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USER MANUAL – APEX-SBE PROFILER

APEX-SBE INSTRUMENTS
Serial # 3591~3560

WRC Job no. 1376 INCOIS
Park and Profile with 28-bit ID and
SBE IDO Oxygen
Manual rev 10-09-07
Software Rev 09-11-07

I. ALKALINE BATTERY WARNING

The profiler contains batteries comprised of alkaline manganese dioxide “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 H_2O, and the instrument has been designed to relieve excessive internal pressure buildup by having the upper end cap 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. Maximum Operating Pressure

The APEX design is rated for 2000db (2900 psi) maximum operating pressure. However, for shallower applications, thinner pressure cylinders are often used. The thinner cylinders have a reduced pressure rating, and less mass, allowing installation of more batteries. There are three cylinder pressure ratings: 2000, 1500 and 1200 db.

For example, if an APEX is specified for 1400 db maximum (profile) depth, then the 1500 db cylinder would be used.

CAUTION for users who:
- expose APEX to hydrostatic pressure during ballasting or testing

  OR
- intend to re-ballast and re-program floats for a depth greater than original specification

Please contact Webb Research to confirm the pressure rating of specific floats.
Do not exceed rated pressure, or the float may collapse.

III. 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 plastic bag and three plugs from CTD sensor, if they have not already been removed.

2. The minimum internal temperature of the float is -2.0 °C. If necessary, let float warm indoors before proceding.

3. Carefully remove black rubber plug from bottom center of yellow cowing to verify bladder inflation (per below). **Use fingers only- tools may puncture bladder. Be sure to replace plug before deployment.**

4. 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).

5. 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.**

6. The air pump will operate for 1 second.

7. The PTT will transmit 6 times at 6 second intervals. Place ARGOS receiver/beeper close to antenna to detect transmissions.

8. The piston pump will begin to operate. The piston will move to full extension.

9. The oil bladder will expand, this should take 15 - 25 minutes.

10. After the piston pump stops, PTT will transmit at specified ARGOS rate. (If repetition rate is <u>120</u> seconds, the controller is not communicating properly with CTD and float should <u>not</u> be deployed).

11. 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.

12. 6 hours after reset, transmissions will cease, the bladder will deflate, and the piston pump will retract, the profiler begins its programmed mission.

13. 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 6 test transmissions during step six, and/or if bladder does not inflate, then the self-test has failed and the instrument should not be deployed.</u>**

IV. 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 interval. Typical repetition rate is 90 seconds or less. (Programmed repetition rate can be found in the Missions section of this manual).

- If the repetition rate is 120 seconds the controller is not communicating properly with the CTD and the float should not be deployed.

- Six hours after reset, the piston pump will retract and bladder will deflate.
  Important: deploy within 6 hours of reset, or reset again to re-initialize 6 hour period. (Purpose is to have instrument on surface to receive test transmissions, and to ensure proper buoyancy control)

- Pass a rope through the hole in the damper plate.

- Holding both ends of rope bight, carefully lower float into water. Do not let rope slide through hole in disk- this may cut the plastic disk.

- Take care not to damage antenna.

- **Do not leave the rope with the instrument**, release one end and retrieve the rope.

- The float will remain on surface until 6 hour interval has expired.

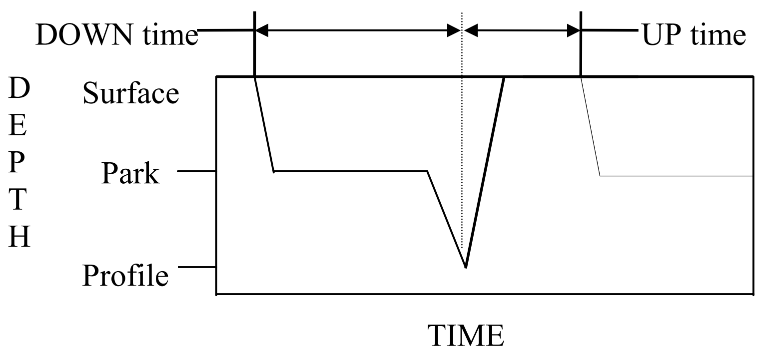
V. PARK and PROFILE Feature

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).

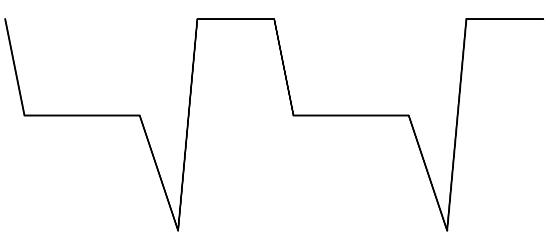
Terminology:
PARK: intermediate depth at which the float drifts
PROFILE: maximum depth to which the float descends before profiling up.
DOWN time: spent during descent and at park depth.
UP time: includes ascent and time at surface.

Ascent rate: approximately .08 meters per second.

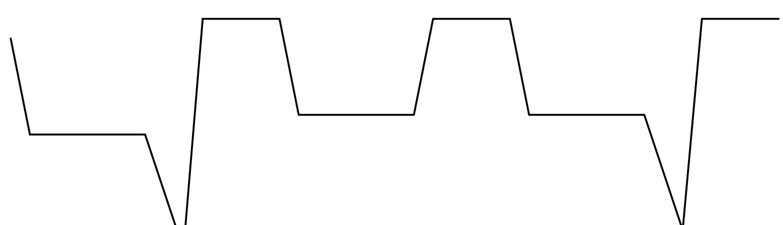
Total Up time is typically set to 12 to 20 hours, increasing proportional to depth and amount of data to be transmitted per profile. Another factor is deployment location: due to the polar orbit of ARGOS, the number of passes per day increases at high latitudes.



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



PD = 1
deep profile every cycle



PD = 2
deep profile every 2nd cycle

VI. Optional Sensors

Optional sensors are sampled at the same time as the SeaBird CTD, at pressure values listed in the depth table.

A. SeaBird IDO Integrated Dissolved Oxygen

SeaBird's IDO Integrated Dissolved Oxygen (IDO) sensor is integrated to the CTD on the upper end cap of the float. See section VI, part C, for conversion of telemetered data to useful units.

Below is an example of out put from the SeaBird IDO oxygen sensor.

S S 15.8 V 004	command **SS**
-0.05, 19.9108, 0.0099, 17617	decimal pressure (db), T (deg C), S, Oxygen (Hz)
0000 4DC7 000A 44D1	hexadecimal

VII. 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: 31 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.

* Using Argos 28-bit ID Format, 31 data bytes are transmitted in each message. With 20-bit ID Format, each message had 32 data bytes. (see Appendix D for more information).

B. *DATA FORMAT no. 38, for 28-bit ID format with SBE Dissolved Oxygen*

Data are sent via ARGOS in 31 byte hex messages. The number of 31 byte messages sent depends on the programmed quantity of temperature measurements per profile. See appendix D

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 eight byte STDO measurements in the profile. Total number of bytes of STDO 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 **Profile piston position** *(park and profile floats only)*
- 17 **Air bladder pressure** measured in counts - approximately 148 counts
- 18 & 19 **Park temperature**, sampled just before instrument descends to target depth.
- 20 & 21 **Park salinity**, sampled just before instrument descends to target depth.
- 22 & 23 **Park pressure**, sampled just before instrument descends to target depth.
- 24 & 25 **Park Dissolved Oxygen**, sampled just before instrument descends to target depth.
- 26 **Park battery voltage**, no load
- 27 **Park battery current**
- 28 & 29 **Surface Pressure,** as recorded just before last descent with an offset of +5 dbar**
- 30 **Internal vacuum** measured in counts- approximately 101 counts
- 31 **Park piston position**

Format for message number 2:

Byte #

- 01**CRC**, described in section C.
- 02 **Message number**
- 03 **SBE pump Voltage**
- 04 **SBE pump current**
- 05 to 31 10 bytes- **in sequence and continuing into following messages****
-

  2 bytes **temperature**
  2 bytes **salinity**
  2 bytes **pressure**
  2 bytes **Dissolved Oxygen**

**Note byte pairs will split between messages. For instance byte 31 of message #2 will contain half of the byte pair. The other half byte pair will appear in byte 3 of message #3.

Sampling continues as shown above relevant to the number of depth table points sampled. After the last data point in last message a Hex value of FFFF will fill remaining bytes.

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.

Format for message number 3 and higher

Byte #

- 01 **CRC**, described in section C.
- 02 **Message number**
- 3-31 In 8 byte per depth table measure sequence describe above.

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. 12

1	555	31	255
2	545	32	245
3	535	33	235
4	525	34	225
5	515	35	215
6	505	36	205
7	495	37	195
8	485	38	185
9	475	39	175
10	465	40	165
11	455	41	155
12	445	42	145
13	435	43	135
14	425	44	125
15	415	45	115
16	405	46	105
17	395	47	95
18	385	48	85
19	375	49	75
20	365	50	65
21	355	51	55
22	345	52	45
23	335	53	35
24	325	54	25
25	315	55	20
26	305	56	15
27	295	57	10
28	285	58	4 or Surface.
29	275		
30	265		

* 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. Conversion of SeaBird IDO oxygen data

Note: this description applies to SeaBird model **IDO** oxygen sensor (not earlier model **43**)

Unlike P, T and S values that are fully converted, with calibration coefficients, to scientific units before being output by the CTD, the oxygen data are telemetered as integer frequency values with a resolution of 1 Hz. Typical values will range from 3 kHz (approx zero-oxygen) to 24 kHz (approx saturation). If the oxygen value is 0 Hz the sensor is not working (unpowered or signal disconnected).

The Oxygen Calibration equation is:
Oxygen (ml.l) =

Soc * (F + Foffset) * (1.0 + A * T + B * T^2 + C * T^3) * OxSol(T, S) * exp(E * P / K)

where:

- F = oxygen sensor output frequency in Hz
- T = CTD temperature in degrees Centigrade
- S = CTD salinity in PSU
- P = CTD pressure in decibars
- K = temperature in degrees Kelvin
- Soc, Foffset, A, B, C, and E are calibration coefficients

Exp() is the natural exponential function,
Check value: exp(0.1) = 1.10517

SxSol is oxygen solubility in seawater in ml/l per:

Garcia and Gordon (1992) "Oxygen solubility in seawater: Better fitting equations", Limnology & Oceanography, vol 37(6), p1307-1312.

Example calculation:

A) conversion of hexadecimal telemetry to useful units:

	Hex →	decimal	=	converted	units
Temperature	3E80	16000	=	16.000	deg C
Salinity	88B8	35000	=	35.000	PSU
Pressure	1D4C	7500	=	750	decibars
DO Frequency:	2710	10000	=	10000	Hz

B) Sample calibration coefficients (from sensor no. 0167):

Soc = 5.5239e-5
Foffset = -3038.9578
A = 1.0069e-3
B = 4.1562e-5
C = -7.6834e-7
E = 0.036

C) Determination of OxSol(T, S)
OxSol(T, S) = OxSol(16.0, 35.0) = 5.581

D) Calculation of oxygen concentration:

Oxygen (ml/l) =

Soc * (F + Foffset) * (1.0 + A * T + B * T^2 + C * T^3) * OxSol(T, S) * exp(E * P / K)

= 5.5239e-5 *(10000 - 3038.9578) * (1.0 + (1.0069e-3 * 16.0) + (4.1562e-5 * 256.0) + (-7.6834e-7
* 4096.0)) * 5.581 * exp(0.036 * 750.0 /289.15)
= 5.5239e-5 * 6961.042 * (1.0 + 0.0161 + 0.0106 – 0.0031) * 5.581 * 1.0979

= 2.412 ml/l

C language implementation of OxSol():

```
double OxSol(double t90,double s)
{
double Ts,Ts2,Ts3,Sol;

/* from Garcia and Gordon: L&O 37(6), 1992, 1307 - 1312
 Provides better fit and better estimation of O2 solubility at end
members
test data: 10 deg C, 35.000 PSU = 6.315 ml/l
*/

      Ts = log((298.15 - t90) / (273.15 + t90));
      Ts2 = Ts * Ts;
      Ts3 = Ts2 * Ts;

      #define OA0  2.00907
      #define OA1  3.22014
      #define OA2  4.0501
      #define OA3  4.94457
      #define OA4 -0.256847
      #define OA5  3.88767
      #define OB0 -0.00624523
      #define OB1 -0.00737614
      #define OB2 -0.010341
      #define OB3 -0.00817083
      #define OC0 -0.000000488682
```

```
      Sol = OA0 + OA1 * Ts + OA2 * Ts2 + OA3 * Ts3 + OA4 * Ts2 * Ts2 +
OA5 * Ts2 * Ts3;

      Sol = Sol + s * (OB0 + OB1 * Ts + OB2 * Ts2 + OB3 * Ts3);

      Sol = Sol + OC0 * s * s;

      return(exp(Sol));

}
```

D. 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 31 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 two second intervals (Hex)
- 07 **Flag (2) byte**
- 08 & 09 **Current pressure,** in bar
- 10 **Battery voltage**
- 11 **Current Bladder pressure,** in counts
- 12 **Flag (1) Byte**
- 13 **Up time**, in hours
- 14 & 15 **Down time**, in hours
- 16 & 17 **Park pressure,** in bar
- 18 **Park piston position**, in counts
- 19 **Depth correction factor,** in counts
- 20 **Storage piston position**, in counts
- 21 **Fully extended piston position**, in counts
- 22 & 23 **Profile pressure,** in bar
- 24 **Profile piston position**, in counts
- 25 **OK vacuum count at launch**, in counts
- 26 **Ascend time**, in intervals
- 27 **Target bladder pressure**, in counts
- 28 **Deep profile cycle counts**
- 29 **Month**, software version number (in decimal).
- 30 **Day**, software version number (in decimal).
- 31 **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 Data entry error
6 Measure battery
7 Piston motor running
8 Negative SBE number

E. 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. 2)
- 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

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.

VIII. Mission Parameters

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 #3591

APEX version 09 11 07 sn 3623 038 012
285D2BE ARGOS ID number
038 seconds rep rate
108 hours DOWN
012 hours UP
0500 d-bar park pressure P1
030 park piston position P2
012 ascent rate correction P3
100 storage piston position P4
251 piston full extension P5
0500 d-bar profile pressure P6
022 profile piston position P7
115 OK vacuum count P8
004 ascend time intervals P9
152 air bladder pressure PB
255 deep profile count PD
002 oxygen pump sequence PS
025 Initial piston extension

INSTRUMENT #3592

APEX version 09 11 07 sn 3624 038 012
285D2C7 ARGOS ID number
038 seconds rep rate
108 hours DOWN
012 hours UP
0500 d-bar park pressure P1
030 park piston position P2
012 ascent rate correction P3
100 storage piston position P4
251 piston full extension P5
0500 d-bar profile pressure P6
022 profile piston position P7
115 OK vacuum count P8
004 ascend time intervals P9
152 air bladder pressure PB
255 deep profile count PD
002 oxygen pump sequence PS
025 Initial piston extension

INSTRUMENT #3593

APEX version 09 11 07 sn 3625 038 012
285D2D4 ARGOS ID number
038 seconds rep rate
108 hours DOWN
012 hours UP
0500 d-bar park pressure P1
030 park piston position P2
012 ascent rate correction P3
100 storage piston position P4
254 piston full extension P5
0500 d-bar profile pressure P6
022 profile piston position P7
115 OK vacuum count P8
004 ascend time intervals P9
152 air bladder pressure PB
255 deep profile count PD
002 oxygen pump sequence PS
025 Initial piston extension

INSTRUMENT #3594

APEX version 09 11 07 sn 3626 038 012
285D2E1 ARGOS ID number
038 seconds rep rate
108 hours DOWN
012 hours UP
0500 d-bar park pressure P1
030 park piston position P2
012 ascent rate correction P3
100 storage piston position P4
254 piston full extension P5
0500 d-bar profile pressure P6
022 profile piston position P7
115 OK vacuum count P8
004 ascend time intervals P9
152 air bladder pressure PB
255 deep profile count PD
002 oxygen pump sequence PS
025 Initial piston extension

INSTRUMENT #3595

APEX version 09 11 07 sn 3627 038 012
285D2F2 ARGOS ID number
038 seconds rep rate
108 hours DOWN
012 hours UP
0500 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
0500 d-bar profile pressure P6
022 profile piston position P7
115 OK vacuum count P8
004 ascend time intervals P9
152 air bladder pressure PB
255 deep profile count PD
002 oxygen pump sequence PS
025 Initial piston extension

INSTRUMENT #3596

APEX version 09 11 07 sn 3628 038 012
286F300 ARGOS ID number
038 seconds rep rate
108 hours DOWN
012 hours UP
0500 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
0500 d-bar profile pressure P6
022 profile piston position P7
115 OK vacuum count P8
004 ascend time intervals P9
152 air bladder pressure PB
255 deep profile count PD
002 oxygen pump sequence PS
025 Initial piston extension

INSTRUMENT #3597
APEX version 09 11 07 sn 3629 038 012
286F313 ARGOS ID number
038 seconds rep rate
108 hours DOWN
012 hours UP
0500 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
0500 d-bar profile pressure P6
022 profile piston position P7
115 OK vacuum count   P8
004 ascend time intervals   P9
152 air bladder pressure   PB
255 deep profile count   PD
002 oxygen pump sequence   PS
025 Initial piston extension

INSTRUMENT #3598
APEX version 09 11 07 sn 3630 038 012
286F326 ARGOS ID number
038 seconds rep rate
108 hours DOWN
012 hours UP
0500 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
0500 d-bar profile pressure P6
022 profile piston position P7
115 OK vacuum count   P8
004 ascend time intervals   P9
152 air bladder pressure   PB
255 deep profile count   PD
002 oxygen pump sequence   PS
025 Initial piston extension

INSTRUMENT #3599
APEX version 09 11 07 sn 3631 038 012
286F335 ARGOS ID number
038 seconds rep rate
108 hours DOWN
012 hours UP
0500 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
0500 d-bar profile pressure P6
022 profile piston position P7
115 OK vacuum count   P8
004 ascend time intervals   P9
152 air bladder pressure   PB
255 deep profile count   PD
002 oxygen pump sequence   PS
025 Initial piston extension

INSTRUMENT #3600

APEX version 09 11 07 sn 3632 038 012
286F34C ARGOS ID number
038 seconds rep rate
108 hours DOWN
012 hours UP
0500 d-bar park pressure P1
030 park piston position P2
012 ascent rate correction P3
100 storage piston position P4
251 piston full extension P5
0500 d-bar profile pressure P6
022 profile piston position P7
115 OK vacuum count P8
004 ascend time intervals P9
152 air bladder pressure PB
255 deep profile count PD
002 oxygen pump sequence PS
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 for 28 bit Id

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 31 bytes in an ARGOS message is the CRC.
'The function CRC will compute CRC for byte 2 through 31.
'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(31) AS INTEGER
'RAF11F message number 08 HEX ID 11502 01-02-93   CRC is O.K.
A$ = "d802075d87c64e15078187c64c1f07b287c74a3007ce87c6483f07fe87c246"
        N = 31
        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 31-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

Subtracting Te from the ARGOS time stamp can determine approximate time of surfacing

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
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 7 & 8 of message 02.

<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: Argos ID formats, 28 bit and 20 bit

In 2002 Service Argos notified its users there were a limited number of 20-bit Ids available and to begin preparing for a transition to 28-bit IDs. The 28 bit-IDs reduced from 32 to 31 the number of data bytes in each message. Data provided by Argos will consist of 31 hex bytes per message. Data acquired by use of an uplink receiver will consist of 32 hex bytes per message. The first byte, when using an uplink receiver, is a 28-bit ID identifier used by Argos and is not represented in the Apex Data formats included in this manual.

APPENDIX E: 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.

APPENDIX F: 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

CAUTION: If the float was recovered from the ocean, it may contain water, which presents a safety hazard due to possible chemical reaction of batteries in water, which may generate explosive gases (see Section I. Alkaline Battery Warning). In this case, be sure to remove the seal plug to ventilate the instrument. Use a 3/16 inch hex wrench, or pliers, to rotate the plug counter-clockwise.

Please use provided 3/16” allen wrench to remove this vent plug

rotate counter –clockwise to unscrew plug.

APPENDIX G: CTD Calibration and Ballasting records

(Included in hard copy only)