Webb Research Corporation

82 Technology Park Drive, E. Falmouth, MA 02536-4441 (508) 548-2077 FAX (508) 540-1686

USER MANUAL – APEX-SBE PROFILER

APEX-SBE INSTRUMENTS
759, 760 & 763
Built for Region A,B,C

Contract India NIOT
WRC Job no. 757
Manual Rev Date: 8-20-02
Software Rev 09-25-02
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. **<u>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!</u>**

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. 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 #1

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 appendix A
- 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 **not used**
- 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 **Bottom temperature**, sampled just before instrument ascends.
- 22 & 23 **Bottom salinity**, sampled just before instrument ascends.
- 24 & 25 **Bottom pressure**, sampled just before instrument ascends.
- 26 **Bottom 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 **Bottom piston position**
- 32 **SBE pump current**

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	T1	T6	T11	T16	T21	T26	T31
5 & 6	S1	S6	S11	S16	S21	S26	S31
7 & 8	P1	P6	P11	P16	P21	P26	P32
9 & 10	T2	T7	T12	T17	T22	T27	T32
11 & 12	S2	S7	S12	S17	S22	S27	S32
13 & 14	P2	P7	P12	P17	P22	P27	P32
15 & 16	T3	T8	T13	T18	T23	T28	T33
17 & 18	S3	S8	S13	S18	S23	S28	S33
19 & 20	P3	P8	P13	P18	P23	P28	P33
21 & 22	T4	T9	T14	T19	T24	T29	T34
23 & 24	S4	S9	S14	S19	S24	S29	S34
25 & 26	P4	P9	P14	P19	P24	P29	P34
27 & 28	T5	T10	T15	T20	T25	T30	T35
29 & 30	S5	S10	S15	S20	S25	S30	S35
31 & 32	P5	P10	P15	P20	P25	P30	P35

BTYE #	MSG 9	MSG 10	MSG 11
3 & 4	T36	T41	T46
5 & 6	S36	S41	S46
7 & 8	P36	P41	P46
9 & 10	T37	T42	T47
11 & 12	S37	S42	S47
13 & 14	P37	P42	P47
15 & 16	T38	T43	T48
17 & 18	S38	S43	S48
19 & 20	P38	P43	P48
21 & 22	T39	T44	T49
23 & 24	S39	S44	S49
25 & 26	P39	P44	P49
27 & 28	T40	T45	T50
29 & 30	S40	S45	S50
31 & 32	P40	P45	P50

* Tp, Sp, and Pp are bottom 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. Profile length, and number of ARGOS messages, may 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.

Indicators of float grounding:

- Bottom pressure (bytes 24 & 25 of message 01) is reduced
- Profile length (byte 07 of message 01) is reduced. This may result in fewer ARGOS messages.
- Bottom piston position decreases to 12 (typical value is 20-30)

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. 47

Sample Point	Pressure (dbar) Bottom	Sample Point	Pressure (dbar)
1	2000	27	140
2	1900	28	130
3	1800	29	120
4	1700	30	110
5	1600	31	100
6	1500	32	90
7	1400	33	80
8	1300	34	70
9	1200	35	60
10	1100	36	50
11	1000	37	45
12	900	38	40
13	800	39	35
14	700	40	30
15	600	41	25
16	500	42	20
17	450	43	15
18	400	44	10
19	350	45	5
20	300		
21	250		
22	230		
23	210		
24	190		
25	170		
26	150		

* 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**
- 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 **not used**
- 28 **not used**
- 29 **not used**
- 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. *Telemetry error-checking (CRC)*

Because ARGOS data contains 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.

Appendix (B) lists 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

E. *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 <u>negative</u> 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.

V. MISSIONS

This section lists the parameters for each float covered by this manual.
The parameter listing appears when the float is RESET while connected to a terminal.

INSTRUMENT # 759

APEX version 09 25 02 sn 1080 001 047
D1BB2 ARGOS ID number.
090 seconds repetition rate.
001 hour Trip interval.
221 intervals DOWN.
019 intervals UP.
2000 d-bar park pressure.   P1
030 park piston position.   P2
012 ascent rate correction. P3
100 storage piston position. P4
253 piston full extension.   P5
115 OK vacuum count.   P8
011 ascend time intervals.   P9
146 air bladder pressure.   PB
025 Initial piston extension..

INSTRUMENT # 760

APEX version 09 25 02 sn 1081 001 047
D4958 ARGOS ID number.
090 seconds repetition rate.
001 hour Trip interval.
221 intervals DOWN.
019 intervals UP.
2000 d-bar park pressure.   P1
030 park piston position.   P2
012 ascent rate correction. P3
100 storage piston position. P4
248 piston full extension.   P5
116 OK vacuum count.   P8
011 ascend time intervals.   P9
147 air bladder pressure.   PB
025 Initial piston extension.

INSTRUMENT # 763

APEX version 09 25 02 sn 1082 001 047
D49AD ARGOS ID number.
090 seconds repetition rate.
001 hour Trip interval.
221 intervals DOWN.
019 intervals UP.
2000 d-bar park pressure.   P1
030 park piston position.   P2
012 ascent rate correction. P3
100 storage piston position. P4
249 piston full extension.   P5
115 OK vacuum count.   P8
011 ascend time intervals.   P9
146 air bladder pressure.   PB
025 Initial piston extension.

Appendix A: 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.

Appendix B: CRC Algorithm in BASIC

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
```

Appendix C: Surface arrival time, and total surface time

Some users may wish to determine surface arrival time, and total surface time, in order to calculate drift vectors.

Although each 32-byte message is time-stamped by ARGOS, there may not be a satellite in view when the float surfaces.

When the float surfaces (ie detects surface pressure recorded before last descent) it will begin ARGOS telemetry. Messages are transmitted in numerical order, starting with message no. 1.

When all messages have been transmitted, the cycle starts again at message no. 1.

<u>Elapsed time since surfacing (Te)</u>

Te = (m-1)*n*r

Where: m = message block number (byte 03 of message 01)
n = total number of messages to transmit profile
r = repetition rate

Total number of messages (n) is described in section IV (b), or may be determined from the ARGOS data. Note (n) may be less than specified in user manual if the float is operating in shallow water, causing reduced profile length.

Repetition rate (r) is the time interval between ARGOS transmissions. This value can be determined from section V, or from the ARGOS data.

<u>Approximate time of surfacing</u>

Approximate time of surfacing can be determined by subtracting Te from the ARGOS time stamp

<u>Example</u>

Below is message 01 in DS format

2001-11-02 22:47:54 1 CF 01 05 02
AF 02 2F 00
85 01 01 01
16 92 17 19
FF 9E 94 01
AD 85 09 1F
48 97 9B 00
46 62 24 0E

m = message block number (byte 03) = 5
n = total number of messages to transmit profile = 11
r = repetition rate = 62 seconds

Te = elapsed time since surfacing = (m-1)*n*r = (5-1)*11*62 s = 2728 s = 00h 45m 28s

Approximate time of arrival at surface:
ARGOS time stamp - Te = 22:47:54 - 00:45:28 = 22:02:26

<u>Total time spent at surface transmitting (Tsurf):</u>

This is determined by subtracting ascent time from UP time.
Tsurf = (UP time, hr) - (bottom pressure)/(ascent rate 0.08 dbar/s)/3600

Bottom pressure is telemetered as bytes 24 & 25 of message 01.

<u>Example</u>:

For bottom pressure of 2000 dbar, and UP time of 18 hours
Tsurf = (18 hr) - (2000/0.08/3600) = 11 hr

APPENDIX D: CTD Calibration and Ballasting records