale
Туре	Cone Pen	etrometer		mv	lb	lb	lb	Error (%)
Manufacturer	· Fug	jro		0.000000	0.0	-13.6	13.6	-0.08
Model Number	F7.5CKE	SW2/B1		279,800000	620.0	621.9	1.9	0.01
Serial Number	1701-1788	(Friction)		884.600000	1990.0	1995.4	5.4	0.03
HGL Instrument Number	ft10	00		1562.300000	3520.0	3534.5	14.5	0.09
Excitation (V)				2212.200000	5010.0	5010.5	0.5	0.00
Gain/Span Setting	N.	Α .		3308.900000	7510.0	7501.2	8.8	-0.05
Full Range Output (V)								
Full Range/Capacity (lb)	168	58						
Date Verified	. 11/5/:	2007						T
Date Due	11/4/:	2008						
Service Status	In Se	rvice						
Accept. Abs. or FS Error (%)	0.1	X FS;	Abs.					
Verification/s	Standard Equipment							
Туре	Load Cell (A2AL APPROVED)							
Manufacturer	INTERFACE							
Model Number	1211EX	-10K-B						
Serial Number	113	655						
HGL Instrument Number			+					
Date Verified			-اسبب					
Temperature	°C=	° F	. — — .				·	
Linear Regression, U		ummary						
Correlation Coeff. (R2)	0.9999	87431						
Intercept (ib)	-13,553	356528						
Slope (lb/mv)	2.2710	68817						
Verification (Calib.) Factor	2.2710	06882						
Verification Factor Units	. lb/i	mv						
Absolute Zero (V)								
Floating Zero (V)								
Combined Uncertainty (lb)	2.3981	88297						
Coverage Factor		2						
Expanded Uncertainty (lb)	4.7963	76595						
Max. Abs. or FS Error (%)	0.09	X FS;	Abs.		MTS	Yes; X No	)	





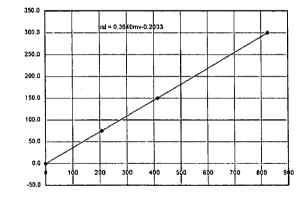
Source of Uncertainty	Value in Ib	Distribution	Divisor	Туре	Uncertainty (ui)	u <sub>i</sub> ²	Commer
Standard's Uncertainty		N	2.0000	В			
Abs. Error-STDEV <sup>1</sup>	2.3982	N	1.0000	Α	2.3982	5.7513	
Resolution of Instrument	0.0000	R	3.4641	В	0.0000	0.0000	
Repeatability <sup>2</sup>		N	1.0000	A			
Resolution of Standard	#N/A	R	3.4641	В			
Combined Uncertainty	2.3982	Co	verage Factor		2	for 95% confidence	ce level.
xpanded Uncertainty (Best Measur	rement Capability)3	4.7	96	lb			

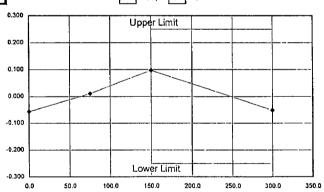
(3) This uncertainty represents an expanded uncertainty ex	pressed as approximately the 95% confidence level u	sing a coverage factor of k=2.	Λ.
Verified By:	Input By:	Reviewed By:	Checked By: FU
File:			
Remarks:			

#### **HGL** Instrument Verification

DATE:	11/5/2007	Instrument No.: pt	Location:	Houston	. LVt	OT?: Yes; X No
_	Type Analysis:	X BF; NonBF;	X FS; Abs.	Readin	g Resolution of Instrum	ent: 0.000001

.,,,,,	,,,,	, L				TTCSCIGNON ON I		
Instrument (	dentification/Data	•		Instrument	Standard	Prediction	Abs. Error	Full Scale
Туре	Cone Penetrome	ter	**	mv	psi	psi	psi	Error (%)
Manufacturer	Fugro			0.000000	0.0	-0.2	0.2	-0.06
Model Number	F7.5CKESW2/E	31		206.700000	75.0	75.0	0.0	0.01
Serial Number	1701-1788-1233109	(Piezo	0)	413.600000	150.0	150.4	0.4	0.10
HGL Instrument Number	pt			824.200000	300.0	299.8	0.2	-0.05
Excitation (V)								
Gain/Span Setting	NA							
Full Range Output (V)								
Full Range/Capacitý (psi)	360							
Date Verified	11/5/2007						· ·	
Date Due	11/4/2008							
Service Status	In Service							<b>_</b>
Accept. Abs. or FS Error (%)	0.25 X FS	3;	Abs.					
Verification/S	tandard Equipment							
Туре	PT(ANSI/NCSL APPI	ROVE	D)					
Manufacturer	Eaton							
Model Number	UPS3000CC							
Serial Number	A0813							
HGL Instrument Number			-					1
Date Verified						1		
Temperature	°C= °F	* -						<b></b> -
Linear Regression, Un	certainty, & Error Summa	ry						
Correlation Coeff. (R2)	0.99999592							
Intercept (psi)	-0.20331044							
Slope (psi/mv)	0.364010552							
Verification (Calib.) Factor	0.36401055							
Verification Factor Units	psi/mv							
Absolute Zero (V)								
Floating Zero (V)	<del></del>			1				
Combined Uncertainty (psi)	0.064150208							
Coverage Factor	2							
Expanded Uncertainty (psi)	0,128300415							
Max. Abs. or FS Error (%)	0.10 X F	s: T	Abs.	1	MTS	Yes; X No	,	





	T				1 7	
Value in psi	Distribution	Divisor	Туре	Uncertainty (u <sub>i</sub> )	· u <sub>l</sub> *	Comment
	N	2.0000	В			
0.0642	N	1.0000	Α	0.0642	0.0041	
0.0000	R	3.4641	В	0.0000	0.0000	
	N	1.0000	Α			
#N/A	R	3.4641	В			
						<u> </u>
0.0642	Co	verage Factor	1	2	for 95% confidence	e level.
	0.0000	0.0642 N 0.0000 R N #N/A R	N 2.0000 0.0642 N 1.0000 0.0000 R 3.4641 N 1.0000 #N/A R 3.4641	N 2.0000 B 0.0642 N 1.0000 A 0.0000 R 3.4641 B N 1.0000 A #N/A R 3.4641 B	N 2.0000 B 0.0642 N 1.0000 A 0.0642 0.0000 R 3.4641 B 0.0000 N 1.0000 A #N/A R 3.4641 B	N 2.0000 B 0.0642 N 1.0000 A 0.0642 0.0041 0.0000 R 3,4641 B 0.0000 0.0000 N 1.0000 A 1.0000 A 1.0000 B 0.0000 D 0.0000 B 0.0000

(1) This equation follows the approach presented by AZLA, not that typically used in uncertainty calculations; i.e., STDEV of the Mean.

(3) This uncertainty represents an expanded uncertainty expressed as approximately the 95% confidence level using a coverage factor of km2.

(2) This value is unique for type (model) of equipment.

us uncertainty represents an expanded uncertainty o	expressed as approximately the 95% confidence level (	using a coverage factor of K=2,	Λ
Verified By:	Input By:	Reviewed By:	Checked By: KU
File:			
Remarks:			

#### **Calibration Verification Certificate**



Device Type:

Piezo Cone Penetrometer

Device Number:

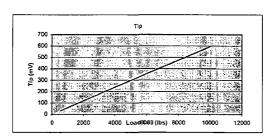
F7.5CKE3SW2/B 1701-0750

#### **TIP CALIBRATION**

Tip area = 15 cm2 = 0.0161 ft2

Tip readings in mV

				TIP
Load	Load	load/area	Tip	Cal Factor
lb	Tons	tsf	mV	Мра
0	0	0	0	0
530	0.265	16.45963	31.5	50.0376197
5010	2.505	155.5901	298.1	49.9812458
7490	3.745	232.6087	445.2	50.0331664
10020	5.01	311.1801	595.9	50.0064083
15050	7.525	467.3913	895.2	49.9974383
19910	9.955	618.323	1184.3	49.9966444

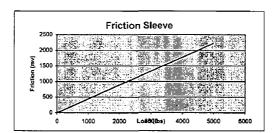


#### **FRICTION CALIBRATION**

Sleeve area = 200 cm2 = 0.2153 ft2

Friction readings in mV

				Friction
Load	Load	load/area	Friction	Cal Factor
lb	Tons	tsf	mV	Мра
0	0	0	0	0
520	0.26	1.207617	231.3	0.49996647
2490	1.245	5.782629	1107.3	0.50008891
3750	1.875	8.708778	1665.6	0.50069555



#### PORE PRESSURE TRANSDUCER CALIBRATION

2.505 11.63493

3.755 17.44078

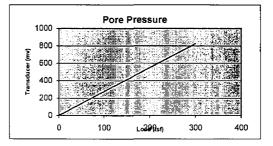
Serial: 8091223

5010

7510

Pore Pressure readings in mV

		V	
Pressure	Pressure	Transducer	P.Pres.
		readings	Cal Factor
psi	tsf	m∨	Mpa
0	0	0	0
75	5.4	206.8	2.50052053
150	10.8	413.5	2.50112525
300	21.6	825.7	2.50506307



#### Temperature Calibration (30 - 115 degrees F)

remperature	Odiibid	11011 (30 - 113	uegiees i j				
Temp (deg Til	P (mV)	FRIC (mV) P	IEZO (mV)	Deviation	mV	Мра	% Full Scale
30	0.946	0.783	-0.132	Tip	0.378	0.0189	0.0378
50	0.983	0.974	-0.077	Friction	0.988	0.000494	0.0988
75	1.012	1.114	0.264	Piezo	1.124	0.00281	0.1124
100	1.297	1.267	0.357				
115	1 324	1 771	0.992				

Eriction

2228.3 0.50000833

3340.2 0.50001224

TIP CALIBRATED BY GEOTAC (A2LA APPROVED) LOAD CELL:

Model 560K, Serial No. 129739

FRICTION CALIBRATED BY INTERFACE (A2LA APPROVED) LOAD CELL:

Model: 1211EX-10K-B, Serial: 113655

PORE PRESSURE TRANSDUCER CALIBRATED BY GE SENSING (AANSI/NCSL APPROVED)

Pressure Indicator Model: UPS3000CC, Serial: A0813

TEMPERATURE CALIBRATED BY HOUSTON PRECISION TYPE K THERMOCOUPLE (A2LA APPROVED)

Model # 8528-40, Serial # C95005824, ID # TD-001

Calibration Verified by: Dennis Stauffer

Date:

4/23/2008

Checked By

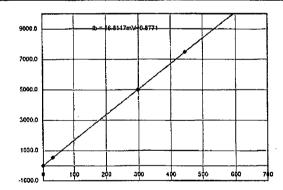
: Recep Yilmaz

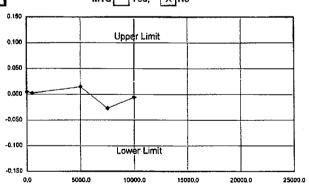
Date: 4/23/2008

#### HGI Instrument Verification

			LIGE INSUMINEUR AC	imcanon	
DATE:	4/23/2008	Instrument No.: ft100	Location:	Houston	LVDT?: Yes; X No
_	Type Analysis:	X BF; NonBF;	X FS; Abs.	Reading Resolutio	n of Instrument: 0.000001

Instrumen	t Identification/Data		Instrument	Standard	Prediction	Abs. Error	Full Scale
Type	Cone Penetrometer-TIP	<del>,</del>	m∨	lb_	lb	lb	Error (%)
Manufacturer	Fugro		0.000000	0.0	0.9	0,9	0.01
Madel Number	F7.5CKEW2/B		31.500000	530.0	530,4	0.4	0,00
Serial Number	1701-0750		298.100000	5010.0	5012.5	2.5	0.01
HGL Instrument Number	ft100		445.200000	7490.0	7485.5	4.5	-0.03
Excitation (V)			595,900000	10020.0	10019.0	1.0	-0.01
Gain/Span Setting	NA NA		895.200000	15050.0	15050.7	0.7	0.00
Full Range Output (V)			1184.300000	19910.0	19911.0	1.0	0.01
Full Range/Capacity (lb)	16858			_			
Date Verified	4/23/2008						
Date Due	4/23/2009						
Service Status	In Service						
Accept. Abs. or FS Error (%)	0.1 X FS;	Abs.					
Verification/	/Standard Equipment						
Туре	Load cell (A2LA APPROVI	ED)					,
Manufacturer	GEOTAC						
Model Number	560K						
Serial Number	129739						
HGL Instrument Number		*					
Date Verified							
Temperature	°C= °F						
Linear Regression, U	Incertainty, & Error Summary						
Correlation Coeff, (R <sup>2</sup> )	0,99999907	,				·	
intercept (lb)	0.877122495						
Slope (ib/mV)	16.81173849		1				
Verification (Calib.) Factor	16.81173849						
Verification Factor Units	lb/mV						
Absolute Zero (V)							
Floating Zero (V)							
Combined Uncertainty (lb)	0.54832333						
Coverage Factor	2						
Expanded Uncertainty (lb)	1.09664666						
		Abs.				<u> </u>	





Source of Uncertainty	Value in 1b	Distribution	Divisor	Туре	Uncertainty (u <sub>i</sub> )	Ui <sup>2</sup>	Commen
Standard's Uncertainty		N	2.0000	В			
Abs. Error-STDEV <sup>1</sup>	0.5483	N.	1.0000	Α	0.5483	0.3007	
Resolution of Instrument	0.0000	R	3.4641	В	0.0000	0.0000	
Repeatability <sup>2</sup>		N	1.0000	Α			
Resolution of Standard	#N/A	R	3.4641	В			
Combined Uncertainty	0.5483	Co	verage Facto		2	for 95% confidence	ce level.
xpanded Uncertainty (Best Measu	rement Capability)3	1.0	97	· lb			

(3) This representation represents a	n evnandad i meedalmbi evorecaed i	e annountimetals the 95% confide	ence level using a coverage factor of k=2.

his uncertainty represents an expanded uncertainty e	expressed as approximately the 95% confidence level u	sing a coverage factor of k=2.	$\rho$	
Verified By:	Input By:	Reviewed By:	Checked By:	
File:				
Remarks:				

2000.2 (06/14/07)

Tip0750.xls, 4-23-2008 6/5/2008

FUGRO CONSULTANTS INC

		<b>HGL</b> Instrume	nt Verification	n			
DATE:4/23/2008	Instrument No.: ft100	Locatio	n:			LVDT?:	Yes; X No
Type Analysis: 🔾	K BF; NonBF;	X FS; Abs.		Reading	Resolution of	Instrument: 0	0.000001
Instrume	ent Identification/Data		Instrument	Standard	Prediction	Abs. Error	Full Scale
Тур		etrometer	mv	lb	lb	lb	Error (%)
Manufacture			0.000000	0.0	0.4	0.4	0.00
Model Number			231.300000	520.0	520.5	0.5	0.00
Serial Number			1107.300000	2490.0	2490.1	0.1	0.00
HGL Instrument Number		10	1666.600000	3750.0	3747.7	2.3	-0.01
Excitation (V	<u>'                                       </u>		2228.300000	5010.0	5010.6	0.6	0.00
Gain/Span Settin		<u>\</u>	3340.200000	7510.0	7510.7	0.7	0.00
Full Range Output (V	<u> -   </u>						
Full Range/Capacity (It					ļ		
Date Verifie							l
Date Du	<del></del>						
Service Statu							
Accept. Abs. or FS Error (%		X FS; Abs.			, <del></del>		
	on/Standard Equipment						
Тур							
Manufacture			_[				
Model Number							
Serial Numbe	er 1136	555					
HGL Instrument Number	<u>:r</u>	· <b>▼</b>					
Date Verifie	Date Verified						
	Temperature °C = °F						
	, Uncertainty, & Error Si						
Correlation Coeff. (R							
Intercept (It	0.42196	34823					
Slope (lb/m)							
Verification (Calib.) Facto				· · · · · · · · · · · · · · · · · · ·			
Verification Factor Unit		1V					
Absolute Zero (V							
Floating Zero (\					<u> </u>		
Combined Uncertainty (It		25144					
	Coverage Factor 2				ļ		
Expanded Uncertainty (It						<u></u>	<u> </u>
Max. Abs. or FS Error (%	5) -0.01	X FS; Abs.		MTS	Yes; X No		
6000.0			0.150			-:-	<del>- ;</del>
Ib = 2.2484r	my40 4270				·		
5000.0			0.100		Upper Limit		
	· •						
4000.0			0.050		<u> </u>		
	<b>/</b>						
3000.0			0.000	<b>***</b>		<b>-</b>	
					<b>~</b>		
2000.0			-0.050				
		1	I .	1	1	1	: I

_	UII	certainity Budge	t Analysis F	or midu			
Source of Uncertainty	Value in 1b	Distribution	Divisor	Туре	Uncertainty (u <sub>i</sub> )	u <sub>i</sub> <sup>2</sup>	Comment
Standard's Uncertainty		N	2.0000	В			
Abs. Error-STDEV <sup>1</sup>	0.3198	N	1.0000	Α	0.3198	0.1023	
Resolution of Instrument	0.0000	R	3.4641	В	0.0000	0.0000	
Repeatability <sup>2</sup>		N	1.0000	Α			
Resolution of Standard	#N/A	R	3.4641	В			
Combined Uncertainty	0.3198	Co	verage Facto	r	2	for 95% confidence	ce level.
Combined Uncertainty Expanded Uncertainty (Best Measu				r lb	2	for 95% confidence	ce level.

(1) This equ	ation follows the approach pr	esented by AZLA, not that	typically used in unce	rtainty calculations; i.e.,	STDEV of the Mean.	
(3) This ring	ertainty represents an expans	led uncertainty expressed a	e annovimately the	95% confidence level us	sing a coverage factor of	k=2

2000

2500

1000

(2) This value is unique for type (model) of equipment.

Lower Limit

is uncertainty represents an expanyled uncertainty expressed as approximately the 95% confidence level using a coverage factor of k=2.								
Verified By:	Input By:	Reviewed By:	Checked By: KU					
File:								
Remarks:								
			<del></del>					

#### **HGL Instrument Verification**

		Location:		Houston			Yes; X N
Type Analysis: X	BF; NonBF; X FS;	Abs.		Reading	Resolution of	nstrument: (	0.000001
Instrument	Identification/Data		Instrument	Standard	Prediction	Abs. Error	Full Scale
Туре	Cone Penetrometer		m∨	psi	psi	psi	Error (%)
Manufacturer	Fugro		0.000000	0.0	-0.1	0.1	-0.03
Model Number	F7.5CKEW2/B		206.800000	75.0	75.0	0.0	0.01
Serial Number	1701-0750-8091223		413.500000	150.0	150.1	0.1	0.04
HGL Instrument Number	pt		825.700000	300.0	299.9	0.1	-0.02
Excitation (V)							
Gain/Span Setting	NA NA						
Full Range Output (V)							
Full Range/Capacity (psi)	360						
Date Verified	4/23/2008						
Date Due	4/23/2009						
Service Status	In Service						
Accept. Abs. or FS Error (%)	0.25 X FS;	Abs.			<u> </u>		
	Standard Equipment						
Туре	PT(ANSI/NCSL APPROVED	D)					
Manufacturer	Eaton				<u> </u>		
Model Number	UPS3000CC						ļ
Serial Number	A0813			.=			
HGL Instrument Number		*					
Date Verified							
Temperature	°C= °F						
	ncertainty, & Error Summary						
Correlation Coeff. (R <sup>2</sup> )	0.99999198						
Intercept (psi)	-0.101633254						
Slope (psi/mv)	0.363351683						
Verification (Calib.) Factor	0.36335168						
Verification Factor Units	psi/mv						
Absolute Zero (V)							
Floating Zero (V)							
Combined Uncertainty (psi)	0.021757343					ļ	
Coverage Factor	2					ļ	
Expanded Uncertainty (psi)  Max. Abs. or FS Error (%)	0.043514685 0.04 X FS;	Abs.	<u> </u>	MTS	Yes; X No		<u> </u>
Max. Abs. of 13 Eno. (70)	0:04   X   1 3,	AUS.		WIIG	] 1 es,		
350.0	, : : : : : :	(	0.300	1	Jpper Limit		1
psi = 0.3634mv-0	).1016				, pper Emilia	-	_
300.0		(	).200	······································		# ************************************	
250.0				i		1	£
		(	0.100				
200,0							
150.0		(	0.000				<b>→</b>
					44	1	i
100.0		4	0.100				
						A. C.	
50.0		-4	0.200				
				,	accept the late		

		Uncertainity Budg	get Analysis	ror pt			
Source of Uncertainty	Value in psi	Distribution	Divisor	Туре	Uncertainty (u <sub>i</sub> )	u <sub>i</sub> ²	Comment
Standard's Uncertainty		N	2.0000	В			
Abs. Error-STDEV <sup>1</sup>	0.0218	N	1.0000	Α	0.0218	0.0005	
Resolution of Instrument	0.0000	R	3.4641	В	0.0000	0.0000	
Repeatability <sup>2</sup>		N	1.0000	Α			
Resolution of Standard	#N/A	R	3.4641	В			
Combined Uncertainty	0.0218	Co	verage Facto		2	for 95% confiden	ce level

800

(1) This equation follows the approach presented by A2LA, not that typically used in uncertainty calculations; i.e., STDEV of the Mean.
(3) This uncertainty represents an expanded uncertainty expressed as approximately the 95% confidence level using a coverage factor of k=2.

(2) This value is unique for type (model) of equipment.

100.0

150.0

200.0

his uncertainty represents an expanded uncertainty e	expressed as approximately the 95% confidence le	evel using a coverage factor of k=2.	$\circ$
Verified By:	Input By:	Reviewed By:	Checked By: KU
File:	· ———		
Remarks:			

100 200

FUGRO CONSULTANTS INC DCN# TUR512

300.0

350.0

#### **Calibration Verification Certificate**



Device Type:

Seismograph

Device Manufacturer Geometrics, Inc.

Model Number:

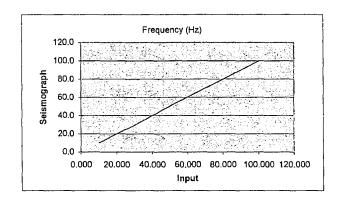
ES-3000

Serial Number:

5138

#### Frequency (Hz)

	, ,,,,,,
Input	Seismograph
10.055	9.9
20.037	19.9
30.071	29.3
40.040	40.1
50.061	50.6
60.048	60.3
70.005	70.2
80.011	79.9
90.090	90.1
100.014	99.8



FREQUENCY CALIBRATED BY INSTEK GOOD WILL INSTRUMENTS (A2LA APPROVED) FREQUENCY COUNTER: Model: GFC-80101H, Serial No. CF871549
FREQUENCY GENERATED BY EZ DIGITAL, INC (A2LA APPROVED) OSCILLISCOPE WITH BUILT IN FUNCTION GENERATOR Model: OS-5020G, Serial No.: 3080209

Calibration Verified by: Dennis Stauffer

inis Staulier

Date:

1/22/2008

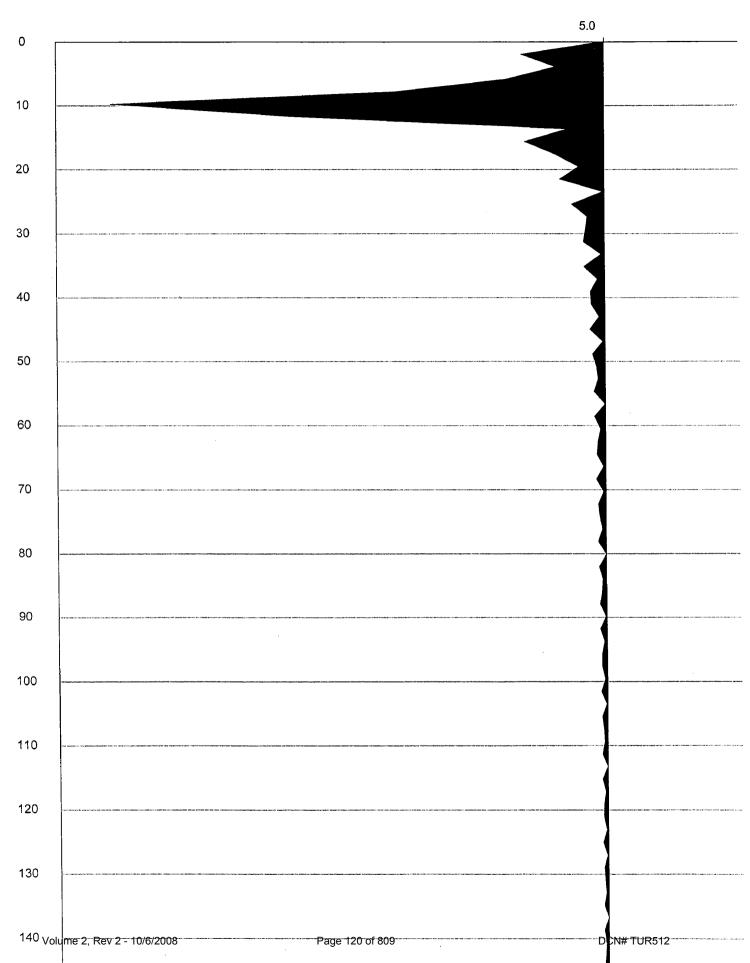
Checked By

: Recep Yilmaz

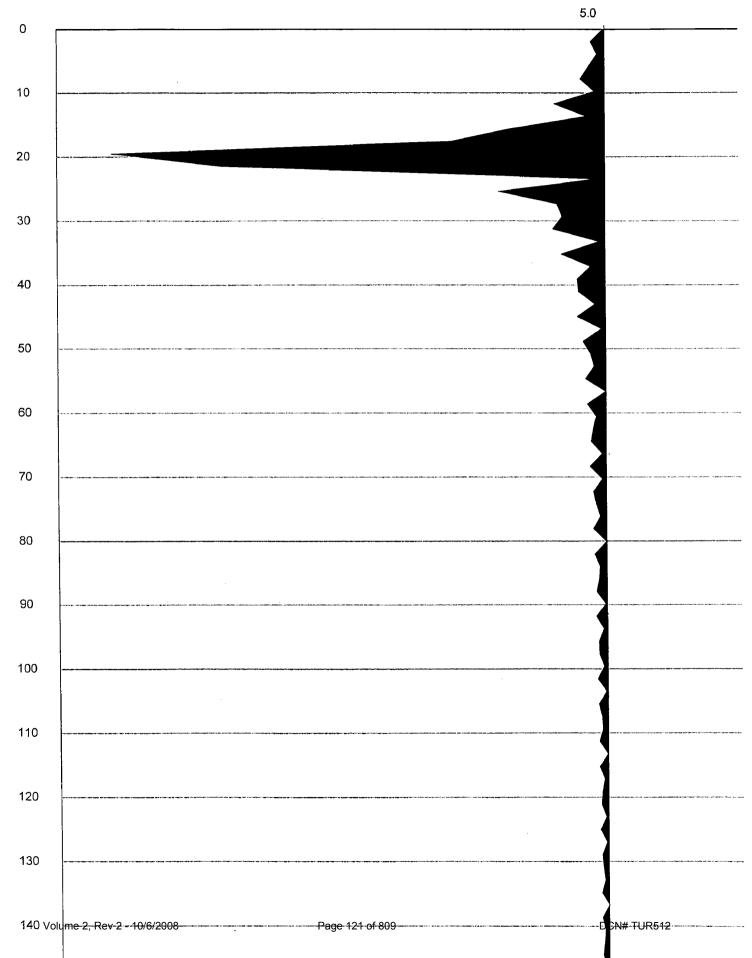
Date:

1/22/2008

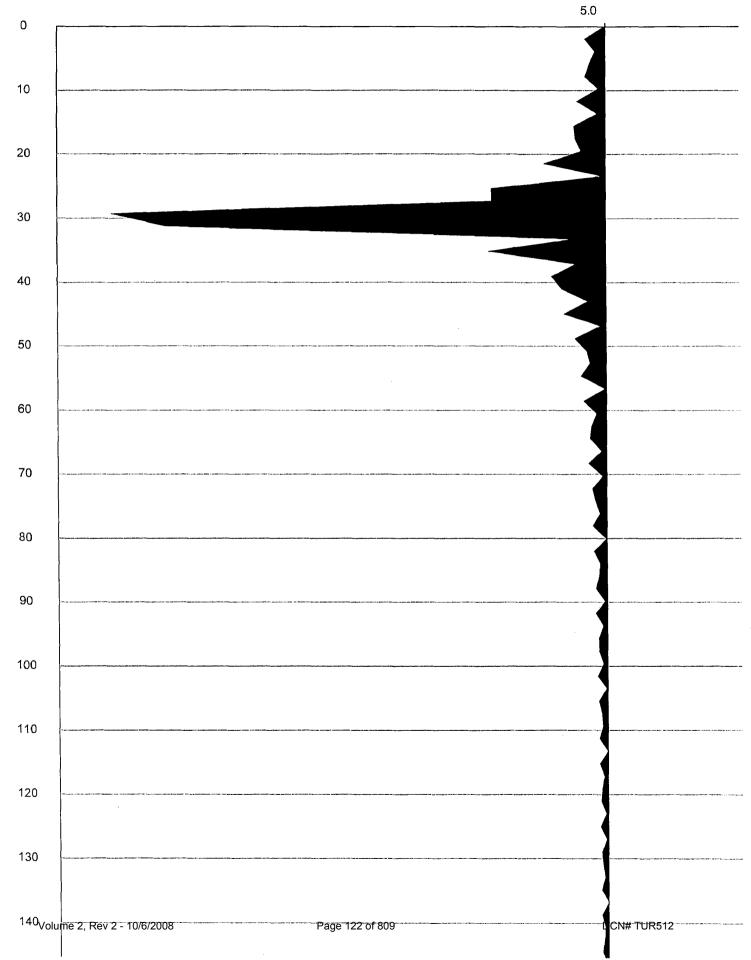
Frequency (HZ) In: 10.055 Seismograph: 9.9



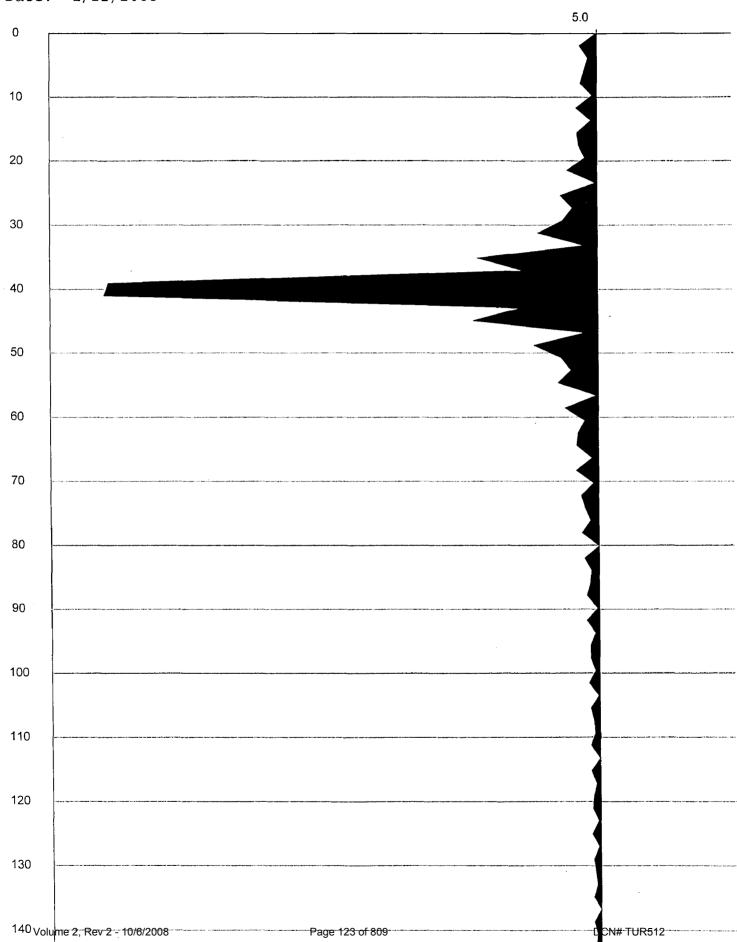
Frequency (HZ) In: 20.037 Seismograph: 19.9



Frequency (HZ) In: 30.071 Seismograph: 29.3



Frequency (HZ) In: 40.040 Seismograph: 40.1



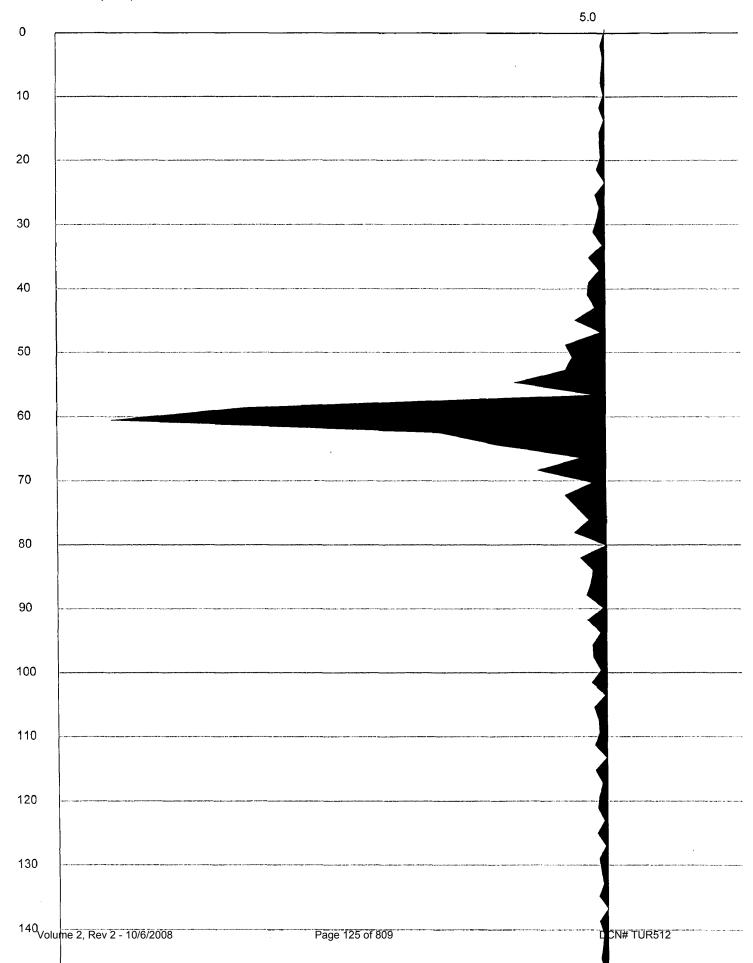
Geometrics ES-3000 S/N 5138 Frequency (HZ) In: 50.061 Seismograph: 50.6 Date: 1/22/2008 5.0 

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CN# TUR512

Frequency (HZ) In: 60.048 Seismograph: 60.3



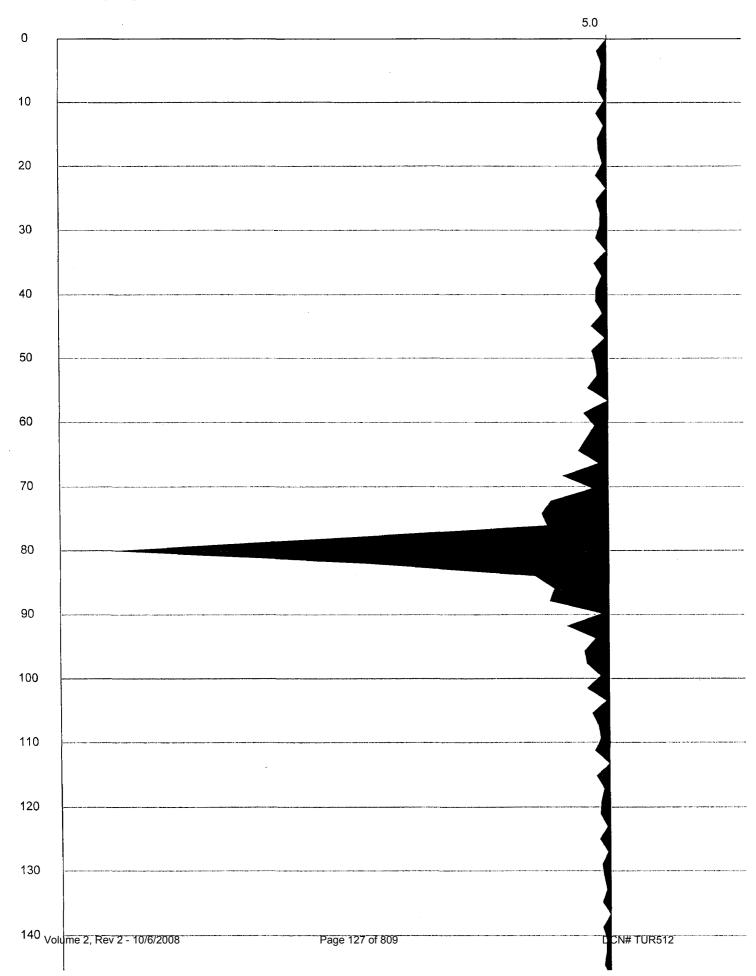
Geometrics ES-3000 S/N 5138 Frequency (HZ) In: 70.005 Seismograph: 70.2 Date: 1/22/2008 5.0 

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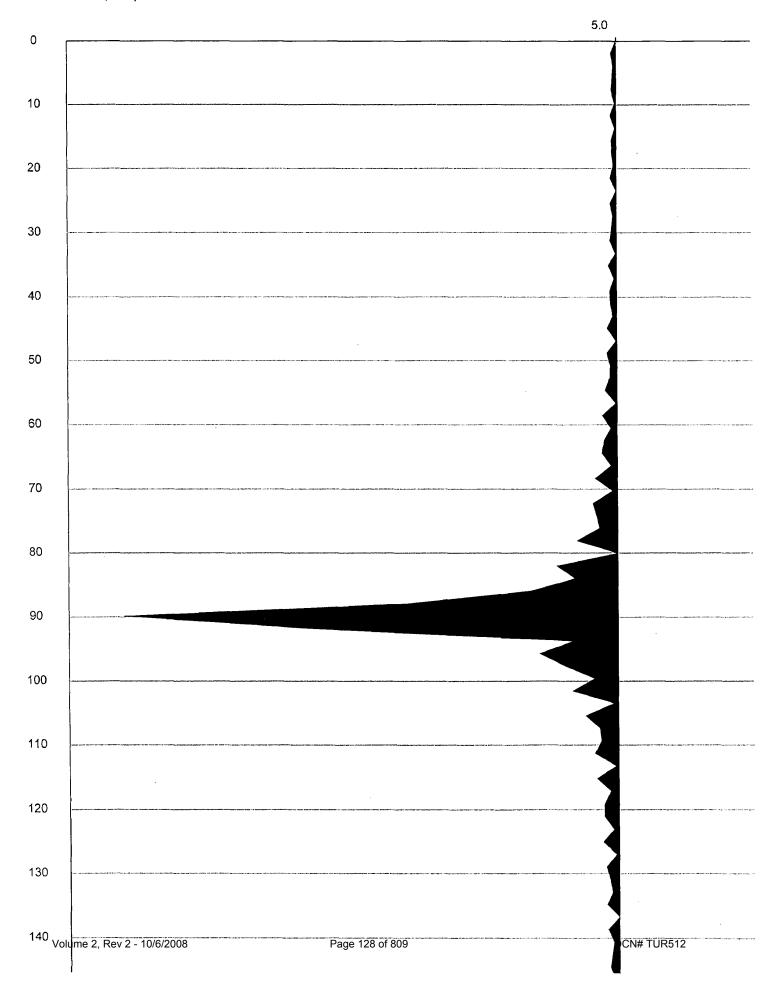
DCN# TUR512

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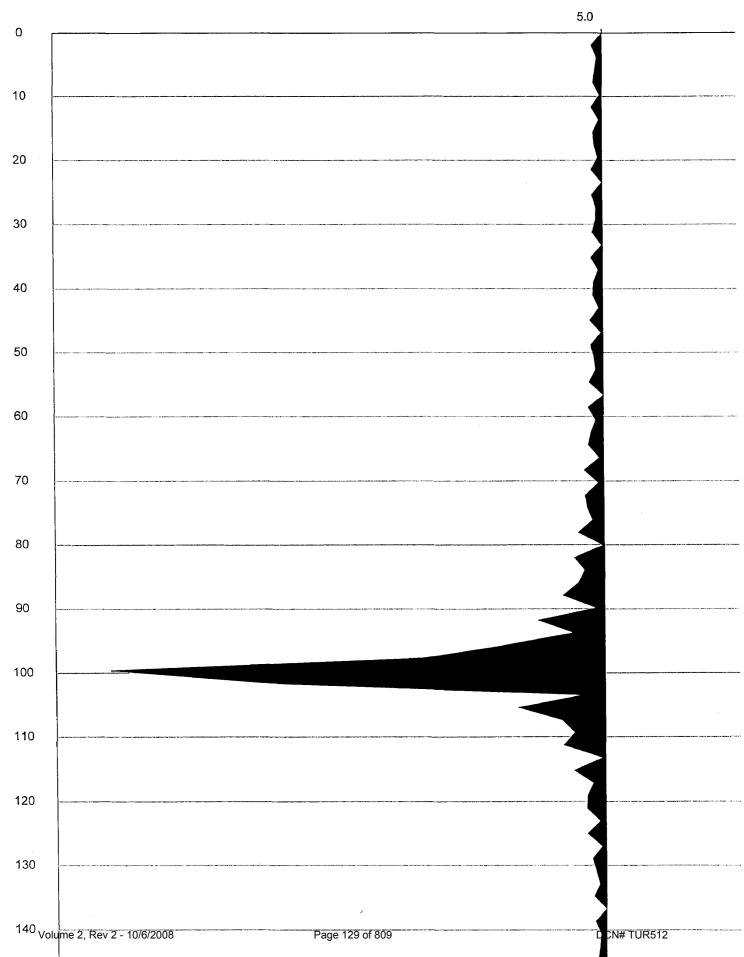
Frequency (HZ) In: 80.011 Seismograph: 79.9



Frequency (HZ) In: 90.090 Seismograph: 90.1



Frequency (HZ) In: 100.014 Seismograph: 99.8



# POST JOB CALIBRATION VERIFICATION

#### **Calibration Verification Certificate**



Device Typa:

Piezo Cone Penetrometer

Device Number:

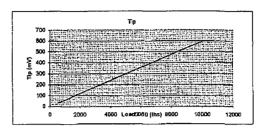
F7.5CKE3SW2/B 1701-0750

#### TIP CALIBRATION

Tip area = 15 cm2 = 0.0161 ft2

Tip readings in mV

				1119
Load	Load	load/area	Tip	Cal Factor
lb	Tons	tsf	mV	Mpa
0	0	0	0	0
540	0.27	16.77019	32.1	50.0287963
5015	2.5075	155.7453	298.3	49.9975831
7510	3.755	233.2298	446.2	50.0543352
10005	5.0025	310.7143	594.3	50.0659763
15010	7.505	466.1491	892.6	50.0098021
19980	9.99	620.4969	1186.6	50.0751739

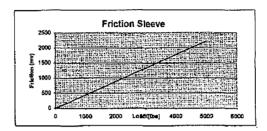


#### **FRICTION CALIBRATION**

Sleeve area = 200 cm2 = 0.2153 ft2

Friction readings in mV

				Friction
Load	Load	load/area	Friction	Cal Factor
ΙÞ	Tons	tsf	mV	Mpa
0	0	0	0	0
500	0.25	1.16117	220.3	0.50474111
2520	1.26	5.852299	1110.6	0.50461022
3755	1.8775	8.72039	1666.2	0.5011826
4990	2.495	11.58848	2215.9	0.50079912
7505	3.7525	17.42917	3335.8	0.50033843

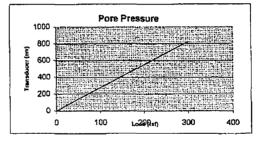


#### PORE PRESSURE TRANSDUCER CALIBRATION

Serial: 8091223

Pore Pressure readings in mV

		,	
Pressure	Pressure	Transducer	P.Pres.
		readings	Cal Factor
psi	tsf	mV	Мра
. 0	0	0	0
75	5.4	206.6	2.50294116
150	10.8	413.3	2.50233557
300	21.6	823.4	2.51206045



#### Temperature Calibration (30 - 115 degrees F)

restiperatu	ne canbra	PO11 (00 - 11)	acg,cco i j				
Temp (deg	TIP (mV)	FRIC (mV) F	PIEZO (mV)	Deviation	m۷	Mpa	% Full Scale
30	0.957	0.788	-0.124	Tip	0.395	0.01975	0.0395
50	0.994	0.957	-0.065	Friction	0.964	0.000482	0.0964
75	1.054	1.037	0.258	Piezo	1.137	0.002843	0.1137
100	1.284	1.236	0.369				
115	1.352	1.752	1.013				

TIP CALIBRATED BY GEOTAC (A2LA APPROVED) LOAD CELL:

Model 560K, Serial No. 129739

FRICTION CALIBRATED BY INTERFACE (A2LA APPROVED) LOAD CELL:

Model 560K, Serial No. 129739

PORE PRESSURE TRANSDUCER CALIBRATED BY GE SENSING (AANSI/NCSL APPROVED)

Pressure Indicator Model: UPS3000CC, Serial: A0813

TEMPERATURE CALIBRATED BY HOUSTON PRECISION TYPE K THERMOCOUPLE (A2LA APPROVED)

Model # 8528-40, Serial # C95005824, ID # TD-001

Calibration Verified by: Dennis Stauffer

Date:

6/2/2008

Checked By

: Recep Yilmaz

Date:

te: 6/2/2008

#### **HGL** Instrument Verification LVDT?: Yes; X No DATE: 6/2/2008 Instrument No.: ft100 Location: Houston Type Analysis: X BF; NonBF; X FS: Abs. Reading Resolution of Instrument: 0.000001 Instrument Identification/Data Standard Prediction instrument Abs. Error Full Scale Type Cone Penetrometer-TIP mV Error (%) Manufacturer Fugro 0.000000 0.0 1.3 1.3 0.01 Model Number F7.5CKEW2/B 32,100000 530,0 541.0 11.0 0.07 Serial Number 1701-0750 298.300000 5010.0 5016.1 6.1 0.04 446.200000 7490.0 7502.5 0.07 HGL Instrument Number ft100 12.5 Excitation (V) 594,300000 10020.0 9992,3 27.7 -0.16 Gain/Span Setting NA 892,600000 15050.0 15007.1 42.9 -0.25 1186.600000 19910.0 19949.6 Full Range Output (V) 39.6 0.23 16858 Full Range/Capacity (ib) Date Verified 6/2/2008 Date Due 6/2/2009 Service Status In Service Accept. Abs. or FS Error (%) X FS: Abs. Verification/Standard Equipment Load cell (A2LA APPROVED) Type Manufacturer Geotac Model Number 560K 129739 Serial Number HGL Instrument Number Date Verified ٥F Temperature Linear Regression, Uncertainty, & Error Summary Correlation Coaff. (R2) 0.999986128 1.347403615 Intercept (lb) Slope (lb/mV) 16.81127161 16.81127161 Verification (Calib.) Factor Verification Factor Units lb/mV Absolute Zero (V) Floating Zero (V) Combined Uncertainty (lb) 6.258542548 Coverage Factor 12.5170851 Expanded Uncertainty (lb) MTS Yes: X No Max. Abs. or FS Error (%) -0.25 X FS; Abs 0.150 Upper Limit 9000.0 0,100 0.050 7000.0 0.000 3000 £ Lawer Limit -0,150 -0.200 0,0 10000,0 25000,0 20000.0 Uncertainity Budget Analysis For ft100 Uncertainty (ui) Source of Uncertainty Value in Ib Distribution Divisor υj² Туре Comments Standard's Uncertainty 2.000D В N Abs. Error-STDEV 6.2585 N 1.0000 6.2585 39.1694 Resolution of Instrument 0.0000 Ŕ 3,4641 B 0.0000 0.0000 Repeatability N 1.0000 А #N/A Resolution of Standard 3,4641 В Combined Uncertainty 6.2585 Coverage Factor for 95% confidence level. Expanded Uncertainty (Best Measurement Capability)3 12.517 (2) This value is unique for type (model) of equip ny expressed ao approximately the 95% confidence level using a coverage factor of 1=2. Verified By: Input By: Reviewed By: Checked By: File: Remarks:

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Tip0750.xls, 6-2-2008 6/26/2008

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Type Analysis: X	strument No.: ft100 F; NonBF; ]	Location X FS; Abs.			Reading	Resoluti	on of In	LVDT?:	Yes; [ 0.000001
Instrument	identification/Data	· · · · · · · · · · · · · · · · · · ·	Instrument	S	tandard	Predic	tion	Abs. Error	Full S
Туре	Cone Penel	trometer	mv		lb	lb		lb	Error
Manufacturer	Fugr		0.000000		0.0	7.:		7.3	0,0
Model Number	F7.5CKE3		220,300000	1	520.0	503		17.0	-0.
Serial Number	1701-0	75D	1110.600000	1 2	2490.0	2506		16.3	0.1
HGL Instrument Number	ft10		1666.200000		3750.0	3758	<del></del> }	6,5	0.0
Excitation (V)			2215.900000		0.010	4993		16.6	-0.
Gain/Span Setting	NA	<del></del>	3335,800000		7510.0	7513		3,4	0.0
Full Range Output (V)			1	-	-	1			<del>                                     </del>
Full Range/Capacity (lb)	1685	58	-			<del>†</del>			<del> </del>
Date Verified	5/2/20		<b>†</b>			-			
Date Due	6/2/20					1			
Service Status	in Sen		<del> </del>			<del></del>	<del></del>		
ccept. Abs. or FS Error (%)		X FS: Abs.		1		<del>                                     </del>			<del></del> -
	Standard Equipment	74 J. C.	<del></del>			<del> </del>			
	Load Cell (A2AL	APPROVEDY				-{			
Type Manufacturer	Geot		- <del> </del>	+		-}			-
	56DI			+-		<del> </del>			<del> </del>
Model Number			<b></b>			<del></del>	$\longrightarrow$	<i></i>	+
Serial Number	1297		<del></del>	-		<del> </del>			<del></del> -
HGL Instrument Number	<del></del>	ŢÍ.	<u> </u>			<b>↓</b>			<u> </u>
Date Verified						1			
Temperature		F				1	i		1
	ncertainty, & Error Su	mmary							L
Correlation Coeff. (R2)	0.99997	6621							
intercept (ib)	7.28079	1244						•	
Slope (lb/mv)	2.25017	7247							
Verification (Callb.) Factor	2.2501	7725		$T^{-}$			.,,		
Verification Factor Units	m/dl	tv							
Absolute Zero (V)						7			
Floating Zero (V)			T						1
Combined Uncertainty (lb)	2.49219	5376	<del>-</del>						
Coverage Factor	2		<del> </del>						~
Expanded Uncertainty (lb)	4.98438			_					
Max. Abs. or FS Error (%)	-0.10	X FS; Abs.			MTS	Yes;	X No	L.	
		<del></del>	Q150		ا				
6000.0			2.50	1				1	
1		1			;	1		•	
b = 2.2502mv	2805	1			. }	Upper	Hmir	1	!
5000,0 b = 2.2502mv	7.2806	<del></del>	0.100	<u> </u>	1	Upper	nwir	<del>  </del>	<del>-   -</del>
) )	72806			<u>                                     </u>		Upper	Limit		
) )	72808		0.100			Upper	i i		
5000,0	72806		0.050			Upper	umit		
5000,0	72806					Upper	umit.		
5000.0 4000.0	72806		0.050			Upper	i i mit		
6000.0 4000.0 3000.0	22006		0.050			Upper	i i i i i i i i i i i i i i i i i i i		
5000.0 4000.0	22006		0.050			Upper	i i i i i i i i i i i i i i i i i i i		
5000.0 4000.0 3000.0	22806		0.050						
6000.0 4000.0 3000.0	/2806		0.000			Lower			
5000.0 4000.0 3000.0	22006		0.050 0.000 -0.050 -0.160			Lower	Limit		
5000.0 4000.0 3000.0		0 2500	0.050 0.000 -0.050 -0.160	000.0	2000.0 3	Lower	Limit	000,0 6000.0	7000.0
6000.0 4000.0 2000.0		0 2500	0.050 0.000 -0.050 -0.160	000.0	2000.0 3	Lower	Limit	000,0 6000.0	7000.0
6000.0 4000.0 2000.0			0.050 0.000 -0.050 -0.160 0.0 10		2360.0 3	Lower	Limit	000,0 6000.0	7000.0
6000.0 4000.0 2000.0		o 2500 Uncertainity Budge	0.050 0.000 -0.050 -0.160 0.0 10		2000.0 3	Lower	Limit		7000.0
6000.0 4000.0 2000.0			0.050 0.000 -0.050 -0.160 0.0 10			Lower	Limit	Oce. 6 6000.0	
5000.0 4000.0 2000.0 1000.0 0.0 500 110	00 1500 2000 Value in lb	Uncertainity Budge	0.050 0.000 -0.050 -0.160 0.0 10	ft100		Lower	Limit		7000.0
5000.0 4000.0 2000.0 1000.0 0.3 500 1000.0	Value in lb	Uncertainity Budge Distribution	0.050 0.000 -0.050 -0.160 0.0 10	ft100 Type	Uncerte	Lower	Limit 00.0 6	U <sub>i</sub> ²	
Source of Uncertainty Standard's Uncertai Abs. Error-STD	Value in lb	Uncertainity Budge Distribution N N	0.050 0.000 -0.050 -0.160 0.0 10 10 10 10 10 10 10 10 10 10 10 10 10 1	ft100 Type B	Uncerte	Lower	Limit 00.0 6	u <sub>i</sub> ²	
Source of Uncertainty Standard's Uncertai Abs. Error-STD	Value in ib  V1 2.4922 ent 0.0000	Uncertainity Budge Distribution N N R	0.050 0.000 0.050 0.160 0.050 0.160 0.050	Type B A B	Uncerte	Lower	Limit 00.0 6	U <sub>i</sub> ²	
Source of Uncertainty Standard's Uncertai Abs. Error-STDI Resolution of Instrum Repsatabl	Value in ib  Value in ib  Vi 2.4922  Int 0.0000  iy 2	Uncertainity Budge Distribution N N R N	0.050 0.000 0.050	Type B A B A	Uncerte	Lower	Limit 00.0 6	u <sub>i</sub> ²	
Source of Uncertainty Standard's Uncertai Abs. Error-STD	Value in ib  Value in ib  Vi 2.4922  Int 0.0000  iy 2	Uncertainity Budge Distribution N N R	0.050 0.000 0.050 0.160 0.050 0.160 0.050	Type B A B	Uncerte	Lower	Limit 00.0 6	u <sub>i</sub> ²	
Source of Uncertainty Standard's Uncertai Abs. Error-STDI Resolution of Instrum Repsatabl	Value in ib  Value in ib  Vi 2.4922  Int 0.0000  iy 2	Uncertainity Budge Distribution N N R N	0.050 0.000 0.050	tt100 Type B A B	Uncerte	Lower	Limit 00.0 6	u <sub>i</sub> ²	
Source of Uncertainty Standard's Uncertai Abs. Error-STDI Resolution of Instrum Repeatabl Resolution of Stand	Value in lb  Value in lb  Vi 2,4922  int 0,0000  iy 2  and #N/A	Uncertainity Budge Distribution N N R R R	0.050 0.000 0.050	tt100 Type B A B	2.4 0.0	Lower	- imit	u <sub>1</sub> <sup>2</sup> 5.2110 5.0000	Comm
Source of Uncertainty Standard's Uncertai Abs. Error-STDI Resolution of Instrum Repeatabl Resolution of Stand	Value in lb  Value in lb  Vi 2.4922  int 0.0000  ty 2  and #N/A	Uncertainity Budge Distribution N N R R N R Co	0.050 0.050	R100 Type B A B A B	Uncerte	Lower	- imit	u <sub>i</sub> ²	Comm
Source of Uncertainty Standard's Uncertai Abs. Error-STDI Resolution of Instrum Repeatabl Resolution of Stand	Value in lb  Value in lb  V1 2.4922  Int 0.0000  ty2  Int #N/A  Anty 2.4922  Aceasurement Capability	Uncertainity Budge Distribution N N R R N R Co	0.050 0.000 0.050	tt100 Type B A B	2.4 0.0	Lower 400 400 400 400 400 400 400 400 400 40	£irrit 00.0 6	u <sub>1</sub> <sup>2</sup> 5.2110 5.0000	Comm

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Remarks;

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A I E: 01.	2/2008 Instri	ument No.: pt	Location:	:	Houston		LVDT?:	Yes;
T	ype Analysis: X BF;	; NonBF; X FS;	;Abs.		Read	ling Resolutio	on of instrument:	0.000001
	Instrument id	lentification/Data		instrument	Standard	Predict	tion Abs. Error	r Full Sc
	Type	Cone Penetrometer -	Piezo	mv	psi	psi	psi	Error (
	Manufacturer	Fugro		0.000000	0.0	-0.2		-0.0
	Model Number	F7.5CKEW2/B		206.600000		75.1		0.02
	Serial Number	1701-0750-80912	23	413.300000		150.		0.10
HGL Ins	strument Number	pt	<del></del> -	823.400000	300.0	299.	8 0.2	-0.0
	Excitation (V)			<del>                                     </del>	<del> </del>	<del></del>		<del></del>
	Range Output (V)	NA		<del> </del>	<del></del>	<del></del>	<del></del>	-
	ge/Capacity (psi)	360		<del>                                     </del>				+
, on reality	Date Verified	6/2/2008		<del> </del> -	<del> </del>			<del></del>
	Date Due	6/2/2009		<del></del>	1			
	Service Status	In Service			1			<del></del>
Accept. Abs	, or FS Error (%)	0.25 X FS;	; Abs.					
	Verification/Sta	andard Equipment						
	Type	PT(ANSI/NCSL APPR	OVED)					
	Manufacturer	Eaton		ļ				
	Model Number	UPS3000CC		<del> </del>	<del></del>			
	Serial Number	A0813		↓				
HGL Ins	strument Number	_	▼]	<b></b>		_ <u> -</u>		
	Date Verified							
	Temperature	°C= °F		<del>-</del>	<del></del>			<del></del>
		ertainty, & Error Summar	ry	<del></del>	<del></del>			
Corre	lation Coeff. (R <sup>2</sup> )	0.999995309 -0.225296318		<del> </del>	+		<del></del>	
	Intercept (psi) Stope (psi/mv)	0.364374132		<del> </del> -	<del> </del>		<del></del>	<del></del>
Vedfication	on (Calib.) Factor	0.364374132		<del>                                     </del>				
	tion Factor Units	psi/mv		<del> </del>	+	-+		
	Absolute Zero (V)	pa		1	+			<del> </del>
	Floating Zero (V)			1	<del>                                     </del>			<del> </del>
Combined	Uncertainty (psi)	0.064742646						
	Coverage Factor	2						
	Uncertainty (psi)	0.129485291	1 - 1 - 1					
Max. Abs	s. or FS Error (%)	0.10 X FS	Abs.	J	MTS	Yes;	X No	
350.0			<del></del>	0.300	<del></del>	Upper Limi		
	psi = 0.3644rmv-0.22	53				Oppos cinii		
300.0				0.200	<del>  </del>			
250.0	1 1 1							
	]   [			0.100				
200.0				0.000				
150.0	<del>                                     </del>				T			
			ł	-0.100				
100.0								
50.0				-0.200	++			
	1     1					Lower Lim		_
0.0	100 200 300 400	0 500 500 700 800	990	-9.300	11			
-50.0				0.0	50.0 100.0	150,0	200.0 250.0	300,0
		lina	ertainity Budge	Analysis Fac				
Source	of Uncertainty	<del></del>	Distribution			rtainty (u <sub>i</sub> )	u <sub>i</sub> <sup>2</sup>	Commo
	tandard's Uncertainty		N	2,0000	Type Uncer B			Comme
	Abs. Error-STDEV <sup>1</sup>	0.0647	N			0647	0.0042	
Rac	solution of Instrument		R	1.0000 3.4641		0.0647	0.0042 0.0000	
			N	1.0000	A	.5555	0,000	
					/ 1 E		•	
	Repeatability <sup>2</sup> esolution of Standard							
	esolution of Standard		R	3.4641	В			
R		#N/A	R				for 95% confidence	level

Source of Uncertainty	Value in psi	Distribution	Divisor	Туре	Uncertainty (u <sub>i</sub> )	u <sub>i</sub> ²	Comment
Standard's Uncertainty		N	2.0000	В			
Abs. Error-STDEV <sup>1</sup>	0.0647	N	1.0000	Α	0.0647	0.0042	
Resolution of Instrument	0.0000	R	3.4641	В	0.0000	0.0000	
Repeatability <sup>2</sup>		N	1.0000	Α			T
Resolution of Standard	#N/A	R	3.4641	В			
Combined Uncertainty	0.0647	Co	verage Facto	r	2	for 95% confidence	ce level
Expanded Uncertainty (Best Measu		0.1		psi		The second of th	

Verified By: \_7 Input By: Reviewed By: \_\_

File:

Remarks:

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FUGRO CONSULTANTS INC

2000.2 (06/14/07)

# FINAL DATA REPORT Rev. 2 GEOTECHNICAL EXPLORATION AND TESTING

# TURKEY POINT COL PROJECT FLORIDA CITY, FLORIDA

October 6, 2008

# VOLUME 2 Appendix D – Geovision Downhole and P-S Logging Report

Prepared By:

MACTEC Engineering and Consulting, Inc. Raleigh, North Carolina

**MACTEC Project No. 6468-07-1950** 

**Prepared For:** 

Bechtel Power Corporation Subcontract No. 25409-102-HC4-CY00-00001



## DOCUMENTATION OF TECHNICAL REVIEW SUBCONTRACTOR WORK PRODUCT

Project Name: Turkey Point COL Project Number: 6468-07-1950 Project Manager: Scott Auger Project Principals: Al Tice and Tom McDaniel The report described below has been prepared by the named subcontractor retained in accordance with the MACTEC QAPD. The work and report have been reviewed by a MACTEC technically qualified person. Comments on the work or report, if any, have been satisfactorily addressed by the subcontractor. The attached report is approved in accordance with section QS-7 of MACTEC's QAPD The information and date contained in the attached report are hereby released by MACTEC for project use. REPORT: Report Boring Geophysical Logging. Report 8083-03 rev 0, July 24, 2008 SUBCONTRACTOR: GeoVision DATE OF ACCEPTANCE: 7-25-08 TECHNICAL REVIEWER: 7-25-08

DCN TUR - 483





# BORING GEOPHYSICAL LOGGING BORINGS B-601 (DH), B-604 (DH), B-608 (DH), B-610 (DH), B-620 (DH), B-640 (DHT), B-701 (DH), B-704 G (DH), B-708 (DH), B-710 G (DH), B-720 G (DH) AND B-740 (DHT)

**FPL TURKEY POINT COL** 

Report 8083-03 rev 0

July 24, 2008

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# BORING GEOPHYSICAL LOGGING BORINGS B-601 (DH), B-604 (DH), B-608 (DH), B-610 (DH), B-620 (DH), B-640 (DHT), B-701 (DH), B-704 G (DH), B-708 (DH), B-710 G (DH), B-720 G (DH) AND B-740 (DHT)

### **FPL TURKEY POINT COL**

Report 8083-03 rev 0 July 24, 2008

Prepared for:

MACTEC Engineering and Consulting, Inc.
3301 Atlantic Avenue
Raleigh, N. C. 27604
919-831-8000
MACTEC Job number 6468-07-1950

Prepared by

GEOVision Geophysical Services
1124 Olympic Drive
Corona, California 92881
(951) 549-1234

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MACTEC Engineering and Consulting, Inc. FPL Turkey Point COL Geotechnical Data

INTRODUCTION

Boring geophysical measurements were collected in ten uneased and two cased borings located

at the Florida Power and Light (FPL) Turkey Point Combined Operating License (COL)

Application Project, located near Florida City, Florida. Geophysical data acquisition was

performed between March 8 and June 26, 2008 by Robert Steller, Charles Carter, Anthony

Martin and Nathan Baldwin of GEOVision. Data analysis was performed by Robert Steller and

Anthony Martin, and reviewed by John Diehl of GEOVision. Report preparation was performed

by Robert Steller and reviewed by John Diehl of GEOVision. The work was performed under

subcontract with MACTEC Engineering and Consulting, Inc., (MACTEC) with Stephen

Criscenzo serving as the point of contact for MACTEC.

This report describes the field measurements, data analysis, and results of this work.

SCOPE OF WORK

This report presents the results of boring geophysical measurements collected between March 8

and June 26, in twelve borings, as detailed in Table 1. The purpose of these studies was to

supplement stratigraphic information obtained during MACTEC's soil and rock sampling

program and to acquire shear wave velocities and compressional wave velocities as a function of

depth, as a component of the FPL Turkey Point COL Project.

The OYO/Robertson Suspension PS Logging System (Suspension System) was used to obtain

in-situ horizontal shear (S<sub>H</sub>) and compressional (P) wave velocity measurements in ten borings

at 1.6 foot intervals. Measurements followed **GEO** Vision Procedure for P-S Suspension Seismic

Velocity Logging, revision 1.31. The acquired data was analyzed and a profile of velocity

versus depth was produced for both compressional and horizontally polarized shear waves.

The Robertson ELGX and 3ACS probes were used to collect long and short normal resistivity, single point resistance (SPR) Spontaneous Potential (SP), natural gamma and 3 arm mechanical caliper data at 0.05 foot intervals in the ten uncased borings to aid in identification of stratagraphic transitions. Measurement procedures followed these ASTM standards:

- ASTM D5753, "Planning and Conducting Borehole Geophysical Surveys
- ASTM D6167 "Conducting Borehole Geophysical Logging Mechanical Caliper"
- ASTM D6274, "Conducting Borehole Geophysical Logging Gamma"

The acquired data was combined and a profile of these parameters versus depth was produced.

The Robertson High Resolution Acoustic Televiewer (HiRAT) was used to collect deviation data at 0.04 foot intervals and acoustic televiewer images of the rock section of each boring at 0.008 foot intervals in the ten uncased borings. Measurements followed the **GEO**Vision HiRAT Field Procedure, revision 1.0. The acquired data was analyzed and a profile of boring deviation versus depth was produced for each boring, and an image of the rock portions of the uncased borings, with 4 arm caliper dimensions superimposed, was produced.

The Downhole Seismic velocity logging system was used in the two PVC cased borings as a validation of the suspension velocity data collected at this site. In this method, the source remains stationary at the surface, while a single receiver travels down the cased boring at 5 foot intervals. Source energy is transmitted down the soil column from the surface and velocity is calculated from first arrival travel time and receiver depth. Measurements followed **GEO***Vision* Procedure for Downhole Seismic Velocity Logging, revision 1.1. The acquired data was analyzed and a profile of velocity versus depth was produced for both P- and S<sub>H</sub> -waves.

A detailed reference for the suspension PS velocity measurement techniques used in this study is:

<u>Guidelines for Determining Design Basis Ground Motions</u>, Report TR-102293, Electric Power Research Institute, Palo Alto, California, November 1993, Sections 7 and 8.

INSTRUMENTATION

**Suspension Velocity Instrumentation** 

Suspension velocity measurements were performed in ten uncased nominal 3.88 - 5.0 inch

diameter borings using the suspension PS logging system, manufactured by OYO Corporation,

and their subsidiary, Robertson Geologging. Components used for these measurements are listed

in Table 2. This system directly determines the average velocity of a 3.3 foot high segment of

the soil column surrounding the boring of interest by measuring the elapsed time between

arrivals of a wave propagating upward through the soil column. The receivers that detect the

wave, and the source that generates the wave, are moved as a unit in the boring producing

relatively constant amplitude signals at all depths.

The suspension system probe consists of a combined reversible polarity solenoid horizontal

shear-wave source (S<sub>H</sub>) and compressional-wave source (P), joined to two biaxial receivers by a

flexible isolation cylinder, as shown in Figure 2. The separation of the two receivers is 3.3 feet,

allowing average wave velocity in the region between the receivers to be determined by

inversion of the wave travel time between the two receivers. The total length of the probe as

used in these surveys is 19 feet, with the center point of the receiver pair 12.1 feet above the

bottom end of the probe.

The probe receives control signals from, and sends the digitized receiver signals to,

instrumentation on the surface via an armored 4 conductor cable. The cable is wound onto the

drum of a winch and is used to support the probe. Cable travel is measured to provide probe

depth data, using a 3.28 foot circumference sheave fitted with a digital rotary encoder.

The entire probe is suspended in the boring by the cable, therefore, source motion is not coupled

directly to the boring walls; rather, the source motion creates a horizontally propagating

impulsive pressure wave in the fluid filling the boring and surrounding the source. This pressure

wave is converted to P and S<sub>H</sub>-waves in the surrounding soil and rock as it passes through the

casing and grout annulus and impinges upon the wall of the boring. These waves propagate through the soil and rock surrounding the boring, in turn causing a pressure wave to be generated in the fluid surrounding the receivers as the soil waves pass their location. Separation of the P and  $S_{II}$ -waves at the receivers is performed using the following steps:

- Orientation of the horizontal receivers is maintained parallel to the axis of the source, maximizing the amplitude of the recorded S<sub>H</sub> -wave signals.
- 2. At each depth, S<sub>H</sub>-wave signals are recorded with the source actuated in opposite directions, producing S<sub>H</sub>-wave signals of opposite polarity, providing a characteristic S<sub>H</sub>-wave signature distinct from the P-wave signal.
- 3. The 6.3 foot separation of source and receiver 1 permits the P-wave signal to pass and damp significantly before the slower S<sub>II</sub>-wave signal arrives at the receiver. In faster soils or rock, the isolation cylinder is extended to allow greater separation of the P- and S<sub>II</sub>-wave signals.
- 4. In saturated soils, the received P-wave signal is typically of much higher frequency than the received S<sub>H</sub>-wave signal, permitting additional separation of the two signals by low pass filtering.
- 5. Direct arrival of the original pressure pulse in the fluid is not detected at the receivers because the wavelength of the pressure pulse in fluid is significantly greater than the dimension of the fluid annulus surrounding the probe (meter versus centimeter scale), preventing significant energy transmission through the fluid medium.

In operation, a distinct, repeatable pattern of impulses is generated at each depth as follows:

- 1. The source is fired in one direction producing dominantly horizontal shear with some vertical compression, and the signals from the horizontal receivers situated parallel to the axis of motion of the source are recorded.
- 2. The source is fired again in the opposite direction and the horizontal receiver signals are recorded.
- 3. The source is fired again and the vertical receiver signals are recorded. The repeated source pattern facilitates the picking of the P and S<sub>H</sub>-wave arrivals; reversal of the source changes the polarity of the S<sub>H</sub>-wave pattern but not the P-wave pattern.

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The data from each receiver during each source activation is recorded as a different channel on the recording system. The Suspension PS system has six channels (two simultaneous recording channels), each with a 1024 sample record. The recorded data are displayed as six channels with a common time scale. Data are stored on disk for further processing. Up to 8 sampling sequences can be summed to improve the signal to noise ratio of the signals.

Review of the displayed data on the recorder or computer screen allows the operator to set the gains, filters, delay time, pulse length (energy), sample rate, and summing number to optimize the quality of the data before recording. Verification of the calibration of the Suspension PS digital recorder is performed every twelve months using a NIST traceable frequency source and counter, as outlined in Appendix E.

### **Downhole Velocity Instrumentation**

Downhole velocity measurements were performed in two 2 inch PVC cased borings using a Geostuff BHG-3, 3-component borehole geophone, serial number B-3079. This system orients the downhole geophones parallel to the axis of excitation at the surface, insuring that signals received at the downhole geophones are of maximum amplitude, and are not subject to errors in travel time caused by incorrect phase of first arrival picks, as found with non-orientable downhole probes. The downhole probe consists of horizontal and vertical geophones mounted on a rotatable structure with a fluxgate magnetometer compass sensor. The structure can be preset on the surface to match the azimuth of the horizontal geophone axis with the azimuth of the surface shear wave source whenever power is applied to the compass sensor and orientation servo mechanism. The probe receives control signals from, and sends the geophone signals to, instrumentation on the surface via cable. Cable travel is measured to provide probe depth data. The probe is locked into the boring using a motor driven clamp mechanism. The BHGC-4 controller directs the voltages to control the clamping mechanism and orientation mechanism. A meter monitors motor current to indicate the clamping action and force.

A triaxial geophone is placed on the surface adjacent to the boring collar, to record reference waveforms to validate the function of the hammer switch, as well as to monitor shifts in timing due to changes in source coupling to the soil.

The S<sub>H</sub> -wave energy source consists of an 88-pound elastic band accelerated hammer striking horizontally against the ends of a steel capped traction plank. The traction plank is weighted by placing it beneath the rear end of a truck supported on an air suspension, as shown in Figure 2. The P-wave energy source utilizes the same energy source operating in a vertical orientation, striking an aluminum plate, as shown in Figure 3. A hammer switch mounted on the steel plank caps or aluminum plate is used to provide consistent triggering from each hammer blow. During logging operations, a repeatable pattern of impulses, similar to that produced by the suspension source, is generated at each measurement depth as follows:

- The plank is struck with the hammer laterally in one direction, producing dominantly
  horizontal shear with some vertical compression, and the signals generated by the
  horizontal receivers are recorded. The signals are checked, and repeated (stacked) as
  needed.
- 2. The plank is struck in the opposite direction and the horizontal signals are recorded, and stacked as needed.
- 3. The plate is struck on top, and the signals generated by the vertical receivers are recorded. The repeated source pattern facilitates the picking of the P- and S<sub>H</sub>-wave arrivals, since the reversal of the source direction changes the polarity of the S<sub>H</sub>-wave pattern but not that of the P-wave pattern.

The signals from the BHG-3 geophone were recorded on a Geometrics Geode seismograph, controlled by a laptop computer. Geode S/N 3458 was used on both borings. The Geode is a 24-bit exploration seismograph with 113dB dynamic range. Triggered by the hammer switch (see procedure, Appendix G) the seismograph recorded the responses of the borehole and surface sensors. Data was reviewed on the computer screen, and stored internally on hard disk. Multiple hammer blows can be summed to improve the signal-to-noise ratio of the signals. Review of the displayed data on the screen allows the operator to set the gains, filters, sample rate, and summing number in order to optimize the quality of the data before recording to disk for later processing.

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Caliper / Natural Gamma Instrumentation

Caliper and natural gamma data were collected using a Model 3ACS 3-leg caliper probe, serial

number 5368, manufactured by Robertson Geologging, Ltd. With the short arm configuration

used in these surveys, the probe permitted measurement of boring diameters between 1.6 and 16

inches. With this tool, caliper measurements were collected concurrent with measurement of

natural gamma emission from the boring walls. The probe was 6.82 feet long, and 1.5 inches in

diameter.

This probe is useful in the following studies:

Measurement of boring diameter and volume

Location of hard and soft formations

Location of fissures, caving, pinching and easing damage

Bed boundary identification

Strata correlation between borings

The probe receives control signals from, and sends the digitized measurement values to, a

Robertson Micrologger II on the surface via an armored 4 conductor cable. The cable is wound

onto the drum of a winch and is used to support the probe. Cable travel is measured to provide

probe depth data, using a 3.28 foot circumference sheave fitted with a digital rotary encoder.

The probe and depth data are transmitted by USB link from the Micrologger unit to a laptop

computer where it is displayed and stored on hard disk.

The caliper consists of three arms, each with a toothed quadrant at their base, pivoted in the

lower probe body. A toothed rack engages with each quadrant, thus constraining the arms to

move together. Linear movement of the rack is converted to opening and closing of the arms.

Springs hold the arms open in the operating position. A motor drive is provided to retract the

arms, allowing the probe to be lowered into the boring. The rack is coupled to a potentiometer

which converts movement into a voltage sensed by the probe's microprocessor.