Testing the compressive strength of sea ice with a borehole jack: field instructions for decayed ice strength testing spring/summer 2000

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CHC CANADIAN HYDRAULICS CENTRE
CENTRE D'HYDRAULIQUE CANADIEN

TESTING THE COMPRESSIVE STRENGTH OF SEA ICE WITH A BOREHOLE JACK:

FIELD INSTRUCTIONS

R. FREDERKING

CANADIAN HYDRAULICS CENTRE
NATIONAL RESEARCH COUNCIL

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ABSTRACT

This report was prepared to aid in measuring and documenting the properties of decayed ice. Outlined is a procedure by which to measure the confined compressive strength of sea ice with a borehole jack. Also included are instructions pertaining to measurements of ice thickness, temperature, salinity, freeboard and snow depth. The report was prepared as part of a joint research project between Canadian Ice Service and Canadian Hydraulics Centre, whereby the properties of Arctic sea ice were measured in late spring and early summer 2000.

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TESTING THE COMPRESSIVE STRENGTH OF SEA ICE WITH A BOREHOLE JACK: FIELD INSTRUCTIONS FOR DECAYED ICE STRENGTH TESTING SPRING/SUMMER 2000

1. BOREHOLE JACK TEST PROTOCOL

1.1 Pre-Test Preparations

1) Assemble borehole jack, hoses, pressure gauge and pump in camp.

2) Run pump to extend and retract jack.

3) Place assembled borehole jack system on Komatik.

4) Check that Campbell logger battery voltage is greater than 10.5 V. (see Manual)

5) Prepare Campbell logger and synchronize time on CR10 with Keypad. (see Manual). Keypad may be left connected and inside enclosure.

6) Place white logger enclosure in aluminum shipping box. Also place Sandwell signal conditioning box in aluminum box.

1.2 Field Test Procedure

1) Pick test site of size approximately 30 m by 30 m. Between 6 and 12 weekly to bi-weekly tests will be done repeatedly in this area. Test sites should be at least 5 m apart. Ice should be level with no sign of roughness or pressure ridging. Also pick an area with a moderate snow thickness.

2) Set up test system: Connect pressure transducer and displacement transducer to Sandwell signal conditioning box. Connect pressure transducer and displacement transducer output to Campbell Scientific logger. Check that program is in CR10 (*0 gives LOG1).

3) Three holes will be drilled 1.5 to 2 m apart in a circular pattern. At each hole ice thickness, freeboard and snow depth are to be measured (Figure 1) and recorded on Data Sheet (see page 7). Use wooden straight edge across hole to get precise measure of freeboard.

4) Core from first hole is for temperature measurements. A full ice thickness core should be recovered. Take temperature measurements at 15 cm intervals,as indicated on Data Sheet.
5) Lower jack into hole to a depth of 30 cm.

6) Set pump lever in ***Extend*** position (PRESSURE).

7) Start data logger with Keypad and note start time on Data Sheet.

8) Start pump pressing down and holding button switch.

9) Watch pressure gauge, when pressure stops increasing, or starts to decrease stop pump, switch lever to ***Retract*** position and immediately retract jack. Listen for free running sound of pump when jack is fully retracted. Stop pump and switch lever to neutral position. Note: if pressure on gauge reaches 35 MPa, stop pump and ***Retract***. Sea ice should not be this strong – you have found cold multi-year ice!

10) Stop data logger with Keypad.

11) Loosen jack in hole, rotate 90° and lower to next depth, 60 cm.

12) Repeat steps 6) to 11).

13) When borehole jack tests are completed in first hole, replace core pieces in hole.

14) Move to next hole location. Core from second hole is for salinity measurements. A full ice thickness core should be recovered. Take temperature measurements at 15 cm intervals, as indicated on Data Sheet. A 2-cm-thick section of core is sufficient.

15) Repeat borehole jack strength test sequence as outlined in steps 5) to 13) above.

16) Move to final hole location. Core from third hole is not used for temperature or salinity tests.

17) Repeat borehole jack strength test sequence in third hole as outlined in steps 5) to 13) above.

Each test should take 2 to 5 minutes. Assuming 5 to 6 tests per hole, the testing should be completed in 1 to 1½ hours.

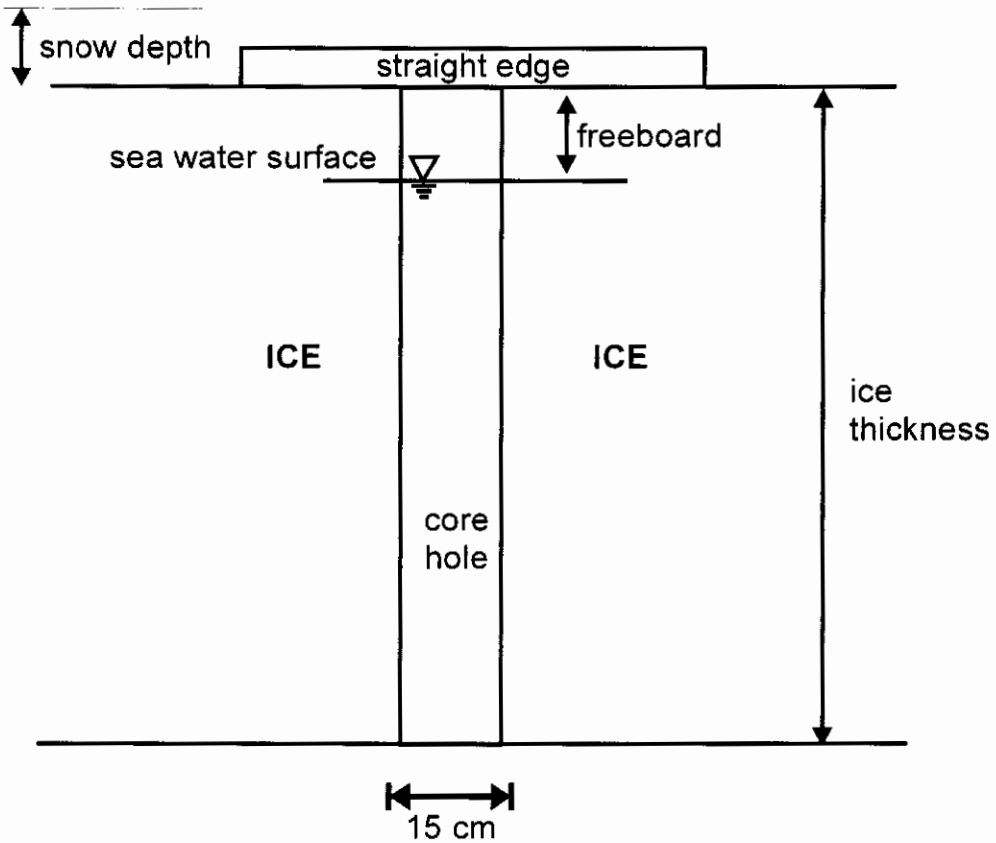


Figure 1 Measurements of Ice Thickness, Freeboard and Snow Depth

Ice Thickness: measure from straight edge on ice surface, cm precision

Freeboard: measure with tape measure from lower edge of straight edge to water surface. In this case mm measuring precision is required.

Snow depth: measure undisturbed snow depth, cm precision.

2. ENERPAC HUSHH PUP PUMP

Figure 2 shows the top view of Hushh-Pup pump showing the lever positions for extend and retract. The pressure gauge and pressure transducer are connected to the outlet beneath the lever when it is in the **Extend** position. This hydraulic hose is marked with Yellow arrow tape.

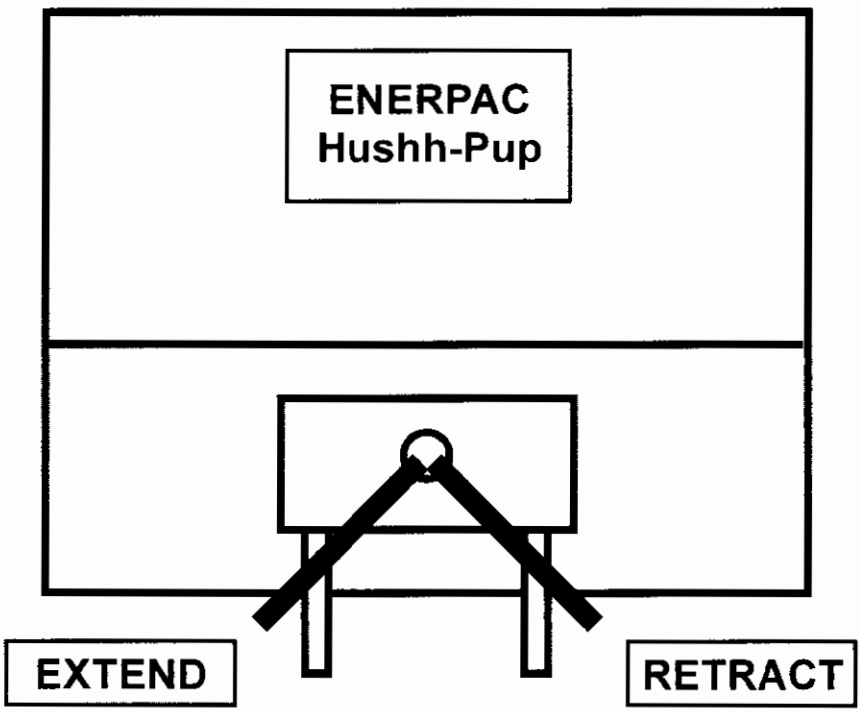


Figure 2 Top view of Hushh Pup

The hydraulic line marked with Green arrow tape is connected to the fitting beneath the lever when it is in the **Retract** position.

The connections of hydraulic lines to the Hushh-Pup and the borehole jack head are shown in Figure 3, Figure 4 and Figure 5.

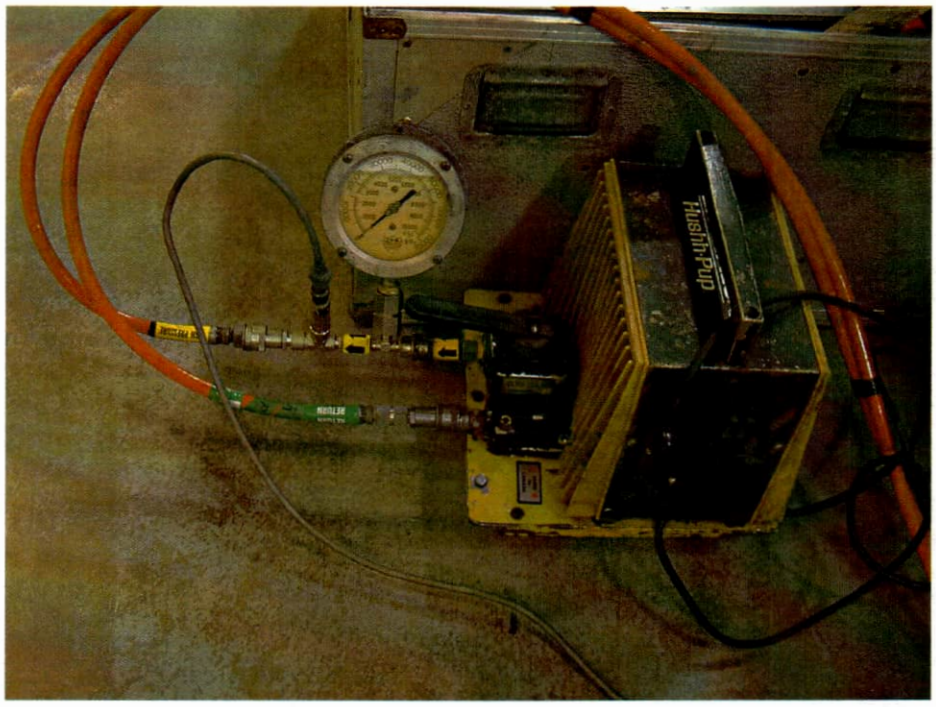


Figure 3 Hushh Pup

Figure 4 Borehole Jack Assembly

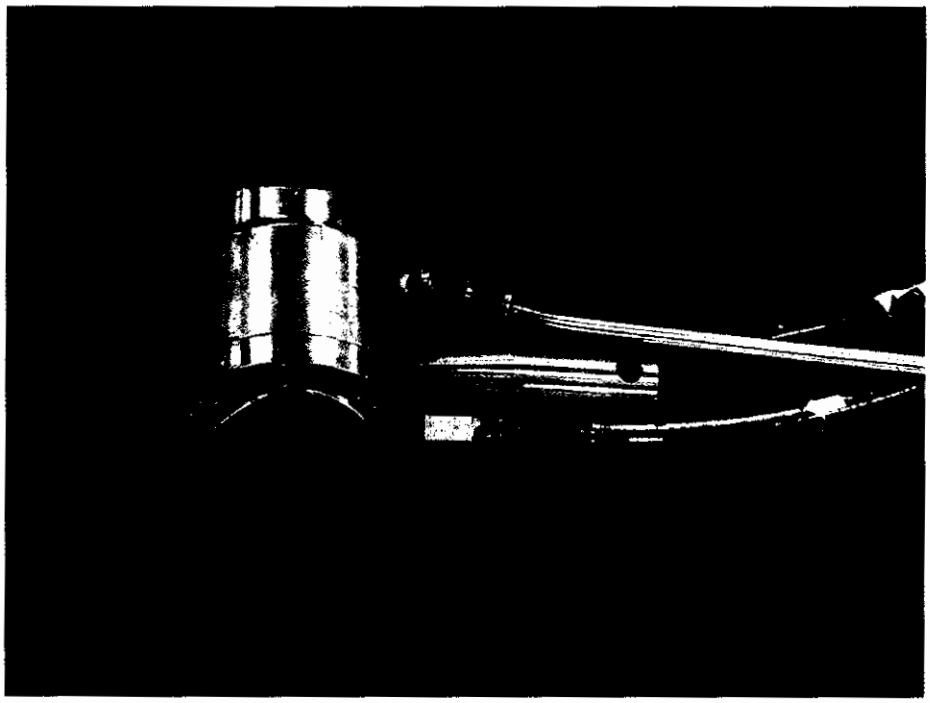


Figure 5 Borehole Jack Head

3. DATA SHEET FOR DECAYED ICE PROGRAM

Data Sheet - Decayed Ice Strength Test Program

Date: _____ Julian Day: _____

	Temperature Core 1	Salinity Core 2	Core 3
snow depth, cm			
ice thickness,cm			
freeboard, cm			

depth, cm	temp.	o/oo
0		
15		
30		
45		
60		
75		
90		
105		
120		
135		
150		
165		
180		
195		
210		

	Borehole Jack Strength		
	Hole 1	Hole 2	Hole 3
depth, cm	start time	start time	start time
30			
60			
90			
120			
150			
180			

Photograph?_____

Sketch of site

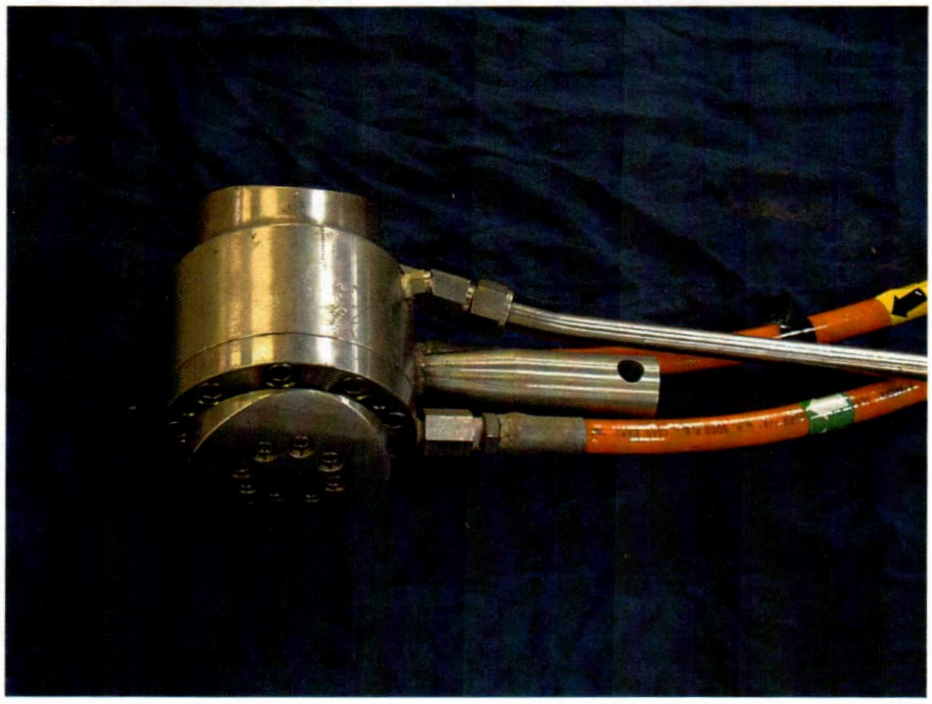


Figure 5 Borehole Jack Head

4. MANUAL FOR USING THE CAMPBELL SCIENTIFIC STORAGE MODULE, DATALOGGER AND THE KEYPAD

MANUAL TO BE USED WHEN TESTING THE COMPRESSIVE STRENGTH OF ICE USING THE BOREHOLE JACK SUMMER 2000

Note: This manual is written for PC208W version 2.2; the higher version of PC208W might have slightly different layout of the windows.

Acronyms: SM716 – Storage Module
CR10 – Datalogger
WP – Wiring Panel
PS – power Supply

4.1 OPERATIONS TO BE DONE IN THE CAMP

4.1.1 INFORMATION

4.1.1.1 BASIC SETTINGS

The setup is described in detail in the ACTION part of this document:

Setup = COM# (# depends on the computer port, but is usually 1) ⇒ CR10 ⇒ SM716 in this sequence (Setup window)
Baud Rate = 9600 (Setup window)
SM716 Address = 1 (StgModule window)
SM716 Storage Mode = Fill and Stop (StgModule window)
SM716 Programs = has to be stored in location Prog 8 (StgModule window)
Program Used (if 5 readings per second) = BHJ_05.dld
(if 10 readings per second) = BHJ_10.dld

4.1.1.2 DOWNLOADING DATA FROM SM716

Downloading data from the full storage module – takes about 15 minutes.
Erase and Test the storage module – takes about 4 minutes
Downloading new program – takes about 30 sec depending on the size of the program

4.1.1.3 CONNECTING DATALOGGER CR10*

(should not need, but mentioned for information)

Through SC32A (optically isolated RS232 interface)* cable
Datalogger = to datalogger
Terminal printer = to computer

| NOTE Every time before disconnecting the Keypad press *0 |

* Refers to Campbell Scientific components and accessories

4.1.1.4 CONNECTING SM716*

Through SC532 (9 pin peripheral to RS interface)* cable
"Peripheral" side connected to the SM716 through the blue ribbon cable
"RS232" side connected to the computer
Has to be powered up (120V | 9V DC supply)

4.1.1.5 SETTING UP SM716 & CR10 WITH PC208W

1. Select "Setup" (left hand corner) on PC208W main menu to open the Setup window
2. Select the *Hardware tab*
3. Select COM (COM1)
4. Click on "Add Devices" button and add CR10 (as CR10 Datalogger) and SM716 (as SM192/716), in this sequence
5. Switch setting (for Borehole jack ice strength) = 9600 Baud Rate
6. Save the devices and the setting by clicking on the "Save Edits" button

4.1.2 STORAGE MODULE SM716

Select "StgModule" on PC208W main menu to open the Storage Module (SMS) window

Select the middle top tab (*SM192/SM716*)

Select the *Setup tab* (on the bottom of the left hand half of the SMS window) – make sure the right port - COM (COM1/COM2) and Baud Rate (in our case 9600) is selected

At this stage either close the program or proceed to downloading (storing) the program to SM716.

4.1.2.1 STORING PROGRAM IN SM716

1. Select "StgModule" on PC208W main menu to open the Storage Module (SMS) window
2. Click on the "Connect" button
3. Erase data from and test the SM716

Erasing data

a) Select the *Erase tab*

b) Click on the "Erase and Test Module" button (if full takes about 10 – 15 minutes)

*4.*Select the *Programs tab*

5. Store a program → Select the check box "Prog 8" → Click on the "Store" button → select the program you want to store from either the floppy disk from Canadian Hydraulics Centre or your local drive (in our case it is BHJ_05.dld for recording readings 5 times per second or BHJ_10.dld for recording readings 10 times per second)

6. Select the *Advanced tab* (on the right hand half of the SMS window)

7. Change "Storage Mode" option to "Fill and Stop"

8. *The Storage Module setup should be as:*

*a.*on the *Programs tab* Program No.8 = USED

*b.*on the *Status tab* under "Switch Settings" : 76800/9600 Baud Fill and Stop ..... ASCII Mode Address 1

9. Click on the "Disconnect" button

Now the program is stored in the SM716.

Check battery voltage of PS12 12V POWER SUPPLY, it should be at least 10.5 V. The terminals on the battery pack in the power supply are easily accessible when the cover is off the unit. (The minimum voltage to operate the logger is 9.5 V).

Ensure that the power switch in the power supply (PS12 12V POWER SUPPLY) is in OFF position.

Place the SM716 into the white Campbell Scientific box where wiring panel (WP), datalogger (CR10), and power supply (PS12 12V POWER SUPPLY with charging regulator) are mounted. Connect the SM716 through the blue ribbon cable to the WP with CR10. Then turn on the power switch inside the PS12 12V POWER SUPPLY (note; CHG light does not come on). The program is now automatically downloaded from SM716 to CR10. Place cover back on PS12 12V POWER SUPPLY and close white box.

NOTE: the SM716 has to be connected to the CR10 prior to turning on the power switch so the program from the SM716 is automatically downloaded to the CR10. Keep power on continuously while tests are being run and data logged.

The following task in mentioned here, however it is not performed until the SM716 storage module has data stored on it and is brought back to camp after borehole jack testing in the field.

****
*

4.1.2.2 DOWNLOADING DATA FROM SM716

This task (downloading data and viewing data) is to be done at the end of each day when tests were performed after returning back to the camp from the field. Remember to connect SM716 to the notebook computer using SC532 (see top of page 2).

1. Select "StgModule" on PC208W main menu to open the Storage Module (SMS) window
2. Click on the "Connect" button
3. Select the *Data tab*
4. Select the "New Name for Each file" option button from "File Naming Options"
5. Click on "Get All" button to download all files stored in the storage module. Dialog box appears asking for the name of the file = select the path where you want to have the file stored and the name under which you want to store the file. Suggested name BHJ### where ### is the Julian Day of the tests. Then wait while data downloads. Note that the file is a comma delineated ACSII file with a .DAT file extension.
6. Click on the "Disconnect" button

4.1.2.2.1 Viewing data

1. Select "View" on PC208W main menu to open the View window | File | Open | select the proper path and the file. The columns in each file represent: Array ID; Julian Day; Time (hh:mm); Seconds; Displacement (mV); Pressure (mV), respectively (See example below)

```
10,108,1920,32.5,2144,4.626

10,108,1920,32.75,2143,4.626
10,108,1920,32.88,2144,4.626
10,108,1920,33.13,2143,4.626
10,108,1920,33.25,2144,4.626
```

Use "View" to check that the beginning and end times on the file correspond to field notes.

IMPORTANT!! Make back-up copy of BHJ### DAT file onto a floppy diskette

After making sure data file is backed-up, follow the 9 steps on page 2 for STORING PROGRAM IN SM716.

****

The following operations should be done in camp before going into the field to do borehole jack tests.

4.1.3 KEYPAD CR10KD

This can be done without connecting the Borehole jack system.

1. Making sure the SM716 is connected, power up the datalogger in the white box (turn on the power switch inside the battery enclosure PS12).
2. Connect the keypad to the blue ribbon cable. When the Keypad is connected to the CR10 after the power was turned on, the display is meaningless. Press *0 (LOG1 appears on display), and then proceed with appropriate keystrokes.
3. If the Keypad is connected to the CR10 (blue ribbon cable) prior to being powered up, the "HELLO" message is displayed while the CR10 checks memory. Wait until number "96" appears on the display.
4. Press *0 (LOG1 appears on display), and then proceed with appropriate keystrokes.
5. If LOG1 does not appear, or only LOG appears, the program has not been downloaded from the SM716.

| NOTE Every time before disconnecting the Keypad press ***0** |

4.1.3.1 SYNCHRONIZING THE CLOCK

The clock has to be set up every time the power is turned on. Press keystrokes as described in the following procedure:

Procedure:
- *5 (HH:MM:SS appears on display = current datalogger time)
- A (0500 appears on display) → Type in "00" (for Year 2000) → you should see 0500
- A (050000 appears on display) → Type in the number indicating Julian Day (i.e. 101 for April 10th ; 101 = April 10th because of the leap year) → you should see 05101
- A (050000 appears on display) → Type in the time (HH and MM, i.e. 1545 for 3:45 p.m.) → you should see 051545
- A clock set and running appears on display (in this case 15:45:SS)
- *0 to exit the instruction for synchronizing the clock

Disconnect the Keypad from the blue ribbon cable

WARNING: Be sure to leave the power on!! Otherwise all the time settings are lost, and any data stored on the CR10 are lost. Nothing has to be done to download the program to the CR10, it is done automatically from the SM716, but the SM716 has to be connected to the CR10 with the blue ribbon cable **prior** to turning the power on. If the power is turned off and then on again, the clock has to be synchronized again (using the Keypad).

4.2 OPERATIONS TO BE DONE IN THE FIELD

Connect displacement output to cable from white Campbell Scientific logger box
Connect pressure output to cable from white Campbell Scientific logger box
Connect the Keypad to the blue ribbon cable (the display will be meaningless. Press *0 (LOG1 appears on display), and then proceed with the keystrokes as described below.

4.2.1 KEYPAD CR10KD

4.2.1.1 START LOGGING

The following keystrokes have to be entered into the Keypad to activate recording the data.

Procedure: *6 (060000 appears on display)
A (01 0.#### appears on display)....#### represents a four digit number
D (00000000 appears on display)
1 (10000000 appears on display; if first 0 is not changed to 1 the test has not been activated!!! => repeat the whole procedure!)

4.2.1.2 STOP LOGGING

The following keystrokes have to be entered into the Keypad to stop recording the data.

Procedure: *6 (060000 appears on display)
A (01 0.#### appears on display)....#### represents four digit number
D (10000000 appears on display)

1 (00000000 appears on display; if first digit (1) is not changed to 0 the test has not been stopped!!! => repeat the whole procedure!)

DISPLAY DISPLACEMENT AND PRESSURE READINGS ON THE KEYPAD DISPLAY

This provides a means to check in the field that the data logger has stored data. Displacement data are being stored in location 1, the pressure data in location 2. Step through the locations using the keystrokes in the following procedure:

Procedure: *6 (060000 appears on display)

Use A to advance through locations

A (01 "displacement reading in mV" appears on display, second digit indicates the location, i.e. here 01 = location 1)

A (02 "pressure reading in mV" appears on display, second digit indicates the location, i.e. here 02 = location 2)

Use B to back up through locations

B (01 "displacement reading in mV" appears on display, second digit indicates the location, i.e. here 01 = location 1)

*0 to exit the instruction for displaying readings

When back in the camp, turn the power off (turn off the power switch inside the battery enclosure (power supply box)), remove the SM716 and download data as described on page 3.

5. CAMPBELL BOX WIRING DIAGRAMS

Figure 6 shows the general layout of the components in the white Campbell Box and gray Sandwell signal conditioning box. The SM716 module in not in the Campbell Box , however the wiring panel above the CR10 logger and the PS12 12V POWER SUPPLY can be seen.

Figure 7 is a schematic of the wiring from the displacement transducer and the pressure transducer to the wiring panel. The connections are described below.

D DISPLACEMENT
female banana plug; red to red wire (+), black to black wire (-)

P PRESSURE
female banana plug; red to white wire (+), black to green wire (-)

The four-conductor cables goes into a simple voltage divider **IN GRD GRD IN** (terminal strip bolted to side of white Campbell box).

Output from DISPLACEMENT side of voltage divider; red wire from **OUT** to **1H** on wiring panel.

Output from PRESSURE side of voltage divider; white wire from **OUT** to **1L** on wiring panel.

Two green ground wires go from two **GRD**s to 2nd and 3rd **G** positions on wiring panel.

Output from **PS12 12V POWER SUPPLY**; red wire (+) to **12V** on wiring panel, black wire (-) to **G** on wiring panel.

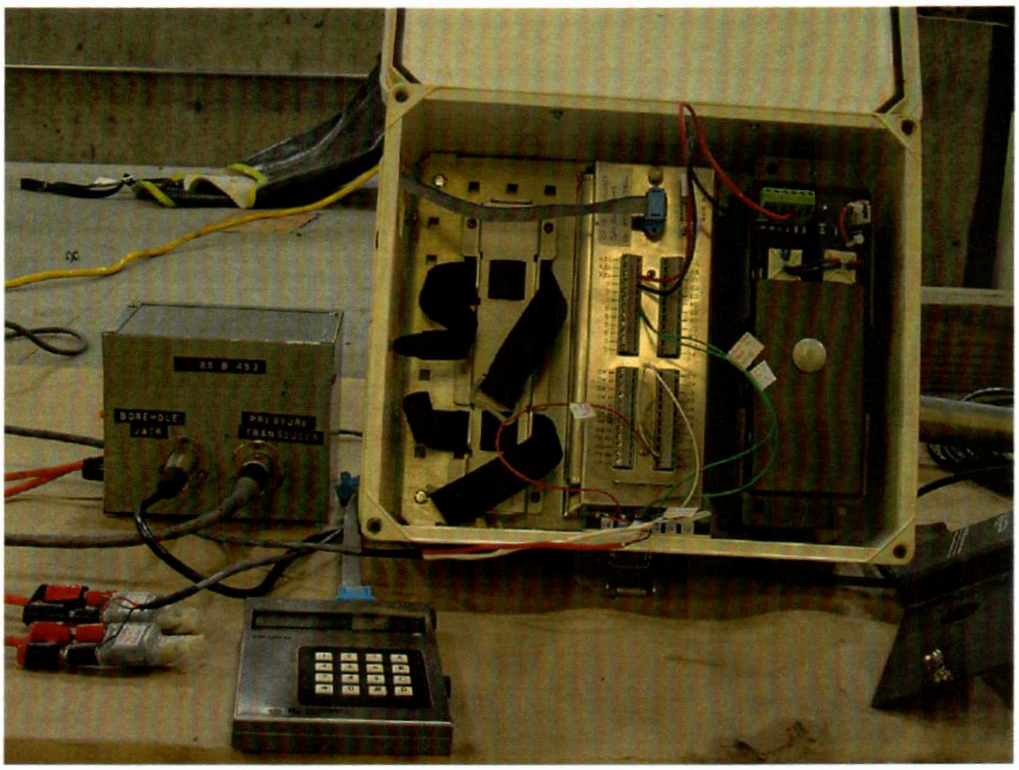


Figure 6 Campbell Box

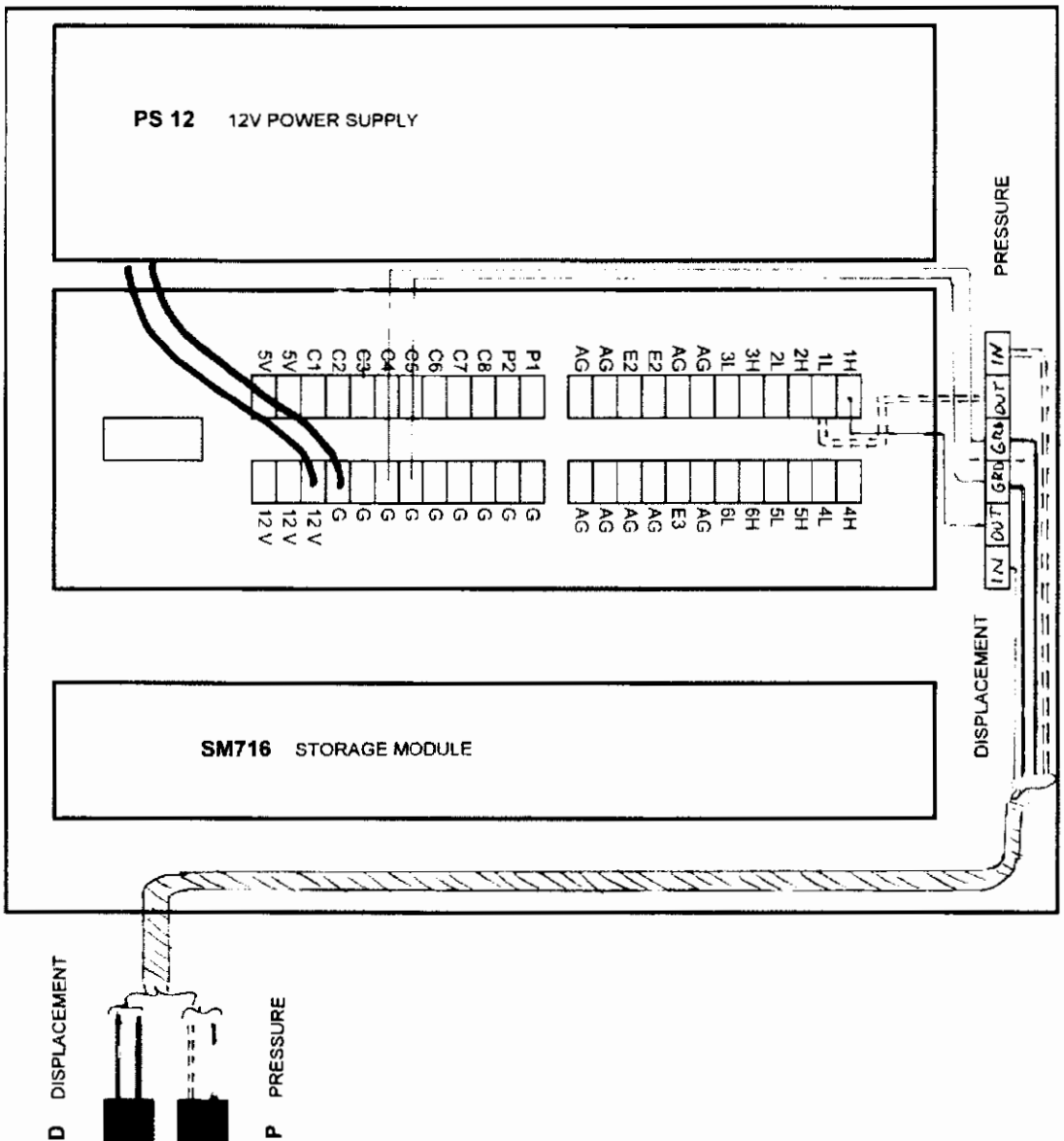


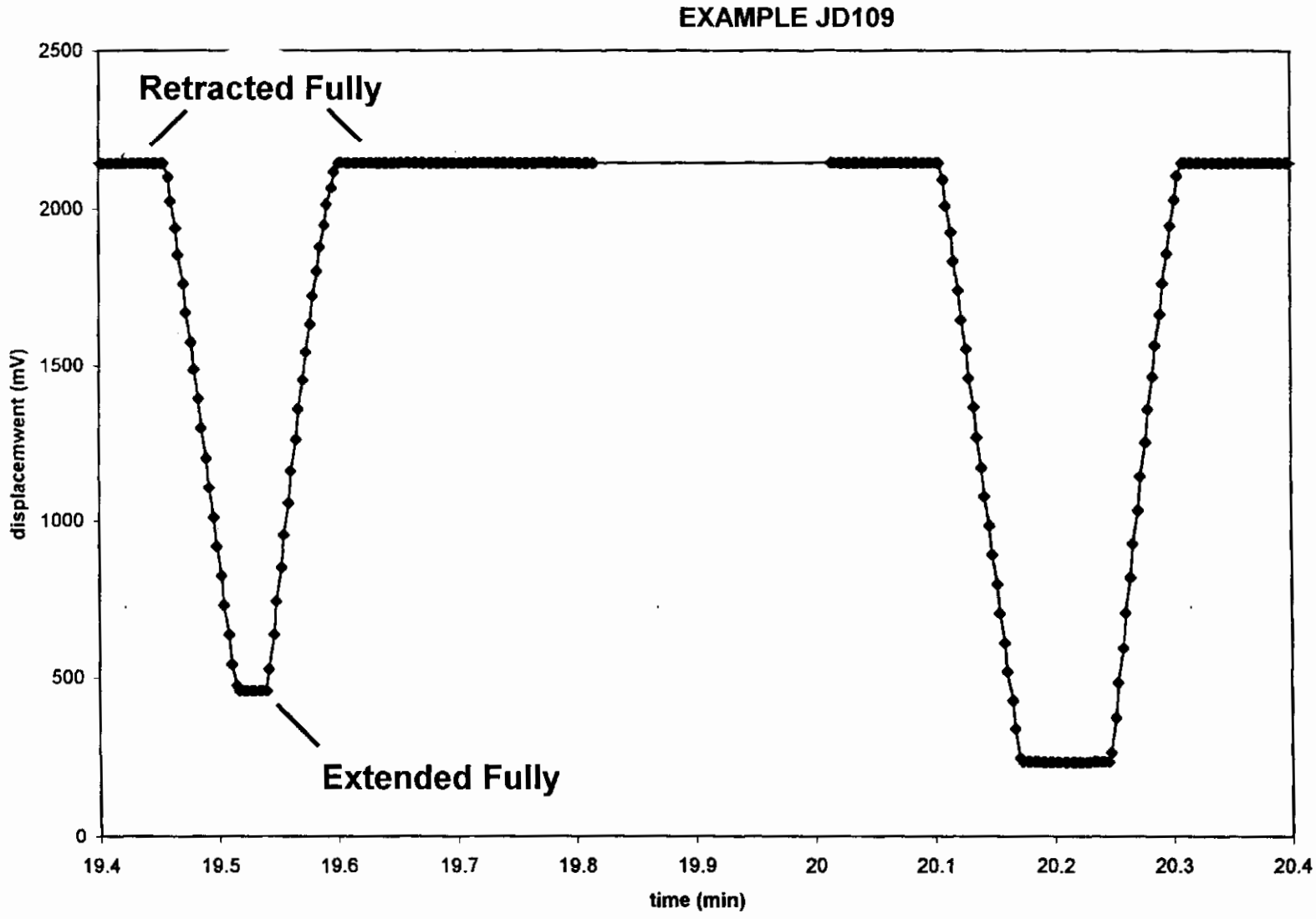
Figure 7 PS12 12 V Power Supply Wiring Diagram

6. JULIAN DAY CALENDAR FOR 2000

JULIAN DAYS FOR 2000

	DAY OF THE MONTH																													
month	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**
JAN	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
FEB	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60		
MAR	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91
APR	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	
MAY	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152
JUN	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	
JUL	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212	213
AUG	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243	244

APPENDIX A
EXAMPLES


EXAMPLE JD109
Retracted Fully
Extended Fully
displacemwent (mV)
time (min)
2500
2000
1500
1000
500
0
19.4
19.5
19.6
19.7
19.8
19.9
20
20.1
20.2
20.3
20.4

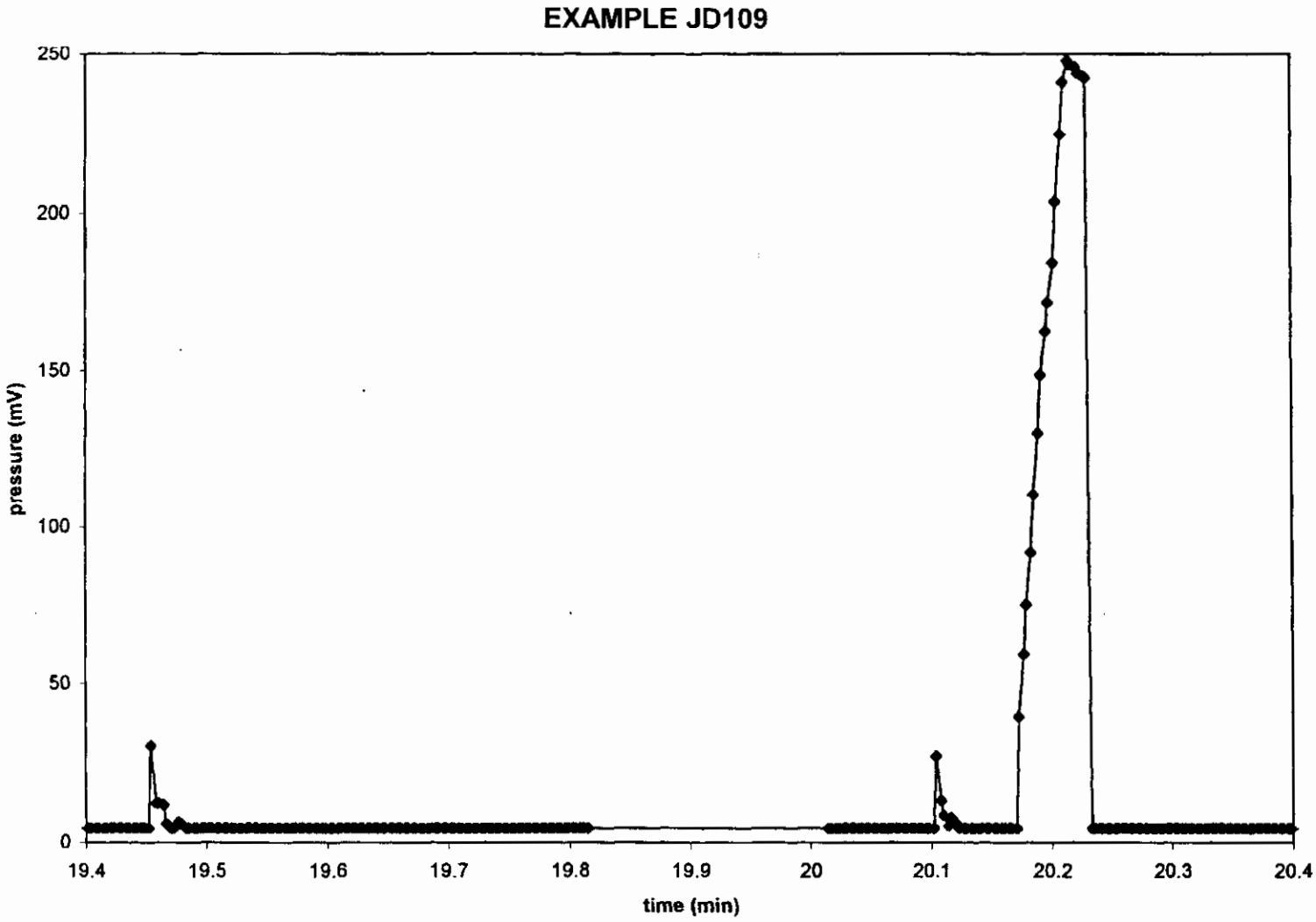

EXAMPLE JD109
250
200
150
100
50
0
pressure (mV)
19.4
19.5
19.6
19.7
19.8
19.9
20
20.1
20.2
20.3
20.4
time (min)

Figure 3 – Station 3 – Natural Ice – March 18, 1999
Ice Thickness = 1.2 m
(courtesy of Sandwell Engineering, Inc.)

Figure 3A

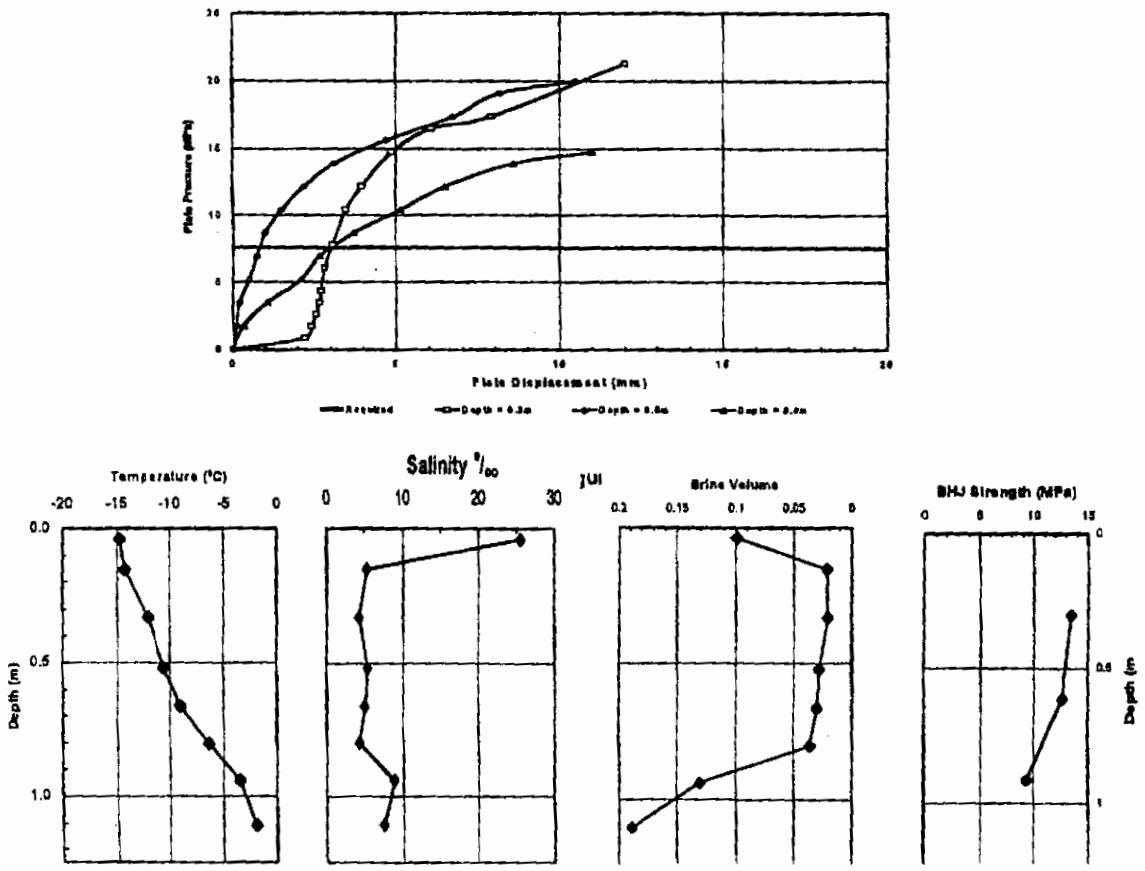


Figure 3 continued
Figure 3C

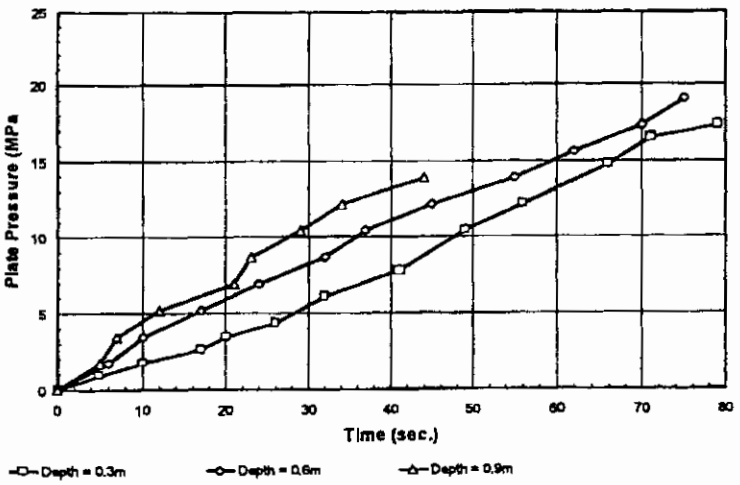
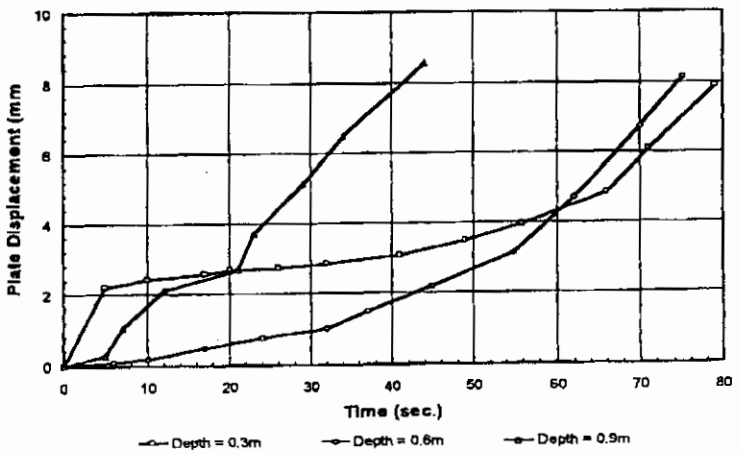
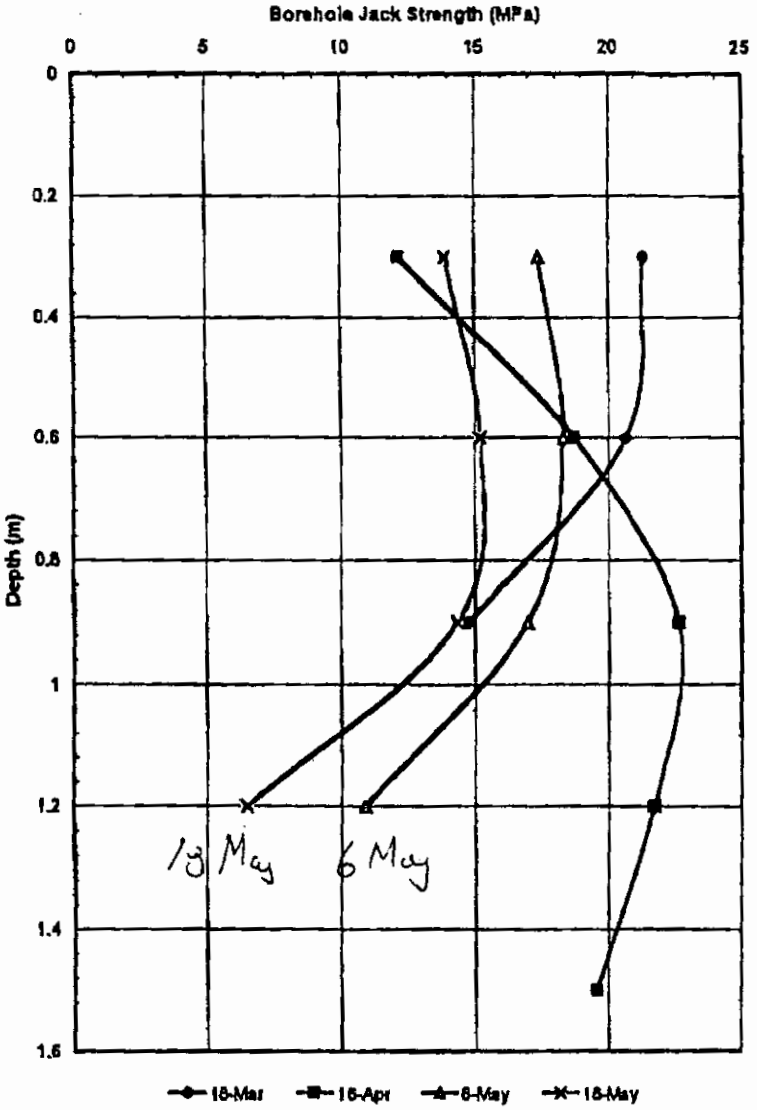


Figure 3D




Borehole Jack Strength (MPa)
0
5
10
15
20
25
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
Depth (m)
13 May
6 May
18-Mar
16-Apr
6-May
18-May

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TESTING THE COMPRESSIVE STRENGTH OF SEA ICE WITH A BOREHOLE JACK

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NOTES

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BOREHOLE JACK, FREEBOARD, ICE THICKNESS, SALINITY, DECAYED ICE

SUMMARY/SOMMAIRE
This report was prepared to aid in measuring and documenting the properties of decayed ice. Outlined is a procedure by which to measure the confined compressive strength of sea ice with a borehole jack. Also included are instructions pertaining to measurements of ice thickness, temperature, salinity, freeboard and snow depth.

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