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CONE PENETROMETER SUBSURFACE INVESTIGATION REPORT

SUNNOCO, INC.
BELMONT TERMINAL
2700 PASSYUNK AVE.
PHILADELPHIA, PA

Jack Mannix
Senior Hydrogeologist

HANDEX CONE PENETROMETER DIVISION
61-C Carolyn Boulevard Farmingdale, New York 11735

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INTRODUCTION

Handex was retained by Sunoco Inc. to conduct a Cone Penetrometer Technology (CPT), characterization at 2700 Passyunk Ave., Philadelphia, PA. The CPT is used to assess and partially delineate the subsurface petroleum impacted areas of concern using electronic sensors and a Fuel Fluorescence Detector (FFD). The investigation was completed in September of 2000 and utilized the Handex CPT which is equipped with a Fuel Fluorescence Detector (FFD) to identify and delineate the presence of subsurface hydrocarbons. The following report, geologic logs and model output summarizes the results of the CPT / FFD soil investigation.

The Handex CPT is equipped with a fuel fluorescence detector that projects ultraviolet light through a sapphire window onto the soil as the tool is being advanced into the ground. If hydrocarbons are present they absorb the ultraviolet (UV) light and emit energy in the form of fluorescent light. This light passes back through the sapphire window and is collected by a fiber optic cable and transmitted to two photo-multipliers in the FFD probe. Here the optical signal is converted to two electric signals and transmitted through a cable into the truck, where the signals are amplified and logged by the on-board data acquisition system. The resulting output is two continuous FFD profiles displaying fluorescence intensity verses depth below the land surface.

The wavelength of the excitation light source located in the FFD module is 254 nanometers (nm) (Bratton and Shinn). If hydrocarbons are impacted by the excitation light source, they will fluoresce. The fluorescent response signal is split and then filtered at each photo-multiplier. One half of the signal is filtered to remove wavelengths below 280 nm and above 450 nm

while the other half is filtered to remove wavelengths below 450 nm and above 575 nm. The fluorescence response signal for gasoline and fuel oil (diesel) range hydrocarbons is observed in the 280 to 400 nm wavelength range. The fluorescence response from heavier compounds such as creosote and coal tar residuals are observed at longer wavelengths, primarily impacting the photo-multiplier equipped with the long pass filter (only allowing 450nm to 575nm wavelength range of light to pass). Since all of the hydrocarbons encountered at this site had a more significant response from the higher wavelength FFD (HFFD) and are best represented by this signature, only the HFFD was used to generate the hydrocarbon distribution model shown in the Figures section of this report. The intensity of the FFD signals are expressed in volts and in previous applications have been found to be proportional to the amount of hydrocarbon present in the pore space in the sediments along with air and groundwater.

FIELD INVESTIGATION

CPT/FFD Sounding Program

A total of 22 CPT/FFD soundings were completed at the site to depths ranging from approximately 21 to 53 feet Below Land Surface (BLS). All locations were cleared to 5 feet with an air knife prior to the CPT/FFD sounding to insure that subsurface utilities were cleared before the work began. The locations of the CPT soundings are shown on the site plan (Figure 1).

Site Geology and CPT Soil Classification

The CPT data was collected in accordance with ASTM D 3441-1986 and was used to determine the subsurface stratigraphy. The CPT sounding profiles generated from the data are included as Appendix A.

The site is primarily underlain by sand and gravelly sand to a depth of about 30 feet BLS. Most of the soundings displayed 1 to 4 foot thick layer of sand mix or clayey silt between 20 and 30 feet BLS, which is within the primary sand layer. A fine grained sand mix, clayey silt and clay was detected under the primary sand layer in most soundings, starting between 31 and 41 feet BLS and extending to the bottom of the soundings.

Fuel Fluorescence Detector Results

The FFD tool was calibrated with a card that has a black area and a white area designed to give a known difference in FFD output from each of the colors, on each of the FFD detectors. The voltage output was in the same range as previous outputs for the same calibration card. The results of the FFD calibration are provided in Appendix B. In Appendix A, the columns

labeled "LFFD" and "HFFD" represent the fluorescent light response, which is located 2.37 feet above the cone tip. This is the reason the FFD profiles are shorter than the terminal depth of the push.

High FFD responses were encountered in all soundings except CPT-19 which met refusal at 20.61 feet BLS, above the expected hydrocarbon level and CPT-20 which was the farthest point from the loading rack. Since the locations were cleared to 5 feet BLS prior to performing the soundings, most of the data above 5 feet BLS was lost. High FFD readings were observed at various depths from 5 feet BLS to approximately 38 feet BLS. The responses were not detected at uniform depths in all soundings, but the following trends in the data should be noted.

As shown on Figure 4 (3D Hydrocarbon Distribution Model), the Hydrocarbons were detected predominantly within two elevation intervals. The upper interval is between 10 and 30 feet in elevation (at grade to 20 feet below grade) and the lower interval is between negative 10 and -5 feet in elevation (20 to 35 feet below grade). Figure 4 also shows a connection between the two levels near the western-most loading rack. The hydrocarbon connection can be observed in this area where elevated FFD readings exist between the two levels. Three good example soundings where hydrocarbons were detected between these two elevations are CPT-3, CPT-8, and CPT-12. The lower level FFD readings generally occur within the primary sand layer and below the 1 to 4 foot thick sand mix or clayey silt layer. Two different hydrocarbons were detected in the lower level that are distinguished primarily by their fluorescent properties. The LFFD readings are higher near the top of the hydrocarbon impacted zone while the HFFD readings are higher near the bottom of the zone. These two lower level

hydrocarbon saturated zones are separate in some soundings and they run together in others.

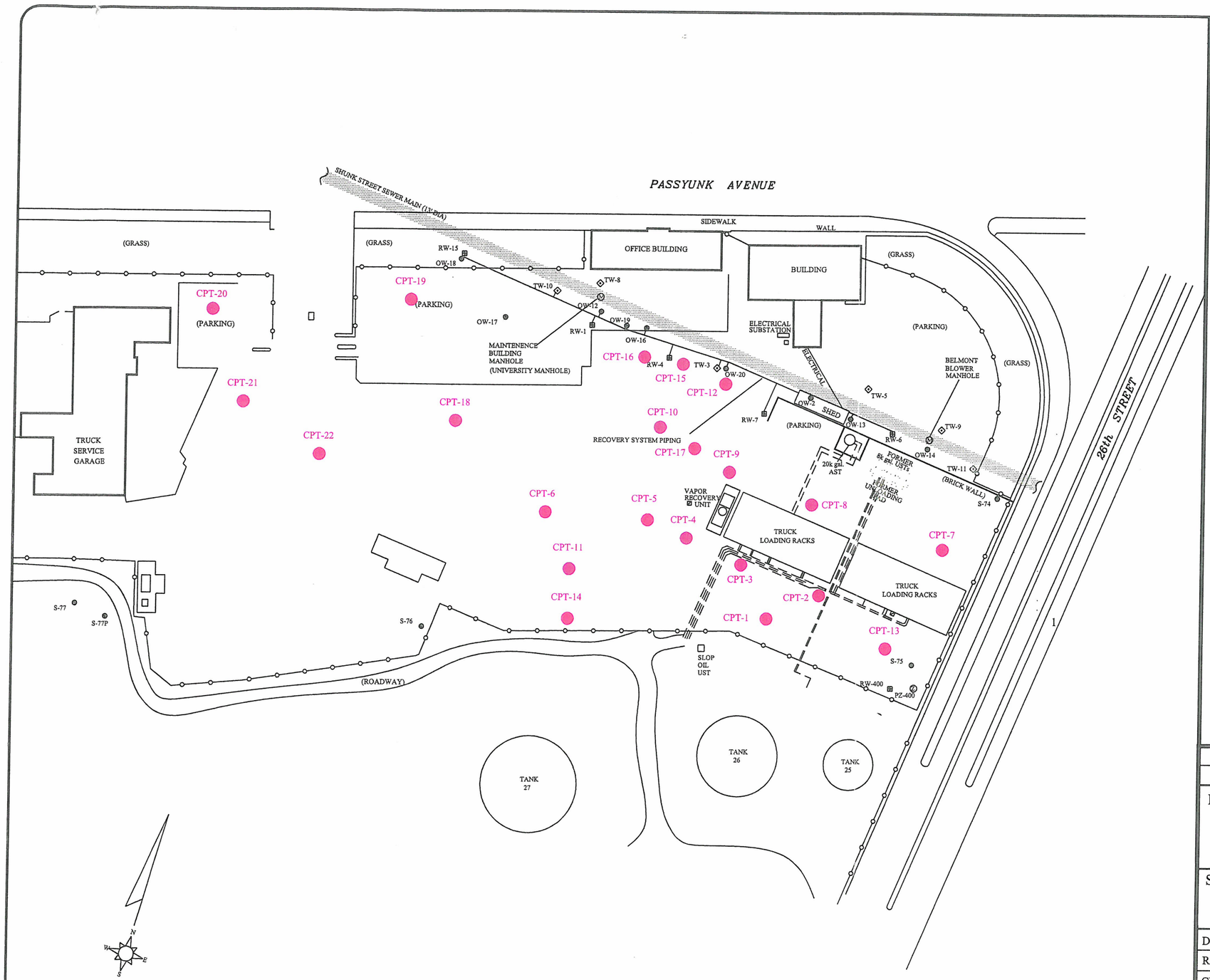
The upper level hydrocarbons (between 10 and 30 feet in elevation) were detected primarily under the loading racks, under the paved area between the loading racks and the main parking lot and just to the south of the main entrance. The lower level hydrocarbons produced the highest FFD readings in three areas. The first was just to the south of the loading racks, the second was approximately 140 feet south of the main parking lot in sounding CPT-6 and the third was just south of the main entrance in CPT-22. Please note that the two eastern-most areas of lower level hydrocarbons may be connected as the sounding separating the two areas (CPT-4) did not go deep enough to detect the lower level hydrocarbons.

Conclusions / Recommendations

Based on the interpolated fuel fluorescence intensity maps shown on Figure 2 and Figure 3, the upper level hydrocarbons and the lower level hydrocarbons are centered along two different lines. Figure 2 shows the upper level hydrocarbons' intensity at it's highest on a line from CPT-7 to CPT-16. Figure 3 shows the lower level hydrocarbons' intensity at it's highest farther to the southwest, on a line from CPT-13 to CPT-22.

In order to fully delineate the extent of hydrocarbons on this site, additional delineation should be performed on the western portion of the site.

FIGURES



LEGEND

- MANHOLE
- RECOVERY WELL
- OBSERVATION WELL
- TEMPORARY WELL
- CPT SOUNDING LOCATION
- FENCE
- SHUNK STREET SEWER
- PRODUCT LINES BELOW GRADE

0 120 240 360 480

SCALE IN FEET

NO.	BY	DATE	REVISION	APP'D.
1.				

PROJECT:

SUNOCO, INC. (R&M)
BELMONT TERMINAL
2700 PASSYUNK AVENUE
PHILADELPHIA, PENNSYLVANIA

SHEET TITLE:

FIGURE # 1 - SITE PLAN

DRAWN BY: F. DeVITA	SCALE: 1 " = 120 '	PROJECT NUMBER: 110535.001
REVISED BY: F. DeVITA		
CHECKED BY: J. MANNIX	FILE NAME:	
DATE: SEPTEMBER 12, 2000	S:/ DRAFTING/CLIENTS/HNDX-MRY/110535/110535-1.DWG	

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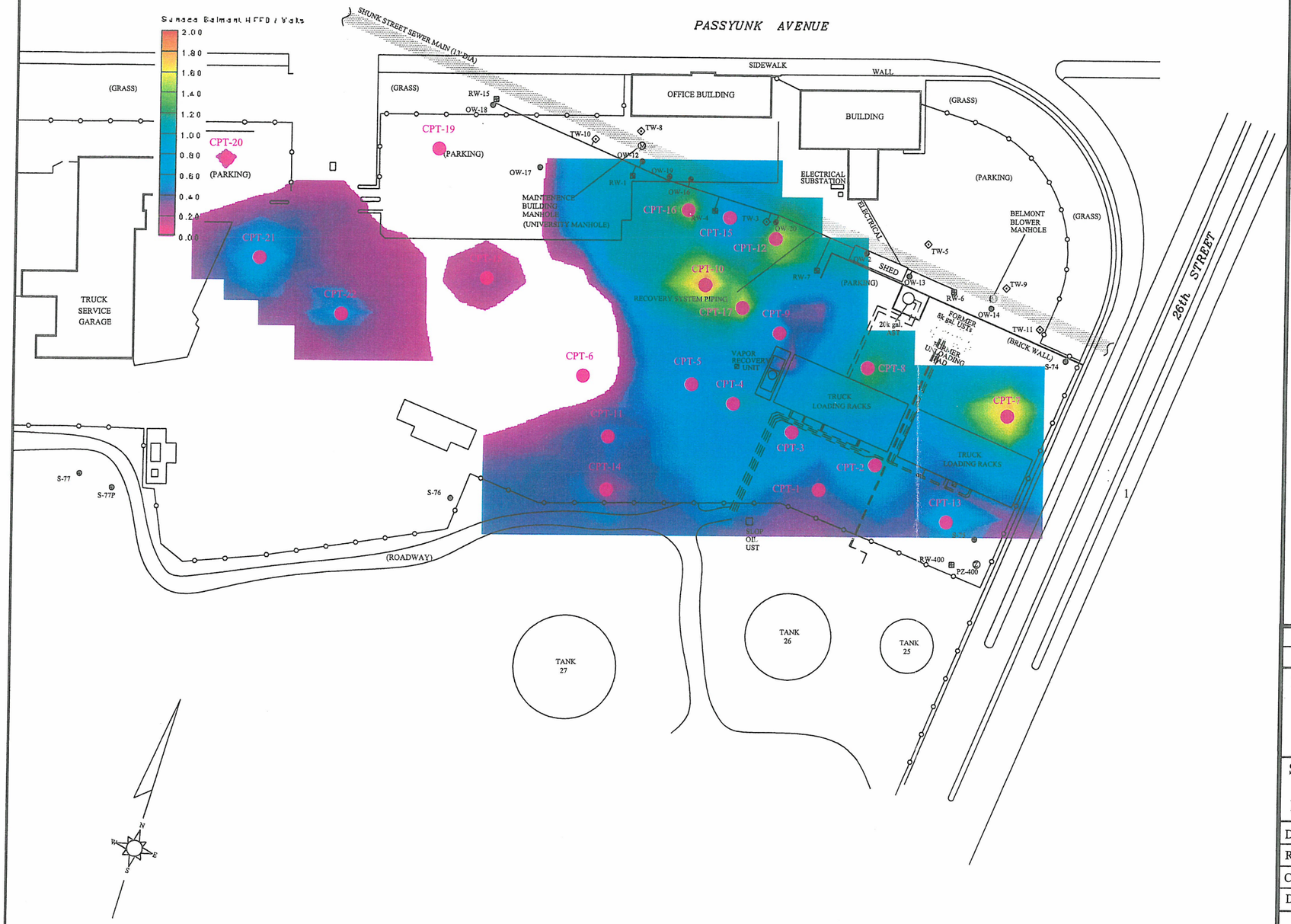

LEGEND

- MANHOLE
- RECOVERY WELL
- OBSERVATION WELL
- TEMPORARY WELL
- CPT SOUNDING LOCATION
- FENCE
- SHUNK STREET SEWER
- PRODUCT LINES BELOW GRADE

0 120 240 360 480

SCALE IN FEET

NO.	BY	DATE	REVISION	APP'D.
1.				

PROJECT:

SUNOCO, INC. (R&M)
BELMONT TERMINAL
2700 PASSYUNK AVENUE
PHILADELPHIA, PENNSYLVANIA

SHEET TITLE:

FIGURE # 2 - SITE PLAN WITH INTERPOLATED FUEL FLUORESCENCE INTENSITY @ UPPER LEVEL (10 - 30 ft ELEVATION)

DRAWN BY: F. DeVITA	SCALE:	PROJECT NUMBER:
REVISED BY: F. DeVITA	1 " = 120 '	110535.001
CHECKED BY: J. MANNIX	FILE NAME:	
DATE: SEPTEMBER 12, 2000	S:/ DRAFTING/CLIENTS/HNDX-MRY/110535/110535-1.DWG	

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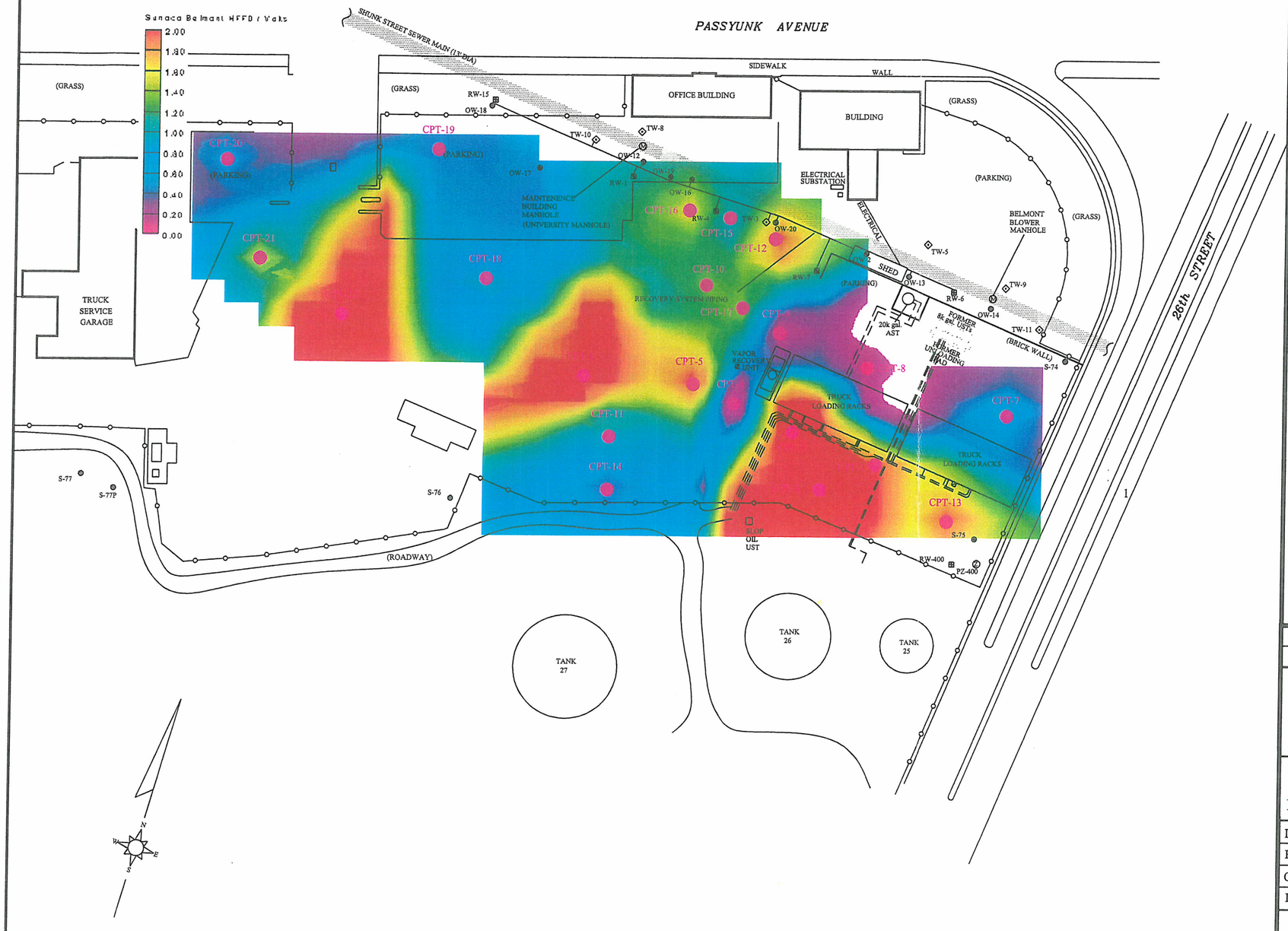

LEGEND

- MANHOLE
- RECOVERY WELL
- OBSERVATION WELL
- TEMPORARY WELL
- CPT SOUNDING LOCATION
- FENCE
- SHUNK STREET SEWER
- PRODUCT LINES BELOW GRADE

0 120 240 360 480

SCALE IN FEET

NO.	BY	DATE	REVISION	APP'D.
1.				

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2700 PASSYUNK AVENUE
PHILADELPHIA, PENNSYLVANIA

SHEET TITLE:

FIGURE # 3 - SITE PLAN WITH INTERPOLATED FUEL FLUORESCENCE INTENSITY @ LOWER LEVEL (10 to -5 ft ELEVATION)

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CHECKED BY: J. MANNIX	FILE NAME:	
DATE: SEPTEMBER 12, 2000	S:/ DRAFTING/CLIENTS/HNDX-MRY/110535/110535-1.DWG	

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3D Hydrocarbon Distribution Model

Sunoco Belmont HFFD / Volts

2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00

Materials

-99Undefined
-99Undefined
1Sensative_Fines
2Organic_Soil-Peats
3Clays
4Silt_Mixtures
5Sand_Mixtures
6Sands
7Gravelly_Sands
9OC

Z
Y
X

8X Vertical Exaggeration

Figure 4

APPENDIX A

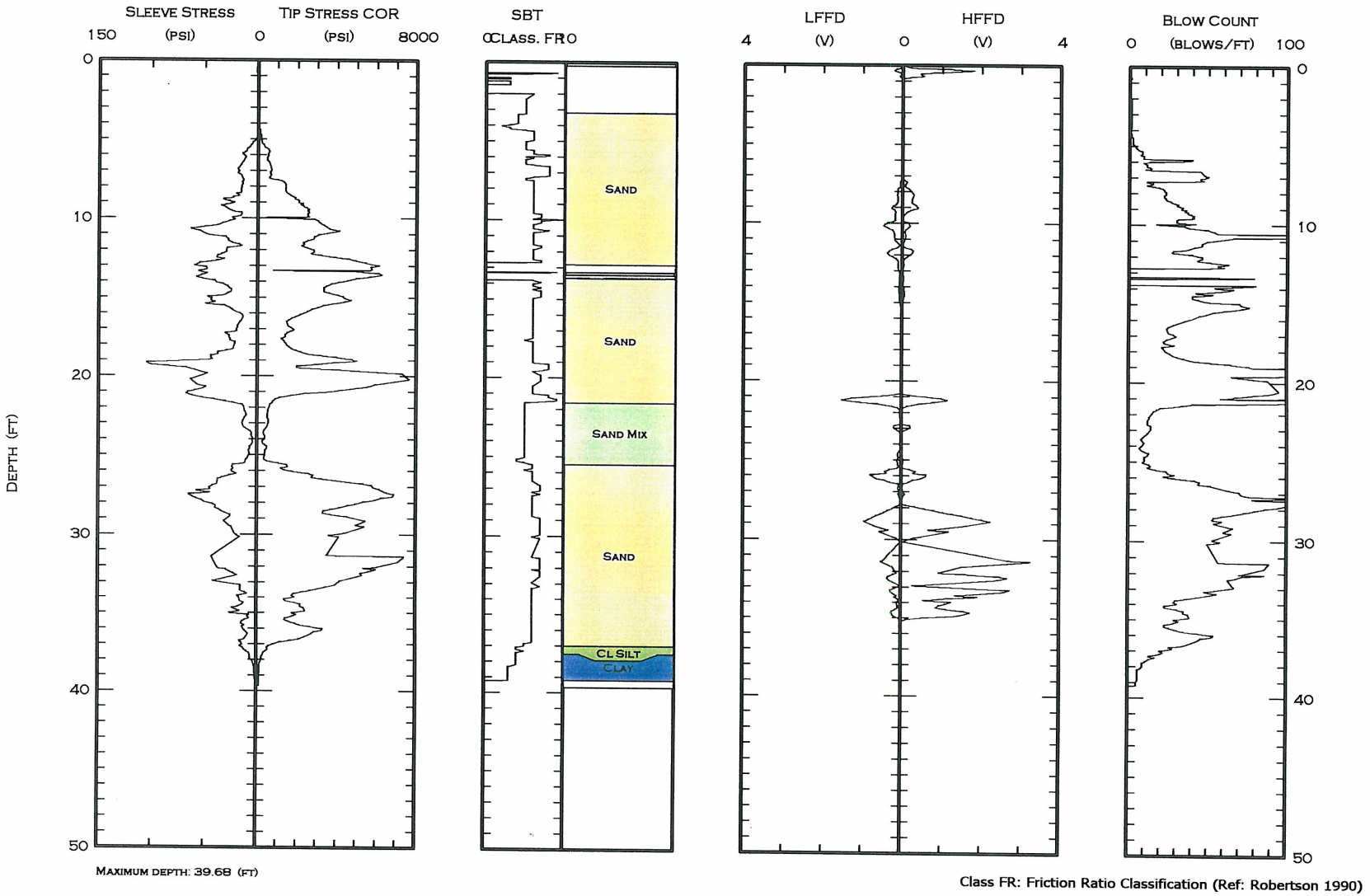
CPT SOUNDING PROFILES

Handex
Farmingdale, NY 11735
(631)-752-7878
Email: JMannix@Handexmail.com
http://www.Handex.com

Northing:
Easting:
Elevation:

Date: 28/Aug/2000
Test ID: CPT-1
Project: PhlSun

Client: Sun
Site: Sunoco Belmont Refinery



MAXIMUM DEPTH: 39.68 (FT)

Class FR: Friction Ratio Classification (Ref: Robertson 1990)

Handex
Farmingdale, NY 11735
(631)-752-7878
Email: JMannix@Handexmail.com
http://www.Handex.com

Northing:
Easting:
Elevation:

Date: 28/Aug/2000
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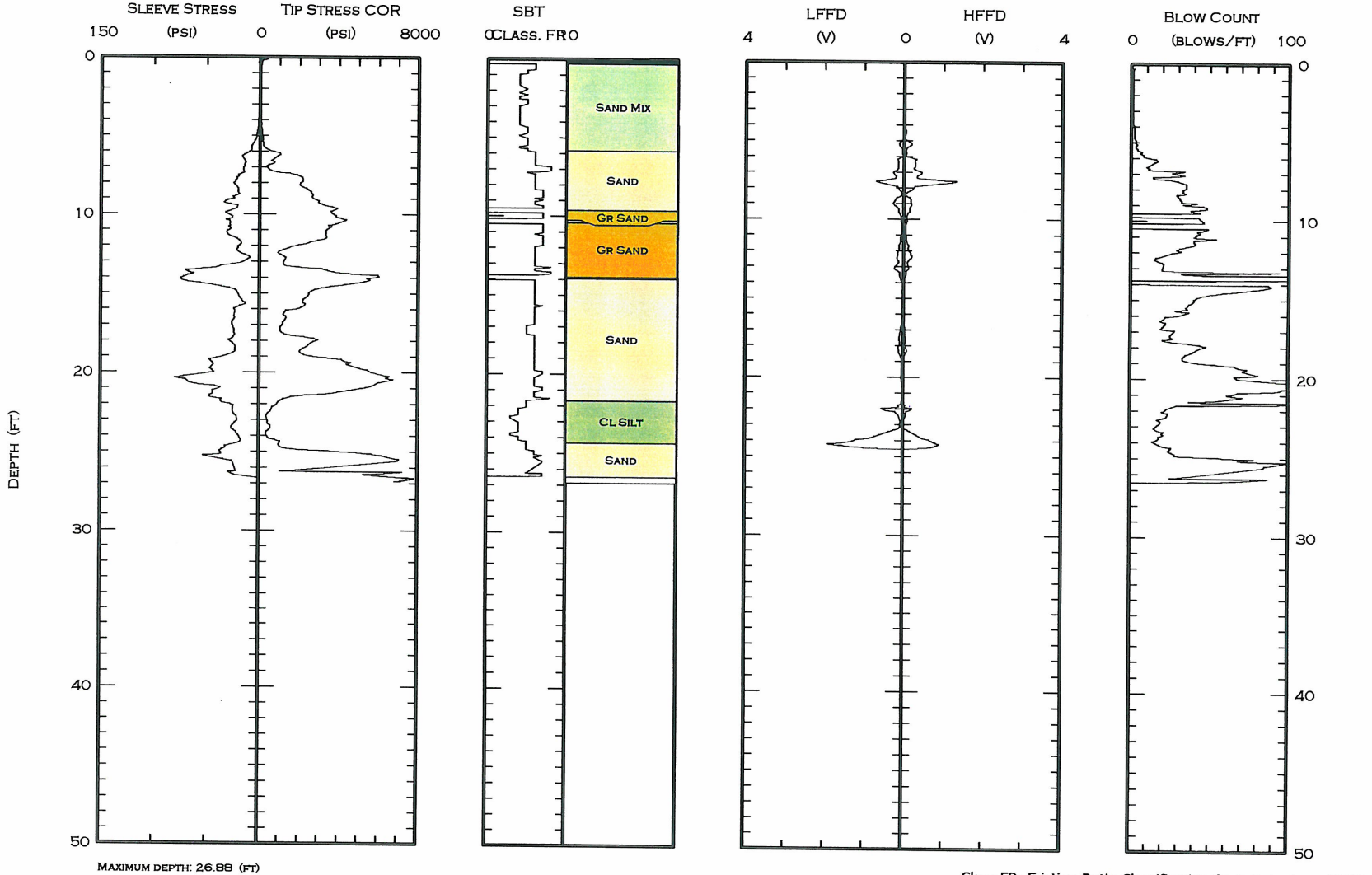
Project: PhlSun

Client: Sun
Site: Sunoco Belmont Refinery



MAXIMUM DEPTH: 26.88 (FT)

Class FR: Friction Ratio Classification (Ref: Robertson 1990)

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FILE: Z28G0004C.ECP

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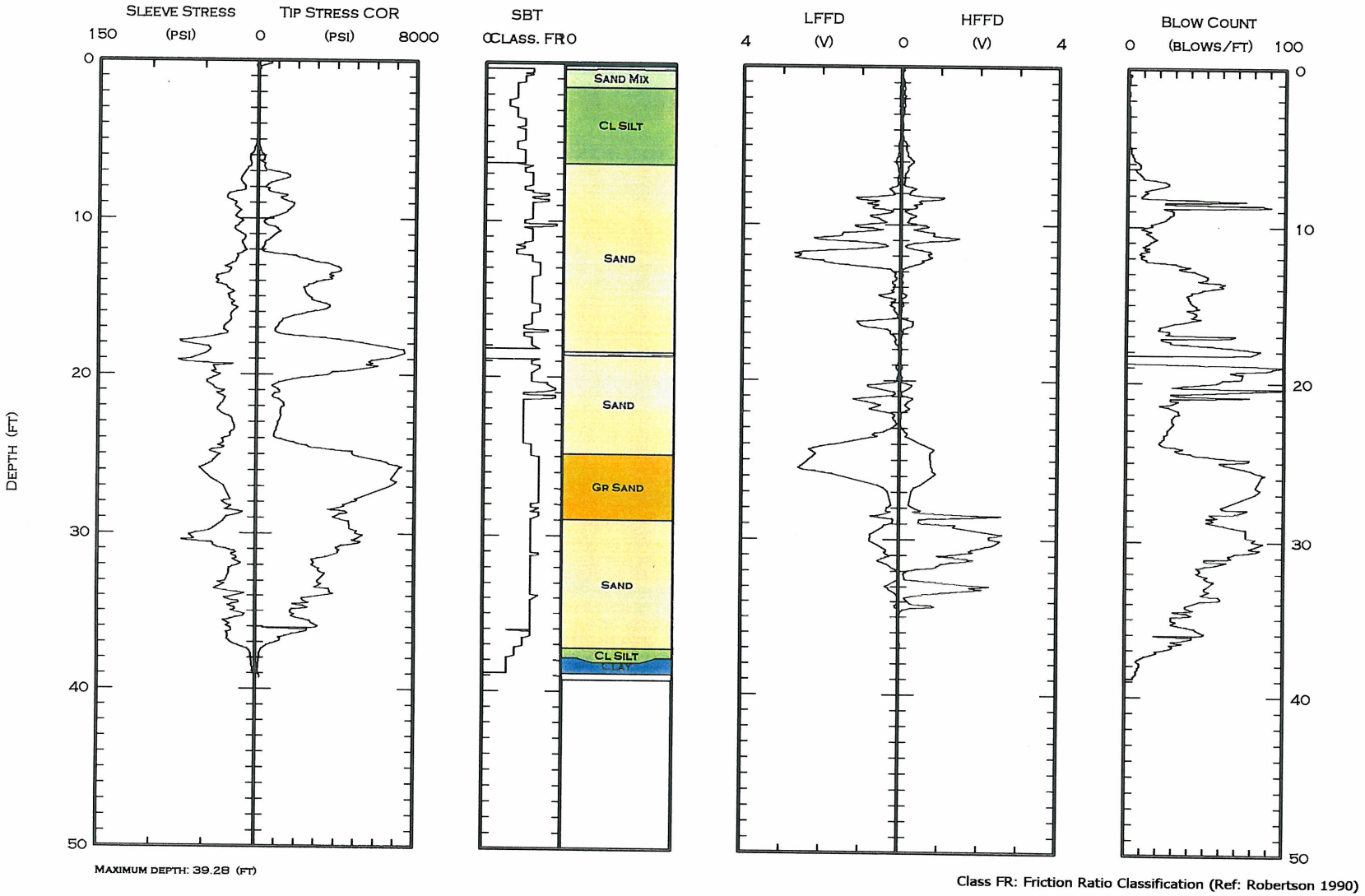
Farmingdale, NY 11735
(631)-752-7878
Email: JMannix@Handexmail.com
http://www.Handex.com

Northing:
Easting:
Elevation:

Date: 28/Aug/2000
Test ID: CPT-3
Project: PhlSun

Client: Sun
Site: Sunnoco Belmont Refinery



MAXIMUM DEPTH: 39.28 (FT)

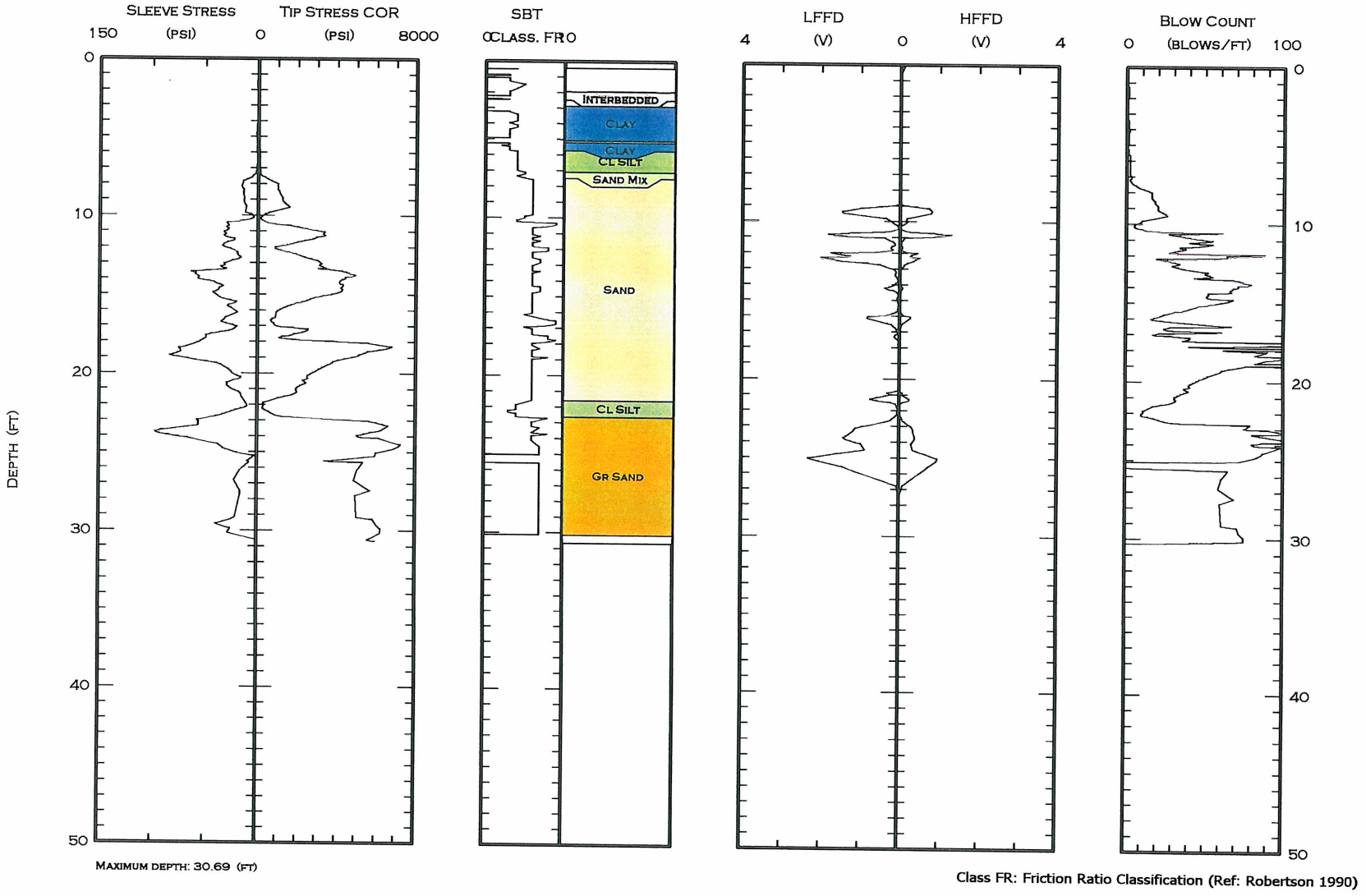
Class FR: Friction Ratio Classification (Ref: Robertson 1990)

Handex
Farmingdale, NY 11735
(631)-752-7878
Email: JMannix@Handexmail.com
http://www.Handex.com

Northing:
Easting:
Elevation:

Date: 28/Aug/2000
Test ID: CPT-4
Project: PhlSun

Client: Sun
Site: Sunnoco Belmont Refinery



MAXIMUM DEPTH: 30.69 (FT)

Class FR: Friction Ratio Classification (Ref: Robertson 1990)

Handex
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(631)-752-7878
Email: JMannix@Handexmail.com
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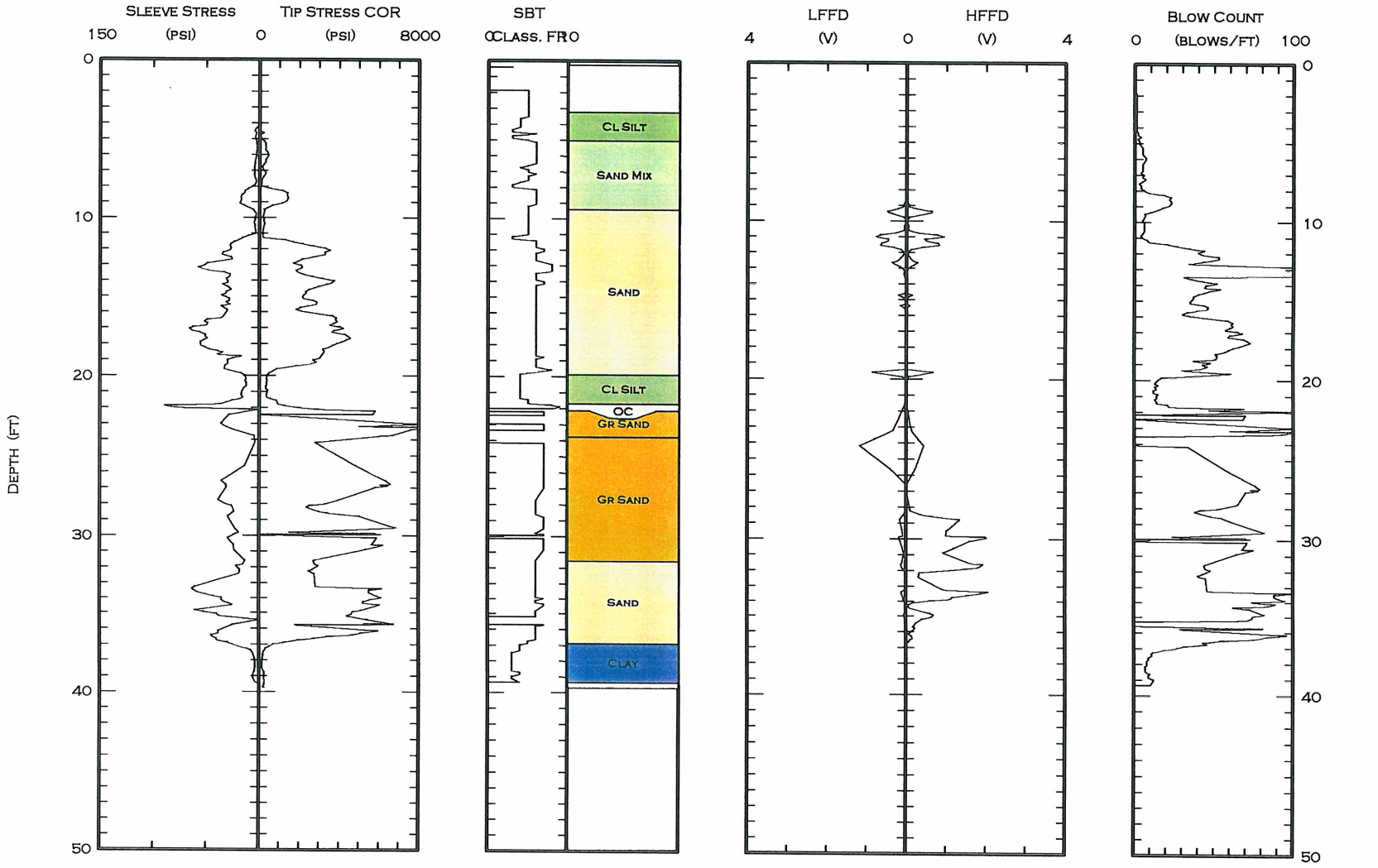
Easting:
Elevation:

Date: 28/Aug/2000
Test ID: CPT-5
Project: PhlSun

Client: Sun
Site: Sunnoco Belmont Refinery



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Class FR: Friction Ratio Classification (Ref: Robertson 1990)

Handex
Farmingdale, NY 11735
(631)-752-7878
Email: JMannix@Handexmail.com
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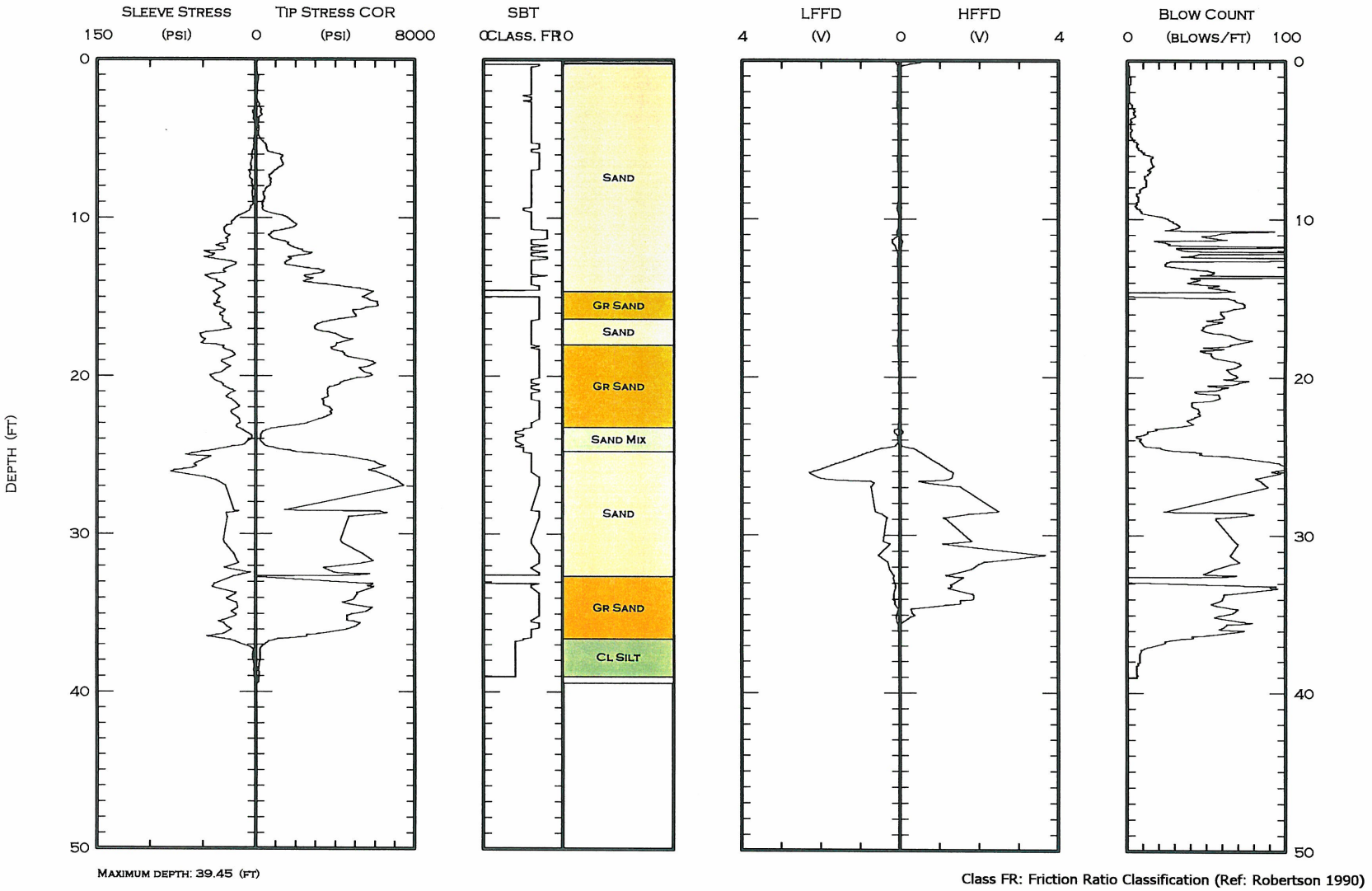
Easting:	Test ID: CPT-6
Elevation:	Project: PhlSun
Client: Sun	
Site: Sunnoco Belmont Refinery	



Maximum depth: 39.45 (ft)

Class FR: Friction Ratio Classification (Ref: Robertson 1990)

Handex
Farmingdale, NY 11735
(631)-752-7878
Email: JMannix@Handexmail.com
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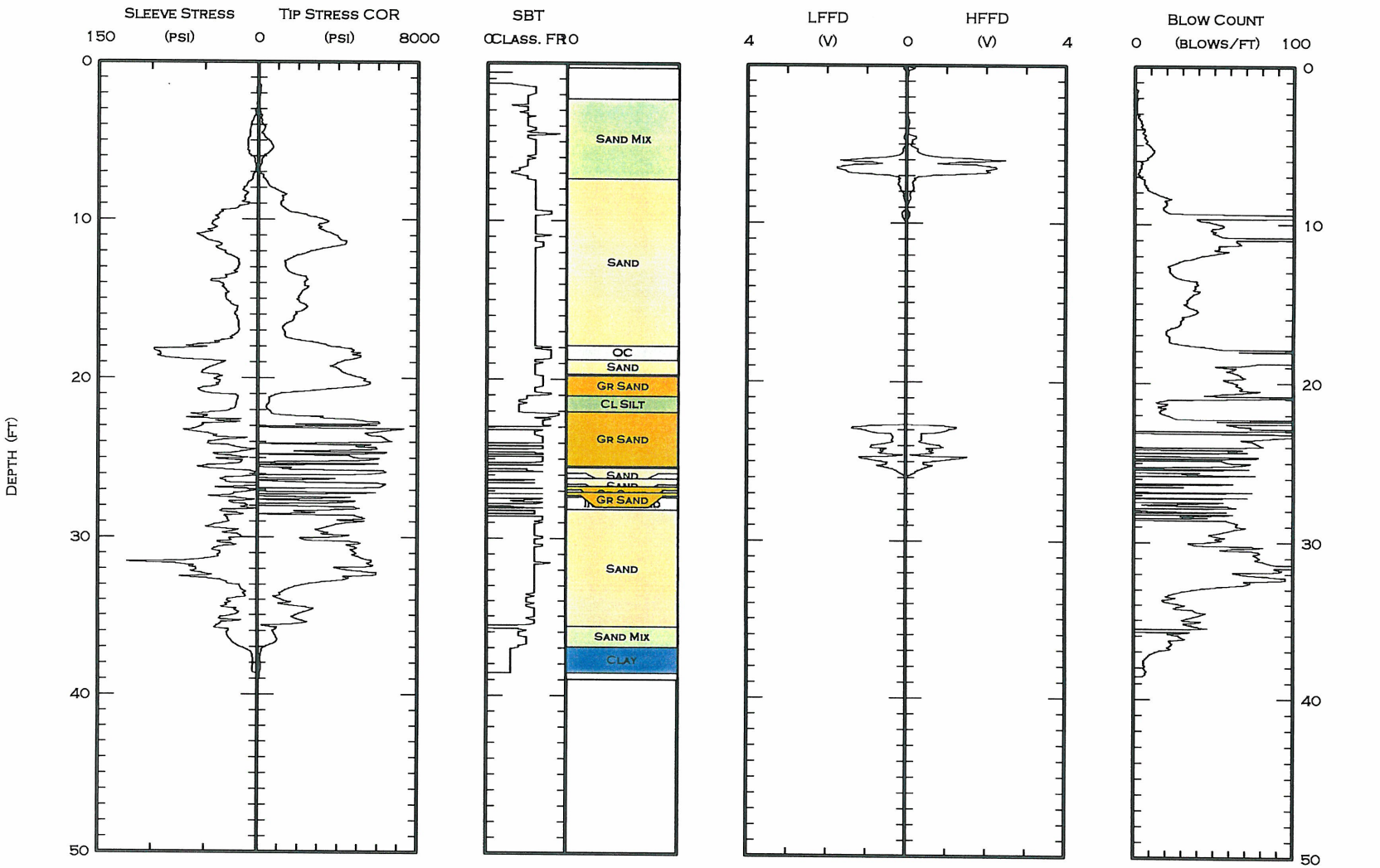
Northing:
Easting:
Elevation:

Date: 29/Aug/2000
Test ID: CPT-7
Project: PhlSun

Client: Sun
Site: Sunnoco Belmont Refinery



MAXIMUM DEPTH: 38.99 (FT)

Class FR: Friction Ratio Classification (Ref: Robertson 1990)

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Handex
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(631)-752-7878
Email: JMannix@Handexmail.com
http://www.Handex.com

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Elevation:

Date: 29/Aug/2000
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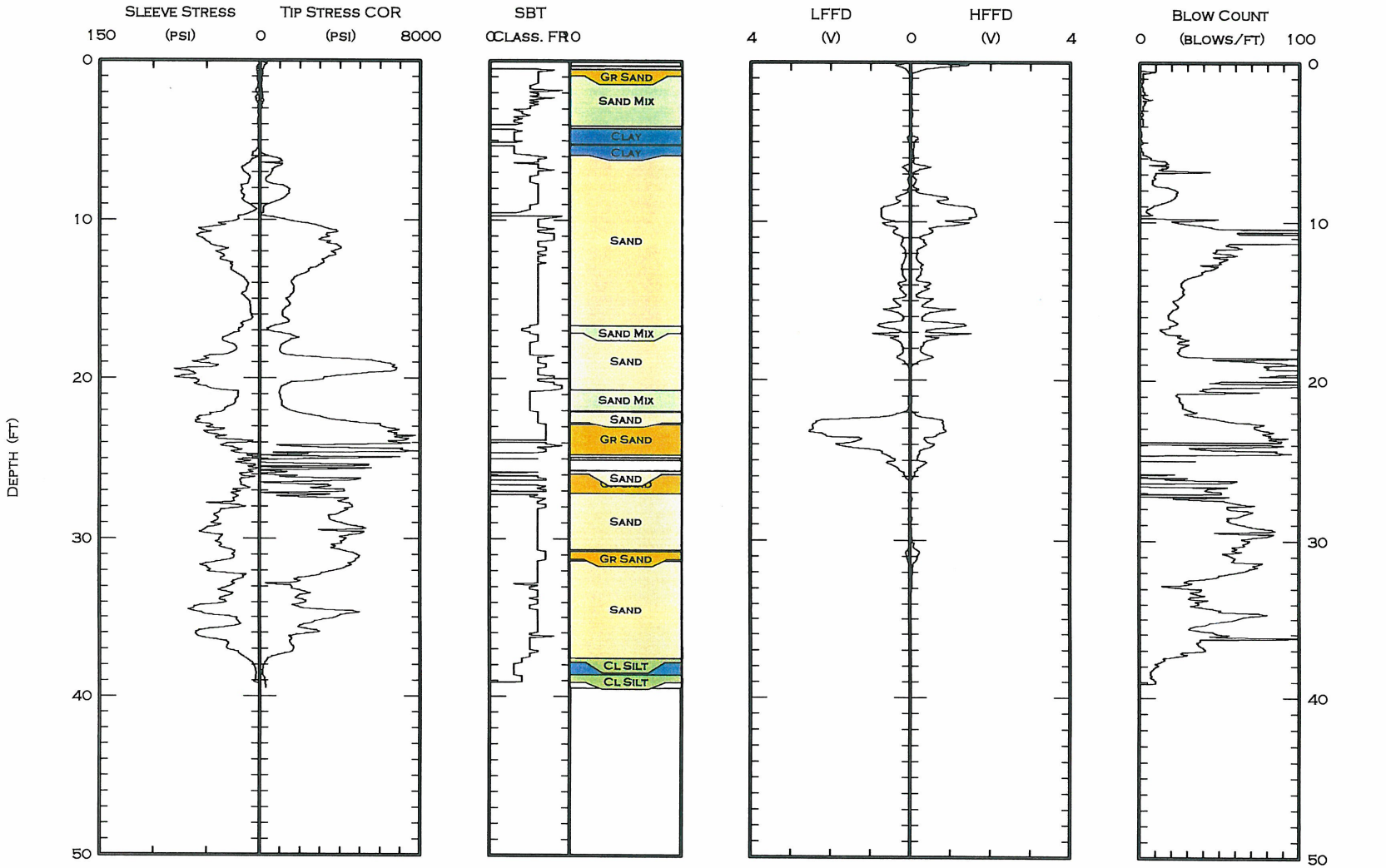
Project: PhlSun

Client: Sun
Site: Sunnoco Belmont Refinery



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Class FR: Friction Ratio Classification (Ref: Robertson 1990)

Handex
Farmingdale, NY 11735
(631)-752-7878
Email: JMannix@Handexmail.com
http://www.Handex.com

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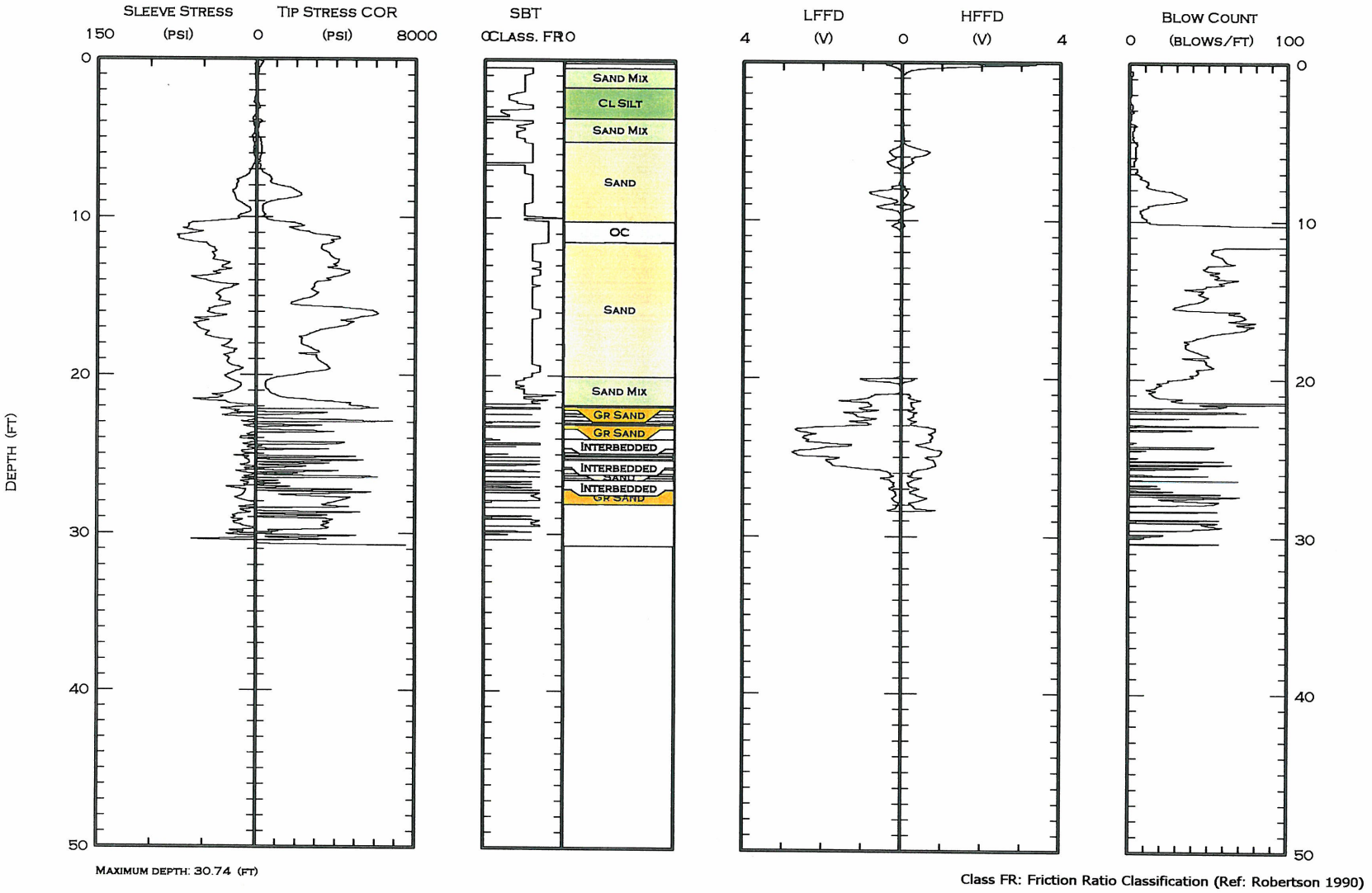
Elevation:

Date: 29/Aug/2000
Test ID: CPT-9
Project: PhlSun

Client: Sun
Site: Sunnoco Belmont Refinery



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Class FR: Friction Ratio Classification (Ref: Robertson 1990)

Handex
Farmingdale, NY 11735
(631)-752-7878
Email: JMannix@Handexmail.com
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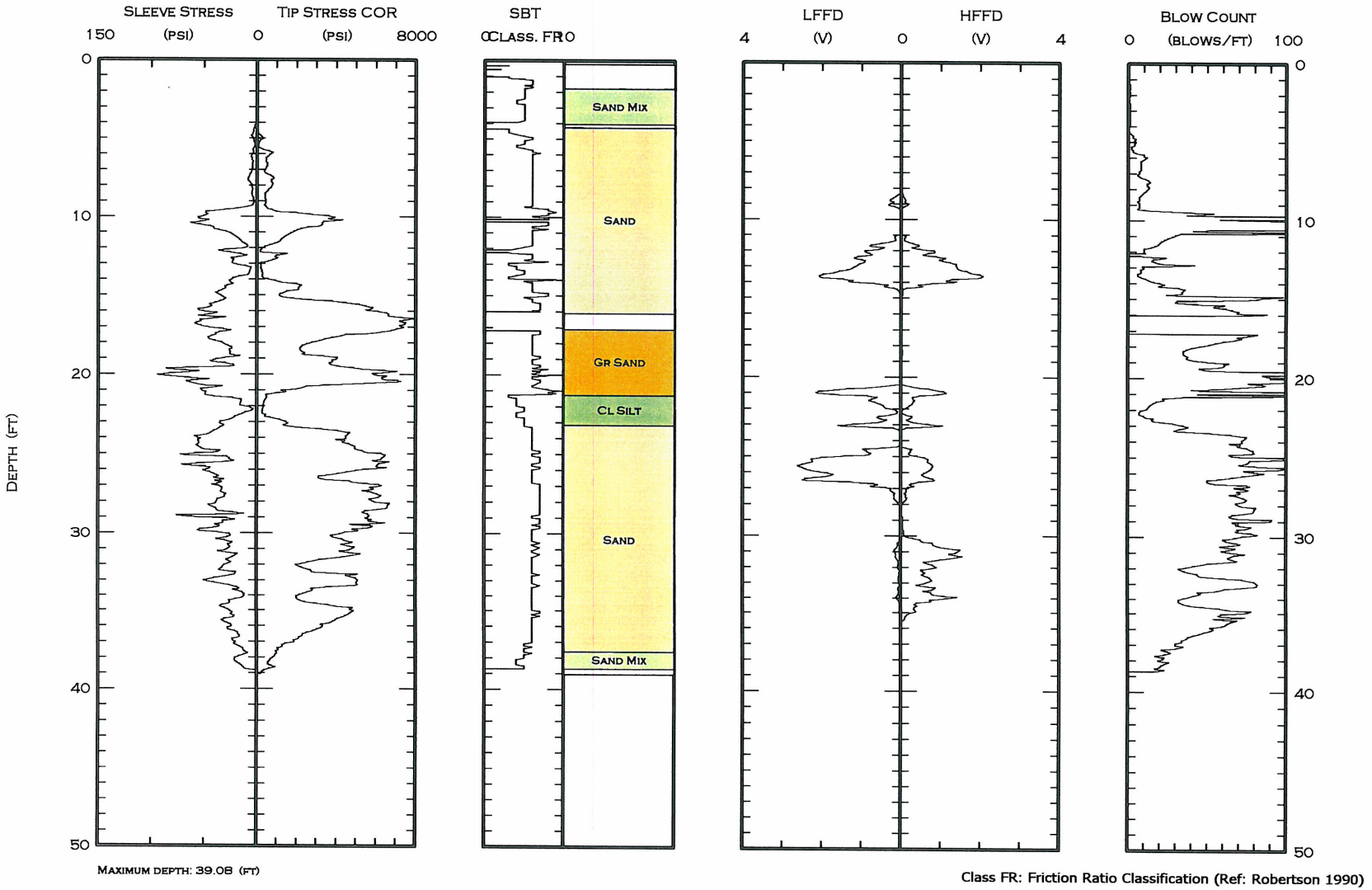
Northing:
Easting:
Elevation:

Date: 28/Aug/2000
Test ID: CPT-10
Project: PhlSun

Client: Sun
Site: Sunnoco Belmont Refinery



MAXIMUM DEPTH: 39.08 (FT)

Class FR: Friction Ratio Classification (Ref: Robertson 1990)

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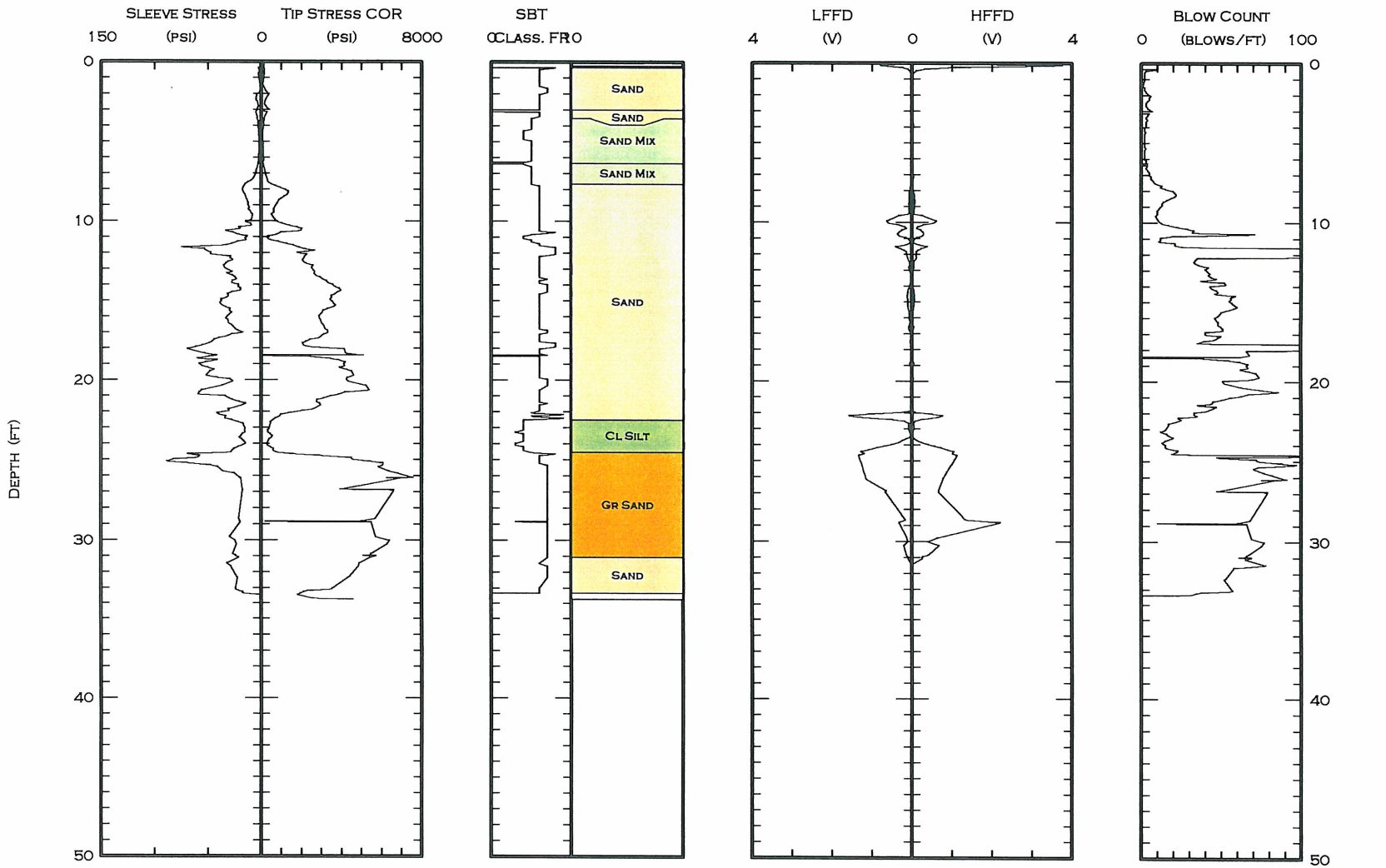
Northing:
Easting:
Elevation:

Date: 28/Aug/2000
Test ID: CPT-11
Project: PhlSun

Client: Sun
Site: Sunnoco Belmont Refinery



MAXIMUM DEPTH: 33.75 (FT)

Class FR: Friction Ratio Classification (Ref: Robertson 1990)

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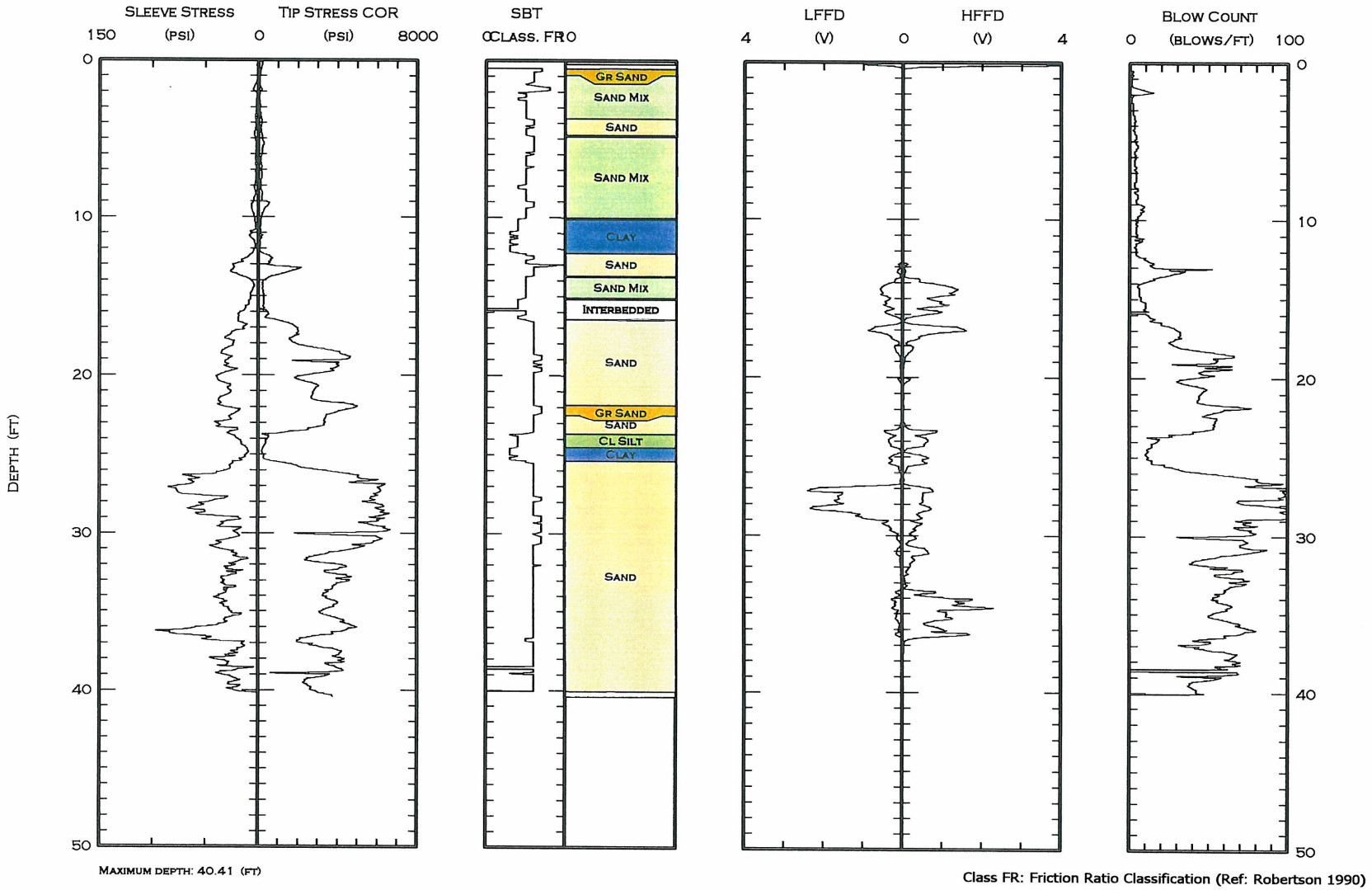
Northing:
Easting:
Elevation:

Date: 29/Aug/2000
Test ID: CPT-12
Project: PhlSun

Client: Sun
Site: Sunnoco Belmont Refinery



MAXIMUM DEPTH: 40.41 (FT)

Class FR: Friction Ratio Classification (Ref: Robertson 1990)

Handex
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(631)-752-7878
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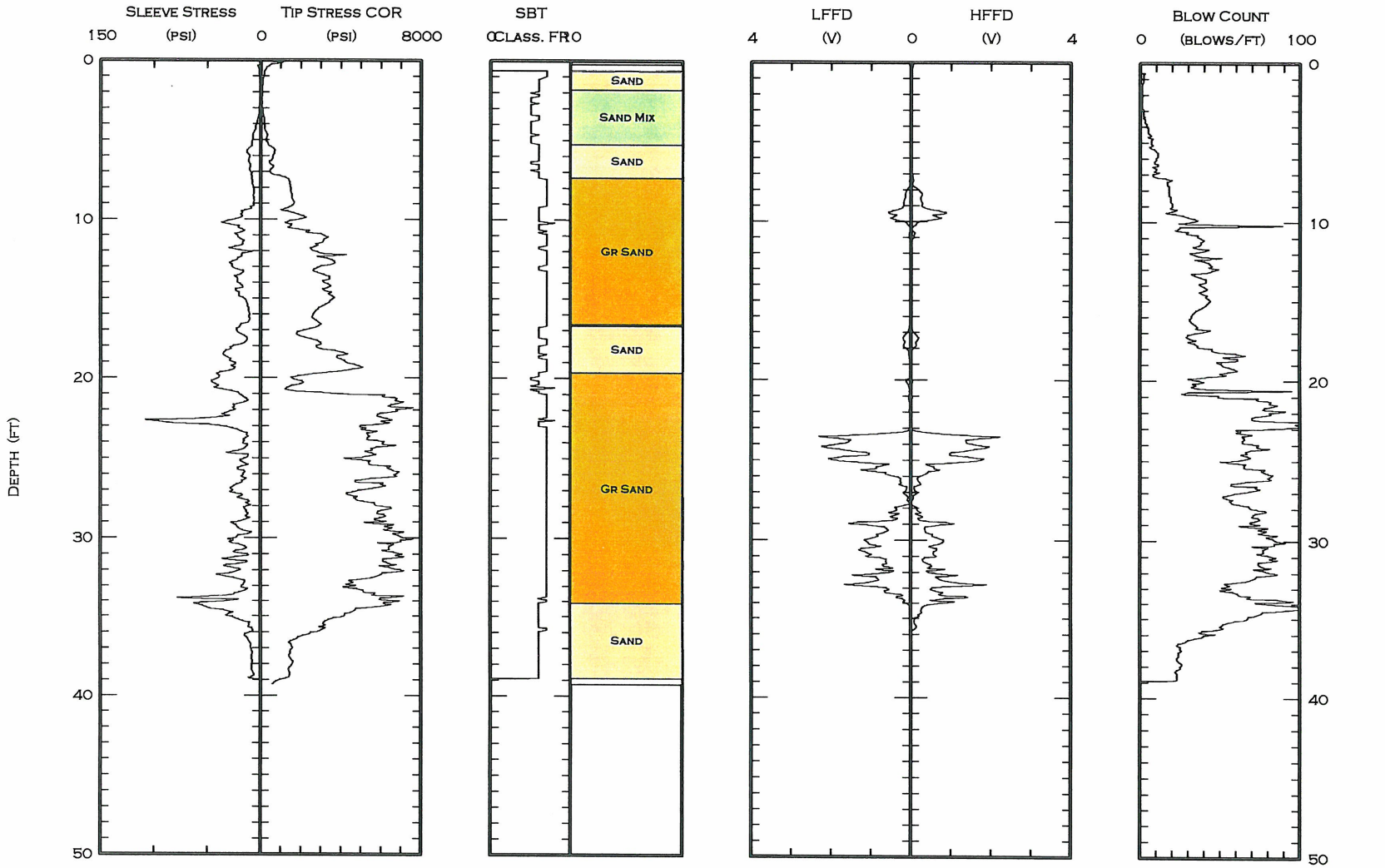
Northing:
Easting:
Elevation:

Date: 30/Aug/2000
Test ID: CPT-13
Project: PhlSun

Client: Sun
Site: Sunnoco Belmont Refinery



Maximum depth: 39.29 (ft)

Class FR: Friction Ratio Classification (Ref: Robertson 1990)

Test ID: CPT-13
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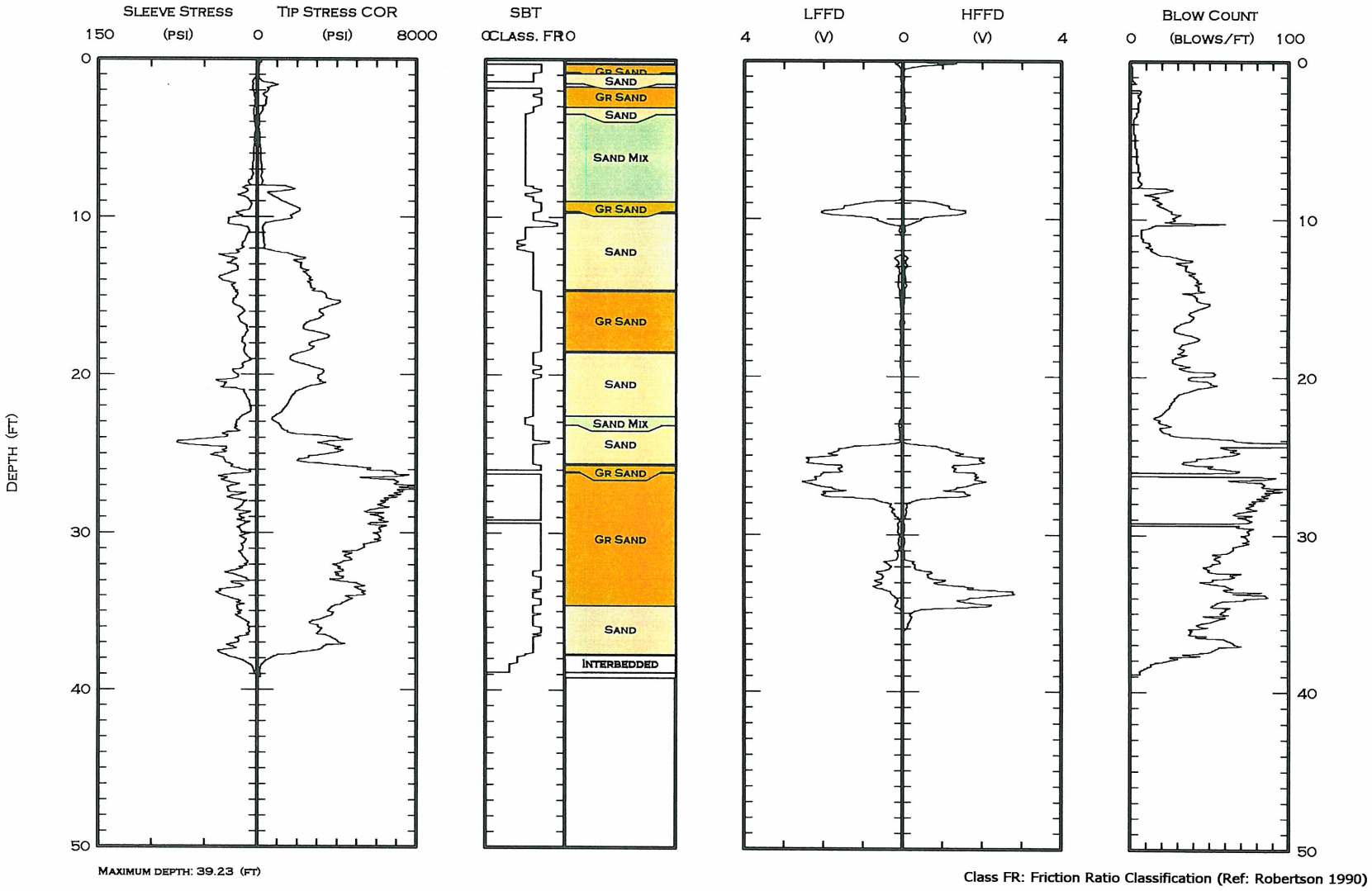
Email: JMannix@Handexmail.com
http://www.Handex.com

Northing:
Easting:
Elevation:

Date: 30/Aug/2000
Test ID: CPT-14
Project: PhlSun

Client: Sun
Site: Sunnoco Belmont Refinery



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Class FR: Friction Ratio Classification (Ref: Robertson 1990)

TEST ID: CPT-14
FILE: Z30G0001C.ECP

Handex
Farmingdale, NY 11735
(631)-752-7878
Email: JMannix@Handexmail.com
http://www.Handex.com

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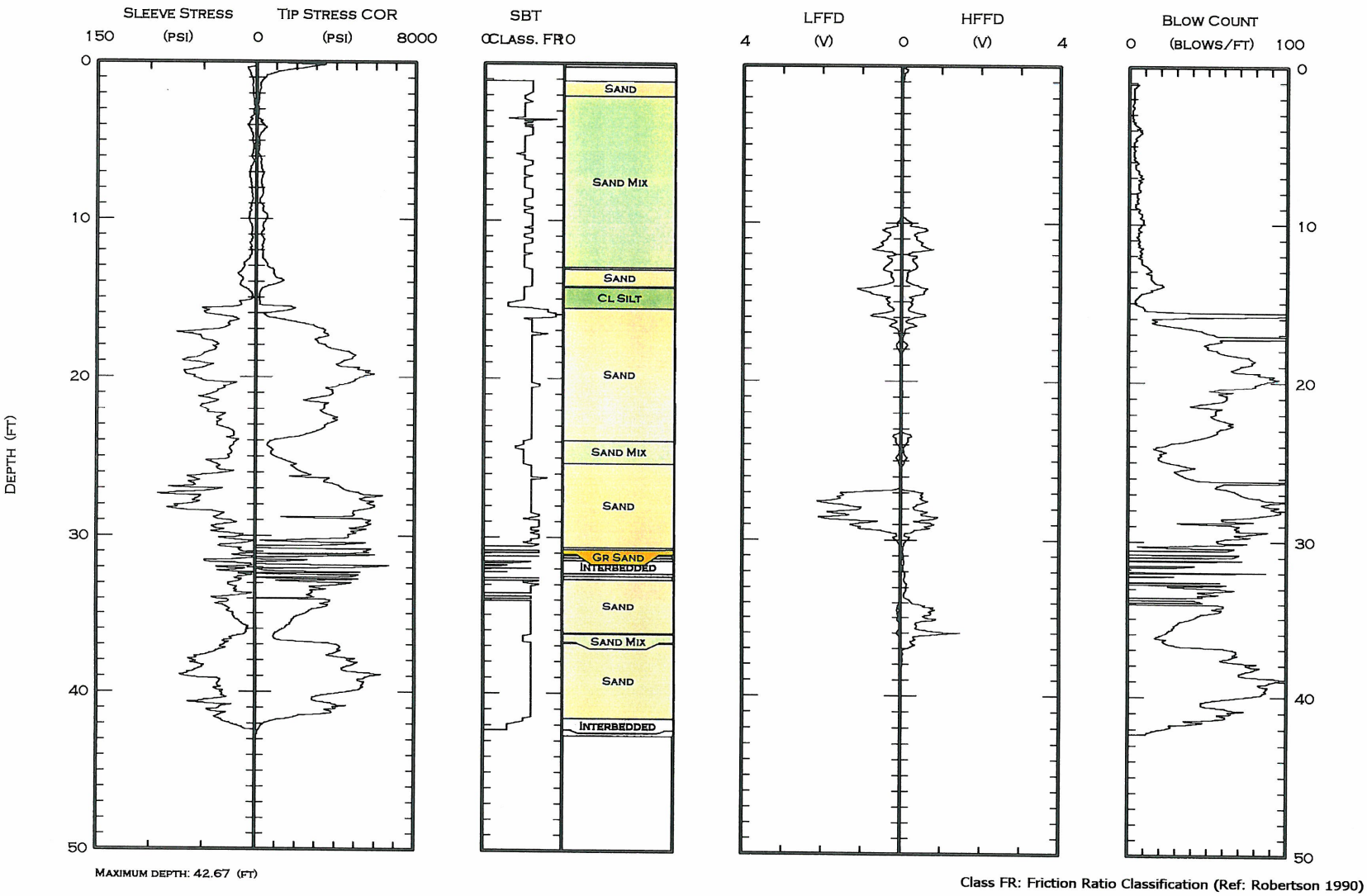
Easting:	Test ID: CPT-15
Elevation:	Project: PhlSun
Client: Sun	
Site: Sunnoco Belmont Refinery	



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Class FR: Friction Ratio Classification (Ref: Robertson 1990)

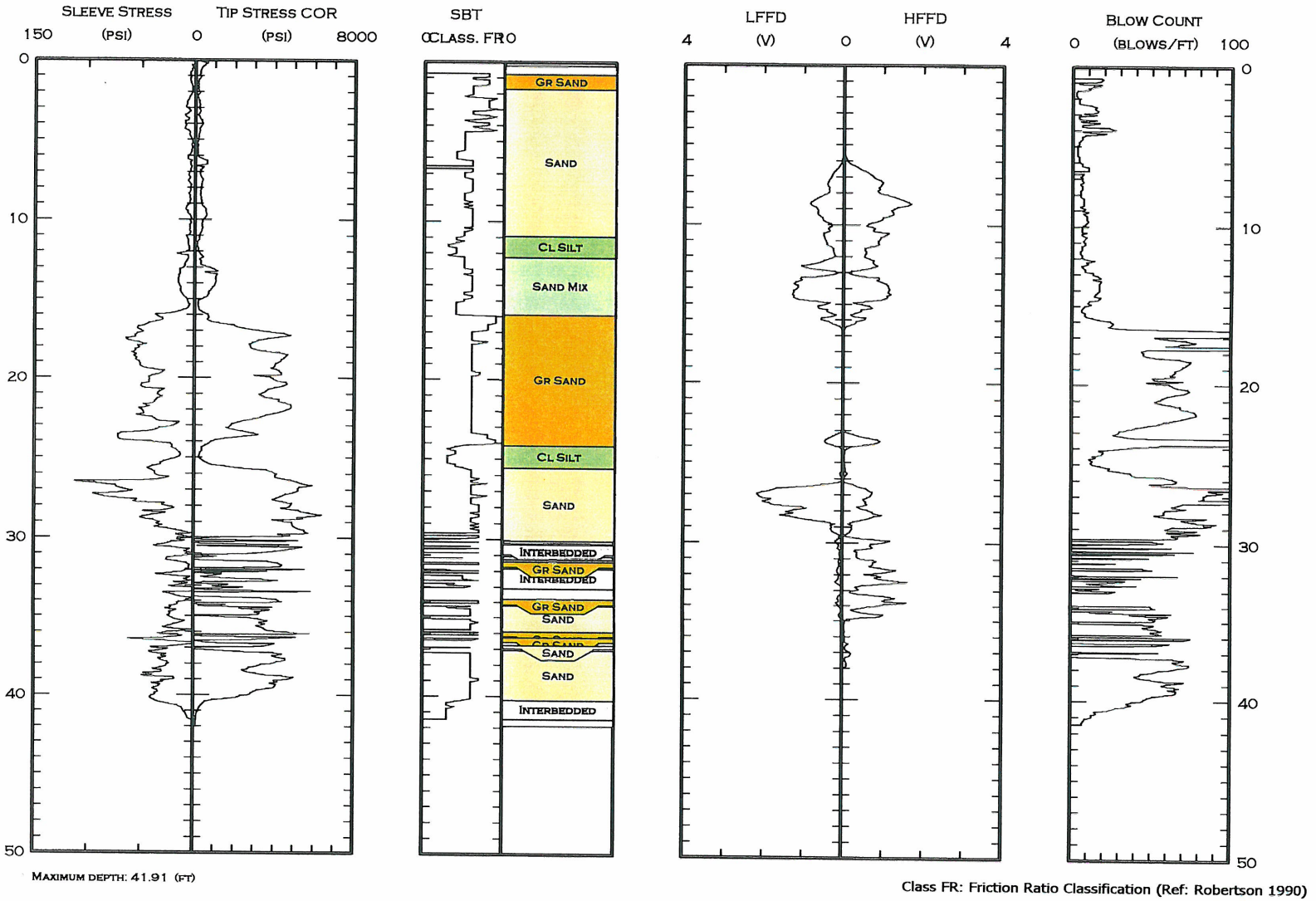
TEST ID: CPT-15
FILE: Z29G0007C.ECP

Handex
Farmingdale, NY 11735
(631)-752-7878
Email: JMannix@Handexmail.com
http://www.Handex.com

Northing:
Easting:
Elevation:

Date: 29/Aug/2000
Test ID: CPT-16
Project: PhlSun

Client: Sun
Site: Sunnoco Belmont Refinery

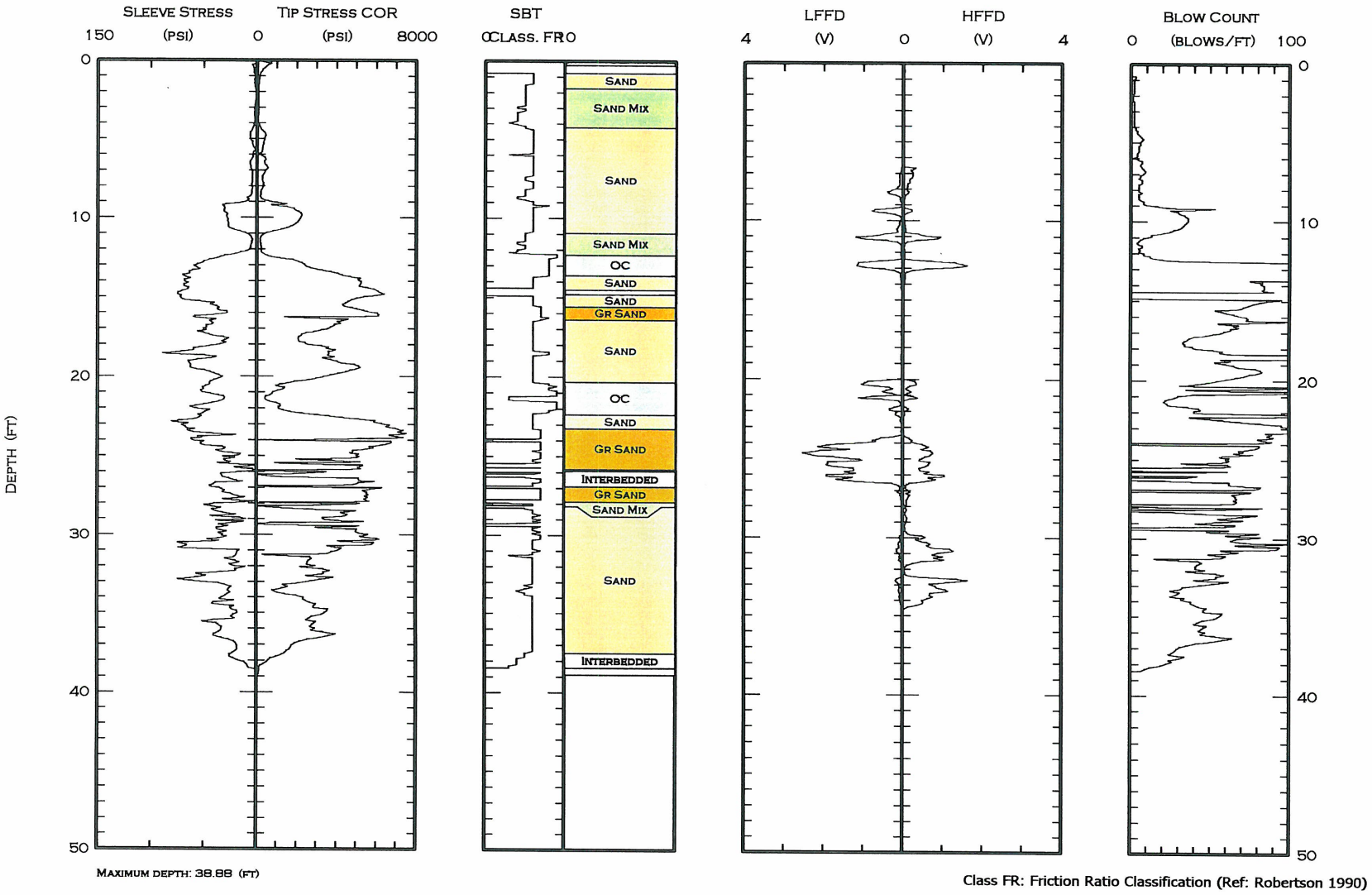


MAXIMUM DEPTH: 41.91 (FT)

Class FR: Friction Ratio Classification (Ref: Robertson 1990)

Handex
Farmingdale, NY 11735
(631)-752-7878
Email: JMannix@Handexmail.com
http://www.Handex.com

Northing:	Date: 29/Aug/2000
Easting:	Test ID: CPT-17
Elevation:	Project: PhlSun
Client: Sun	
Site: Sunnoco Belmont Refinery	

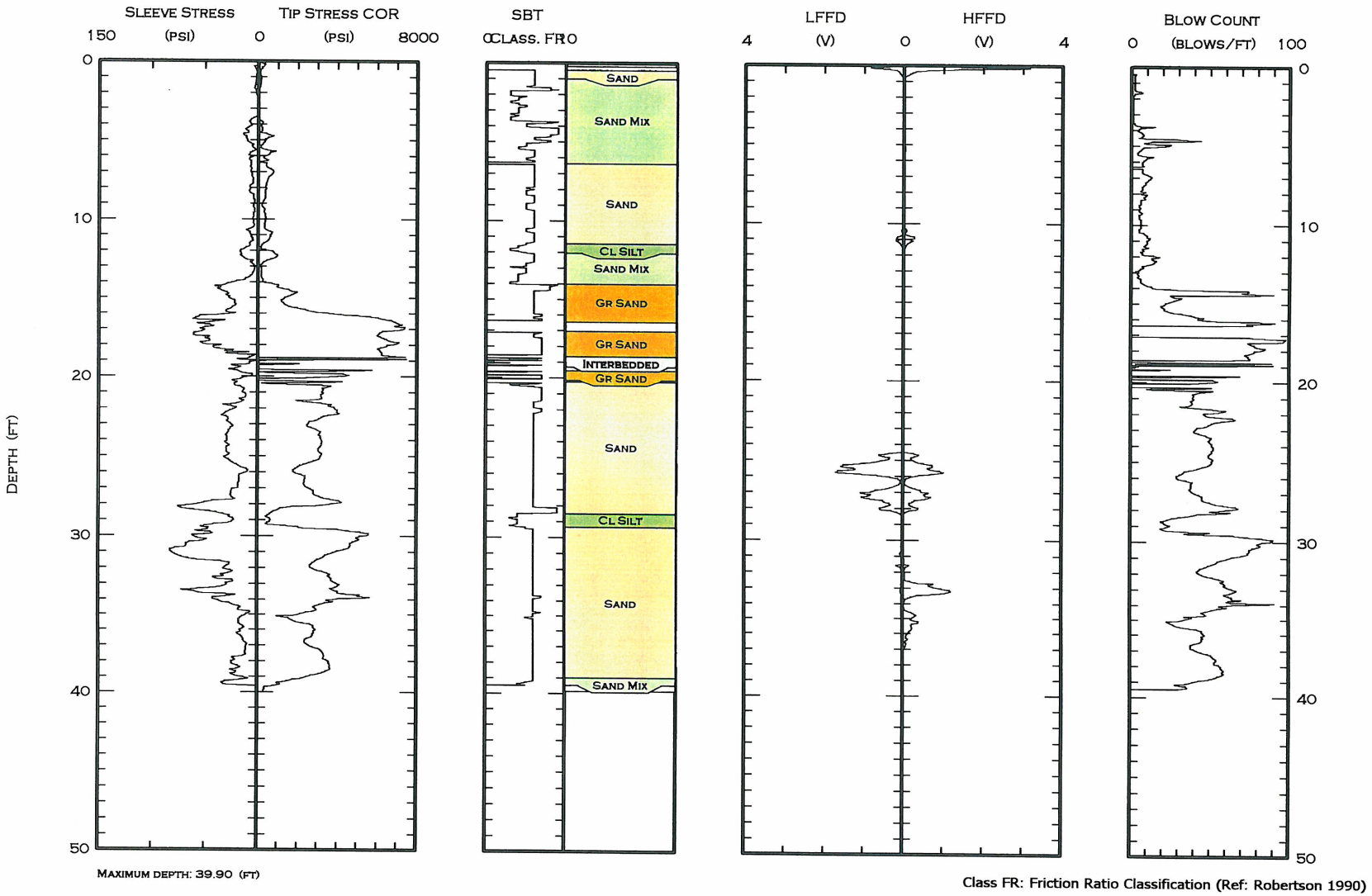


MAXIMUM DEPTH: 38.88 (FT)

Class FR: Friction Ratio Classification (Ref: Robertson 1990)

Handex
Farmingdale, NY 11735
(631)-752-7878
Email: JMannix@Handexmail.com
http://www.Handex.com

Northing:	Date: 29/Aug/2000
Easting:	Test ID: CPT-18
Elevation:	Project: PhlSun
Client: Sun	
Site: Sunnoco Belmont Refinery	



MAXIMUM DEPTH: 39.90 (FT)

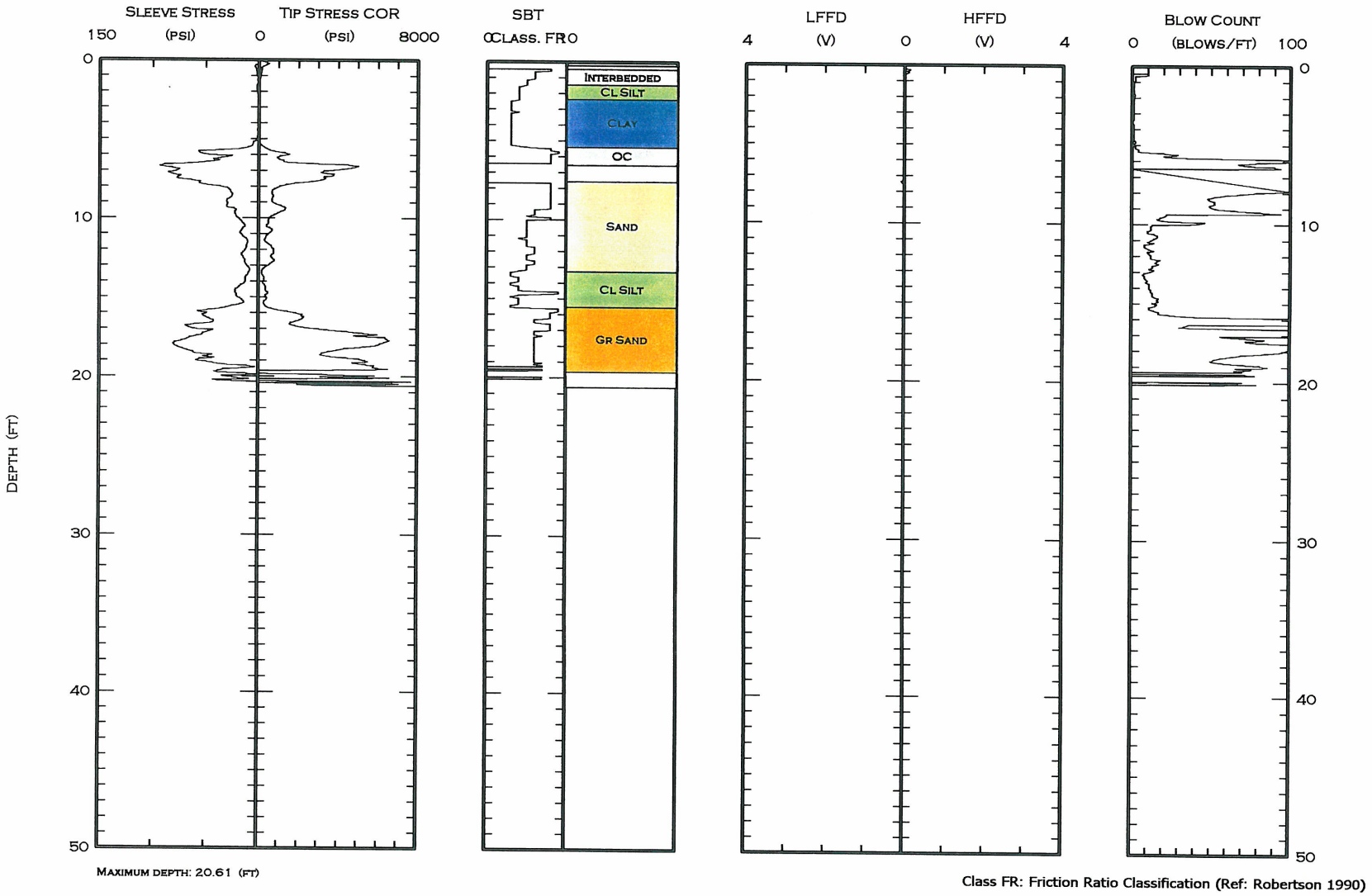
Class FR: Friction Ratio Classification (Ref: Robertson 1990)

Handex
Farmingdale, NY 11735
(631)-752-7878
Email: JMannix@Handexmail.com
http://www.Handex.com

Northing:
Easting:
Elevation:

Date: 29/Aug/2000
Test ID: CPT-19
Project: PhlSun

Client: Sun
Site: Sunnoco Belmont Refinery



MAXIMUM DEPTH: 20.61 (FT)

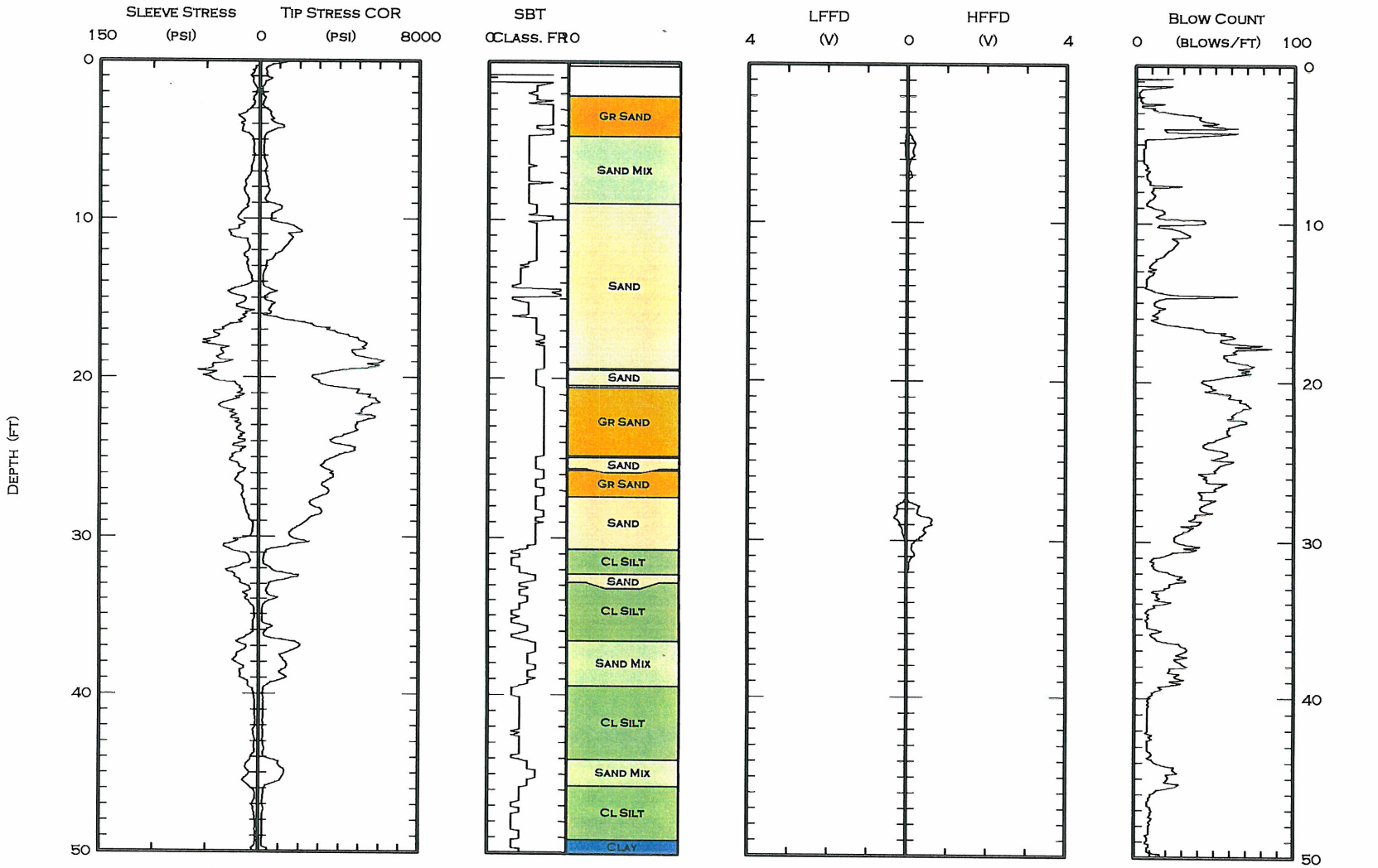
Class FR: Friction Ratio Classification (Ref: Robertson 1990)

Handex
Farmingdale, NY 11735
(631)-752-7878
Email: JMannix@Handexmail.com
http://www.Handex.com

Northing:
Easting:
Elevation:

Date: 30/Aug/2000
Test ID: CPT-20
Project: PhlSun

Client: Sun
Site: Sunnoco Belmont Refinery



Maximum depth: 52.45 (ft)

Class FR: Friction Ratio Classification (Ref: Robertson 1990)

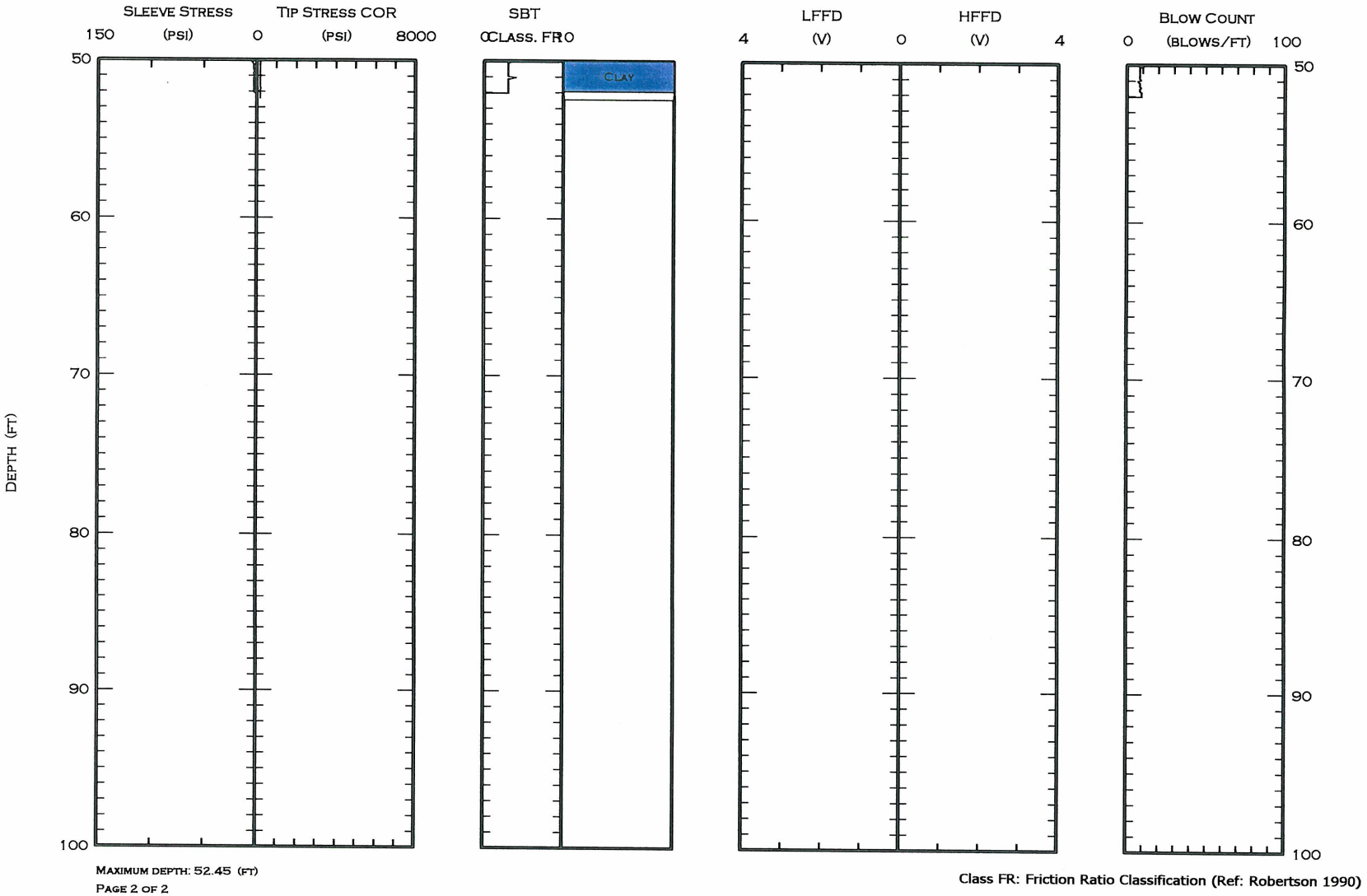
Test ID: CPT-20
File: z30g0005c.ecp

Handex
Farmingdale, NY 11735
(631)-752-7878
Email: JMannix@Handexmail.com
http://www.Handex.com

Northing:
Easting:
Elevation:

Date: 30/Aug/2000
Test ID: CPT-20
Project: PhlSun

Client: Sun
Site: Sunnoco Belmont Refinery



MAXIMUM DEPTH: 52.45 (FT)

Class FR: Friction Ratio Classification (Ref: Robertson 1990)

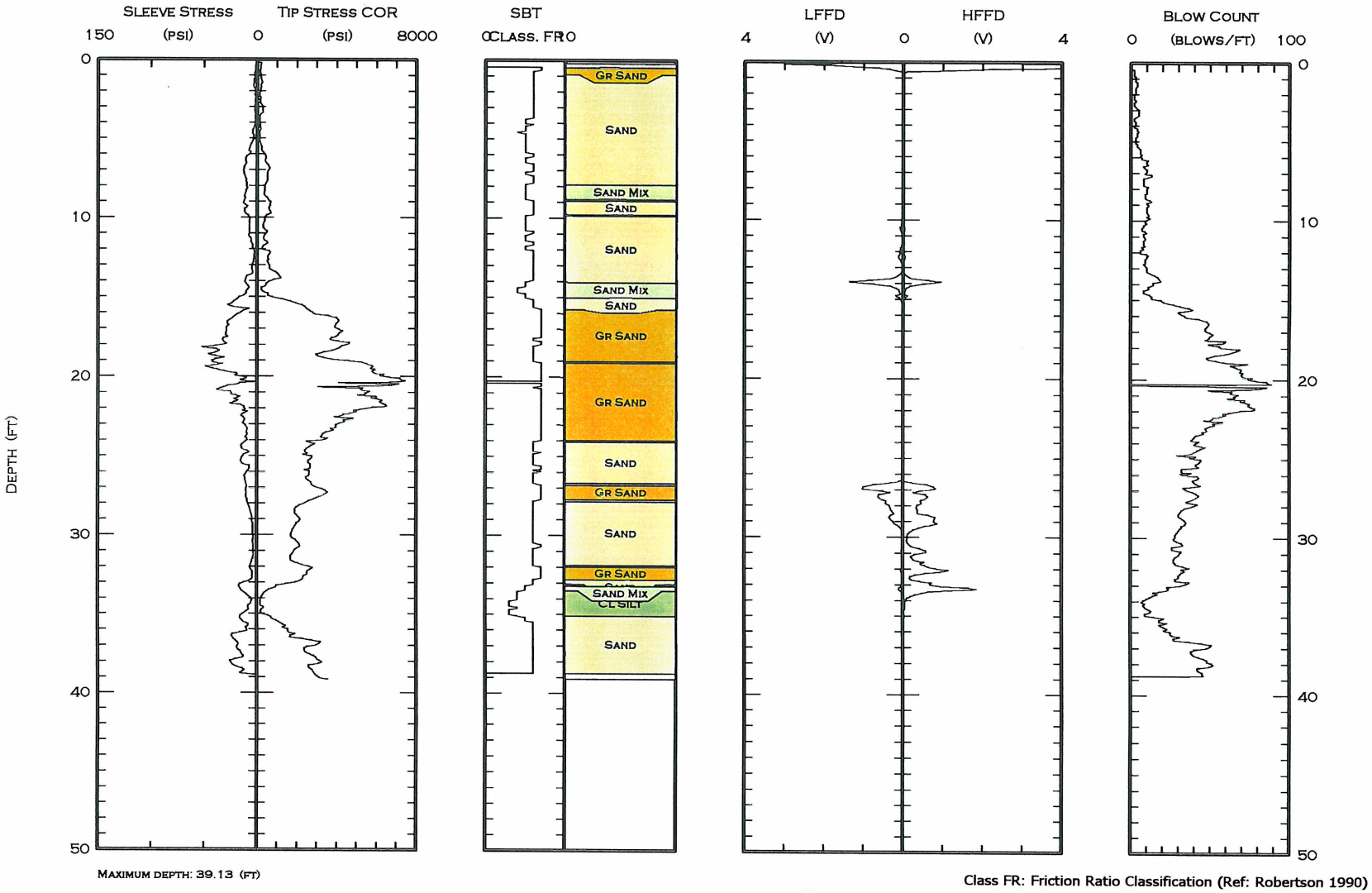
TEST ID: CPT-20
FILE: Z30G0005C.ECP

Handex
Farmingdale, NY 11735
(631)-752-7878
Email: JMannix@Handexmail.com
http://www.Handex.com

Northing:
Easting:
Elevation:

Date: 30/Aug/2000
Test ID: CPT-21
Project: PhlSun

Client: Sun
Site: Sunnoco Belmont Refinery



MAXIMUM DEPTH: 39.13 (FT)

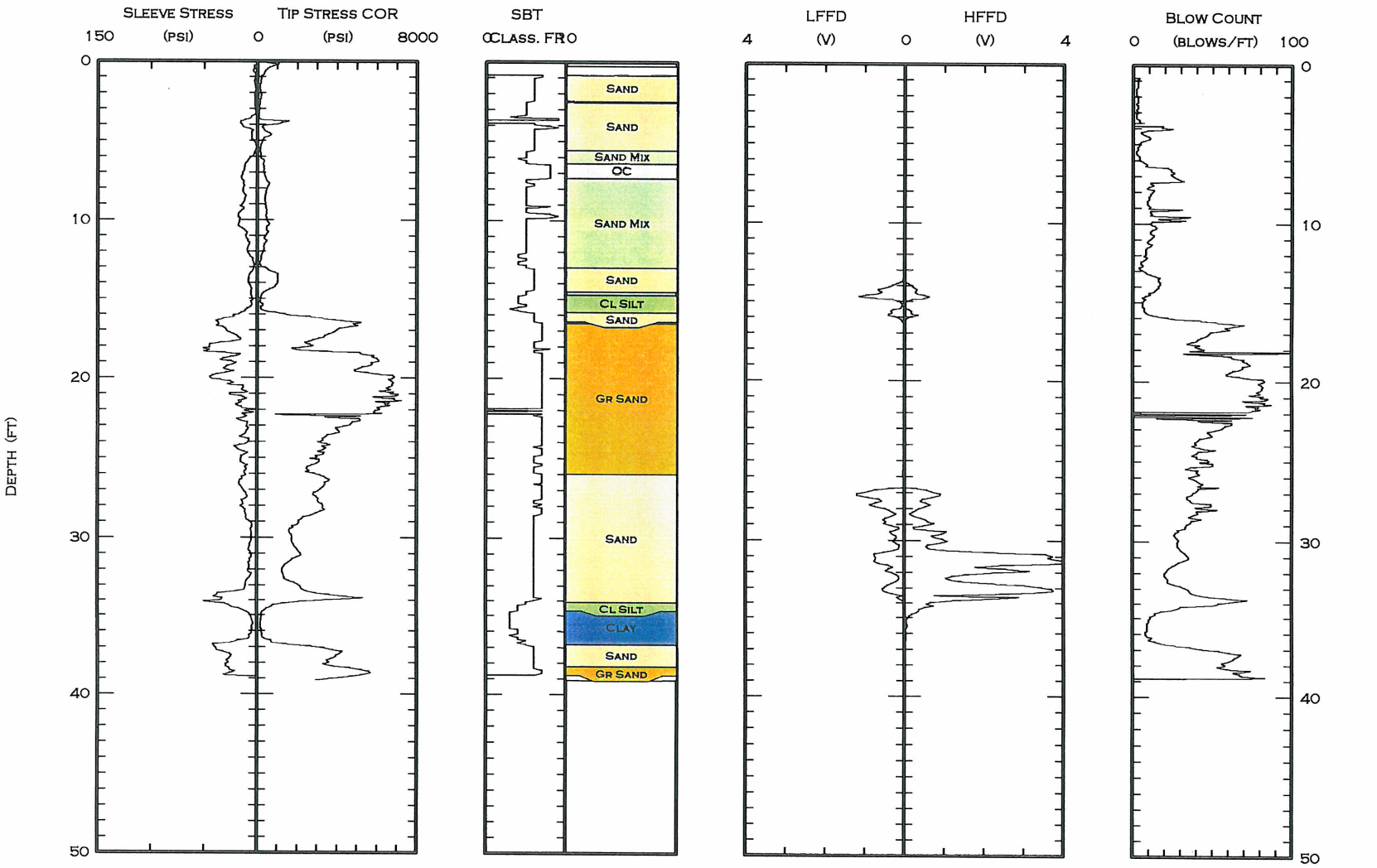
Class FR: Friction Ratio Classification (Ref: Robertson 1990)

Handex
Farmingdale, NY 11735
(631)-752-7878
Email: JMannix@Handexmail.com
http://www.Handex.com

Northing:
Easting:
Elevation:

Date: 30/Aug/2000
Test ID: CPT-22
Project: PhlSun

Client: Sun
Site: Sunnoco Belmont Refinery



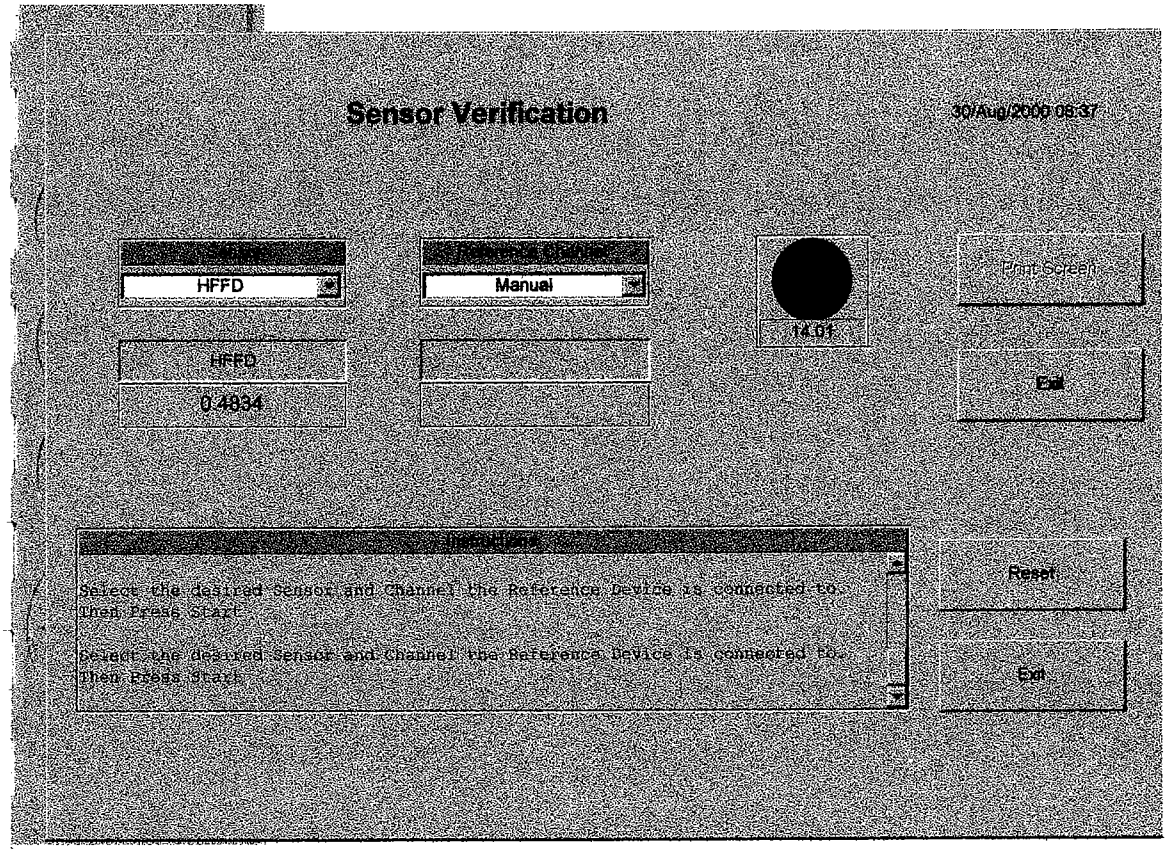
MAXIMUM DEPTH: 39.13 (FT)

Class FR: Friction Ratio Classification (Ref: Robertson 1990)

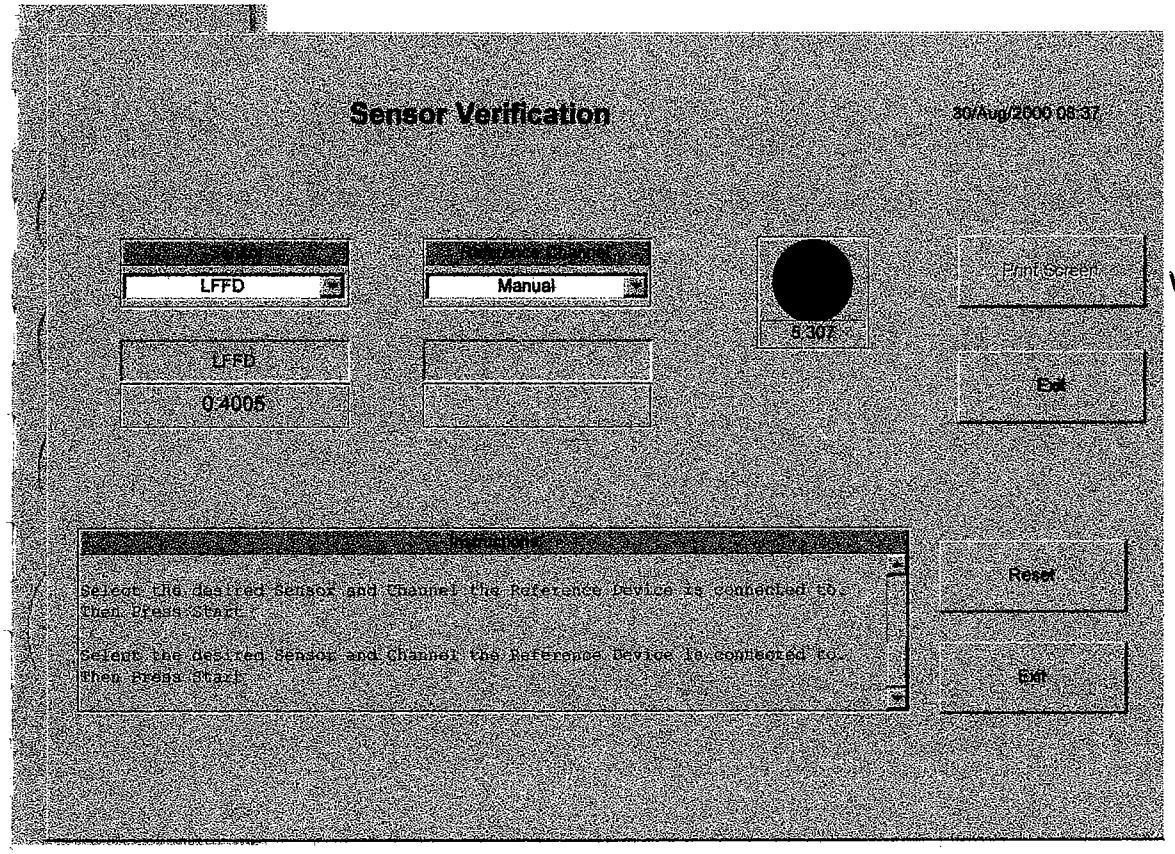
APPENDIX B

SITE CALIBRATION DATA

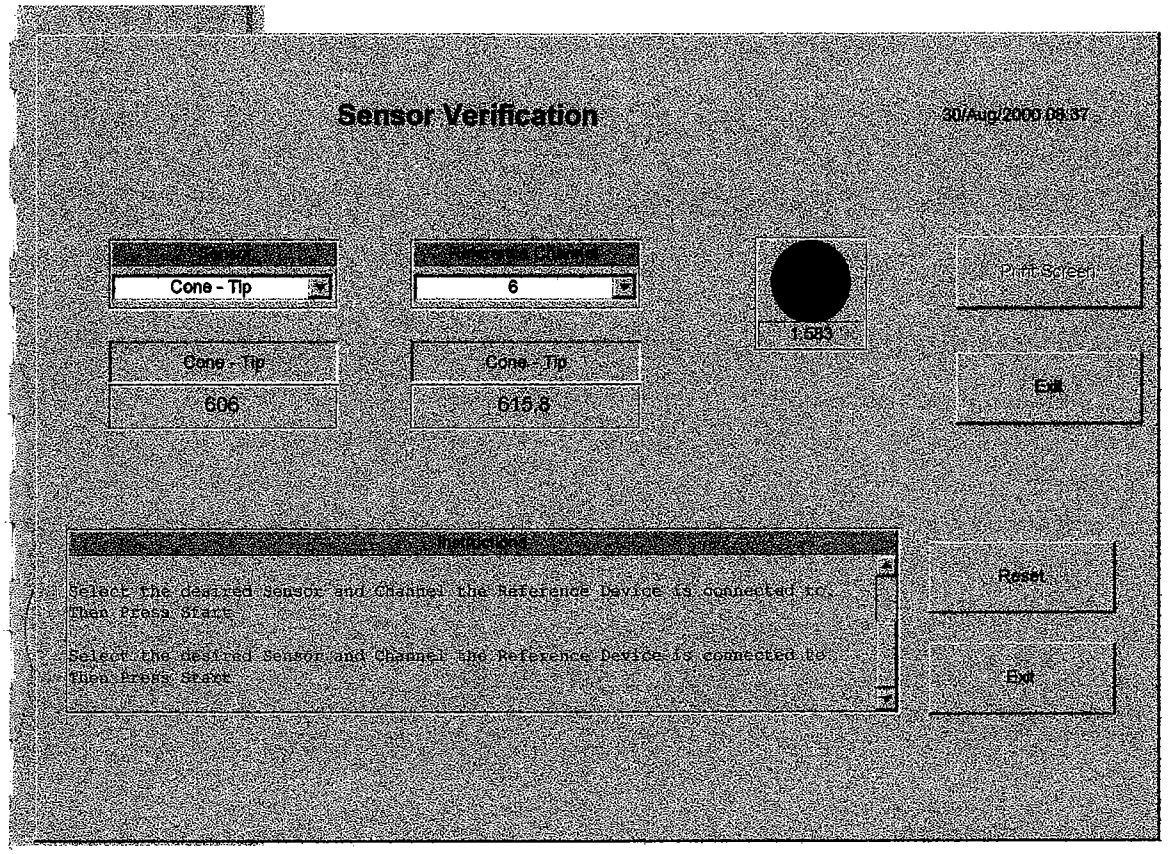
(CPT/FFD MODULE)

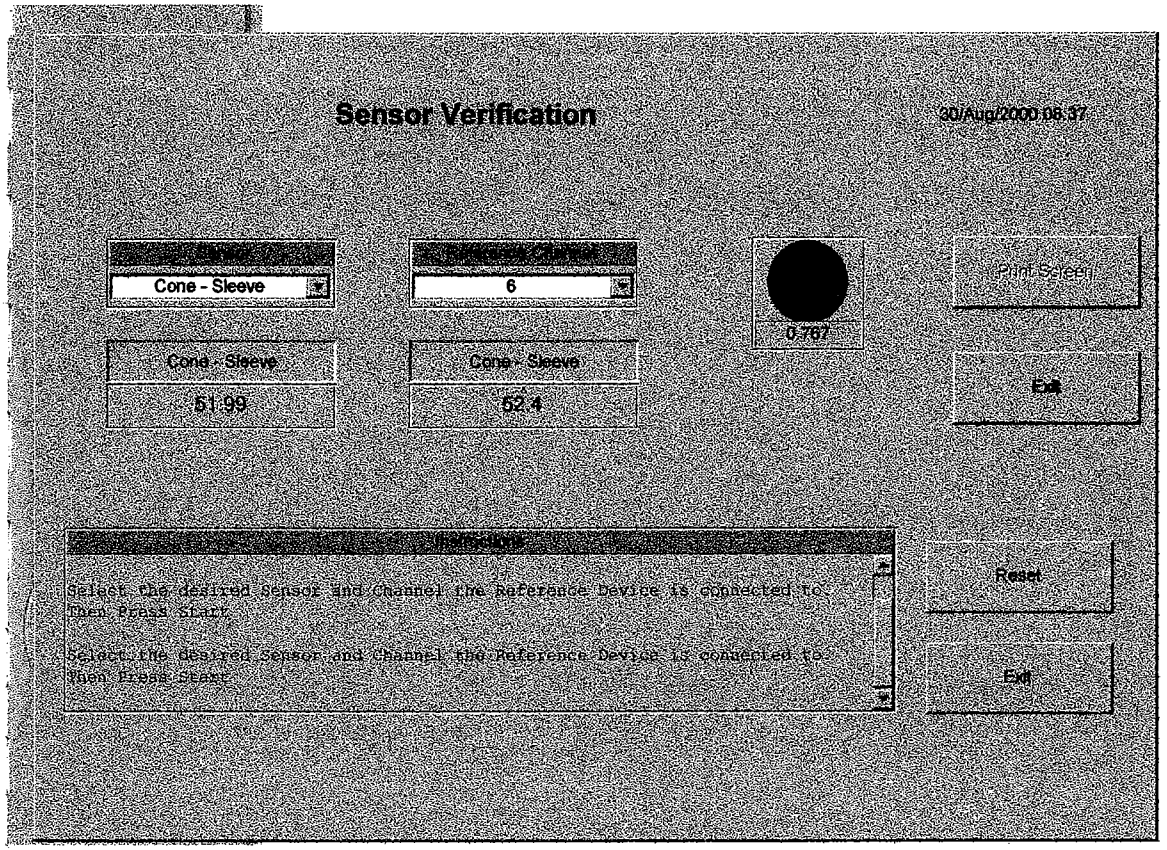


Vertek Calibration Card #2

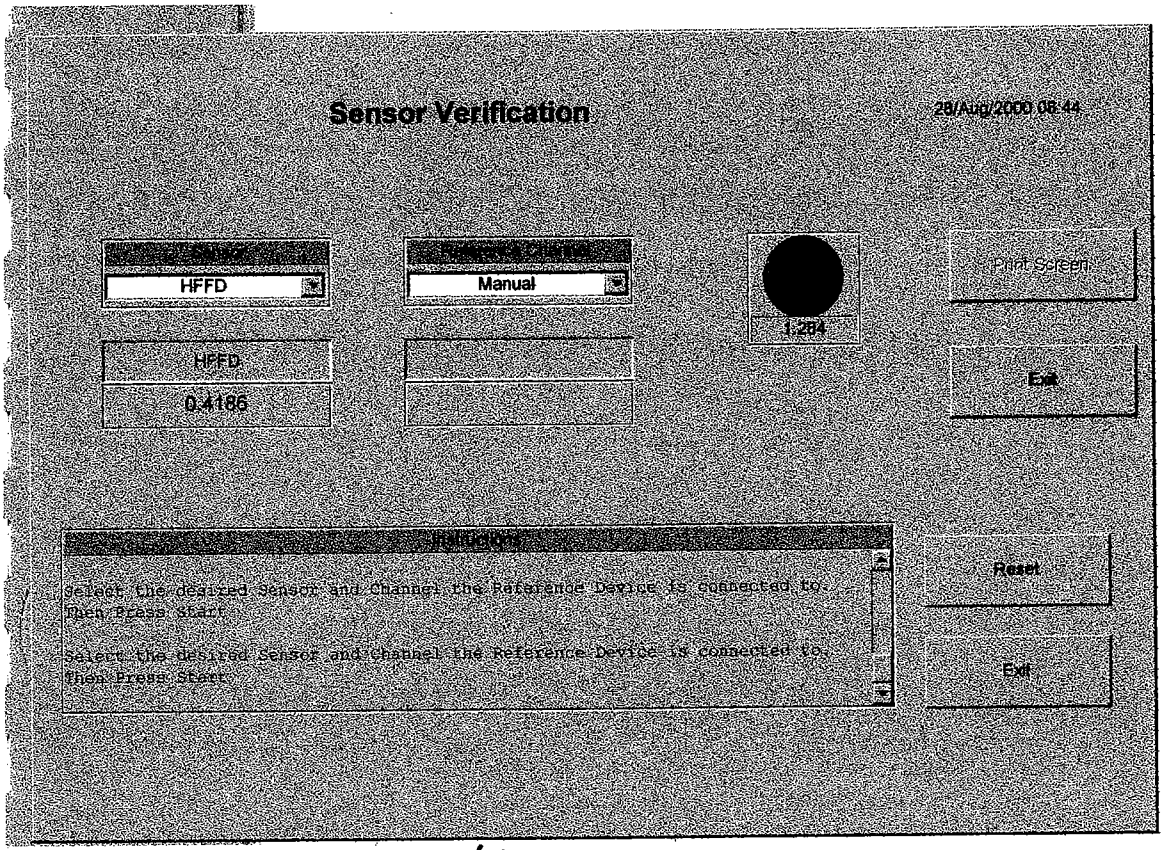


Vertek Calibration Cord #2


Sensor Verification
30/Aug/2000 08:37
Cone - Tip
6
1.633
Print Screen
Cone - Tip
606
Cone - Tip
615.8
Exit
Instructions
Select the desired Sensor and Channel the Reference Device is connected to.
Then Press Start
Select the desired Sensor and Channel the Reference Device is connected to.
Then Press Start
Reset
Exit

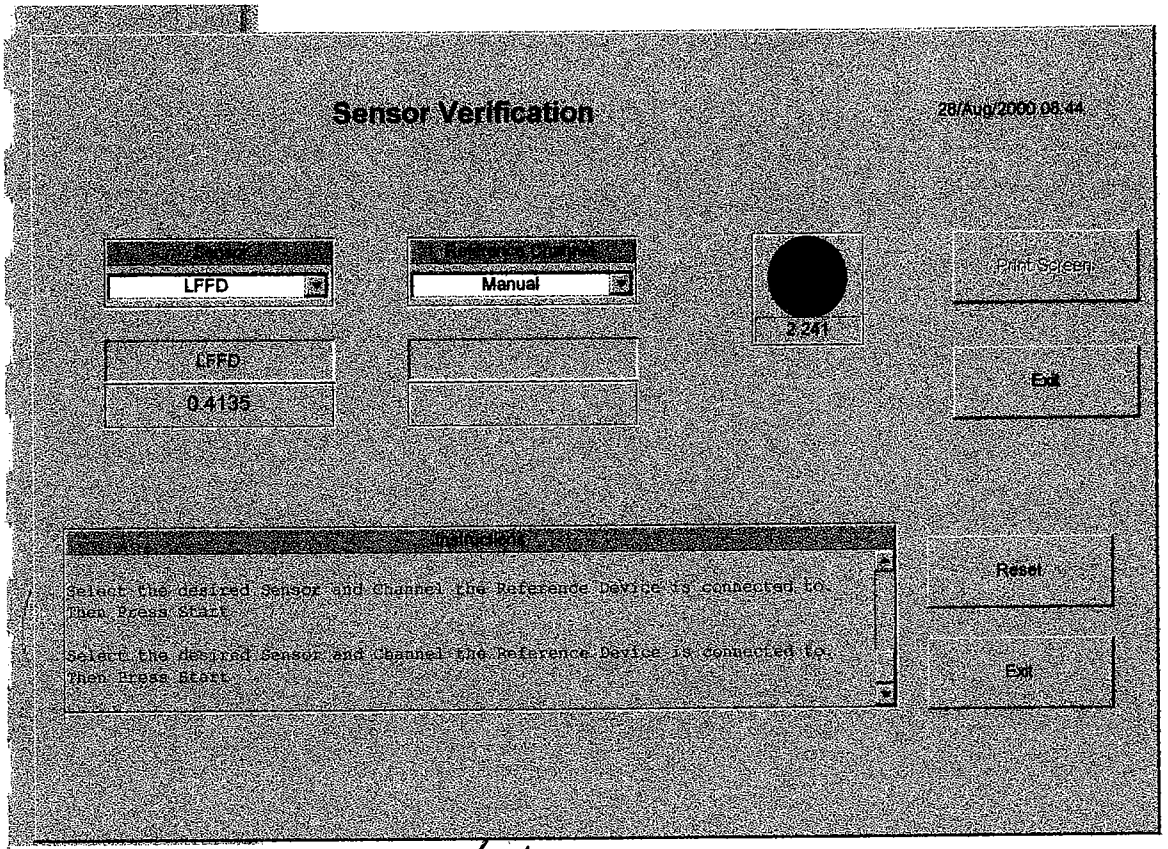

Sensor Verification
30/Aug/2000 08:37
Reference Device
Cone - Sleeve
Reference Channel
6
0.767
Print Screen
Exit
Cone - Sleeve
51.99
Cone - Sleeve
52.4
Instructions
Select the desired Sensor and Channel the Reference Device is connected to.
Then Press Start.
Select the desired Sensor and Channel the Reference Device is connected to.
Then Press Start.
Reset
Exit

Mon 28/Aug/2000 09:05:42

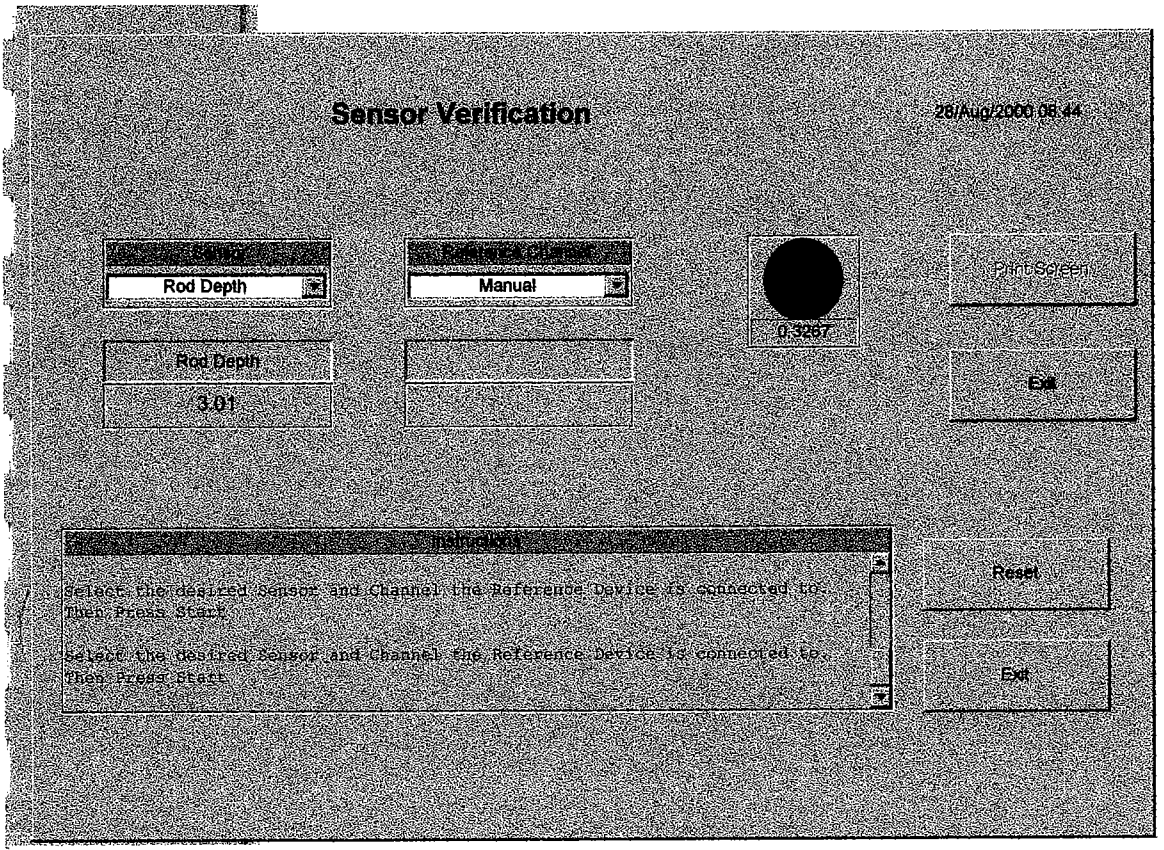


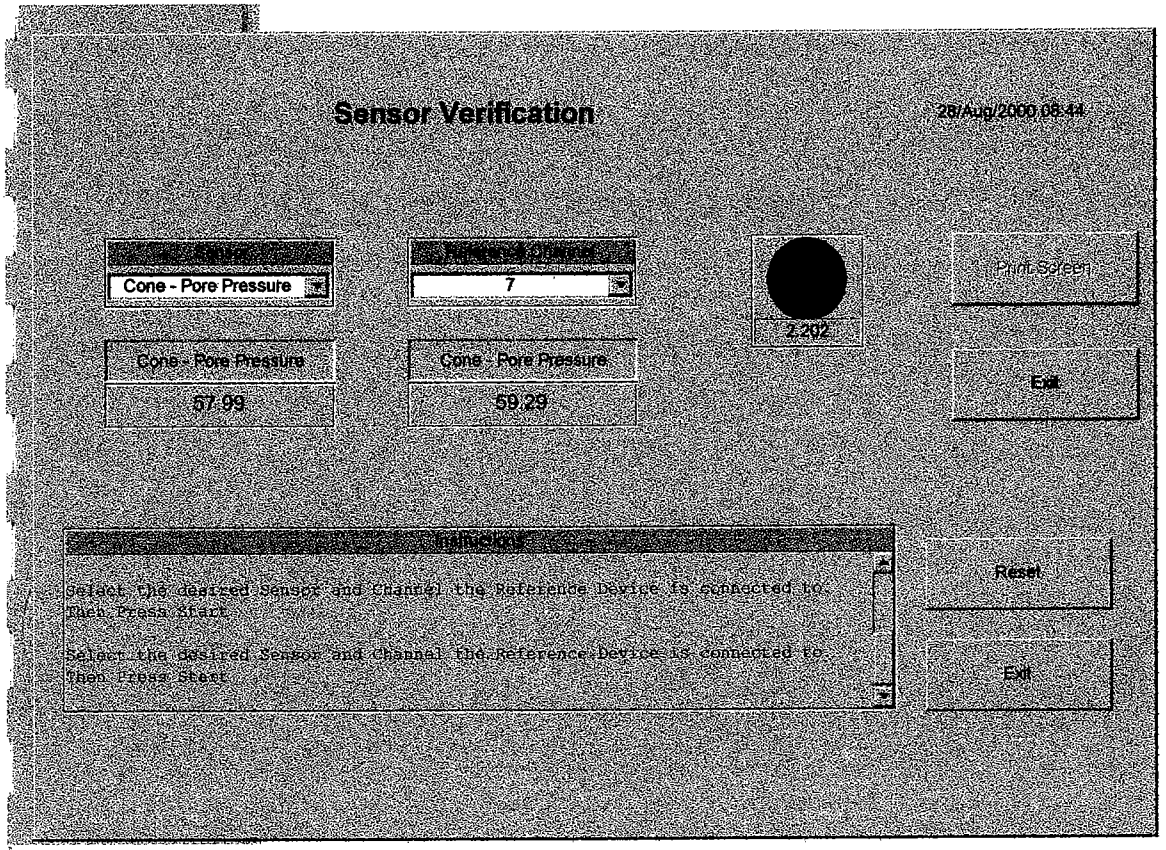
Vertek Card #2

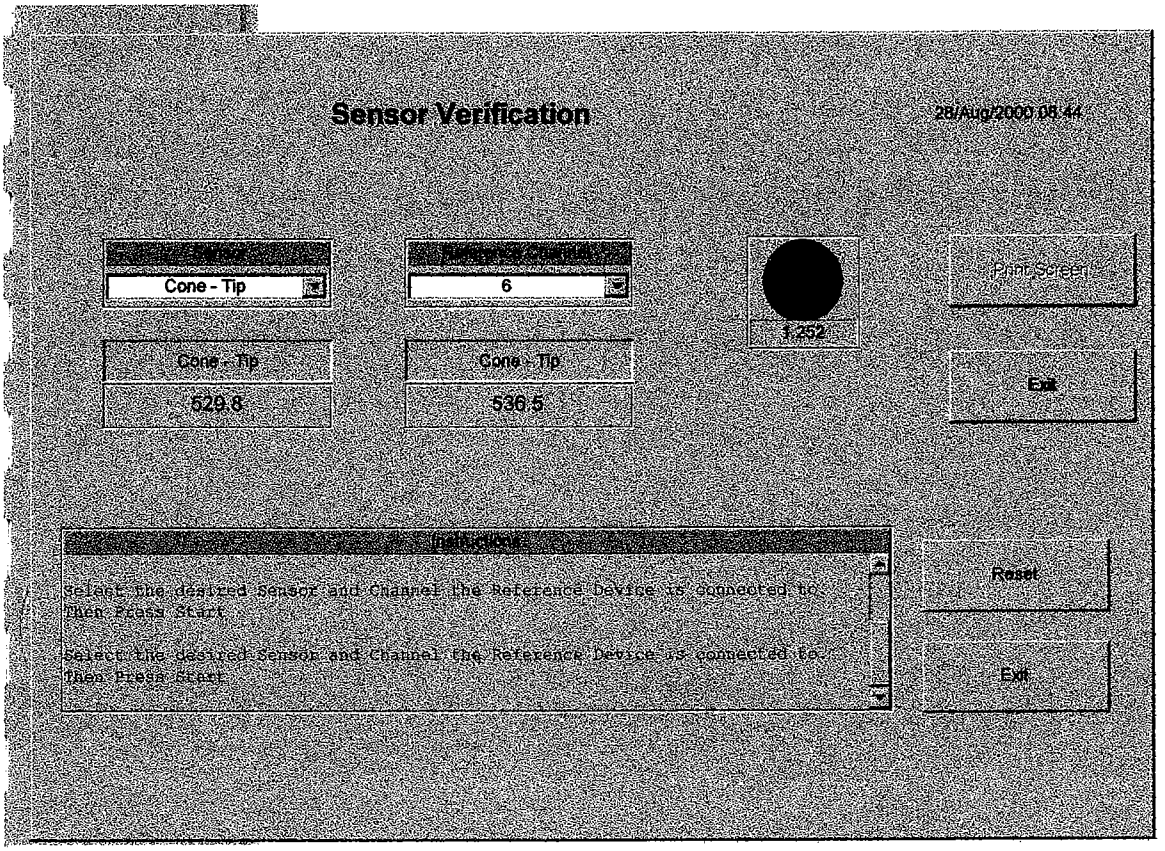
Mon 28/Aug/2000 09:04:32

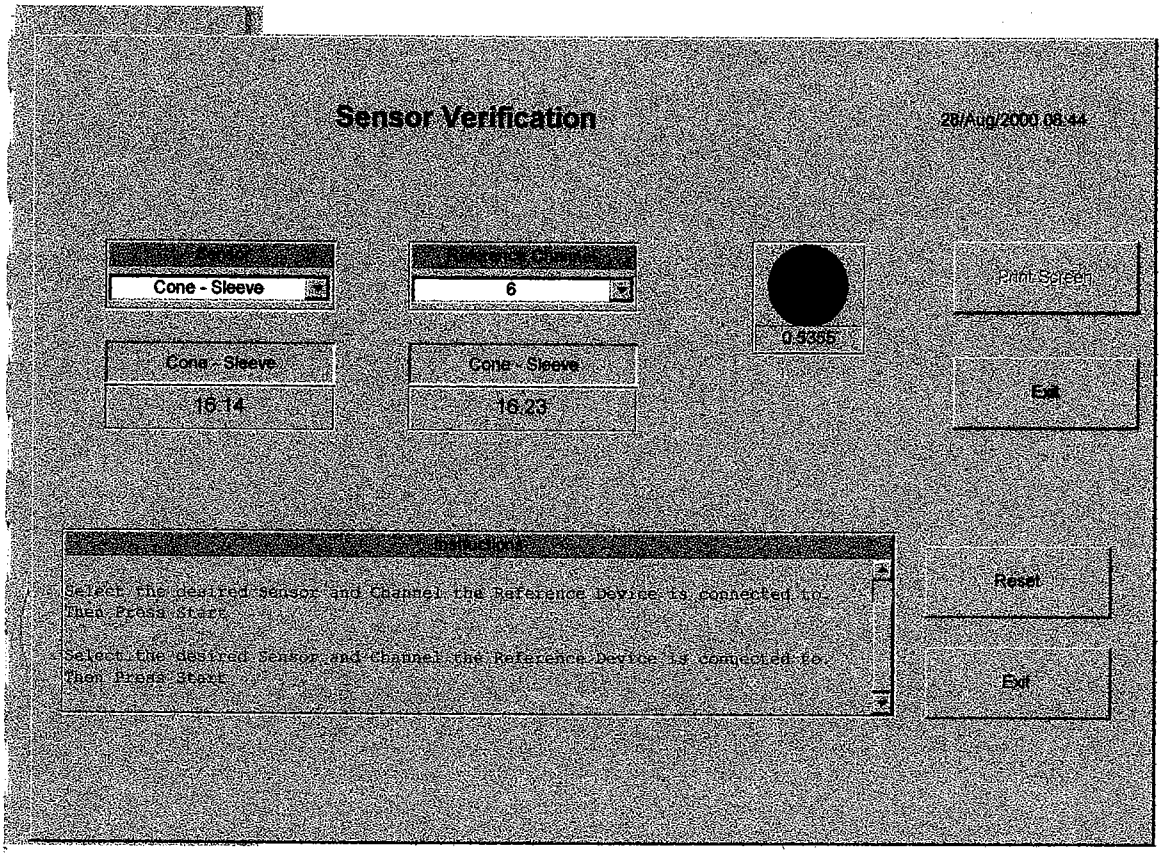


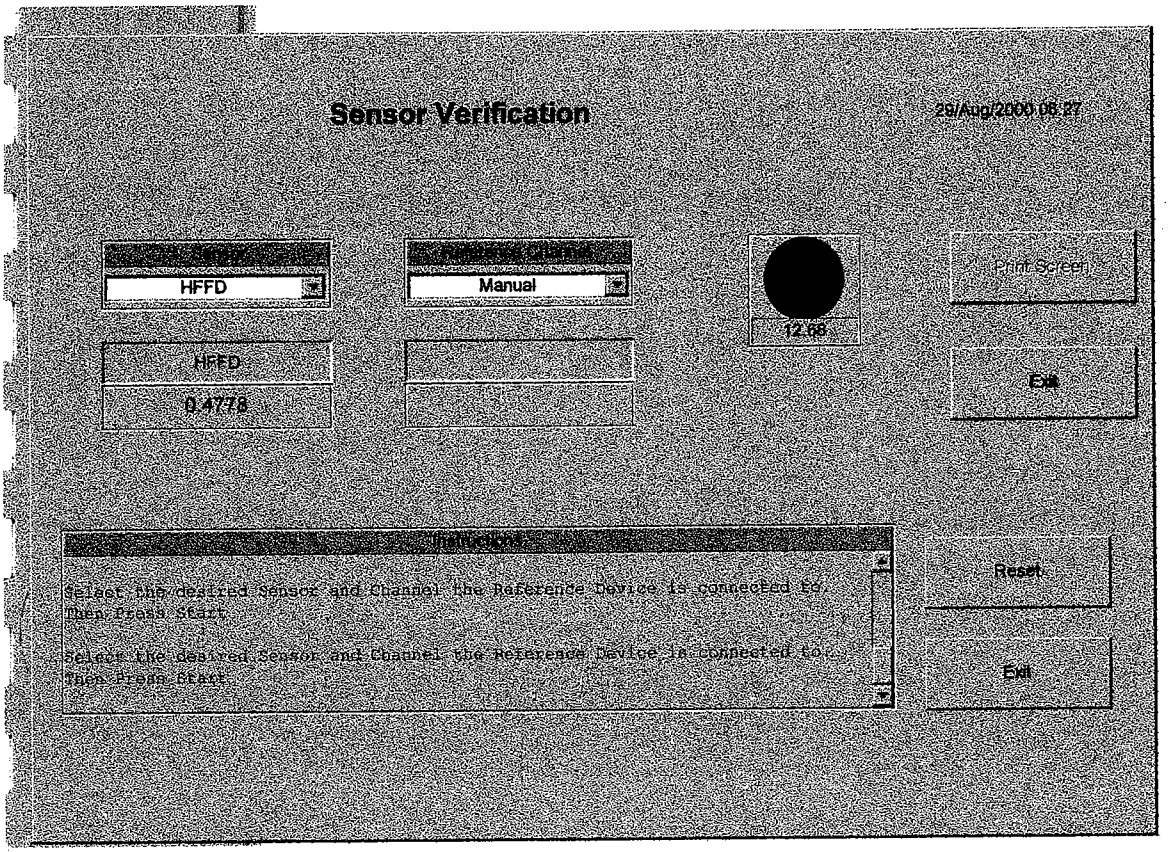
Vertek Card #2


Sensor Verification
28/Aug/2000 08:44
Sensor
Rod Depth
Reference Channel
Manual
0.3267
Print Screen
Exit
Rod Depth
3.01
Instructions
Select the desired Sensor and Channel the Reference Device is connected to.
Then Press Start.
Select the desired Sensor and Channel the Reference Device is connected to.
Then Press Start.
Reset
Exit

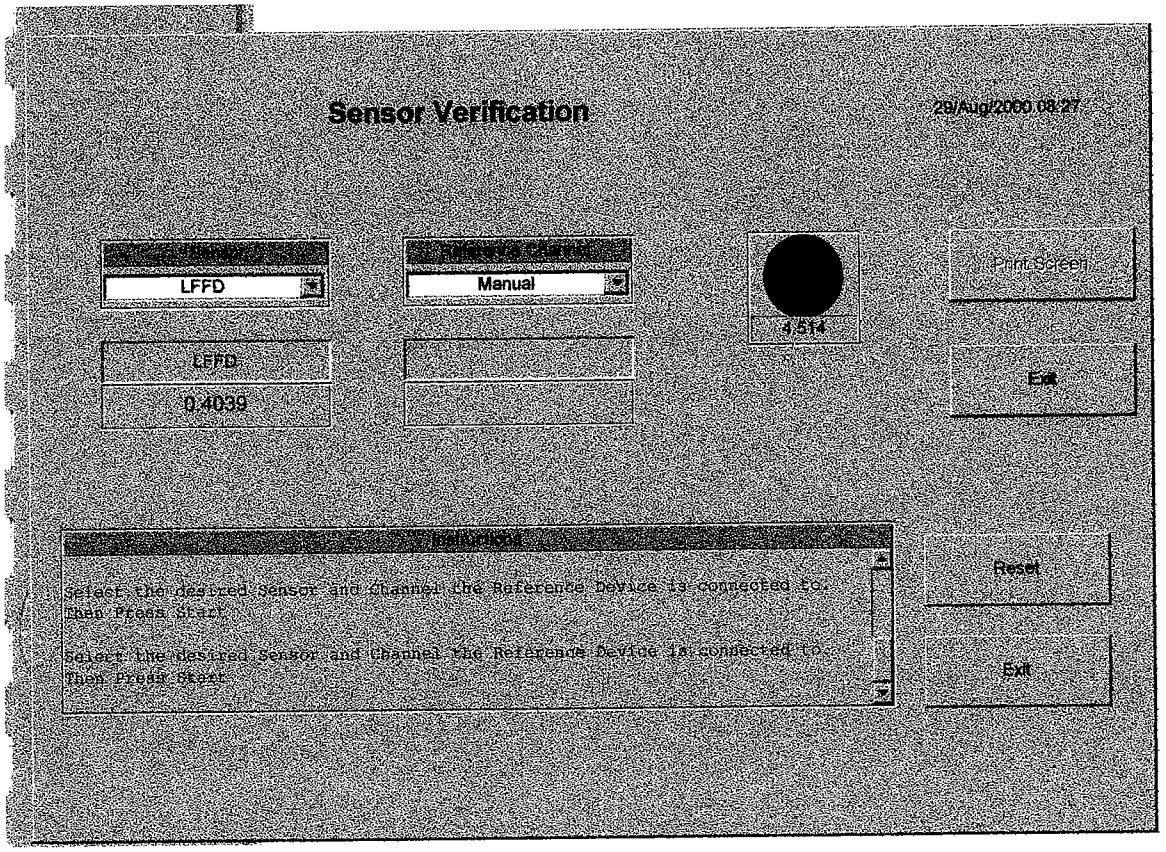

Sensor Verification
28/Aug/2000 08:44
Cone - Pore Pressure
7
2.202
Print Screen
Cone - Pore Pressure
57.99
Cone - Pore Pressure
59.29
Exit
Reset
Exit


Sensor Verification
28/Aug/2000 08:44
Sensor
Cone - Tip
Reference Channel
6
1.252
Print Screen
Exit
Cone - Tip
529.8
Cone - Tip
536.5
Instructions
Select the desired Sensor and Channel the Reference Device is connected to.
Then Press Start
Reset
Exit

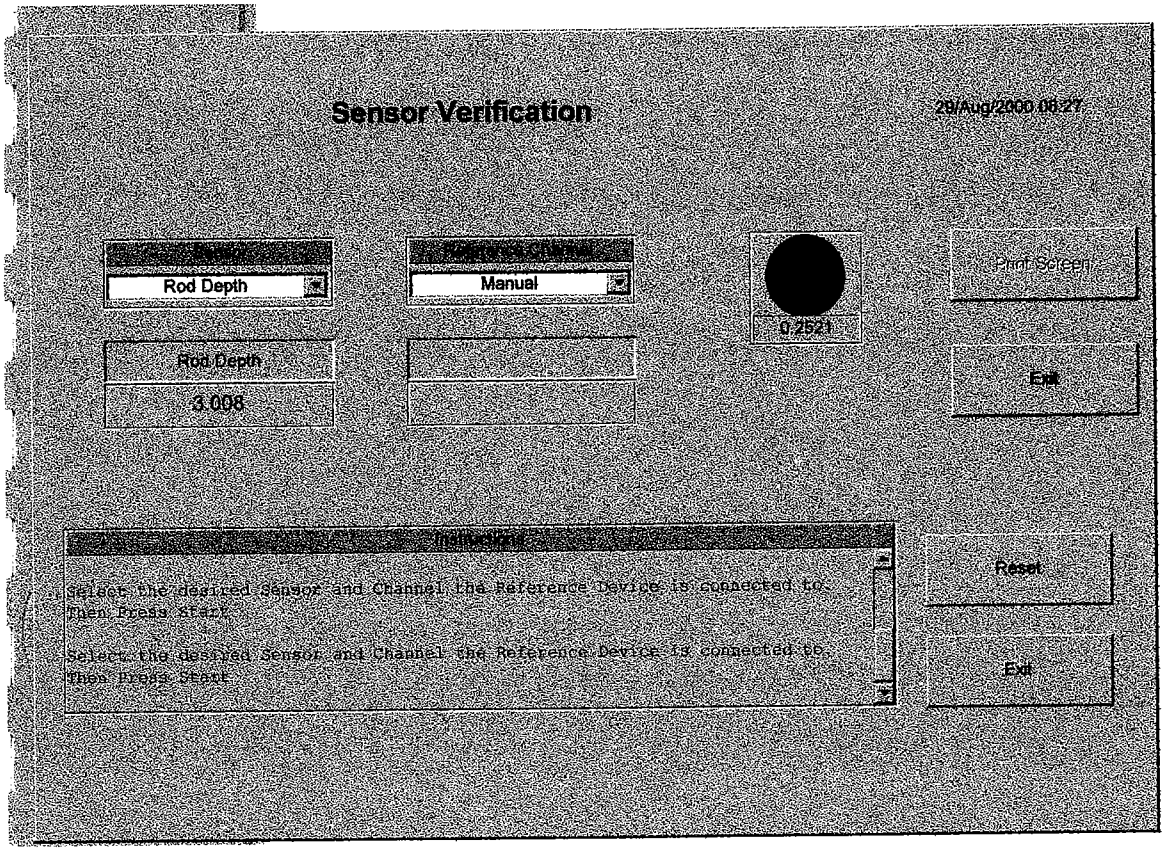

Sensor Verification
28/Aug/2000 08:44
Sensor
Cone - Sleeve
Reference Channel
6
0.9385
Print Screen
Exit
Cone - Sleeve
16.14
Cone - Sleeve
16.23
Instructions
Select the desired Sensor and Channel the Reference Device is connected to. Then Press Start.
Select the desired Sensor and Channel the Reference Device is connected to. Then Press Start.
Reset
Exit

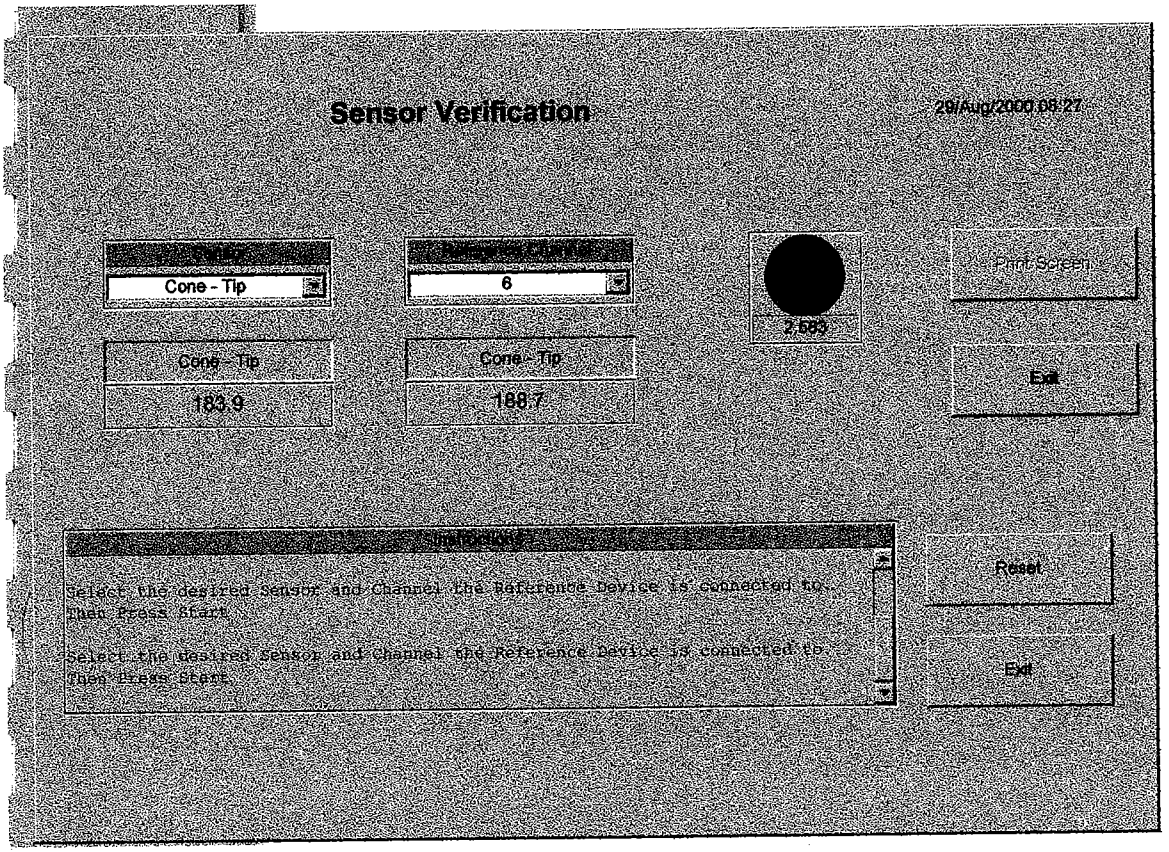

Sensor Verification
29/Aug/2000 08:27
Sensor Select
HFFD
Reference Channel
Manual
12.66
Print Screen
Exit
HFFD
0.4778
Instructions
Select the desired Sensor and Channel the Reference Device is connected to.
Then Press Start
Select the desired Sensor and Channel the Reference Device is connected to.
Then Press Start
Reset
Exit

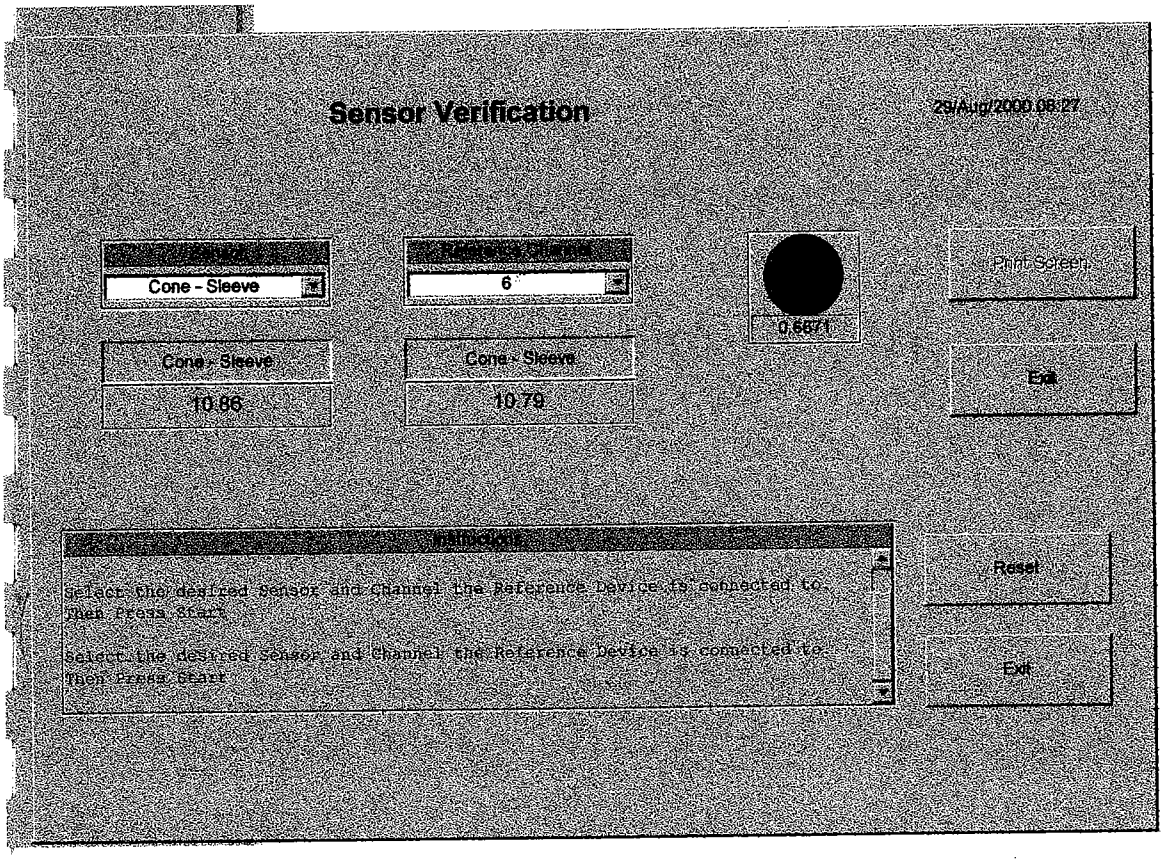
Tue 29/Aug/2000 08:51:01



Tue 29/Aug/2000 08:47:31




Sensor Verification
29/Aug/2000 08:27
Cone - Tip
6
2.685
Print Screen
Exit
Cone - Tip
183.9
Cone - Tip
188.7
Select the desired Sensor and Channel the Reference Device is connected to.
Then Press Start
Reset
Exit


Sensor Verification
29/Aug/2000 08:27
Cone - Sleeve
6
0.6671
Print Screen
Exit
Cone - Sleeve
10.86
Cone - Sleeve
10.79
Instructions
Select the desired Sensor and Channel the Reference Device is connected to.
Then Press Start
Select the desired Sensor and Channel the Reference Device is connected to.
Then Press Start
Reset
Exit