CTD Troubleshooting

Examples and Suggestions for Identifying and Solving SBE911*plus* Problems

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What we'll cover-

- Dave- Available SeaBird troubleshooting resources and support for the 9, 11, 32 and related systems.

- Marshall and Dave- Examples, suggestions and techniques from some user experiences

** Participation is strongly encouraged!

Discussion points

- Where do ResTechs find the most problems with the overall CTD system?
- What issues have been the most difficult to solve?
- What resources helped the most?
- What else can we do for the ResTechs?

Consider the Big Picture

We want to consider the entire SBE911*plus* system, including:

- SBE9, SBE32 and underwater sensors, cables, housing
- Sea cable, from termination to lab connector,
- SBE11 and its immediate peripherals
- User procedures and training

We’ve asked ResTechs for
their most challenging,
most unusual and
most common
issues or incidents,
how they identified the problem,
and how (if?) it was solved.

Issues by category:

- SBE9plus unit.
- Underwater sensors from SBE and others.
- Underwater cables and connectors.
- SBE32 pylon and release assembly.
- Termination and Sea cable.
- SBE11plus.

Note- SBE SeaSave acquisition software, system configuration and operations are not covered.

SBE9plus troubleshooting

- Identification of the SBE9 itself as the source of the problem may take several steps.
- Most issues are with XSG/AG306 connectors and require cleaning or field changeout.
- Have only had two times in 15 years where we needed to do SBE9 circuit board change in field.
- Recently had o-ring failure on pressure port of 15 year old SBE9, causing minor field-repairable water damage.

Underwater sensors

- SBE3, SBE4 and SBE43 sensors
- SBE5 pumps and plumbing
- WETLabs ECO series fluorometers/turbidity
- WETLabs C*Star transmissometers
- Benthos PSA-916 altimeters
- Biospherical PAR
- Seapoint STM turbidity

Underwater sensors: Diagnosing flooded sensor or cable

- Connector moisture is the most frequent issue, followed by sensor fault.
- Rx #1: swap cables or sensors until problem disappears… but may take time.
- Rx #2: If A/D port available, use voltage monitor dummy to observe +15V supply for noise during cast (15kΩ+4.7kΩ RN60C resistor voltage divider on AG206 lead).

Underwater sensors: SBE3 and SBE4

- Few issues with these sensors. Most relate to damage to the XSG connector.
- Most frequent issue is surface oil fouling or bio-fouling during cast (salp, krill, etc).

  Rx: Use comparative or difference graphics in SeaSave.
- Next biggest issue is incorrect calibration data in SeaSave.

  Rx: Make use of .XML calibration files to avoid entry errors, and make use of report function in SeaSave to cross-check.
- Very few incidents of cell damage on the SBE4.
- Use of Triton-X per SBE procedure not rigorously followed until an issue is found.
- Calibration stability of the SBE3plus and SBE4 has been very good at WHOI.

Underwater sensors: SBE43 oxygen

- Most frequent issue is mismatch with titrated H_2O samples. Careful titration is a must.
- Noise in O_2 profiles may indicate membrane damage or fouling
- If in bio-active waters, self-clearing bio-fouling is often found.

  Rx: Use second SBE43 on secondary loop.
- Often issue is not observed for many casts.

  Rx: closely compare with prior cast O_2 profiles.
- Take care not to use Triton-X on membrane.

Underwater sensors: SBE5 pumps and plumbing

- Biggest issue is clogged air valves on vertical SBE9s. Symptoms are no or delayed pump turn-on, erratic T/S/O_2 data as seen on SeaSave.

  Rx: place stainless 26AWG wire on cage and USE it regularly on all air valves.
- SBE5 erratic flow. Symptom- poor profile comparison.

  Rx: clean body and impeller, or swap and service.
- At WHOI, pumps are the least returned SBE item for service- should return regularly.

Underwater sensors: WETLabs ECO series

- Most frequent issue is incorrect calibration setup, especially with combined fluorometer/turbidity (FLNTU, FLNTURTD)
- Some output voltage failures required service.
- Orient ECO face into water path, keep clean.
- No leaks or connector failures observed yet.

Underwater sensors: WETLabs C*Star transmissometers

- For 25cm 6000m cases, many units returned due to window fogging due to window seal or case o-ring failure, 5x/5 yrs.
- Recessed screw point on back of case have anodizing failure with water ingress, 3x/5 yrs.
- Failure of light source or output voltage, 2x/5 yrs.
- Have changed over connector from LSG-4 to MCBH6M on WHOI units, $250 at WETLabs.
- WETLabs encourages annual service, rarely done.

Underwater sensors: Benthos PSA-916 altimeters

- Design based on LM1812 chip, obsolete in mid 1980s. Benthos using NOS for production.
- Most reported issue is erratic bottom detection, often less than 20m.
- At 200kHz, range is most dependent on condition of seafloor.
- Flooding due to case o-ring failure, or failure of transducer seal, 4x/5 yrs.
- WHOI evaluating newer altimeters for performance and compatibility with LADCP and USBL systems.

Underwater sensors: Benthos PSA-916 altimeters, cont'd

- WHOI's extensive Towcam work over nearly a million images while using the PSA-916 for ranging help us understand the correlation of range with observed and sampled bottom type.
- Marshall's PSA-916 Rule: For any arbitrary bottom, likelihood of five consecutive PSA-916 observations that are the expected altitude is:
  - 20% at 50m
  - 40% at 40m
  - 60% at 30m
  - 80% at 25m

Underwater sensors: Biospherical PAR

- Using QSP2300 with MCBH connectors.
- Damage to light ball still biggest issue.

  Rx: Mount carefully and ALWAYS protect sensor after recovery of rosette.
- Retrofit from LSG connectors is available from Biospherical for nominal cost. This has worked well for WHOI's QSP-200L4S still in service.

Underwater sensors: Seapoint STM turbidity

- Used on rosettes and towcam.
- Earlier 2-piece design prone to moisture damage. Look for seam on case. Rx: none- must replace.
- Failure of voltage output most common issue, 6x / 4 yrs. No warranty on these.
- Clouding of optical face on some (see photo). Rx: found car headlight lens restorer kit works well.

Underwater cable and connectors

- Most shipped SBE9 and support sensors use XSG/RMG connectors.
- About half of new SBE systems shipping with Impulse MCBH wet-pluggable connectors.
- SBE retrofit service is a growing volume of SeaBird service work.
- For lubrication, use DC4 for XSG/RMG, and non-petroleum carrier silicone spray for MCBH/MCIL connectors (see Impulse and Subconn guides.)

Underwater cable and connectors Issues with XSG/RMG

- Biggest issue with XSG/RMG connector systems is moisture failure at connector.
- Causes:
  - Moisture on connector before seating,
  - Inability to "burp" the connector properly,
  - Excessive or insufficient grease,
  - Loss of pliability of RMG due to cold or age embrittlement.
- Next biggest issue is pin bending or breakage due to misalignment.

Underwater cable and connectors Issues with XSG/RMG cont'd

Rx:

- Always dry connectors before removing.
- If cold, warm with warm water or warm air.
- Always wipe clean both XSG and RMG after disconnecting, use isopropanol to clean if needed.
- Always inspect both sides before lubing.
- Lubricate XSG side *lightly* with DC4. Do NOT use silicone spray.
- Carefully orient, install and burp. Repeat, and install locking sleeve.

SBE32
Pylon and release assembly

- Few issues, but most due to lack of rinsing and maintenance.
- Sticking release levers:
  - Dirt, armor rust flakes, bio-fouling.
  - Tiodizing failure, flaking and titanium exposure. (see to right->)
  - Bent lever arms.
- Bad lanyard geometry from bottle to lever.
- Solenoid damage from potting failure from corrosion.

SBE32 cont'd
Solenoid corrosion

- Solenoid potting failure due to corrosion on inside perimeter of armature can allow moisture ingress into SBE32. Factory repair 5x/6yrs. One case caused flooding destruction of entire SBE32.

SBE32
Solenoid corrosion cont'd

- First symptom may be erratic lever release.
- Rx:
  - Clean with high-pressure fresh water rinse after EVERY cast.
  - Weekly, remove release assembly and clean to SBE recommendations (placing in dishwasher hot wash cycle with NO detergent works well.)
  - Inspect solenoids weekly for corrosion, take pictures.
  - No field solution for corrosion. Return to SBE.

Sea cable and Termination Mechanical System View

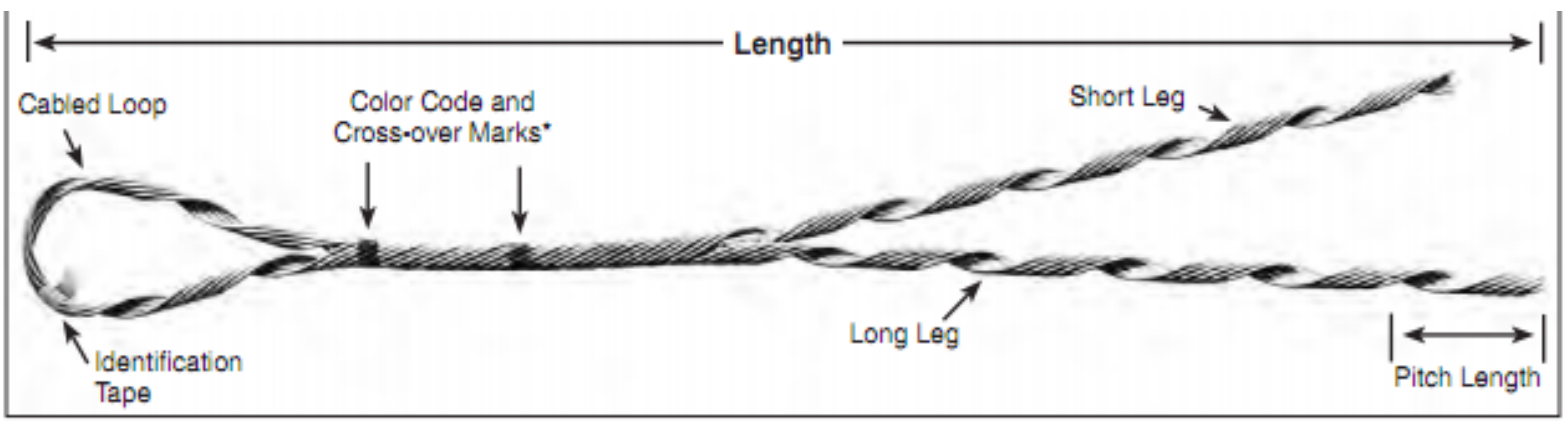
- Viewed as mechanical system:
  - Common types of mechanical termination
    - Cerrobend potted clevis
    - Dead-end (chinese finger)
    - Clamped ring-wrap
  - Maintenance and evaluation of condition of cable and termination.
  - Frequency and costs of changeout and failure of the cable and termination.

Seacable and Termination Cerrobend poured clevis

- Long experience in fleet with this design, produced at WHOI and elsewhere.
- Benefit is short length allowing use on small ships.
- Stress concentration and inability to inspect cable at entry to Cerrobend increase likelihood of unseen corrosion damage.
- Cerrobend 186 contains cadmium and is considered to be a hazardous material when melted and handled.
- Termination must use bend-restricting boot to reduce risk of damage at top of clevis.

SeaCable and Termination Dead-End mechanical termination

- Also known as “chinese finger” or “Guy-Grips.”
- Very low cost ~ $3 each, quickly installed and readily available.
- Exceptionally reliable with over 100 years of experience in electric utility markets.
- WHOI pull testing confirms strength significantly exceeds A301592 cable breaking strength.
- At 31 in (<0.8m) installed length, it is longer than the Cerrobend poured termination, which restricts use to those ships with clearance.



Sea cable and Termination Electrical System View

- Many failure points to consider between rosette and lab:
  - Termination pigtail connector
  - Splice of pigtail to sea cable to conductors and armor
  - Sea cable conductors and armor condition
  - Sea cable axle end splice to slip ring axle-side pigtail connector
  - Slip ring axle-side pigtail connector
  - Slip ring body
  - Slip ring static end to lead-in pigtail connector
  - Splice of slip ring lead-in pigtail connector to lead-in
  - Lead-in cable
  - Lead-in to SBE11 deck unit splice or terminals
  - Pigtail to SBE11 connector (MS3106-12S-3P)
- Consider any combination of above may stop your work!

Sea cable and Termination Electrical System View cont'd

- Most common issues:
  - Failure of splices at termination and slip ring connectors.
  - Sea cable insulation aging or damage.
  - Pigtail insulation aging and damage.
  - Short-radius bends of connector at body cause internal wire intermittents or failures.
  - Loose SBE11 deck unit pigtail connector (MS3106A-12S-3P) cable clamp allows shorting of conductors.
  - Slip ring low insulation resistance or open circuits due to moisture, corrosion or storage. (MXOs must be stored VERTICALLY!)
- These will cause open, short circuits or low insulation indications during testing and operation.

Testing of Sea Cables
Insulation Resistance testing

- WHOI uses two types of test instruments for evaluation of conducting sea cables.
  - AEMC model 1060 insulation tester.
  - Megger model CFL-535 automated cable fault locator (automated long-distance TDR).
- Both have been supplied to each ship and one set ashore.
- A regular insulation resistance test program is a good Preventive Maintenance practice to establish and maintain health status of this critical path resource.

Testing of Sea Cables
Insulation Resistance Test

- AEMC model 1060 gives us repeatable, objective and reportable measurements of insulation resistance, DAR (dielectric Absorption Ratio) and PI (Polarization Index) to quantify insulation condition between all conductors and armor.
- WHOI runs six tests for 10 minutes each (3x conductor to conductor, 3x conductor to ground) on A301592 cable.
- Test results are compared to Rochester specification and history for that cable.
- Conductors can be avoided if their circuit indicates low insulation resistance.

Testing of Sea Cables
Example of Atlantis results 11/13/2011

(Special Thanks to Allison Heater, WHOI SSSG)

On Sun, Nov 13, 2011 at 8:57 AM, Atlantis SSSG <sssg@atlantis.whoi.edu> wrote:
With regard to the use of the .322 conductor wire with the the SDSL Data-Link:

We recently cut 50 meters off the conductor wire and re-terminated. The new Termination was pull tested to 2500 lbs for 10 minutes. I then megohmmetered the entire wire from the termination through to the computer lab following Marshall's instructions. The results were:

INSULATION RESISTANCE:

	Ohms	DAR	PI	microF
white-red	2.254 GOhms	1.06	1.07	0.709
white-black	2.046 GOhms	1.05	1.39	0.753
white-green (ground)	2.011 GOhms	1.13	1.17	1.147
red-black	2.481 GOhms	1.07	1.11	0.750
red-green	2.591 GOhms	1.14	1.23	1.088
black-green	1.957 GOhms	1.24	1.09	1.092

CONTINUITY
Continuity: expected value each conductor: (9.804 km)(30.8 ohms/km) ~302 ohms

green to ship = < 1 ohms
red = 293 ohms
black = 294 ohms
white = 294 ohms

So, the conductor wire is ready to go for CTD and SDSL DATA-LINK operations using any and all conductors.

Testing of Sea Cables
Evaluation of AT continuity test results

The equation for resistance correction, for temperature other than 20 °C, is:

```
R1 = R2 * [ 1 + a * (T1 - T2)]
 where:
R1 = resistance at 20 °C.
R2 = resistance at new temperature °C.
a = 0.0039/°C, the temperature coefficient of resistance of annealed copper
     at 20°C (note 1).
T1 = 20 °C, the reference temperature.
T2 = observed temperature in °C.
```

The expected resistance at 20 °C can be found by applying the equation above is shown here:

```
T1 = 20.0 °C
T2 = 14.0 °C
a = 0.0039/°C
R1 = expected resistance in ohms when corrected to 20 °C.
R2 = 294Ω, observed resistance in ohms at 14 °C.

R1 = R2 * [1 + a * (T1-T2)]
   = 294Ω * [1 + 0.0039/°C * (20.0°C - 14.0°C)]
   = 300.8Ω
```

Now add the series resistance of the lead-in and slip rings I determined in 2009 (assuming it is still valid), adding 0.5Ω:

```
R1 total circuit = 300.8Ω sea cable at 14 °C + 0.5Ω for lead in and slip rings...
R1 = 301.3 Ω.
```

QED.
(Note: This is within one ohm of the actual observed resistance of the sea cable conductor.)

SBE11 Deck Unit

- These have been highly reliable, but do take significant physical vibration and shock loads.
- Issues in descending order of occurrence:
  - Blown 0.5A sea cable fuse from cable or equipment fault.
  - Incorrect settings for NMEA or Surface PAR configuration via software (SBE11 ver 2), or switches for Surface PAR (on SBE11 ver 1).
  - Loose internal ribbon connectors.

SBE11 Deck Unit Related issues

- Users must be familiar with the interaction of SeaSave and the SBE11 displays and controls to take full advantage of the system. Read and understand the manual and Application notes!
- Lack of or improperly formatted NMEA 0183 (GPS) data will prevent SeaSave from starting, and has been incorrectly attributed to the SBE911 configuration.

Thanks

We wish to thank those who have contributed their experience and suggestions now and in the past, especially

- Allison Heater, Robbie Laird, Robb Hagg, George Tupper and Andy Girard, WHOI.
- Bill Fanning, URI.
- Ken Feldman, UW/OOI.