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USER MANUAL – APEX RAFOS-SBE PROFILER

APEX-SBE INSTRUMENTS
Serial numbers #'s 1733~1735
With RAFOS and Optode

Manual Rev: 06-06-05
WRC Job no. 1009 AWI
Software Rev 09-09-04
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. System Description – Subsurface Acoustic Tracking

For this application, a RAFOS acoustic receiver was integrated to the APEX CTD profiler, to enable subsurface acoustic tracking. The acoustic receiver is made by SeaScan, and was integrated to the APEX controller by Bathy Systems. A Benthos AQ-16 hydrophone, mounted to the upper end cap, is connected to the receiver.

The standard APEX profiler carries a SeaBird model 41 CTD sensor, which samples salinity, temperature, and pressure during up cast. Samples are taken at predetermined pressure values (ie the depth table, see section V, part B).

One acoustic reception windows 90 minutes long is opened each day. The acoustic receiver is active only during these windows, which must be synchronized with the acoustic source transmissions. For each acoustic reception window, six correlation height (one byte) and a corresponding six travel times (2 bytes) are recorded.

Note the acoustic window time is programmed in firmware and cannot be changed via an external terminal.

Correlation height range is 0 – 255 decimal. .

Travel time: elapsed time between start of 90 minute window and end of 80s acoustic signal. For example, if start of 80s acoustic signal coincides with start of 90 minute window, value returned is 80s. Each count = 0.3075 seconds

A. TIMING and CLOCK SETTING/CHECKING

All time values are entered in GMT.
Note the APEX clock is momentarily interrupted (stopped) when the RESET magnet is used to activate the float.
Note: Apex Rafos clock time is transmitted in message 1 in bytes 18 & 19. Clock error can be determined by comparing to Argos time stamp.
To Check Apex Clock time, while connected to a terminal enter upper case T
To Set Apex Clock time enter lower case t followed by hh mm ss (spaces necessary), time is set on carriage return.
<u>Screen shot of Time check and set:</u>

```
    T 16:17:22
    +
    t Set clock as hh mm ss.  Esc to exit.
    16 17 46
    16 17 46
+
```

B. Acoustic Receiver Test

When deployed the acoustic receiver has one 90 minute listen period per day begun at 00:25 followed by a CTD sample. With a terminal connected to the float the listen period can be tested. The Rafos Acoustic Receiver can be tested by Issuing command Ir (case sensitive). A 10 minute “listen” period will be opened. 11 (or more) minutes after Ir command is issued the command Ic should be issued and the results will be displayed on the screen. The Apex will then list in hex the three best correlation heights and corresponding times. Each count equals .3075 seconds.
<u>Screen shot</u>
I c D5 13A8 8E 1B4A 81 22E7

In example above the first correlation height of D5 is a decimal value of 213 and 13A8 (hex) is a time of 1547.3 seconds. The second height and time are 8E and 1B4A and third is 81 and 22E7

C. Ice detection feature

1) The median of 7 near-surface temperature points (50, 45, 40, 35, 30, 25, 20 db) is calculated. If the median is less than -1.79 C, there is a high probability of ice, so ascent is aborted, and the profile data are discarded. The next profile will occur on the same schedule, and the profile number (byte 06 of message one) will increment for each ascent, regardless of whether or not the abort occurs. If a profile has been aborted due to ice detection byte 18 of message one will increment by one for each occurrence.
2) If ASCEND TIME (P9) expires before pressure has reached the surface pressure, and current T < -1.79 C (one sample) then abort. If T $\geq$ -1.79 C, the float will go to maximum buoyancy condition and attempt to surface.

Ascend time is typically set to 150-200% of expected time required for ascent at 0.08 m/s.
A standard float goes to maximum buoyancy when ascend time expires. This feature is intended to ensure that the float reaches the surface in locations with unusual near-surface stratification.

III. Optional Aanderaa Oxygen Sensor

In addition to SeaBird model 41 CTD sensor, these APEX carry the (optional) Aanderaa Oxygen Optode 3830. All sensors are mounted to the upper end-cap. The oxygen sensor communicates with the APEX controller via RS-232C interface, and provides absolute oxygen content in micro molar (μM), as well as temperature. Relative air saturation (%) is not returned.

Note: both the CTD and optode provide temperature data.

Terminology: in this manual, temperature from the SeaBird (SBE) CTD is designated SBE temperature, while temperature from the optode is T_{optode}.
Oxygen content is designated O_2conc.

O_2conc and T_{optode} are sampled:

- After each 90 minute listen window
- during upcast profile whenever CTD is sampled per depth table

NOTE re handling: do not lift or pull on the oxygen optode or RAFOS hydrophone.

IV. 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 *5 to 6 hours with the bladder extended, and then begin its pre-programmed mission.

Note Rafos Apex Floats will descend at the beginning of the 6th hour after reset. Ie if float is reset at 00 30 00 float will descend at 05 00 00

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 plastic bag and three plugs from CTD 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 provided magnet at RESET position marked on for several seconds, then remove magnet.

Note: Magnetic 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 ARGOS receiver/beeper close to 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, PTT will transmit at 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>**

V. 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

VI. 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 #29*

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 10 byte STD and Aanderaa 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 **Profile Piston position**
- 17 **Air bladder pressure** measured in counts - approximately 148 counts
- 18 & 19 **Time** one count = +2 seconds from 00:00:00
- 20 **Ice detect** aborted profile count: Increments by one every time a profile aborted due to ice detection

APF-8R RAFOS listen schedule and data storage format
Listening schedule: 90 minute listen period at 00:25

For each listen period the following data are recorded and transmitted

1 byte largest correlation height
2 bytes largest travel time one count = .3075 seconds
1 byte second largest correlation height
2 bytes second largest travel time one count = .3075 seconds
1 byte third largest correlation height
2 bytes third largest travel time one count = .3075 seconds
1 byte fourth largest correlation height

2 bytes fourth largest travel time one count = .3075 seconds
1 byte fifth largest correlation height
2 byte fifth largest byte travel time one count = .3075 seconds
1 byte sixth largest correlation height
2 byte sixth largest travel time one count = .3075 seconds

2 bytes each: Temperature, Salinity, Pressure O_2conc and T_{optode} recorded at end of 90 minute window each day**.**

RAFOS data end:

two bytes "**DD**" Marker for end of Rafos data

- two bytes **park temperature**, sampled just before instrument ascends.
- two bytes **park salinity**, sampled just before instrument ascends.
- two bytes **park pressure**, sampled just before instrument ascends.
- two bytes **O_2conc** sampled just before instrument ascends.
- two bytes **T_{optode}** sampled just before instrument ascends.
- one byte **park battery voltage**, no load
- one byte **battery current**
- two bytes **Surface Pressure** as recorded just before last descent with an offset of +5 dbar
- one byte **Internal vacuum** measure in counts- approximately 101 counts
- one byte **park piston position**
- one byte **SBE pump voltage**
- one byte **SBE pump current**
-

Depth Table Sampling begins

- two bytes **Bottom temperature**
- two bytes **Bottom salinity**
- two bytes **Bottom pressure .**
- two bytes **O_2conc**
- two bytes **T_{optode}**

T, S, P, O_2conc., T_{optode} Sampling Continues Per Depth Table

Format for message number 2 and higher:
Byte #

- 01 **CRC**, described in section C.
- 02 **Message number**
- 03-32 T,S,P samples continue per above.

FFFF: Invalid data points to fill last 32-byte ARGOS message (end of Depth Table Sampling)

Note: Should the first byte of a two-byte value fall in byte 32, the remaining byte will be byte # 3 in the next message.

Profile length, and number of ARGOS messages, may change if bottom pressure varies. APEX records a profile during ascent (ie up cast). 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 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 38

Sample point	Pressure dbar	Sample point	Pressure dbar	Sample point	Pressure dbar	Sample point	Pressure dbar
1	2000	21	440	41	200	61	50
2	1900	22	420	42	190	62	45
3	1800	23	400	43	180	63	40
4	1700	24	380	44	170	64	35
5	1600	25	360	45	160	65	30
6	1500	26	350	46	150	66	25
7	1400	27	340	47	140	67	20
8	1300	28	330	48	130	68	15
9	1200	29	320	49	120	69	10
10	1100	30	310	50	110	70	7
11	1000	31	300	51	100	71	4 or surf
12	900	32	290	52	95		
13	800	33	280	53	90		
14	700	34	270	54	85		
15	650	35	260	55	80		
16	600	36	250	56	75		
17	550	37	240	57	70		
18	500	38	230	58	65		
19	480	39	220	59	60		
20	460	40	210	60	55		

* 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** one count = +2 seconds from 00:00:00
- 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 **Rafos Receiver Serial #** (last two digits)
- 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	Flag (1) byte:	1 Trip interval time
	2 Pressure reached zero		2 Profile in progress
	3 25 minute Next Pressure timeout		3 Timer done
	4 piston fully extended before surface		4 UP/ DOWN
	5 Ascend time out		5 Arithmetic round up
	6 Test message at turn on		6 Measure battery
	7 Six hour surface message		7 Piston motor running
	8 Aanderaa of Sbe string length error		8 Negative SBE number

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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
O_2conc	612f→	24879	=	248.79	absolute O_2 conc (µM)
T_{optode}	929→	2345	=	23.45	C

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

T_{optode} <u>negative</u> temperatures -.00 (FFFF) -.01 (FFFE) -.02 (FFFD)

**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.

VII. 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 # 1733

APEX version 09 09 04 sn 1998 029 038
7A185 ARGOS ID number.
044 seconds repetition rate.
221 hours DOWN.
019 hours UP.
0800 d-bar park pressure. P1
095 park piston position. P2
012 ascent rate correction. P3
100 storage piston position. P4
249 piston full extension. P5
2000 d-bar profile pressure. P6
025 profile piston position. P7
115 OK vacuum count. P8
009 hours ascend time. P9
145 air bladder pressure. PB
001 deep profile count. PD
025 Initial piston extension.
12:45:54

INSTRUMENT # 1734

APEX version 09 09 04 sn 2011 029 038
7A413 ARGOS ID number.
044 seconds repetition rate.
221 hours DOWN.
019 hours UP.
0800 d-bar park pressure. P1
095 park piston position. P2
012 ascent rate correction. P3
100 storage piston position. P4
249 piston full extension. P5
2000 d-bar profile pressure. P6
025 profile piston position. P7
115 OK vacuum count. P8
009 hours ascend time. P9
145 air bladder pressure. PB
001 deep profile count. PD
025 Initial piston extension.
12:48:28

INSTRUMENT #1735

APEX version 09 09 04 sn 2136 029 038
7A794 ARGOS ID number.
044 seconds repetition rate.
221 hours DOWN.
019 hours UP.
0800 d-bar park pressure. P1
095 park piston position. P2
012 ascent rate correction. P3
100 storage piston position. P4
248 piston full extension. P5
2000 d-bar profile pressure. P6
025 profile piston position. P7
115 OK vacuum count. P8
009 hours ascend time. P9
145 air bladder pressure. PB
001 deep profile count. PD
025 Initial piston extension.
13:00:58

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.

Elapsed time since surfacing (Te)

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.

Approximate time of surfacing

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

Example

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

Total time spent at surface transmitting (Tsurf):

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.

Example:

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

APPENDIX E: CTD Calibration and Ballasting records