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USER MANUAL – APEX-SBE PROFILER

APEX-SBE INSTRUMENTS
Serial numbers 2224~2228
Bay of Bengal

Contract India NIOT
WRC Job no 1035
Software Rev 03-21-03
Park depth: 1500 dbar
Profile depth: 2000 dbar

I. ALKALINE BATTERY WARNING

The profiler contains alkaline "D" cells.
There is a small but finite possibility that batteries of alkaline cells will release a combustible gas mixture. This gas release generally is not evident when batteries are exposed to the atmosphere, as the gases are dispersed and diluted to a safe level. When the batteries are confined in a sealed instrument mechanism, the gases can accumulate and an explosion is possible.
Webb Research Corp. has added a catalyst inside of these instruments to recombine Hydrogen and Oxygen into H2O, and the instrument has been designed to relieve excessive internal pressure buildup by having the upper endcap release.
Webb Research Corp. knows of no way to completely eliminate this hazard. The user is warned, and must accept and deal with this risk in order to use this instrument safely as so provided. Personnel with knowledge and training to deal with this risk should seal or operate the instrument. Webb Research Corp. disclaims liability for any consequences of combustion or explosion.

II. Reset and Self Test

Profilers are shipped to the deployment site in Hibernate mode. Shortly before deployment, reset the profiler by passing a magnet over the marked location on the pressure case. The profiler will run a self-test, transmit for 6 hours with the bladder extended, and then begin its pre-programmed mission.

The six ARGOS transmissions during self-test and the transmissions during the initial 6 hour period contain data about the instrument and are outlined in (V) ARGOS DATA, part (C) TEST MESSAGE FORMAT.

Procedure:
1. Secure float in horizontal position, using foam cradles from crate.
IMPORTANT: Remove three plugs from Seabird sensor, if they have not already been removed.

2. Minimum temperature –2 deg C. If necessary, let float warm indoors before proceding.

3. Carefully pry black rubber plug out of bottom center of yellow plastic cowling to verify bladder inflation (per below). **Be sure to replace plug before deployment.**

Note: it can be very difficult to replace plug when air bladder is fully inflated. Replace plug during beginning of air bladder inflation.
Purpose of plug is to prevent silt entry if float contacts sea floor.

4. Hold the provided magnet at RESET position marked on the hull for several seconds.

Note: The internal magnetic reed switch must be activated (held) for at least one second to reset the instrument. (This is to provide a safety against accidental reset during transport.) **Thus, if the float does not respond as below, the instrument was probably not reset.**

5. The air pump will operate for 1 second.
6. The PTT will transmit 6 times at 6 second intervals. Place the ARGOS receiver/beeper close to the antenna to detect transmissions.
7. The piston pump will begin to operate. The piston will move to the retracted Storage Position, if not already there, pause 2 seconds and then move to full extension.
8. The oil bladder will expand, this should take 15 - 25 minutes.
9. After the piston pump stops, the PTT will transmit at the specified ARGOS rate.
10. At every PTT transmission, the air pump will turn on for 6 seconds until the air portion of the bladder has been inflated, the pump should turn on 8 – 10 times.
11. 6 hours after reset, transmissions will cease, the bladder will deflate, and the piston pump will retract, the profiler begins its programmed mission.
12. Reminder - replace black rubber plug in cowling hole before deployment.

During self-test, the controller checks the internal vacuum sensor. If the internal pressure has increased above a preset limit (i.e. hull leakage caused loss of vacuum), the instrument will not pump. **If you do not detect the 6 test transmissions, and if the bladder does not inflate, then the self-test has failed and the instrument should not be deployed!**

III. Deployment

- RESET instrument.
- SELF-TEST starts automatically (see above).
- When piston pump stops, air pump inflates, external bladder is full, PTT will transmit for 6 hours at ARGOS Repetition rate intervals. Normally 90 seconds.
- Six hours after reset, the piston pump will retract and bladder will deflate. Deploy before this time is up or reset the instrument again to re-initialize the 6 hour period. The purpose is to have the instrument on the surface and receive test transmissions.
- Pass a rope through the hole in the damper plate.
- Holding both ends of the rope, carefully lower the float into the water.
- Take care not to damage the antenna.
- Do **not** leave the rope with the instrument, release one end and retrieve the rope.
- The float will remain on the surface until the 6 hour interval has expired.

IV. PARK and PROFILE Feature

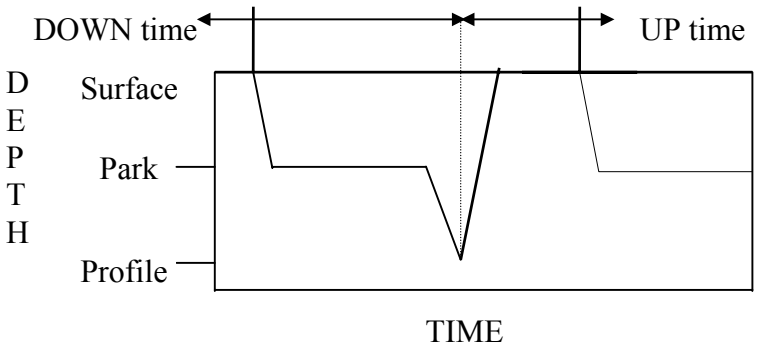
APEX floats with park and profile feature can be set to profile from a maximum depth (profile depth) after a given number of profiles from a shallower depth (park depth).

Terminology:
PARK: intermediate depth at which the float drifts
PROFILE: maximum depth to which the float descends before profiling up.
DOWN time: spent during descent and at park depth.
UP time: includes descent from park to profile depth (~6 hr), ascent, and time at surface.

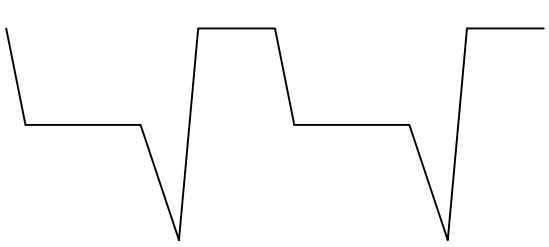
Ascent rate: approximately .08 meters per second.

Integer multiples of "trip interval" **T** are used to define Up time (**U** x **T**) and Down time (**D** x **T**). See section VI, Missions.

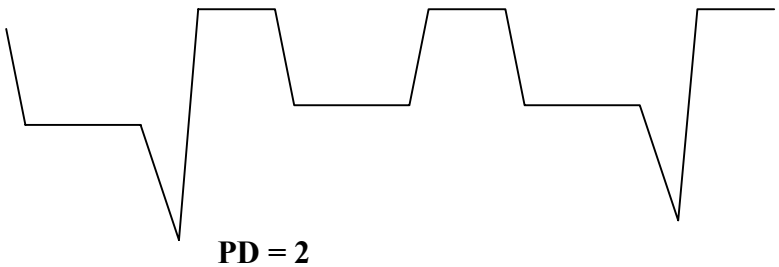
Total Up time is typically set to 12 to 20 hours, increasing proportional to depth and amount of data to be transmitted per profile. Another factor is deployment location: due to the polar orbit of ARGOS, the number of passes per day increases at high latitudes.



Parameter **PD** determines the frequency of deep profiles.
Schematic examples:



PD = 1
deep profile every cycle



PD = 2
deep profile every 2nd cycle

V. ARGOS DATA

A. SERVICE ARGOS PARAMETERS

The user must specify various options to Service ARGOS. These choices depend on how the user wishes to receive and process data. Typical parameters are listed below:

- Standard location.
- Processing: Type A2 (pure binary input; hexadecimal output)
- Results Format: DS (all results from each satellite pass), Uncompressed.
- Distribution Strategy: Scheduled, all results, every 24 hours.
- Number of bytes transmitted: 32 per message

Note: Webb Research strongly recommends all users to use ARGOS "Multi Satellite Service", which provides receptions from 3 satellites instead of 2 for a small incremental cost.

B. DATA FORMAT #4

Data is sent via ARGOS in 32 byte hex messages. The number of 32 byte messages sent depends on the programmed quantity of temperature measurements per profile
Format for message number 1 only:
Byte #

- 01 **CRC**, described in section C.
- 02 **Message number**, Assigned sequentially to each 32 byte message (Total number of messages per profile is shown below). Messages are transmitted in sequential order starting with 1 and incrementing by one for the data set.
- 03 **Message block number**, begins as 1 and increments by one for every ARGOS message data set. This, combined with the ARGOS repetition rate (section VI), allows the user to track surface drift. Byte 03 will roll-over at 256 and will reset to 1 on each new profile.
- 04 & 05 **Serial number**, identifies the controller board number. (This may not be the same as instrument number.)
- 06 **Profile number**, begins with 1 and increases by one for every float ascent.
- 07 **Profile length**, is the number of six byte STD measurements in the profile. Total number of bytes of STD data from each profile depends on the sampling strategy chosen.
- 08 **Profile termination flag byte 2 -**see section D
- 09 **Piston position**, recorded as the instrument reaches the surface.
- 10 **Format Number** (identifier for message one type)
- 11 **Depth Table Number** (identifier for profile sampling depths)
- 12 & 13 **Pump motor time,** in two second intervals. (multiply by 2 for seconds)
- 14 **Battery voltage,** at initial pump extension completion
- 15 **Battery current,** at initial pump extension completion, one count = 13 mA
- 16 **Air pump current,** one count = 13 mA
- 17 **Profile piston position** *(park and profile floats only)*
- 18 **Surface piston position** typically 25 counts more than byte 9 for excess buoyancy
- 19 **Air bladder pressure** measured in counts - approximately 148 counts
- 20 & 21 **Park temperature**, sampled just before instrument descends to target depth.*
- 22 & 23 **Park salinity**, sampled just before instrument descends to target depth.*
- 24 & 25 **Park pressure**, sampled just before instrument descends to target depth.*
- 26 **Park battery voltage**, no load
- 27 **Surface battery voltage,** no load
- 28 & 29 **Surface Pressure,** as recorded just before last descent with an offset of +5 dbar
- 30 **Internal vacuum** measure in counts- approximately 101 counts
- 31 **Park piston position***
- 32 **SBE pump current**

*these points will be bottom values for non park and profile floats sampled just before ascent.

Format for message number 2 and higher:

Byte #

- 01 **CRC**, described in section C.
- 02 **Message number**
- 03 to 32 6 bytes in sequence:
  - 2 bytes **temperature**
  - 2 bytes **salinity**
  - 2 bytes **pressure**

Message Format and Sampling Depths

BTYE #	MSG 1
20 & 21	Tp*
22 & 23	Sp*
24 & 25	Pp*
28 & 29	Ps**

BTYE #	MSG 2	MSG 3	MSG 4	MSG 5	MSG 6	MSG 7	MSG 8
3 & 4	Bottom T	T5	T10	T15	T20	T25	T30
5 & 6	Bottom S	S5	S10	S15	S20	S25	S30
7 & 8	Bottom P	P5	P10	P15	P20	P25	P30
9 & 10	T1	T6	T11	T16	T21	T26	T31
11 & 12	S1	S6	S11	S16	S21	S26	S31
13 & 14	P1	P6	P11	P16	P21	P26	P31
15 & 16	T2	T7	T12	T17	T22	T27	T32
17 & 18	S2	S7	S12	S17	S22	S27	S32
19 & 20	P2	P7	P12	P17	P22	P27	P32
21 & 22	T3	T8	T13	T18	T23	T28	T33
23 & 24	S3	S8	S13	S18	S23	S28	S33
25 & 26	P3	P8	P13	P18	P23	P28	P33
27 & 28	T4	T9	T14	T19	T24	T29	T34
29 & 30	S4	S9	S14	S19	S24	S29	S34
31 & 32	P4	P9	P14	P19	P24	P29	P34

Bytes 3~8 in message **#2** only are **Bottom** T, S & P sampled just before ascent and are not points from the depth table.

BTYE #	MSG 9	MSG 10	MSG 11	MSG 12	MSG 13	MSG 14	MSG 15
3 & 4	T35	T40	T45	T50	T55	T60	T65
5 & 6	S35	S40	S45	S50	S55	S60	S65
7 & 8	P35	P40	P45	P50	P55	P60	P65
9 & 10	T36	T41	T46	T51	T56	T61	T66
11 & 12	S36	S41	S46	S51	S56	S61	S66
13 & 14	P36	P41	P46	P51	P56	P61	P66
15 & 16	T37	T42	T47	T52	T57	T62	T67
17 & 18	S37	S42	S47	S52	S57	S62	S67
19 & 20	P37	P42	P47	P52	P57	P62	P67
21 & 22	T38	T43	T48	T53	T58	T63	T68
23 & 24	S38	S43	S48	S53	S58	S63	S68
25 & 26	P38	P43	P48	P53	P58	P63	P68
27 & 28	T39	T44	T49	T54	T59	T64	T69
29 & 30	S39	S44	S49	S54	S59	S64	S69
31 & 32	P39	P44	P49	P54	P59	P64	P69

BTYE #	MSG 16
3 & 4	T70
5 & 6	S70
7 & 8	P70
9 & 10	T71
11 & 12	S71
13 & 14	P71
15 & 16	**FFFF**
17 & 18	**FFFF**
19 & 20	**FFFF**
21 & 22	**FFFF**
23 & 24	**FFFF**
25 & 26	**FFFF**
27 & 28	**FFFF**
29 & 30	**FFFF**
31 & 32	**FFFF**

* Tp, Sp, and Pp are Park Temperature, Salinity, and Pressure values

** Ps is surface Pressure

*** T, S, and P are Temperature, Salinity, and Pressure values

**** **FFFF**: Invalid data points

Data format chart above assumes that bottom pressure (maximum hydrostatic pressure at start of profile) was reached. Data format will change if bottom pressure varies.

APEX records a profile during ascent (ie upcast). Bottom pressure may change due to several causes, such variation of insitu density, internal waves, float grounding in shallows, change of float mass, etc. APEX automatic depth adjustment will compensate in most, but not all, cases.

The number of sample points taken is proportional to depth, as per sample depth table below. The first (i.e. deepest) sample is taken at the first point in the depth table above bottom pressure.

Depth Table No. 26

Sample Point	Pressure (dbar) Bottom	Sample Point	Pressure (dbar)	Sample Point	Pressure (dbar)
1	2000	27	700	53	180
2	1950	28	650	54	170
3	1900	29	600	55	160
4	1850	30	550	56	150
5	1800	31	500	57	140
6	1750	32	450	58	130
7	1700	33	400	59	120
8	1650	34	380	60	110
9	1600	35	360	61	100
10	1550	36	350	62	90
11	1500	37	340	63	80
12	1450	38	330	64	70
13	1400	39	320	65	60
14	1350	40	310	66	50
15	1300	41	300	67	40
16	1250	42	290	68	30
17	1200	43	280	69	20
18	1150	44	270	70	10
19	1100	45	260	*71	4 or Surf.
20	1050	46	250		
21	1000	47	240		
22	950	48	230		
23	900	49	220		
24	850	50	210		
25	800	51	200		
26	750	52	190		

* The SeaBird CTD is not sampled at zero pressure, to avoid pumping the cell dry and/or ingesting surface oil slicks. The shallowest profile point is taken at either 4 dbar or at the last recorded surface pressure plus 5 dbar, whichever value is larger.

C. TEST MESSAGE FORMAT

The test message is sent whenever an **I2** command is given, the six transmissions during the startup cycle, and during the six hour surface mode period prior to the first dive. Each test message has 32 bytes, in hex unless otherwise noted, with the following format:

Byte #

- 01 **CRC**, described in section C.
- 02 **Message block number**, begins as 1 and increments by one for every ARGOS message.
- 03 & 04 **Serial number**, identifies the controller board number. (This may not be the same as instrument number.)
- 05 & 06 **Time from start up,** in seconds
- 07 **Flag (2) byte**
- 08 & 09 **Current pressure,** in dbar
- 10 **Battery voltage**
- 11 **Current Bladder pressure,** in counts
- 12 **Flag (1) Byte**
- 13 **Up time**, in intervals
- 14 & 15 **Down time**, in intervals
- 16 **Interval time,** in hours
- 17 & 18 **Park pressure,** in dbar*
- 19 **Park piston position**, in counts*
- 20 **Depth correction factor,** in counts
- 21 **Ballast / storage piston position**, in counts
- 22 **Fully extended piston position**, in counts
- 23 **OK vacuum count at launch**, in counts
- 24 **Ascend time**, in intervals
- 25 **Target bladder pressure**, in counts
- 26 & 27 **Profile pressure,** in dbar *(Park and profile floats only)*
- 28 **Profile piston position**, in counts *(Park and profile floats only)*
- 29 **Deep profile cycle counts** *(Park and profile floats only)*
- 30 **Month**, software version number (in decimal).
- 31 **Day**, software version number (in decimal).
- 32 **Year**, software version number (in decimal).

Flag (2) byte:
1 Deep profile
2 Pressure reached zero
3 25 minute Next Pressure timeout
4 piston fully extended before surface
5 Ascend time out
6 Test message at turn on
7 Six hour surface message
8 Seabird string length error

Flag (1) byte:
1 Trip interval time
2 Profile in progress
3 Timer done
4 UP/ DOWN
5 Arithmetic round up
6 Measure battery
7 Piston motor running
8 Negative SBE number

*these points will be bottom values for non park and profile floats sampled just before ascent.

D. FLAG BYTE DESCRIPTION

Two memory bytes are used, one bit at a time, to store 16 different bits of program flow information. Both of these bytes are telemetered in the test messages sent at startup and for the initial 6 hour surface period. Only flag byte 2 is sent in the data messages, as part of message number 1. Bit one is set for each deep profile and bit 8 is set each time the last SBE sensor value used an arithmetic round up.

Below is a list of what each bit in each byte signifies.

	bit	
Flag (2) byte:	1	Deep profile
	2	Pressure reached zero
	3	25 minute NextP timeout
	4	Piston fully extended
	5	Ascend timed out
	6	Test message at turn on
	7	Six hour surface message
	8	Seabird string length error

	bit	
Flag (1) byte:	1	Trip interval time
	2	Profile in progress
	3	Timer done (2 min bladder deflate time.)
	4	UP/DOWN
	5	Arithmetic round up
	6	Measure battery while pumping
	7	Piston motor running
	8	Negative SBE number

The flag bytes are transmitted as two hex characters with four bits of information encoded in each character. Each hex character can have one of 16 different values as shown in the following table.

1	0	0000	10	9	1001
2	1	0001	11	A	1010
3	2	0010	12	B	1011
4	3	0011	13	C	1100
5	4	0100	14	D	1101
6	5	0101	15	E	1110
7	6	0110	16	F	1111
8	7	0111			
9	8	1000			

Bit 8 is the most significant bit and bit 1 is the least significant bit in the byte.

As an example: if a deep profile ended with the piston fully extended and ascend had timed out, then bits 1, 4 and 5 would be set in the termination byte. This binary pattern, 0001 1001, would be transmitted as the two hex characters, 19.

As another example: if a regular profile ended with the piston fully extended and the 25 minute next pressure had timed out, then bits 3 and 4 would be set in the termination byte. This binary pattern, 0000 1100, would be transmitted as the two hex characters, 0C.

E. CRC

Because ARGOS data may contain transmission errors, the first byte of each message contains an error checking value. This value is a Cyclic Redundancy Check (CRC), and is calculated as a function of the message content (bytes 2 to 32).

- For each message, calculate a CRC value
- Compare the calculated CRC to the transmitted CRC (byte no. 1)
- If the calculated and transmitted CRC values are not equal, the message has been corrupted and should be deleted before further data processing.

Below is a sample program (in BASIC) to calculate the CRC value for a message. This program can be provided upon request in Basic, Fortran or C.

```
DECLARE FUNCTION CRC% (IN() AS INTEGER, N AS INTEGER)
'CRC routine to check data validity in ARGOS message.
'Bathy Systems, Inc. RAFOS Float data transmission.
'3 December, 1990.
'The 1st of 32 bytes in an ARGOS message is the CRC.
'The function CRC will compute CRC for byte 2 through 32.
'Hasard is used for Random because Random is reserved by BASIC.
'Stored as file CRC in C:\RAFOS\RAF11.
DECLARE SUB Hasard (ByteN AS INTEGER)
DEFINT A-Z
DIM in(32) AS INTEGER
'RAF11F message number 08 HEX ID 11502 01-02-93   CRC is O.K.
A$ = "8F00081C8E47239148A4D2E9743A1D0E070381C06030984C2693492492C964B2"

        N = 32
        FOR I = 1 to N
                in(I) = VAL("&H" + MID$(A$, 2 + I - 1, 2))
        NEXT I
        PRINT in(1); CRC(in(), N);

FUNCTION CRC% (IN() AS INTEGER, N AS INTEGER) STATIC
DIM ByteN as INTEGER
         I = 2
 ByteN = in(2)
                DO
                        CALL Hasard(ByteN)
                        I = I + 1
                        ByteN = ByteN XOR in(I)
                LOOP UNTIL  I = N
        CALL Hasard (ByteN)
        CRC = ByteN
END FUNCTION

DEFINT A-Z
SUB Hasard (ByteN AS INTEGER) STATIC
x% = 0
        IF ByteN = 0 THEN ByteN = 127: EXIT SUB
        IF (ByteN AND 1) = 1 THEN x% = x% + 1
        IF (ByteN AND 4) = 4 THEN x% = x% + 1
        IF (ByteN AND 8) = 8 THEN x% = x% + 1
        IF (ByteN and 16) = 16 THEN x% = x% + 1
        IF (X% AND 1) = 1 THEN
                ByteN = INT(ByteN / 2) + 128
        ELSE
                ByteN = INT(ByteN / 2)
        END IF
END SUB
```

F. Conversion from hexadecimal to useful units

The pressure is measured every 6 seconds. Temperature, salinity and pressure are measured and stored at each point in the depth table.

Two hex bytes are stored for each sensor. The decimal numbers from the STD sensors are converted to hex for compression in the ARGOS transmission as follows:

Temperature: 5 digits, 1 milli-degree resolution.
Salinity: 5 digits, .001 resolution
Pressure: 5 digits, 10 cm resolution.

To convert the hex ARGOS message back to decimal numbers:

	hex →	dec	=	converted	units
Temperature:	3EA6 →	16038	=	16.038	C
Temperature*:	F58B →	02677	=	-2.677	C
Salinity**:	8FDD →	36829	=	36.829	
Pressure:	1D4C →	7500	=	750.0	decibars
Current	0A→	10	=	130	mA
Volts	99 →	153	=	15.7	volts

Voltage (V) = counts/10 + .4 (counts is in decimal number) nominally 15 V and decreasing.
Current (mA) = counts *13 (counts is in decimal number)
Vacuum (inHg) = counts *-0.209 + 26.23 (counts is in decimal number) nominally 5 inHg.

*Note regarding negative temperatures (T °C < 0)
Positive temperature range is 0 to 62.535C (0 to F447 hex)
Negative temperature range is -0.001 to -3.000C (FFFF to F448 hex).
If (hex value) ≥ F448, then compute FFFF - (hex value) = Y
Convert Y to decimal = dec_Y
(dec_Y + 1) / 1000*-1 = degrees C

**The 5 most significant salinity digits are telemetered. The 6 digit salinity number is rounded up and converted to hex. 36.8286 rounds to 36.829 and converts to 8FDD.

VI. Storage conditions

For optimum battery life, storage temperature range is +10 to +25 degrees C. When activated, the floats should be equilibrated at a temperature between -2 and +54 degrees C.
If optional VOS or aircraft deployment containers are used, these must be kept dry, and should be stored indoors only.

VII. Returning APEX for factory repair or refurbishment

Contact WRC before returning APEX floats for repair or refurbishment.
All returns from outside USA, please specify our import broker:
Logan International Airport, Boston
c/o DHL-Danzas Freight Forwarding Agents,
Phone (617) 886-5605, FAX (617) 241-5917
500 Rutherford Avenue, Charlestown, MA 02129

Note on shipping documents: US MADE GOODS

VIII. MISSIONS

INSTRUMENT #2224

APEX version 03 21 03 sn 2485 004 026
8EBFF ARGOS ID number.
044 seconds repetition rate.
001 hour Trip interval.
104 intervals DOWN.
016 intervals UP.
1500 d-bar park pressure. P1
045 park piston position. P2
012 ascent rate correction. P3
100 storage piston position. P4
251 piston full extension. P5
2000 d-bar profile pressure. P6
025 profile piston position. P7
115 OK vacuum count. P8
009 ascend time intervals. P9
145 air bladder pressure. PB
005 deep profile count. PD
025 Initial piston extension.

INSTRUMENT #2225

APEX version 03 21 03 sn 2486 004 026
8EF76 ARGOS ID number.
046 seconds repetition rate.
001 hour Trip interval.
104 intervals DOWN.
016 intervals UP.
1500 d-bar park pressure. P1
045 park piston position. P2
012 ascent rate correction. P3
100 storage piston position. P4
251 piston full extension. P5
2000 d-bar profile pressure. P6
025 profile piston position. P7
115 OK vacuum count. P8
009 ascend time intervals. P9
145 air bladder pressure. PB
005 deep profile count. PD
025 Initial piston extension.

INSTRUMENT #2226

APEX version 03 21 03 sn 2487 004 026
8EFD0 ARGOS ID number.
044 seconds repetition rate.
001 hour Trip interval.
104 intervals DOWN.
016 intervals UP.
1500 d-bar park pressure. P1
045 park piston position. P2
012 ascent rate correction. P3
100 storage piston position. P4
250 piston full extension. P5
2000 d-bar profile pressure. P6
025 profile piston position. P7
115 OK vacuum count. P8
009 ascend time intervals. P9
145 air bladder pressure. PB
005 deep profile count. PD
025 Initial piston extension.

INSTRUMENT #2227

APEX version 03 21 03 sn 2488 004 026
8F0C9 ARGOS ID number.
046 seconds repetition rate.
001 hour Trip interval.
104 intervals DOWN.
016 intervals UP.
1500 d-bar park pressure. P1
045 park piston position. P2
012 ascent rate correction. P3
100 storage piston position. P4
250 piston full extension. P5
2000 d-bar profile pressure. P6
025 profile piston position. P7
115 OK vacuum count. P8
009 ascend time intervals. P9
145 air bladder pressure. PB
005 deep profile count. PD
025 Initial piston extension.

INSTRUMENT #2228

APEX version 03 21 03 sn 2489 004 026
8F170 ARGOS ID number.
044 seconds repetition rate.
001 hour Trip interval.
104 intervals DOWN.
016 intervals UP.
1500 d-bar park pressure. P1
045 park piston position. P2
012 ascent rate correction. P3
100 storage piston position. P4
254 piston full extension. P5
2000 d-bar profile pressure. P6
025 profile piston position. P7
115 OK vacuum count. P8
009 ascend time intervals. P9
145 air bladder pressure. PB
005 deep profile count. PD
025 Initial piston extension.

IX. RECORDS & CALIBRATIONS